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DEPARTMENT OF
AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY.
L. L. FOSTER, Commissioner.

SECOND ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY OF TEXAS,

1890.

E. T. DUMBLE, F. G. S. A.,
STATE GEOLOGIST.

AUSTIN:
STATE PRINTING OFFICE.
1891.

LETTER OF TRANSMITTAL.

OFFICE OF COMMISSIONER OF AGRICULTURE,
INSURANCE, STATISTICS, AND HISTORY,
AUSTIN, TEXAS, May 1, 1891.

Hon. J. S. Hogg, Governor of Texas:

DEAR SIR—I have the honor to transmit herewith the Second Annual Report of the Geological and Mineralogical Survey of Texas. The work of that branch of this Department has been in charge of Prof. E. T. Dumble from its organization up to the present time, and whatever of success has attended the inauguration and first two years' work of the Survey is largely due to his skill as an organizer and ability as a geologist. Considering the limited means placed at the command of the Department for use in that branch of the office, the character and extent of the work accomplished will, in my judgment, compare favorably with that done by the Surveys of other States.

These Reports have resulted in acquainting our own people with the mineral resources and wealth of the State, and attracting the attention of capitalists and investors, both at home and abroad, thereto. Indeed, this is only a modest claim for the practical benefits to the people of the State resulting from the work of the Survey.

Since the Survey has demonstrated its right to live, and its effect on the material development of the State is becoming better understood, it is to be hoped that more liberal appropriations will be made for the prosecution of the work.

I have the honor to remain, with great respect, your most obedient servant,

L. L. FOSTER,
Commissioner of Agriculture, Insurance, Statistics, and History.

FINANCIAL STATEMENT.

Appropriation for the Geological Survey of Texas, January 1, 1890, to December 31, 1890.

Balance unexpended December 31, 1889		$7,588 72
Appropriation March 1, 1890, to February 28, 1891		35,000 00
Expended:		
Salaries	$23,851 49	
Field equipment	766 02	
Field expenses	6,104 00	
Instruments and apparatus	318 55	
Furniture and fittings	490 18	
Books and maps	981 78	
Laboratory supplies	927 09	
Printing	371 65	
Office supplies	37 65	
Incidentals	399 63	
Balance	8,340 68	
	$42,588 72	$42,588 72

GEOLOGICAL SURVEY OF TEXAS.

REPORT OF THE STATE GEOLOGIST

FOR

1890.

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Part II. Fuels and their Utilization.

Part III. Description of Counties.

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REPORT ON THE GEOLOGY OF NORTHWESTERN TEXAS, BY W. F. CUMMINS.

REPORT ON THE GEOLOGY AND MINERAL RESOURCES OF THE CENTRAL MINERAL REGION OF TEXAS, BY THEO. B. COMSTOCK.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY,
GEOLOGICAL SURVEY OF TEXAS,
AUSTIN, TEXAS, May 1, 1891.

Hon. L. L. Foster, Commissioner of Agriculture, Insurance, Statistics, and History, Austin, Texas:

DEAR SIR—I have the honor to transmit herewith the Second Annual Report of the Geological and Mineralogical Survey of Texas.

This Report is mainly devoted to the description of the mineral resources of the State, so far as determined by the work of the Survey during the two years ending December 31, 1890.

We have endeavored to make these statements in such manner as that they will be valuable to every citizen, be he land owner, farmer, mechanic, capitalist, or what not, and have used illustrations and maps freely to make clear the conditions under which the various materials occur. I greatly regret that at the last moment circumstances arose which prevented the coloring of the maps of the Central Mineral Region and of Trans-Pecos Texas, to indicate the geology of the areas, as had been arranged for, and hope that they may be so issued in the near future.

Owing to the necessarily great mass of matter, and the limited appropriation for printing, it has been found necessary to omit several reports which it was intended to include in this volume. I would suggest, in order to get them out more speedily, that they be printed as a Bulletin.

In conclusion, I desire to express my most sincere thanks for the perfect freedom of action you have granted me and the unfailing assistance and advice you have so kindly given at all times. Only under such conditions was the amount of work which has been accomplished by the Survey during the brief period of its existence a possibility.

Yours, very truly,

E. T. DUMBLE,
State Geologist.

SECOND ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY OF TEXAS.

E. T. DUMBLE, State Geologist.

INTRODUCTORY.

The character of work required to carry on the investigations of the Survey during its second year, in accordance with the plan outlined in the First Annual Report, was necessarily somewhat different from that which preceded it.

The broader features of the different geological formations had been determined, the character of the materials composing them and some idea of their extent had been ascertained, and with this as a basis we were prepared to take up in greater detail the study of each formation with its various economic minerals and possibilities.

The work of the different field parties was therefore planned and carried out as nearly as possible with this end in view. Numerous difficulties were encountered, and in some instances the results are not as definite in character as I had hoped to have them, but the general and total result is most satisfactory.

WORK OF THE SECOND YEAR.

TOPOGRAPHY.

One of the most serious troubles experienced by the different field parties was the lack of accurate maps. Without a correct map on which to plot his observations the field geologist is working to the greatest disadvantage. Our county maps are insufficient for the purpose. Many of them are old. They do not show the proper courses of the streams. Few roads are laid down, and these, owing to the frequent changes, are often differently located on the map from their actual location on the ground. Even the railroads do not appear in some of them. Therefore in endeavoring to carry on this detailed work we are met on every side by this great want, and much of the time that should be spent in the study of the geology must be given to correcting inaccuracies of the maps.

I have made an earnest effort to remedy this deficiency as far as possible. With this in view I went to Washington and had a conference with Major Powell, Director of the United States Geological Survey. As was stated in the First Annual Report, the topographic work carried on under the direction of the United States Geological Survey had been completed over some twenty-four thousand square miles in the center of the State. More exactly, the area covered by this work to June 1, 1890, was bounded by parallels 30° and 33°, and meridians 97° and 99° 30′.

These maps are engraved in sheets on the scale of two miles to the inch. On this scale each square degree forms four sheets. The principal points are located by triangulation, and the relative heights and differences of elevation are based upon the railroad levels of the country. Where there is a system of railroad lines which cross one another at various points a series of checks is afforded, and the degree of accuracy with which these levels are run is sufficient for the best of these maps. With these levels for a basis the reliefs of the whole country are determined by running lines of levels, plane table work, and barometric observation.

The maps are printed in three colors; the water-courses, lakes, etc., being in blue; the contour lines, by which each difference of elevation of fifty feet is shown, in brown; and the roads, railways, and other cultural features and lettering in black. They are by far the most accurate maps in existence of the region which they cover, and have been of great service, since they are fully sufficient for any but the most detailed work or that requiring a larger scale and greatest accuracy in detail. The intention was to extend eastward by this season's field work. I therefore requested of Maj. Powell that the field work of the present year be planned to meet our requirements more nearly, and instead of working to the east of the area given above that they take up that area lying between meridians 99° 30′ and 100°. The completion of this tier of sheets would give us the topography of all the Central Mineral Region, part of the Abilene-Wichita country, a large portion of the Cretaceous area, and all of the Central Coal Field except that portion lying north of the completed line of work of last year—the 33d parallel of latitude.

I also requested that if possible the United States Geological Survey take up the entire topographic work west of the Pecos River, or if unable to do that, at least to finish the primary triangulation for us in order that we might take up such detached areas as we desired to study and have accurate connection between them such as this would give. Maj. Powell promised compliance as far as possible, and under date of June 9 writes:

"It has been arranged that during the field season of 1890 topographic field work will be carried on in the tier of sheets indicated by you, immediately west of the area already mapped—that is, between 99° 30′ and 100° of longitude. It is hoped that the maps resulting from this work will prove of service to you.

"It is not yet possible to indicate what topographic work will be done this year in the Trans-Pecos region. The addition of the irrigation investigation to the work of the Geological Survey has led to the assignment of all topographic work in the region to the Irrigation Survey, and the order in which different districts are surveyed is determined by the needs of the irrigation investigation."

He also informed me in the same letter that although the United States Geological Survey could not undertake triangulation in Texas as a basis for our own topographic work, the United States Coast and Geodetic Survey was especially authorized by law to co-operate with any State which is conducting a geologic or topographic survey by executing triangulation for it.

Having already been assured by Dr. T. C. Mendenhall of such co-operation as he could give, I immediately wrote him asking that the United States Coast and Geodetic Survey, of which he is the superintendent, take up the primary triangulation of Trans-Pecos Texas. In his reply of June 28 he says:

"In response to your request I will say that we can begin the primary triangulation along the boundary line of Texas near the point to which you refer, commencing with your base line if desired, but preferably perhaps at El Paso, and running down the Rio Grande. This triangulation would cover possibly a strip of fifty miles wide, and would furnish you with a number of points and bases from which a local triangulation for topography could proceed. I would endeavor to begin the work during the present season and push it as fast as possible, but the high character of the triangulation demanded would necessarily make it somewhat slow. This, however, would not in any way impede your own operations in topography and secondary or tertiary triangulation."

The co-operation thus secured will be of the greatest benefit to our work in Trans-Pecos, as it will enable us to take up the topographic mapping of detached areas according to their importance and to connect them by doing the intervening flats and less important portions more at leisure.

CO-OPERATION OF THE UNITED STATES GEOLOGICAL SURVEY.

The work of the United States Geological Survey in this State during the years 1889 and 1890 was as follows:

1889. In topographic mapping surveys were completed for sheets covering approximately the counties of Shackelford, Palo Pinto, Parker, Tarrant, Dallas, and Johnson. 6 sheets.

1890. Sheets covering approximately the counties of Concho, Taylor, Runnels, Jones, and parts of Falls, McLennan, Hill, Coke, and Tom Green. 8 sheets.

This, together with the twenty-three sheets already surveyed, twenty-one of which have been engraved, gives us a total of thirty-seven sheets, representing an area of nine and a quarter square degrees, or about forty thousand square miles.

During the past field season the work in this State has been in general charge of Mr. R. U. Goode, Geographer. It has been prosecuted by four parties as follows:

Triangulation party, in charge of Mr. C. T. Urquhart.

Party for establishing primary levels, in charge of Mr. A. E. Wilson.

Two topographic parties in charge of Messrs. H. L. Wallace and H. O. Gordon, respectively.

In astronomic work Prof. R. S. Woodward, assisted by Mr. A. P. Davis, determined the location of the 105th meridian of west longitude at a point east of the town of Sierra Blanca, Texas. This was effected by first determining an astronomical position at Sierra Blanca, the longitude being ascertained by telegraphic exchange of time signals with the observatory at Washington University, Saint Louis, and the latitude by the method of zenith distances. From the astronomical position, longitude 105° 21′ 24″ west, latitude 43° 35′ 58″ north, thus determined, the 105th meridian was located by triangulation, and a zenith mark on the meridian established.

ERRATUM.

Page xx, last line, for "zenith" read "azimuth."

The following is a list of the topographic map sheets of this State which were engraved up to the first of December, 1890:

Bastrop,	Burnet,	Meridian,
Austin,	Llano,	Hamilton,
Blanco,	Mason,	Brownwood,
Fredericksburg,	Gatesville,	Coleman,
Kerrville,	Lampasas,	Granbury,
Taylor,	San Saba,	Stephenville,
Georgetown,	Brady,	Breckenridge.

CO-OPERATION OF THE UNITED STATES COAST AND GEODETIC SURVEY.

Assistant Stelman Forney, of the United States Coast and Geodetic Survey, left Washington late in November for El Paso, where he will begin the reconnaissance for primary triangulation. His scheme will follow the general direction of the Mexican boundary line, and will be connected with the base lines measured by this Survey and by the United States Geological Survey.

WORK OF THE STATE SURVEY.

TRANS-PECOS TEXAS.

In this district an effort was made by Prof. Streeruwitz, assisted by Mr. Wyschetzki, to complete the section begun last year by mapping the area between the Quitman Mountains and the Rio Grande. This was, however, found to be impracticable on account of lack of facilities for securing supplies and the impassable condition of the old roads south of the mountains. It was therefore thought best to map in the Diabolo and Carrizo mountains on the northeast, which was accordingly done.

The accuracy of the work done in this district is fully established by Dr. Woodward's remeasurement of many of the angles with instruments of great precision, with resulting differences well within the limit of error of the smaller instrument belonging to the Survey, and his verification of the Texas Base Line to within $\frac{1}{32000}$.

For the benefit of the surveyors of West Texas Dr. R. S. Woodward, of the United States Geological Survey, in connection with Prof. Streeruwitz, erected monuments in the vicinity of Torbert, giving the true north and south line, and also an accurately measured line for the correction of their chains. This is marked by monuments in the Texas Base Line.

That portion of the work which was finished appears with the report of Prof. Streeruwitz on the geology of his district.

CENTRAL MINERAL REGION.

The topographic work in Dr. Comstock's district was carried on by Mr. J. C. Nagle, and is intended to furnish, in connection with the work of the United States Geological Survey, the accurate topography of the entire area of the rocks older than the Coal Measures in Central Texas, as a basis for mapping the complicated geology of this region. The work was carried as far as possible in the time allowed by the present field season, and the map as far as completed accompanies this Report.

In September Mr. Nagle was elected Assistant Professor of Engineering at the Agricultural and Mechanical College of Texas, and the completion of the plotting of the map has been done by him without cost to the Survey.

MAP OF TEXAS.

The map of Texas used in the First Annual Report was printed from the plates belonging to the United States Geological Survey, by permission of Major Powell. As it was necessary for us to have maps of the State on several different scales, we began early in the year to collect materials for getting as correct data as possible for use in construction.

Maps of each county were sent to the respective county surveyors and all required alterations noted. These were compiled on a post route map of the State corrected to late date, and the copy from which engraving is to be made was drawn from this corrected base.

This has been engraved on the following scales for the use of the Survey and the Department of Agriculture:

$\frac{1}{1267200}$, or 20 miles to one inch.

$\frac{1}{2534400}$, or 40 miles to one inch.

$\frac{1}{6336000}$, or 100 miles to one inch.

GEOLOGY.

EAST TEXAS.

On March 28th Mr. W. Kennedy was sent into East Texas to continue the work of mapping the iron ores of Cass, Harrison, and other counties, and at the same time to study the associated clays and lignites. In pursuance of instructions he proceeded to Cass County, after mapping which he took up the investigation of Harrison County, and before returning to Austin made a brief reconnaissance of parts of Gregg and Marion counties.

In order to complete enough of the mapping of the district to make a satisfactory report, it was determined to send Messrs. J. B. Walker and J. H. Herndon into the field. Mr. Walker went out, under instructions of June 6, to map the iron ores of Rusk, Panola, Shelby, and Nacogdoches counties, and in addition to make such observations of the geology as his time would allow.

To Mr. Herndon was given the study of Smith County, including its iron ores, clays, lignites, and building stones, on the completion of which he returned to Austin and resumed his regular work in the chemical laboratory.

These counties were gone over as thoroughly as the time permitted, and their studies have added much to our knowledge both of the general and economic geology of the region.

The reports of these gentlemen will be found in Part II of this Report—"The Iron Ore District of Eastern Texas."

During the field season I visited Mr. Kennedy while he was at work in Cass County, spent several days in working with Mr. Herndon in Smith County, and visited Anderson and Houston counties for the purpose of collecting specimens of ore from certain localities previously mapped by Mr. G. E. Ladd, or reported on by Dr. Penrose, which were needed for analysis. My investigations were greatly facilitated by the kind assistance of the citizens of Palestine and Crockett.

The artesian water belt of the Gulf coast being a very important factor in the economic geology of the region, I tried to take up the study of it in such intervals as occurred in my administrative work. I visited Ledbetter, from which point I was enabled through the kindness of Captain A. W. Littig, superintendent of the First Division of the Houston and Texas Central Railway, to visit several of the most favorable localities for the study of the outcrops of the Fayette Sands, which constitute the catchment basin of the artesian belt. The results were of importance in this connection. Later I visited Galveston and Houston to investigate the results of the artesian borings at those places. It is to be regretted that more time could not have been given to this important work, but it was found impracticable to complete it. Consequently only a brief statement is made concerning it.

THE CRETACEOUS AREA.

In February, 1890, Mr. Robt. T. Hill, having resigned from his professorship at the State University of Texas, was appointed Geologist in charge of the Cretaceous area. Under this appointment he first prepared his paper on "The Cretaceous Rocks of Texas and Their Economic Uses," for the First Annual Report.

This report comprised the material contained in the introduction to Bulletin No. 4, together with some new matter which had been obtained in tracing the Cretaceous-Tertiary parting north of the Colorado River, to which was added brief mention of the economic features of the formation.

His work for the present year, as outlined in his letter of instructions, was the economic geology of that portion of the Cretaceous lying north of the Colorado River, including its soils, marls, building and paving stones, cement and lime materials, artesian water conditions, and such additional work in general or special stratigraphy as might be carried on with the above ends in view.

He began field work in the latter part of March, starting from Texarkana to make a study of the region adjacent to Red River. He continued to work westward, taking in such portions of the Indian Territory as became necessary to the proper understanding of his region. With his various assistants he covered as rapidly as possible the area of the Cretaceous north of the line of the Texas and Pacific Railway, and also considerable portions to the south of that line such as had not previously been examined.

His work, as detailed in his letters from April 8 to July 23, proved of the greatest interest both from a scientific and economic point of view.

Among the facts thus determined were: the presence of a great fault north of Denison, which has its effect on the present course of Red River; the absence in North Texas of the "Alternating Beds" of the Fredericksburg Division; the separation of the Trinity Sands, between Comanche and Wise counties, into two beds by a stratum of limestone, which has, in some places, a thickness of two hundred feet; and the presence of greensand marls.

On the 26th of July he was called in for consultation in regard to the preparation of his report, the amount of his allotment not permitting longer field work. At the same time a request was made by the citizens of El Paso that he be sent to examine and report on the probabilities of artesian water at that place. He was instructed to make this and a similar investigation at Georgetown, to start his assistants on the preparation of their notes for his use, and to have his report ready as near the 1st of October as possible.

On the 26th of August he presented his resignation from the Survey, to take effect as soon as his report was prepared. On his return from El Paso he expressed a desire to have his resignation take effect at once, and that he be allowed to make his report when he could, as he wished to enter into business arrangements which his connection with the Survey would prevent and which would pay better than Survey work. This being found impracticable, he presented a physician's certificate on September 26, stating that he was physically unable to make a report, at this time, and on September 30 he presented another resignation, to take effect at once without a report. Under the circumstances this was accepted, under the conditions that he return all his notes, maps, and materials to this office and observe his written agreement in regard to the publication of the results. This terminated his connection with the Survey and explains the reason for the non-appearance of a report on the region included in this investigation with the present volume.

He had, as assistants in this work, Messrs. J. S. Stone, J. A. Taff (who was transferred to Prof. Streeruwitz's division in May), L. T. Dashiel, G. H. Ragsdale, and W. T. Davidson, the work of all of whom he frequently commended highly in his letters.

NORTH TEXAS.

Prof. Cummins was instructed to take up the detailed study of the Coal Measures of the Central Coal Field. His field force was the same as that of the preceding year.

He first traced the partings between the Permian and Carboniferous to the Brazos River, and the upper part of Coal Seam No. 7, and then made an instrumental section entirely across the Carboniferous from the edge of Throckmorton County southeast by Graham and Milsap, and tracing at the same time the outcrop of Coal Seam No. 1 from

Wise County to its southern terminus, continuing the section down the Brazos to the line of Hood County, about ten miles above Thorpe's Springs, thus giving a connected section entirely across the Brazos Coal Field from the Permain on the west to the Cretaceous on the east. From here the party moved back to Palo Pinto and then to Crystal Falls, where the work of tracing Coal Seam No. 7 was again taken up and carried south to Cisco. I was with this party during this part of the work.

The second line of instrumental section was across the Colorado Coal Field from near the head of Pecan Bayou, where the Carboniferous is overlaid by the Cretaceous, southeast to San Saba.

Careful measurements were made on the dip of each coal seam at various points, in order to get the average dip. Examinations were made of all mines and prospects within reach of the line, and the outcrops of both of the workable coal seams were mapped as closely as possible in the time allowed for field work. The instrumental work was done by Mr. N. F. Drake, assisted by Duncan Cummins, and the result of the season's work in giving us an exact knowledge of the different members of the Coal Measures, their relations and thickness, has a most important bearing on the question of coal mining and consequent fuel supply in Central Texas, and has also added greatly to our knowledge of the building stones, soils, and other economic features of the region.

GUADALUPE MOUNTAINS.

From all the information at hand concerning the Guadalupe Mountains it seemed probable that an examination of them would add considerably to our knowledge of the relations of the rock structure of the Central and Western region to that of the Trans-Pecos, and give valuable information as to artesian well possibilities. Mr. Tarr was, therefore, instructed to make a reconnaissance of the mountains, and in order to more fully familiarize himself with the section of the Texas Permian to drive from Lampasas to Pecos City, by which route he would cross the entire series of Carboniferous and Permian beds. This part of the trip was satisfactorily accomplished; but on his arrival at Pecos City it was found that circumstances would prevent the entire completion of the trip as planned, and his work in these mountains was limited to the Guadalupe Mountains proper, and did not include their extensions southward far enough to get the connections desired. He, however, fully verified the results of Dr. G. G. Shumard's work in regard to artesian water supply, and ascertained the probable absence of deposits of ores or coal in the region. Upon his return from this trip he resigned from the Survey. The results of his work will be found among the papers accompanying this Report.

CENTRAL TEXAS.

Dr. Comstock took the field this year under instructions to complete his general work in the regions which he was unable to reach the previous season, and to give especial attention to working out the mineral resources of his district as fully as possible. The work was carried on as far as possible with these ends in view, but the difficulties arising from the fenced up condition of the country, lack of suitable roads, and often of water, provisions, and feed for teams accessible to the places at which work was contemplated, rendered it impossible to do all that was anticipated. His general route was from near Burnet south and west by Flat Rock Creek and Round Mountain, through Blanco and Gillespie counties, with excursions into the southern part of Llano County in working out the geology of Honey Creek Cove and the Riley Mountains. Then through Mason, Kimble, Menard, and Concho counties as rapidly as possible, tracing the western boundary of his district.

Following the northern boundary through McCulloch County he then turned into the region of Katemcy, Fredonia, and Cherokee to Silver Mine Hollow, Burnet County, at which point I joined his party for a few days. From there his party worked south and came into Austin.

This general route was interrupted by frequent trips toward the interior of the district for the examination of such localities as had been passed by during the last year for lack of time, but the hindrances mentioned above proved so great that it was found impossible to visit all that he wished. In November Dr. Comstock also devoted a week to the field study of the district in which tin was discovered by him.

The results of this season's work fully confirm the general statements made regarding the stratigraphic geology of the region in the First Annual Report, while in economic results it has given returns of greatest value. Among them may be noted the mapping of the area of the Burnet marbles, the various outcrops of granites, special study of the lead-bearing districts already known and the discovery of new ones, the study of the brines, the mapping of the general outcrops of the veins of iron ores, more detailed study of the gold, silver, and copper ores of the district and the determination of the probability of their existence in workable quantities, and finally the discovery of the existence of tin, which is in itself one of the most important of all.

TRANS-PECOS TEXAS.

Prof. W. H. Streeruwitz, having practically completed the topographic mapping of an important area, including the Quitman and Sierra Blanca mountains, parts of the Eagle, Diabolo, and Carrizo mountains, and the foot hills adjacent to them, was instructed to investigate its geology, with special reference to the valuable deposits of precious metals already determined as existing in it. He accordingly went to Fort Davis and got together his teams which had been at pasture, and after some trouble in securing assistants, finally started work with Mr. Ralph Wyschetzki as Assistant Topographer, and Mr. J. A. Taff as Assistant Geologist. Mr. Taff was given the study of the Cretaceous strata of the region, Prof. Streeruwitz working on the crystalline and older stratified rocks. The winter having been an unusually dry one, great difficulty was experienced in getting water at places convenient to the work without long hauling. The summer heat was also excessive, and lacked the invigorating breezes which are usual in that section. Taking it altogether, the work was done under very considerable disadvantage and even hardship, and it required the best of good nature and all the enthusiasm which the intensely interesting features of the geology of that region evokes to overcome them and succeed as fully as has been done.

The work that has been done includes the tracing and mapping of the various mineral veins of that district, specimens of all of which were taken and are now in the laboratory for analysis. Of the value of the district as a mining region there can be no doubt, and since excellent water occurs in the deeper workings and is found in the Quitman Valley, there is no longer any fear of a lack of this important item.

Besides this, the general geology of the region has been studied, and, as far as the limited time permitted, compared with similar adjacent areas; and while it is not possible to fully correlate the older rocks with those of other regions, much has been done towards the clear understanding of the structure and the stratigraphic relations of the various granites, porphyries, quartzites, marbles, etc. The fine porphyries and marbles have been collected for the purpose of showing their great beauty as building and ornamental stones.

In the Cretaceous a clear and comprehensive section of the system as it appears in the area has been obtained, which not only develops facts of some scientific importance, such as the absence of the Alternating Beds of the Fredericksburg Division, but furnishes economic results also that will in time be of considerable interest to that portion of the State.

PALEONTOLOGY.

The necessity for a correct knowledge of the fossils occurring in the different formations, and even in the different beds of the same formation, is as absolute for the correct determination of certain economic relations as any other branch in the science of geology.

The fossils are the guide boards of the geologist, and in spite of the fact that in many cases practical men look upon the labors of those whose time is given to such study as an utter waste, they must be studied in order that the exact succession of the rocks be known and their relations accurately defined. This is easily understood and appreciated if we take into consideration that each separate series of rocks has its own characteristic fossils, and that having definitely determined these, and by them the relations of the underlying and overlying strata, we can make a section showing the succession and thickness of each series of beds, and from such section in many cases tell exactly the chances for artesian water, for coal, or oil, or natural gas, and many other substances, at any point at which any one of the beds so determined may appear upon the surface, and often very closely approximating the depth at which they lie. In the Coal Measures, for instance, there is a persistent band of limestone with a certain association of fossil forms. We have determined them and know from observation that a coal seam lies a certain distance below them. Therefore at any place at which this limestone appears upon the surface, or where we find its characteristic fossils, we immediately begin the search for the coal seam. Many other instances of equal importance might be given of the economic use of the study of fossil forms. Of its relations to knowledge from the standpoints of biology and world-building it is unnecessary to speak.

While this is true, we have found it almost impossible to do anything in this direction here owing to a lack of books and type specimens for reference. We have therefore taken advantage of the kind offers of assistance that have been made at different times, and have by this means succeeded in getting a large amount of much needed work done at very little money cost to the Survey.

Prof. Angelo Heilprin, of the Philadelphia Academy of Sciences, took up the study of the fossils from the Tertiary beds which were collected by Dr. Penrose and myself. He has completed the work and sent me a list of his determinations. These, together with the descriptions of such as were undescribed or unfigured, will appear in the Transactions of that Academy at an early day.

Dr. Ferdinand Roemer, Professor in the University at Breslau, Germany, was the first geologist who wrote of the Texas Cretaceous, and his works are still our textbooks in paleontological matters. It was thought best on that account to ask his co-operation in determining and describing the numerous fossils of the Cretaceous. His reply was prompt and favorable, and the third shipment of material is now on the way to him.

In the trip made by Prof. Cummins and myself from Abilene to the Double Mountains in September, 1889, a number of new Nautiloid forms were found, and after they were gotten together in the Museum I forwarded some of them to Prof. Alpheus Hyatt, of the Boston Society of Natural History, for examination. They proved to be of such interest that he has made a study of them in connection with similar forms from Kansas and other places, and has furnished descriptions of all of them, together with accurate engravings, for incorporation in this Report.

Prof. E. D. Cope, of the Philadelphia Academy of Sciences, who has already described many of the fossils from the Permian beds of Texas, has offered his services in the determination of such Vertebrate fossils of that period as we may collect, and has given us such aid as he could in furnishing a check list of those which he has already described.

By the means of such co-operation I have secured for the Survey assistance that will be of greatest value, and have had forms identified which could not be done by the Survey itself in anything like a satisfactory manner.

CHEMICAL LABORATORY.

Soon after the completion of the work required for the First Annual Report, Mr. J. H. Herndon was given field work, as has been stated, in East Texas.

During Mr. Herndon's absence in the field Mr. Magnenat made all analyses and carried on other necessary laboratory work in the Survey laboratory.

Mr. P. S. Tilson continued the work of soil analysis, to which were added a number of East Texas iron ores, until the last of July, when he tendered his resignation as Chemist to the Survey to accept the position of Assistant Professor of Chemistry at the Agricultural and Mechanical College of Texas.

Upon his resignation such material and apparatus as was the property of the Geological Survey at the laboratory of the Agricultural and Mechanical College was brought to Austin, and the chemical work was all concentrated in our own laboratory.

On Mr. Herndon's return from the field he again resumed charge of the laboratory, and he and Mr. Magnenat have had the entire work since that time.

A general statement of the work of the year is given in another place. It has been almost entirely analytical, and little time was available for any original work, although there are many questions of interest which await investigation in connection with the ores and other materials collected.

LIBRARY.

I have added to our reference library as many books as I could bearing directly upon our work, but it is still very incomplete. Even the sets of Geological Reports of the various States and the different United States Surveys are still incomplete, and the Transactions of the numerous Scientific Associations are either unrepresented or present only in detached numbers. Numerous exchanges are arranged for, and further purchases will be made as rapidly as the appropriation will admit. Our distance from all public libraries renders the building up of one of our own a prime necessity.

MUSEUM.

There has been little change in the Museum. The difficulty of securing suitable field assistants for the character of work wanted compelled me to use all the force in the field, and in consequence there was no one to take up the Museum work; Mr. McCulloch, to whom it had been assigned in January, having been fully engaged in assisting me in reading the proof of the First Annual Report and other office work until just before his resignation from the Survey. It is intended to improve its condition as far as possible as soon as the present Report is ready for the printer.

OFFICE WORK.

My office work this year has required much closer application than that of last year, and in consequence I had little time for field work. In addition to the usual routine and correspondence I was engaged until June 1 in editing and revising the manuscript and reading the proof of the First Annual Report. I then used a few weeks in the necessary work of visiting the different field parties, and on the resignations of Mr. McCulloch in August, and Mr. Jones in September, I was left entirely without office assistance for more than a month. The amount of correspondence is steadily increasing. Letters of inquiry are coming in constantly from the different portions of the State regarding different points of interest which require time and study for proper answers. These include such questions as artesian water supply at many different points, the utilization of the greensand marls of Eastern Texas in particular localities, the lignites and their uses, localities and descriptions of clays for pottery and fire brick, the availability of certain waters and soils for irrigation purposes, the prospect for coal at certain localities, the location and extent of the deposits of bitumen, and many other similar subjects.

I have also been called upon for special detailed reports on several subjects, among which may be mentioned:

A report on the artesian water conditions of Texas west of the 97th meridian and north of San Antonio. This report was made at the request of Hon. J. M. Rusk, Secretary of Agriculture, for the use of Congress in their inquiries in regard to the use of artesian water in irrigation.

A report on the iron ores, fuels, manganese, fire clays, and other materials requisite for steel making which are found in Texas, with especial reference to their use at San Antonio. This report was made at the request of the Board of Trade of San Antonio for submittal to the officers of the Army Board, who were charged with the duty of selecting or recommending a site for the erection of works for the manufacture of heavy ordnance.

In October Dr. Otto Lerch was appointed Assistant Geologist, and given the special work of collating the results of the lignite industry in Germany from such literature as was available (the most of which was kindly loaned us from the library of the University of Texas), and preparing a statement of this in connection with the lignites of Texas. Upon the completion of this work he began the preparation of a preliminary statement of the history, present conditions, and probable future of irrigation in Texas.

Mr. W. S. Hunt was appointed to the position formerly filled by Mr. J. L. Jones, and began work November 10.

PUBLICATIONS.

The First Annual Report was the only volume issued by the Survey during the year 1890. The edition was not large enough to meet the demand for it, and after the required number was reserved by law and a few for exchanges, those remaining were distributed to the best advantage over the State and United States. I have, however, furnished the daily newspapers with a series of papers on the mineral resources of the State, and have also issued some of these in circular form, as there were numerous requests for them from different portions of Texas.

CO-OPERATION WITH THE PUBLIC SCHOOLS.

There having been several inquiries for collections of minerals of Texas for use in the public High Schools of the State, in connection with the study of Mineralogy and Geology, I began the arrangement of sets for such a purpose, which should consist of a fairly representative collection of the various minerals and rocks found in Texas and described or mentioned in the elementary works on Geology. Having gotten together enough materials for about twenty collections, I notified Hon. O. H. Cooper, Superintendent of Public Instruction, of my readiness to supply the collections, in the following letter:

AUSTIN, TEXAS, February 10, 1890.

Hon. O. H. Cooper, State Superintent of Public Instruction, Austin, Texas:

DEAR SIR—As numerous requests have been received during the past six months for collections of the rocks and minerals of Texas for the purpose of illustrating the study of Geology in the various High Schools of the State, I have made up a collection of specimens of suitable size, which are numbered and labeled plainly and ready for use in the way desired. These specimens, besides the ordinary educational value of such material, have the additional advantage of being all from the State, and therefore just such forms as the student will meet with in his field studies.

These collections will be furnished to any High School in Texas on application of the Principal, approved by the School Board, the only requirement being that a suitable case be provided for their preservation.

An ordinary show case, eight feet in length, with locks on the doors, will answer admirably; or, if an upright case be preferred, a book case with glass doors will answer.

Similar collections of the characteristic fossils of the different geologic periods will be prepared for the fall term.

Yours, very truly,

E. T. DUMBLE, State Geologist.

This was published in the Texas School Journal and other papers, and the consequent demand for the collections has been far beyond our ability to supply. Forty-one sets, more or less complete, were furnished, and since their shipment we have had applications for something over twenty more. During the last field season attention was given to securing the materials needed for supplying the specimens lacking in some of the collections sent out, and for furnishing complete collections to the other applicants.

It is proposed to follow these collections of rocks and minerals with others giving the characteristic fossils of our various geological formations, and it is hoped that each High School in the State will sooner or later have both these collections as a help in teaching Geology and interesting the young people of the State in the study of the natural features around them.

Collections were furnished the following schools and institutions:

Atlanta Male Institute, J. B. Madden, President.
University of Texas, Prof. F. W. Simonds.
Agricultural and Mechanical College, College.
Austin High School, I. H. Bryant, Principal.
Austin Colored High School, H. T. Kealing, Principal.
Abilene Public Schools, Geo. W. Roach, Superintendent.
Chappell Hill Female College, F. W. Tarrant, President.
Cisco Public Schools, C. G. Faust, Superintendent.
Colorado Public Schools, Jacob J. Hill, Superintendent.
Comanche High School, C. O. Smith, Superintendent.
Calvert High School, A. W. Kinnard, Principal.
Corsicana High School, Chas. J. Alexander, Superintendent.
Crockett Academy, E. A. Pace, Principal.
Dallas High School, T. G. Harris, Principal.
Denton High School, E. B. Keyte, Principal.

Ennis High School, Joseph C. Watkins, Superintendent.
El Paso High School, Miss Ella B. Meekins, Principal.
Fort Worth High School, P. M. White, Superintendent.
Hempstead High School, S. H. Dean, Principal.
Gonzales High School, Oscar Chrisman, Superintendent.
Gainesville High School, W. L. Lemmon, Principal.
Kyle Seminary, Milton Park, Principal.
Lovelady High School, H. W. Browder, Principal.
McKinney High School, J. T. Johnson, Superintendent.
Pecos High School, A. D. Wallace, Principal.
Paris High School, D. R. Cully, Superintendent.
Richmond High School, E. W. Smith, Principal.
San Antonio High School, W. Schoch, Principal.
Timpson High School, T. R. Day, Principal.
Tyler High School, Percy Pennybacker, Superintendent.
Whiteright Grayson College, Anderson & Butler, Proprietors.
Winsboro High School, E. H. Trammell, Principal.
St. Mary's Academy, San Antonio, Brother Lewis, Principal.
St. Mary's Academy, Austin, Sisters of the Holy Cross.
Texas Deaf and Dumb Asylum.
Taylor High School, A. P. Hill, Superintendent.
Texas State Geological and Scientific Association, Houston.
Waco High School, Mrs. W. D. House, Superintendent.
Bastrop High School, J. L. Hood, Principal.
Pleasant Grove High School, E. H. Tramwell, Principal.

MINERAL RESOURCES OF TEXAS.

INTRODUCTORY.

The mineral resources of Texas are too varied in their character and too widespread in their occurrence to permit more than a brief review of the results obtained by the investigations of this Survey during the past two years.

Previous to the organization of the present Survey little systematic work had been done toward securing definite and accurate information of the various economic products of the geology of the State. Many mineral localities were known, and the qualities of many ores, soils, and other materials had been tested by analyses. A few mines and manufactories scattered here and there over the State had tested some of these deposits practically, but there was nowhere a statement of such facts concerning them as would enable the owner or prospector to form any definite idea of their relations or probable values.

The following statements are based for the greater part on the work of myself and associates of the present Survey (although all reliable sources of information accessible to us at present have been examined), and many of the facts will be found stated in much greater detail in the various papers accompanying this and preceding Annual Reports, to which the reader is referred.

FUEL AND OILS.

WOOD.

Over Eastern Texas the amount of wood suitable for fuel purposes is seemingly inexhaustible; but as we go west it grows less and less, until in many places mesquite roots or even the "Mexican dagger" are the principal source of supply. The investigations of the Survey up to the present have been confined to an examination of the wood supply of certain counties with reference to the manufacture of charcoal for iron smelting, and this will be more fully discussed in Part II of this Report, "Report on the Iron Ore Region of East Texas." Other facts are also given in other parts of the Report.

LIGNITE.

Intermediate between peat and bituminous coal we find a fossil fuel known as lignite or brown coal. It contains less water and more carbon than peat, but has more water and less carbon than bituminous coal. Lignites are the product of a later geologic age than bituminous coal, and the bituminous matter has not been so fully developed as in the true bituminous coal.

Lignite varies in color from a brown to a brilliant jet black, and occurs in all degrees of purity, from a lignitic clay to a glossy coal of cubical fracture. The greatest amount of our lignites, however, are of black color, changing to brownish black on exposure, often with somewhat of a conchoidal fracture and a specific gravity of about 1.22.

Lignite occurs in beds similar to those of bituminous coal, although they are not always as regular and continuous.

LOCALITIES.—The area in which the lignites occur in Texas was defined in general terms in the First Report of Progress, p. 20, as follows:

"The lignite field is by far the largest field we have, and the coal strata it contains are of much greater thickness than those of either of the others. As nearly as we can at present mark its boundaries they are as follows: Beginning on the Sabine River, in Sabine County, the boundary line runs west and southwest near Crockett, Navasota, Ledbetter, Weimar, and on to Helena and the Rio Grande, thence back by Pearsall, Elgin, Marlin, Richland, Salem, and Clarksville to Red River.

"It includes fifty-four counties in whole or part, and while we do not know of the occurrence of lignite in every one of these, it will in all probability be found in all of them sooner or later."

Within the area thus defined lignite has been observed at hundreds of localities. Drs. Shumard and Buckley reported many of these, and many others have been described by members of the Survey. The beds vary from a few inches to as much as twelve feet, which thickness has been observed and measured in numerous places.

The lignites have been mined in greater or less quantities in several places, among which may be mentioned:

Athens, Henderson County.
Seven miles east of Emory, Rains County.
Alamo, Cass County.
Head's Prairie, Robertson County.
Calvert Bluff, Robertson County.
Rockdale, Milam County.
Bastrop, Bastrop County.
Lytle Mine, Atascosa County.
San Tomas, Webb County, and others.

Of these localities the Laredo "San Tomas" coal stands out sharply above the rest. Although it is classed as a lignite on the ground of its geologic occurrence, it is much superior to any of the ordinary lignites, as is shown by its analysis. A description of the bed and analysis of the coal were given in the First Annual Report.

Uses of Lignite.—The real value of this material as fuel is not at all appreciated. Lignite, up to the present time, has been regarded as of very little value. Two causes have been instrumental in creating this impression; first, the quality it possesses of rapidly slacking and crumbling when exposed to the air; and second (and perhaps this is the principal cause), all who have attempted to use it have done so without first studying its character and the best methods of burning it, and they have in most cases endeavored to use it under the same conditions which apply to a bituminous coal containing little water. While lignite may not differ materially from bituminous coal in weight, its physical properties are entirely different. This is due not only to the amount of water contained in the lignite, amounting to from ten to twenty per cent of its weight, but also to the fact that it is the product of a different period of geologic time, and it may be that the development of the bituminous matter differs in some way in the two. Therefore in any intelligent effort to make it available for fuel, these considerations must be taken into account and proper allowances made for them. In Europe, where fuel is scarcer than here, lignites of much poorer quality than our average deposits are successfully used, not only as fuel for domestic purposes but also for smelting.

The fact that lignites have not been used in the United States is taken by some as an evidence of their worthlessness, but if we turn to Europe we find that their usefulness is of the highest character. From the Jahres Berichte der Chemischen Technologie,* by Dr. R. Wagner (1855 to 1889), I have had a careful compilation made of the progress of the lignite industry in Germany. From this we learn that although the German lignites are inferior to those of Texas, as proved by numerous chemical analyses, they are in use for every purpose for which bituminous coal is available, and for some to which such coal is not suited. Their principal use is, naturally, as fuel. They are used in the natural state, or "raw," in places for household purposes, and also to a very large extent in Siemens' regenerator furnaces; and, even in connection with coke made from the lignites themselves, as much as forty to seventy per cent of raw lignite is used in the smelting of iron ores in furnaces of suitable construction.

Raw lignites are also used in the conversion of iron into steel by the Bessemer process, but require a small addition of coke for this purpose.

For general fuel purposes, however, the lignites are manufactured into briquettes, or coal bricks, of different sizes, by pulverizing them, evaporating the surplus water, and compressing them under presses similar to those used in the manufacture of pressed brick. Many of the German lignites contain as much as thirty to forty per cent of water, and the heat which is necessary to drive this off acts on the chemical elements of the lignite and develops the bituminous matter

* This work is a yearly review of the progress of applied chemistry and chemical industries in Germany. It gives accurate descriptions of all new processes and reviews all publications on subjects connected with the application of chemistry to manufactures, and is also devoted to everything connected with the science of chemistry itself. It is of the highest authority.

sufficiently for it to serve as a bond or cement under the semi-fusion caused by the heavy pressure which is applied to make it cohere. Such coals as do not form their own cement in this way are made to cohere by the addition of various cementing materials, such as bitumen, coal tar, pitch, starch, potatoes, clay, etc.

Lignites prepared in this way are fully equal to ordinary bituminous coal as fuel for all purposes, and possess, in addition, several important advantages. They are more compact, and are in the regular form of blocks which can be stored in four-fifths the amount of space occupied by the same weight of coal. They are much cleaner to handle, and the waste in handling, which in the case of bituminous coal is often as much as twenty per cent, is very little.

Owing to its physical structure it burns with great regularity and without clinkers, making it a very desirable steam fuel. For these reasons it is often preferred to bituminous coal.

Coke of excellent quality is made from lignites in ovens properly constructed for the purpose. These ovens are of various designs suited to different characters of lignite, but all accomplish similar results, and the coke thus produced is used for all purposes for which other cokes are adapted.

Illuminating gas of very superior quality is manufactured from lignites, and is in use in many German manufactories.

Lignite also forms the base of many other important industries. Up to the time of the discovery of the oil fields of America and the great deposits of mineral wax, or ozocerite, the lignite was the principal source of supply of paraffine and illuminating oils, and even now, although comparatively few factories are run solely for their production, as was formerly so largely the case, the amount manufactured as by-products is very large.

These substances are the results of distilling the lignites in the same manner in which gas is produced from bituminous coal, and the product consists of gas, water, tar, ammonia, coke, and ash. The tar contains paraffine and mineral oils, as well as being the basis for the analine dyes for the production of which great quantities of lignite are used.

Powdered coke from lignites is used in the manufactnre of gunpowder, of blacking, and for filters, and is substituted in many places for the more costly boneblack.

Finally lignite is used very successfully in the place of boneblack in clarifying sugar. In this, as in all uses of lignite, reference must be had to the particular kind of lignite to be employed.

Just as bituminous coals vary, and that from one locality proves more suitable for certain purposes than that of another seam at no great distance, so the lignites differ and the characteristics of each must be studied in order to ascertain for which of these many uses it is best adapted.

With such evidence as this before us—the results of fifty years of experiments and trial ending in successful operation in all these various uses of lignites—there can remain no shadow of doubt of the adaptability of the great lignite fields of Texas, and other parts of America as well, to meet the wants of the people for cheap fuel.

The ease and cheapness of mining, the small cost of preparation, and its value when prepared, will enable it to compete with wood in the best wooded portions of the State, with coal in close proximity to the coal mine, and it will prove of inestimable value in those localities in which it is the only fuel.

BITUMINOUS COAL.

The work of the Survey during the past two years has resulted in fully determining the limits of the Central Coal Fields, in ascertaining the number, thickness, and dips of the workable seams of coal, and in approximately mapping their lines of outcrop.

The coal measures consist of beds of limestones, sandstones, shales, and clays, having an aggregate thickness of some six thousand feet. The dip of these beds is very gentle, averaging less than forty feet to the mile in seam No. 7, and about sixty-five in seam No. 1, and is toward the northwest or west. Very little disturbance has been noted in it beyond a few slight folds and small faults. These two facts—slight dip and undisturbed condition—are of great importance in the mining of the coal.

Two seams of workable coal were found, Nos. 1 and 7, respectively, of the Texas section. None of the other seven seams observed are of sufficient thickness to be of economic value.

The Central Coal Field is divided by a strip of Cretaceous south of the line of the Texas and Pacific Railway. The two divisions thus formed have been named after the principal rivers which cross them—

the Brazos* Coal Field, or Northern, and the Colorado Coal Field, or Southern.

In the Brazos Coal Field both of the workable seams of coal are found but No. 1 has not yet been identified in the Colorado Coal Field, and No. 7 is therefore its only workable deposit.

Coal seam No. 1 first appears at the surface in Wise County, some eight miles southwest of Decatur. It outcrops in a southwestern direction nearly to the southwest corner of the county, when it turns more sharply west and appears in the southeastern portion of Jack County. It crosses into Palo Pinto County near its northeastern corner and its outcrops appear in a south-southwest direction entirely across this county and down into Erath, until it disappears beneath the Cretaceous hills and is found no more. On this seam are located several mines and prospects, among which may be mentioned those of the Wise County Coal Company, Mineral Wells Coal Company, Lake Mine, Carson and Lewis, Gordon, Johnson, Palo Pinto, and Adair. The output from these mines is gradually increasing.

These mines, as well as those on Seam No. 7, were briefly described in the First Report of Progress, and those now in operation are described more fully in this Report.

Coal Seam No. 7 is first observed outcropping near Bowie, in Montague County. From this point it bends southwestward, passing north of Jacksboro, between Graham and Belknap, when it turns south, running just west of Eliasville, by Crystal Falls and Breckenridge, to and below Cisco, when it, too, passes under the Cretaceous ridge.

South of this ridge we find it again on Pecan Bayou, in Coleman County, and from here the outcrops extend in a southerly direction, near Santa Anna Mountain, to Waldrip in McCulloch County.

On this seam we have the Stephens Mine, in Montague County, and various prospects in Jack County. Considerable work has been done in Young and Stephens counties, and coal of fair quality mined, but lack of railway facilities prevents anything like systematic mining. The seam becomes thinner and much poorer toward Cisco, graduating into a material little better than a bituminous shale. Probably the largest amount of work ever put on a coal seam in Texas was expended in this county, but the whole thing was given up at last as impracticable.

*The name Brazos was originally applied to the northwestern portion of this field by Dr. Chas. Ashburner in a paper read before the American Institute of Mining Engineers in 1879. It is now extended to cover the entire area north of the Cretaceous ridge mentioned.

On the southern portion of this seam, or that within the Colorado Coal Field, there have been numerous prospecting shafts sunk, but no coal of any consequence has been mined except for local consumption. The various mines were described in the First Annual Report. The principal ones are located north of Santa Anna, on Bull Creek, Home Creek, and at and near Waldrip.

The thickness of these two seams is about equal, each averaging about thirty inches of clean coal. They are similar also in having at most places a parting of clay, or "slate," of a few inches in thickness. While the outcrops of the two seams are parallel to each other in a general way, they vary from twenty-five to forty miles apart.

In the northern portion the seams are separated by some twelve hundred feet vertical thickness of limestones, clays, and shales. This thickness, however, increases rapidly toward the south.

As has been stated, the dip is gentle; that of seam No. 1 will not average over sixty-five feet, and that of No. 7 is less than forty feet. The average increase of elevation of the surface of the country toward the west is only a few feet per mile (not exceeding ten), and in consequence the extension of these beds can be found anywhere within eight to ten miles west of their outcrops at less than six hundred feet in depth.

The linear extent of the outcrops of these two seams is fully two hundred and fifty miles. They are probably workable for at least ten miles west of their line of outcrops, giving us an area of twenty-five hundred square miles of coal lands. Even if only two-fifths of this area prove to be fully adapted to coal mining, we have one thousand square miles, each of which contains nearly three millions of tons of coal.

The roof of these coal seams is sandstone, limestone, or a hard clay which makes a good roof. The mines are generally dry.

The quality of the coal varies considerably. In some few places it is high in sulphur, in others very little is found. It also varies greatly in the amounts of ash and moisture contained in it, as well as in its fuel constituents, but careful selection will result in a fuel that will give perfectly satisfactory results.

Of its value as a steam coal there can be no doubt, for it has been fully tested for railroad and other uses, and is taken as fast as it can be mined, leaving practically none to be sold for ordinary purposes.

So far as I am informed there has been but one attempt at testing its coking qualities in regular coking ovens. This was done by the manager of the Johnson, or Texas and Pacific, Mine. The quality of coke produced gives every promise that, with proper care in selecting material and attention to burning, it will produce a coke fully adapted for the best metallurgical uses.

In addition to this Central Coal Field there are others on the western borders of the State. One of these, the Nueces Coal Field, was described in the First Report of Progress of this Survey, and again in the First Annual Report. Since that time a boring made at Eagle Pass, four miles from the outcrop on which the Hartz Mine is situated, reached the same coal at five hundred and thirty-one feet. This coal cokes in the crucible, and there is no doubt but that an excellent coke can be made from it, if ovens of suitable construction are used.

This seam is the thickest in the State, averaging nearly five feet, and must prove of very great economic value.

A second coal field is that containing the deposits in Presidio County between the Capote Mountain and the Rio Grande. The specimens of this coal which have been furnished for analysis show it to be very high in sulphur, but no detailed examination of it has yet been made.

BITUMEN OR ASPHALTUM.

This valuable material exists in Texas under several conditions. Its most frequent occurrence is probably in tar springs. These are found in many places in the Tertiary and Cretaceous formations, and occasionally among those that are older. It is in these cases the seepage from the beds which contain it. So far few, if any, of these beds have been examined to ascertain their extent or quality, for there has been little or no demand for the material. Among these may also be included the Sour Lakes of Hardin and Liberty counties, at which both bitumen and gas occur in large quantities.

In other places it is found as deposits of greater or less extent, impregnating the accompanying sands, sandstone, and limestone. These have not been given much more attention than the springs, but some of the localities have been examined and specimens of the material analyzed.

The tar springs are of frequent occurrence in certain beds of the Timber Belt Series, which stretch across the State in a belt approximately parallel to the Gulf coast and from 100 to 150 miles inland, and are at places connected more or less with deposits of oil.

They are also found along the belt of country underlaid by the Fish

Beds, or Eagle Ford Shales, of the Cretaceous, as may be seen in the vicinity of Fiskville and other localities in Travis County, and still others southwest of the Colorado. Similar springs are found in Burnet and other counties in the older rocks.

The deposits which have been examined most fully are those of Anderson County east of Palestine, where there is an asphalt bearing sand. This appears to be due to the oxidation of the residuum of oil left in the sand. Here they are of unknown and somewhat uncertain extent, as they are apt to run into an oil bearing sand. This is possibly the case with many of the deposits of East Texas.

In Uvalde County there are several outcrops of bitumen impregnating both sandstone and limestone. Of the former, Mr. Owen says (First Report of Progress, page 72): "This oyster bed is underlaid by eight feet of black asphaltum sandstone, from which in warm weather the asphaltum exudes and forms small pools." This is on the Nueces River fourteen miles southwest of Uvalde. The stratum here described is continuous. The stratigraphical position is some thirty feet below the San Tomas coal vein (that which is worked above Laredo), and Mr. Owen states that the sandstone occurs at nearly every locality where its stratigraphical position was exposed. The connection of this asphaltic material and the coal seam mentioned over an area exceeding one thousand square miles opens one of the most profitable fields of fuel industry in Texas.

Analyses of these asphaltum sands give an average of fourteen per cent asphaltum. Beds of similar sands are known in Jack, Montague, Martin, and other counties. Analyses gave the following percentages of bitumen:

Montague County, 8.90 to 10.20.

Martin County, 10.72.

The asphaltic limestone found in Uvalde County, specimens of which are in the Museum, is richer in asphaltum than any of the sandstones, the average of three analyses giving 20.35 per cent of bitumen. This gives it the same composition as the best grade of asphaltic limestone gotten in the Val-de-Travers, Switzerland, of which the famous asphalt streets of Paris are made. It is a natural mixture of asphaltum and limestone in the best proportion for good road making.

OIL.

Oil is often an accompanying material when the tar springs and deposits of bitumen are found in the Timber Belt and Eagle Ford beds. Thus, in the counties of Sabine, Shelby, Nacogdoches, San Augustine, Anderson, Grimes, Travis, Bexar, and others, oil in small quantity has been found. Most often, it is true, the quantity has been too small to be of much economic importance, but in Nacogdoches County one of the fields has had considerable development and the results are satisfactory. Besides these deposits there are others in the Carboniferous region, where small quantities of oil are secured in wells and springs which appear to have a larger quantity of the lighter oils connected with them. The only places at which oil is at present produced are Nacogdoches and San Antonio.

NACOGDOCHES OIL WELLS.—In the vicinity of Chireno, Nacogdoches County, a number of oil wells have been bored, many of which became producers. A pipe line was run connecting the wells with the railroad at Nacogdoches, and shipments of oil have been made from time to time. This locality produces only a lubricating oil, but it has the property (through absence of paraffine) of withstanding very severe cold, and is therefore of high market value for railroad use where such oils are needed.

SAN ANTONIO OIL WELL.—Mr. Geo. Dulnig, when boring on his place for water, at a depth of three hundred feet struck petroleum, and subsequently, in another boring at some distance from the first, came upon it at two hundred and seventy feet. The flow is only about twenty gallons a day, but is continuous and regular. The oil is a superior article for lubricating purposes.

GAS.

Another economic product accompanying these beds of bitumen and oil is Natural Gas. Its existence has long been known in Shelby, Sabine, and adjoining counties, and it was found in well boring in Washington County and elsewhere many years ago. Within the last two years fresh borings have been made in the vicinity of Greenvine, in Washington County, and the flow of gas found to be of considerable amount. It has been found near San Antonio at depths of from four hundred to eight hundred feet, and also at Gordon and other places in the Carboniferous area. No attempt has yet been made to bring it into use, or even to fully test the character or extent of the fields thus far determined.

FERTILIZERS.

Under this heading might well be included everything that can be applied to a soil for its amelioration or the increase of its fertility. This would therefore, in its widest application, embrace even the addition of sands to clay soils of such sticky character as our famous black waxy. The deposits, however, which will be mentioned here are Apatite, Bat Guano, Gypsum, Glauconite (or Greensand Marl), Chalk Marl, Limes, and Clays.

APATITE.

This mineral, which is a phosphate of lime, has as yet only been found in very small quantities in Texas. Its value as a fertilizer is due to its contents of phosphoric acid, and if it can be discovered in any quantity will be of very considerable value in connection with the greensand and other marls in sandy lands low in that essential element. Phosphate of lime is also the chief constituent of bone, and any deposits of this character will also prove of value. As yet known no deposits rich in phosphatic material have been found in Texas.

BAT GUANO.

As a fertilizer Bat Guano occupies a place second to nothing, except it be the Peruvian guano. Its great value as a fertilizer is due to its salts of ammonia, potash, and phosphorus. It is found in caves in Williamson, Burnet, Lampasas, Llano, Gillespie, Blanco, Bexar, and other counties of Texas in great quantities. It varies greatly in quality. Many of the caves are so situated that water has access to the beds, and parts of the valuable salts of ammonia are dissolved and carried off. In others, fires have by some means got started and immense bodies of the guano burned. Many analyses have been made from different caves, and large quantities of it have been shipped, but the present lack of railroad facilities in the vicinity of the deposits has prevented their successful working.

Analyses of guano from Burnet and Gillespie counties gave a value of over $50 per ton.

GYPSUM.

As a top dressing for many crops Gypsum is of great use, and when ground for this purpose is known as land plaster. Ground Gypsum is also an excellent deodorizer.

Texas is abundantly supplied with this material. Not only does it occur in immense deposits in the Permian Beds west of the Abilene-Wichita country, but all through the Timber Belt Beds it is found along the streams and scattered through the clays as crystals of clear selenite, often miscalled "mica" or "isinglass." It is of all degrees of purity, from the pure selenite to an impure gypseous clay. So far it has been little used for this purpose in Texas.

GREENSAND MARL.

This marl is a mixture of sand and clay with greensand, and often contains quantities of shells. Greensand, or glauconite as it is often called, is a mineral of green color composed of silica (sand) in chemical combination with iron and potash, and usually contains variable quantities of other substances. This marl also contains more or less phosphoric acid, and the shells furnish lime. Where it occurs in its original and unaltered condition it is of a more or less pronounced green color, due to the color of the greensand in it. Where it has been subjected to chemical action the greensand is gradually decomposed and the iron unites and forms hydrous oxide of iron, or iron rust. This alteration gives rise to a great variety of color in the different beds of the material. When it is fully altered in this way it forms the red or yellow sandstone so much used in East Texas.

Numerous analyses have been made of these marls, both in their original and altered conditions. They contain, in all the samples tested at least, lime, potash, and phosphoric acid, just the elements that are required to fertilize the sandy soils and to renew and increase the fertility of those that have been worn out. These elements occur in the marl in variable amounts, and less in the altered than in the unaltered material. In nearly every instance, however, the amounts were sufficient to be of great agricultural value to every field within hauling distance of such a deposit. It often happens, too, that these beds of marl lie in closest proximity to the very soils on which they are most needed, and all the farmer has to do to secure the desired results is to apply it as a fertilizer.

If any proof is wanted of the adaptability of these marls, and of their great value on just this character of soil, it is shown in New Jersey, where exactly similar conditions exist. In that State there were large areas of pine land soils which were, like ours, of little agricultural value because of the small amounts of potash, phosphoric acid, and lime contained in them. There were, however, large deposits of greensand marl adjacent to them, and its use has been of the highest benefit. This is fully attested both by the agricultural and the geological reports of the State. The late State Geologist, Prof. Geo. H. Cook, said of them:

"It gives lasting fertility to the soils. I have never seen a field which has once been marled that is now poor. One instance was found where poor and sandy land was marled more than thirty years ago and has ever since been tilled without manure, and not well managed, which is still in good condition. Fruit trees and vines make a remarkable growth and produce fruit of high flavor when liberally dressed with this marl."

This is testimony that can not be doubted, and although the greensand marls of East Texas are not as rich as those of New Jersey, they are nevertheless rich enough to be of the same use to our lands. Nearly two hundred thousand tons of greensand marls are used yearly in New Jersey.

The first requisite to the best results is that the marl should be powdered as finely as possible before spreading it on the land. The greensand decomposes and is dissolved very slowly, and the finer it is powdered the more rapid will be its action. It should also be spread evenly and uniformly over the ground. It is ordinarily wet when first dug, but after a certain amount of drying it can be easily pulverized, or it can be dried more rapidly and rendered more friable by the mixture of a small amount of quicklime with it. It could also be improved by composting it with barnyard manure or guano. Owing to the difficulty with which the greensand is dissolved the effects are not always so apparent the first year, but it is a lasting fertilizer, as is shown by the quotations given above.

The amount required will of course vary with the composition of the soil and the quality of the greensand. From three to ten wagon loads per acre would perhaps be the usual amount required, although some soils might need even more.

CALCAREOUS MARLS.

Lime is already used to a large extent in agriculture, and will be used more largely still. Its uses are to lighten clay soils and to make sandy soils more firm, while sour soils or swamp lands are sweetened by its application. In addition to this the chemical action brought about by its presence in the decomposition and rendering soluble of other constituents of the soil is very great, so that its action is both chemical and physical. Its use is perhaps most beneficial when composted with organic manures or the greensand marls.

When the calcareous marls are soft enough to be easily powdered they may be applied as they are, and in this condition the action of the lime is much more gradual and of longer continuance. When they exist as harder rocks they will have to be burned before applying them.

Among the rocks of the Cretaceous series are many deposits which are especially adapted for use in this way. Localities are numerous in the divisions known as the Austin chalk and the Washita limestone which will afford a soft material well suited for the purpose.

It often happens that in the greensand beds themselves there are large deposits of fossil shells still in their original form as carbonate of lime. Where these occur the marl is of great value, as it contains that which will render it most valuable on such sandy lands as need it.

CLAYS.

Some of the Clays of East Texas will prove of value as fertilizers on account of the large amount of potash they contain—as high as five and six per cent in certain cases. While it is true that much of the potash is in chemical combination with silica, and therefore only soluble with difficulty, if composted with quicklime this substance will be rendered more soluble and prepared for plant food.

FICTILE MATERIALS.

Texas has not yet begun to take that place among the manufacturers of pottery and glassware which the character, quality and extent of the materials found within her borders render possible. For pottery making there exist clays adapted to every grade, from common jug ware and tiling through Yellow, Rockingham, C. C., White Granite or Iron Stone China, to China or Porcelain of the finest quality. Glass sands are also found of a high degree of purity, and many other materials of use or necessity in the manufacture of these various grades of goods are found here.

While the subject of clays has not yet received the attention that it is proposed to give it, numerous specimens have been secured and analyzed, with the result of proving the facts as stated above.

Among the clays of the Division known as Coast Clays are some that will answer for the coarser stoneware, such as jugs, flower pots, drain tile, etc., and others which from their refractory character are well adapted for the manufacture of charcoal furnaces, and possibly of sewer pipe.

The Fayette Beds, as was stated in their description in the First Annual Report, contain beds of light colored clays, many of which are pure white. These beds of clay not only underlie and overlie the middle beds of Fayette Sands, but are also found interbedded with that Series. The excellent qualities of these clays were first stated by Dr. W. P. Riddell, of the First Geological Survey of Texas under Dr. Shumard. His specimens were obtained from the Yegua, in Washington County, and in the vicinity of Hempstead. Since that time many analyses have been made of clays of various portions of these beds, and while some of them are too high in alkalies or fusible constituents, others are well suited to the manufacture of all grades of earthen ware below that of porcelain, or French china as it is called. Clays of this character have been secured in various localities from Angelina to and below Fayette County.

There are beds in the Fayette Sands that will be of value in glass making. Some of the beds are composed of clear angular quartz grains without tinge of iron, having only an occasional grain of rounded red or black quartz.

In the Timber Belt Beds there are other clays and sands well suited to the manufacture of earthenware and glass. Most of the beds of pottery clays of this Division examined so far in Eastern Texas are, however, only suited for the coarser grades of earthenware, but in Grimes and Robertson counties (and possibly in others as well) clays of higher grade are found.

In Robertson County, not far from the town of Mexia, there is a deposit of sandy clay which is readily separated by washing into a kaolin of excellent quality and a perfectly pure quartz sand. This kaolin has been tested practically and produces a good porcelain.

Potteries have been erected in various parts of the State within the limits of the Fayette and Timber Belt beds for the manufacture of common earthenware, flower pots, etc., and several are now in successful operation. Among localities of potteries may be mentioned Lavernia, Wilson County; Athens, Henderson County; Kosse, Limestone County; Burton, Washington County, and others.

KAOLIN.

In addition to the kaolin already mentioned in Robertson County, kaolins of excellent quality are found in Edwards and Uvalde counties. These are pure white in color, somewhat greasy to the touch, and are infusible in the hottest blow pipe flame. Being practically free from iron, they are adapted to the making of the best grades of china. They are free from grit and every other objectionable impurity. A comparison of the analyses of these kaolins with those of established reputation will more fully show their value. The analyses of the Texas specimens are by Dr. Everhart, of the State University:

	Nassau, Germany.	Ivrieux, France.	Devonshire, England.	Nueces Co., Texas.	Edwards Co., Texas.
Water	18.	13.	12.	4.53	6.05
Alumina.	32.	27.30	38.	33.66	43.17
Silica	45.06	46.80	47.	46.60	48.41
Lime	.74	.....	.....	.43	.38
Magnesia	.....	.....	.....	.96	.10
Alkalies	.....	2.50	1.76	1.65	1.78
Oxide Iron	.90	.....	.....	.....	.....

Of the other materials needed in the manufacture of pottery we have deposits of feldspar well suited for glazing; gypsum for the manufacture of plaster of paris for moulds; clays suitable for the saggers, and cheap fuel in abundance.

BUILDING MATERIALS.

BUILDING STONE.

The variety and widespread occurrence of the rocks of Texas suitable for construction is so great that it will be impracticable to allude to them in any other than general terms. They will therefore be grouped under general headings.

GRANITES.

Granites occur in widely separated portions of the State. The first locality is what has been termed in our reports the Central Mineral Region, the second is in the extreme west, or Trans-Pecos Texas. The granites of the first or Central region are of different colors. The best known is the red granite, such as was used in the construction of the Capitol building. The color is red to dark reddish-gray, varying from fine to rather coarse grain in structure, and susceptible of high polish.

The outcrop of the granite, which can be quarried to any desired dimensions, covers an area of over one hundred square miles.

There is a quarry now in operation on the portion from which the granite was taken for the building of the Capitol, on account of which it was originally opened, the material used having been donated by the owners, Col. Norton, Dr. Westfall, and Geo. W. Lacy.

Beside this particular granite there are many others in this region which will prove as useful. In the northern part of Gillespie County there is a brownish granite of very fine grain which takes a beautiful polish; and in addition there are found in various portions of the region granites varying in color from light to dark gray which are well adapted for building purposes, and in some instances will prove of decided value for ornamental and monumental purposes.

The granites of Trans-Pecos Texas, like those of the Central Mineral Region, are well suited both for building and ornamental purposes. The western granites, however, lack the variety of color which is found in those of the Central Region, being for the most part a lighter or darker gray, the felspar being very light colored in all of them. They are adjacent to railway transportation, however, as the Southern Pacific Railway passes very near their outcrop in the Quitman Mountains and directly by them in the Franklin Mountains, near El Paso, and will sooner or later come into market.

PORPHYRIES.

Among the most beautiful and indestructible of our building stones we must place the porphyries. Their hardness, however, and the difficulty of quarrying and dressing them, often prevent their taking the place in actual use that their good qualities would otherwise secure for them, but where the elements of durability and beauty are sought their worth must be properly recognized.

Porphyries of almost every shade and color abound in Trans-Pecos Texas. There are in the Museum specimens taken from the outcrops in the Quitman Mountains alone which are readily divisible into twenty or more shades. These vary through light grays, yellows, reds, purples, and greens to black, and their polished surfaces are especially rich. The quantity and accessibility to railroad transportation must prove sufficient inducement for their development.

MARBLES.

The deposits of the marbles, like those of the granites, are found both in the Central Mineral Region and in Trans-Pecos Texas. In addition to these deposits there occur in numerous places limestones more or less altered from various causes which are locally called marbles, and are sometimes both beautiful and useful when properly dressed. Among such deposits may be noticed what is known as the Austin Marble, a stratum of the Cretaceous which has been altered until its fossils have been changed to calcite. The body of the stone is when polished of a light yellow color, and the tracings of the contained shells in pure calcite, which gives a very pretty effect, although their fragile character detracts greatly from the usefulness of the stone. Other deposits of similar semi-marbles of various colors are found among the Carboniferous limestones of the northern portion of the State. The marbles and semi-marbles of the Central Mineral Region are the altered limestones of the Silurian and older beds, some of which are of fine texture and capable of receiving an excellent polish. The marbles of the Silurian beds found in San Saba, Burnet, Gillespie and other counties, which are known as "Burnet Marbles," are both of solid color and variegated. They are found in beautiful pink, white, buff, blue, and gray shades, and although not true marbles are well adapted for many uses.

The marbles belonging to what are called the "Texan Beds," a formation older than the Silurian, are, however, real marbles. They are found near Packsaddle Mountain, Enchanted Peak, and in the Comanche Creek region of Mason County. They are often snowy white in color, of even grain, and among the deposits are found strata of medium thickness. They are not, however, as extensive as the deposits of the semi-marbles.

In Trans-Pecos Texas marbles belonging, as is supposed, to the same geologic age, exist in great abundance, and for beauty in color can not be surpassed.

From the Carrizos to the Quitman Mountains outcrops occur in the vicinity of the railroad of marbles which are certain at no distant day to become the basis for great commercial industry. They are found banded or striped and clouded as well as pure white. They are fine grained, and can be quarried in stone of almost any dimensions. Some of them when polished will rival the Aragonite or Mexican Onyx in delicacy of coloring.

LIMESTONES.

The limestones of Texas which are suited for building purposes are abundant and widespread in their occurrence. The Cretaceous formation which covers fully one-fourth of the entire area of the State abounds in limestone well adapted for structural purposes. In addition to this we have the limestones of the Carboniferous, Permian, and Silurian systems, so that the total area is largely increased.

The limestones of the Cretaceous occur both in its upper and lower divisions. In the Austin chalk there are beds which furnish excellent stone which is quarried for use in many places, but a large portion of it is too chalky and not firm enough for general use. The best limestone of this formation is that contained in the Fredericksburg and Washita divisions of the Lower Cretaceous.

These limestones are of color varying from white to yellow, very rarely darker, and are often somewhat soft when first quarried, becoming harder on exposure.

Among the materials of the Clear Fork division of the Permian formation are some even bedded limestones of square fracture, fine even grain, and good color, that will prove valuable as building material. These were observed in the northwestern part of Shackelford County, and will also be found north and south of that locality along the outcrop of these beds. Seymour and Ballinger show buildings constructed of these limestones.

SANDSTONES AND QUARTZITES.

The sandstones are fully as widely distributed as the limestones, being found in nearly all districts in greater or less quantity.

In the Fayette sands are found beds of indurated sands of light color which have been used in various localities along their line of outcrop for building purposes. Rock has been quarried from these deposits from many localities, principally at Rockland, Tyler County; Quarry Station, on the Gulf, Colorado, and Santa Fe Railroad; Rock Quarry, on the Houston and Texas Central Railway, in Washington County, and in various parts of Fayette, Lavaca, and other counties to the southwest.

In the Timber Belt Beds the altered (and even the unaltered) greensand marls are sometimes so indurated as to be used for building purposes. In addition to which many of the hill-cappings of sandstone, which at times replace the iron ore, are valuable building stones.

In the Cretaceous area north of the Colorado River there are no sandstones of any particular value so far as our examinations have extended.

The area of the Central Coal Field abounds in excellent sandstone for building stone, some of which has been extensively quarried and used in the construction of buildings from Dallas west to Cisco. It is of good color, quarries well, and presents a handsome appearance in the wall. It is so generally found in this district that it is impossible to name the localities.

In the Permian there are some sandstones which will be of wide application in the buildings of the State. East of Pecos City, at Quito, on the Texas and Pacific Railway, a company has recently opened a quarry in a compact, well jointed red sandstone which is probably of Permian age. It is of a beautiful red color, uniform in texture and color, easily worked yet durable, and in every way adapted to the best uses in building. The company in boring a well at the place have passed through more than one hundred feet of this red sandstone, thus proving its unlimited quantity. It will compare favorably in every way with the sandstones formerly imported into the State for the fronts and trimmings of buildings.

Beyond the Carrizo and Diabolo Mountains there is a fine grained red sandstone which is destined to be one of the finest building stones of the State. It is a little darker in color than the Quito stone, finer grained, firmer, of even texture, and will lend itself to almost any character of decoration.

In this Trans-Pecos Region there are many other sandstones and quartzites which will in time come into use for structural purposes.

SLATE.

The two areas in which the older rocks are found both give promise of furnishing slate suitable for roofing. In the Central Mineral District several localities have been examined which on the surface give indication of furnishing good roofing slate, and in the vicinity of the Carrizo Mountains, El Paso County, similar indications are found.

It will of course require some actual work in opening the quarry sufficiently to ascertain the condition of the material below the surface to fully decide the value of the deposits, but the indications are very favorable and warrant such an attempt at development.

Thus it is readily apparent that in building stone there is no lack of variety, as well as an ample supply of all that can be made useful.

CLAYS FOR BRICK, TERRA COTTA, AND DRAIN TILE.

Clays suitable for brick making are found in all the different formations occurring in the State. All are not of equal value, and indeed the brick made from some few are quite inferior, but the majority produce good serviceable brick. The colors of the brick vary from yellow or cream color, such as are made at Austin, through various shades of browns and reds, according to the character of the clay. In Eastern Texas, as well as in the Carboniferous area, the brick are usually mottled from the amount of iron in the clays. Selected clays, however, in these localities produce brick of excellent color. The importance of this industry will be seen by the following statement of the aggregate of brick production for the year 1889, which was received from the operators of the brick kilns in answer to inquiries:

Brick burned during 1889, 95,000,000.

Many of the clays of the Tertiary examined during the past year are well suited to the manufacture of Terra Cotta and drain tile. These are found in the region covered by the Timber Belt Beds, as well as among the Fayette Clays. Those of the other areas have not yet been examined fully enough to determine their availability for these purposes, but it is probable that many Carboniferous clays will prove well adapted for them.

LIME.

As is well known, the lime made from the rocks of that horizon of the Cretaceous formation known as the Caprina Limestones (which is the most persistent bed of all the formation) is unsurpassed for quality. The fame of the Austin lime is well established. Other beds of the Cretaceous will answer well in lime making, although some of them contain too much clayey matter, or are otherwise unfitted for this use.

Lime is also made from the limestone of the other deposits, but none of these have been so successfully operated as those above mentioned. The reports received for 1889 gave a total production of 190,000 barrels.

CEMENT MATERIALS.

Cements are of two kinds, Natural, or Hydraulic, and Artificial, or Portland.

Natural, or Hydraulic, cement is made from certain clayey limestones, which, when burned and ground, have the property of setting or becoming hard under water. Portland cements are of similar character, but are made by artificially mixing the limestone and clays in the proper proportion.

Materials for both characters of cement exist in abundance within the State. The limestones of certain beds of the Cretaceous are argillaceous enough to make cement when properly calcined and ground, and the same properties are claimed for some of those found in the Tertiary, but our tests have so far failed to bear out the claim. Some of the limestones belonging to the Clear Fork Beds of the Permian might answer if the percentage of magnesia was not too great.

The materials for Portland cement are, however, more abundant, and the product of so much better quality as to render the natural cement a matter of comparatively small importance. The Austin Chalk is rather widespread in its distribution and adjacent to clays of almost any required grade.

The entire practicability of the manufacture of Portland cement has been shown by the two factories which have undertaken it, one at San Antonio, the other at Austin. The former supplied much of the cement used in the erection of the present Capitol building, and as the reports of it by Gen. Gilmore show, it was of very excellent quality.

The works at Austin are now under way, and it is proposed to increase their capacity.

PLASTER PARIS.

Plaster Paris is produced from gypsum by driving out the percentage of water which is chemically combined with it. Its manufacture on any desired scale is entirely practicable in the Permian region of Texas, where many beds of gypsum of great purity occur.

SANDS FOR MORTAR, ETC.

Sand for mortar, plaster, etc., is found in many places. The Cretaceous is perhaps the area in which it is scarcest, and it can be brought in from either side. The locations will be more fully discussed in the descriptions of counties.

METALS AND ORES.

IRON.

Probably the most important of our ore deposits are those of iron, which in various forms are found in many parts of the State.

Beginning at the Louisiana line with a breadth of nearly one hundred and fifty miles, stretching southwest in a gradually narrowing belt and probably fading out in Caldwell County or just beyond, there is found a series of hills of greater or less elevation which are capped with ferruginated material, varying from a sandstone with a small amount of oxide of iron in the matrix, to limonite ores of high grade. Of this division only a few of the counties of East Texas have been fully examined, but enough has been done to show the probability that the greater amount of workable ores of this belt lie east of the 96th meridian, although there may be localities west of that line at which ores of value occur. These ores are associated entirely with rocks of the Tertiary and later periods.

In the Cretaceous no iron ores of any consequence are known except in the extreme west, where deposits of ochre seem to occur in connection with strata belonging to the Fredericksburg Division of the Lower Cretaceous Series.

There are only a few ores of any value found in the Carboniferous area, and those of the Permian are not of much importance.

The Central Mineral Region, however, contains, in connection with its deposits of older rocks, large deposits of very valuable ores, including magnetite, red hematite, and various hydrated ores.

Finally, in Trans-Pecos Texas, Iron ores of the hematite and magnetic types are found in veins of considerable thickness.

Thus it will be seen that the distribution of the ores is general, extending entirely across the State from east to west.

The ores of East Texas all belong to the class of limonites, or brown hematites. They have been divided according to their physical structure, due to the manner of their formation, into three general classes: 1. Laminated Ores. 2. Geode, or Nodular, Ores. 3. Conglomerate Ores. To which it may be necessary to add a fourth, Carbonate Ores.

The origin and character of these different classes of ores were discussed in the First Annual Report, and the results of our further studies will appear in this Second Annual Report. In brief these are:

Laminated Ores.—These ores are brown to black in color and vary in structure from a massive to a highly laminated variety in which the laminæ vary from one-sixteenth to one-quarter of an inch in thickness, frequently separated by hollow spaces, and sometimes containing thin seams of gray clay. The average thickness of the ore bed is from one to three feet, although it may exceed this in places. This class of ores is most extensively developed south of the Sabine River.

The ore bed is generally underlaid by a stratum of greensand marl from ten to thirty feet in thickness, and overlaid by from one to sixty feet of sands and sandstones.

NODULAR, OR GEODE, ORES.—These ores, which are best developed north of the Sabine River, usually occur as nodules or geodes, or as sandy clay strata. These were described at page 76 of the First Annual Report, as follows:

"It generally occurs in nodules or geodes, or as honey-combed, botryoidal, stalactitic, and mammillary masses. It is rusty brown, yellow, dull red, or even black color, and has a glossy, dull, or earthy lustre. The most characteristic feature of the ore is the nodular or geode form in which it occurs. Some of the beds are made up of these masses, either loose in a sandy clay matrix or solidified in a bed by a ferruginous cement. The ore lies horizontally at or near the tops of the hills, in the same manner as the brown laminated ores to the south of the Sabine River. The beds vary in thickness from less than one foot to over ten feet, the thicker ones being often interbedded with thin seams of sand. The ore bearing beds are immediately overlaid by sandy or sandy clayey strata."

CONGLOMERATE ORES.—These were described, at page 81 of the First Annual Report, as quoted below:

"The variety of ore included under this head consists of a conglomererate of brown ferruginous pebbles one-quarter to two inches in diameter and cemented in a sandy matrix. Sometimes a few siliceous pebbles are also found. The beds vary from one to twenty feet thick, and are generally local deposits along the banks and bluffs and sometimes in the beds of almost all the creeks and streams in the iron ore region just described. Sometimes they cap the lower hills. They are generally of low grade, but could be concentrated by crushing and washing out the sandy matrix. They usually contain more or less ferruginous sandstone in lenticular deposits, and are much cross-bedded."

The investigations of the Survey in East Texas show an aggregate iron bearing area of one thousand square miles. This is not all a solid bed of commercial ore, but the area within which commercial ores are known to exist. If even one-fourth be taken as productive iron land, and the bed be estimated at two feet in thickness, both very safe estimates, we have a total output of fifteen hundred million tons of iron ore.

The quality of the ores vary from those adapted to the manufacture of steel, or "Bessemer ores," to those of low grade.

CRETACEOUS IRON ORES.

The ochres of the Cretaceous are found in Uvalde and Val Verde counties, and probably elsewhere. From analyses they appear to be of very high grade, but no examination has yet been made of them by the Survey.

CARBONIFEROUS IRON ORES.

A great quantity of hematite ironstone is reported to occur in the beds adjacent to the Waldrip-Cisco Division, which, if it equal the sample analyzed, is a very valuable ore. It will be found described on page 215, First Annual Report.

IRON ORES OF THE CENTRAL MINERAL REGION.

These ores are of three classes, Magnetites, Hematites, and Hydrous ores, each of which has its own place and mode of occurrence. The Magnetites lie in the northwest trend in the Archæan rocks, which for practical purposes may be confined between "northwest-southeast lines drawn through Lone Grove town upon the east and through Enchanted Rock upon the west. This blocks out a district twenty miles wide, and extending perhaps thirty miles in the direction of the strike. Within this field, however, various structural features have prevented, in many places, the outcropping of the iron bearing system, so that probably two-thirds of the area is not in condition to yield ore without removing thick deposits of later origin. Assuming that one-third of the territory, in scattered patches, will show the Fernandan beds at surface or at depths that may be considered workable from an economical standpoint, it must be understood that only a small fraction of the thickness of these strata is iron ore. Keeping in mind also the folded condition of the rocks, it is evident that the chances for mining will be dependent largely upon the character of the erosion, it being premised that the iron bed, if such it be, is not very near the top of the system to which it belongs."*

The general section of this system of rocks shows that the magnetite, sometimes associated with hematite, occurs in a bed usually about fifty feet thick at a definite horizon in it. The investigations of the Survey

*First Annual Report, p. 348.

show that there are several belts within which valuable deposits are known or may be discovered.

The most eastern of these is the Babyhead belt, and the outcrops follow a line bearing southeastward, west of Babyhead Postoffice and Lone Grove, and coming out southward very near the Wolf crossing of the Colorado River. Probably the best exposure of this belt is in the Babyhead Mountains, and its northern boundary does not cross the Llano County line. To the southeast good results may be expected as far as Miller's Creek.

A second belt west of this occupies the area between Packsaddle and Riley mountains, and stretches northwestward by Llano town toward Valley Spring. Ores of value have been found in many places in this belt, the surface indications of the underlying beds of magnetite being hematite or limonite.

The third, or the Iron Mountain belt, is that on which the greatest amount of work has been expended, and in two places in it large and valuable masses of magnetic iron have been exposed. The bed is most persistent, and can be traced for miles. At Iron Mountain a shaft has been sunk down the side of the iron outcrop to the depth of fifty feet, and a cross-cut of twenty-two feet cut in the lead. The quantity of magnetite and hematite exposed here is very great. About three miles south of Llano City considerable prospecting has been done by drilling with diamond drill, and also opened by a shaft, disclosing iron almost identical with the Iron Mountain product.

The most western of these belts lies between the Riley Mountains and Enchanted Rock in the south, and possibly having a greater width to the northwest. While it is covered in places by later rocks, the indications are good for the discovery of important masses of iron ore in it.

In quality the magnetites are high grade Bessemer ores, being low in silica, phosphorus, and sulphur, and very high in metallic iron.

HEMATITES.—These ores seem to be chiefly derived from alteration of the magnetites. They usually crop out along portions of the northern border of the magnetite area, and are chiefly segregations in sandstone, and although none of the exposures have yet been worked, valuable deposits will be found following the trend of the magnetite beds. These segregations are to be found chiefly in the red sandstone of the Cambrian system. They will be of value as Bessemer ores.

THE HYDRATED IRON ORES.—The ores included in this variety embrace many different varieties. These appear almost exclusively in veins, for the most part in the older rocks. While they are not abundant enough to sustain any industry by themselves, they may become valuable in addition to the other iron ores.

PROSPECTS OF THE IRON INDUSTRY IN TEXAS.

Taking the iron ore deposits of the State as a whole, and considering their wide distribution, their excellent quality, their relation to fuel supply and other necessaries for smelting and manufacturing them, no doubt can remain of the magnitude which the iron industry is bound to assume in this State, and that Texas is destined to become one of the great iron and steel producing centers of the world.

COPPER.

The copper ores of Texas are of two characters. Those of the Central Mineral Region and Trans-Pecos Texas occur in veins, while the ores of the Permian area are found as impregnations and segregations in the clays.

THE PERMIAN COPPER ORES.

The copper ore of this division was first described by Capt. R. B. Marcy in his report on the exploration of Red River in 1852, when he found specimens of it in Cache Creek.

In 1864, Colonel J. B. Barry sent a party with Indian guides to Archer County and secured a considerable amount of ore, which was shipped to Austin and part of it smelted and used for the manufacture of percussion caps for the Confederacy, under the superintendence of Dr. W. De Ryee. After the war several attempts were made to develop these deposits, but lack of transportation facilities and the fact that the high grade ore bodies were in pockets and irregularly distributed prevented the success of the undertaking. Still later General McLellan and a strong company made an effort to utilize the deposits of Hardeman and adjoining counties, but it seems that the true nature of the deposits were not fully appreciated, and the result was the same as those of earlier date.

As has been stated, these ores occur as impregnations or segregations in the clays at certain definite horizons in the formation. They are not in veins, therefore, but in beds, and are not to be mined by sinking shafts to lower depths, but more after the manner of coal deposits. There are three (and possibly a fourth) of these horizons, one in each division of the

Permian. The Archer County deposits belong to the lower or Wichita beds, the California Creek bed to the Clear Fork beds, and the Kiowa Peak stratum or strata to the Double Mountain beds. The general manner of occurrence is the same in all. The ores are found in a bed of blue clay from three to four feet thick. It is sometimes found in a pseudomorphic form after wood, in which case the oxide of copper has replaced the material of the woody fibre in the same manner as is done by silica in ordinary petrified wood. In other places it occurs in rounded nodules of different sizes, "like potatoes in a bed," as it is graphically described. In addition to this the stratum of clay is impregnated with copper to the extent of forming a low grade ore in places. Analyses from various localities of average specimens of these copper clays yield from 1.6 to 4.5 per cent of copper. In any successful attempt to utilize these ores the work must be undertaken with a view of recovering the copper from the copper clays by lixiviation as the principal object. The extent of the deposits and amount of copper contained in them in places seem to warrant this character of development, and the probability of finding many rich pockets, such as have been found in nearly all the workings so far attempted is additional inducement for the erection of such works. Some of these pockets have yielded as much as six thousand pounds of ore assaying sixty per cent copper.

The general lines of the outcrop of copper clays are as follows: The lower bed appears at Archer, and from there northeast to the mouth of Cache Creek, the original place of discovery. The next bed is found in a line running from Paint Creek, in Haskell County, northeast through the northwestern part of Throckmorton County, and crossing Baylor County west of Seymour, and Wilbarger County east of Vernon into Indian Territory.

The upper bed appears at Kiowa and Buzzard Peaks, and passing through the northwestern part of Hardeman is finally found on Pease River west of Margaret.

COPPER ORES OF THE CENTRAL MINERAL REGION.

In this region copper ores are known principally from the surface indications of carbonates and sulphides, which are found in outcrops and scattered through the rocks in various localities. The principal outcrops are confined to the Babyhead District, extending westward from the Little Llano to the head of Pecan Creek. A few others are found still further westward in Mason County, and some in Llano, but all are apparently connected with the same series of rocks.

The ores at the surface are largely carbonates, both Azurite and Malachite occurring, but the latter predominating. Tetrahedrite is more or less common, and sometimes carries considerable silver. Chalcopyrite is also present in small quantities, and in some places Bornite occurs.

The various prospecting works which are scattered through this area, beginning at the Houston and Texas Central Railway diggings on the east, includes many trial shafts and pits sunk by Capt. Thomas G. McGehee on Little Llano, Yoakum, and Wolf Creeks, Hubbard Mining Company on Pecan Creek, others by the Houston Mining Company on Wolf Creek, and the Miller Mine also on Pecan. Further west in Mason County similar prospecting works are found. In addition to these some prospecting has been done in the vicinity of Llano, and also southeast of that city. Specimens taken from the different localities by different members of the Survey assayed all the way from one per cent to forty five and six-tenths per cent copper, in silver from nothing to 107.8 ounces per ton, and of gold from nothing to one-fifth ounce.

There have been several attempts at development, but there are no mines in successful operation at present. The work that has been done on the different outcrops has not been carried sufficiently far, nor has it been of such a character, as to make it possible to speak with certainty regarding the existence of extensive bodies of copper ore in the district. What has been done, however, taken in connection with the outcrops and assays, and our knowledge of the geological formation of the country, suggests the accumulation of ores of considerable importance below, and will justify a much larger expenditure for the purpose of developing them than has yet been made.

COPPER ORES OF TRANS-PECOS TEXAS.

The ores of this district have been known for many years, and considerable prospecting has been done on them. There is, however, only one mine in operation at present—the Hazel Mine in the Diabolo Mountains, near Allamore, El Paso County. This mine is situated at the foot of the Sierra Diabolo on a lime-spar lead cutting through a red sandstone. The principal ore is copper glance or sulphide of copper, at times carrying a good deal of wire silver, and occasionally rich pockets of grey copper. This pay streak runs in a vein from a few inches up to ten feet in width, in a gangue of strongly siliceous limestone, which

VIEW FROM QUITMAN MOUNTAINS TOWARD FOOTHILLS.

is also impregnated with the ore. The width of this gangue is in some places as much as thirty-five feet, and the material is a low grade ore of about fifteen dollars per ton.

In the Carrizo Mountains and further south in the Apache or Davis Mountains are other good copper prospects, in addition to the many outcrops in the Quitman Mountains and Sierra Blanca region which show copper at the surface.

LEAD AND ZINC.

While many finds of lead ore have been reported in many portions of the State, all those outside of the Central Mineral Region and Trans-Pecos Texas have proved to be merely float specimens. In the Central Mineral Region the lead ore occurs sparingly in veins in the older rocks, under similar conditions and within the same area as marked out for the copper ores, but it is principally found in the rocks of the Cambrian or Silurian age under circumstances similar to that in which it is found in Missouri.

Perhaps the most extensive "digging" on any of the veins of galena was that of the Sam Houston Mining Company, who worked in the Riley Mountains. This shaft, which followed the irregular course of the vein, was one hundred and sixty feet or possibly more in depth. There was a string of galena, sometimes widening out and sometimes almost entirely missing, but enough ore was not secured to satisfy the owners and work was stopped.

The deposits which occur in the horizon of an age apparently corresponding to that of the Missouri galena ores have been prospected, chiefly in Burnet County. The principal work is at Silver Mine Hollow. The galena is not only scattered through the sandy, ferruginous vein material, but is found abundantly in the adjacent dark gray to green magnesian limestone. Its original source is probably the "cavern limestone" of the Silurian, but up to the present time there has not been sufficient development to make it possible to speak with any degree of certainty regarding the exact locality of the ores.

No zinc ores at all are known in the Central Mineral Region.

In Trans-Pecos Texas ores of both lead and zinc are very abundant and contain silver and gold in variable quantities. The prospects of the Quitman Mountains and vicinity are the best known. These mountains are crossed by numerous vein outcrops and indications of ore, and wherever prospecting holes have been sunk there are promising indications, and even distinct veins of lead carrying silver, most of them at least having traces of gold. Occasionally, also, tin is present. "The outcrops are generally composed of iron silicates, with probably some carbonate and oxide of iron, usually containing a little silver; a few feet below the surface the copper stain begins; deeper down the quantity of copper increases and traces of lead appear with the copper. This becomes stronger the lower the shaft is sunk, and shows zinc and bismuth in greater depths."* The zinc sometimes amounts to thirty per cent of the whole, and even pure argentiferous zinc ores are found. One fact observed is that on the northeast slopes of the mountains uranium is found in connection with the ores, while on the southwest slopes this metal gives place to molydenum even on the same vein traced across the crest of the mountain.

There are a number of shallow prospect holes scattered over this region, but very few of them reach a depth of fifty feet.

Several mines have, however, made shipments of ore, the principal shippers being the Alice Ray and Bonanza mines, both of which are on the same vein. Their ores have an average value of $60 to $65; but owing to the fact that they contain twenty-five to thirty per cent of zinc and that the El Paso smelters are not prepared to properly treat such ores, it has not been found possible to work them profitably after paying for roasting the zinc out of the ores in place of receiving pay for it. The Bonanza is the best developed mine in the Quitman range. The lead runs about east and west, dipping almost vertically in a contact between granite and porphyry. A shaft ninety-five feet deep is sunk to a drift below, running on the vein and about three hundred and fifty feet in length, which shows a seam of galena from two to ten inches in thickness. This carries an average of about thirty ounces of silver, although it sometimes reaches as high as sixty ounces, to the ton. The shipping average of this ore is about thirty per cent of lead, twenty-five to thirty per cent zinc, and thirty ounces of silver to the ton, and about five hundred tons have been shipped. From the drift a winze is sunk one hundred and ten feet deep.

On the Alice Ray claim, at a distance of three thousand feet from the Bonanza, a tunnel is run into the same lead. This mine is five thousand and ninety-five feet above the sea level, which, when compared with the deepest body of the Bonanza, shows an ore body four hundred and fifty feet in height by about four thousand feet long. The ore body of the

*First Annual Report, p. 221.

Alice Ray, like that of the Bonanza, is a well defined vein of galena, running from two to eight and ten inches in width.

There are many other valuable prospects in this district, which are more fully described in the reports.

Beside the ores of this district, ores are found in districts on the east and south. The Chinati region is, however, the only other one in which much prospecting has been done. Here there are a great many prospecting shafts, as well as some well developed mines. The ore on the river side is galena, the outcrops being strongly ferruginous streaks, similar to those of the Quitman Mountains. Some outcrops show carbonates and sulphides containing both bismuth and silver. An assay of one of these outcrops gave silver ten ounces, bismuth three and five-tenths, lead forty and five-tenths per cent. On the eastern side the contacts between the porphyries and crystalline limestones are very clearly marked, and it is on these that the most satisfactory prospecting work has been done. These yield both fine milling silver and galenas.

In the other ranges examined to the south and east similar ores also exist, but they are at present so difficult of access that little work has been done on them.

GOLD AND SILVER.

The precious metals occur in connection with the ores of copper, lead, and zinc, as has already been stated under those heads. They occur also in a free state. Small amounts of free gold have been found by panning in the Colorado River and in some parts of Llano County, but the amount found is too small for profitable working. Native silver has not yet been reported. In Trans-Pecos Texas, however, the conditions are more favorable, and there are two mines now working a free-milling silver ore in Presidio County, and many trial shafts have been put down in the surrounding region. In the Quitman Mountains some of the quartz and ferruginous outcrops show traces of gold, and by using the pan colors of gold are frequently found in the gravel and sand. A small piece of quartz found near Finlay assayed eleven ounces of gold to the ton. Taking this evidence, with the general geologic features of the Quitman and surrounding mountains, the presence of gold is established, although the probable quantity is still uncertain. Free gold has also been observed in certain ores received from Presidio County.

The best developed mine in this region is generally known as the

Shafter or Bullis mine, and is owned and operated by the Presidio Mining Company, who are now working two mines—the Presidio and Cibolo. In the former, which was discovered in 1880, the mine consists of pockets and bunches of ore of irregular shapes and sizes, generally isolated from each other, imbedded in a limestone country rock, thus forming chamber deposits.

The Cibolo has the same general character, but, in addition, has an ore body situated in a well defined fissure, and is a contact deposit. This company work their own mill and ship their product as bullion. The mill, which is of ten stamps of the common California pattern, is located on a hillside, so that the ore from the crusher falls to the automatic feeder at the stamps, from which the pulp is lifted to the amalgamaters. The amalgam is freed from the excess of quicksilver by straining, as usual, when retorted and fused. This mill averages from thirty to thirty-five tons of ore per day, which yields from forty to forty-five ounces of silver per ton. The motive power is an eighty-horse power engine. There is an ample water supply in Cibolo Creek to permit an increase in the size of this mill and the erection of others as well, and there is also good opportunity to build storage reservoirs along it. There are other locations being worked up, many of which promise good returns, and there is no doubt that this district must soon become one of the centres of the mining industry in Texas.

IMPORTANCE OF THESE INDUSTRIES.

From the foregoing description of the occurrence of copper, lead, zinc, silver, and gold, it is clearly evident that we have in Texas deposits of the ores of these metals which are abundant in quantity and of sufficiently high grade to fully warrant the claim so often made of our great resources in this direction. The work of the Survey has established the connection and relations existing between many of these ore deposits and the rock materials enclosing them. It has proved the continuity of the veins over considerable distances. It has proved and asserted the value of the ores, and stated the certainty of profitable returns from systematic and intelligent prospecting and mining. It has pointed out places at which prospecting could be carried on, and in some special instances has given advice to those at work. The ores are here. They are abundant enough and sufficiently rich to justify the rapid and extensive development of our mining industry, but this development is hindered, not only by lack of transportation facilities and proper reduction works, which may be remedied by private enterprise, but also by the uncertainty of land lines and other things which can and should be changed by legislation. Until the locations of land lines are definitely settled, and the prospector has some assurance that after his work in developing a mine he will be secured in its possession at a reasonable cost, and not be called upon for a heavy royalty, or even have to give up his work entirely, little will be done. The State has millions of acres of University and other lands in Trans-Pecos Texas. By a generous policy toward prospectors and settlers (for much of it will ultimately be made agricultural land if proper assistance is granted), this land can be made to bring its proper revenue from taxation instead of lying untaxed as at present.

TIN.

The occurrence of tin was reported, doubtfully, in the Central Mineral District last year, and it was also found in connection with lead ores in Trans-Pecos Texas. In November, during the examination of specimens collected by members of his party, Dr. Comstock found some excellent pieces of Cassiterite, or Oxide of Tin, and made a special trip to decide the reality and manner of its occurrence. This resulted in the discovery that it occurred not only as Cassiterite, but in small quantities in connection with other minerals in the rocks of a certain portion of the Burnetan System extending from the western part of Burnet to the eastern part of Mason County, a distance of fifty miles, and having a width of eight to ten miles. In this belt the tin ore has been found at four or five localities. It occurs in a quartz of somewhat banded appearance, and when pure may often be recognized by its weight, being of greater specific gravity than the iron ores.

Near the divide between Herman Creek and tributaries of the San Saba River, in Mason County, are the remains of two old furnaces, and considerable slag which carries tin in little globules scattered through it.

While it is impossible to speak positively of the probable quantity of ore, the indications are favorable for its existence in amounts sufficient to be of economic value.

In Trans-Pecos Texas tin was found by Prof. Streeruwitz in connection with some of the ores of the Quitman Range.

MERCURY.

Like tin, this metal has been reported from several localities, but up to the present we have not succeeded in verifying any of the reports or of finding any traces of it.

MANGANESE.

The only workable deposits of manganese yet defined by the Survey are those of the Central Mineral Region. These deposits are both in the form of manganese ores and of combinations of iron and manganese ores in different proportions.

The Spiller Mine, south of Fly Gap, Mason County, is the only known occurrence of the manganese ore on an extensive scale anywhere in the region, although surface croppings were traced, which seemed to indicate companion belts to the one which has been opened at the locality mentioned.

The ore is rather siliceous psilomelane, with patches of pyrolusite and more or less black wad, filling cavities and crevices in the vein, which is three or four feet wide. The ore seems to lie as an interbedded vein, and numerous borings were made on it with a diamond drill, presumably for the purpose of prospecting in the direction of its dip.*

Manganese ores are found under similar circumstances in the region between Packsaddle and Riley Mountains, and specimens are reported both from Gillespie and Blanco counties.

Manganese also occurs as an ingredient of the various limonitic ores, and in one instance such an ore was found to contain as much as eleven per cent of this metal in the form of dioxide. These deposits, however, are not likely to prove of much economic value.

BISMUTH.

Bismuth occurs in small quantities in connection with the ores of the Quitman range, and in one vein examined in the region of the Chinati Mountains as much as three and one-half per cent of this metal was found in the ore (galena).

ABRASIVES.

BUHRSTONE.

In the Fayette Sands are found stones of excellent quality for use as millstones. In Jasper and other counties millstones which have given perfect satisfaction in use have been cut from certain horizons of these sands.

GRINDSTONES.

Certain sandstones in the Carboniferous and older formations furnish

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*First Annual Report, p. 345.

excellent materials for grindstones, but up to the present they have only been utilized for local use.

WHETSTONES.

No whetstones have yet been manufactured in Texas, although excellent material exists for such a purpose. The Fayette Sands probably furnish the best of the material, and some specimens from Fayette County are now in the Museum. Other material suitable for the purpose is found in the Central Mineral Region and in the Central Coal Field.

INFUSORIAL EARTH.

Several localities of deposits of this material are known in Hopkins, Leon, Polk, and Crosby counties. Very little has been mined for shipment.

ORNAMENTAL STONES AND GEMS.

Among the gem stones may be mentioned Beryl, Smoky Quartz, Rose Quartz, Silicified Wood, Garnet, Agate, Moss Agate, Amethyst, Jasper, Sardonyx, Tourmaline, and others.

QUARTZ.

The clear white variety, which is known as "crystal," is sparingly found in masses of a size suitable for use. Clusters of crystals are found which form handsome ornaments, but the greater part are stained or milky.

SMOKY QUARTZ.—The Central Mineral Region produces fine crystals of smoky quartz of deep color. Barringer Hill, Llano County, is one of the best localities.

ROSE QUARTZ.—Beautiful shades of rose quartz are found in Llano and Gillespie counties.

AMETHYST.—Gillespie County furnishes some amethysts of fair color, but the deeper colored ones have so far been found only in the Sierra Blanca or Quitman region.

THETIS HAIR STONE.—This variety of limpid quartz with fine needles of actinolite scattered through it is found in the northern part of Gillespie County, near Enchanted Rock.

BERYL.—Some very large fine crystals of beryl have been found in Gillespie County, and occasionally in Llano County.

Garnet.—Garnets are abundant both in the Central Mineral District and in Trans-Pecos Texas.

Fine cabinet specimens showing both large and attractive crystals are in the Museum, but no systematic work has been done in working the deposits. There are several colors—brown, black, and green—and they occur in abundance. Among the localities may be mentioned Clear Creek valley on Burnet and Bluffton road, Babyhead, King Mountains, and similar areas in Llano and Gillespie counties; in the Quitman Mountains, and other localities in Trans-Pecos Texas. In Llano County fine crystals are also found of Idocrase, or Vesuvianite, which is near the garnet in character.

Tourmaline.—Black tourmaline is abundant in certain granites of Llano County, and will be useful for all purposes for which it can be employed, although there is no prospect of specimens of value for cabinet purposes being found.

Chalcedony.—Some fine specimens of chalcedony have been found in Travis County in the neighborhood of the disturbances caused by the Pilot Knob eruption. They also occur in Presidio County and other portions of West Texas.

Carnelian.—Carnelians have been found in the vicinity of Van Horn, El Paso County.

Sardonyx.—Beautiful specimens of sardonyx are found in the Trans-Pecos region in El Paso or Jeff Davis counties. A number of specimens are now in the Museum.

Jasper.—In this same region are found handsome varieties of plain and banded jasper, but, like the other deposits, there has been no attempt at development, and only a few specimens have been collected by persons happening on them. Pebbles of jasper are also abundant in the drift as far north as the Staked Plains.

Agate.—The occurrence of this beautiful stone has been mentioned in the former reports of this Survey. It is found abundantly in several parts of West Texas and occasionally in the river drift of the Colorado. In West Texas they are found in a schistose material and scattered over the surface in large quantities, from fragments to boulders of considerable size. The colors are rich, and the banded and fortification agates show beautiful bandings and stripes. Moss agates are also plentiful, and there is ample room for the establishment of an industry in this material, even if they are only collected for shipment abroad. The average price paid for rough agate for manufacturing purposes at Idar, Oldenburg, Germany, one of the principal manufacturing cities of this material, is about twenty-five cents per pound, and the beauty of the varieties occurring in Texas would add materially to that price.

PUDDING STONE.—Of equal beauty with the agates are some varieties of metamorphosed pudding stones brought from the lower mountains by Prof. Streeruwitz. They take fully as fine a polish, and the variety of color and shape of the inclusions are very pleasing.

SERPENTINE.—Some of the serpentines of West Texas will be valuable as ornamental stones. So far no "precious serpentine" has been found, but some of the red and green varieties will come into use as the region is developed. Central Texas also affords varieties which may be utilized.

SILICIFIED WOOD.—While the greater part of the silicified wood of the State is not of much value as an ornamental stone, there are certain horizons in the Fayette Beds in which the wood has been opalized and presents a pleasant variety of color and banding. These will probably be used quite largely for various purposes in ornamental work so soon as their beauty is properly shown.

PEARLS.—Texas is one of the principal pearl producing States of the United States. Mr. Kunz, in "Gems and Precious Stones," mentions one from Llano valued at ninety-five dollars, which was sold in New York. The pearls are found in the Unios, or fresh water mussels, which abound in the Colorado, Llano, and Concho rivers, and many other streams in Texas. They have been collected in large numbers, and in collecting them great numbers of the shell fish have been destroyed. In order to avoid this wholesale destruction, and leave the animal to propagate more valuable progeny, Mr. Kunz recommends that instruments similar to those used in Saxony and Bavaria be introduced here. One of these is a flat iron tool, the other a pair of sharp pointed pliers, both fashioned for the purpose of opening the shells for examination without injury to the animal, which, if no pearl is found, is replaced in the shoal.

ALABASTER.—Alabaster of fine grain and translucency occurs both among the rocks of the Cretaceous formation and in the gypsum region of the Permian. Its uses in vases and statuary are well known, and material suitable for any of these purposes can be secured in any desired quantity.

REFRACTORY MATERIALS.

Refractory materials, or those which will stand very high degrees of heat without injury, are of the highest importance in manufacturing.

They enter into the construction of all furnaces for iron, or steel, or pottery, or glass, or the various other products of high temperatures, and are an absolute necessity in the proper development of such manufactures. Of such substances fire clay is doubtless the most important. The essentials for a good fire clay are not so much the proportions of silica and alumina, although the larger the percentage of silica the greater its refractory power seems to be, but its freedom from materials such as lime, soda, potash, magnesia, or oxide of iron, which could unite with the silica and form a glass, and thus cause fusion.

FIRE CLAYS.

Of our Texas fire clays only two or three have had any decided or extensive trial. These are from the beds found in Henderson, Limestone, and Fayette counties. The first two are found in connection with the Timber Belt Beds, the third in the Fayette Beds. In use the brick made at Athens from the Henderson County clay have proved to be of excellent quality. They have stood the severe test of the iron furnace at Rusk and of some of the lime kilns, and are highly recommended for their good qualities. The brick from the beds of Limestone County are also of good quality, and proper care in their manufacture will make them fully equal to any. The Fayette Clays which have come under my notice, which are classed as fire clays, seem to be somewhat high in fluxing constituents, but more careful selection of the clays may entirely obviate this difficulty.

The fire clays are found usually in connection with the lignite beds, and in the Central Coal Field directly underlying the coal seams. They are therefore found scattered over a wide area of the State, but only a few of them have been examined by the Survey. These are nearly all from Eastern Texas, and were collected during the past field season. While they have not yet been fully studied, numerous analyses have been made, and it is found that many of them are too "fat," or contain too much alumina for use in the state in which they are dug, but require a large mixture of sand to correct the excessive shrinkage that would otherwise take place in drying them, amounting in some specimens to one-fourth of their original bulk. Others, however, are of excellent quality, and careful selection of localities for mining will yield very favorable results, and clays be secured suitable for brick for furnaces, kilns, ovens, fire boxes, retorts, saggers, and the many other similar articles.

GRAPHITE, OR PLUMBAGO.

In the Central Mineral Region are deposits of limited extent of an impure graphite in shales and schists. In view of the larger deposits of pure material in other localities it is not probable that this will be of much value.

SOAPSTONE.

This highly infusible stone, which is used as firestone in stoves, hearths, and furnaces, is found in large quantities. One of the best exposures is about two miles south of west from Smoothing Iron Mountain, and the most favorable districts for its further occurrence are that between House and Smoothing Iron Mountain and the King Mountains, and to the west of that area in Llano and Mason counties; also southeast in Llano, Gillespie, and Blanco counties. As a lining for furnaces and other purposes which do not require a very firm texture this material is fully adequate, and it can be cut or sawed into blocks or masses of any desired shape, with a perfectly smooth surface if desired.

MICA.

While mica is a very abundant mineral in both the Central and Trans-Pecos regions, it is not commonly of such transparency and size as to be commercially valuable. Specimens are in the Museum, however, from both localities which combine these requisites, and it is entirely probable that workable deposits may be found. It is used in stove fronts, lanterns, etc., also in the manufacture of wall paper and as a lubricant.

ASBESTOS.

Asbestos has often been reported from the Central Region, and many specimens have been received bearing that name. Upon examination this is found to be fibrolite, and may answer for many purposes for which asbestos is used as refractory material, but not for the finer uses of the manufacture of cloth, etc.

ROAD MATERIALS.

Among the various materials suited for road making are the large gravel deposits which are found in many portions of the State; some of the quartzitic sandstones which occur in the Fayette Beds; the eroded flints of the Cretaceous; some of the firmer limestones of the lower divisions of the Cretaceous and the Carboniferous areas; the basalt of such areas as Pilot Knob in Travis County; some of the sandstones or siliceous iron ores of the iron region of East Texas; the granites and other tough rocks of the Central Region are especially valuable, and similar rocks and the quartzites and porphyries of West Texas will also prove of value when transportation charges will admit of their use.

The occurrence of asphaltum in various portions of the State has already been noticed, and its use as paving material is well known.

For the construction of sidewalks, in addition to the material above mentioned, flagstones are found in various localities.

MATERIALS FOR PAINTS.

GRAPHITE has already been mentioned under refractory substances.

OCHRE.—This is a hydrated oxide of iron, usually containing more or less clay or sand and giving various shades of yellow, red, and brown. The most valuable is that which on preparation furnishes the color called Indian red. Ochres are found in connection with the geode and nodular ores of East Texas, forming centers of the geodes, and also deposits of limited extent. It is reported at many localities in the area covered by the Timber Belt Beds. In the Cretaceous area good ochres occur in Uvalde and Val Verde counties, in the latter of which one locality has been developed to some extent and the material shipped. Other deposits have been opened and worked very slightly for local use in different parts of the State.

BARYTES is found in Llano County, but has not been put to any use at all as yet.

OTHER ECONOMIC MATERIALS.

SULPHUR.

Specimens of native sulphur of a high degree of purity have been received from Edwards County, but up to the present no detailed examination has been made to ascertain its quantity or the condition of its occurrence.

SALT.

Like many of the other valuable deposits of Texas, the occurrence of the salt is widespread. Along the coast to the southwest are lagoons or salt lakes from which large amounts of salt are taken annually. Besides the lakes along the shore many others occur through Western

Texas, reaching to the New Mexico line, while northeast of these in the Permian region the constant recurrence of such names as Salt Fork, Salt Creek, etc., tell of the prevalence of similar conditions. In addition to the lakes and creeks from which salt is secured by solar evaporation we have also extensive beds of rock salt.

That which is at present best developed is located in the vicinity of Colorado City, in Mitchell County. The bed of salt was found by boring at 850 feet, and proved to have a thickness of 140 feet. A vein of water was struck below it which rises to within 150 feet of the surface. This is pumped to the surface and evaporated, and the resulting salt purified for commerce.

In Eastern Texas there have long been known low pieces of ground called "salines," at which salt has been manufactured by sinking shallow wells and evaporating the water taken from them. At one of these, Grand Saline, in Van Zandt County, a well was sunk, and at 225 feet a bed of rock salt was struck, into which they have now dug 300 feet without getting through it. Many other similar salines are known in Eastern Texas and Western Louisiana, and the great deposits of rock salt developed at Petit Anse and Van Zandt under practically similar circumstances is certainly warrant enough for boring at the other salines for similar beds. Some of these localities are in Smith and Anderson counties.

In the Carboniferous area many of the wells yield salt water, sometimes strong enough to render them unfitted for any ordinary purpose, but no attempt has been made at their utilization. There are also brine wells in limited areas in Central Texas.

ALKALIES.

The source from which the salts of potash and soda can be obtained in Texas are:

The alkali lakes, where there is a large percentage of sulphate of soda (Glauber salts) deposited by the evaporation of the water. Its impurities consist of some sulphate of lime, or gypsum, and common salt.

THE BAT GUANO.—Nitre, or saltpeter, was made from this material during the late war, but the necessity for its manufacture ending, it was abandoned.

ALUM.

The best material for the manufacture of alum is found in the clay of the lignitic portion of the Timber Belt, or Fayette, Beds, which contain both pyrites and lignitic matter. Nearly all the material used in the production of alum in this country is imported. Special attention will be given to the search for proper clays for this purpose during the next field season.

STRONTIA.

Two minerals having this earth as a base (celestite and strontianite) are found in the lower magnesian rocks of the Cretaceous of Central Texas. It is found at Mount Bonnel near Austin, and in the vicinity of Lampasas, and can be expected to occur wherever the proper horizon of the Cretaceous rocks containing it are found at the surface. It is not only used in the form of nitrate for fireworks, but also in the manufacture of sugar.

EPSOMITE.

Crystalline masses of Epsom salts are found in the same series of beds that contain the strontianite and celestite. It is extremely doubtful, however, whether it can be made commercially valuable.

THE ARTESIAN WATER CONDITIONS OF TEXAS.

Artesian water is rain water which has fallen on some porous bed or stratum of earth and has followed the sloping course of this bed between other beds, which were sufficiently impervious to confine it until it has found an opening to the surface, either natural or artificial, at a lower level than its original source, through which it rises and flows off. When this opening is a natural one it is a spring; when artificial it is an artesian well.

The artesian water conditions* of a region are dependent upon its geology, topography, and its rainfall. The geologic conditions are that there shall be a continuous porous stratum enclosed between two strata that are impervious. Topographically it is necessary that the exposed portion of this porous stratum—the "catchment" basin—be at sufficient elevation above that of the mouth of the wells to force a steady flow of water by hydrostatic pressure; and finally the rainfall must be sufficient within the area covered by the catchment basin to secure the steady supply of water. Unless all of these conditions be favorable there can be no constant supply of flowing water obtained.

*The conditions of artesian wells were fully discussed by Prof. T. C. Chamberlin in the Fifth Annual Report of the United States Geological Survey. A brief statement of the main features, compiled from this valuable article, was published in the First Report of Progress of this Survey, pp. 21–28.

For the purpose of this discussion, Texas is readily separable into three divisions:

1. The Gulf Slope, ... Cenozoic.
2. The Central Basin, ... Paleozoic.
3. The Western Mountain System, ...

The area covered by the Gulf Slope includes all the region east and south of the western and northern boundary of the Grand Prairie plateau, which stretches southward from the Red River to the Colorado, and thence westward to the Rio Grande. In area this comprises fully one-half of the State and by far the most thickly settled portion.

The Central Basin includes all that portion of the State west and north of the Grand Prairie, extending to the Gaudalupe Mountains on the west.

The Western Mountain System covers the remainder of Trans-Pecos Texas.

The Gulf Slope is in a certain degree a continuation of the topographic and geologic features of the States east of us which border upon the Gulf, but in some ways its differences are as pronounced as its resemblances. Thus, with the exception of a little marshy ground in the southeastern corner there is none along the entire coast. Differences in amount and character of rainfall and of temperature have also resulted in the production of a somewhat different topography, especially toward the Rio Grande, and the soils of certain formations are of far greater fertility than those derived from rocks of similar age in the other States, owing to peculiar conditions of formation.

The different sediments which now appear covering the surface of this area were laid down by the waters of a great sea, which in its present restricted basin we call the Gulf of Mexico.

Beginning at the coast in low and almost level prairies the ascent is gradual towards the interior, in many places not exceeding one foot per mile for the first fifty miles. Through this comparatively level plain, which comprises the exposure of the strata embraced under the general name of "Coast Clays," the streams move sluggishly in tortuous channels, and for the most part through an open prairie country, the only timber being along such water courses and in scattered motts or islands. As we pass inland this is succeeded by other belts which, having been longer subjected to erosion, show a surface more and more undulating as we recede from the Gulf. The ascent is also more rapid, and some elevations of as much as seven hundred feet are found, as at Ghent

Mountain, Cherokee County, but such are unusual south of the Grand Prairie. This character of country is continuous from the Gulf to the western scarp of the Grand Prairie, east of the Brazos River. West of the Colorado River the undulating country ends at the foot of the southern scarp of the Grand Prairie, which is a line of elevations known as the Balcones, from the top of which the Grand Prairie stretches away north and west to the Rio Grande. The eastern portion of these belts is heavily timbered, but throughout the greater portion—west of the 96th meridian—the quantity of timber rapidly decreases and the prairie conditions become almost universal. The general elevation east and south of the Grand Prairie is less than five hundred feet.

The Grand Prairie itself is a great plateau, preserved in its present extent by the resistence to erosion afforded by its capping of limestones, and is a marked topographic feature of the State. Beginning at Red River it extends in a gradually widening belt to the south, until its western border meets the Colorado in Lampasas County, from which point it is contracted rapidly until it finds its narrowest exposure in crossing the river in Travis County north of Austin. From this point west it broadens rapidly, until it is merged into the mountainous Trans-Pecos region. Its height above the country on either side is variable. On its eastern border, from Red River to the Brazos, there is not that abruptness of separation which distinguishes it at other places from the upper and lower formations. In the northern portion this plateau begins with an elevation of from six hundred to twelve hundred feet above sea level. West of the Colorado its northern edge reaches a height of twenty-three hundred feet in the ridge which forms the divide between the water flowing into the Colorado and that flowing south. The southern border is, however, hardly ever more than seven hundred feet in height, and usually not so high. The western and northern edge of the Grand Prairie is, generally speaking, topographically higher than the eastern and southern, and the dip of the beds is very gentle toward the southeast.

The break between the Grand Prairie and the Central Basin region is equally as decided as that between the undulating country and "Balcone's country" on the south, and were it not for its intimate relations, geologically, with the Coastal Slope, the topographic features of the Grand Prairie would entitle it to be considered a division by itself.

Both topographically and geologically this area presents a gradual fall from the interior toward the Gulf coast, but the average slope of the surface toward the southeast is less than the dip of the strata in the same direction, and as there have been no disturbances of sufficient magnitude to complicate the geology, except the uplift which brought up the Balcones (and that of Pilot Knob and similar areas if it be later, as it possibly is), we find the outcropping edges of the beds of earlier and earlier age as we pass from the coast to the interior. These various beds are exposed in bands of less or greater width, which are, in a general way, parallel with the present Gulf coast. The formations comprised in this belt are:

1.	Coast Clays, ...	Port Hudson—Quaternary.
2.	Orange Sands, . . .	Quaternary.
3.	Fayette Beds, ...	Grand Gulf—Miocene.
4.	Timber Belt Beds, } . .	Claiborne, etc.—Eocene.
5.	Basal Clays, }	
6.	Black Prairie, ...	Upper Cretaceous.
7.	Grand Prairie, . . .	Lower Cretaceous.

The relative position of these formations is indicated upon the map accompanying the First Annual Report.

The Coast Clays, which are the most recent of these, and which form a part of the present floor of the Gulf, are very impervious, variously colored, calcareous clays, which often form bluffs along the bay shores and river banks. The level belt of this formation varies from fifty to one hundred miles in width.

The Orange Sands underlying these are mottled red and white sands which are well exposed below Willis, on the International and Great Northern Railroad, and at other places.

The Fayette Beds, which underlie these, are made up also of sands and clays, but of entirely different character and structure. The sand greatly predominates, especially in the centre, where great beds of sand and sandstone and millstone grit occur.

The clays, instead of being massive, are usually thinly laminated and of very light color wherever exposed to the air, and are found both underlying and overlying the sands, as well as interbedded with them. They extend along the line of the Houston and Texas Central Railway from Waller to near Giddings. A study of these beds in the vicinity of Ledbetter showed nearly four hundred feet of sandy strata included between the two series of clays.

The dip of the strata toward the Gulf is not much greater than that of the surface of the country. For this reason the exposure of the sand bed on the surface is very wide—a circumstance of greatest importance, as it gives an immense catchment area for the rain water.

These Fayette Sands form a range of hills and give rise to the most striking topographic feature of the Coast region. Every river in its passage to the Gulf pays tribute to and is deflected by them. Many smaller streams have their course entirely determined by them, while the coast rivers, of which the San Jacinto and Buffalo are types, have their origin on their southern slope. At Rockland, in Tyler County, and along the various railroads that cross the area of these sands, as shown upon the map, typical sections can be seen. The base of these beds are sandy clays and sands, with some lignite.

The strata often contain carbonate of lime in appreciable quantities, and sulphur and gypsum are of frequent occurrence.

The Timber Belt Beds are composed of siliceous and glauconitic sands with white, brown, and black clays, and have associated with them lignite beds sometimes as much as twelve feet in thickness; iron pyrites, gypsum, and various bituminous materials also occur. Carbonate of lime is also widely disseminated throughout the beds, sometimes as limestone, but more often as calcareous concretions or in calcareous sandstones.

The Basal Clays are, as the name implies, beds of stratified clays and contain masses of concretionary limestone and large quantities of gypsum.

The Upper Cretaceous is composed in its upper members of great beds of clay somewhat similar to the Basal Clays above, which were doubtless derived from these. This is underlaid by the Austin Chalk, below which we find another series of clay shales overlying the Lower Cross Timber Sands.

The rock formation of the Grand Prairie belongs to the Lower Cretaceous series, and consists of a great thickness of limestones and chalks—magnesian, arenaceous, and even argillaceous in places—which is underlaid by a great bed of sand and conglomerate, known as the Trinity Sands.

We have in these formations, therefore, well marked and definite sandy or porous beds, which are enclosed by others practically impervious. Some of these are:

The Orange Sands.

The middle portion of the Fayette Beds.

The Lower Cross Timber Sands.

The Upper Cross Timber or Trinity Sands.

On the lower Rio Grande there occurs a sandstone known as the Carrizo Sandstone, the geologic age of which is not yet exactly determined, but which must be included among the other water-bearing beds.

That these belts are indeed catchment basins and fully capable of supplying the belts nearer the Gulf with flowing water has been amply verified by actual and successful boring. In the Coast Clay belt artesian water has been secured in many places, as at Houston and vicinity, at Galveston, at Velasco, at Corpus Christi, and at various other points. The shallowest of these wells is at Yorktown, De Witt County, where artesian water was secured at a depth of a very few feet. At Houston water is obtained in wells from one hundred and fifty to four hundred feet deep, and the water is practically free from mineral matter. At Galveston, fifty miles southeast, the wells are from six hundred to ten hundred feet deep, and yield water carrying salt, etc., in small quantities. The flow at Velasco is reported to be good, but at Corpus Christi it is highly charged with mineral matter. The quantity of mineral matter contained in the water seems to vary with the depth and distance from the outcrop of the catchment basin.

It can be stated, therefore, from our present knowledge that throughout the Coast Clay district artesian water can be obtained where the topographic conditions are suitable, but that it may be more or less impregnated with mineral matter leached out of the containing stratum.

While the Timber Belt Beds are not classed as artesian beds, it is nevertheless the fact that favorable conditions exist in numerous localities, and although no great flows have been secured, still flowing water has been found in several places; for example, various localities in Robertson County and at Livingston, Polk County.

The Lower Cross Timbers form the second catchment basin, but from their location have not been found to yield as good a flow as can be obtained by going deeper to the Trinity Sands.

The Carrizo sandstone outcrops along a line drawn at a point on the Nueces River south of the town of Uvalde to a point ten miles west of Carrizo Springs, and ten miles north of that point, on the ranch of Mr. Vivian, produces a stream of excellent water four inches in diameter from a well one hundred and seventy-five feet deep. This stratum of sandstone ought to be reached at Laredo at a depth of from five hundred to six hundred feet.

The third and possibly best explored collecting area is that of the Trinity Sands.

This bed, the Trinity or Upper Cross Timber sands, is the base of the Lower Cretaceous system, and is the great water-bearing bed east and south of the Central basin. In its many exposures and from the material brought up from it in boring, its composition is shown to be clear white grains of quartz, slightly rounded to much worn, containing a few grains of red and black chert. It is for the most part practically free of soluble mineral matter, and the water derived from it is often of excellent quality. From its position, character, and extent, it forms a most important member in the geology of Texas. The water which falls upon the exposed edge of this belt is carried under the limestone of the Grand Prairie plateau, and part of it breaks forth in a system of great springs which extend from Williamson County by Austin, San Marcos, and New Braunfels, toward the Pecos. These springs are natural artesian wells, which owe their existence to the fault lines caused by the disturbances, already alluded to, which formed the Balcones. The remainder of the water continues its course below the overlying formations, and can be reached at almost any point east and south of the Grand Prairie to the border of tne Basal Clays of the Tertiary. Wells are very numerous and vary in depth with distance from catchment area from one hundred to two thousand feet. They can not be named in detail here, but the principal boring has been at Fort Worth, Dallas, Waco, Austin, Taylor, San Antonio, and in Somervell, Coryell, Hood, and Bosque counties. These prove that artesian conditions exist, and there can be no doubt that wells bored in suitable localities will prove successful.

West of the Grand Prairie plateau we find the Central Basin region, which is principally occupied by strata of the Paleozoic formations. The eastern and southern border of this area is plainly marked by the scarp of the Grand Prairie. Its western border is not determined further than that in Texas it is terminated by the Guadaloupe Mountains in El Paso County. In its topography it shows a gradual elevation toward the west, most usually, however, in a series of steps which rise one above the other, having the ascent facing toward the southeast and a long gentle slope toward the west, the average rise being less than eight feet pei mile.

At the edge of the Staked Plain, which is a newer formation superimposed upon these, there is an abrupt elevation of from two hundred to three hundred feet in places, and a continued rise toward the west to a height of three thousand one hundred feet. West of the Pecos the rise is much more rapid, being about fifteen feet per mile. The dip of the strata, which on the east is toward the northwest not exceeding forty feet to the mile, is reversed, that is, it is to the southeast, and brings the edges of the strata to the surface again after crossing the river. In the southeast corner of this region we find the Archæan area of Llano County, around which the upturned edges of the older Paleozoic rocks are exposed at a considerably greater elevation than that of the basin north of them, giving the overlying rocks of the basin itself a northward dip.

The western extension of this southern border has not been examined. We find the northern border of our basin in the Wichita Mountains in the Indian Territory, where the edge of the Silurian rocks is again exposed at a higher altitude than the interior portion of our region. This region is, therefore, of a basin form of structure, with the exposed edges of its lower members and the underlying rocks topographically higher on the northern, western, and southern borders than on the east or in the center.

The formations which occupy this basin, if we except some overlying Cretaceous and the Plains formation, are almost entirely confined to the Carboniferous and Permian systems. These consist of beds of limestone, sandstone, sands, clays, and shales, with coal, gypsum, and salt as associated deposits. The general dip of all the strata in the eastern portion of the basin is to the northwest, but its elevation along the eastern border is less than in almost any portion of it; consequently there can be little hope of finding artesian water from any catchment area on this side, although some of the strata (the lower sandstone and shales) are well adapted for carrying water, and where suitable topographic conditions exist do furnish artesian water. An instance of this is found in the flowing well at Gordon, but such cases are the exception and not the rule. The same series of sandstones and shales are exposed on the southeastern border, and the flowing wells at and around Trickham and Waldrip find their supply in them. The conditions are very favorable in the valley of the Colorado and some distance north between the 99th and 100th meridians for similar wells. The rocks of this age are covered by later deposits in the Wichita Mountains, and it is therefore impossible to judge of the possibility of their water-bearing character there. Similar rocks are exposed on the western border of this basin, in the vicinity of Van Horn and further north in the Guadaloupe Mountains. They are reached by a well eight hundred and thirty-two feet deep at Toyah, some seventy miles east of Van Horn. This well has an abundant flow. We have, therefore, in the lower members of the Carboniferous rocks of this basin water-bearing strata, the exposed edges of which on the southeast and west are sufficiently elevated to furnish artesian water to portions of the basins in their immediate vicinity.

We do not know what interruptions to the subterranean flow may exist in the way of dikes or fissures, and therefore the areal extent of this portion favorably situated can not be given until the topography and geology are better known. The quality of the water from every well thus far secured in this basin, which has its origin in this series of rocks, is highly saline, and it is safe to assume from this and from the character of the deposits that no fresh water can be obtained from this source. Therefore, if the supply be general over the entire region, it will only be adapted for limited uses. In addition to this, this water-bearing bed can be reached in the greater portion of the region only after passing through the entire series of Permian strata and those of the uppermost Carboniferous, amounting in all to two thousand or three thousand feet, or even more in places.

If there be any other hope for an artesian water supply in this region the catchment area must be either in the pre-Carboniferous rocks of the Central Mineral Region and the Wichita Mountains or in the Guadaloupe and connected ranges. That such a catchment area exists on the south is fully proved by the powerful springs at Lampasas and in San Saba County, all of which have their origin below the rocks of Carboniferous age. Some of these springs, such as the Lampasas, have their vent through rocks of this period, but they belong to the very lowest strata, and the temperature of the water proves that it comes from still greater depths. All such water is highly mineralized, but much of it seems suitable for general uses after exposure to the air has dispelled the sulphuretted hydrogen. Others of these springs, like that at Cherokee, San Saba County, spring through rocks below the Carboniferous, and these furnish water of an excellent quality. The dip of these rocks is much greater than the overlying Carboniferous, and the water supply would therefore be rapidly carried beyond the depths of ordinary artesian borings. The conditions of outcropping strata are similar in the Wichita Mountains to those of Llano and San Saba counties, but we have no such evidence in the way of springs to prove their value, and no boring has been carried far enough to test the matter, although preparations are now under way to do so. No rocks of similar age have been observed in the Guadaloupes. We must therefore conclude that while the artesian conditions of the Central Basin are not unfavorable, the probabilities are against securing an adequate supply of water sufficiently free from mineral matter to be of use for general purposes (unless it be from the sandstones of the Guadaloupe Mountains, which would require sinking to impracticable depths in most places). All exceptions will be of purely local extent and will require much local topographic and geological work for their designation.

There still remains the area of the Staked Plains formation to be discussed, but our knowledge of its geology is too limited to permit anything but the most general statement. The upper portion of these plains is composed of strata of later Tertiary or possibly Quaternary age, underlaid by a conglomerate and sandstone of earlier date than the Trinity Sands, dipping southeast. It is this bed that furnishes the surface water of the Plains, and from it gush the headwaters that form the Colorado, Brazos, and Red rivers. The beds underlying this are probably Permian on the southern border, but newer formations may intervene towards the north. It is possible that this conglomerate bed may yield artesian water near the western border of the State, and I understand that one such well has been secured. It is my opinion, however, based on such knowledge as I can obtain, that the probabilities of artesian water on the Plains are rather unfavorable than otherwise.

It will require a considerable amount of work in western New Mexico to decide the matter finally.

The well at Pecos City most probably belongs to the series newer than that described under the Grand Prairie Region, and therefore gives us no clue to the area north of it.

The Trans-Pecos mountain district from the Guadaloupe Mountains to the Rio Grande consists of numerous mountain ranges and detached peaks which rise from comparatively level plains. These plains are composed of loose material which has been derived from the erosion of the mountains and sometimes has a thickness of over a thousand feet, as is proved by the wells along the Texas Pacific and Southern Pacific railways. The geologic formations of the mountains themselves consist of granites, sandstones, schists, and quartzites and Silurian, Carboniferous, and Cretaceous limestones. The whole area is faulted, broken, and cut by intrusive porphyries, basalts, granites, and other eruptives.

These conditions of structure prevent any other than a general unfavorable report on the district, although in certain localities conditions may, and probably do, exist favorable to the securing of artesian water.

ACKNOWLEDGMENTS.

It gives me great pleasure to be able to publicly acknowledge the kind assistance rendered the Survey by the press of the State in the notices printed of our First Annual Report and the publication of many extracts from it, as well as the special articles furnished them by this office, whereby many items of interest and value have been disseminated among the people more thoroughly than could have been done by means of the regular report.

The assistance rendered the geologists and their parties during their field work by the citizens of the various sections visited has been of greatest service, not only by the actual aid given, which was very great, but still more by the fact thereby evinced of their interest in and appreciation of our work.

The co-operation of the United States Geological Survey, the United States Coast and Geodetic Survey, and of Professors Heilprin, Hyatt, Cope, and Dr. Roemer have already been mentioned, and our thanks are due for it.

To those who have worked with me on the Survey and have given, each in his own field, their best efforts; who have cheerfully carried out the general plans of work as outlined by me; who with conscientious and continued labor, sometimes through hardships, and even at the sacrifice of personal advantages, have by their work brought out the great scientific and economic facts concerning the resources of Texas which appear in part in these reports, and which will mark an important era in the material advancement of the State; who have at all times shown me all courtesy—to all of these I express my deep appreciation of their kindness and return my most sincere thanks.

GEOLOGICAL SURVEY OF TEXAS.

REPORTS OF GEOLOGISTS

1890.

REPORT OF MR. W. VON STREERUWITZ.

AUSTIN, TEXAS, December 30, 1890.

Mr. E. T. Dumble, State Geologist, Austin, Texas:

In accordance with instructions I left Austin the ninth day of May, to continue the field work in Trans-Pecos Texas. Arrived at Fort Davis I found the animals that were turned loose last February at Capt. Dolan's ranch, near Fort Davis, in very poor condition, owing to the want of grass, and more of water, in consequence of long lasting drouth. They were, in fact, so weak that it took six days to transport the nearly empty wagons to Torbert, a distance of only eighty-five miles. It took over two weeks of rest, with food and water, which last, through kindness of Mr. Martin, superintendent of this section, I could secure from the water cars of the Southern Pacific Railway, to restore the animals sufficiently for light service.

In Sierra Blanca Junction, where Mr. J. A. Taff joined me in the capacity of Assistant Geologist, I found Dr. R. S. Woodward, Astronomer of the United States Geological Survey, assisted by Mr. A. T. Davis, taking observations for the final determination of the 105th meridian.

Not having been able to organize my party, and as mentioned before being compelled to rest the animals, I offered our services to Dr. Woodward, since I knew the determination of the meridian, as well as other astronomical points—such as our base, mountain peaks, etc.—to be of the greatest importance for badly needed regulation of the surveys of the country west of the Pecos River, at the same time to locate as to latitude and longitude that part of this country which we had topographed during the last campaign.

The grass getting scarce around Torbert, and the water tank being nearly empty, I moved the camp to Rattlesnake Tanks, west of the Van Horn Mountains, on a spur of this mountain range. But the water of this waterhole was not only contaminated with the carcass of a dead cow, but running very low, and the grass very scanty, so I camped there only three days—long enough to make reconnoitering observations referring to eruptive rocks and crystalline schists, Mr. Taff sectionizing the Cretaceous strata. The animals were not yet in a condition to carry the needed water from the nearest point, the wells at Finney's ranch. I left Mr. Taff in charge of the camp, which I had moved to Finney's ranch, and went to Sierra Blanca to meet Dr. Woodward, leaving instructions with Mr. Taff to move the camp to about two miles west of Eagle Springs as soon as he was through with sectionizing the sandstone and limestone strata surrounding the northwest slope of the Eagle Mountains. A reconnoitering of the Green River Canyon had shown that neither in this canyon nor in some tanks along the more southwestern slope of the Eagle Mountains (Sierra Cola de Aguila) could any water be found.

But the water of the Eagle Springs was so scarce that we again had to fall back for part of the needed water on a scanty supply of the railway tank in Torbert. So after Dr. Woodward and Mr. Davis had finished the computation for the determination of the meridian, and we had set the monuments (one near the intersection of the old stage road to El Paso with the Southern Pacific Railway on the north side of the railway, and one about one mile south of the first one), in the presence of Mr. Davis, Major Marmion, county surveyor of Presidio County, representing also Jeff Davis County, and myself, I removed the camp to a well in the flat on Glenn's Creek, where we found a sufficient supply of good water. But the scarcity of grass, as well as clouds of small gnats which nearly killed the animals, compelled me again to move the camp, which besides was a long distance from the points where observations were to be made.

Up to this time (July) it was impossible to secure the help of a topographer at the salary of last year. I left Mr. Taff with one team at Sierra Blanca Junction to work up the Cretaceous hills in the surroundings, and moved myself to the Bonanza district between the first (north) and the second (main) range of the Quitman Mountains. Here the party was joined by Mr. Ralph Wyschetzki, who had successfully worked with me as topographer during the last field campaign. After having worked up the Bonanza district, I moved the camp to the west side of the main range of the Quitman Mountains (formerly Sierra de los Dolores), where since the last rains I had found water in a drift of the Queen Ann prospect. From this camp Mr. Taff, who being through the work around Sierra Blanca and on the hills between this place and the Quitman Mountains, had joined the party, began to sectionize the strata of the Cretaceous hills on the west side, and the older limestones extending from the Quitman Mountains into the flat and into the Cretaceous Malone hills. I myself, with Mr. Wyschetzki, started the topographical work from the points from which we had left off work at the close of the last field campaign. Later Mr. Wyschetzki carried on the work assisted by one of the drivers until I secured the help of Mr. Leon Perl as assistant topographer.

I removed the camp about four miles down the mountains to the location of the Mule prospect, the last place on the mountain slope accessible by wagons, and we finished the geological and topographical work down to the Quitman Pass (formerly Puerta de las Lamentaciones). Rains and waterspouts had destroyed the old stage road and all other roads to and through part of the pass, and in order to take the east side of the Quitman Mountains and the pass I had to move round by Sierra Blanca, going to camp first at the foot of the Cretaceous ranges west of the Devil's Ridge, about nine miles southeast of Sierra Blanca, and later to near the east side of the Quitman Pass, where I left Mr. Wyschetzki in charge of the camp, and moved with Mr. Taff to an old shaft about three miles northwest of Eagle Flat Station, from where we began to work the Carboniferous strata and underlying older rocks of this part outlaying from the Carboniferous cliffs of the Sierra Diabolo.

After Mr. Wyschetzki had finished the topography of the Quitman Mountains through the pass, I directed his camp to Allamore, at the northeast slope of the Carrizo Mountains, where we connected the topographical work already done with the 105th meridian and began the topography of this mountain group. After this I joined Mr. Taff, whom I had directed to go to camp at the pass through the Carrizo towards the Hazel mine and the cliffs of the Sierra Diabolo, to compare the metamorphic rocks and brecciatic conglomerations with those farther west, near Eagle Flat.

Moving the camp farther towards the Diabolo Cliffs, and thence passing the Hazel mine to the Van Horn Pass, intending to take in the east side of the mountains south of the Sierra Diabolo proper. Here the wagon broke down on the rough road. I left Mr. Taff in charge of the camp and went to Toyah, where I took the old wagon left there by Mr. Tarr and sent the same, after some hasty repairs and makeshifts, for Mr. Taff, and being instructed to quit field work I hastened to make arrangements for the storage of instruments and camp outfit at the railway depot at Sierra Blanca, as the safest place in reach, and turned the animals loose at "Uncle Charley's" ranch, where I expect they will find enough water and grass to winter through.

Having put up rock piles on the level of many horizontal curves at the points at which we left off work, the topographical work (the indispensable base for geological observations in Trans-Pecos Texas) can easily be resumed.

There are many difficulties to be overcome besides the want of reliable maps; as for instance, the excessive metamorphoses of older deposits, destroying and obliterating all organic remains—metamorphoses evidently due to forces and influences of varied character, acting at different periods and under different conditions. Another difficulty is that even if we could neglect the work referring to the economic features, the observations can only be made by sacrificing much time in hunting or waiting for grass and water in one or the other locality, or by putting in the field more expensive outfits for carrying water, etc., than I had at my disposal. Some of the difficulties will be removed by the triangulation of the country along the Rio Grande, which will be started this winter by a United States Coast Survey party, and which will establish a number of points connected with our Texas base and with each other, enabling the geologist for west Texas to work at such points where at different seasons of the year water can be found. We can therefore leave out temporarily the large flats without losing the connections, and study the relations of the mountain ranges and groups closer to the Rio Grande independently from each other.

But before we can arrive at safe final conclusions with regard to the older rocks, the study not only of this part of the West Texas mountains, but also those of Mexico, New Mexico, and Arizona, will be required; they belong to the same system, and can and will be understood only after careful comparative study of the whole system.

As far as the economic part is concerned, it can be safely said that the mineral resources, if developed, will put the mountainous country of West Texas on equal footing with the best mining districts of the United States, and that the variety and excellent quality of the building stones and the facilities to transport them to railways are hardly equalled anywhere in the United States.

From observations of the climate continued during two summer and two winter seasons, from the general lay out of the ground and the quality of the soil, I came to the conclusion that the conditions for a future use of the soils for agricultural and horticultural purposes are anything but hopeless. True it will take time and money, but it will be done as soon as the drawbacks which I mentioned in my last and this year's reports, and the prejudice which stamps Trans-Pecos Texas as a valueless and hopeless desert, shall be removed.

Hundreds of thousands of acres of public school and university lands are located in the country west of the Pecos River, and it is in the interest of the public in general not only to ascertain but also to acknowledge publicly the value of this part of the State, by taking legal steps to remove drawbacks and to facilitate the development.

W. VON STREERUWITZ,
Geologist for Trans-Pecos Texas.

REPORT OF MR. THEO. B. COMSTOCK.

Austin, Texas, December 31, 1890.

Hon. E. T. Dumble, State Geologist, Austin, Texas:

Sir—Herewith is respectfully submitted the administrative report of the work performed since April 1, 1890, under my direction as Geologist of Central Texas.

In accordance with your instructions, I joined Mr. Cummins in the field early in May, and made with him an exploration of a district in Indian Territory (the Wichita Mountains) for the purpose of gaining a better understanding of certain difficult problems relating to the structure of the Central Mineral Region. Devoting a few days only to this work, I returned to Austin and prepared at once to resume field work in my own district. Your general instructions to "complete the survey of the Central Mineral Region, including the outlying pre-Carboniferous strata, and such exposures of the Carboniferous as may lie within this area or adjacent to the same upon the east and south," have been carried out as fully as possible in the limited time which could be allowed for the work. The field has now all been explored, by far the greater part in sufficient detail for the construction of a geologic map; but as the area is very much greater than we had supposed, and the facilities for travel in the dry season are rather limited, I have been unable to present a report which can be regarded as final in any permanent sense. We were in the field but three months this year, as against five months in 1889. With a larger party, the equipment was reduced from motives of economy, rendering the executive duties more onerous and giving less available time for the geological work.

The field party was organized as follows:

Theo. B. Comstock, in charge.

J. C. Nagle, Topographer.

Charles Huppertz, Geological Aid.

H. B. Jones, Compassman.

J. F. Clark, Contact Runner.

H. H. Harris, Rodman.

R. A. Thompson, Rodman.

Harry Foster, Hostler.

Frank Tuttle, Cook.

Upon the return from the field, September 2, the party was disbanded, Mr. J. C. Nagle and Mr. R. A. Thompson being retained for office work. Mr. Thompson left me to attend the University before the end of September, and soon after Mr Nagle received well merited promotion to the responsible charge of the Department of Civil Engineering and Physics in the State Agricultural and Mechanical College. Mr. Frank S. Ellsworth, at present engaged as general assistant, began work October 23, 1890. Mr. G. V. Skelton has been employed since December 5 as draughtsman.

The region traversed the past season is very largely made up of Silurian rocks at surface, and these afford comparatively few economic minerals, but we have been able to trace out the principal ore belts and to study the limits of the fields in which the mineral resources abound. The map which accompanies my report for 1890 gives all details of structure and distribution which have been collated to date.

The method of survey adopted has been somewhat different from the plan followed in 1889, but in essential features it is the same. Each day's work was arranged by myself, the topographers, field assistants and camp men having routes and duties assigned so as to bring all together again at night, usually in a new camp. In 1889 we made sixty-six camps, whereas in 1890, owing to the difference in the country and the lack of subsistence except what we carried, I was compelled to keep my whole force constantly within reach, and to have the headquarters almost daily in motion. We therefore made seventy-four camps in 1890 in a little more than three months.

The work performed by individual members of the party is credited below:

MR. JAMES C. NAGLE.—While the topographic work has necessarily been subsidiary to the geologic, the areas traversed and the maps constructed having been in accordance with methods and designs of my own selection, it is but just to state that the execution has been entrusted to Mr. Nagle from the beginning. I have constantly given every detail such oversight as was requisite in order to be able to assume responsibility for the accuracy of the results, but the credit for such accuracy, and for the utmost faithfulness in the performance of every detail of an exceedingly onerous task extending over sixteen months, is due my assistant, whom I also owe frank acknowledgment of many generous courtesies which were not demanded by his position. The topographic portion of the map appended to this report will clearly attest the justice of what is here written of Mr. Nagle's field and office work, but it is proper to add that a very large part of the office work of 1890 has been done by him without expense to the State.

MR. CHARLES HUPPERTZ.—The duties assigned my chief geologic aid were various, but mostly of a character which necessitated skill, endurance and abilities of special character as an independent observer and collector. Mr. Huppertz's notes form, in many instances, a part of the basis upon which important conclusions rest. I have satisfied myself most fully of his reliability and accuracy, and desire here to express my appreciation of his valuable services.

All the other assistants performed their duties well, and bore uncomplainingly the vicissitudes of an unusually trying season. Mr. Jones was employed in meandering streams and tracing special geologic boundaries. Mr. Clark was for the most part engaged in keeping the record of the geology within easy reach from the topographer's transit lines. Both these young gentlemen are undergraduates of the University of Texas, and in their work have reflected credit upon that institution. The rodmen and campmen have my thanks for their unflagging zeal and faithful performance of every duty.

Referring to the maps and my full report for a more detailed account of what has been done in connection with the economic geology of the region, I will only add a general statement of the manner in which the whole has been accomplished, in order to give an idea of its thoroughness and accuracy.

The small sketch map of transit and section lines illustrates the courses of the profiles taken by the topographer with the solar transit (Gurley's). The large map has been constructed from the vertical and horizontal angles observed along these lines at short intervals, the intervening topography having been sketched in. In a few instances (over small areas which could not be covered by our lines in the limited time allowed us), the topography has been worked in from the sheets of the United States Geological Survey, but in every case of this kind I have personally gone over the tracts and satisfied myself that those portions of the sheets are reliable, or I have had the inaccuracies corrected by special work with the compass. The result is a topographic map much more accurate than any hitherto published, and one which is suited to the correct delineation of the geology as far as we have been able to carry our studies. The monuments of the United States Geological Survey Geodetic Corps have been placed with precision, and these have furnished valuable checks upon our work. The field notes, including the geology, were all plotted first upon the scale of one thousand and forty feet to the inch, reduced by pantograph to $\frac{1}{62500}$, and this again reduced in the office to $\frac{1}{125000}$ and carefully drawn for further reduction by photography, the engraving being upon the scale of $\frac{1}{250000}$, or three and nine-tenths miles to the inch. The geology was worked up in detail along the transit lines, which were usually laid out with reference to the structure, and many complicated areas were thus studied minutely. Contacts of the different terranes have been instrumentally run as far as has been possible, and details of this character which can not be given from actual knowledge are shown upon the map in broken or dotted lines. Subsidiary topography was also largely worked out by the compass.

The geologic conclusions tentatively announced by myself in the First Annual Report are mostly confirmed by subsequent work in the field.

Besides the results announced in my accompanying report, there remains a large amount of partially elaborated material, and some which is in a more advanced stage of preparation, but which could not be arranged and edited in time to appear therewith. A series of thin slices of our crystalline rocks is being made in the laboratory, and some exchanges with other workers have given us a fair beginning in this department.

The fossils obtained from the Cambrian, Silurian, and possible Devonian strata have been given a preliminary examination, but little more can be done with them until more complete collections can be secured. A table of the minerals of my district, with ample notes of localities, modes of occurrence, special characteristics and economic relations, is so far advanced that its publication as a Bulletin might be feasible at an early date.

The recent discovery of tin ores by myself necessitated a special trip to Llano and Mason counties in November. With Mr. Ellsworth as assistant, I made a careful exploration of a tract which we had previously been obliged to neglect, devoting a week to its study. The results of this examination are embodied in the main report.

Again I must acknowledge the welcome interest taken by the citizens of my district in our work, and the constant aid and encouragement rendered by hundreds whose names it is impossible to give. There has not been one instance of anything but courteous and generous treatment by all whom we have encountered in several thousand miles of travel through the region.

Allow me to assure you, personally, of my appreciation of all that you have done to render light the burdens of a comprehensive Survey. No small share of what has been accomplished is due to your unwavering support and indulgent treatment in both the field and office.

Very respectfully,

THEO. B. COMSTOCK,
Geologist for Central Texas.

REPORT OF MR. W. F. CUMMINS.

Austin, Texas, December 31, 1890.

Hon. E. T. Dumble, State Geologist, Austin, Texas:

Dear Sir—In compliance with your request I herewith hand you a report of the field work done by myself and assistants since January 1, 1890. Previous reports have embraced the work done up to that date. When the previous report was written we were encamped at Dockum, in Dickens County, at the foot of the Staked Plains.

The weather turned very cold, my men got sick with "la grippe," and it being impossible to get feed for the stock for some distance after leaving this locality, I abandoned the project of making another complete section across the Permian formation from this place, as I had intended.

I made such observations in that vicinity as was possible without moving camp, going in one instance up Blanco Canyon as far as the south line of Floyd County.

After supplying ourselves with provisions and feed for the stock we began our return trip, going northeastward, crossing the head of the north fork of of Croton Creek, to the head of the south fork of the Big Wichita River We traveled down the north side of that stream to the old McKenzie trail. Crossing the river at that place, we kept down the south side of the river to Benjamin, the county seat of Knox County. This is the first place at which we could get feed for the stock after leaving our camp in the vicinity of Dockum. From Benjamin we traveled over the broad plateau between the Brazos and the Big Wichita rivers to Seymour, the county seat of Baylor County. A few miles west of Benjamin we left the gypsum formation, having been in it since reaching Kiowa Peak on our outward trip, except the time we were camped at Dockum.

We began a line of levels at Flat Top Mountain, six miles north of Seymour, in Baylor County, and ran eastward to Wichita Falls, for the purpose of getting the thickness of the Wichita Beds of the Permian. The profile is shown in another part of this Report. We found the top of the Wichita Beds to be near the eastern line of Baylor County, at the place where our line of levels crossed the county line.

From Wichita Falls we returned to Baylor County and traced the line of contact between the Wichita and Clear Fork Beds of the Permian to where the line of contact reaches the Brazos River, and which is probably the most southern extension of the Wichita Beds. The point at which we reached the river is a few miles west of the mouth of Spring Creek, and of the northeast corner of Throckmorton County.

From thence we went down the river to the line of contact between the Permian and Coal Measures, and then turned northeastward, tracing the line of contact between these two formations to Red River, near the northwestern corner of Montague County.

We went to Henrietta, in Clay County, where I was joined by Dr. T. B. Comstock, of the Survey, who came for the purpose of making a hurried reconnaissance of the country in the vicinity of the Wichita Mountains in the Indian Territory. We took the direct road to Fort Sill, crossing Red River at the mouth of the Big Wichita River. Our route lay up the east side of Cache Creek to Fort Sill, where we reached the contact between the Permian and the Silurian and granitic rocks. We went from there along the southern base of the mountains almost directly westward for fifteen miles, then turning northward through a gap in the mountains we passed through the range and found the Silurian resting upon the granitic rocks on the northern side of the range. We turned southwestward and crossed the North Fork of Red River into Greer County, near the town of Navajoe. From this place Dr. Comstock took the stage for Vernon, while I turned eastward along the Fort Sill road, recrossing the North Fork of Red River and Otter Creek; then turning southeastward to the head of Deep Red Creek I continued down that stream to its confluence with the Cache Creek, and thence down that stream to the upper Henrietta road, and thence south, crossing Red River and Big Wichita River to Henrietta, having been gone about two weeks.

From Henrietta we went southward to the west fork of the Trinity River, in Jack County, for the purpose of tracing Coal Seam No. 7, which outcrops in that vicinity. We went along the line of outcrop as far eastward as Mr. Cooper's place, on the southeast quarter of section No. 2, made for the Southern Pacific Railway Company, file No. 2879. We then turned southwestward along the line of strike and traced the coal seam by its outcrop, passing near the town of Gertrude, Flat Top Mountain, and the mouth of Coal Creek to Belknap.

From there we returned to the point on the Brazos River, near the mouth of Spring Creek and near the eastern line of Throckmorton County, where we had found the contact between the Permian and Coal Measures, for the purpose of running a line of levels and making a complete section across the Coal Measures. We began the line near the mouth of Camp Creek and ran southeastward, passing through the towns of Belknap and Graham in Young County, Finis in Jack County, Mineral Wells in Palo Pinto County, Millsap in Parker County, to a point on the south side of the Brazos River near the west line of Hood County and near the town of Buckner.

At Rock Creek, five miles east of Mineral Wells, we had crossed Coal Seam No. 1, and traced it by its outcrop both northeastward and southwestward along the line of strike for several miles in each direction. From Buckner we went westward to Gordon, passing the town of Santo, for the purpose of tracing Coal Seam No. 1 from where we had left off following it southwestward on the occasion just mentioned. We traced the coal from hill to hill, passing the old Gordon mine, the towns of Gordon and Thurber, and to the Bridgefarmer place eight miles south of Strawn, where the seam is overlaid by the higher part of the formation and Cretaceous.

We turned north, and recrossing the Texas and Pacific Railway line at the Coal switch, and thence to the town of Palo Pinto, and then northwestward to Eliasville, in Young County, where we again took up the work of tracing Coal Seam No. 7 from Belknap, where we had left off that work on a previous occasion. We traveled from there southwestward, passing Carbondale, Crystal Falls, and the mouth of Sandy Creek, and thence up that creek to Cisco, where the seam passes entirely out of sight under the newer beds.

We then traveled west along the line of the Texas and Pacific Railway to Putnam, and thence south, passing over the high Cretaceous hills to Pecan Bayou, where we again found the Carboniferous formation.

In order to get a complete section across the Central Carboniferous field, and to secure data by which to correlate this part of the formation with that north of the Cretaceous belt just mentioned, we turned up Pecan Bayou and found the line of contact between the Carboniferous and Permian to be at the head of the bayou, near the western line of Callahan County. At this point we began a line of levels and ran southeastward down the bayou to Brownwood, and thence southward along the upper or western San Saba road to the town of San Saba, where we reached the base of the formation in this part of the State. We then turned eastward along the strike of the San Saba Sandstone to the head of Lynch Creek, in Lampasas County, and thence to the town of Lampasas, where the survey practically ended.

The outfit was sent to Austin, where the wagons and camping outfit are stored and the horses and mules properly cared for.

At this place I will briefly refer to a few facts which will be presented in greater detail in the body of the report herewith submitted.

In the brief time which I had for the examination of the beds in the vicinity of Dockum, and which in the First Annual Report, 1889, I called the Dockum Beds, I could not get enough material by which to definitely determine the horizon to which they belong, but am of the opinion that they are the same as the Shinarump beds of Hayden, a member of the Triassic formation in Arizona. The beds constituting the upper part of the Staked Plains are of a later date, and are without doubt Tertiary. In these I found only fragments of vertebrates, and not enough to definitely determine the horizon to which the beds belong. A more detailed examination of that part of the country is required to determine any of the stratigraphic relations.

I still see no cause for changing my opinion that all the strata from the Coal Measures to the Dockum Beds belong to the Permian. I think this will be fully proven by the facts collected on this expedition, as will be shown in the body of the report. I have made as large a collection of fossils from the several beds as it was possible to make in the time at my disposal for such purposes.

The two complete sections made across the Carboniferous, one along the Brazos River and the other along Pecan Bayou, have enabled me to correlate the strata of the Carboniferous south of the Cretaceous belt that extends across the country just below the Texas and Pacific Railway with the beds in the northern part of the State.

The highest and lowest beds of the Carboniferous occur in the southern part of the field, while only the intermediate ones are found in the extreme northern part.

Both the workable beds of coal are in the northern division, while only No. 7 is found in the southern division.

The relation of the several beds will be shown in the body of the Report.

Mr. N. F. Drake has been in charge of the topographic work, and to his efficiency in that branch of the service, and in making observations of the stratigraphic relations of the different beds, I am indebted for the completeness of the sections published elsewhere in the Report.

W. F. CUMMINS,
Geologist for Northern Texas.

REPORT OF MR. J. B. WALKER.

AUSTIN, TEXAS, December 31, 1890.

Mr. E. T. Dumble, State Geologist:

DEAR SIR—In accordance with your letter of instructions of June 6 assigning to me for the field season the counties of Panola, Shelby, Nacogdoches, and Rusk, I herewith transmit notes of the observations made.

The object of the field work in the counties named was to examine the quality of the iron ore deposits and define the boundaries of such ores as would probably be of immediate economic value, with "such observations on the character of the surrounding geologic formations as the time (summer, 1890) will permit." The quotation from your letter of instructions.

The want of reliable geographic maps, and the fact that no contour maps of this section exist, together with a paucity of local names for many of the "mountains," as they are locally called, and the difficulty of finding persons acquainted with the boundaries of headright surveys, has rendered exact outlining of the ore beds within the allotted time an impossibility, but sufficient data has been obtained to show the location and approximate extent of the beds of iron ore most suitable for manufacturing purposes, while other observed facts will tend to assist in determining the character and relations of the strata to each other, and the period of the formations as a whole.

The plan of operations consisted in selecting the county seats respectively as central localities, and from these centres radial loops or excursions were made into the different parts of each county, mainly in search of iron bearing beds, and casually noting any facts bearing on the stratigraphy of the country that came within my observation. It was in this way only, as it appeared to me, that the three thousand four hundred and ninety square miles of territory in my district could be approximately covered in the stated time.

In conclusion, allow me to express my indebtedness to you for many useful suggestions and courtesies received, and to the many hospitable and public spirited citizens of the counties in my district for the interest manifested in the Survey, donations to the Museum, and the time they cheerfully gave to accompany me on many local journeys in the heat of summer.

Very truly yours,

JOSEPH B. WALKER,
Assistant Geologist.

REPORT OF MR. J. H. HERNDON.

AUSTIN, TEXAS, November 7, 1890.

Hon. E. T. Dumble, State Geologist:

DEAR SIR—In accordance with your instructions of June 8, for me to undertake the study of Smith County and make a report on its geology, with especial regard to its economic features, I took the field on June 22 and made a rapid reconnaissance of the county, which has an area of nine hundred and fifty-seven square miles, and necessarily took a long time in order to get a general idea of its geology. This was followed by a systematic study of the county in detail.

I made Tyler my headquarters, and rode over the whole county on horseback, and have succeeded in mapping out the iron ore beds, pottery clays, lignites, and other economic products. My aim has been to present the economic features of the county in such a shape that they may readily be grasped by all, in the hope that by leaving out the details of stratigraphy, which have been discussed at length by other geologists, that this brief report would meet the wishes of those most interested in developing the mineral resources of the county.

I desire to express my thanks to Mr. R. T. Hill for valuable hints and assistance.

In conclusion, my thanks as well as my gratitude are due you for the personal interest you took in me by visiting me and giving me a fair start in my work. The valuable instructions and methods of investigation which you imparted to me in those few days when you were with me, the perfect freedom and the many facilities afforded me in presenting this work, have rendered it a possibility.

Very respectfully,

J. H. HERNDON,

Chemist in Charge, Geological Survey of Texas.

REPORT OF MR. W. KENNEDY.

AUSTIN, TEXAS, December 19, 1890.

Hon. E. T. Dumble, State Geologist:

DEAR SIR—The work assigned to me during last season is detailed in your letter of instructions under date March 28, 1890, as follows:

"The work to which you are assigned for the present is the continuation of the mapping of the iron ore deposits of Eastern Texas. You will therefore proceed to Cass County, which is now partially finished, and complete it. Then make reconnaissance of Bowie County to determine amount of iron in that county.

"In addition to the mapping of these ores, you will make such observations in the clays and lignites as you are able to do, thus preparing yourself to take up their study in detail as soon as the present work is completed."

With the view of carrying out these instructions, I left Austin on the morning of the 29th March, and on arrival at Queen City began the work of mapping the iron ores of Cass County. The greater part of the month of April was unfit for field work, owing to the flooding of the streams due to an excessive rainfall. Another cause of delay in the finishing of the work of surveying Cass was the failure of my predecessor, Mr. A. G. Taff, on account of his serious illness, to supply me with his note book or a copy of his notes. I was not supplied with a copy of Mr. Taff's notes, or other details of the work performed by him, until late in the season, and after I had resurveyed and mapped the greater part of the district over which Mr. Taff had already gone. On receipt of Mr. Taff's notes I did not visit the few remaining points where he had been, but confined my attention to such parts of the county as had not been already visited. In the preparation of the report Mr. Taff's notes were used for the few places not visited by myself.

In addition to the mapping of the iron ores in Cass County, all the known deposits of clay of any known, or which might eventually prove to be of any value were visited and examined, and the same course was also pursued with respect to all known lignite outcroppings. As the geological structure of the county was also under consideration, as many natural sections from stream cuttings and washouts, as well as sections from the cuttings along public roads and railways and from wells, as possible were measured and the general topography of the county ascertained as correctly as possible with the instruments at my command and by the aid of profiles of the railways intersecting the county. Some of these sections and levels are given in my report, and the others are on file pending the complete topographical survey of the whole of that part of the State. A map of the county on a scale of one inch to the mile, containing the meanderings of the streams and bayous corrected, is now in course of construction and will be completed shortly.

From work along the Sulphur River and a few trips made into Bowie, it was seen that the existence of iron ore in that county was at best problematic, and the proposed reconnaissance into Bowie was abandoned.

On the completion of the work in Cass County I proceeded according to your instructions to Harrison County.

No work had been done previously in this county, and, with the exception of a visit to Hynson's Springs, had not been visited by Dr. Penrose in his reconnaisance of East Texas. Owing to better facilities in the form of roads and other means of transportation from place to place, the work of surveying and mapping the iron ores, clays, and lignites of Harrison County was carried on with much greater celerity than was possible in Cass, and the work was completed in a much shorter period of time. The work in Harrison County was finished by the 10th of October.

The character of the work performed in Harrison County was similar to that done in Cass County. The iron ores were examined and mapped. All the clay and lignite exposures were visited and examined and described, and the general geological and topographical structure of the county worked in detail as far as possible. Many natural as well as other sections were measured and recorded, and many elevations from railway profiles and barometric readings were obtained As with Cass, some of these sections and elevations appear in the report, while the others are held pending fuller investigations and the correlation of the several deposits.

No attempt has been made to correlate these deposits, or to assign them to any position in the geologic scale. They have simply been considered as forming parts ot Penrose's Timber Belt Beds.

After the completion of the work in Harrison County, I spent a few days in the vicinity of Jefferson, Marion County, examining the clay deposits and greensand marls of that region.

During the month of October a reconnaissance was made of Gregg County, with the view of ascertaining the existence, probable extent, and quality of the iron ore of that county, with the intention, if found necessary, of making a complete survey of Gregg County some time during the next season.

Field operations were finished in the beginning of November, and since that time I have been engaged in the office, working out such portions of the reports as could not be done while in the field.

Numerous specimens of iron ores, ferruginous sandstones and clays, with some greensand marls, were obtained during the course of the work and forwarded to Austin from time to time. All necessary analyses of these have been made, and some of the clays have been submitted to practical fire tests with the view of determining their refractory qualities. Some of the other clays have yet to be tested.

In conclusion, allow me to thank you for your advice and personal assistance during the course of the work.

Very respectfully,

WM. KENNEDY.
Assistant Geologist.

CHEMICAL DEPARTMENT.

REPORT OF MR. J. H. HERNDON.

AUSTIN, TEXAS, December 14, 1890.

Hon. E. T. Dumble, State Geologist:

DEAR SIR—I have the honor of herewith laying before you a brief report of the character and amount of work done in the Chemical Laboratory of this Survey during the period embraced between January 1 and December 13, 1890. During this time six hundred and fifteen analyses have been made by Mr. Magnenat and myself. These analyses have been made especially with a view to show the economic value of the various ores and mineral resources of Texas. From the results obtained in the laboratory and reported to you it will be seen that no State in the Union is more blessed in mineral resources than Texas, and when once intelligent home and foreign capital begin to develop these resources, our State will make a gigantic stride towards progress and civilization which will give her the first place in the Union in wealth, power, and population.

The tables of analyses which I have given below only show the most important work done, of which a record has been kept. A large amount of work has deen done in the laboratory, such as testing of minerals, qualitative work, special assays, and the like, of which no record has been kept by me.

In the table under the head of assays sometimes as many as four or five different determinations have been made, so I have reported all analyses of zinc, lead, copper, antimony, and bismuth ores along with the assays, as in these ores silver and gold is always called for. In this short Report I can not discuss our ores at length, and can only hint at their possibilities.

The East Texas iron ores will make a fine grade of iron, and I have the assurance of prominent railway men who have tested them, that car wheels made from the iron are longer lived and wear better than those manufactured in any other State. These ores mixed with the requisite amount of magnetic ores of Central Texas will make a fine grade of steel. In the Central Mineral Region we have a fine grade of Bessemer ores unsurpassed by any in the world.

In Edwards County is found a pure white kaolin that will make the finest grade of porcelain ware, and in Eastern Texas clays are very abundant that can be utilized for manufacturing coarse pottery of every description, and a few that will make good fire brick. Our gold and silver ores assaying from one to eleven hundred ounces of silver and from one to ten ounces of gold to the ton. The manganese ores of Mason and Llano counties are very fine.

The lead ores assay as high as eighty-five per cent of metallic lead, zinc ores fifty-six per cent of zinc, copper ores seventy-eight per cent of copper. Bismuth, tin, antimony, molybdenum are found in small quantities.

Analyses made in the laboratory of the lignites of Texas have been compared by you with the German lignites which are used for making briquettes and coke, and shown to be superior to them both as fuel and as steam generators.

The fertilizers (Greensands) of Texas are not so good as those of New Jersey, yet can be used with great profit on our poorer lands. In fact, there is hardly a mineral of economic value that is not found in our State.

As to the monetary value of the work done by the Chemists in the Laboratory during the year, at present I can only give approximate figures. Counting each analysis as valued at $20, which is a very low figure, as most of the ores will far exceed this estimate if regular prices were charged, it will amount to more than $12,000. At the end of the year, if a careful estimate of the work is made, I have not the slightest doubt but that it will exceed $25,000.

Below is a table showing the amount and character of work done during the year:

IRON ORES FROM CENTRAL MINERAL REGION AND OTHER POINTS NOT IN EASTERN TEXAS.

	No. of Analyses.
Hematites, complete analyses	39
Magnetites, complete analyses	12
Limonites, Turgites, and vein ores, complete analyses	16

IRON ORES FROM EASTERN TEXAS.

Brown Hematites.

Laminated Limonites, complete analyses	25
Concretionary or Nodular Ores, complete analyses	40
Conglomerate Ores, complete analyses	14
Limonites, complete analyses, unclassified	71
Limonites, Nodular, Conglomerates, Veinstones and Sandstones, Orange Sands, etc., partial analyses	67

ASSAYS.

For Gold, Silver, Copper, Lead, Bismuth, and Zinc	167

Manganese Ores.

Yellow and Black Wad, complete analyses	5

Fertilizers.

Greensand Marls, complete analyses	24

Limestones.

Limestones, complete analyses		5
Chalks, complete analyses		4
Cement Rocks, complete analyses		3

Pottery Clays.

Kaolin, complete analyses		3
Clays (pottery), complete analyses		34
Clays, partial analyses	5	

Soils.

Cretaceous Soils, complete analyses		5

Brown Coal.

Lignites (proximate)		15

Mineral Waters.

Of all characters		8

Materials.

Miscellaneous ores, complete analyses		8
Miscellaneous ores, partial analyses	11	
Qualitative analyses on record	12	

SPECIAL ANALYSES.

Alkaline deposit (test its fitness for glass making)		1
Soda Ash (Bremer & Co.—used for glass making)		1
Ziegelerz (78.5 per cent of metallic copper)		1
Ochre, mineral paint		2
Fertilizers, bat guano		2
Pig Iron (Cass County)		1
White Sand Rock		2
Albite		2
Asphaltum		3
Phosphate Rock		1
Clay Iron Stones		6
Total number of complete analyses		532
Total number of partial analyses	83	83
Total		615

Very respectfully,

JOHN H. HERNDON,
Chemist in Charge.

CHEMICAL WORK OF THE SURVEY AT THE LABORATORY OF THE AGRICULTURAL AND MECHANICAL COLLEGE.

Mr. P. S. Tilson, during the seven months of his connection with the Survey in 1890, made sixty-nine examinations of soils, clays, and iron ores which were divided as follows:

SOILS.		
Complete chemical analyses	25	
Mechanical analyses	12	37
CLAYS.		
Complete analyses	1	1
IRON ORES.		
Limonites, from Cass County, complete analyses	25	
Limonites, from Cass County, partial analyses	6	31
Total		69

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY.

PAPERS ACCOMPANYING THE ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY OF TEXAS

FOR

1890

REPORTS

ON

THE IRON ORE DISTRICT

OF

EAST TEXAS.

CONTENTS.

PART I.

A GENERAL DESCRIPTION

OF THE

IRON ORE DISTRICT OF EAST TEXAS.

BY E. T. DUMBLE.

INTRODUCTION.

That part of Texas of which the following pages treat is situated in the northeastern corner of the State, being the territory lying east of the 96th degree of longitude and north of the 31st parallel of latitude. From this area we exclude, as being non-iron bearing, the portion north of Sulphur Fork, and also the northwestern corner, in which the black waxy prairies of the Cretaceous are the prevailing formation.

In this district, so restricted, there are nineteen counties: Cass, Morris, Marion, Upshur, Wood, Harrison, Gregg, Panola, Smith, Van Zandt, Rusk, Cherokee, Henderson, Anderson, Houston, Nacogdoches, Shelby, Sabine, and San Augustine, containing in the aggregate 14,430 square miles. In each of these counties iron ore exists in greater or less quantities and of varying qualities.

Ores of similar character are reported from other counties west and southwest of this area, but our investigations have not extended further than the limits stated.*

As will be seen by reference to the accompanying map, the iron ores are very unevenly distributed through this region, and as we have mapped them cover an area of about 1000 square miles. The scale, however, on which the map is published is such that many of the deposits which are really valuable do not appear at all, owing to their comparatively small size. In addition to the map, the boundaries and location of the ore deposits are given in detail in the various reports, so far as it has been possible to define them.

* It has not been found possible to complete the work in this district in as detailed manner as was intended. In Gregg, Sabine, Morris, Houston, and San Augustine counties no attempt has been made to do detailed work, and we have had to content ourselves with a reconnaissance of them for the purpose of ascertaining the presence or absence of workable deposits of ore. In four counties only have we gone over the subject as thoroughly as we intend working the entire area. For these reasons the present must only be considered a partial report.

In order that the work might be completed more rapidly, there have been several geologists in the field, and the reports on the separate counties are given as made by them. *

HISTORICAL.

The existence of beds of iron ore in the eastern part of this State has been known almost from the time of its first settlement.

In a new country, where supplies had to be brought from great distances by the slow methods of transportation in use at that time, it was only a matter of course that the abundance of wood for charcoal, the purity of the ore, and the probability of a remunerative market at home should prove sufficient inducement for men of enterprise to engage in its manufacture. Such was the case; and some time in the fifties Mr. J. S. Nash erected a small furnace in Cass County. Of this furnace Dr. B. F. Shumard states, in 1859, that "it was erected several years since." This was the first attempt to utilize these ores of which we have any knowledge.

The investigations of the Geological Survey under Dr. Shumard, which were carried on during the year 1859, proved that the ores were not confined to Cass County alone but were very abundant. He says: †

Until the commencement of the present survey, it was not known that we had workable deposits of iron, except in one or two localities. But our labors have demonstrated the important fact that we have a vast iron region in the eastern part of the State, embracing considerable areas in Cass, Harrison, Rusk, Panola, Smith, San Augustine, and Shelby counties. The ore deposits belong to the tertiary era, and consist chiefly of hematites and limonites, of which there are several varieties. We have also found in this district extensive beds of carbonate of iron.

According to Dr. G. G. Shumard, Cass county alone is capable of supplying a number of furnaces with an abundance of excellent iron ore for many years. The ore occurs here in regular layers, which sometimes obtain a thickness of fifty feet. The only iron furnace our State can boast of is located in this county. It was erected several years since by Mr. Nash and has been in nearly constant, and I believe profitable, operation up to the present time. The ore is mined near the furnace, and the kinds preferred are a porous variety of hematite, termed by the proprietors "honeycomb ore," and

* Such descriptions as are written by myself are of counties examined by Dr. Penrose and the iron ore localities mapped by Mr. G. E. Ladd. These are written from the notes of Dr. Penrose, to which the results of my own examinations are added in places. Much of the other matter contained in this report is taken either from the former published reports on this region by Dr. Penrose or from his notes, which are admirable in their clearness and detail. Quotations not otherwise credited are from Dr. Penrose's writings.

† First Report of the Geological and Agricultural Survey of Texas. B. F. Shumard, M. D. This report is reprinted as an appendix to "A partial report on the Geology of West Texas." Dr. G. G. Shumard. Austin, 1886, pp. 142, 143.

compact brown hematite. The pig metal and castings produced from these ores are of excellent quality and command a high price in the market.

Our detailed examinations in Rusk county have developed the occurrence of almost inexhaustible deposits of workable hematite, similar to that found in Cass, while our general surveys in Cherokee, Nacogdoches, and the other counties above enumerated have convinced us that further explorations will reveal there also the existence of equally extensive accumulations of this important element of State wealth.

Other deposits of iron occur in the tertiary strata in the middle division of the State, but so far as our observations have been carried these ores are inferior to those found in the East. In the counties of Caldwell and Guadalupe, examined by Dr. Riddell, are heavy deposits of iron ore, but they contain such a large proportion of silex, in the form of sand, as to render them generally unfit for profitable smelting. We have fair workable ores from Bastrop and Llano counties, but further researches are necessary before we can give a positive opinion respecting their value.

Dr. Riddell's analysis of an average specimen of the honeycomb variety from the Nash mines yielded the following result:

Specific gravity, 2.2891.

Moisture and matter volatile at red heat	12.227
Silica	8.122
Peroxide of iron	79.604
Loss	.047
	100.000

Dr. Riddell's analysis of a specimen taken from an extensive ore deposit in Rusk County, about four miles east of Sulphur Springs, gave:

Specific gravity, 3.3245.

Alumina	1.0360
Siliceous matter insoluble in acids	8.7941
Peroxide of iron	71.7826
Water	18.3873
	100.0000

The specimen analyzed represents a variety that is very common throughout the iron region of this part of the State.

This is the first clear statement which we have of the character, extent, and age of these ores, and, although the actual thickness of the beds is much below that claimed for them, it is nevertheless sufficient to fully warrant the conclusion of a practically unlimited supply.

The extra session of the Eighth Legislature, in 1861, which suspended the Geological Survey, showed the value of its work by the following:

Joint Resolution Concerning Iron Foundries in the State of Texas.

WHEREAS, There is in the counties of Marion and Cass, in this State, an inexhaustible supply of iron ore; and, whereas, foundries are at this time in successful operation in said localities, fostered by the enterprise of the citizens of Texas; therefore,

1. *Be it resolved by the Legislature of the State of Texas*, That the government of the Confederate States of America is hereby respectfully invited to consider the propriety and importance of establishing in said localities a foundry and manufactory for the manufacture of ordnance and arms for the Confederate States.

2. That the Governor is hereby requested to cause a copy of this joint resolution to be transmitted to the delegates of this State in the Congress of the Confederate States, to be by them laid before the government of said Confederate States; and that this joint resolution take effect and be in force from and after its passage.

Approved April 8, 1861.

In response to this invitation the Confederate Government took charge of some of the furnaces already in operation and ran them for the purpose indicated. Others were erected in various localities, and gun barrels and other supplies and munitions manufactured. Effort has been made to secure the official records of the operations of these furnaces, but the volume of Records of the Rebellion in which they will appear is not yet published.

In addition to the works erected in this way a few others were constructed by private capital. In this way the total number of furnaces was somewhat augmented, although the total output of iron was comparatively small on account of the small size of the works.

The iron made at the small bloomaries, from the rich ores of the region, was very malleable and tough, and the traveler of to-day finds many articles in daily use among the farmers, in the neighborhood of these old bloomaries, which, they will tell you, were made directly from the ore at the "foundery," as they always call them.

The Ninth Legislature, in 1863, reorganized the Military Board, which was composed of the "Governor of the State, who shall be ex officio President of the Board, and two other members, who shall be appointed by the Governor." This Board was given control of all public works and supplies, and empowered "to aid producing within the State by the importation of articles necessary and proper for such aid."

They were authorized to erect iron works by the following Act:

An Act to Provide for the Manufacture of Iron by the Military Board.

SECTION 1. *Be it enacted by the Legislature of the State of Texas*, That it shall be the duty of the Military Board to erect and put into operation one or more furnaces and forges and other suitable works for the manufacture of iron, to be located at such place or places as may be selected by said Board.

SECTION 2. That all iron manufactured by said Board, or under their direction, not needed for the defense of the State or in the performance of their duties, shall be sold to the people, according to such regulations and on such terms as said Military Board may establish, and the proceeds of such sales paid into the Treasury of the State.

SECTION 3. That one million dollars, or so much thereof as may be necessary, be and the same is hereby appropriated for the purpose of carrying into effect the provisions of this bill.

SECTION 4. That this act take effect from and after its passage.

Approved December 16, 1863.

Among the special laws passed by this Legislature was one incorporating the Texas Iron Company, of which J. S. Nash, James Alley, William Nash,

H. P. Perry, Josiah D. Perry, and others were the charter members, approved March 5, 1863.

Under this incorporation the Nash furnace was continued in operation, and pig iron and castings were manufactured at it.

This same session of the Legislature passed a general law offering as an inducement to manufactories a section of land for each one thousand dollars invested in the erection of such manufactories. The Sulphur Fork furnace was the first to take advantage of this law.

SULPHUR FORK IRON COMPANY.

This company was incorporated under an act of the Legislature entitled "An Act to incorporate the Sulphur Fork Iron Company," approved December 4, 1863.

On June 15 the company was organized with nineteen stockholders. The shares were valued at one thousand dollars each, and among the stockholders was the State of Louisiana, which owned fifty-two shares.

The furnace was built of brick and was thirty-four feet square and thirty-six feet high. In addition to the furnace stack, the entire plant was of substantial construction, and consisted of large coal shed, engine room, molding room, steam saw and grist mill, machine shop, and necessary dwellings, etc., for operatives. This furnace was located on Horton's headright, just west of Springdale

The daily capacity of the stack was eight tons, and the articles manufactured were pig iron and hollow ware. These works continued in operation until the first of April, 1865, when they stopped running.

The value of this plant, as determined by a commission appointed for the purpose of determining how many sections of land were due them under the law mentioned above, was $97,500.

HUGHES FURNACE.

The erection of this furnace was begun in 1859, but the manufacture of iron was not undertaken until two years later. It was located about one and a half miles southeast of Hughes Springs, in the southwestern portion of Cass County. From the best information now obtainable it had a capacity of twenty tons daily.

Mr. Hughes built the furnace, but never operated it, as the Confederate Government took charge of it soon after its erection, under the invitation extended them by the State of Texas. Under government management a very large amount of pig iron and castings were manufactured, and at the close of the war the furnace was continued in operation for a short time by the Federal authorities.

YOUNG'S IRON WORKS.

About eight miles southwest from Jacksonville and three miles from the Neches River was located one of the most extensive iron works of its time in the State. It was generally called by the name of the president of the company owning and operating it, "Young's Iron Works."

The smelter was of the most substantial construction, built of selected brown sandstone, which abounds in the vicinity. Its outside dimensions were a square of thirty-four feet at the base, and it had the same height. This smelter was operated successfully for a time and pig iron and castings manufactured, but the explosion of the boiler and killing of one or two men thereby interrupted the work for a time, and the close of the war caused its final stoppage. Everything was put in order and left to await the building of a railroad to the furnace. Dr. Young secured the charter for the Houston and Great Northern Railroad, which was projected to run just by the side of the works, and the building of the road was begun, but before twenty miles of it had been constructed Dr. Young was killed in an accident. Nothing further was ever done with this furnace, which is still standing.

PHILLEO'S IRON WORKS.

"South of Rusk about eight miles, amid pine clad hills, and at a perennial stream of clear water, is Philleo's Iron Works, where ore was smelted on a large scale during the war, at the close of which smelting was suspended and only the foundry business continued; hence the works are now in a very dilapidated and decaying condition. During their operation three hundred men were employed."*

THE NECHESVILLE BLOOMARY.

Dr. J. B. Bussey, of Timpson, furnishes the following account of the bloomary located near Nechesville, Anderson County, in which he was personally interested.

In the year 1863, Col. Chas. Bussey, father of Dr. Bussey, and Mr. Joseph P. Griggs began to erect works to make iron. They began with one twenty-five-horse power engine, using the ordinary fan blast. They soon found that this would not answer, and that it would be necessary either to enlarge the plant or stop operations. About this time Dr. J. B. Bussey returned from the army, and thinking that it was a good investment, took a third interest in the works. Another engine was bought, additional sheds were erected, and two tub bellows, or blowing cylinders, were made; in fact, almost an entirely new bloomary plant was erected.

With this plant it was expected to manufacture from three to four thou-

* Dr. S. B. Buckley, First Annual Report, etc.

sand pounds of iron daily, and operations were continued until a production of about fifteen hundred pounds daily was reached, and new fire places were being added as rapidly as possible. Perfect success seemed an assured fact when the works were burned, as is supposed, by an incendiary.

The production of this bloomary was only fifty thousand pounds all told. The ore was taken from a mountain a mile north of Nechesville, and was of the "curly" variety. As nearly as could be determined it worked nearly sixty per cent The iron produced from it was of superior quality. The fuel used was pine charcoal, burned in the vicinity.

THE MONTALBO BLOOMARY.

This bloomary, which was situated about ten miles south of the Nechesville works, was in operation at the same time. It was located on the south bank of Mount Prairie Creek, some eight or nine miles north of Palestine. This was one of the plants operated under the management of the Confederate Government. From the iron smelted there gun barrels and other munitions of war were manufactured.

THE KICKAPOO BLOOMARY.

A short distance north of the Nechesville bloomary, in the vicinity of Kickapoo, the Confederate Government began the erection of a bloomary of the same character as the others scattered over the adjoining country, but, so far as can be ascertained, it was never completed.

THE McLAIN, OR LINN FLAT, BLOOMARY.

This bloomary was located in the northern part of Nacogdoches County, about twelve miles from the town of Nacogdoches and six miles from Linn Flat. It was constructed and operated during the latter part of the war, and at the cessation of hostilities work was stopped. According to Dr. Buckley,* 150,000 pounds of hammered iron bars were made here in the eight months during which it was worked. These works suffered the same fate, that of fire, that befell most of the others.

Besides the furnaces and bloomaries already mentioned, another was begun by the Confederate Government a few miles east of Nechesville, in Cherokee County. The war ended before it was in running order, however, and it was abandoned.

KELLEYVILLE FURNACE.

This furnace was erected in 1869 by G. A. Kelley. It was located five miles north of Jefferson, and was put into blast in 1870. In 1882, owing to

* First Annual Report of the Geological and Agricultural Survey of Texas. S. B. Buckley, State Geologist, p. 19. Houston, 1874.

financial embarrassments, it was sold to the Marshall Car Wheel and Foundry Company, which company changed the name of the establishment to "Loo Ellen" furnace, and continued to run it until 1886, when, owing to the fact that the Car Wheel and Foundry Company could not use all the iron made, and the dilapidated condition of the furnace, it was blown out.

The stack was originally square, but was changed to a round in 1874. Bosh, nine feet; height originally, thirty-four feet, but afterwards raised to forty-five feet, and its capacity was ten tons per day.

Fuel used was charcoal, while for flux limestone was gotten from Dallas.

The iron produced was hot blast charcoal soft foundry iron when made by Mr. Kelley. That made by the Car Wheel Company was a hard iron, especially suitable for chilled castings, such as car wheels, etc., that being the character of iron wanted by the company.

Mr. Kelley reports that the amount of flux needed was ten per cent of weight of ore. Fuel, one hundred and thirty-three bushels of charcoal to produce one ton of metal. Cost of metal, $13 per ton. Ore averaged fifty-five per cent.

Mr. Kelley used a low pressure blast, the Car Wheel Company high pressure.

THE STATE FURNACE.

The aid afforded in the development of the iron industry of Eastern Texas by the building and operation of the "Old Alcalde" furnace by the State at the Rusk penitentiary can hardly be overestimated. By its careful management and successful operation it has fully demonstrated the workability and superior excellence of the ores which surround it.

From the biennial reports of the Superintendent of the Texas State Penitentiaries* we get the following account of its construction and operation:

The penitentiary was located at Rusk on account of the deposits of rich iron ores in the vicinity, and for the purpose of employment for convict labor for making iron, and at other industries growing out of it. The prison had no railroad connections, and could not be successfully organized and utilized as a prison until such connections were made. As soon as the Board was fully satisfied in regard to railroad connections, it had an examination made as to the character, quantity, and quality of the iron ore, with the view of having erected a blast furnace for making pig iron. Mr. G. A. Kelley, employed to make such investigation, reported very favorably, and the Board secured the services of Mr. E. C. Darley, of St. Louis, a furnace engineer, to furnish plans and estimates for a small furnace, and to superintend the construction of the same. The plans submitted and adopted are for about a twenty-five ton furnace, which is estimated to cost about $25,000. The castings, boiler, and part of the other machinery and material are on the ground.

The blast furnace was started in the latter part of February last, but the results from it were unsatisfactory, as it failed to turn out the quantity or quality of

*Biennial Report, November, 1880, to October, 1882, pp. 4, 5. Austin, 1882.

iron expected, the yield being only about eight or ten tons per day, when the furnace was expected, under proper management, to yield twenty-five or thirty tons per day. The trouble was attributed to various causes, but finally it was concluded that the furnace was not properly constructed, and that the bosh, or lower part of it, was not in the right shape to produce the best results. Hence, after a blast of about two months, it was blown out and the bosh changed. It was blown in about the first of June, and, it was claimed, made more and better iron, but still its workings were far from satisfactory, and it was banked and stopped about the first of September.*

The Nineteenth Legislature made an appropriation of $50,000 for the development of the iron industries at Rusk. I had been directed by your Board to employ an expert to visit Rusk and make an examination of the furnace, plant, iron ore, lime rock, timber, etc., and make report of the result of his examination. After corresponding with, and upon the recommendation of several leading iron men, I employed Mr. John Birkinbine, of Philadelphia, to make the examination His visit and examination was made about the first of June, 1885, and in July he submitted an interesting and exhaustive report, in the conclusion of which he says: "I have no hesitation in saying that you have a furnace plant better equipped than a majority of the charcoal furnaces in the United States. In fact, I do not think there are more than fifteen in the country which may be considered equal to it in all respects. The ore supply seems to be sufficiently abundant for the requirements of the present and near future, and the quality, as indicated by analysis made, will give you an ore richer than the average ores throughout the United States, and produce iron of good quality. You have unusual facilities for manufacturing charcoal cheaply, and of superior quality. You are unfortunate in having no supply of good flux immediately available, but this disadvantage is less than it would be in a furnace using mineral fuel. You can produce iron with an expenditure for labor no greater than the average at charcoal furnaces throughout the United States, and the cost of making pig iron at Rusk is less than the majority of the furnaces in the country. You are at a disadvantage in having but one railroad, and that a narrow gauge, but that may be overcome largely by the cordial co-operation of the officers, which, they assure me, you would receive. There seems to be a variety of industries which can be made to pay, and utilize a large portion of the pig iron produced in the furnace, but it is probable that you will have to, at least for the present, combine several of these to obtain satisfactory results, and afterwards, if the indications point to certain of these being most advantageous, the others can be dropped. With the large area of your State, its rapid growth, and increased demand for all manufactures of iron which accompany such development, there would seem to be a good opportunity for the transformation of such of the product of your furnace as you cannot sell into merchantable commodities."

After the consideration of Mr. Birkinbine's report, your Board determined to make immediate preparation for starting the furnace, and authorized me to employ Mr. R. A. Barrett, of St. Louis, as furnace superintendent. Mr. Barrett had superintended the construction of the furnace, and had great confidence in making it perform all that had originally been promised. He came on at once and set about making the necessary preparation for its operation. He put in a new bosh, changing the shape of the same as originally constructed. We had a supply of coal on hand, taken in the settlement with

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*Reports of the Superintendent and Financial Agent of the Texas State Penitentiaries for two years ending October 31, 1884, p. 12. Austin, 1885.

Comer & Fairis, and we procured lime rock from Coryell County, by the Texas and St. Louis Railroad, at a cost of about $4 per ton delivered. The furnace was started for an experimental test on the 30th of November, 1885, and ran, with splendid results, to the 10th of January, 1886, when the coal became exhausted, and it was blown out. The output of iron was seldom less than twenty-five tons per day, and frequently over thirty tons per day. From this blast the total yield was 1044 tons of excellent iron.

The furnace was again put in blast on the 1st of July last, and is now in blast, and the yield to date from this second blast is 3069 tons. Total output of the two blasts 4113 tons, which is worth at a fair cash valuation $16 per ton, or $65,808.

As to quality of the iron, I submit the following extracts from letters received from iron men to whom samples were sent:

The Johnson Iron Works, New Orleans, says: "The sample of pig iron sent us has been used up in the manufacture of machine castings. The iron is of excellent quality and runs well in the mould. We would have no hesitation in using this grade of iron for any class of our work."

Mr. J. L. Smyser, vice-president of Lithgow Manufacturing Company, of Louisville, Ky., says: "I thank you for the samples of iron just received. I want to say promptly that they have every outward evidence of being excellens; better than any irons being sold in this market. I am positively astonished that Texas is making any iron at all, to say nothing of its quality. If there is plenty of this iron, Texas would be a good place for a foundry."

Mr. Paul A. Fusz, secretary of the Chouteau, Harrison & Valle Iron Company, St. Louis, writes Mr. R. A. Barrett, thus: "Your piece of pig iron came to hand to-day. The pig is the best I have ever seen from a charcoal furnace. It appears to be perfect."

More than half of the yield of the furnace has been of the quality from which we have such flattering reports.

I can assure you that these results have been very gratifying, and they are due, to a great extent, to the skill and ability of Mr. Barrett, who has made but few pretentions, but has in a quiet, modest way performed much more than he promised. The results, too, demonstrate the fact that the former failure of the furnace was not attributable to a faulty construction, but to the want of proper management.

Contract for Capitol Castings.—It was very fortunate that soon after the determination to operate the iron furnace an opportunity presented to make a large contract for castings, which would consume a large amount of the products of the furnace. On the 26th of October, 1885, a contract was made by your Board with Mr. Gus. Wilke for a large amount of the cast iron work for the new Capitol; principally columns, with their pedestals, bases and caps, and the castings for the dome of the building. The prices agreed upon were $2\frac{3}{4}$ cents per pound for the columns, bases, etc., and 4 cents per pound for dome castings, delivered in Austin. The estimate of the amount of castings is about two million pounds, which at an average of $3\frac{3}{8}$ cents is $67,500. The work to be performed was difficult, but Mr. R. A. Barrett, our furnace manager, agreed to take general supervision over it, which he has done, and his services in this respect, as in others, have been invaluable to us. It took considerable time and outlay of money to get our foundry and machine shops properly equipped for this new character of work. A good foundryman had to be employed; also an experienced, skillful pattern maker. All of this was done as soon as possible, and we now have probably the best equipped foundry south of St. Louis. The foundry department is under the immediate charge of Mr. Frank Kavanuagh and the pattern shop under Mr. R. Flachs, both competent, good men. The character of the work in the foundry has necessitated the employment of a citizen moulder, Mr. Ed. Robinson. With this exception the work is all done with convict labor. We have made and shipped under this contract the columns, pedestals, bases, and caps for the first, second, and third stories of the Capitol building, amounting to 609,860 pounds, and are now at work on the fourth story castings. The work so far done is in Austin to show for itself, and has been pronounced excellent by all who have seen it. The contractor and Capitol Commissioners have expressed themselves as well pleased, both with the material and workmanship.

The castings for the dome will be of a different character of work and more difficult to execute, but I have full confidence in our ability to do it. The margin for profit in this contract is not large, but three objects will be accomplished: 1. The consumption of the product of the furnace. 2. The employment of a large number of convicts within the walls. 3. The training of a large number of convicts into skilled moulders. In addition to the foregoing advantages, the display of our work from iron manufactured in the State will be a splendid advertisement, both for the State and our prison industries.

THE PIPE FOUNDRY.— Mr. John Birkinbine, before alluded to, discussed in his report the various industries connected with the manufacture of pig iron which might be carried on with convict labor. He says: "The manufacture of cast iron water and gas pipe would consume a large quantity of iron, but would use a small amount of labor per pound of metal, and would require more expensive appliances than the manufacture of car wheels; but with the rapid growth of Texas, and the fact that no iron pipe of any amount are made nearer than St. Louis, Mo., or Birmingham, Ala., this specialty would seem worthy of careful consideration, as the contracts made would be with safe parties and in large amounts."

In the latter part of January last, when on your visit to Rusk, and after thorough discussion of the matter in all its phases, you determined to inaugurate this as one of the industries for the Rusk Penitentiary, and directed me to proceed and have erected the necessary buildings and appliances for such foundry. I placed the work under the entire control of Mr. Barrett, who went to St. Louis to get the necessary information as to details of construction, to enable him to get up the detailed drawings and plans for the work. The work is of considerable magnitude, requiring much labor and material, and as a great deal of this material consists of castings (about five hundred and fifty thousand pounds), which had to be made in our own foundry, it has been somewhat delayed to avoid conflicting with our Capitol contract. There has been delay, also, in obtaining material from St. Louis, because of the strike. This material has recently arrived and we are rapidly finishing the other castings. The pipe foundry has been placed at the end of the furnace cast house, so that when the furnace is in operation we can use its product to a considerable extent for pipes without remelting, thus saving the cost of coke and the wear and tear of the cupola in remelting.

We have, however, fitted up cupola and blower, so that the pipe foundry can be operated when the furnace is out of blast. The appliances of this pipe foundry are first class in every particular, and it will be complete and ready for operation in a short time, and will utilize the labor of from thirty of fifty convicts.

From the number of inquiries constantly made about water pipe, I feel satisfied that the capacity of the furnace and foundry will be hardly sufficient to supply the demand.*

* Reports of the Superintendent and Financial Agent of the Texas State Penitentiaries, for two years ending October 31, 1886. Austin, 1886.

The successful operation of the iron furnace, reported in my biennial report of 1886, has continued up to the present time. The furnace has not been operated constantly, having had to blow out two or three times for repairs and coal. The product in the two years is reported at about nine thousand tons; the amount on hand twenty-six hundred and fifty-four tons. During the two years there has been sold 6540, and consumed by the foundries at Rusk prison 2389 tons. The records show during the last two years there have been used in producing pig iron 18,903 tons of iron ore, 4523 tons of limestone, 1276 cords of wood, and 1,207,761 bushels of charcoal.

The iron turned out is kept up to a high standard as to quality. Until a few months ago the product was altogether hot blast iron, but recently there has been some demand for cold, or rather warm, blast iron to make car wheels, and a large lot of this kind has been made to supply this demand, and it is giving excellent satisfaction.

The success of this furnace has accomplished one object of its erection, viz., the development of the iron resources of Eastern Texas, and has thus induced capital and enterprise to come from abroad and invest in similar enterprises.

The town of New Birmingham has been located and is being built up within two miles of the penitentiary, one or more new furnaces are to be erected, and other enterprises contemplated and promised, which will all, directly or indirectly, benefit the industries of our prison, especially if better transportation facilities are thereby induced.

The Water Pipe Foundry.—This was completed and put in operation after the date of my last report. It is an excellent plant, and from it has been turned out a large quantity of excellent pipe, ranging in size from three to twelve inches in diameter.

I can not say that we found such a ready sale for water pipe as anticipated, from the fact that high railroad rates have operated against us. With a much more favorable rate, recently obtained, we can no doubt find ready sale for all we can make.

The pipe foundry gives employment to about seventy-five convicts.*

The record for the past two years is but a continuation of the success which has attended it under its present management, and pig iron of most excellent quality is made, besides large amounts of iron pipe, etc.

NEW FURNACES.

In addition to the furnaces mentioned, others are now completed or in process of erection at New Birmingham and Jefferson. One, the Tassie Belle, has just been put in blast at New Birmingham, and is reported as working very successfully.

TOPOGRAPHY.

The fundamental idea of the topography of this district is that of a comparatively level plateau, which has risen gradually and slowly from beneath the waters of the Gulf, in which the various beds of clays and sands of which it is composed were deposited. Its present varied surface; hills spreading out in

* Reports of the Superintendent and Financial Agent of the Texas State Penitentiaries, for two years ending October 31, 1888. Austin, 1889.

table lands, or solitary cones or buttes, or often presenting only a vista of gentle undulations; valleys, which are in places only steep-sided ravines, but further on widen out into pasture land and farm and meadow; and the lower lying river bottoms, often miles in width, through which the sluggish rivers wind their way in tortuous channels, spreading out here and there into lakes; these are all carved out from this ancient table land by erosive action, assisted in some measure by the later submergences to which it has been subjected. So far we have found little evidence of any disturbance of the strata which cannot readily be referred to the action of just such agencies as are now at work over the entire region. Faults are not uncommon, but usually they are of slight extent, and are in most cases certainly only due to sub-erosion or induced by the drying and shrinking of the strata. These causes are ample, also, to explain many of the numerous benches which may be observed in various places.

THE HIGHLANDS.—This table land was not confined by the limits given to the district, but stretched into Arkansas and Louisiana on the northeast and east, as well as still further to the southwest. By far the larger portion of it which remains in this part of Texas is to be found in a series of plateaus or flat-topped mountains, mesas, and buttes, beginning in the southern part of Cherokee County, running north and northwest, and spreading across the Neches into Anderson County and east into Rusk and Henderson. Southeastward areas are found in Nacogdoches, Sabine, and other counties. Northward they extend into Smith County, beyond which their identity is lost; the other highlands, although originally parts of the same table land, lacking the distinguishing marks of these principal remnants.

These plateaus have, in almost every case, "their summits capped by a horizontal or nearly horizontal bed of iron ore or sandstone, and to this covering they owe their existence, it having protected them from the erosion which has worn down the surrounding country. The hills, locally called 'mountains,' sometimes occur as small flat-topped hills—the butte and mesa of the west—and in others spread in broad plateaus, sometimes covering an area of twenty or thirty square miles, deeply cut by the steep-sided canyons, and often showing an almost perpendicular slope."

The highest points now remaining of this old table land are parts of the flat-topped hills of Cherokee County, which have an extreme altitude of six hundred and sixty feet. From this the elevation decreases in all directions, sinking in some places to or even below the three hundred feet level. Four hundred and fifty feet is probably the extreme variation of elevation in the entire district.

"These are the uplands of this portion of the State, and possess a soil far different from the surrounding lowlands, and a climate excellently adapted to the cultivation of fruit. In fact, such lands are now among the greatest fruit districts of Texas, and bid fair to be a worthy competitor of the California fruit country.

"Gent Mountain, in the western part of Cherokee County, is a beautiful example of this plateau country. It comprises over twenty square miles of area, is largely underlaid by iron ore, capped by a sandy soil, and thickly covered with oak and hickory. From its summit, looking south and west, can be seen the lowlands of the Neches River bottom, and beyond the rolling country of Anderson County. To the north can be seen Gray's Mountain, Grimes Mountain, Ragsdale Mountain, and many other iron clad hills. To the east looms up a similar range, constituting the iron ore plateau of Rusk and New Birmingham."

The soils of these table lands are of a gray sandy character, and are underlaid by clay subsoil, often stained red by iron. "The gray surface soil blends into and is doubtless derived from the red subsoil, to which it owes its agricultural value."

The Lowlands.—Surrounding these highlands we find large areas from which erosion has removed the beds of iron ore or sandstone and the great bed of greensand that immediately underlies these, and has brought to view the numerous and varied beds of clay and sands upon which they were originally deposited. These form the lowlands, the gently rolling and undulating portion of the region. The lowland soils are of three kinds: red clayey, red sandy, or mulatto. "These soils are extensively represented in East Texas, and form some of the richest lands of the region. They are not sharply divided from each other, but gradually blend together. They are underlaid by the clay and sandy strata of the Timber Belt beds, and owe their color to the decomposition of glauconite and other iron bearing minerals.

"The 'mulatto' soils are of a brownish red color, and are generally the result of the decomposition of the large glauconite beds of the region, and as they contain the fertilizing ingredients of that mineral, they are very productive. Next to the river bottom lands, they are the most productive soils of East Texas, and are extensively developed in Anderson, Smith, Cherokee, Rusk, Gregg, Harrison, and other counties."

While there is no doubt that the entire region has been submerged more than once since its first emergence, the evidence seems to prove that the principal drainage channels established in Quaternary times, or possibly earlier, continue to be the principal ones of to-day.

In Texas the primary systems of this region are those of Red and Trinity rivers. These have their source far west of this region, and their channels cut deeper into the underlying beds than do those of the rivers of later derivation, such as the Sabine and Neches. In the northern portion of the area the main rivers flow a little south of east; further south their courses are more nearly south. In the first case they belong to the drainage system of Red River and its adjacent lake system, while in the latter case the drainage is towards the Gulf.

"The Red River rises in the eastern slopes of the Staked Plains, in Northern Texas, passes through the Red (gypsiferous) Beds, the Paleozoic rocks, and the great Cretaceous area of Central Texas, and finally deposits in East Texas a sediment composed of materials from these regions, in the form of a highly calcareous red silt. The Trinity rises in the Carboniferous rocks of Northern Texas, but far east of the Staked Plains, and passing down through the Cretaceous prairies becomes charged with calcareous matter. Hence its sediments, though often calcareous, do not have the red color of Red River. The Sabine rises still east of the Trinity, while the smaller rivers, such as the Neches and Angelina, rise in the timber region, and the character of the sediment of them all varies with the region they rise in and flow through.

"Though traces of gravel and river silt are found along the rivers, and sometimes reach down to the water's edge, yet all of them may be said to flow in channels cut in the older sediments, as such strata crop out at very frequent intervals along their courses. In this respect they resemble the Mississippi, in connection with which a similar statement has been made by Humphreys and Abbot.*

"All of the Texas rivers are navigable to a greater or less extent, and until the introduction of railroads an extensive shipping business was carried on in transporting the cotton production of the region. Of course the amount of freight that could be carried depended on the high or low condition of the water. Now, however, boats rarely go up them for any considerable distance, as the journey takes a long time on account of the currents in the rivers, and, consequently, competition with railroads is impossible. The Sabine was formerly navigated for three hundred miles from its mouth, while cotton boats capable of carrying one thousand bales made regular trips up the Trinity to Green's Landing, in the northwestern part of Anderson County."

The rainfall is very considerable throughout the district, being greatest during the winter and spring, and the erosion is proportionally extensive. The soft, unindurated character of much of the material composing the geological formations of this region are very favorable to the percolation of water, and springs are very abundant in every portion of the district. This soft condition of the materials also renders the work of erosion the more easy and rapid.

These agencies are steadily continuing the work which has already sculp-

* "Report on the Physics and Hydraulics of the Mississippi River," by Capt. A. A. Humphreys and Lieut. H. L. Abbot. 1861.

tured the country into its present contours; the fall and rush of surface waters wearing away the exposed beds of sands and clays; the springs by their slower but more continuous action performing the part of sub-erosion, and undermining and breaking down many hills and plateaus that would otherwise stand unimpaired on account of their more impervious coverings.

This region is heavily timbered. On the south is the terminus of the long leaf pine belt of the South Atlantic and Gulf States, which to the north gives way to the short leaf pine, the oak, the gum, and the hickory.

STRATIGRAPHY.

The iron ore region of East Texas, as here defined, is underlaid for the most part by strata of Tertiary age. In only a few places are there exposures of Cretaceous strata, and when they do appear as inliers they belong to its uppermost members, and are accompanied by salines.

"The uppermost part of the Cretaceous and the base of the Tertiary strata are both composed of soft clay and sand beds, which succumb readily to the weathering action of the atmosphere, and consequently the line of separation is often impossible to locate exactly. The uppermost beds of the Cretaceous in Texas and Arkansas are composed of sandy and 'glauconiferous' strata, sometimes reaching a maximum thickness of three hundred feet. These have been termed the 'glauconitic' division by Hill. They vary in composition from beds of pure siliceous sand to beds composed entirely of glauconite, and between these two extremes are found all gradations in the relative proportions of the two materials. These beds are the equivalent of the Ripley Division of Alabama, and probably are the Southern representative of the 'Fox Hills' Beds of Nebraska. The 'glauconitic' deposit becomes more argillaceous towards its base, and gradually runs into a great deposit of calcareous clay over twelve hundred feet thick, and characterized by large quantities of *Exogyra ponderosa.* This bed represents the 'Exogyra Ponderosa Marls' of Hill's Upper Cretaceous section, and underlies a large part of the great prairie region of Central Texas. These Upper Cretaceous beds dip gently to the south and southeast, and formed the Texas shore line of the early Tertiary sea. Upon their much eroded surfaces were deposited the Eocene clay and sandy strata which underlie East Texas.

"The Tertiary deposits of East Texas, overlying these Cretaceous strata, consist of a vast thickness of sand, clay, and glauconite beds, in some places characterized by great quantities of lignite, and in others by beds of littoral fossils. In fact the whole series represents a succession of coastal, subcoastal, or brackish water deposits, alternating with marine deposits of a littoral character, and between these two extremes we find all gradations. The lagoon or subcoastal deposits compose by far the greater part of the series, and the marine strata represent slight and temporary submergences of the coastal area.

"The Tertiary strata strike in a general northeast and southwest direction, approximately coincident with the coast, and dip gently toward the east or southeast at an angle varying from 0 to 5 degrees. This dip, however, is very irregular and undulating, and no estimates of thickness of strata based on it can be relied on. In fact, a northerly or northeasterly dip is of no uncommon occurrence, though it is simply a local phenomenon.

"This variable character of the dip, however, does not require the supposition of a disturbance or upheaval of the strata for its explanation. It is doubtless due to the natural sinking and warping in a great thickness of soft beds. In fact, it would seem a most unnatural thing to see several hundred feet of soft clays and sands, covering an area of many thousand square miles, lie horizontally when they were exposed to the influence of atmospheric agencies. The unequal expansion and contraction of strata of different constituents, due not only to heat but to the drying out of the beds, would alone account for much or all of the warping that is exhibited throughout the Tertiary country. Besides, the chemical action that has gone on in these beds is probably also accountable for a part of the variable dip. Faults are of frequent occurrence, and are to be accounted for on the same principle as the variations of dip. They are rarely over eight or ten feet in throw, and play no important part in the features of the country. Jointing is also a very common phenomenon throughout the whole of the East Texas region.

"Estimations of thickness of the Tertiary strata of this region are attended by peculiar difficulties, as the dip is too variable to be relied on in such estimations. The strata are rarely exposed in such a way as to show any considerable thickness of any beds, and reliable records of well-borings are very scarce. It seems possible, also, that much of the Tertiary area may have grown by a gradual encroachment of the land on the sea by a process of accretion, such as is seen in many places on the Atlantic coast to-day, and that it does not always require the supposition of a submergence.*

"For the sake of convenience in description, the Tertiary strata underlying East Texas have been divided as follows:

SECTION OF THE GULF TERTIARY OF TEXAS.

LATER TERTIARY? (*Grand Gulf*, Hilgard):	Fayette Beds.	Sands, clays, and lignites.	300 to 400 feet.
EOCENE:	Timber Belt, or Sabine River Beds.	Sands, clays, lignites, and glauconites, or green-sand marls.	800 to 1000 feet.
	Basal, or Wills Point, Clays.		250 to 300 feet.

*The estimates of thickness given are simply approximations, and are intended more to show the relative size of the different divisions, than to represent absolute thickness.

"Sufficient data have not as yet been collected to warrant an attempt at a detailed correlation of all the Texas Tertiary with that of the other Gulf States, and therefore the various strata are provisionally divided as above. The classification depends, first on their lithological character; and secondly, on the very different and very characteristic topography that each of the three divisions gives to the country underlaid by it. The Basal or Wills Point Clays underlie a narrow strip of rich rolling prairie region, east of and parallel to the great Cretaceous prairie of Central Texas. The Timber Belt sands and clays underlie the great timber region of East Texas. Throughout the whole of the Eocene area no evidence of any considerable break in deposition can be seen. The lagoon and marine deposits appear to have alternated with each other in an unbroken series. Frequently there are found in one bed fragments of the stratum that underlies it, but no great amount of erosion of these lower beds appears to have taken place, and the little that has gone on is simply what might have been expected to accompany a gradual transition from one kind of deposition to another. The paleontological evidence on this point, though as yet somewhat meagre, all tends to show a gradual and almost continuous deposition from bottom to top of the series, and the few breaks in the fauna that have been observed can probably all be explained by the interposition between the fossiliferous beds of the lignitic and other non-marine strata. In this continuity of deposition the Texas Eocene closely resembles that of Mississippi, the different stages of which, according to Hilgard,* 'are intimately interconnected by community of species, from Claiborne to Vicksburg.'"

BASAL OR WILLS POINT CLAYS.

"At the base of the Tertiary and immediately overlying the eroded surface of the uppermost Cretaceous strata in East Texas is a great bed of stratified clay, which, on account of its position as the lowermost bed of the Eocene in this region, has been provisionally called the Basal Clays. These underlie a stretch of interspersed prairie and timber lands, the country being composed mostly of prairie, with occasional belts and groves of timber. The timber is all hard wood, consisting mostly of post oak, blackjack, and hickory. The belt is sometimes over ten miles wide, and runs between the western edge of the timber and the Central Texas prairies, from the northern part of the State to the Colorado River and beyond. The stratification of these beds is very characteristic, and is very different from the massive structure of the underlying Upper Cretaceous 'Ponderosa Marls,' but on a weathered surface, where the stratification is not seen, the clays of the two formations are not

* "The Old Tertiary of the Southwest," Am. Jour. of Science, Vol. XXX, Oct., 1885, p. 267.

easily distinguished.* They consist of a stiff laminated clay, yellow, gray, blue, or bluish-green in color, frequently interbedded with seams and laminæ of sand, containing many concretionary masses of gray non-fossiliferous lime-stone, the latter much cut up by veins of brown crystalline calcite, and varying in size from a few inches to six feet in diameter. They are generally of a flat elliptical shape, and of a gray color. Large quantities of gypsum are also found in places in the clay. One of the most constant characteristics of the clay is the presence in it of soft small white calcareous concretions one-tenth of an inch to two inches in diameter, and often having the cauliflower-like form of some of the geyserite of the Yellowstone Geyser basins. These are found very plentifully, and often collect in large quantities in creek beds. No lignite beds have been seen as yet in these clays.† Such deposits are found well developed at Wills Point, in Van Zandt County. West of Wills Point is seen a deposit of shell limestone, composed almost entirely of shells of Lower Eocene fossils It is traceable up and down Rocky Cedar Creek for seven miles, and underlies the divide between Rocky Cedar and Muddy Cedar creeks, a distance of four miles. The following section of a well on this divide shows the character of this bed.

1. Sand, gray and buff color	3 feet.
2. Gray and yellow clay (Basal Clays)	9 feet.
3. Shell limestone	3 to 4 feet.
4. Coarse sand	1½ to 2 feet.
5. Shell limestone	3 to 4 feet.
6. Sand in bottom of well.	

The Rocky Cedar limestone is probably the lowermost bed of the Tertiary series in this part of the State. The shell limestone bed is probably of limited extent, occupying no very important stratigraphical position, and appearing at the base of, and as a component part of, the Basal Clays. It is of great importance, however, as showing the geological position of the lowermost Tertiary strata in Northern Texas."

THE TIMBER BELT OR SABINE RIVER BEDS.

"The Basal Clays, everywhere from the northern part of the State to the Colorado River, blend upwards into the sandy Timber Belt Beds. These form the mass of the Tertiary formation in Texas, and underlie the great timber region of the eastern part of the State. They are composed entirely of siliceous and glauconitic sands, with white, brown, and black clays. The clays,

*The Basal Clays are probably largely derived from the destruction of the underlying Cretaceous strata.

†These clay beds probably represent the Eo-lignitic of Heilprin's Eocene section, the base of Hilgard's "Northern Lignitic" in his Mississippi section, and the Arkadelphia Shales at the base of Hill's "Camden Series" in Arkansas.

however, are greatly in the minority, and the siliceous sands compose by far the larger part of the whole series. Lignite beds are of very frequent occurrence, varying from a few inches to ten and twelve feet thick; and the sands and clays are often impregnated with vegetal matter to such an extent that numerous traces of petroleum, asphalt, and natural gas have been found in the East Texas region, sometimes in quantities of considerable economic importance. Many of the black and brown clays and sands owe their coloring matter to this ingredient of vegetable material, and burn white or buff color when exposed to heat. The sands are generally much cross-bedded, gray to buff in color, and contain black specks, which are often glauconite. This latter mineral is a common constituent in many of the beds, and there are found all gradations, from a pure siliceous sand to a pure green-sand bed, such as are well developed in the iron ore regions of Anderson, Cherokee, Rusk, and other counties. All the sand beds are more or less impregnated with carbonate of lime, and often it is in such quantities as to form beds of calcareous sandstone, where it acts as a cement and forms a soft, friable rock. Sometimes even beds of limestone are found, and calcareous nodules and concretions are of very frequent occurrence throughout the whole of the Timber Belt Beds. One of the most characteristic features of the region depends on this presence of carbonate of lime in the sandy beds. It is the occurrence of great masses of sand, varying from one to ten feet and more in diameter, and cemented into a hard rock by the calcareous matter. These rocks vary much in shape and hardness. Sometimes they have a concretionary shape and weather in concentric layers; at others they show the horizontal stratification of the beds in which they occur, and gradually blend into the soft enclosing sand.

"This presence of carbonate of lime is of the greatest importance, from an agricultural point of view, to the welfare of East Texas, as it renders soils underlaid by such strata of great fertility and durability; whereas without it, many of them would be perfectly barren. Many of the sands are also intimately mixed with a fine impalpable white clay, which renders the beds soft and highly plastic when wet, but when dry it forms a hard, solid mass, often occurring as a friable sandstone. When such beds are exposed to erosion by creeks and in gullies they break up into lumps, which become rolled and rounded, and form putty-like pebbles. This is a very characteristic kind of erosion in some of the Lower Tertiary strata, and such beds are well developed in central Van Zandt County. The sand beds are generally also variable in composition. They blend by insensible gradations, both vertically and laterally, into clay or sandy clay beds, so that minute correlations, even in beds very close to each other, are difficult to make. This extreme variability in composition is simply one of the many proofs of a near shore deposit. The sand beds often contain considerable quantities of dark brown or gray mica. The clay beds of this division vary from a pure white highly plastic clay to a dark brown, or even black, material containing large quantities of lignitic matter. They are generally laminated, or finely stratified, and frequently occur interbedded with thin seams of sand,* the latter often in lenticular streaks, while the clay is generally continuous. A very characteristic deposit of this kind is seen underlying the Claiborne greensands in the iron ore regions. The seams of clay vary from one-twentieth to one-eighth inch in thickness, and the sandy seams are but very little thicker. The whole formation shows a peculiar undulating section, the undulations being due to the thinning and thickening of the sandy seams, and not to lateral pressure.* The lignite beds of this series are composed mostly of brown or black varieties, which have not as yet been put to any important economic uses. Silicified wood is of very frequent occurrence in these strata; sometimes occurring as small fragments, and at others as large trunks of trees.

"Carbonate of iron, in the form of clay ironstone, is of very frequent occurrence throughout the Timber Belt Beds. It rarely occurs in a continuous seam, but is found in lenticular masses and nodules, often occupying the same plane of stratification for considerable distances. Sometimes these masses coalesce into a bed continuous for a few hundred yards. They are rarely over three or four inches in thickness, and are generally rusty from oxidation. They are probably the source of some of the brown hematite ores in the counties north of the Sabine River. Iron pyrites is an almost inseparable accompaniment of the Timber Belt Beds, and is also the source of many of the iron ores south of the Sabine. One of the most striking appearances in these beds is the mottled red, yellow, and white character of many of the strata. This is due to weathering, and though it is of very common occurrence throughout the Tertiary, it is also seen in deposits of Quaternary age."

QUATERNARY.

The extent of the Quaternary modifications of the underlying materials

*"The sand seams look like a series of connected lenses blending into each other at their edges. This interlamination of sand and clay was caused by the different velocity of the waters that flowed over the beds during their deposition—the swifter waters carrying and depositing the sand and the more sluggish waters depositing the clay. It is natural that such waters as would carry sand would have sufficient velocity to give a gently undulating surface to the beds that they are depositing, and not the smooth level surface of a still-water sediment. Thin beds of clay laid down afterwards on such a surface would naturally conform to the inequalities of the surface, and hence the undulating section that we see does not require the supposition of a lateral pressure for its formation. It seems possible that this same phenomenon may also account for the undulations in many of the old gneissic and schistose rocks, many of which may have once been in the form of sands and clays."

and the deposits directly referrable to that period have not yet received sufficient study to enable us to do more than indicate their existence and designate some of the members. The iron ores are in part at least of this period, while the overlying quartzitic and quartzose sandstones and gray, yellow, or buff-colored sands, together with some of the mottled sands or sandy clays and gravel, certainly belong to it.

THE ORES AND THEIR MODE OF OCCURRENCE.

The mode of occurrence and the association of the iron ores differ considerably in the different districts, and therefore for the sake of convenience in description, they have been grouped under three different headings, and will be treated separately.

1. Brown Laminated Ores.
2. Nodular or Geode Ores.
3. Conglomerate Ores.

1. BROWN LAMINATED ORES.

"These ores are extensively developed south of the Sabine River, especially in the counties of Cherokee, Anderson, Smith, Rusk, Harrison, Panola, Nacogdoches, and Shelby. The extension of this belt to the southwest across the Trinity River also remains to be examined.

"The ore is a brown hematite of a rich chestnut color, and often of a highly resinous lustre. In structure it varies from a compact, massive variety showing no structure, to a highly laminated form, the laminæ varying from one-sixteenth inch to one-quarter inch thick, frequently separated by hollow spaces, and sometimes containing thin seams of gray clay. These often give it a buff color and a crumbly nature, and hence the name often applied to it of 'Buff Crumbly Ore.' The laminæ frequently show a black glossy surface, though the interior is always the characteristic rich chestnut brown color.

"The ore occurs in a horizontal bed from one to three feet thick, and averages between eighteen inches and two feet in thickness. It is flat on top, but is bulging and mammillary below and lies at or near the summits of the highest hills in the region. In fact, it is to this protecting cap of hard material that the hills owe their existence, as it has saved the underlying soft strata from the effects of erosion, which otherwise would quickly have lowered them to the level of the surrounding rolling country. The iron ore bed is directly underlaid by a deposit varying from thirty to forty feet thick of a soft yellow indurated glauconite (greensand). This bed is sometimes hardened into a soft rock, easily cut with a saw or axe, and locally used as a building stone. The interior of the bed, however, where it has not been exposed to the atmosphere, retains the dark green color of the unaltered greensand. It contains considerable iron pyrites and numerous casts of fossils of the Claiborne epoch. This bed in turn is underlaid by a great series of sands and clays, constituting the Timber Belt Beds. Sometimes thin seams of iron ore are found in the greensand below the main ore bed, but they are small and rarely of value. At times they lie horizontally, and at others occupy joint cracks. The main ore bed is usually directly overlaid by a thin seam of dark brown and very hard siliceous sandstone, varying from one to six inches thick, and averaging about one and a half inches. It adheres closely to the iron ore bed, though the line of separation is sharp and well defined. Above this is a gray sandy deposit, becoming more clayey and ferruginous towards its base, and varying from one to sixty feet thick. This latter thickness is, however, very extreme, and the average is about six to eight feet. As a rule the thickness of the ore depends, in a general way, on the thickness of the overlying sand bed, it being thicker where the sand is less than fifteen or twenty feet than where it is greater. Other conditions, however, enter into the thickness and continuity of the iron ore bed, and these often upset the working of this rule. Nevertheless, the general fact holds good that when the ore is capped by a great thickness of sand it is liable to be thin and discontinuous. The hills on which the ore occurs are steep and show a broad flat plateau-like surface, heavily capped with post oak, blackjack and hickory, generally of a small size, but very dense. The ore crops out on the brinks of these hills, forming a protruding rim or crown, and often covering the slopes with great masses which have broken off from the main bed. They are often deeply cut by the ravines of creeks which have originated in springs in the superficial sand and which flow away from the plateau in all directions, cutting deep gullies and exposing the ore bed along their courses. On top of these plateau areas the covering of sand often conceals the ore for a distance of several miles at a time, but it is always found cropping out at the top of the slopes, and in wells, proving its continuity over very large areas. But, as has been stated above, when the overlying sands and sandy clays reach a great thickness, the ore grows thin and very often runs out altogether.

"The following section on the slope of the plateau and just east of Gent shows the occurrence of the ore:

1. Gray or buff colored sand	1 to 10 feet.
2. Siliceous sandstone capping	1 to 2 in.
3. Brown laminated iron ore	2 feet.
4. Indurated greensand with thin seams of clay and casts of fossils	45 feet.
5. Coarse white clayey sand	20 feet.
6. Dark blackish-brown sand, more clayey towards the base, nodules of rusty clay ironstone showing shrinkage cracks	31 feet.
7. Brownish-gray sand to base of section	11 feet.

2. NODULAR, OR GEODE ORES.

"These ores, though somewhat similar in chemical composition, are distinctly different in physical character and in their mode of occurrence from those already described. They are well developed in the northern part of Marion County and in southern Cass County, and extend thence into Morris, Camp, Upshur, and the counties lying to the west.

"The ore is a brown hematite and occurs in a great variety of forms. It very rarely shows the laminated structure of the brown laminated ores or their resinous lustre. It generally occurs as nodules or geodes, or as honey-combed, botryoidal, stalactitic, and mammillary masses. It is rusty brown, yellow, dull red, or even black in color, and has a glossy, dull, or earthy lustre. The most characteristic feature of the ore is the nodular or geode form in which it occurs. Some of the beds are made up of these masses, either loose in a sandy clay matrix or solidified in a bed by a ferruginous cement. The ore lies horizontally at or near the tops of the hills, in the same manner as the brown laminated ores to the south of the Sabine River. The beds vary in thickness from less than one foot to over ten feet, the thicker ones being often interbedded with thin seams of sand. The ore-bearing beds are immediately overlaid by sandy or sandy clayey strata. The sand beds are in the majority, though pure clay is found at some distance below the ore. The overlying sands are at times entirely eroded and the solid floor of brown hematite is exposed to view. In other places it is covered by from one to thirty feet or more of sand. This overlying stratum varies considerably in character; sometimes the sands are loose and gray, at others more or less solidified and deeply stained by iron. Sometimes they contain considerable clay and show ferruginous segregations, so that a section of the bed discloses lumps of hard, yellow semi-hardened sandy clay. The beds also often have a mottled red, yellow, and white appearance, and contain thin seams and lumps of clay. The sands are very much cross-bedded, and frequently layers of hard-pan or thin ore are seen following the lines of cross-bedding. Unlike the ores of Cherokee, these beds are not dependent on the thickness of the immediately overlying sands.

"Sometimes, though not so often as in Cherokee County, the ore is capped by a stratum of hard ferruginous sandstone* varying from one inch to over a foot in thickness, and occasionally similar beds are interstratified with the ore. The line of separation of the top sandstone and the ore bed is sharp and well defined. Though the iron ore is usually found near the tops of the hills, one or more beds are often seen at a lower level, lying horizontally like the upper bed, and separated from it by sands. These lower beds, unlike those

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*Frequently this sandstone is found alone and without any ore. In such cases it sometimes reaches a thickness of over twenty feet. (See Building Stone.)

in Cherokee, are often just as thick or thicker than the top beds. Such a formation as this, with its interstratification of soft and hard beds, gives a very characteristic topography to the country. As in the Cherokee region, the horizontal strata have been cut through by the numerous rivers and creeks, leaving flat-topped hills and plateaus, with steep escarpments and an alternately receding and protruding outline, resembling, on an exceedingly small scale, the sides of the western canyon.

"The beds of the creeks are generally very sandy from the detritus washed down from the uplands, and frequently large beds of conglomerate, composed of ferruginous pebbles in a sandy cement, have been formed along the stream.

"In many places benches are seen along the slopes of the hills. These, unlike those in the land of the brown laminated ore, probably owe their origin to the alternation of hard and soft beds."

3. CONGLOMORATE ORES.

"The variety of ore included under this head consists of a conglomerate of brown ferruginous pebbles one-quarter to two inches in diameter and cemented in a sandy matrix. Sometimes a few siliceous pebbles are also found. The beds vary from one to twenty feet thick, and are generally local deposits along the banks and bluffs, and sometimes in the beds, of almost all the creeks and streams in the iron ore regions just described. Sometimes they cap the lower hills. They are generally of low grade, but could be concentrated by crushing and washing out the sandy matrix. They usually contain more or less ferruginous sandstone in lenticular deposits, and are much cross-bedded. These ores are seen throughout East Texas from the Red River to the Brazos, but have as yet been put to no practical use, on account of the abundance of the other ores. On White Oak Creek, in Cherokee County, and at the house of William Smith, a bed of rock is seen which in places is twenty feet thick, and interbedded with sandstone. It rises from the bed of the creek upwards, and is traceable at intervals for several miles above and below this place. Similar beds are seen on the Neches and Angelina rivers in many places, as well as on Larrisson, Bowles, Box, Gum, Killough, Mud, Sulphur, and other creeks in the same county. Such beds are also found in Anderson, Smith, Rusk, and the surrounding counties. In Marion and Cass counties they are also plentiful. Near Lasater, Marion County, conglomerate ore is found at the foot of Leverett's Hill, and also in the streams running off Berry Hill."

PART II.

FUELS AND THEIR UTILIZATION.

CHAPTER I.

CHARCOAL MANUFACTURE IN TEXAS.

BY JOHN BIRKINBINE.

The existence of iron ores in the State of Texas naturally directs attention towards the possibility of smelting them within the State, but the primary requisite of fuel commands first attention, for unless future developments indicate sources of mineral fuel different from what is now known, it may be assumed that there is no immediate prospect of obtaining a supply of this necessary article of a character suitable for iron manufacture within the limits of the State. There is, however, another source of fuel, namely, charcoal. upon which our earlier American iron industry was developed, and which to-day is used in the production of a large quantity of pig iron, amounting in the United States during the census year ending June 30, 1890, to 655,520 net tons. This amount of iron was produced in nineteen States, one of which was Texas; and it is probable that a total of over 75,000,000 bushels of charcoal were consumed in the census year for the production of pig iron alone. In addition, a large quantity was used for other purposes connected with the iron and other industries, for the smelting of silver ores, etc.

Unfortunately, personal knowledge of the iron ore resources of Texas is confined to the eastern portion, as the writer has not yet had an opportunity of inspecting the deposits of Llano and adjacent counties. Although it has been his privilege to traverse the State from Texarkana to Laredo, from El Paso to Denison, and from Denison to Taylor, as well as minor trips throughout the State, the remarks here made will be necessarily confined to the production of charcoal for smelting iron ores in the eastern portion of Texas.

The great Southern yellow pine belt, which extends into Texas, furnishes wood from which excellent charcoal can be produced, and it is from this class of fuel that most of the charcoal pig iron of Alabama is made. The product of Alabama in the census year included 103,964 net tons of pig iron made with charcoal. In addition to the yellow pine belt, the hard woods which form a considerable portion of the vigorous forests of Eastern Texas will produce charcoal of superior quality. The extent and character of the timber which can be utilized offer facilities and inducements for the production of charcoal with which to smelt the local ores, and thus enrich the manufacturing interests of the commonwealth. Much of the timber is of such an excellent quality and of such large size as to cause regret that it should be sacrificed for burning into charcoal, were it not for the consolation that the maintenance of large timbered areas is essential to the continuance in activity of blast furnaces, where this fuel is the basis upon which the smelting operations are carried on. The necessity of maintaining these large timber areas naturally encourages a system of protection which none of the other utilizations of forest products warrant, and if an active pig-iron industry is established in the State it may necessitate, for its continuous life, the reforestration of areas denuded of their timber, as well as an encouragement to protect forests from ravages by cattle, damages by fire, etc.; and the operation of a blast furnace using charcoal as fuel will, to a large extent, reduce the sacrifices of standing timber by farmers, who girdle the trees to encourage their decay and to permit of their more ready removal for the purpose of clearing the ground.

Charcoal is manufactured in a number of ways, but these may all be divided into three classes:

(A) Charring in Pits or Meilers.—This is ordinarily carried on in the woods where the timber is cut, although in rare cases wood is hauled to a convenient center and there charred, so as to reduce the cost of attention and watching. The pits or meilers differ considerably in form, but the plan most generally adopted in this country is a circular or conical heap or pile of wood covered with leaves or turf. In Europe these heaps are sometimes made rectangular, and in China the pits are wells sunk into the ground, the tops being covered so as to secure slow combustion. In some of the heaps logs can be charred, but the usual practice in this country is to cut the wood into four feet lengths and place it in the heaps.

The yield of charcoal in meilers varies considerably in accordance with the kind of wood used, the depth and character of the cover, and the skill of the attendance. Taking the standard bushel as adopted by the United States Association of Charcoal Iron Workers (namely, 2748 cubic inches), the yield obtained from meilers will range from twenty-eight to forty bushels, the average approximating thirty-three bushels, or one hundred bushels for three cords. This estimate, like all others which follow, is based upon using four foot wood, well cut and properly ranked so as to obtain a good cord measure.

(B) Charring in Kilns has an advantage over charring in meilers in the fact that the enclosing walls, being generally of brick masonry, are tighter than a turf covering, and therefore the operation of producing charcoal can be more readily controlled, and the loss from radiated or condensed heat is less. The form of kiln varies from a rectangular construction with arched roof, holding one hundred cords or over, to a conical one having a capacity of but twenty-five cords. Between these two extremes the shapes of kilns vary as well as their capacity; some are of the form of a truncated cone, with solid cover and with a flat dome roof, while others more closely approximate the bee hive form. Although some kilns are constructed of stone masonry, brick masonry is preferred, and thin walls are less liable to crack and cause leakage than thick walls.

Several attempts have been made to introduce semi-portable kilns or meilers in which the walls are made of metal, but unless these are protected by an outside covering, the loss from radiation is so great as to prevent a good control of the coaling operation. As a rule, kilns are fired internally in the same manner as meilers; that is, a portion of the wood which is placed in the kilns is consumed to furnish the necessary heat for carbonization, the admission of air being controlled by suitable openings placed in the walls. In some batteries of kilns which have been used in connection with the utilization of the by-products of carbonization, the heat is obtained from an outside fireplace, the results of combustion being carried into the kilns. In these instances the batteries of kilns are connected by series of trunks or pipes with an exhaust, which draws the smoke from them, passes it through condensers to obtain pyroligneous acid; the remaining gas, which is combustible, being returned to the fireplace outside of the kilns.

As ordinarily built, kilns will produce from thirty-three to fifty bushels of charcoal, the average in this country being about forty bushels of the standard named, so that taking the same volume of wood it is possible to obtain from the ordinary form of kiln from twenty per cent to twenty-five per cent more charcoal than is yielded in meilers or pits, and if the outside fireplace is used a still greater saving is produced, of course at the expense of fuel burned elsewhere than in the kilns.

(C) Retort charring is the carbonization of wood in closed metallic vessels, the heat being applied externally and the products of combustion carried to condensors so as to obtain the pyroligneous acid, the uncondensed gases being passed under retorts to assist the solid fuel in the combustion chamber.

Retorts are of various forms; they are horizontal cylinders with one end arranged to be opened so as to receive the wood, or they are cylindrical buckets filled with wood, elevated by a crane and placed over a fire, or they are cylinders placed on an incline. The form most used in the latter position is a modified lune shape, in cross section, the object being to secure a practically uniform thickness of the wood over the fireplace. As none of the wood need be consumed, the possible output from retorts is greater than is obtained from kilns, the yield ranging from forty-five to sixty bushels, the average being probably fifty-two bushels; that is retorts produce from twenty per cent to thirty per cent more charcoal than kilns, and from thirty-five per cent to sixty per cent more charcoal than meilers from the same variety of wood. It is necessary in some forms of retorts to reduce the size of wood much smaller than is used in kilns. This is done at an expense of labor, but produces a more uniform size and more regularly carbonized product. It is also possible to collect a larger proportion of the vapor which produces the by-products from retorts than from kilns, and a smaller amount of wood being under treatment, retorts permit of better control and a more perfect carbonization than kilns.

A tradition among colliers is that charcoal made under dirt covers is of a superior quality to that made either in kilns or retorts. This should not be the case except, possibly, in so far as the turf covering, following the shrinkage of the pile of wood as it carbonizes, prevents, to a certain extent, over carbonization; but the percentage of imperfectly charred wood, or "brands," is generally greater in meilers than in kilns or retorts. The control given by a practically tight masonry structure or a perfectly tight metallic one should permit of producing the grade of charcoal desired, and much of the failure to obtain satisfactory results is undoubtedly due to the operators.

Michigan is the largest producer of charcoal pig iron in the United States, its output for 1889 being 234,817 net tons, and the charcoal for producing almost all of its iron was made in masonry kilns or retorts. In Alabama, which ranks next to Michigan as a producer of charcoal iron, kilns are not so largely used, and considerably more than one-half of the charcoal used there last year was made in meilers.

The utilization of the pyroligneous acid which is condensed from the vapors resulting from charcoal kilns or retorts is in the direction of producing acetates for dyeing and for methylic alcohol. The practicability of such utilization depends largely upon the location of the plant, for unless a market for the by-products is accessible it will not pay to collect them. The quantity of alcohol and acetates obtained from a cord of wood also varies greatly, in accordance with the kind of wood used, and therefore before taking up the possible utilization of the by-products, the cheapness of the production of charcoal, the character of the wood used, and the possible markets for the by-products must be carefully considered.

True economy will dictate that in any enterprise which is planned to consume a large amount of charcoal, the process should be mapped out which will obtain the greatest amount of fuel from a given acreage of wood, and hence coaling under dirt covers (that is, in meilers or pits) would not commend itself to those who favor protection of the timber areas of the State. Not only do kilns or retorts produce a larger amount of charcoal from the same quantity of wood, but they can be placed in nests or groups at convenient points, where wood can be assembled without much outlay, and from which the charcoal can be delivered to the point of consumption conveniently. Placed thus they also permit of more thorough attention and oversight.

The form of kiln or kind of retort are subjects which must be considered individually for each location, and it would seem that the most promising method which an iron industry established in Texas should follow, at the present time, would be one which did not sacrifice any timber which could be saved without seriously increasing the material cost of charcoal.

If a cord of wood costs seventy-five cents to cut, and the yield is thirty-three bushels per cord, the outlay for wood per bushel of charcoal will amount to about two and one-third cents. If, however, forty-two bushels per cord were obtained, the cost of wood per bushel of charcoal will be only one and three-fourths cents; whereas if fifty bushels per cord are secured the outlay would be but one and one-half cents per bushel. It will thus be seen that there is economy in hauling wood to a common centre and producing charcoal from it in such manner as to obtain as large a yield as possible.

CHAPTER II.

LIGNITES AND THEIR UTILIZATION, WITH SPECIAL REFERENCE TO THE TEXAS BROWN COALS.

DR. OTTO LERCH.

Brown coal,* often called lignite, is but a variety of mineral coal. It does not differ in its chemical composition from other mineral coals. Graphite, anthracite, and the large number of the different varieties of stone coal all possess the same constituent chemical elements—carbon, hydrogen, nitrogen, oxygen, and a number of inorganic compounds called ash. The varying proportion of the constituent elements alters the physical and chemical properties of the coals, and, correspondingly, their economic value. The cause of this different proportion of the constituent elements in the materials is generally, though not always, the geological age of the coals—the amount of carbon contained in them increasing with increasing age. Lignite is a product of Mesozoic and Tertiary times, and its more recent origin is indicated by its woody structure being generally well preserved. The formation of the brown coal has taken place through long geological ages, under varying conditions, and consequently the composition, quality, and economic value of the lignites change from a hard black and glossy coal, of which the lignitic nature can be detected only by chemical analysis, through various stages to a product resembling the common peat but recently formed in our marshes.

Brown coal is well distributed all over the globe, and many of its deposits are mined and utilized in various parts of the civilized world. Germany produced in 1887, 18,000,000 tons of lignite, constituting one-fourth of her total coal production, and all other European countries produced the brown coal in similar proportions.

The rapid growth of manufacture, and with it the increasing demand for fuel, has steadily increased the production of brown coal, and countless experiments have been conducted to enhance the intrinsic value of this coal by making it suitable for various manufacturing purposes.

The patient and constant labor of scientist and manufacturer, liberally supported by capital, has been successful, and brown coal is now used, according to its quality, in the manufacture of paraffine and mineral oils, illuminating gas, blacking, powder, tanning material, artificial manure, tar, coke, briquettes, and for smelting purposes. In addition to this, the lignite is largely in use in a raw state or in form of briquettes as fuel for household purposes.

* In this article lignite and brown coal are used as synonomous terms.

The State of Texas possesses immense deposits of this mineral treasure covering a large part of her eastern territory, frequently associated with deposits of valuable iron ores. The age of the coal, as determined by the different State Geological Surveys, is Tertiary, and according to analyses made by different members of the present Survey, the coal is frequently of the finest quality, far superior to that so extensively used in European countries.

These deposits have long been known by the people of Eastern Texas, but have been generally considered valueless, and consequently but little, indeed almost no mining of the material has been done in this region, with the exception of a few places where the coal has been used for household purposes. Dr. Buckley first gave a general outline of the formation in which the lignite occurred, and in the First Report of Progress* of the present Survey it was more fully defined as "Beginning on the Sabine River in Sabine County, the boundary line runs west and southwest near Crockett, Navasota, Ledbetter, Weimar, and on to Helena and the Rio Grande; thence back by Pearsall, Elgin, Marlin, Richland, Salem and Clarksville to Red River; including fifty-four counties in whole or in part." The following year explorations were continued by the Survey, and a large amount of valuable material has been collected. The geologic features of the basin have been studied, the association of the lignites with the iron ores worked out, a number of analyses have been made to determine the economic value of the coal, and it is now beyond question that the lignitic basin of the east will be in the future an extensive iron and coal producing district of the State. This report is intended to call the attention of the people to the wealth of this district, to show in a preliminary way how the brown coal has been utilized in European countries, especially in Germany, and to compare the material now used for various manufacturing purposes with the brown coal of the East Texas lignitic basin. Space and time are limited, and it must be left to future reports to treat more fully of this interesting subject, which promises so much for this portion of the State.

DISTILLATION OF LIGNITES.

TAR AND ITS DERIVATIVES.

The basis of a number of valuable products, paraffine, mineral oils, colors, etc., is the tar obtained from lignites, and the process is therefore highly important. Its main feature is the dry distillation of the lignite, which is effected by different methods. One of these, which was long in common use and well illustrates the principles, consists of a plant of from twelve to twenty-four cast iron retorts, each of which measure from seven to ten feet

* Page 20.

in length, about thirty inches in width and twelve inches in height. The retorts are filled from the front, each being supplied with a movable iron cover. All the retorts are placed in one furnace and heated at the same time through cross fires. The vapors as they distill are conducted into a collecting main, which is connected with the back of each retort by smaller pipes and elbows.

This system has its disadvantages, as at each filling the resulting coke has to be removed and the retorts have to be shut off during the operation from the collecting main, causing an interruption in the process.

A very ingenious apparatus, allowing the continuous manufacture of the tar, consists of a number of vertical cylinders of cast iron or chamotte mass. These cylinders, from twelve to sixteen feet high and nearly three feet in diameter, contain a system of rings with oblique walls (bell shaped). These rings are placed one over another vertically, so as to form a second interior cylinder, which is covered with an iron cone, over which the filling of the apparatus takes place. The exterior and interior cylindrical chambers formed by this system of rings are connected through spaces left between the walls of the rings. The apparatus terminates below in a cone communicating through its lower aperture with a box, which can be shut off from the cylinder. After filling, the coal gradually sinks between cylinder and ring walls. Flues passing around the cylinders furnish the heat necessary for distillation. The vapors of the distilling coal enter between the rings into the interior cylindrical chamber, from which they escape into the collecting and condensing apparatus. On opening the lower cone the ashes fall into the box beneath. The ashes are removed every two hours.

Notwithstanding the advantages that this process offers are very great, the distillation of the coal in retorts is still preferred by a number of manufacturers for various reasons which, however, can not be mentioned here. After distillation the tar is refined and rectified, and its further treatment depends on the qualities it possesses and the various products of manufacture for which it is to be worked.

The many varieties of tar obtained differ but little in external appearance. If the process of manufacture was well conducted they possess a light coffee-brown color, solidify on cooling on account of their paraffine contents, are of alkaline reaction, rarely acid or neutral, and of a strong odor, resembling that of creosote. Exposed to the air, they oxidize and assume a dark brown, sometimes deep black, color, their specific gravity varying between .880 and .975 (water 1.000).

PARAFFINE.

One of the products resulting from the dry distillation of brown coal is paraffine, the obtaining of which was the main object of the European brown coal industry for many years after the discovery of the possibility of its manufacture from lignites. The labor of the most prominent chemists and manufacturers was long directed to the development of the process of its manufacture; and although it has lost in importance since the utilization of the large deposits of ozocerite for this purpose, and since kerosene oil has so extensively taken the place of candles, a number of factories are still profitably engaged in its manufacture.

Paraffine was discovered in 1830, by Reichenbach, who at once recommended it for the manufacture of candles, because it burned without soot. Notwithstanding its valuable qualities for this purpose were fully recognized at this early day, the cost of its manufacture limited its common use until in 1850 James Young erected a factory at Manchester, manufacturing the paraffine from coals and lignites. Ever since this time it has kept a prominent place in the industry of candles, and its manufacture has been highly developed.

One of the oldest methods of manufacturing paraffine from lignite will be mentioned here, as the principle of the process has not changed, though the details have been altered and improved. This process consisted of the following various manipulations: The lignite is broken into fragments of the average size of a walnut, and if it contain sulphur it is moistened with lime-water. The coal so prepared is transported to the drying oven, which is generally two hundred feet long by twenty feet wide, and so constructed that the hot ash remaining after the distillation in the retorts can be used for the dessication of the lignites. After the coal has been thoroughly dried it is subjected to distillation, one firing being sufficient for the heating of two retorts. The firegas is conducted below them into a chimney of considerable draft, usually forty feet high. A large reservoir receives the liquid products of distillation and serves to separate the ammonia from the tar. The ash is treated with the ammonia and furnishes an excellent fertilizer largely in demand. To remove the hydrosulphuric acid and ammonia still contained in the tar, it is well mixed in a large revolving drum with a solution of copperas and then subjected to distillation with superheated steam. The vapors, as distilled, are condensed in cooling spirals and separated into mineral oils (photogene and solar oil), lubricating oils, and paraffine. The paraffine is obtained from the remaining liquid through crystallization, and the raw product purified through repeated pressing and washing with sulphuric acid and liquor of potash. The construction of the oven can be such and the process can be so conducted that but little coke is produced, and principally ash, tar, ammonia, water, and volatile matter be produced from the distillation of the lignite.

As mentioned before, the process has been greatly improved in all its phases, but only a few of the most important changes need be noticed. In order to avoid the repeated distillation necessary according to the old process, the tar is subjected to a treatment with sulphuric acid, and after separation from the acid is distilled over hydrate of lime; the paraffine obtained by crystallization and for purification is pressed with white lignite tar. This process, by avoiding a second distillation and the decomposition caused thereby, yields a superior article and a larger amount of paraffine.

MINERAL OIL.

Since the discovery of the large North American oil fields, the product obtained from them has gradually, and now almost entirely, supplanted the oils artificially produced from lignites. At present there is hardly a single factory in the world in which the production of these oils from brown coal forms the main object. However, as they frequently constitute side-products in the various branches of the brown coal industry, their qualities remain of interest, and will be briefly noticed.

The mineral oil proper is a clear, colorless, thin liquid, gradually assuming a yellowish color, of moderately strong, though not very agreeable, odor. It burns without soot in lamps constructed for the purpose.

The solar oil possesses a similar, though somewhat different, odor, is clear and colorless after distillation, but turns brownish on keeping. It is used successfully for illuminating purposes in suitable lamps.

The lubricating oil is of an iridescent brownish or greenish color, has the consistency of a heavy oil, and possesses a weak and not disagreeable odor.

GAS.

The manufacture of illuminating gas from brown coal is an industry of considerable importance. Experience proves that smelting works and factories which are located in the lignitic region can employ such plants with profit. As early as 1859 Tashé published a number of experiments conducted on a large scale at his factory in Salzhausen by Nidda, in Hesse, Germany, and even at that date expressed his opinion that a profitable utilization of lignites for the manufacture of illuminating gas was beyond all doubt. He obtained three hundred and fifteen cubic feet of gas from one hundred pounds of brown coal in small fragments. In the same year Kohlmann used lignite tar in the manufacture of gas, and his experiments were very successfully repeated in 1866 by Rouvel, who pronounced the gas to be possessed of high lighting power, simple and cheap in its manufacture, and valuable for small as well as for large establishments. Walker and Smith add that the gas is of far superior quality to that produced from common stone coal, and preferable for house use on account of the absence of sulphur, better lighting power, lower rate of consumption, and less heating effect. They produced in their factory at Egeln one hundred and ten cubic feet of gas of four candle-power from ten pounds of tar by injecting the tar into the highly heated retorts and thereby hastening the process. With a slow flow of tar into the heated retorts they increased the lighting power of the gas to eight candle-power, but lessened the quantity produced. By this method ten pounds of tar furnished sixty cubic feet of illuminating gas of eight candle-power. This process was practically tested and is highly recommended by a number of factories and smelting establishments after many years use.

More recently very satisfactory results have been obtained in the manufacture of illuminating gas from brown coal by treating it with paraffine oil. The materials have to be well mixed, and after a few days standing it will be found that the lignite has completely absorbed the oil, and is then ready for transportation. The coal prepared in this way furnishes an illuminating gas of excellent quality, and can be used in common stone coal retorts.

DYES.

The manufacture of the so-called tar colors, analine, etc., has become of the highest economic importance, but as it constitutes an independent industry it must suffice in this place to notice that lignite tar has been largely and successfully used in color factories. The attention of manufacturers was early called to the fact that the tar obtained from the distillation of brown coal was, in its constituent parts, very similar to stone coal tar; and A. C. Lieberman and O. Burg showed that the tar conducted through heated tubes filled with charcoal changed into a mixture of hydro-carbon, containing, like stone coal tar, four per cent of benzol and toluol and nine-tenths per cent of raw anthracen, and generally very much resembled the stone coal tar used in the manufacture of dyes. The results have been fully satisfactory.

LAMP BLACK.

The manufacture of blacking powder from brown coal deserves mention. Kramer described the process of its manufacture in 1855, and mentioned especially the superiority the product possesses over the bone black then in use. He states its price to be half of that of bone black by superior covering quality, and not requiring, like the former, an addition of sulphuric acid. F. Matthey and others have more recently treated the subject.

TANNING MATERIAL.

In order to use brown coal for tanning purposes, W. Skey heats the coal with nitric acid and evaporates the mixture to dryness. The dark brown residue dissolves in water, possesses a bitter, astringent taste, and precipitates lime from water solutions.

SUGAR REFINING.

Lately lignites have been very advantageously used in the purification of sap in sugar factories, supplanting the costly bone black. It is claimed that in many instances it is sufficient to filter the sap over the coal. In others, however, it is necessary to prepare the lignites for use. The coal is thoroughly dried, converted into a fine powder, well mixed with the sap, and the purified liquid pressed or filtered from the mass. The lignite, after having served for this purpose, can be used as fuel.

FERTILIZERS.

The use of brown coal refuse in the manufacture of artificial manure has been mentioned before.

FUEL.

Far superior in importance, however, to any utilization of brown coal yet treated of, especially with reference to Texas lignite, is its use as burning material in form of coke or briquettes. The fortunate association of lignites with the iron ores of the eastern part of the State makes them one of the most valuable mineral products the State possesses, and the time is not far distant when their high economic value in Texas iron smelters will be fully realized. On this account the following pages will treat more fully of the subjects enumerated, though, like the foregoing, they are intended only to be preliminary to a more exhaustive discussion, with special reference to modern improvements in the manufacture of coke and briquettes and their utilization in iron smelters, to be made in a future report.

COKE.

The history of coke dates back for a number of years, and the principle features of its rational manufacture have been long known. It was obtained by the dry distillation of coal when the production of illuminating gas was the object of the process. It has also been obtained in various other branches of the coal industry, and large establishments have been erected to obtain it.

It may not be altogether uninteresting briefly to review the early history of coking lignites, which dates back more than fifty years. As a matter of course, the first experiments were crude and the results not very satisfactory. The coking of the material was effected in those early times in coal kilns, that is, the brown coal was heaped up in piles, containing sometimes not less than sixty tons of coal, covered with earth. The coke obtained by this method was generally of the same quantity and quality, about forty per cent of small pieces of considerable hardness. These experiments were followed about 1860 by others conducting the coking in closed iron chambers or brick ovens, and the process further improved by cementing the lignites with tar before subjecting them to the coking in retorts and ovens of more modern and recent construction. The results have been quite satisfactory; the coke is obtained in larger pieces, and hard enough to stand transportation without breakage.

It is used for fuel, lamp black, in filters, and for the manufacture of gunpowder; more frequently, however, it is manufactured for use in smelting works. The largest amount of the product is secured when the process is so conducted that no carbon of the coal, or but little of it, is burned through admission of air, and when the retorts are kept at a uniform heat in all their parts during the coking process. The efforts of experts engaged in this industry have been directed, from its beginning up to the present, to obtain a more perfect construction of the ovens for increasing their producing capacity and saving fuel.

It is now everywhere conceded that the experiments so patiently conducted through many years have been successful, and that though the process may admit of further improvements, the results obtained so far have been highly satisfactory. A plant consisting of a number of furnace ovens was used in Belgium very early. The ovens were of small dimensions with a large number of flues, passing below the floor, meandering along their sides, and conducting the distilling vapors of one oven to the next, where they serve to heat the coal. An admission of air into the horizontal canals secured the burning of the gas and a full utilization of its heating capacity.

A coke of excellent quality is also obtained from the refuse coke remaining in the retorts after the distillation of lignite for the manufacture of mineral oils and paraffine. The material is ground to a fine powder, well mixed with from eight to ten per cent of tar, and formed into briquettes which are heated in retorts with the distilling vapors.

An oven for the manufacture of lignite coke of the following construction was long successfully used in Duerkheim a. d. Haardt, Bavaria, Germany, where a seam of brown coal occurs about three feet thick. The material is, however, so crumbling that it is impossible to mine it in pieces of a size suitable for burning purposes, and on that account it was considered perfectly worthless till it was found that it could be manufactured into coke of the finest quality. The product obtained is so superior an article that it has been successfully used as filter coal, as lamp black, and in gunpowder factories. The coking of the lignite is effected in an oven containing two ranges of cylindrical retorts of fire clay, generally twelve in number, about eighteen inches in diameter and eight feet high. The filling of the retorts takes place from above through cast iron cylinders supplied with covers of the same material. The retorts are connected below with cast iron cones immersed about four to nine inches in water contained in a shallow slanting brick basin. This construction facilitates the removal of the prepared product. The process, as may be seen at a glance, is continuous. The filling from above corresponds to the removal of the coke below. One hundred pounds of lignite furnish fifty pounds of coke, on an average, and also about five hundred cubic feet of gas, which, of course, is used for the coking process. The product obtained is of a deep black color and of a shining fracture. The coke, after being ground in a common grist mill, is washed to remove the impurities, ground over in a moist state, dried, and is then ready for use as lamp black. Ground in a dry state and less fine, the coke is in demand as filter coal, or for the manufacture of gunpowder.

A number of improvements have been made by various manufacturers in the construction of coke ovens, of which a few will be mentioned. The retorts have been placed in a horizontal position, with iron covers in front. The filling is effected as in stone coal retorts used in the manufacture of illuminating gas, and the removal of the coke is through bent tubes connected with the back of each retort and of equal dimensions with it. The ends of the tubes are immersed in water. A very ingenious apparatus has been suggested by Richard Wintzeck essentially differing from ovens of older construction in the following feature. An air canal is placed below the base of the oven, which receives heat from the escaping vapors of the coking room and conducts the warmed air through fissures in the base of the oven into that apartment. The high temperature of the air causes instant ignition of the distilling vapors of the coal lumps, hastens the process, and produces a more complete coking of the coal.

Ovens which, together with the manufacture of coke, make it an object to increase the production of ammonia and tar, have largely taken the place of those which neglect these products. The following is their distinguishing feature: The distilling vapors produced by the coal are drawn into an apparatus serving for the condensation of tar and ammonia, and thence returned to the oven, where they enter heated canals. Below the base of the oven they are mixed with warm air, and undergo combustion here as well as on their way to the chimney. As soon as it has sufficiently heated a system of flues, the progress of the escaping fire gas is reversed. Thus the gas coming from the condenser passes these heated canals, while the escaping fire gas serves to reheat the parallel system of flues, cooled by the gas on its former way from the condenser to the base of the oven.

Various improvements have been made since in the construction of the coke ovens, and C. Otto describes a coke factory now in operation for a number of years at Gottesberg, Germany. Its principal feature is a connection of the ovens with Siemen's gas regenerators, and the results are so favorable that the larger number of factories in Germany are operated on this plan.

Lately, however, only the air necessary for combustion of the gas is heated. This has been found more profitable, as a long system of flues conducting gas and air in parallel canals may, by occasionally occurring leaks, mix in the regenerators, cause melting, and thereby disturb the process of manufacture. Besides, the volume of air necessary for combustion is about six times the volume of gas to be burned, and for these as well as for other reasons it seems to be of higher importance only to heat the air intended for combustion of the gas.

BRIQUETTES.

Of higher economic importance still than the utilization of brown coal in the form of coke has become the manufacture of briquettes from lignites. This article is very extensively and successfully used in Europe as fuel for household purposes, and for production of steam it is frequently preferred to common stone coal. Its form is convenient for shipment, it is more cleanly in use, and its heating effect generally the same, sometimes better, than that of common coal.

Like in any other industry, the first experiments in the manufacture of briquettes were very crude. Generally lignites do not furnish more than from ten to fifteen per cent of coal in pieces large enough for fuel, and in order to utilize the refuse the same was mixed with water, formed into coal bricks, and were ready for use when air dried. Though the manufacture of these bricks was soon supplanted by machines, the product was not very satisfactory for on account of their considerable water content, frequently as high as forty per cent, they could not be subjected to a higher pressure, were easily decomposed on exposure to the atmosphere, and in consequence crumbled to dust. Finally convinced that this product would not yield the expected and desired success, experiments were made to evaporate the water of the lignites to give the coal a higher heating capacity, and form the dried product under high pressure into coal bricks, which were then called briquettes.

The press for the manufacture of briquettes now in use in Germany was invented about 1856 by Exter, in Munich, and since its early introduction has been changed but little. Till 1860 a number of experiments were made in the manufacture of briquettes, almost without success; but at that time it became commonly understood that the most important point in the manufacture was the drying of the lignites, and not the pressing of the coal bricks. Since then the experiments have been prosecuted with new zeal in this direction, and at the present, after thirty years of costly experience, it may be said that a lasting success of the manufacture of briquettes is secured. It is necessary to reduce the water contents of the lignites to about fifteen per cent before they can be profitably subjected to the press. An addition of tar is, however, very rarely necessary, for the lignites generally contain enough to serve as a cement for the coal particles when under a pressure from one thousand to fifteen hundred atmospheres. The bitumen already prepared during the drying process is molten under this enormous pressure, and in this state cements the coal particles. As the contents of bitumen and water are very different in the lignites, the manufacture of briquettes requires a great deal of attention, and the oven as well as the press must be adapted to the physical and chemical properties of the coal in order to afford a good commercial article.

The process of the manufacture of briquettes consists of the following manipulations: The lignites are crushed into small fragments and fall from the crusher into the collecting room, where they are received by a slow revolving roller provided with ribs, and thrown through apertures below upon a sifter placed in an oblique position. By a very simple but ingenious contrivance an upward and downward as well as a forward and backward motion of this apparatus is effected at the same time, and consequently the coal is thrown over it with a springing motion. The smaller fragments of uniform size which have passed during this process through the meshes of the sifter fall upon an elevator and are transported to the coal room above the drying oven. The coal is here collected in larger quantities, so that the drying process can be prosecuted night and day, Sunday and holiday, without interruption. Only with a continuous operation can the highest results be effected.

DRYING THE LIGNITES.

The most difficult part in the manufacture of briquettes, as mentioned before, is the drying of the lignites. A coal rich in bitumen needs less water than one poor in hydro-carbons, but no rule has been laid down to fix the amount of water necessary for the different varieties, though it is generally considered that lignites containing from fifteen to twenty per cent of water are ready for the press. The process is not alone intended to evaporate the superfluous water, frequently from thirty to forty per cent, but also to equally dissolve and distribute the bitumen throughout the coal.

By a very early method the drying of brown coal to be used for smelting purposes was effected in chambers placed on both sides of a long and small building, leaving a passage between them. Only one of the smaller sides of the building communicated with the air, where a furnace of considerable capacity was located, from which constantly hot vapors were conducted in tubes through the passage to the chimney. The heated air of the building was then forced by a fan placed on the opposite side into the chambers filled with the coal.

Improvements followed upon improvements, and in 1878 a method was patented in which the introduction of drums formed an entirely new part.

This system permitted the lignites to be brought in close contact with hot air or the escaping fire gas, thus avoiding the loss of heat sustained through its expansion in large rooms. It also allowed the regulation of the temperature and removed the danger of an ignition of the coal through the sparks frequently contained in the fire gas.

Ludwig Ramdohr substituted in the succeeding year, very successfully, super-heated steam for the hot air. On account of their expansive force the aqueous vapors penetrate the coal without mechanical aid; they are chemically indifferent to it and do not cause ignition even with a higher temperature.

It may be mentioned here that if the coal refuse or dust frequently used in the manufacture of briquettes is too poor in bitumen to cement the particles when under the press, various substances have been recommended to supply the deficiency; tar, starch, potato flour, albumen, lime, gypsum, alum, and others The organic compounds are objected to on account of their higher price. The inorganic material increases the amount of ashes. The selection of one or the other has to be governed by the surrounding circumstances. As stated previously, however, the use of an artificial cement is rarely necessary in the manufacture of briquettes from lignites. A few years later a drying apparatus, then in successful operation, was described, consisting of a large cast iron cylinder with double walls, the chamber between the walls receiving the escaping steam from the engine room through an aperture on one side and emitting the vapors on the other, after passing them around the cylinder. The apparatus was surrounded with a wooden mantle. Between both mantle and cylinder wall air was warmed and conducted into two tubes placed on the inner circumference of the cylinder. These tubes consisted of a number of small truncated cones, one over another, so as to leave spaces between them. The hot air, on entering the cylinder through these apertures, passed the coal, to escape through a tube of similar construction in the center of the apparatus. The drying process is continuous. The filling is done from above, using lignites which have been warmed by the air escaping from the central tube. The dried lignites fall below upon a revolving table, from which a scraper throws them into the receiving vessels.

Enough has been said to indicate the direction in which the improvements proceeded, and it is now only necessary to mention the different systems mostly in use to complete this brief review.

Ovens in which the Drying is Effected through Escaping Fire Gas.—The apparatus consists of circular cast iron plates, generally fifteen in number, each about twelve feet in diameter, and placed one over the other. A revolution of a central axis causes a system of scrapers connected with it, two over each plate, to turn the lignites upon them and gradually move them through small openings from the uppermost to the lowest plate, where they are received by a cone conducting them into the collecting room. The whole is placed in a square oven, the fire gas of which enters the drying apparatus above described and passes through the coal from plate to plate through an opening below, on its way to the chimney These ovens are profitably used only in the drying of lignites poor in bitumen, requiring a high temperature.

An apparatus in which the drying of the brown coal is effected with superheated steam is of similar construction and possesses the same system of scrapers to move the coal over the plates. It differs, however, from the former in its double walled plates resting on four hollow columns, of which two serve to conduct the steam between the double walls of the plates, and the others constitute canals through which it passes on its way to the chimney. A mantle of sheet iron enclosing the oven keeps the working room free of dust. This drying apparatus can be used with advantage for almost all varieties of brown coal except those requiring a high temperature.

An oven used with great advantage in some instances consists of a large revolving drum, placed in an oblique position and containing a number of tubes. The axis is hollow and conical towards the center and its mantle perforated. The steam from the engine enters its upper part, passes through the apertures into the interior of the drum, and after passing around the tubes escapes through the lower opening in the axis. A cone is placed above the higher part of the drum from which the coal enters the tubes and gradually slides, pushed by the revolutions and oblique position of the apparatus, towards the lower front, falling into the collecting room.

Finally, a system frequently used consists of a peculiar arrangement of sheet iron of an interrupted form, over which the coal slowly slides down. The hot air used with this method is warmed by the escaping steam of the engine and forced through the coal, entering the apparatus below and escaping above into the chimney. Sometimes these ovens are also supplied with a system of tubes through which steam passes, aiding the drying process. The above short review shows clearly that the main difficulty in the European, and especially German, briquette manufacture is the drying of the lignites, and notwithstanding the numerous and costly experiments which had to be conducted to overcome this obstacle, this industry has flourished and has enriched the people engaged in it.

PRESSING THE BRIQUETTES.

The pressing of the briquettes, though a simple process, has to be conducted in accordance with the quality of the lignites, a coal of larger grain requiring less pressure than one of dusty consistency. The briquette machines resemble the well known pressed brick machines of this country. As mentioned before, the Exter press, with about eighty revolutions (eighty briquettes) per minute, and double compression is still extensively used in Germany. The Couffinhal press, largely used in France, possesses also the advantage of exerting a double compression, thus yielding bricks of equal density on both sides with a minimum at or near the middle.

LIGNITES IN SMELTERS.

The utilization of raw and dried brown coal in smelters was an object long desired by iron manufacturers, and at the present a number of furnaces are in profitable operation constructed for the use of this material. An appropriate construction of the smelters for this purpose is necessary, that the peculiar composition of these coals, their loose texture and crumbling quality, may not disturb the reducing process. The carbonization of the lignites must be effected with the escaping gas near the mouth of the smelter, as, on account of their just mentioned quality of crumbling and their predilection to absorb moisture, they can not be subjected to a further transport. Kern uses a combination of smelter and coke oven, the smelter not over seventeen feet in height. The escaping gas is utilized to carbonize the coal, to roast the ores, and to heat the air necessary for the blowers. A cylinder containing the ores and prepared coal is placed above the smelter and parted from it through a cone over which the material rolls into the furnace on lifting the cylinder with levers. The escaping as passes around this apparatus, flows through several canals, in which a number of cast iron retorts are placed to carbonize the lignites, is used in the ore roasting ovens, and heats the wind for the smelter on its further way to the chimney. There is nothing theoretically which will make the utilization of raw brown coal objectionable in iron smelting. However, the preparing room must be large enough to permit the coking of the coal inside the oven. A use of the unprepared coal seems to be desirable, furnishing a gas of a greater heating capacity and a larger quantity of it, by avoiding the very considerable cost of a separate coking establishment. The only question is, what method can be most profitably employed to supply all, or the largest amount, of firing material in use by lignites for the manufacture of iron. To obtain this desirable end several important points have to be considered. As mentioned, a large preparing room, the inconvenient size of which can be somewhat diminished by working hot ores; and secondly, an oven of small vertical dimension, to lessen the density of the smelting column. The use of coal of a larger grain is desirable, and blast of high temperature evenly distributed through the smelter and under adequate pressure will greatly facilitate the process of smelting. By observing these conditions an addition of from fifty to seventy per cent of raw lignite has been made for a number of years at Zellweg, Germany, Kalan, Siebenbuergen, and other places.

A smelter of horizontal extension has been in use for several years in Friedrichshuette, near Rokitzan, Bohemia. The oven consists of a vertically placed cylindrical chamber (Gicht) opening into the large square preparing room, continued by the conically shaped reduction chamber and the smelting apartment. The different chambers are placed obliquely inside the oven and surrounded by a system of flues to conduct the escaping gas on its further way to the chimney. After filling the oven with coal and heating it to the necessary temperature, the ore and lignites, crushed to fragments of convenient size, are thrown through the mouth into the preparing room, and slide along the oblique floors of the different chambers into the smelting apartment, their forward motion assisted by a transporting screw. The further management of the process is the same as in the vertical iron smelters. Though the question whether the raw or dried brown coal can advantageously supply the use of coke or charcoal in iron furnaces has not been solved, it has been shown conclusively that an addition of raw or prepared lignites to coke, made either from lignite or bituminous coal, will give very satisfactory results, and this method has been used in a number of smelters uninterruptedly for many years. The process of smelting with lignite coke is conducted in the same manner as with bituminous coke in common smelters, and only needs to be mentioned.

RAW LIGNITE IN THE MANUFACTURE OF STEEL.

The utilization of raw brown coal has also been successfully introduced in the manufacture of steel. To heat the Bessemer retorts, however, a small addition of coke is necessary during the process of manufacture. The flame of the coal is long, and though it heats on this account the higher portion of the walls satisfactorily, the desired temperature of the bottom of the retort can only be secured through an addition of coke. For all other firing purposes, however, the smelting of the raw iron, the heating of the boilers, etc., this coal has been used with the greatest advantage.

OCCURRENCE OF TEXAS LIGNITES.

The lignites of Texas, as mentioned before, occur in the Fayette Beds and Timber Belt Beds of the Tertiary deposits. The borders of this area, which may be termed the lignitic region of Texas, have been determined and were fully described by Prof. E. T. Dumble in the Mineral Resources of the United States, 1887, and First Report of Progress of the Geological Survey of Texas, since which time they have not been changed materially by the later investigations. They are copied in full on page 39 of this Report. The Fayette Beds underlie the Coast Clays and other Quaternary deposits of Texas. Their outcrops cross the entire State from the Sabine River to the

Rio Grande, and consist of clays, sands, limestones, and pebble deposits. The underlying Timber Belt Beds are composed of siliceous sand and greensand marls, interstratified with clays, generally of a brown color, and thin beds of limestone. The beds of lignites contained in both these series of rocks are very numerous, sometimes occurring in lenticular masses of greater or less extent, thinning out in every direction, and again form extensive seams of considerable thickness, frequently fourteen feet. A correct mapping of these deposits has not yet been completed. The Texas Tertiary has been but little disturbed. The force lifting these strata to their present level has caused a gradual and slow elevation, leaving them as originally laid down by the Tertiary sea. However, though no violent volcanic eruptions have distorted these beds, they are nevertheless found sometimes broken, faulted and bent, caused by the drying and compression of loose moist underlying deposits.

CALVERT BLUFF SECTION.

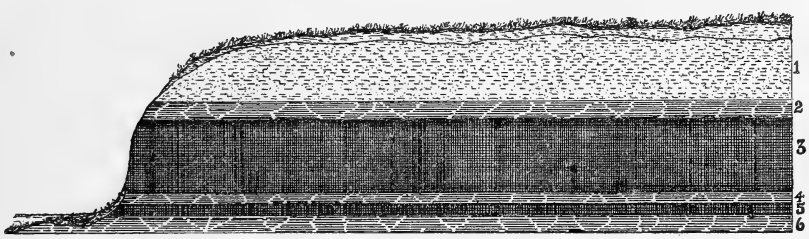

Fig. 1.

Profile of Calvert Bluff, Robertson County, Texas.

Texas. I.—1.	Brown and red river silt	10 feet.
2.	Gray clay	0 to 3 feet.
3.	Lignite	12 feet.
4.	Gray clay	2 feet.
5.	Lignite	2 feet.
6.	Gray clay	3 feet.

After R. A. F. Penrose Jr.

ALAMO SECTION.

II.—1.	Sand and clay	26 feet.
2.	Gray clay	23 feet.
3.	Lignite, black and often glossy	20 inches.
4.	Gray sand	2 feet.
5.	Hard slaty clay	9 feet.
6.	Lignite	4 feet 2 inches.

After R. A. F. Penrose Jr., Geological Report of Texas, First Annual Report, 1889, E. T. Dumble, State Geologist, I, p. 26; II, p. 35.

The European lignites are of the same geological age, were formed under similar conditions, and consequently they resemble in composition and qualities the Texas brown coal.

The European lignites vary in physical and chemical qualities according to the more or less complete decomposition of the original material from which they are derived. Principally, however, their vegetable origin is well preserved, and can be easily traced in the woody structure of the different varieties, which very frequently contain the stems, leaves, and branches of trees and plants in a good state of preservation. The coals form compact, brittle masses, with conchoidal fracture, or they exhibit an earthy or woody texture, and, according to their appearance and qualities, they are distinguished as pitch coal, fibrous coal, woody coal, paper coal, wax coal, and common brown coal. Their existence has exerted a marvelous influence upon the industry and prosperity of European countries. They belong to the class of mineral fuels, and, with iron, are the most useful minerals found on our globe, upon the development of which modern civilization is based.

In Europe, as well as on this continent, in Texas, the lithological material which composes the beds containing the brown coal deposits consists mainly of loose sands, various colored clays, and sandstones.

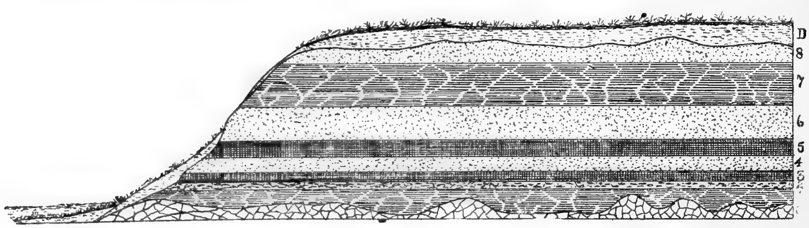

Fig. 2.

Profile der Oligocaenformation in der Gegend von Halle a. d Saale nach Laspeyres. Credner Elemente d. Geologie, p. 641.

Germany.	G.	Aelteres Gebirge	Porphyry.
	1.	Kapselthon	Clay.
	2.	Knollensteine	Shingle.
	3.	Unterfloetz	Lignite.
	4.	Stubenoder Quarzsand	Sand.
	5.	Oberfloetz	Lignite.
	6.	Magdeburger sand	Sand.
	7.	Septarienthon	Clay.
	8.	Glimmersand	Sand with mica.
	D.	Diluvium	Diluvium.

COMPARISON OF LIGNITES.

The economic value of lignites can only be estimated correctly from a comparison of the analyses of Texas brown coal with coals worked advantageously for many years in Europe. Their analyses must therefore be of the highest interest.

ANALYSES OF TEXAS LIGNITES.

	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Rockdale, Milam County, analysis by J. H. Herndon.	13.800	43.550	36.830	5.320	1.350
Leon County, analysis by J. H. Herndon. .	14.670	37.320	41.070	6.690	0.250
Laredo, analysis by J. H. Herndon	2.500	51.050	39 100	7.350	1.500
Eagle Pass, analysis by J. H. Herndon.....	3.675	39.420	41.700	15.205	0.810
Eagle Pass, analysis by J. H. Herndon.....	6.870	35.551	47.231	9.240	1.108
Montague County, analysis by J. H. Herndon.	12.090	35.840	42.310	9.760	0.800
Hopkins County, analysis by E. T. Dumble.	14.020	36.100	44.130	5.750	(*)
Angelina River, analysis by E. T. Dumble. .	16.230	32.540	37.770	13.460	(*)
Brazos River, near Calvert, analysis by E. T. Cox, of Indiana.	11.000	39.500	45.000	4.500	......
Average of a number of analyses of Texas lignites, analyses by W. V. Streeruwitz.	12.600	38.100	47.750	11.550	......
Atascosa County, analysis by J. H. Kalteier.	14.000	16.000	56.000	14.000	......
Lignites rich in Bitumen.					
Robertson County, analysis by J. H. Herndon.	16 475	58.400	18.675	6.450	1.330
Atascosa County, analysis by J. H. Herndon.	13.285	59.865	18.525	8.325	2.360

* Not determined.

ULTIMATE ANALYSES OF FOREIGN LIGNITES.

Jahresbericht der Chemischen Technologie, R. Wagner, Jahrg. xxxv, pp. 146–151.

	Carbon.	Hydrogen.	Hyg. Water.	Chemically combined water.	Nitrogen.	Ash.
Lobeditzer lignite	35.05	1.28	35.38	13.61	0.44	14.24
Braun kohle, no locality given.	40.78	1.23	29.23	18.20	0.68	9.42
Braun kohle, no locality given.	44.33	1.61	34.50	15.72	0.48	3.36
Duxer kohle.......	47.42	2.14	28.84	15.54	0.44	5.62
Duxer und Biliner kohle.....	45.74	2 22	31.66	13.79	0.48	6.11
Braun kohle, no locality given.	45.98	2.05	31.27	14.43	0.48	5.79

For further information see above quoted work, "Brown Coals, their Economic Value, and comparison with Stone Coals in furnaces of different construction."

ULTIMATE ANALYSIS OF TEXAS LIGNITE.

	Carbon.	Hydrogen.	Hyg. Water.	Chemically combined water.	Nitrogen.	Ash.
Rockdale, Texas, analysis by J. H. Herndon.	53.41	3 77	19.93	16.79	0.35	5.65

ANALYSES OF FOREIGN LIGNITES.

	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Koflach, Germany, analysis by Kerply	26.000	28.860	41.800	3.340	(*)
Vascovado, Italy, analysis by E. Kopp.....	21.800	26.480	42.520	9.200	......

* Undetermined.

The following table prepared and published by E. T. Dumble in 1884, shows the comparative value of Texas and European lignites of best localities:

	Coke.	Ash.	Heat units.
South of France	49.100	4.990	12.312
Mouth of Rhone	41.100	13.430	10.783
Hessen Cassel	48 500	1 770	11.826
Lower Alps	49.500	3.010	11.790
Golden City, Colorado	49.400	3.850	....
Texas	58.000	10.000	12.520

METHOD OF ANALYSIS.

The proximate analyses of lignites made in the laboratory of this Survey were made according to the following method: Two grammes of the finely pulverized lignite were dried in a weighed platinum crucible at 115 C., weighed, and this operation repeated till an increase in weight indicated an incipient oxidation. The percentage of moisture was calculated from the lowest weight.

To determine the amount of volatile combustible matter, the above crucible, with contents, was covered, ignited in the strongest heat of a good Bunsen burner, and again over a blast lamp; then cooled and weighed.

Fixed carbon was found by removing the cover from the crucible and burning off the remaining carbon over a Bunsen burner.

The sulphur was determined in the form of sulphate of barium.

A glance at the foregoing tables will show that the Texas lignites are superior in quality to European brown coals, to nearly all of which the analyses have been given. However, in order to determine the economic value of a natural product, and to admit of its profitable use, a number of other conditions must be favorable. After its quality has been tested and found sufficient or suitable for the purpose for which it is intended to be used, the manufacturer has to consider its location, quantity, demand, and facilities for transportation to market in order to insure success.

Texas brown coals could not well be more favorably located for any of the different manufactures enumerated than they are. Their almost exhaustless deposits cross the entire State sub-parallel to the coast, holding a central position between the timberless prairies of the northwest and the Gulf of Mexico in the southeast. A large number of railroads, connecting the inland cities of the State with the ports along the coast, pass on their way through the lignite region of Texas and furnish convenient communication to either side. The prepared product may serve to transport the manufactured article to market. A steady increase of the population of the State will increase the demand for fuel and all the other articles derived from the working of the coals. The association of lignites with valuable iron ores will develop the iron industry, and the vicinity of the Gulf to the coal fields will give the State an advantage in building up an export trade which other countries with similar mineral resources do not possess. Of course the development of mines, the building of coke ovens, smelters, etc., will draw a desirable immigration to the State and increase the prosperity of the people.

It has been said that the great body of forest growth of Eastern Texas will prohibit the development of the lignites, and that true stone coal will furnish superior and cheaper material for fuel and other purposes.

Contrary to this, a few men have early recognized the importance of these brown coals. There is, however, little literature on the subject, and the former geological reports only mention the existence of the deposits. Prof. E. T. Dumble, in a number of scattered newspaper articles, beginning as early as 1877, described the localities where outcrops of brown coal occur, pronounced their economic value, and published analyses of the different coals. In 1882 he published an article entitled "Cheap Fuels—Texas Lignites Compressed," which, on account of its importance as containing an account of the first practical test in the manufacture of briquettes to which Texas brown coal has been subjected, will be given almost in full.

"COMPRESSED FUEL FROM TEXAS LIGNITES.

"BY E. T. DUMBLE.

"HOUSTON, TEXAS, 1882.

"Seeking to make the large deposits of lignite in our State available, I projected a means of coking it. My invention was approved and commended by Prof. Silliman, of Yale, who made a personal examination of it. While working in this matter I was led to examine into the practicability of putting the lignite into a better shape for fuel and transportation.

"The heating power of the crude material has been established in very many localities, but its want of density and its liability to crumble on exposure to the air presented objections that had to be overcome.

"Finding that artificial fuel, made by compressing slack coal and lignite, with use of a bond, had been in successful operation in Europe, I set about obtaining information concerning the same, and have found * * * the machinery required.

"The prepared fuel manufactured by this process from refuse coal and lignite has met with such success that the company finds that it pays to break up bituminous coal and prepare it to meet the demand, and are continuing to manufacture these briquettes at a profit.

"From the analysis sent the manufacturers of the machinery, they were satisfied that our Texas lignites could be made into an excellent fuel. I determined to have a conclusive test, and shipped ten tons to France, had it made into fuel, and tried. I now have their report and specimens made from material shipped them. The specimens are hard and dense, and will give a good heat, comparing favorably with Indian Territory coal. Taking their test as a basis of calculation, I find that it is possible to make a good, serviceable fuel from Texas lignites at a very reasonable price.

"The lignite sent was mined from the bluff of the Brazos River, near Calvert, where it had been exposed to the action of the air, and only the surface coal removed before taking the quantity sent. The difference between the quality of this shipment and of the lignite found in the same bed a few hundred feet distant is shown by the two following analyses, the first by the chemist of the manufacturers of an average sample of the material sent, and the other by Prof. E. T. Cox, State Geologist of Indiana, of a specimen from the same bed, not more than four hundred feet distant.

	Havre.	Prof. Cox.
Water	20.30	11.00
Volatile matter	35.94	39.50
Fixed carbon	31.56	45.00
Ash	12.20	4.50
Heat units		13.068
Weight of cubic foot		77 pounds.

"By comparing the amounts of water and ash in these two specimens it will be seen that a low grade of lignite was operated on, as one would naturally expect from the exposed position from which it was obtained. My own analyses of lignite from different parts of the State vary considerably, but none show a lower grade than that of the Havre chemist, so that I think it perfectly safe to use the result given for any locality.

"The manufacture of the fuel consists in mixing it by machinery with certain proportions of adhesive materials, subjecting it to a certain degree of heat, and then passing it under a very powerful hydraulic press and forming it into briquettes. The adhesive materials are coal tar, pitch, or starch.

* * * * * * * * * *

"This, in connection with my process for coking the lignite, will prove fuel adapted to all requirements, for use in households, factories, engines, and smelting works, and at a price which solves the problem of cheap fuel for Texas for years to come.

"In extent the lignite deposits are inexhaustible. They underlie a strip of country from fifty to one hundred miles in width, extending diagonally across the center of our State, from northeast to southwest. These deposits are crossed by every main trunk railway line in Texas, and the Austin branch of the International and Great Northern runs over them almost its entire length. The beds vary from a few inches to twenty feet in thickness, and are associated with vast quantities of very fine iron ore. The abundance and accessibility of these materials give promise that, now a method of utilizing them is offered, only a short while will elapse before manufacturing the ores and products of our State will add to the wealth of the same."

It will be noticed that even at that early date the outlines of the lignite region of Texas were correctly described, the conditions of a prosperous manufacture of the raw material into briquettes were conclusively shown, and the importance of the occurrence of the lignites in association with the East Texas iron ores was fully set forth. The test, made with a large amount of material of the lowest grade, by French manufacturers is of the highest importance, and the results obtained must remove every doubt from the mind of the greatest sceptic that Texas lignites can be used with advantage in the manufacture of briquettes. A careful comparison of the coal used in European countries for the manufacture of coke and other derivates of the lignites with the brown coal found and examined in Texas can leave no doubt that the State possesses a material far superior in quality for the manufacture of the named commercial articles.

Notwithstanding their inferiority, notwithstanding the near vicinity of extensive coal fields containing the very best stone coal, and notwithstanding that the most of them can be obtained only by deep mining, that immense forest tracts are cultivated with the utmost care, that almost every tree cut is replanted as quickly as removed, millions of dollars have been advantageously invested in European lignites. Their manufacture sustains a large and skilled population, and exerts the most important influence upon the prosperity and wealth of the countries in which the coal beds are located.

How much higher will be the results obtained in our State by a judicious working of the immense quantity of coals of the very finest quality. Though it is true that we luckily have also large fields containing stone coal, and that still large tracts of piny woods cover the eastern part of the lignite region of Texas, the experience gained in Europe shows conclusively that neither the forest constantly replaced, which even in this Southern clime can not be done in less than twenty years, nor the vicinity of stone coal will retard the development of this independent industry, even under the most unfavorable conditions. To use the coals advantageously the most costly experiments had to be made; experience had to be gained in the construction of ovens, furnaces, engines, etc. Nothing was known, and yet a steady advance and a progress in the mining and manufacture of the lignites can be noticed, going side by side with the progress in forest culture and a more rational mining of stone coals and their manufacture.

In North Germany alone the briquette manufacture has increased since 1875 from twenty-nine presses, with a working capacity of half a million tons of coal, to one hundred and eighty-six presses in constant operation, working two and one-half million tons of the brown coal per annum.

In the Tertiary lignitic basin of Bohemia brown coal deposits which crop out in places dip to a depth of not less than twelve hundred feet, disturbed by basaltic and phonolitic eruptions.

In the lignitic basin of Albona, Istrien, the brown coal has been mined for the last sixty years, and, notwithstanding the deposits are very irregular in that region, disturbed and of varying thickness, the annual production of the coal has been increased from fifteen thousand tons in 1883 to from sixty-five to seventy thousand tons in 1888. The brown coal is of a bituminous character ("Pechkole"), and used in the factories of Triest, Fiume, Pola, and Venice, on steamers, and in the industrial establishments along the eastern coast of Italy.

The extensiveness of the works may be judged from the fact that in 1882 about fifty-two miles of railway were used in the mines to win the coal.*

How different are the conditions in our State at the present time. There is no risk to take; the experience of Europe for the last fifty years is at command. With little trouble drawings for machinery, furnaces, and ovens of latest construction and highest perfection can be procured, and all that is necessary to complete a factory, and which at the present can not be manufactured in this country, can be forwarded from Europe with little cost. Experts who have devoted a lifetime to the brown coal industry can be induced to initiate and conduct the process, saving costly experience which is only to be acquired through many years of actual work in a factory.

Abundant quantities of the most excellent material exist for operation, and, if judiciously selected, for all the different branches of the manufacture of products from lignites.

These coal beds, located in a rich agricultural section with productive soils, a congenial climate, and growing population, where immense quantities of excellent iron ores await the development of the lignite industry, and by their vicinity to the Gulf, offer a limitless market to the ready product.

These are conditions which insure success to the manufacturer, prosperity and wealth to the people.

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PART III.

DESCRIPTION OF COUNTIES.

CHAPTER I.

CASS COUNTY.

BY WM. KENNEDY.

PRELIMINARY NOTES ON CASS COUNTY IRON ORE REGION.

The iron ore region of Cass County extends in a general though somewhat irregular course from the southwest end of the county to the northeast. In the southwest it covers a roughly shaped parallelogram extending along the lower half of the Morris County line southward to the Marion County line, thence eastward along the northern boundary of Marion County for several miles to near the crossing of the Texas and Pacific Railway. From the northeast corner of this parallelogram a long, narrow, irregularly shaped tongue or ridge extends northeasterly to near the town of Atlanta, when it widens out into a rude sort of a triangle, having its northern side somewhat parallel to the course of the Sulphur Fork of the Red River.

The outlines of this ore bearing region are very irregular. Roughly speaking, they may be described as follows:

Beginning at the Marion County line, on the east side of the Ambrosi Douthet headright, the course of the boundary is north to the northeast corner of the same headright. From this point it runs northwesterly along the west side of Jim's Bayou to the southeast corner of the Curliss Jarnigan headright. The line then turns southerly to the north side of the Echols headright. From the Echols land it turns northwest through the southern portion of the A. D. Duncan headright to the northeast corner of the Andrew Hampton survey. The line then turns along the east side of the Benjamin Hawkins and Luanna Ward headrights and easterly across the north side of the John Davis headright to the northeast corner. From there southerly to Jim's Bayou; southeasterly along the Bayou to the Rachel Kimborough headright. From the northwest corner of this headright the line trends easterly through the Kimborough, Buffalo Bayou, and C. R. Railway Company's headrights to the Sherman Grosvenor's survey. It then turns northeasterly to the Texas and Pacific Railway near the centre of the William Donahoo survey; thence east to the west side of the Philip Duty headright; northeast through the northwest corner of the Philip Duty survey, and continues in the same direction to the centre of the Martha Ingram headright; northerly through the Ingram and James Ritchey headrights, and then has a northwesterly course through the Richard M. Allen and Cass County school lands, across Black Bayou, and through the southeast corner of the P. M Keeton headright. The course is then east to the west side of the Jane Ritchey headright, slightly south of east through the Albert Pride headright, and thence northeasterly to the southwest corner of the W. W. Holman survey; thence irregularly to the Arkansas State line, near the northeast corner of the Cass County school land. The line then turns north of west to near Alamo Station, on the Texas and Pacific Railway, southerly along the Texas and Pacific Railway to the northwest corner of the John C. Cooksey headright, westerly to the center of the John Myers headright, and from there in a general west of south direction to the southeast corner of the north Berry Wilkins tract. The line then turns southeast to near the centre of the south side of the Luke Roberts survey; east to the west side of the P. M. Keeton headright. From this point the course of the line is a general west of south direction to the southwest corner of the John Nall headright; then west to the southwest of the Thomas Wilson; north, to north side of the H. J. Storey headright; southwest to the southeast corner of the Jarius Barry headright. From here it turns northwesterly to the northeast corner of the Luanna Ward survey, then west to the southwest corner of the Henry Buckler headright. From this point it turns in a northwesterly direction and passes into the P. H. Tuckett survey in Morris County.

The area embraced within these boundaries has an extent of about four hundred and fifty square miles.

Although this area comprises the chief ore producing region of Cass County it also embraces many miles of territory within which no ore occurs. The oreless regions are chiefly among the bottom lands of the larger creeks and second bottoms in the northeastern portion of the county. Of the bottom lands along the creeks the best example is those of Black Cypress, which, upon the line of road between the town of Linden and the Avinger station, on the East Line Railway, are in the neighborhood of three miles wide. Many of the ridges in the same are also entirely formed of sand, and either contain no ore, or the ore lies too deep for any practical purpose.

The actual area of ore bearing lands within the county will not fall much short of three hundred and fifty square miles, which may be apportioned among the several divisions as

Southwestern field	200 square miles.
Central field	30 square miles.
Northeastern field	120 square miles.
Total	**350 square miles.**

While the outlines given above embrace the great ore belt within the county, there are a few small deposits lying beyond them.

On the east, along the "breaks" of Beach Creek, on the Samuel Burnham headright, a deposit of a dark blue geode or nodular concretionary ore occurs. Toward the southeast of the county, on the James Davenport and John H. Rives headrights, as well as in numerous places along the banks of Frazier's Creek in the same part of the county, there are many outcrops of a siliceous ore much mixed with a ferruginous sandstone. A small hill of the same class of ore is also found in the southeast quarter of the John Watson headright, about three miles east of the Kildare station, on the Texas and Pacific Railway.

In the northern and western portions of the county ore also occurs in isolated patches. The chief of these deposits are those of Lambert's Ridge, on the Wm. Lambert headright, the deposit on the Cusseta Mountains near Cusseta Postoffice, and those on the Cynthia Latimer and John Styles headrights.*

Throughout other portions of the county which have been designated as non-producing ore regions small scattered outcroppings of iron ore are occasionally met with. These outcroppings are occasionally seen in the banks of the streams flowing through the region, but more frequently in the form of isolated bowlders and nodules upon the sides of the sand hills, or as a thin covering of gravel and ore pebbles covering the tops of the higher hills.

Whatever ores may be found within the boundaries of Cass County of sufficient economic importance or value to work will be obtained within the limits of the area above defined.

TOPOGRAPHY OF THE ORE REGION.

The topography of the principal ore bearing district of Cass County may be described shortly as a series of long ridges, having an elevation of from fifty to eighty feet above the lower or second bottom lands of the eastern portion of the county, and having a general elevation of from five hundred to five hundred and eighty feet above the level of the mean tide in the Gulf of Mexico.

These ridges have in the main their long axes extending in a northeast and southwest direction. This, however, is not exclusively the case, as many of the larger ones have lateral branches or spurs extending at right angles, or nearly so, from the main body; that is, in a northwest and southeast direction.

These ridges are generally, indeed, in nearly every instance, divided from each other by steep-sided, narrow, deep ravines, the bottoms of which are

*The ore in these ridges was examined by Mr. A. G. Taff.

usually occupied by narrow streams, fed by the numerous springs found everywhere along the sides of the ridges.

Wherever ore occurs upon the top of a ridge broken masses and fragments are found profusely scattered along the sides, giving to the casual observer the impression that the whole of the ridge, or at least the greater part of it, is composed of ore. It is only when the observer gets down into the stream at the bottom of the ridge that the covering of ore is seen to be superficial. In the perpendicular, lately formed walls enclosing the stream the beds of sand forming the main portion of the ridge are seen. Where trees growing upon the sides of the ridges have been blown over and uprooted, the actual thickness of the ore covering is also disclosed.

In some of the ridges thin seams of a laminated ore occur at depths varying from twenty to forty feet, or even more, from the top of the ridge. Where those seams occur the hills invariably present a terraced appearance. This appears to be due to the protecting influence of the ore bed exerted in favor of the underlying sands. The upper sandy division is generally composed of a light colored, loose, unstratified sand, which erodes more rapidly than the lower division of stratified clayey sands, even where not protected by a lower bed of laminated ore.

This terraced condition, however, does not appear to be altogether the result of an underlying seam of ore. It appears in many places in which the lower bed of ore is absent, and it has been noticed in places where even the surface or upper bed is also wanting. The structure of the hill has something to do with the formation of these terraces. In the places where they occur with only the single upper bed of ore the side of the hill often presents the appearance of having a second bed outcropping at the terrace. The broken condition of the surface bed of ore presents but little protection to the immediately underlying loose and incoherent sand, and this sand being easier eroded than the underlying stratified beds, in a short time wears off and leaves the stratified material in the form of a terrace. The ore being thus deprived of its support falls down upon the terrace, and thus forms a belt of ore along the hillside which might be readily looked upon as an outcropping of a second ore deposit.

Some of these terraces may be attributed to land slides, due to the undermining of the upper beds by the washing away of the lower division of stratified sands, or to an underground drainage attacking the cinnamon-brown and white sands which appear occasionally as underlying the stratified red and white and mottled unstratified sands. These occurrences may have taken place, but they are certainly very rare, and do not appear to be a very prominent factor in the production of the numerous terraces skirting the ridges throughout the portion of Cass County under consideration.

While the want of a good topographical map of the region of course precludes a definite answer to the question, there is a considerable quantity of negative evidence, all of which goes far toward proving not only that these benches are not due to the action of sea or lake, but, on the contrary, that they are due chiefly to causes at present actively engaged in the work.

1. There are no large streams, except Sulphur Fork, within the limits of the region, and there are no evidences of any stream or river or any drainage system older than the present, unless we assume the broken and eroded condition of the lower stratified red and white sands with their accompanying unstratified deposits of mottled sand to be due to the action of sub-aerial streams before the upper beds of brown and yellow unstratified sands were deposited, and even in that case the drainage system of the time of the deposition of the stratified beds must have been in the same general direction and position as that of the present.

2. The streams within the district are all modern in their aspect, even where they pass through the level lands or second bottoms near the Sulphur Fork on the north, or through the flat wooded region to the east and southeast. Throughout the lower level lands in these regions there are, however, numerous evidences of the want of stability of these streams in the matter of channels. There is scarcely one of them that has not changed its course within a very recent period. In nearly every bend there is a chain of ponds or sloughs connected with dry, shallow channels, giving unmistakable evidence of a change of stream bed. The present course of the Sulphur Fork, the largest stream in the district, turns sharply to the north at the southwest corner of the C. Johnson survey, and continues that course in a general way as far as the northwest corner of the J. S. Jackson survey, where it resumes its generally eastern course. Between the Johnson land and the James Wilson survey, about five miles east of the place where the river turns east, there is a chain of deep pools, ranging from one hundred to three hundred yards in length and connected by a series of dry or shallow marshy channels. These pools, with their connections, run in a northeasterly course and indicate a change in the course of the river of over three miles at its greatest extent. This old channel is still used occasionally for lumbering purposes, and saves many miles of rafting.

3. The benches are not uniform in their levels for any distance, nor are the benches where they appear upon both sides of the ravine of the same altitude, the one on the southern side of the stream being usually lower than the northern, this difference depending upon the width and direction of the stream bed. The upper surface of the stratified beds generally indicate the elevation of the local bench when it exists, and the difference of altitude between the two sides of a ravine is due to the dip of these beds. This is, however, not always

the case, as in some instances where beds of ore exist these beds have protected the underlying unstratified material from the rapid erosion to which the overlying sands have been subjected, and in this way have formed benches. These are, as a rule, nearer the top of the hill, and form a second series.

4. The rainfall of the district is peculiarly adapted to rapid erosion. During the summer months the rainfall is light. The summer rains are generally thunder showers, filling the stream beds with torrents while they last. Previously to the advent of the storm the surface sand is light and dry, filling the air with a fine dust. The torrent readily washes this sand down from the hillsides and carries it off to settle in the lower reaches of the stream channel, or, as in the winter and spring, to be deposited over the great extent of territory at that time under water. An illustration of the rapidity of erosion in this region may be obtained on the east side of the A. D. Duncan headright, near Mr. J. M. Lockett's house. The section is as follows:

White sandy soil	1 foot.
Dark bluish sand	4 feet.
Yellowish-brown sand	12 feet.
Concretionary bed of fine quartzite	4 inches.
Black clay	6 feet.
	$27\frac{1}{3}$ feet.

The stream has worn away the upper seventeen feet for over two hundred yards in advance of the quartzite, and within the last ten years has cut a channel one hundred feet long, forty feet wide, and seventeen feet deep; or two thousand five hundred cubic yards of sand have been removed by a stream which is without water at some seasons of the year.

During the winter and spring months the rainfall is comparatively heavy, and is also much steadier than during the summer.

No statistics of temperature or rainfall are kept within the county, and no reliable information can be given upon the subject.

STRATIGRAPHY.

Sections taken at numerous places throughout the county show a comparatively uniform sequence of the different deposits occupying the region. These may be divided into two divisions.

1st. An upper unstratified deposit of sand containing in some places beds or deposits of nodular concretionary iron ore, and occasionally thin beds of laminated iron ore.

These sands are mostly of a light gray color, but change to a yellow, brown, and red. In thickness they vary considerably, ranging from four to eighty or one hundred feet. In texture they vary from a light, soft dust to a hard, compact mass. Where exposed on the tops and sides of ridges they are easily transported by the wind or rain, but lower down towards the bottom of the section these sands become hard and firm and have the consistency of a soft stone.

2d. A lower division consisting of stratified, and in many places unstratified, sands, sandy clays, and clays.

The stratified sands usually appear as thinly laminated material, having alternate laminæ of red or yellow and white sand. Occasionally the white laminæ consist largely of a white sandy clay. These laminæ are from a quarter of an inch to half an inch in thickness. This deposit is always found underlying the laminated ore, and when the ore is absent it is usually covered by a thin stratum of ferruginous sandstone. This covering rarely exceeds one or two inches in thickness.

Closely associated with these stratified beds, and occupying the same horizon, are deposits of unstratified mottled white and red sands—the red appearing as red blotches or spots upon the face of the white.

The stratified sands are much broken, having been cut through by erosion, and where this has taken place the mottled sands appear between the ends of the beds and the eroded portion, forming, as it were, a cushion between the broken ends and the water. These mottled sands have the same texture as the stratified beds, and have the appearance of having originated from the destruction or disintegration of the stratified material. The following section will give an idea of the relations between these two deposits:

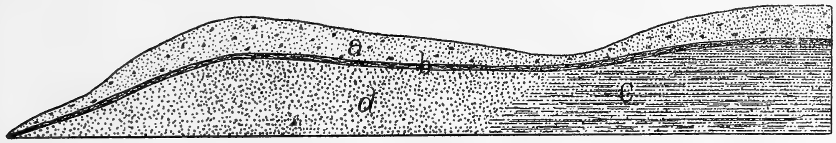


Fig. 3.

a, Overlying unstratified yellow sand. b, Thin deposit of laminated iron ore or ferruginous sandstone. c, Stratified red and white sand. d, Mottled unstratified sand.

The thickness of this deposit varies in different localities. The total thickness seen in the neighborhood of Queen City is about seventy feet. In the cutting of the Missouri, Kansas and Texas Railway near Hughes' Springs it shows a thickness of only twelve feet.

The next underlying bed appears to be a brown sand in some localities, and so far as can be seen has no regular stratification, but is cross-bedded and twisted in every direction.

In the cutting at Hughes' Springs the deposit underlying the red and white stratified sand is a black clay, thinly laminated with partings of dark gray sand and containing occasional bowlders of concretionary iron ore.

The following sections show as far as can be ascertained the structure of Cass County:

1. Alamo section. Elevation above sea level 239 feet.

1.	Sand and clay	26 feet.
2.	Gray clay	23 feet.
3.	Lignite, black and glossy	1 foot 8 inches.
4.	Gray sand	2 feet.
5.	Hard sandy clay	9 feet.
6.	Lignite	4 feet 2 inches.

2. Springdale section. Elevation 370 feet.

1.	Brown sand	40 feet. (?)
2.	Yellow stratified sand with black partings seen	10 feet.

3. Section half a mile north of Queen City. Elevation 384 feet.

1.	Gravelly ore and broken pieces of nodular ore, sandstone, and sand	5 feet.
2.	Laminated ore	4 feet.
3.	Stratified white and red sand, with white sandy clay	65 feet.
4.	Brown sand, with clay mixed at various depths	25 feet.
5.	Lignite	1 foot 6 inches.

4. Section on southeast corner of M. Spell headright. Elevation about 370 feet.

1.	Red clay	10 feet.
2.	Hard white sand	10 feet.
3.	Blackish-gray sand with pyrites	8 to 10 feet.
3.	Gray sand with rock	1 foot.
4.	Lignite	2 feet.

5. Northeast of Thomas H. B. Greer survey. Elevation 261 feet.

1.	Gravel	12 feet.
2.	Sand	14 feet.

6. No. 14, Cass County school land, southwest of Atlanta Station. Elevation 320 feet.

1.	Sand and clay, with bowlders of ore	50 feet.

7. On northwest corner of Lavinia Mornen headright a well thirty feet gives a section of

1.	Concretionary ore and gravel	4 feet.
2.	Yellow sand	4 feet.
3.	Lamininated ore and sand to 19 feet	10 feet.
4.	White sand	11 feet.

The elevation of this well is about 300 feet.

8. Section at A. Duncan headright. Elevation about 350 feet.

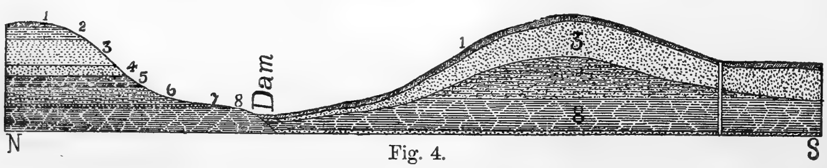


Fig. 4.

Section at A. Duncan Headright.

1.	Surface soil	1 foot.
2.	Bright red stiff clayey sand	15 feet.
3.	Yellow sand streaked with white near bottom of bed	30 feet.
4.	White sand	6 feet.
5.	Black clay	3 feet.
6.	White sandy clay, changing into a white and rusty white and orange sand	10 feet.
7.	Gray sandstone	2 inches.
8.	Black micaceous sandy clay	6 feet.

A well on the same headright half a mile south gives

1.	Surface soil	1 foot.
2.	Yellow sand	16 feet.
3.	Black clay containing nodules of iron pyrites	25 feet.
4.	Yellowsand	4 feet.

Between these two sections there appears a deposit of the stratified red and white sand in a position where it appears to take the place of No. 6 of the first of these two sections, and probably a portion of No. 8. A bed of clay ironstone appears on the top of the stratified sands.

Another section in a stream about half a mile east of this gives the following:

1.	Surface soil, a drab or yellowish gray sand	1 foot.
2.	Dark bluish sand	4 feet.
3.	Yellowish brown sand	12 feet.
4.	Fine grained quartzite, having the appearance of a bed of nodules cemented together	4 inches.
5.	Black laminated micaceous clay, in every respect similar to No. 8 of above section	6 feet.

Passing to the western side of the county, we find the section at Hughes' Springs to be a succession of brown unstratified sands, stratified red and white sands, and black clays.

Section at cut on Missouri, Kansas and Texas Railway, three miles west of Hughes' Springs. Elevation, 409 feet.

1.	Red ferruginous sandy soil, with thinly bedded iron ore and ferruginous sandstones	10 feet.
2.	Stratified brown and white sands, with a broken bed or pavement of nodular ore near centre of bed; ore, 1 foot thick	4 to 6 feet.
3.	Black laminated sandy clay, containing rounded bowlders of ore and sandstone and showing efflorescence of pale yellow	8 feet.

A well on the Joseph Burleson headright, about a mile and a half east of Hughes' Springs, gives the following:

1.	Conglomerate and nodular iron ore with red sand	12 feet.
2.	Black earth, a thinly laminated sand and sandy clay with small patches of white sand and nodules of yellow ochreous matter in lower division.	15 feet.
3.	Greensand	1½ to 2 feet.
4.	White sand to water	6 feet.
		35 feet.

The elevation of the mouth of this well is about 440* feet above sea level. Other sections from pits and wells in the neighborhood show the same succession of strata, but with varying thicknesses.

GENERAL SECTION.

A completed section of the strata of Cass County appears to be, from all the information obtainable, as follows:

Yellow, brown, and red or orange sands, unstratified and irregularly laid down, containing nodular concretionary ore deposits and beds of laminated ore and ferruginous sandstones	200 feet.
Iron ore, mostly laminated, and accompanying sandstones	10 feet.
Stratified and unstratified red and white and mottled sands, black, yellow, and red clays, and sandy clays, and occasional deposits of lignites	183 feet.
	393 feet.

IRON ORES.

The ore beds or deposits of Cass County are generally in the form of aggregations of bowlders and nodules. The conglomerate ores are usually in large irregularly shaped or rough rectangular blocks. The geode, or nodular, concretionary ores, have various forms, usually rounded, oval, or lenticular. There are, with the exception of some small deposits of laminated ore, no continuously bedded ores within the county. The geode, or nodular, ores frequently lie upon the same plane, and are so closely packed together as to give them the appearance of a continuous bed.

THICKNESS.—In thickness these deposits vary from a few inches to a maximum of ten feet. This maximum, however, occurs in very few places, and even then it is generally broken by the intermixture of thin beds of a white or yellowish colored sand.

In the western division the heaviest deposits found have thicknesses of from six to ten feet. Near Hughes' Springs a well on the Burleson headright shows an iron deposit twelve feet thick. In this well the ore is mixed with a yellow colored ferruginous sand. On the E. West headright a well passed through four or five feet of ore. To the north of Hughes' Springs a well on the Burris headright shows ten feet of ore mixed with yellow ferruginous sand. Several old pits dug in the neighborhood of Hughes' Springs show the ferruginous ores to be four feet thick. In the railway cutting, three miles west of Hughes Springs Station, the ore has a thickness of ten feet. Here it is also much mixed with brown sand.

Near Avinger, on the Andrew J. Fowler headright, a siliceous ore four feet thick underlies a yellow sand having a thickness of two feet.

*The altitude of Hughes' Springs Station, on the Missouri, Kansas and Texas Railway, is 379 feet above the level of the mean tide of the Gulf of Mexico, and these levels are from barometric readings, having 379 feet as their base.

Crossing Black Cypress Bayou, to the south side of the Gideon Storey headright, the ore deposits appear in the bluffs to attain a maximum thickness of ten feet. It has the same thickness of ten feet on the east side of the George Davidson headright. Old pits dug at various places east of the Davidson headright, on the Gideon Storey and headright lying south, do not not show this thickness, however. In these pits the ore, so far as could be seen, is not more than five feet.

In the southern part of the county, on the Ambrosi Douthet, Santiago Toscano, John Kettrel, and William Crain surveys, pits dug by prospectors show the iron deposits of this region to have at least a thickness of four to five feet.

On the northwest corner of the Lavinia Mornen survey a well thirty feet deep passed through ore four feet and then alternate beds of sand and ore to twenty feet.

In the same region, at Mr. Renaud's, on section No. 20, Cass County school lands, two wells having depths of fifty-five and sixty-five feet respectively, after passing through the surface ore deposit of four feet, gave thin streaks and nodules of ore mixed with sand to a depth of fifty feet.

The thickness of the ore in this region may be taken as four feet. In some places it may be somewhat more. The thin seams of ores found in the wells are generally separated from each other by deposits of sand varying from four to six feet.

Near Atlanta, on the west side of the Jane Richee headright, an iron mine recently opened by the Lone Star Furnace Company, of Jefferson, has been dug four feet deep. This, however, does not reach the bottom of the deposit. Trial pits dug further down the hill show outcroppings of a laminated ore. The whole thickness here, including laminated and nodular ore, may be taken as having attained the maximum thickness of ten feet. On the west side of the J. B. Mix headright the ore deposits show a thickness of from three to four feet. On the Horatio Cunningham survey the same thickness is observed.

To the east of the Texas and Pacific Railway, and about two miles north by east of Queen City, on the south side of the Albert Emmanuel land, as well as the west side of the D. W. Gilbert survey, the conglomerate ores are found to be about five feet thick, with a probability of being more. This ore is broken into large rudely quadrangular blocks, many of them showing a thickness of over four feet. These blocks rest upon others, but to what extent or thickness it is impossible to say. No excavations have ever been made. About a mile southwest of this deposit, on the M. L. Ware headright, a well was dug showing five or six feet of a broken ferruginous sandstone and nodular ore. Several miles further east blocks measuring from eighteen inches to two feet have been found, but not extensively. On the east side of the Jesse B. Bowman and J. C. Durham headrights the conglomerate bowlders average eighteen inches.

Near Springdale, on the James Horton, Rachel P. Moore, N. Rhea, Amanda Haygood, Memphis and El Paso Railway, W. de Woody, Wm. Kolb, and J. T. Wood surveys the ore averages four feet in thickness. The ore deposits on the Memphis and El Paso Railway and James Horton tracts exceed this in places.

On the southeast corner of the Samuel Harrison headright, on the farm of Matthew Powell, a deposit of conglomerate ore shows blocks measuring over two feet in thickness. These blocks are tilted and lie upon the side of a hill. The deposit here is probably over four feet in thickness.

Character of Ores.—The iron ores found in Cass County may be divided into the three grades or classes adopted by Dr. Penrose. 1st, laminated ore; 2d, geode or nodular concretionary ore; and 3d, conglomerate ore.

The distribution of these ores is such that, with the exception of the conglomerate ore deposits, no separate localities can be stated to contain exclusively any special class. Laminated, geode, and even conglomerate are generally found together and commingled to such an extent that it would be impossible to separate them. In the description of the separate ores, under each heading a few of the places where the particular class of ore under consideration forms the most prominent ore is given. These are not the only places where such ore is to be found, but rather the places in which it forms the largest proportion of the ore found in the locality.

I. LAMINATED ORE.

The heavy deposits of laminated iron ore found in the counties to the south of Cass appear to thin out toward the north, and in Cass County this class of ore is found usually in a fragmentary condition scattered amongst the other ores and ferruginous sandstones of the district. It is also found in thin seams or strata at various depths. Where it is bedded it is generally, if not always, overlaid by a thin stratum of soft sandstone, and by heavy deposits of unstratified yellow or orange-colored sand. In many places it is also underlaid by sands of a similar color and texture, but the greater extent of the beds of laminated ore immediately overlies the heavy deposits of stratified white and red sand, or their equivalent in the form of a mottled red and white unstratified clayey sand having a texture of the same quality as the stratified beds. The overlying unstratified sands vary considerably in their thickness, ranging from four feet to thirty feet, and the underlying ore appears to have a somewhat similar variability as to thickness, it being a kind of a general condition that the thicker the sand deposit the thinner the ore, and in many of the very deep beds the ore deposit is wanting.

The laminated ores of Cass occur in thin laminæ of a dark brown or chestnut color, interstratified with similar laminæ of a bright orange or yellow. These laminæ rarely exceed a quarter of an inch in thickness. The ore also occurs as a massive ore of irregular thickness and associated with a thin overlying stratum of sandstone. It is also found in pieces formed of small cuboidal blocks intermixed with clay, and of such a character as to readily crumble or fall to pieces. This last condition of the ore is not very plentiful in Cass County.

Occasional outcrops of this ore are found in the cuttings along the line of the Texas and Pacific Railway from near Springdale to Kildare, a distance of twenty miles. Laminated ore is also found in wells throughout the part of the county lying west of the railway.

In a cutting about a mile north of the Queen City station a deposit of laminated ore about four feet thick occurs. It is here composed of thin strata, averaging about one-fourth of an inch in thickness and alternately dark chestnut-brown and bright orange in color. The following is a section of the cutting:

1.	Surface ferruginous gravel and orange-colored sand	5 feet.	
2.	Thin stratum of soft sandstone		3 inches.
3.	Laminated ore in alternate laminæ of dark chestnut-brown and orange yellow	4 feet.	
4.	Stratified white and red clayey sand (total thickness not seen)	3 feet.	
		12 feet 3 inches.	

On the hill constituting the Berry Crawford iron mine, on the west side of the Jane Richee headright, about a mile north of Atlanta, a broken bed of massive laminated ore two feet thick lies immediately under three feet of nodular ore. This class of ore also constitutes the greater portion of the ore deposit found on the southwest corner of the J. B. Mix headright and east side of the northern portion of the P. M. Keeton headright. In both of these places it is in massive blocks, broken and tilted on edge and having the appearance of being the outcrop of a bed extending east to the Berry Crawford mine and northward through the Mix survey. Black Bayou runs along the west side of this hill, and, as the underlying material is a sand, there is every probability that the breaking and tilting of these blocks may be due to the erosion of the underlying sand by the water of the bayou and the breaking of the unsupported ore bed.

Extending northward from this place the same class, and probably the same bed, of ore is found on the A. Birmingham and Horatio Cunningham headrights. On the east side of the hill, on the M. S. Mullens headright, laminated ore occurs. It is also found further to the west, on the Widow Powell's farm, on the R. M. Burton headright, and northward on the southeast of the Dickson Dyer, E. C. Simons, Elisha Baty, Josiah Massie, James Batey, and John B. Denton headrights.

The upper surface of this area is for the most part covered by a heavy deposit of yellow sand, and the ore deposit lies exposed at various places along the breaks and small streams in the district. The ore is, as usual, overlaid by a thin stratum of sandstone, which is in turn overlaid by these deposits of unstratified yellow sand. This sand is about ten feet in thickness over the greater part of the area, but in several places on the Douglasville and Atlanta road it rises in hills of over fifty feet. A section of the hill on the east Josiah Massie gives the following:

1.	Yellow sand (unstratified)	10 feet.
2.	Ferruginous sandstone and laminated ore, showing twelve feet on slope of hill and forming a bench	4 feet.
3.	Brownish-yellow sand to foot of hill	20 feet.

This same class of ore is also found on the Squire Frazier headright.

Northeasterly from this place, and on the James Clements headright, an outcrop of the thin laminated chestnut brown and yellow ore is seen in a cutting in an old wagon road along the side of a ridge, near Mrs. Rodgers' house, where it presents a section of

1.	Ferruginous gravel, with nodules of ore and yellow sand	12 feet.
2.	Thinly laminated chestnut and yellow ore	1½ feet.
3.	Brown sand (thickness not seen)	2 feet.
		15½ feet.

Ferruginous sandstones and thinly bedded but much broken laminated ore occur in the northeastern part of the county. On the Nic. Edgar headright, west side of the Daniel McKinney and north side of the Buffalo Bayou and Colorado Railroad Company's surveys, laminated ore in a fragmentary condition occurs. In this district it lies close to the tops of the hills, and in some places forms the cap. This ore is underlaid by an orange colored sand.

In the central part of the county laminated ore occurs in the vicinity of Linden. It is seen in thin beds on the south side of the town, and on the northeast corner of the Matthew Powell headright, a little over a mile north of Linden, it has a thickness of ten or twelve inches and is overlaid by a deposit of yellow sand, which, half a mile southwest, has a thickness of over thirty feet.

In the region containing the Lavinia Mornen survey Cass County school lands, J. N. Jackson, and associated small surveys, laminated ore occurs not only near the surface, but also in small seams or beds at various depths from twelve to sixty feet. With the exception of a few spots of several acres each, the country is covered by a light yellow unstratified sand. Where the ore occurs upon the surface it consists of nodular concretionary ore with a good quality of laminated ore in a broken and fragmentary condition. The wells throughout the region show the underlying beds of laminated ore to be very thin, not exceeding three inches, and to lie enclosed in a yellow sand. In some parts of this region the yellow sand attains a thickness of over forty feet. Where this thick deposit of sand occurs ore is generally absent or exists in the form of a thin gravelly covering lying upon the tops of the ridges.

In the western part of the county the laminated ore deposits are not, as a general thing, very thick. On the upper R. Cornelius survey, according to Mr. Taff's observations, there is a bed having an average thickness of two feet. This bed is disclosed at a depth of fifteen feet in a well boring. On the A. J. Fowler headright another well gives the following section:

1.	White sand	2 feet.
2.	Laminated ore	4 feet.
3.	Yellow sand	26 feet.
4.	Black earth	3 feet.
		35 feet.

On the same survey this same bed of laminated ore occurs in a cutting on the side of an old road. In this place the section is:

1.	White sand	4 feet.
2.	Laminated ore and ferruginous sandstone	4 feet.
3.	Orange yellow clay and sand or clayey sand, hard as a soft sandstone	

In the region extending from Avinger to Hughes' Springs small deposits of laminated ore occur associated with an orange-yellow clayey sand. These deposits overlie and are in direct contact with the orange sand. This same class of ore crops out at various places in the hills on the banks of Turkey Creek, in the Joseph Burleson, Larkin Martin, and W. M. Burrets headrights. It also occurs on the E. A. Merchant headright.

About three miles west of Hughes' Springs, on the Missouri, Kansas and Texas Railway, laminated ore occurs, thinly bedded and lying among red ferruginous sand and thinly bedded sandstones. This deposit, sand, sandstone, and ore, is ten feet thick, and directly overlies the laminated red and white clayey sands found underlying so great an extent of the county.

On the Evan Watson, Jarius Berry, Gideon Story, George W. Davidson, and several other headrights laminated ores occur in varying quantities.

TABLE SHOWING ANALYSES OF LAMINATED IRON ORES FROM CASS COUNTY, TEXAS.

No.	Peroxide of Iron.	Alumina.	Magnesia.	Lime.	Sulphuric Acid.	Silica.	Loss on Ignition.	Phosphoric Acid.	Total.	Metallic Iron.
500‡ (T)	......	......	......	......	......	....	......	......	....	34.71
504‡ (T)	55.90	11.87	......	0.89	0.11	19.04	13.68	0.27	100.959	39.13
507‡ (T)	53.34	11.89	......	0.23	0.57	21.12	12.64	0.27	100.06	37.34
508‡ (T)	53.06	15.76	......	0.44	Trace.	18.00	13.06	0.18	100.50	37.14
509‡ (T)	61.61	14.99	......	0.11	0.47	7 28	14.46	0.98	99.90	43.13
722†	43.75	10.05	Trace.	0.40	0.51	35.80	9.40	Trace.	99.91	30.32
731*	62.33	.....	......	....	0.33	30 00	.....	Trace.	....	43.63

Analyses: ‡P. S. Tilson. †L. E. Magnenat. *J. H. Herndon. (T) Collected by Mr. A. G. Taff.

Localities.

500. Six miles north of Linden, near Charles Tapp survey.
504. James W. Old's survey, five miles north of Linden.
507. Half a mile northwest of Cusseta Postoffice.
508. John Styles headright, north of Cusseta Postoffice.
509. Cusseta Hill, on Crawford & Sanche's headright.
722. Widow Rogers' farm, James Clements headright, on Knight's Bluff road.
731. Near center of A. Emanuel survey, near Queen City.

2. GEODE, OR NODULAR CONCRETIONARY, ORE.

This ore is different from the laminated ore in its mode of occurrence and form. It is usually found in Cass County, forming the capping of the sharper ridges, and in patches where the elevation of the plateau regions rise somewhat higher than the surrounding general level. In common with the laminated ore and sandstones, it also occurs on the tops of many of the benches along the sides of the numerous ridges. Among the yellow unstratified sands forming the upper beds of the region it appears in the shape of a pavement, or loosely bedded.

Geode, or nodular concretionary, ore occurs in the form of irregularly rounded nodules or concretions of varying sizes, ranging from two to eighteen inches and even two feet in diameter. It is also found in flattened oval disk-shaped concretions. Many of these nodules are broken and fragmentary, and lie scattered in cup-shaped pieces along the tops and sides of the ridges. In structure, these nodules are generally formed of concentric rings lying around a solid central nodule of brown or yellow ochre. Some few are hollow, but the greatest proportion have the central space filled with a white or yellow sand of a similar texture to the sand amongst which these nodules lie. In the flattened oval and many of the rounded nodules the central cavity is filled by folds of ore of the same nature and formed from the inner concentric rings or divisions of the nodules.

The outer appearance of these concretions is of a rusty brown, while the interior rings are formed alternately of a dark chestnut and bright orange. The orange partings are generally of an ochre or clay and are very thin, while the chestnut colored ones range from half an inch to one inch in thickness. The inner coating is frequently of a rich glossy black color. In many of the nodules the chestnut color of the concentric rings is replaced by a dark steel blue. This is especially the case with nodules lying along the banks of the small streams in the lower ground in the eastern and southeastern portions of the county.

Nodular concretionary ore occurs extensively throughout Cass county. It is probably more extensive than either of the other classes of ore found in the region. It is not confined alone to the higher grounds, but also occurs in many places throughout the lower eastern portions of the county, where it forms the great proportion of the ore. An extensive deposit occurs along the banks of the Little Beach Creek, on the Samuel Burnham and James Harris headrights, about four miles west of the Arkansas State line. In this deposit the nodules average about ten inches in diameter, and when broken present a steel blue appearance. The deposit lies in a loosely bedded form over the headrights named, and appears to have a thickness of about two feet, and is overlaid by a light yellow sand, averaging from one to ten feet in thickness. Above the ore deposit there lies a broken fragmentary bed of ferruginous sandstone.

Scattered over the Jane Richee headright deposits of nodular ore of varying thicknesses occur. On the road from Atlanta to Queen City the deposit is only a few inches thick and lies upon the stratified white and red sands. In the hills at Berry Crawford's mine this ore has a thickness of three feet. This ore has been mined by the Lone Star Furnace Company, of Jefferson.

Northward from Atlanta nodular ore is found thinly scattered over the greater part of the Willis Pitman, Jane Richee, James Clements, Samuel Harrison, and a part of the Horatio Cunningham headrights. On the Willis Pitman and Jane Richee headrights the ore is covered by a deposit of yellow sand. On the Horatio Cunningham and other headrights it lies mostly upon the surface in a broken condition. Northward, along the line of the Texas and Pacific Railway to near Springdale, the surface of the higher ground is strewn with fragments of this ore.

Beginning near Springdale and extending in a northwesterly direction, a ridge of ore and sand with its spurs embraces the greater parts of the James Horton, Memphis, El Paso and Pacific Railway, A. Goodman, William Kolb, W. de Woody, James T. Wood, Howard Reames, and P. Hall headrights, and the southern half of the John Myers survey. This ridge throughout its greatest extent is covered by a compact ore and gravel associated with a ferruginous sandstone. The P. Hall headright and part of the Cannon Smith headrights have a covering of yellow sand varying from one to ten feet deep overlying the ore. Fragments of laminated and conglomerate ores occur through this ridge, but the nodular concretionary ore forms the greater proportion. The ore in this region is a little over four feet in thickness, and is underlaid by a red clayey sand.

In the central portion of the ore region of the county nodular ore occurs intermixed with light yellow-colored sand. On the Cass County school land, near Mr. Renaud's house, this ore lies upon the surface, and is also found in his well several feet in thickness. At W. R. Brown's house, on the same land, the nodular ore forms the surface, and occurred in a well fifty feet deep all the way down to the depth of thirty feet. Between these two pl ces, a distance of about two miles, the surface of the country is covered with yellow sand having a thickness of about two feet. Nodular ore appears to underlie this sand and crops out on the sides of the hills. In some places it lies scattered over a space of fifteen or twenty feet and forms a belt along the side of the ridge. On the Lavinia Mornen land and on the Martha Ingram headright ore deposits are seen cropping out from beneath a heavy deposit of the same white sand. Similar outcrops are also found upon the banks of several small brooks on the Willis Hester and William Gilbert headrights. The ore deposits on the Ingram, Hester, and Gilbert headrights are very small and of no practical value.

On the George S. Young headright nodular ore extends over the lands occupied by A. Goodman and D. D. Dodd. as well as several other small patches on the same headright.

The greatest development of nodular ore occurs in the western portion of the county. In this region many of the concretions reach a diameter of from one and a half to two feet. On the southwest of the M. L. Ware, south side of the Gideon Story, Louis Strong, Fisher and Miller, James Allen, and George W. Davidson, as well as several other surveys in the same neighborhood, great masses of this ore lie upon the surface of the ground, covering the sides and tops of the ridges, and overlie stratified red and white sandy clay. From this ridge these ore masses extend to the Cypress bottom. On the west side of the Cypress, nodular ore is found on the W. P. Dickson and other headrights west to the Morris County line. In the southern part of this district this ore occurs on the O. H. King and D. H. Edmondson and surveys east to the Andrew J. Fowler headright. It is also found on the James Coffee, William Hutchinson, and other headrights lying upon the higher grounds between Cypress Creek and its tributary streams.

On the John Kettrell headright and several small surveys lying to the west as far as the Cypress; on the south side of the A. D. Duncan, north of the Kettrell survey; on the W. H. Crain, Santiago Toscano, and northern part of the Ambrosi Douthet headrights, concretionary nodular ore associated with a ferruginous sandstone occurs, mixed with an orange colored sand. The ore in this region is over four feet thick.

Small quantities of nodular ore also occur on the south side of the H. J. Story and Evan Watson headrights. It also occurs in small deposits throughout the county, but with very few exceptions, most of which have been mentioned, these deposits are of no practical value.

As bearing somewhat upon the origin of these concretionary ores, it may be noticed that in a creek on the Patrick W. Birmingham survey there are great quantities of rounded and oval-shaped nodules of clayey sand enclosed in a covering of dark red oxide of iron. In appearance these clayey nodules are very similar to ore concretions, and it is only when broken that their texture can be discovered.

TABLE SHOWING ANALYSES OF CONCRETIONARY IRON ORES FROM CASS COUNTY, TEXAS.

No.	Peroxide of Iron.	Silica.	Alumina.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Loss on Ignition.	Total.	Metallic Iron.
706† ...	37.99	49.90	4.31	Trace.	0.80	Trace.	0.20	7.00	100.20	26.59
711* ...	70.83	17.20	3.17	Trace.	Trace.	Trace.	0.24	8.22	99.66	49.88
714* ...	70.83	13.80	3.57	Trace.	0.20	0.22	Trace.	12.01	100.63	49.58
718† ...	61.80	25.30	3.20	Trace.	Trace.	Trace.	1.56	8.50	100.36	43.26
721† ...	37.46	41.80	......	......	......	......	......	......	....	26.22
727† .	80.85	5.55	2.15	......	......	Trace.	Trace.	11.60	100.15	56.59
728* ...	61.44	27.80	5.16	......	0.10	0.28	Trace.	5.25	100.03	43.00
729* ...	74.60	9.00	5.00	Trace.	Trace.	0.32	0.10	10.30	99.32	52.22
730* ...	79.32	6.20	4.68	Trace.	Trace.	Trace.	0.51	9.17	99.88	55.52
732* .	57.92	29.80	4.48	Trace.	Trace.	0.32	0.34	7.35	100.21	40.54
733* ...	77.61	7.60	7.39	......	0.21	0.32	Trace.	6.85	99.98	54.32
735* ...	73.97	14.60	4.63	......	Trace.	Trace.	0.11	6.61	99.92	51.77
740* ...	85.70	0.40	7.50	......	0.50	0.25	Trace.	6.11	100.46	59.99
953* ...	81.36	3.00	4.24	......	0.82	0.32	0.51	9.60	99.85	56.92
954* ...	77.56	9.00	4.04	......	0.51	0.32	0.34	8.15	99.92	54.29
501‡ ...	79.11	1.95	7.47	......	0.69	0.12	0.22	10.95	100.51	55.38
502‡ . .	62.23	10.23	14.79	Trace.	0.65	0.62	0.14	11.86	100.52	44.56
503‡ ...	70.93	3.04	14.03	0.084	......	Trace.	0.19	11.32	99.59	49.65
505‡ ...	67.31	7.20	14.76	0.032	Trace.	0.13	0.25	10.41	100.092	47.12
506‡ ...	71.37	9.14	7.68	......	Trace.	0.32	0.92	11.43	100.86	49.96
510‡ ...	59.30	10.16	16.73	......	0.26	0.93	0.90	12.93	101.20	41.55
511‡ ...	58.90	12.07	16.12	Trace.	0.77	0.94	Trace.	12.02	100.82	41.23
512‡ ...	57.47	14.94	15.18	......	0.45	0.25	Trace.	11.92	100.21	40.23
514‡ ..	76.84	3.07	11.25	......	0.27	0.25	0.57	9.11	101.36	53.79

Analyses made in Laboratory of Geological Survey of Texas by *J. H. Herndon, †L. E. Magnenat, ‡P. S. Tilson at A. and M. College Laboratory.

Localities.

No. 706. Concretionary iron ore, one-half mile southeast of Lanark Station, on Texas and Pacific Railway.

No. 711. Northeast corner Horatio Cunningham's headright.

No. 714. W. R. Gilley headright, near Queen City.

No. 718. West side of Rachel P. Moore headright.

No. 721. Corner of J. Massie headright.

No. 727. Lavinia Mornen headright.

No. 728. Lavina Mornen headright.

No. 729. Mr. Waters' farm, P. M. Keeton headright.

No. 730. Iron geode centre, M. L. Hinton's farm, R. M. Hatfield headright.

No. 732. W. H. Hunt's farm, on Queen City and Douglasville road, on M. S. Mullen headright.

No. 733. Mr. Moore's farm, J. J. Hudson headright, near Atlanta.

No. 735. Berry Crawford's mine, one mile north of Atlanta.

No. 740. Iron geode, south side of A. Duncan headright.

No. 953. S. Burnham survey, on Little Beach Creek.

No. 954. James Horton headright, near Springdale, fourteen miles north of Jefferson.

Specimens collected by Mr. A. G. Taff.

No. 501. One to four miles south of Cusseta, on W. F. Young's survey.

No. 502. Southwest corner of John Lick survey, seven miles northeast of Linden.

No. 503. Five miles northwest of Linden.

No. 505. S. Hill survey, eight miles northeast of Linden.

No. 506. Charles Plank survey, five miles southeast of Atlanta.

No. 510. Cusseta Hill No. 3.

No. 511. From Lambert's Hill, on William Lambert survey, nine miles north of west of Linden.

No. 512. Bowlder foot of hill north of Blackwell, on D. Bryant headright.

No. 514. On Linden and Red Hill road, two miles northeast of Linden.

3. CONGLOMERATE ORES.

Conglomerate ores, although not so extensively developed areally throughout Cass County, are yet of sufficient importance to be considered equal to either of the laminated or nodular concretionary ores.

This ore is a mixture of ferruginous pebbles of sizes ranging from half an inch to an inch in diameter, ferruginous sands and gravels, and occasionally a siliceous pebble cemented together by oxide of iron. In the purer conglomerates siliceous pebbles are usually absent, and these also contain a greater proportion of the iron cementing material.

These ores are generally found occupying positions along the banks of the streams in the district, particularly in places where these streams have cut through the first or lower range of ridges lying between the lowlands of the country toward the east and north and the upper or main ridges. They are frequently found capping or lying high up on the sides of the lower hills occurring amongst the main chain of ridges.

The most extensive deposits of this class of ore found in Cass County occur on the south side of the Albert Emanuel and west side of the David W. Gilbert headrights. This deposit lies upon both sides of a small creek and rises about fifty feet above its bed. The ore is in large quadrangular blocks measuring from two to four feet along each side. The actual thickness of the deposit is not known, as no excavations have ever been made. It is evidently over five feet in thickness. Experimental tests made of this conglomerate show it to produce a fine light gray soft iron, and to carry about thirty per cent of metal.

The next deposit of any extent is on the side of a hill on the southeast corner of the Samuel Harrison headright, close to Mr. M. Powell's house. Here the blocks are scattered, and many of them tilted on edge. They are partially covered by a gravel, which appears to be the result of a disintegration of the conglomerate ores themselves. The hill appears from a section in the stream at Mr. Powell's house to be composed of a mottled sandy clay. The following is a section from the bank of the stream at this place:

1. Yellowish white sand.. 6 feet.
2. Ferruginous sandstone and iron ore nodules.............................. 12 feet.
3. Brownish yellow or orange sand, with patches of mottled white and red sand, the red spots being of a bright turkey red..

The blocks are all tilted towards the small extent of bottom land through which this creek runs, and the tilting appears to be due to the erosion of the soft underlying sands.

A considerable deposit of the same grade of ore occurs on the north side of the Ambrosi Douthet, west side of the Mathias Dillard, and east side of the L. H. Walker headrights, in the southern part of the county. This deposit, like all the others, occurs in large broken blocks of an irregular shape, and fringes the narrow bottom lands along Cunningham's Creek. It also extends northerly to near the edge of the bottom lands on the south side of Jim's Bayou, on the R. C. Graham headright.

Conglomerate ore is also found in small quantities on the west side of Flat Creek, on the M. L. Ware headright.

Half a mile west of Hughes' Springs, on the west J. S. Brown survey, there is a body of conglomerate ore of a very earthy quality, and still containing rootlets belonging to recent vegetation. This deposit has been tested for the manufacture of paint, and several of the houses and workshops in the village are painted with the product. It gives a dark red color, which is said to stand the weather very well, but a great amount of waste occurs in the manufacture.

Near the centre of the George McAdam headright, on the Knight's Bluff and Queen City road, about two miles from Queen City, conglomerate ore occurs on the side of a hill and close to a small stream belonging to the Black Bayou system of drainage. This ore also occurs in broken blocks, and when broken gives a bright red powder. Following down Black Bayou to the Alfred Pride survey, the same quality of ore occurs in the edges of the higher ground overlooking the bottom lands along the bayou. This deposit is, however, very much mixed with and overlaid by a ferruginous sandstone.

Conglomerate ore occurs in greater or less quantities in other parts of the county, but always in association with and close to the streams or water courses. In the northern part of the county, where the district is broken by numerous small streams, this ore is found near where these streams enter the lower lands, approaching the second bottom land of Sulphur. A deposit occurs on the north side of the W. de Woody, northwest of the James T. Wood, northwest of the Jonathan K. Kolb headrights, and in a general southwesterly direction to the large deposit already described on the Samuel Harrison headright.

This ore also occurs at various places along the Frazier Creek from the

Cynthia Latimer survey, on the headwaters of the creek, to the J. H. Jackson headright, near the junction of the Frazier and Johns creeks.

In addition to this conglomerate ore, there is found at various places throughout the county a conglomerate of sand, pebbles, and gravel of a much softer and apparently more recent origin. This ferruginous conglomerate can not be classified as iron ore, as no amount of concentration and washing could make it pay to work.

This conglomerate is always associated with water wherever found; is either close to the high water limit or within a few feet of that line. Outcrops of this material occur on Jim's Bayou, about two miles south of Linden, on the Jefferson road. In this place it consists of sand, ferruginous sandstone, and pebbles, of which a considerable quantity are siliceous. The deposit lies about twenty feet above the water of the creek (low water limit) and is one foot thick. The distance from the bed to the water is covered with pebbles and pieces of sandstone, and the underlying beds could not be seen, but are probably a mottled red and white sand similar to that which appears on the south side of the creek. Another deposit of a similar nature lies on the D. Glaze headright, about eight miles from Linden, on the Daingerfield road. This deposit, which does not exceed two inches in thickness, lies near the top of a hill about sixty feet above the neighboring stream. A cut in the hill shows the following section:

1.	Thin gravelly ore, covering top of the hill and scattered generally over the side	1 to 2 inches.
2.	Brown sand, weathering to a light gray	4 feet.
3.	Conglomerate of ferruginous sandstone and quartz pebbles, pebbles rounded and waterworn, and some a pure white, while others are stained yellow	2 inches.
4.	Brownish yellow sand, containing nodules of ferruginous sandstone, to the bottom of the hill	60 feet.
		64½ feet.

Whatever may have been the origin of these conglomerate ores, their peculiar position and relation to the water courses of the region seem to point to their being of a comparatively recent origin; that is, that their formation began at the same time the present system of drainage commenced. The older and higher conglomerates are therefore less recent, although of the same age, as the lower and softer conglomerates, such as those on Jim's Bayou and other places.

As a material from which to manufacture iron these conglomerate ores, or the best of them, will not work profitably with the present facilities for the obtaining of fuel in Cass County, and can not compete with the nodular concretionary ores so far as expense is concerned.

TABLE SHOWING ANALYSES OF CONGLOMERATE IRON ORES FROM CASS COUNTY, TEXAS.

No.	Peroxide of Iron.	Silica.	Alumina.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Loss on Ignition.	Total.	Metallic Iron.
709† ...	31.53	57.05	......	......	......	......	......	......	....	22.07
715* ...	....	48.00	......	......	......	......	....	......	....	29 42
719* ...	.... ..	35.90	......	......	......	......	......	......	....	30.56
720† ...	57.94	35.00	......	......	......	......	......	......	....	40.56
734* ...	43.42	37.90	......	......	......	......	......	......	....	30.39
736* ...	50.36	31.80	......	......	......	.....	......	......	....	35.25
743* ...	66.29	21.50	3.91	......	2 60	0.25	0.33	5.20	100.08	46.40
703† ...	56.35	35.70	......	......	......	......	0.72	......	....	39.44

Analyses in Laboratory of Geological Survey by *J. H. Herndon, †L. E. Magnenat.

Localities.

No. 709. Luanna Ward headright, one and a half miles west of State line between Arkansas and Texas.

No. 715. Silas Dobbs headright, on Knight's bluff road, three miles west of Queen City.

No. 719. Thomas Young survey, near Lanark switch, Texas and Pacific Railway.

No. 720. South side of Hurricane Creek, three miles from Atlanta.

No. 734. Northwest corner of Luanna Ward's headright, six miles northeast of Queen City.

No. 736. M. Powell's house, southwest corner of S. Harrison headright.

No. 743. Near Hughes' Springs, on E. A. Merchant's headright.

ANALYSES OF CASS COUNTY IRON ORES.

Thirty-nine analyses of the iron ores found in Cass County have been made. Of these, seven are of the laminated class, twenty-four belong to the nodular concretionary grade, and eight are conglomerate ores.

1. LAMINATED ORES.

Of the seven laminated ores, five have percentages of silica ranging from 18 to 35.80 per cent. One reaches the low figure of 7.28 per cent, and in one the total metallic iron only was determined.

In sulphur they vary from a trace to twenty-two one-hundredths of one per cent.

Phosphorus is also present in these ores to a greater or less extent. Traces only are found in two, eleven one-hundredths of one per cent in two more, and another gives a little over four tenths per cent.

While these impurities are comparatively high, the quantity of metallic iron derived from the ores is low, amounting to only 43.63 per cent in the highest one, No. 731, and 43.18 per cent in No. 509, while the others range from 39.13 per cent down to 30.32 per cent.

Were there no other considerations regarding these ores, such as the smallness of the deposits and the high percentages of impurities found in them, the low proportions of metallic iron would militate against their being worked profitably.

2. NODULAR CONCRETIONARY ORES.

Twenty-four analyses of these ores have been made, and with a few exceptions they appear to be sufficiently rich in metallic iron for furnace purposes.

As a general thing such ores run low in silica, the highest being 17.20 per cent. In this ore, although the silica may be somewhat high, it contains 3.17 per cent of alumina, only 0.19 of sulphur, and has only a trace of phosphorus, while the total percentage of metallic iron (49.58 per cent) places it in the rank of workable ores.

No. 735 has a total percentage of metallic iron of 51.77. Its alumina amounts to 4.63 per cent, sulphur only eleven-hundredths of one per cent, and of phosphorus only a trace has been found. The other ores of this group are generally low in silica, most of them ranging from less than two to about ten per cent.

In sulphur and phosphorus the nodular ores are also low. In sulphur the highest shows 0.92 per cent of sulphuric acid, or about three-tenths of one per cent of sulphur. The quantity of sulphur in these ores is so small that by any of the ordinary modes of roasting and washing practiced in the working of this class of ores this impurity can be easily and quickly eliminated. In phosphorus the highest amount shown is fourteen-hundredths of one per cent. Six of the ores analyzed give each this amount. Some of the most extensively developed ores of this class in the county, however, only show traces of phosphorus.

The analyses given have all been made from fair average samples, and the percentages of metallic iron shown could easily be enhanced by picking specimens and by roasting, so as to drive off the contained water and sulphur before analyses.

3. CONGLOMERATE ORES.

Eight analyses of this class of ores have been made, and the results do not justify the use of these ores for the manufacture of metallic iron.

Of the ores found in Cass County, the geode or nodular concretionary class, from an analytic point of view, are decidedly the best. They are also the best and most extensively developed ore within the limits of the county, and, from a practical point of view, appear to be the only ores capable of being profitably and economically worked. The laminated ores are but poorly developed and are of a generally low grade, while the conglomerate ores, though well developed in many portions of the county, especially in the neighborhood of Queen City, are altogether too high in silica to be profitably or economically utilized by any of the present methods of manufacturing iron. These ores are, however, subject to magnetization by roasting at a red heat. It may be possible to concentrate them by crushing, washing, and separating as far as possible the larger siliceous particles, and then by drying and roasting at a red heat, to render these ores sufficiently magnetic to be concentrated by some of the numerous magnetic separators now in use for magnetites, and by these means be rendered fit for use; but in the present condition of the iron markets of the world and the large quantities of better and more easily obtained ores lying useless, these operations could not be carried on without entailing considerable loss to the proprietors of the mine or furnace attempting to use such ores.

FERRUGINOUS SANDSTONE.

In some localities throughout the county the ferruginous sandstones contain a considerable quantity of oxide of iron, many of them showing as high as thirty or even thirty-six per cent of metallic iron. The quantity of silica in these sandstones, however, make them of little or no value from a metallurgical point of view.

These deposits are as a rule very broken, and can not be said to have any regularity of bedding or deposition. They lie in irregular heaps or masses of roughly shaped bowlders, and from their positions appear as if at one time regularly stratified, but afterwards broken up by their own weight, owing to the withdrawal, by erosion, of the underlying sands. The roughness and irregular form of the bowlders forming these sandstone deposits are due to atmospheric action caused by the rain, wind, change of temperature, and in some cases partly to the action of vegetable life.

In some instances these sandstones may be utilized for building material where the roughness of the material will not form an objection, such as in foundations of buildings, or any other underground work, with the exception of well curbing or cistern lining. As a general thing, however, they are too soft to be readily worked or to stand any great amount of weathering where it might be necessary to use them in the construction of buildings. Some have been used by the people throughout the country for building chimneys and fireplaces, but with only partial success, and the general verdict of those who use them is that these sandstones are unsuitable for that purpose, owing to their tendency to break into small fragments when heat is applied to them.

CLAYS.

The clays of Cass County are of comparatively little value. No clay suitable for the manufacture of anything but the coarsest earthenware has been seen in any practical quantity. None of the clays are pure enough to make a white ware. They are all too much stained with iron—a condition which will render any ware such as jugs, jars, churns, etc., being glazed with the "Albany slip" or some other black glaze. The Cass County clays may be divided as follows:

1. POTTERY CLAY.

A small deposit of a light blue clay occurs within the corporate limits of the town of Atlanta. This clay lies under a six foot deposit of yellow sand or clayey sand containing nodules of iron or a ferruginous gravel. It is said this clay was at one time successfully used for pottery business, but no authentic information could be obtained as to its manufacturing qualities. The clay will not make a ware of any other class than black glazed, and is not suitable for fine work. Its areal extent could not be obtained with any degree of accuracy, but it probably covers from ten to fifteen acres in an intermittent manner. The outcrops seen would give it this area.

2. FIRE CLAYS.

A good fire clay must be free from any ingredient which would be liable to combine with any of the other materials and form a flux. For this reason it is necessary that any clay intended for fire purposes should be as free from iron and all alkalies as possible.

The sandy clay lying around the broken edges of the stratified red sand and clay beds is frequently found in a condition free enough from iron and other impurities to render it available for fire clay purposes, and occasional deposits of a comparatively pure siliceous clay are found which may also be profitably used for fire brick making. With judicious washing and working these siliceous clays may also be used for the manufacture of some grades of earthenware.

A deposit of the first class has been found on the southeast corner of the M. Spelman headright. It is seen in a cutting on the Knight's Bluff road. Another and purer deposit occurs on the Texas and Pacific Railway, on the James Howell headright, about half a mile north of Queen City. This deposit underlies two feet of stratified red and white sand. The following is a section:

1.	Thin stratum of concretionary ore and ferruginous gravel	6 inches.
2.	Brownish yellow sand	2 feet.
3.	Stratified red and white sand	2 feet.
4.	Bed of sandy clay	2 feet.
5.	Stratified red and white sand.	

No. 5 is seen about one hundred yards farther south, and also half a mile east, as well as some distance west.

Deposits similar to these two are found in many other places throughout the county.

A deposit of pure white siliceous clay lies on the northeast corner of the Jane Richee survey. It is about five acres in extent and has a known depth in the centre of the deposit of seven feet. From this seven feet centre it slopes off gradually in every direction and thins out to a few inches or passes under a bed of brownish yellow sand. This clay has been tested at the Portsmouth (Ohio) Fire Brick Company's works and recommended as a clay suitable for the manufacture of a high grade of No. 2 fire bricks. An analysis of this clay made in the laboratory of the Survey gives:

Silica	82.60
Alumina	10.25
Ferric oxide	2.25
Lime	Trace
Alkalies, chlorides	4.46
	99.56

The alkalies (mostly soda) are rather high, and the clay can be materially improved by washing, so as to get rid of a part of them.

3. BRICK CLAY.

Materials for the manufacture of ordinary building bricks occur in profusion, being widely scattered over almost every part of the county.

No regularly established brickyard exists in Cass County. Occasional kilns have been burned at Linden, Hughes' Springs, near Avinger, at Atlanta, and Queen City. The yard at Atlanta is the only one which has been continuous for any period. The others are only used once, or probably twice, as demand may arise. The material used is the upper deposit of unstratified sand wherever found of a sufficiently clayey texture. The bricks are all very hard and badly spotted with dark blue iron stains, due to the existence of iron oxide in nodular shape. These bricks are unsuitable for any place where fine work or a pleasing appearance is wanted. The bricks are all hand made, and all front or ornamental bricks are imported from St. Louis.

Owing to the intermittent manner in which the work is carried on, no reliable statistics of the clay industry of Cass County could be obtained.

TABLE SHOWING ANALYSES OF CLAYS COLLECTED IN CASS COUNTY, TEXAS.

No.	Silica.	Alumina.	Iron.	Potash.	Soda.	Lime.	Magnesia.	Loss on Ignition.	Total.
600†	82.60	10.25	2.25	4.46 (potash and soda)		Trace.	......	....	99.56
705† a	66.70	11.43	3.77	4.00 (potash and soda)		1.30	0.08	13.00	100.28
710* h	68.30	12.20 (alumina and iron)		1.42	5.00	Trace.	Trace	13.60	100.52

*a*Dark black clay (lignitic). *h*Dark clay (lignitic).

Analyses made in Laboratory of Geological Survey by *J. H. Herndon, †L. E. Magnenat.

Localities.

No. 600. Near Queen City.
No. 705. Gideon Storey headright.
No. 710. A. Duncan headright.

BUILDING STONE.

With the exception of the light gray or white sandstone and the red ferruginous sandstones, there is no building stone in Cass County. The red sandstones are mostly found in blocks or large flat, slabby bowlders, and are used for laying foundations or piers upon which the houses in the country stand. These sandstones are also often used for building fireplaces and chimneys.

A ledge of bright brown sandstone occurs on the south side of the John H. Rives survey, in the southeastern part of the county, but is not of any extent.

Scattered throughout the southwestern and central part of the county there are deposits of a light gray or white sandstone suitable for building purposes. These deposits occur on the south side of the J. B. Mix and Joshua Hudson headrights. A large deposit also occurs at Linden, where it has been quarried for furnace building. Another deposit, which has also been quarried, occurs on the southeast of the B. Hawkins survey, and a deposit is also found on the northeast of the Evan Watson headright.

These white sandstones are said to have been used at Kellyville and Jefferson for building furnaces, but with what success has not been ascertained. The deposit on the B. Hawkins is soft and easily powdered. It is possible this stone might be utilized for glass making purposes

Some of the mottled sands weather into a fairly hard condition, but whether they would be suitable for building purposes remains to be tested.

MINERAL SPRINGS.

There are numerous springs of a chalybeate nature within the county, but with the exception of Hughes' Spring, on the Missouri, Kansas and Texas Railway, none of them are utilized. Hughes' Spring rises on the side of a hill about a quarter of a mile from the railway station, and at an elevation of about twenty feet above the level of the railway.

Another spring in the southeast of the county, known as Baugus Spring, was at one time largely patronized, but it has now fallen into disuse.

LIGNITE.

Throughout the county various deposits of lignite have been reported as being found in the digging of wells. These deposits, with the exception of those in the neighborhood of Alamo and "Stone Coal" Bluff, on the bank of the Sulphur Fork, near the James P. Francis headright, are of no practical value. In general the lignites are found from thirty to forty feet underground, and do not exceed two feet in thickness.

The Stone Coal Bluff lignite lies in the bottom of the river, and can only be approached at low water. It is reported as having a thickness of six feet, and underlies a bed of sandy clay. The Alamo lignite appears to be divided into two beds, one at forty-nine feet and the second at sixty-five feet. A section of the shaft is

1.	Sand and clay	26 feet.
2.	Gray clay	23 feet.
3.	Lignite	1 foot 8 inches.
4.	Gray sand	2 feet.
5.	Hard slaty clay	9 feet.
6.	Lignite	4 feet 2 inches.

The lower lignite bed was not cut through.

This shaft was sunk by a company with the intention of mining the lignite of the lower bed, but, owing to the difficulties encountered, the undertaking had to be abandoned. The quantity of water accumulating in the shaft, together with the softness of the overlying material, contributed largely to the failure of the company.

Closely allied with, and probably belonging to, the lignitic series there is a black sandy clay. This clay occurs in the section shown on the A. D. Duncan headright and also in a small circular valley on the D. Glaze headright, about eight miles west of Linden. On the Duncan headright it shows a thickness of six feet, and on the Glaze headright six or seven feet.

While this black clay can not be utilized for the purpose of making earthenware, the small proportions of lime and iron will also militate against its being of any value in the way of a glazing material. To serve this purpose a clay requires to possess a great quantity of materials capable of producing fusible silicates; that is, the constituents of the clay will require to be in such proportions as will combine and fuse more readily than the clay constituting the main body of the ware. At the present time the glaze used for making black ware is mostly if not altogether imported from Albany, N. Y., and is usually known among pottery men as "Albany slip." The following is an analysis of this glaze made by Dr. Brackett, of the Arkansas Geological Survey:

Silica	58.05
Alumina	14.86
Ferric oxide	6.76
Lime	6.61
Magnesia	3.08
Potash	1.18
Soda	0.80
Loss on ignition	7.41
	98.75

The fusible qualities of this clay consist of the high proportions of ferric oxide, lime, magnesia, potash, and soda.

GREENSAND MARLS.

Greensand marls are found scattered throughout various places in the county, but these sands are in such an altered condition as not to be of any practical value.

At Hughes' Springs and in the surrounding country unaltered greensands have been found in many of the wells. This sand is usually found at depths varying from twenty to thirty feet, and the thickness of the bed ranges from two feet, found in a well on the Joseph Burleson headright, to six feet, found in another well on the same headright, but about two miles distant. Six feet thickness was also found in a well on the E. A. Merchants headright. The position of this sand is seen in the sections already given on page 73.

The following is an analysis of this sand made in the laboratory of the Survey by J. H. Herndon, Chemist of the Survey:

Silica	60.80
Iron and alumina	22.20
Lime	0.99
Magnesia	0.72
Sulphuric acid	2.69
Potash	0.66
Soda	2.90
Phosphoric acid	Trace.
Loss on ignition	9.50
	100.46

TIMBER.

Over the greater portion of the ore region, and in fact over the greater portion of Cass County, there is a dense growth of timber. The larger timber consists chiefly of pine, red and yellow; oak, including the white, red, black jack, post, and pin oaks; some hickory and walnut. These last two are in small quantities and very scattered. In the lower portions of the county and bottom lands the growth is mostly of gum—sweet and black—some holly, and a considerable quantity of cypress.

The acreage under timber will probably not fall far short of 400,000 acres, and may approximately be apportioned thus:

	Acres.
Red and yellow pine	266,666
White oak	40,000
Red oak	20,000
Black jack	20,000
Post and pin oak	20,000
Cypress, gum, holly, and other trees in scattering lots	33,334
	400,000

Of the smaller growths the principal varieties are sassafras, persimmon, grapevine, and occasionally cane. Many of the woods, especially in the lower lands, are almost impenetrable, owing to the dense undergrowth and wild vines.

It is estimated by the various lumbermen at work in the county that the various classes of timber would yield an average of fifty cords of charcoal timber per acre.

WATER SUPPLY.

There are no navigable streams within the county. Sulphur Fork, the largest, affords facilities for rafting timber during a portion of the year, but that only a short period. The other creeks and bayous of any practical value for mining purposes are Baker's Creek, Little Cypress, Black Bayou, Frazier's Creek, John's Creek, Jim's Bayou, and Black Cypress. From these any large supply of water could only be obtained by storage, as the largest of them consist only of a chain of pools during the summer or dry season. All the smaller streams are completely dry during that season.

CHAPTER II.

MARION COUNTY.

BY WM. KENNEDY.

INTRODUCTORY.

Marion County may be justly looked upon as the pioneer iron county of Texas. Although not the first to establish iron furnaces or bloomaries, she was the first to put them into operation in such a manner and at such a time as to insure their continuance. Some time between the years 1850 and 1859 Mr. Nash erected a furnace on the Walter H. Gilbert headright and began the work of smelting ore from the immediate vicinity of his furnace. This furnace was, after continuing in operation for a number of years, allowed to fall into disuse, and no more furnace work was done in that part of the State for some time. This furnace was in operation when visited by Mr. Shumard in 1859.

In 1859 Mr. Reece Hughes began the erection of a furnace in Cass County, but it was not operated until 1863; and in 1864 the Sulphur Forks furnace was erected in the northern part of the same county, then known as Davis County. These furnaces, however, were but very short lived, neither of them being in operation for more than a few months.

In 1869 Mr. G. A. Kelley established a small furnace at Kelleyville for the manufacture of the ordinary grades of soft foundry pig iron, and also for the manufacture of such iron hollow ware as the trade of the country demanded. In 1870 this furnace began operations and continued under Mr. Kelly's charge until the year 1882, when it was purchased by a Mr. Ware, an Alabama iron man. Mr. Ware operated the works until 1883, when the furnace plant and pig iron on hand were sold to the Marshall Car Wheel Foundry Company, which continued operations until 1886. In that year the furnace required extensive repairs and remodeling. This the Car Wheel Company considered would require rather more expense than they cared to incur, and preferred to let the furnace go out of blast. Since then the works at Kelleyville, or "Loo Ellen," as the furnace was afterwards called, have been idle.

In the tenth census of the United States (1880) Marion County was the only county in Texas represented among the iron producing regions of the United States, and then only by the old Kelleyville furnace. On page 74, Vol. 15, we find Texas ranking nineteenth in the list of iron producing States of the Union, with a production of 3600 tons of ore having a value of $8100, or a spot value of $2.25 per ton. From the same tables we find that the ore averaged between forty-five and fifty per cent, thus giving a net production of metal of 1620 tons. The value of the tools employed is given as fifty dollars and the total cost of labor used in the production of the ore as $7200, or about $4.47 per ton. In 1888 Messrs. John A. Kruse & Co., of Chicago, obtained a franchise from the citizens of Jefferson, the county seat, for the purpose of erecting a charcoal blast furnace of not less than fifty tons capacity, and also for the operating in conjunction therewith a car wheel foundry. These works have been erected, and it is expected that operations will be commenced early in 1891.

GEOGRAPHY AND TOPOGRAPHY.

Geographically, Marion County lies along the north side of the Caddo system of lakes or bayous which form the head of the navigable waters of the Texas division of the Red River system of drainage, with Cass and Harrison counties lying to the north and south, the State of Louisiana on the east, and Upshur County on the west. This area embraces an extent of four hundred and eighteen square miles.

The general elevation of Marion County does not exceed four hundred and fifty feet above sea level at the highest point. Lines of levels along the Texas and Pacific Railway and East Line Division of the Missouri, Kansas, and Texas Railway show the general altitudes to be:

TEXAS AND PACIFIC RAILWAY.

Little Cypress	205 feet.
Height of land between the two bayous	247 feet.
Big Cypress	204 feet.
Jefferson Station	232 feet.
Black Cypress Bottom	199 feet.
Six miles north of Jefferson	311 feet.
Stalls	278 feet.
Seven and one-half miles north of Jefferson	349 feet.
Lodi	256 feet.

STATIONS ON THE EAST LINE.

Jefferson	239 feet.
Kelleyville	298 feet.
Loo Ellen	343 feet.
Lasater	342 feet.
Frenches	390 feet.

Some of the hills are from seventy-five to one hundred feet higher than these elevations, but the extreme height of four hundred and fifty feet is not reached in more than one or two instances.

The surface of the county is rolling and presents the appearance of an undulating plain having no serious or deep breaks, except in the great water courses or streams. These bayous and the smaller creeks running into them have in nearly every instance cut deep ravines through the more elevated surface of the country lying toward the west and northwest. Approaching the lake region these streams have nearly reached the limit of their eroding power, and by wandering backward and forward in very tortuous courses have succeeded in eroding the higher level of the plain to a considerable distance back from the course of the current, and have thus formed for themselves bottom lands, or flood plains of varying extent.

The main drainage system of the county is tributary to the Red River, and is spread throughout the county by Jim's Bayou in the northeastern portion of the county, Kitchen Creek, Black Cypress, and Sechi's Creek running through the central portion, Big Cypress with its tributaries, Johnson and Alley's creeks, along the south side of the central division, and Little Cypress entering the county from the south. The three Cypress bayous unite a few miles east of Jefferson to form the Caddo Lake system of bayous and lakes which extend from this point to the Red River, near Shreveport, in Caddo Parish, Louisiana. Throughout the county there are numerous smaller streams forming tributaries to one or the other of these bayous. Owing to the ease with which the materials forming the soils and subsoils of the county can be eroded, each of these streams has left a more or less distinctive mark upon the topographical features of the county.

In referring to the soils of Marion County, Dr. Loughridge in the Tenth Census of the United States (1880), Vol. 5, p. 727, says the "lands of the county comprise the dark sandy loams of the lowlands and the gray sandy soils of the uplands, interspersed with large bodies of red land, derived from iron ore and red sandstone. The subsoils of most of the soils consist of red or yellow clays more or less sandy, and at depths of from six to ten inches from the surface. They are easily tilled and produce good crops of corn, oats, cotton, sugar cane, potatoes, fruits, and vegetables."

The stratigraphy of the country has not yet been sufficiently studied by the Survey to accurately determine the areal extent or the thickness of any of the deposits. Sections shown by the different cuttings along the line of the Texas and Pacific Railroad running in a south by west direction across the county show a general uniform appearance of the underlying stratified red and white sands so extensively developed in Cass and Harrison counties. These sands appear within a few feet of the surface in the northern part of the county, and apparently retain their same relation to the overlying beds wherever seen.

A section of a small cutting near the county line of Cass and Marion counties shows the following:

1. Brown overlying sands and pebbles.. 3 feet.
2. Ferruginous matter.. 2 inches.
3. Stratified red and white sands, visible.. 3 feet.

These red and white sands have been deposited in thin layers or strata running from one-half to three-fourths of an inch in thickness, but sometimes change to strata having a thickness of six feet. These heavy deposits are, however, more in the form of lenticular masses, and are not in a general way of very extensive duration. In this cut the apparent dip of these beds is towards the northeast. Coming southward along the same line of railway, on the A. Richardson headright, within three miles of the town of Jefferson, a cutting gives a section in which the same material is shown.

The following is a section of this cutting:

1. Gravelly ore, with nodules of concretionary ore...................... 2 feet.
2. Covering of ferruginous matter found overlying No. 3............... 2 to 6 inches.
3. Stratified red and white sands and sandy clay, in layers of from one-half to three-fourths of an inch, and apparently lying in a horizontal position, visible.. 6 feet.

These beds are also seen at various places lying east and west of the line of railway, and as they occur on the A. D. Duncan and John Kettrell headrights and in the vicinity of Hughes' Springs, in Cass County, immediately north of the line, as well as in many places in Harrison County to the south, it is probable that they exist over the greater part of the central and western portion of the county. The eastern, or lower lying, portion of the county is to a great extent occupied by the great beds of sands and clays belonging to the lignite bearing beds of Eastern Texas.

Lying between the Big Cypress and Little Cypress bayous there appears a heavy surface deposit of drift material, consisting of sands, pebbles, and ferruginous matter occupying the higher ground, and extensive tracts of a pale yellowish silty sand occupy the regions in close proximity to the bayous. In places the remnants of an orange-brown colored sandy loam, or brick earth, are found overlying a similarly colored sand.

These loams are the source of the brick making material found throughout the region of East Texas. A considerable extent of this clay loam occurs in the immediate vicinity of the town of Jefferson, on the Urquhart and John Humphries headrights.

The section through Marion County, so far as yet determined, appears to be:

1. Brownish sandy loam, or brick earth, scattered irregularly throughout the county, but best developed in the neighborhood of Jefferson............ 2 feet.
2. Conglomerate and pebbles of quartz, quartzites, and crystalline rocks, rounded and water worn; found over the higher regions of the county ....
3. Light colored yellowish gray and orange-red sands, containing nodules or concretions of geode iron ore.. 30 feet.

4.	Ferruginous sandstone and laminated iron ore in beds of various thicknesses, from one inch to twelve or more feet.	12 feet.
5.	Laminated or thinly stratified white and red sands and sandy clays, merging into and forming a part of the mottled sands found in various parts of the county, sometimes thickening into six feet deposits of clay.	80 feet.
6.	Greensands indurated and laminated and interstratified with small beds of laminated iron ore. These sands in the vicinity of Jefferson are gray, grayish brown, greenish, greenish brown, and brown.	16 feet.
7.	Black micaceous sands and sandy clays, forming the upper portion of the lignitic beds of Eastern Texas, and alternate series of lignites and gray and black clays.	776 feet.
		916 feet.

ECONOMIC MATERIALS.*

The economic materials of Marion County are chiefly iron ores, clays, and lignites. There are some small deposits of greensands at various places, but these are of comparatively little economic value.

IRON ORES.

The iron ore deposits of Marion County belong to the great belt of ores lying in a generally northeast and southwest direction through the various counties composing the eastern division of the State.

These ores are chiefly of the geode, or nodular concretionary variety of limonite, although the other varieties, laminated and conglomerate, are present in considerable quantities.

Northward in Cass County the ores represented are chiefly nodular, with thin scattering deposits of laminated ore and large quantities of conglomerate ore lying as a fringe along the northern boundary of the ore field, and also along the margins of the bottom lands bordering the various creeks and bayous traversing the region. To the southward the ores of Harrison County are mostly of the laminated variety, with a small quantity of nodular ore occurring in places, particularly in the northern portion of the county, and quantities of conglomerate are also found occupying a similar relation to the bayous and creeks as they do in Cass County.

Marion County, from its intermediate position between these two areas, appears to be an area of transition between these two, and the ore beds of the county, while tending to become more and more of a laminated nature, still largely preponderate in favor of the nodular concretionary grade of ore.

As evidenced from the tables of analyses appended to each of the ore areas from which the specimens analyzed were obtained, the iron ores of Marion County appear to be of very good grade. As a general thing, however, these ores all contain a small percentage of sulphur and phosphorous. Out of twenty specimens analyzed six showed only traces of phosphorous, while the others contained that metal in proportions varying from sixteen-hundredths to three hundredths of one per cent. While the sulphur in the same number of analyses shows traces only in five of the specimens, throughout the others the percentage ranges from thirty-seven-hundredths to seven-hundredths.

In silica the Marion County ores rank low. In the twenty analyses made in the laboratory of the Survey, only five rank above seven per cent. Eight have percentages lower than five per cent, and of these eight five do not exceed two per cent. Of the ores exceeding eight per cent of this impurity, Nos. 32, 36, and 332 have the high percentage of

No. 32	27.33 per cent.
No. 36.	26.435 per cent.
No. 332	22.54 per cent.

Three of the ores show the presence of manganese. These are

No. 26, showing	0.1264 per cent of manganese.
No. 29, showing	0.147 per cent of manganese.
No. 36, showing	1.895 per cent of manganese.

None of these ores show any traces of chromium or titanium.

In magnesia and lime only two, Nos. 29 and 36, show any appreciable quantity of magnesia.

No. 29 shows	0.235 per cent of magnesia.
No. 36 shows	1.014 per cent of magnesia.

And Nos. 15, 16, 17, 26, 34, 35, 316, 318, and 320 show traces only. In lime the percentages are also low, and in no analysis made shows over 1.57 per cent.

The most extensive deposits of iron ore found in Marion County are, first, a deposit lying in the western part of the county close to the lines of Morris and Cass counties. This field, which may be designated the Western Iron Field, covers the lands embraced by the John H. Johnson, McKinney, and Williams (two headrights), a triangular area in the northern portion of the Walter H. Gilbert, the whole of the James Graham with the exception of a small portion of the southeast corner, the southeast quarter of the James Alley, and the International and Great Northern Railroad Company's headrights, comprising an area of about four square miles. This bed is but the southern end of the extensive deposits of iron ore bearing material and iron ore which extend into, and have their greatest development in, the southwestern portion of Cass County and along the southeastern border of Morris County.

The ore of this field is mostly limonite of the geode, or nodular concretionary, variety, with some laminated ore, with a deposit of conglomerate ore forming a fringe around the lower elevations and along the courses of the streams.

It was in this field that the old Nash furnace was situated in 1859. The following analyses by J. H. Herndon and L. E. Magnenat are from specimens obtained in this field:

Analysis No. 316—Ochreous limonite, from McKinney and Williams headright.
Analysis No. 321—Nash's old furnace, concretionary ore.
Analysis No. 334—Northwest corner of Marion County, concretionary ore.

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Sulphuric Acid.	Phosphoric Acid.	Loss by Ignition.	Total.
316[1]	67.93	8.92	7.07	1.57	Trace.	0.18	0.32	14.40	100.39
321*[2]	76.34	4.24	8.86	......	....	0.10	0.225	12.60	100.365
334[3]	63.43	24.54	1.58	......	....	0.28	Trace.	10.70	100.52

* See Dr. Riddell's analysis of ore from this field made in 1859, on page 9.
1 Metallic iron, 47.55 per cent. Sulphur, 0.06 per cent Phosphorns, 0.14 per cent.
2 Metallic iron, 53.43 per cent. Sulphur, 0.04 per cent. Phosphorus, 0.162 per cent.
3 Metallic iron, 44.39 per cent. Sulphur, 0.112 per cent.

For additional analyses of ores from this field, see page 84 of the First Annual Report.

The next extensive deposit occurring within the limits of the county, and which may be designated as the North Central Field, embraces the following headrights: The J. F. Burnett, John F. Cherry, H. Pugget; the eastern half of the R. W. Marlar, A. B. Pickens, B. Pickens two tracts; eastern half of the Reuben Mitchell, Samuel Jeffries; the greater portion of the northern half of the Isaac H. Johnson, James Rowland, Nash Lilly; a portion of the west half of W. C. Ward; west side of the Joshua Peters, S. J. Buress, James White, John S. Williams, James Dalton, and Wm. Russell headrights; comprising an area of about twelve square miles.

This field, which also extends across the northern boundary of the county into Cass, is by far the most important iron ore region within the limits of Marion County.

The Missouri, Kansas and Texas Railway intersects this ore field, and the ore is seen in large quantities near Lasater Station. At Leverett's Hill, on the Miles Reed headright, the following section was seen:*

1. Nodular ore, brown or yellow on the outside, black and glossy on the inside, kidney-shaped and rounded, 1 to 24 inches in diameter, mixed in brown sandy clay .... 2 feet.
2. Solid bed of brown, yellow, and black limonite ore (brown hematite)......... 2 feet.
3. Ferruginous sand to base of hill .... 10 feet.

Two miles east of Lasater Station is Lasater Hill, where there is a deposit of ore of a yellowish-brown color, in places over ten feet thick, and overlaid by sand beds carrying a thinner bed of ore. The following section shows its occurrence:*

* From First Annual Report Geological Survey of Texas, pp. 77, 78.

1.	Buff colored sand	1 to 15 feet.
2.	Brown rusty ore	½ to 1 foot.
3.	Yellow and buff sand	20 feet.
4.	Main ore bed	10 feet.

Johnson's Hill is in this field, about three miles south of Lasater Station, and forms part of the divide between the waters of the Big Cypress and Black Cypress bayous. It is about three miles long from north northeast to south southwest, and a mile wide. It looms up as a flat-topped plateau, and its surface is capped with masses of ore broken from the underlying bed. The capping of sand is here often entirely absent, a fact that is most important in facilitating the mining of the ore. A section of the ore bed on this hill shows the following strata:*

1.	Ore bed stratified, and in geode beds brown and black, bed much broken, interbedded with seams of sand	4 to 10 feet.
2.	Ferruginous and mottled clays	3 feet.
3.	Ore similar to stratified part of No. 1	¼ to ⅝ foot.
4.	Interbedded ferruginous sands and clays	20 feet.
5.	Mottled red and white sandy clays	10 feet.
6.	Red ferruginous sandy clays	65 feet.

The iron ores of this field are brown hematites, and mostly of the nodular concretionary variety. These nodules occur in flattened or rounded, oval, honeycombed, botryoidal, stalactic, and mammillary masses, have rusty brown, dull red, or even black color on the outside, and have a glossy, dull, or earthy lustre on the inside. These nodules occur in sizes from one to twenty-four inches in diameter, and are generally hollow, though sometimes they contain a central core or coating of red ochre. Large quantities of this nodular ore are said to have been used at the Loo Ellen furnace, nine miles south of here, and a pile of several hundred tons of it is still to be seen there.

At the base of Leverett's Hill, in the bed of a dry creek, is seen a deposit of conglomerate ore about two feet thick. These conglomerate ores generally consist of brown ferruginous pebbles from one quarter to two inches in diameter, cemented together in a sandy mixture. Sometimes a few siliceous pebbles are also found. These beds of conglomerate are mostly of local occurrence and lie in conjunction with or along the streams or water courses of the district.

Average specimens of ores from this field give the following analyses:

Analysis No. 318—N. Lilly headright.

Analysis No. 320—Brown Ochre from Isaac Johnson's headright.

Analysis No. 322—S. J. Buress headright.

Analysis No. 323—Ochreous Limonite from Samuel Jeffries' survey, two miles northwes of Lasater Station.

Analysis No. 324—Ochreous Limonite, two miles southwest of Lasater Station.

* From First Annual Report Geological Survey of Texas, pp. 77, 78.

No.	Ferrous Oxide.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Sulphuric Acid.	Phosphoric Acid.	Loss by Ignition.	Total.
318[1]	2.61	76.42	3.10	6.20	1.13	Trace.	0.61	0.22	9.90	100.19
320[2]	......	83.40	1.30	2.41	Trace.	. . .	Trace.	0.21	12.80	100.12
322[3]	......	74.87	10.78	1.75	Trace.	Trace.	0.275	0.08	12.20	99.955
323[4]	......	84.46	2.90	Trace.	Trace.	Trace.	0.17	0.19	12.20	99.92
324[5]	......	84.15	1.22	2.05	0.94	Trace.	0.22	0.19	12.20	100.97

1 Metallic iron, 55.52 per cent. Sulphur, 0.24 per cent. Phosphorous, 0.09 per cent.
2 Metallic iron, 58.38 per cent. Phosphorus, 0.09 per cent.
3 Metallic iron, 52.40 per cent. Phosphorus, 0.03 per cent. Sulphur, 0.11 per cent.
4 Metallic iron, 59.12 per cent. Sulphur, 0.063 per cent. Phosphorus, 0.08 per cent.
5 Metallic iron, 58.905 per cent. Sulphur, 0.09 per cent. Phosphorus, 0.08 per cent.
Analyses by J. H. Herndon and L. E. Magnenat.

For additional analyses from this field, see First Annual Report, page 84.

The third or Eastern Field is about seven miles north of Jefferson, and includes that region lying around and including Berry's Hill in the northern part of the county. This ore field embraces the John Kettrell, Isaac R. Jones, J. W. Duncan, N. McHanks, Druery Richardson, north half of W. W. Giddens, northeast quarter of the Jno. A. McKinney, west half of the W. Warnell, southwest portion of the Santiago Toscano and W. H. Crain headrights, and comprises an area of about nine square miles. At the Berry Hill, on the old Hagarty farm, this field forms a broad plateau, comprising some four thousand acres, a large part of which is underlaid by iron ore. The following section shows the general mode of occurrence of the ore:*

1. Red sandy clay, with seams of hardpan and rounded ore pebbles one-fourth to two inches in diameter .... 2 feet.
2. Mottled sandy clay, with same pebbles as 1 .... 5 feet.
3. Interbedded seams of iron ore and hardpan .... 15 feet.
4. Mottled red and white sandy clay .... 10 feet.

Bed No. 4 runs to the foot of the hill and becomes covered by drift sand in the bottom of a creek, so that only ten feet of it can be seen. The iron ore in the above section is a brittle, stratified brown hematite. On a hill to the north of this exposure was seen a bed of conglomerate ore from one to two feet thick, and at about the same level as the last mentioned bed. Some of the pebbles in the conglomerate bed appear to be fragments of broken up limonite geodes.

A quarter of a mile to the northeast of the last exposure was seen a series of alternating beds of conglomerate ore, laminated ore, and a variety composed of geodes from one to eight inches in diameter, cemented together by a sandy ferruginous matrix. Each of these beds is only a few inches thick, and are separated by sand and mottled clays, the whole series having a thickness of about fifteen feet. The geodes are brown on the outside and

* First Annual Report, p. 78.

glossy and black on the inside. They are generally hollow, though they sometimes contain masses of the same mottled clay as that separating the different beds of ore. The clays and sands separating the beds often contain loose geodes.

About a mile northwest of this locality, and on the same plateau, the following section was seen in a pit:*

1.	Sandy clay soil, dark brown, with ore pebbles and geodes composing two-thirds of the stratum	12 to 15 inches.
2.	Brown laminated ore, with some concretions	6 inches.
3.	Ferruginous sand, with concretions and hardpan	18 inches.
4.	Ore in thin seams	4 inches.
5.	Mottled clays, with thin iron seams and geodes	4 feet.

These strata dip at from fifteen to twenty-five degrees northeast.

The following is an analysis by J. H. Herndon of ore from this field:

Ferric oxide	*64.42	per cent.
Silica	26.435	per cent.
Alumina	3.816	per cent.
Lime	0.284	per cent.
Magnesia	1.014	per cent.
Sulphuric acid	†1.838	per cent.
Phosphoric acid	———	per cent.
Water	———	per cent.
Oxide of manganese	1.895	per cent.
Total	99.702	

*Metallic iron, 45.09 per cent. †Sulphur, 0.7352 per cent.

In addition to these three ore fields, there are smaller areas containing a considerable supply of ore of the laminated, nodular, and conglomerate characters. The most important of these is a deposit of nodular and laminated buff crumbly ore lying along the line of the Texas and Pacific Railway, about three miles north of the town of Jefferson, on the M. K. Hammond, A. Richardson, and Joseph Watkins headrights, comprising an area of about two square miles.

The general division of the ore in this field is that of nodular concretionary ore, occupying an area of probably seventy-five or one hundred acres, and having an average thickness of about from eighteen inches to two feet. This ore lies in a brownish orange-colored sand, and is mixed in some places with a conglomerate of transparent quartz crystals imbedded in a brown iron matrix. These crystals do not exceed one-half inch in their greatest diameter, and the conglomerate is broken into small pieces, ranging from two to four inches in diameter.

The following analysis by J. H. Herndon is from a specimen of ore from this field:

* First Report of Progress, p. 57.

Concretionary Iron Ore, from a Field near T. Farrell's House, on A. Richardson Headright.

Silica	7.10	per cent.
Ferric oxide	*79.78	per cent.
Alumina	5.42	per cent.
Sulphuric acid	†0.56	per cent.
Phosphoric acid	‡0.51	per cent.
Lime	Trace.	
Loss on ignition	6.70	per cent.
Total	100.07	

*Metallic iron, 55.84 per cent. †Sulphur, 0.22 per cent. ‡Phosphorus, 0.22 per cent.

The portion lying southeast of the railway track is covered with a deposit of ferruginous sandstones and laminated ore of the buff crumbly variety, which ranges in thickness from one to six feet.

Another deposit of ore occurs at Kellyville, on the south side of the Joseph J. Ward headright. The Kelley, or Loo Ellen, furnace was situated in this field, and for many years the concretionary ore of the district immediately surrounding the furnace formed the chief source of the ore supply.

In the southwestern part of the county, on the height of land lying between the Big Cypress and the Little Cypress bayous, the northern edge of the iron field lying in Harrison County crosses the county line and extends a short distance into Marion County. This ore belongs mostly to the older conglomerate series of ores.

TIMBER.

In all questions relating to the utilization of the iron ores of East Texas the cost of fuel has to be taken into account. As charcoal is at present the only available fuel in the region, all questions relating to the material suitable for the manufacture of this class of fuel have to be considered. With a comparatively limited supply everything looking to the conservation of the timber resources of the ore-producing counties, together with the most economical modes of production of charcoal, have a practical bearing upon the production of metallic iron within Marion County and every other county within the bounds of the East Texas ore region.

Statistics are not available to show to what extent the present timber supply is being utilized for the manufacture of lumber or may be held by saw mills for that purpose.* The main question, however, is not the quantity at present in such a condition as to be available for charcoal purposes as the question, how can the sources of this supply be kept at their full capacity and in such a condition as to be available when required?

The estimated age at which trees, whether of natural growth or cultiva-

*Six saw mills are reported as being located in Marion County by the Commissioner of Agriculture in his Annual Report for 1888–89.

tion, may be used for charcoal purposes is about fifteen years. In Eastern Texas, where the climatic conditions are in every respect suitable for the rapid growth of young timber, this estimate may be considered as satisfactory; but in addition to this period some estimate must be made for the first growth of sassafras, persimmon, and other material which invariably presents itself during the first two or three years after the clearing of the timber or the ceasing of the cultivation of the soil. Taking the duration of these growths at three years, this would place the period required to elapse before the other timber would be suitable at eighteen, or say twenty, years.

A fifty ton charcoal furnace, working three hundred days annually, and using one hundred bushels of charcoal for the production of each ton of metal, would require a supply of five thousand bushels daily, or one million five hundred thousand bushels annually. This measurement only represents the quantity actually going into the furnace. There would in all cases where the coal was produced in the old fashioned way of meiler pit burning be more or less loss in the handling of the material. If ten per cent of the total coal used be allowed for loss, then the total required would be:

Charcoal used in furnace	1,500,000	bushels.
Loss in handling	150,000	bushels.
	1,650,000	

This at forty bushels per cord, and estimating forty cords to the acre, would require the production of about one and one-half square miles of timber land annually to supply the demand. To keep up this supply to its normal standard until the second growth would be available would require an area of thirty-one square miles.

The second growth of this part of Eastern Texas is usually old field pine. a tree of remarkably rapid growth, and the present rate of its annual increase will more than counterbalance the denudation of the timbered lands of their present forests.

The supply of timber suitable for charcoal purposes may probably be estimated at about from seven and one-half to eight million cords In the Report of the Commissioner of Agriculture for 1888 the area under timber in Marion County is given as 195,721 acres, and the estimate given is based on an average of forty cords per acre. This would give a net product of 7,828,840 cords. The classes of timber found in the county are chiefly short leaf pine and the several varieties of oak—white, red, post, pin, black jack and blue jack, black and sweet gums, and some cedar and cypress along the bayous of that name and in the bottom lands lying around the Caddo Lake.

The supply of charcoal derived from this quantity of timber depends largely upon the mode in which the coal is made. The coal can be made in several distinct ways, of which the following three are the most practical and the courses usually pursued. These are, first, burning in the old fashioned pit, in which the wood to be burned is covered by a layer of charcoal dust and earth; second, burning in kiln or oven, in which the charcoal is manufactured in a brick oven; and, third, burning in retorts, in which the wood is carbonized in closed tubes. (For details of methods and difference of cost, the reader is referred to the article by Mr. John Birkinbine,* on pages 33–37 of this Report.)

CLAYS.

The clays found in the vicinity of the town of Jefferson, Marion County, belong to the Timber Belt Beds of Dr. Penrose, and are closely associated with the red and white stratified sands of that series.

On the northern side of the A. Richardson headright the clay lies close to the surface, having as a cover about two feet of a gravelly sand containing a considerable quantity of nodular concretionary iron ore and a small amount of a broken and fragmentary conglomerate of siliceous pebbles, with an iron oxide as the cementing matter. These siliceous pebbles are milky white in color and do not exceed half an inch in the greatest diameter. The clay is exposed in a small creek and around a spring issuing from the side of the hill, and is not more than one hundred yards from Mr. Farrell's house, and about two hundred and fifty yards from the main line of the Texas and Pacific Railway.

The eastern end of the hill upon which this clay lies has been cut through by the railway, and the section shown in the cutting gives the following:

1. Gravelly ore, with nodules of concretionary iron ore.......... .... 2 feet.
2. Stratified red and white sands and sandy clay, in layers of from one-half to three-fourths of an inch, apparently lying in a horizontal condition....... ...... 6 feet.

No. 2 is cut near the center of the cutting by a bed of ferruginous nodules, dipping south at a high angle, and about one foot thick. Near the southern end it is also broken by another deposit of the same sort of material and by thinly laminated ore.

The clays lie above this cutting about twenty-five feet.

The next deposit of clay is found in the Thomas Gillespie and Stephen Smith surveys, and stretches across from Black Cypress Bayou to near the Big Cypress Bayou. This deposit is exposed in numerous localities around Jefferson, the most extensive exposures being those on the Jefferson and Linden road, along which it is seen cropping out in the banks of cuttings and

*Charcoal Burning in Texas. By John Birkinbine, C. E., Secretary of the United States Association of Charcoal Iron Workers. Second Annual Report of the Geological Survey of Texas, page 33.

small creeks for over a mile. A section of the cutting on this road, near Mr. W. C. Hill's nursery, gives the following:

1. Brown and yellow brick earth.......... 6 feet.
2. Thin layer of bluish gray sandy clay .... 1 foot.
3. Light blue clay, having a slightly pinkish shade.......... 2 feet.

On the Jefferson and Daingerfield road this clay deposit is also seen exposed in many cuttings along the road. The best exposure is that at the south side of W. C. Hill's farm. Here the clay is somewhat sandy in the upper portion, and resembles No. 2 of the above section.

The following is a section at the old brick brick yard, on the Daingerfield road:

1. Brown or brownish yellow brick clay.......... 4 feet.
2. Light blue or gray colored clay.......... 14 feet.

Near Black Cypress Bayou the exposure gives the following:

1. Brownish yellow brick earth or clay .... 3 feet.
2. Light blue clay .... 4 feet.

On the Jefferson and Daingerfield road these clays are exposed for nearly two miles beyond Jefferson. These clays are also found in many places in the town of Jefferson, particularly in the region of the railway station of the Texas and Pacific Railway.

From their general elevation these beds appear to lie among, or at the base of the red and white sands found in the railway cutting three miles further north.

The area underlaid by these clays (the lower division), and in which workable beds may be found, cannot be definitely stated, but will probably exceed two square miles, although, owing partly to the irregularity of the surface and partly to the uneven and irregular surface of the clay beds themselves, some portions of the deposit will be found lying too deep for practical purposes. Where the stripping does not exceed four or five feet, or where the upper surface is suitable for the manufacture of ordinary building bricks, a somewhat greater thickness may be profitably worked, provided the brick earth can be utilized to a sufficient extent to pay the cost of laying bare the lower and more valuable clays.

Three bricks, each measuring 3x2x1 inches, were made from these clays and submitted to a partial test of their fitness for the manufacture of earthenware and fire bricks. These bricks, after being allowed to dry in the air for four or five hours, were placed in an air bath at a temperature of 110-115° C., and after being kept in this position for two days they were placed in the muffle of an assay furnace. Here the heat was gradually increased until it was raised to a white heat. The furnace was then closed and this temperature kept up for seven hours, after which it was allowed to cool down and the fire die out. On opening the furnace the clays, which had been marked A, B, and C, representing,

A, upper deposit on Jefferson and Linden road;

B, lower deposit on same road;

C, sandy clay on Daingerfield and Linden road,

were found to be changed in color from a whitish gray to a pale buff or yellow color, except that one end of B, which had been placed close to the side of the muffle and consequently somewhat more exposed to the fire, had become a light shade of brown. Although considerable shrinkage had taken place, the sharp angles of the corners were not visibly affected and showed no signs of even incipient fusion. On breaking, A and B exhibited a close body of a cream or buff color, with small specks of bright red scattered through the mass. In C the texture of the brick is more open and granular, and the contained iron not so pronounced, although more diffused throughout the mass.

These clays may be used for the manufacture of the ordinary earthenware of every day use, and also for the manufacture of pressed ornamental and front bricks. They may also be used for the manufacture of a low grade of fire brick suitable for such work as building fireplaces or for grate linings, and may also be used as a boiler setting. For a high class refractory brick suitable for furnace purposes the clays will require to be treated in such a manner as to get rid of the large quantity of mica these clays appear to contain. Mica, being largely composed of soda or potash, is apt, under an intense and prolonged heat such as is usual in iron furnaces, to resolve itself into its primary constituents, thus setting free the alkalies the mica may contain. These alkalies have an affinity for and are apt to combine with whatever ferric oxide may be in the clay, and this combination forming a slag or glass destroys the brick completely. It is due to this action on the part of the mica that many of the micaceous clays found extensively developed in places, and which are otherwise suitable for many purposes, are rendered quite worthless. The treatment to which these clays will have to be subjected will probably be too costly if necessary to get rid of the whole of the contained mica, but it is probable that by a systematic course of winter curing and afterwards careful washing before using sufficient may be removed to render the Jefferson clays suitable for a medium grade of fire bricks, and also for the manufacture of fire clay goods of a lower grade than necessary for furnace purposes. Any neglect or carelessness in the preparation of the clay will inevitably lead to failure.

These clays may also be used for the manufacture of ordinary drain tiling, and as they will admit of glazing, may be used for a medium grade of sewer pipes or well curbing, but so far as the sewer piping is concerned, these pipes will have a very low resisting power, although strong enough for small or branch sewers.

THOMAS FARRELL'S CLAY BANK.

This bank is situated on the A. Richardson headright, and probably has an areal extent of twelve or fourteen acres. The bed, so far as exposed, has a thickness of about six feet. It may probably be a few feet more. The upper division is very sandy and somewhat stained yellow from the overlying deposit of iron ore and sandy gravel. The lower division of the bank is of a pale blue or lead color, turning paler as the clay deepens in the bank. Throughout the bank there occur half-inch layers, or laminæ, of an iron stone shale.

In composition this clay has a finely laminated appearance, and in its lower division is exceedingly tough and plastic, with a soft, greasy, or oily, touch. This clay contains a considerable amount of mica. If properly treated by washing and wintering and the admixture of a more siliceous clay, or by care in freeing it from the iron layers and mixing the upper and lower beds together, it may be used for many of the purposes already mentioned. Its refractory powers, however, are low, even after the most careful washing and separation of the iron. The extraordinarily high proportion of alkalies in this clay will render it unfit for the manufacture of any article where anything more than a moderate amount of heat is required.

The following is an analysis of the clay dried at 115° C. Analysis by J. H. Herndon:

Silica	62.40
Alumina	20.66
Iron	8.54
Potash	1.12
Soda	7.77
Lime	0.40
Magnesia	Trace
	100.89

The large proportion of iron in this clay is undoubtedly due to the presence of the thin beds of ferruginous matter found at intervals throughout the mass.

W. C. HILL'S CLAY DEPOSITS.

These deposits are, properly speaking, divided into an upper and a lower deposit, with a deposit of mixed sandy clay between. The upper deposit is best developed on the Daingerfield road, where the two clays show a thickness of over fourteen feet. This clay is a very pale shade of blue or bluish gray, and has an almost white tint when dry. This is a very siliceous clay, and contains mica disseminated through it in a considerable quantity. Tests are reported as having been made of this clay for fire brick purposes, and the specimen brick is said to have withstood a high degree of heat. This can hardly be correct, as the brick shown contains enough iron to color it a bluish brown, and the amount of alkalies in the clay, as shown by the analyses, is very high. The process used in making this brick and the maker's name could not be obtained. Thickness of bed, one foot.

The underlying deposit at this place is a light blue clay with a slightly pinkish shade, laminated in thin layers, and where exposed on the Daingerfield road, somewhat mixed with the upper deposit. At Hill's Nursery, on the Linden road, the exposed thickness is about two feet, although it apparently has a greater thickness. This clay is plastic, and stained in spots with brown iron stains. Although containing some mica, it is much freer from that mineral than the others. This clay will be found a much better fire resisting article than the other clays, and if properly ground and mixed may give fair results in fire brick making, although its refractory qualities will not stand very high. Its plasticity will also make it useful as a pottery clay.

Analyses.

The following analyses are of these clays:

Upper deposit, Daingerfield road.

Silica	80.20
Alumina	12.27
Iron	1.53
Potash	1.34
Soda	5.11
Lime and magnesia	Trace.
	100.45

Lower deposit, Linden road.

Silica	58.20
Alumina	23.97
Iron	4.43
Potash	2 09
Soda	5.02
Water	5.36
	99.07

The mixed clays found in association with these two deposits are suitable for the manufacture of clay goods where color or fineness of texture do not enter, such as drain tiling, flower pots, etc.

The extent of these deposits is over two square miles. The overlying cover of brownish yellow sandy clays make a very fair class of ordinary building bricks. These bricks, when burned hard, give a pale gray-spotted brick, and show a considerable amount of shrinkage, chiefly in the air drying.

There are no permanent brick yards in Jefferson, and the only one in operation is a temporary yard opened to supply bricks for the Lone Star Furnace Company, and when the contract is filled the yard will be closed.

TABLE SHOWING ANALYSES OF CLAYS FROM JEFFERSON, MARION COUNTY, TEXAS.

No.	Silica.	Alumina.	Iron.	Potash.	Soda.	Magnesia.	Lime.	Water.	Total.	
901*	58.20	23.97	4.43	2.09	5.02	......	......	5.36	99.07	Dried at 115° C.
902*	80.20	12.27	1.53	1.34	5.11	Trace.	Trace.		100.45	Dried at 115° C.
903*	62.40	20.66	8.54	1.12	7.77	Trace.	0.40	.. ..	100.89	Dried at 115° C.
930*	76.00	9.45	4.75	2.00	4.00	......	Trace.	4.70	100.90	Bricks.

Analyses made in the Laboratory of the Geological Survey of Texas by *J. H. Herndon.

Localities.

No. 901. Linden road, one and one-half miles from Jefferson.
No. 902. Daingerfield road, one mile from Jefferson.
No. 903. A. Richardson headright.
No. 930. J. Higgins' yard.

2. MOULDING SANDS.

A good moulding sand is more of the texture of a fine clay loam than a sand proper. Many of the brownish yellow sands around Jefferson are in every respect suitable for moulding purposes. The extent of these sands is co-extensive with the brick earths, and the moulding sands generally lie from one to three feet under the surface.

3. GREENSAND MARLS.

In a bluff overlooking Big Cypress, at a place known as the Yankee Camps, and within the corporate limits of Jefferson, there is an exposure of greensand marl having a length of about one hundred and fifty yards and a thickness of about twelve or fourteen feet. This deposit extends from the low water level in the bayou to within four feet of the surface of the bank, and presents a more or less variegated appearance. If found suitable for fertilizing purposes, it has the advantage of being readily accessible at ordinary stages of the water level in the bayou. The following is a section of the bluff:

1. Yellow sand, with ferruginous and quartz pebbles.................. 4 feet.
2. Thin layer of iron.. 2 inches.
3. Ash gray colored sand.. 2 feet 6 inches.
4. Black micaceous clay.. 10 inches.

5. Dark brown and greenish colored sand, showing a dark chocolate colored interior........ 3 feet.
6. Thin layer of iron........ 2 inches.
7. Ash gray and blackish green colored sand to water........ 3 to 5 feet.

These sands, although hard when taken from the bank, are very friable and readily crumble between the fingers.

The following is the analysis of this sand:

Silica	45.80
Alumina and iron	38.40
Lime	2.20
Magnesia	2.23
Potash	1.14
Sulphur	0.77
Phosphorus	Trace.
Soda	6.00
Loss on ignition	4.21
	100.75

LIGNITES.

Several deposits of lignites are known to exist in various parts of the county. In the boring of a deep well at Jefferson three beds of lignite were passed through at different depths, the first one being struck at thirty-four feet. Lignitic deposits are also found at many places along the north side of Caddo Lake, both in the wells and in the channels of many of the numerous streams which enter the lake on that side These deposits are, however, reported as being too thin for practical purposes, the thickest at present known being not more than eighteen or twenty inches in thickness.

These lignite beds have not yet been studied sufficiently to determine their actual thickness or areal extent and qualities.

The lignite deposits of Marion County belong to the great lignitic deposits which are found extensively developed throughout the whole of Eastern Texas, lying at different depths and of varying thicknesses, and at the same time of a generally fair character.

In speaking of Texas lignites, Dr. Penrose says (First Annual Report of the Geological Survey of Texas, p. 95): "These lignite beds occur throughout all East Texas, from the top of the basal clays on the western edge of the timber to beyond the middle of the Fayette Beds, sometimes to within a hundred miles or less of the gulf coast. They are not confined to any special strata. Yet they are so numerous and often so thick that if they were to be used on a large scale vast quantities of the material could be obtained. They vary in thickness from a fraction of an inch to over twelve feet."

CHAPTER III.

HARRISON COUNTY.

BY WM. KENNEDY.

THE IRON ORE REGION.

The iron ore deposits of Harrison County form a part of the great ore bearing belt extending through East Texas from Sulphur Fork of the Red River, on the northern boundary of Cass County, southward through Cass, Marion, Harrison, Upshur, Gregg, and other counties.

The boundaries of the Harrison County ore bearing lands may be roughly localized as follows: Beginning at the Gregg County line, near the south side of the David Hill headright, and running east to the west side of the W. S. Smith headright, thence turning southeasterly to the southwest corner of the W. C. Crawford headright. From this point it turns north, curving around to the southwest corner of the upper division of the W. McIlvain headright, thence east to the middle of the western half of the south side of the William Patton headright, and then southeasterly through the Jose Sanchez headright, extending a short distance into the John M. Dorr headright. The line then turns east by north to near the northeast corner of the same headright, and then follows the left bank of the Potter Creek, at a short distance west of the creek, into and through the S. P. Hall headright. Turning on the left bank of Potter's Creek, it follows the course of that stream to near the centre of the Clery Grillet headright. The line then turns sharply east to the southeast corner of the Ephraim Tally headright, thence north along the east side of the same to the south side of the Samuel Jordan headright. From the Jordan headright the line continues in a broken condition to the east side of the Robert W. Smith headright, with a few detached outlying knolls on the D. Macdonald and J. Prewitt headrights. From the southeast corner of the Robert W. Smith headright the main line turns northerly through the Smith and Henry Martin headrights, northeasterly through the Thomas Gray, Joseph E. White, and John Johnson headrights, and into the Joel B. Crain headright. In the southwestern end of the Crain headright the ore line turns westerly through the Crain, J. C. Post, Lewis Watkins, and Thomas Gray headrights to the bottom lands of the Little Cypress Creek. The line then follows the margin of the Cypress bottom lands to the southwest corner of the James Gormon headright, and then south by east through the Henry W. Vardaman headright to the northwest corner of the Buffalo Bayou, Brazos and Colorado Railway Company, westerly through a part of the W. D. Mize, and into the southeast corner of the John Page headright. From near the centre of the John Page headright the line runs southwesterly through the Francisco Calvillo, Martin V. Lout, S. Choate, and M. L. Downing headrights, into the southeast of the Micajah Lindsey headright. The line turns northwest for a short distance through the Lindsey headright, and then turns in a general west by south direction to the centre of the Samuel Porter headright. It then passes through the north side of the Philip H. Pearson and runs west to the county line, on the north side of the David Hill headright.

The northern side of this division is broken in several places by creeks. The two most important of these breaks are made by the wide bottom lands of Blalock's Creek, in the Thomas Gray and Henry W. Vardaman headrights, and Ray's Creek, running northerly through the William D. Mize and Robertson Ascher headrights.

The southern portion of the boundary of this field is very broken, and from the southeast corner of the Ephraim Tally headright to the Lake bottom lands appears more in the form of detached portions or hills, containing ore in greater or less quantities.

The northern iron field of this county lies altogether upon the north side of the Little Cypress Creek. The southern boundary of this field begins on the west on the south side of the Eli Casey headright, extends east to the southeast corner of the E. N. Eubank headright, thence southeast to the north side of the David Adams, through this headright, and then curving southerly to the north side of the W. C. Allan headright. From here it turns easterly, curving around towards the north to the southeast corner of the M. Hunt headright; thence northerly through the Ward and the S. T. Watt headrights, and northeasterly to the northeast corner of the A. J. Oney. From this point the line runs almost due north to the Marion County line. In some places this boundary line rises abruptly from the edge of the bottom lands and at others by easy, gradual stages or benches.

The total area of ore land within Harrison County lying in the East Texas ore belt may be placed at two hundred and forty-five square miles, divided thus:

North of Little Cypress	95 square miles.
South of Little Cypress	150 square miles.
	245 square miles.

Small ore bearing areas are found at various places to the south and east, lying without the limits given above. These are generally in the shape of rounded or oval shaped hills, capped with thin deposits of ferruginous sandstones and laminated iron ore in a broken and fragmentary condition. Nodular concretionary ores are also found in the same localities, and occasionally in the neighborhood of the streams bowlders of conglomerate ore occur, but usually of little or no economic value.

Deposits of this class occur on the Josiah Prewett and southeast corner of the John Johnson headrights. These deposits are chiefly ferruginous sandstones in small fragments, and lie upon the tops of small rounded hills of brown sand. Another deposit occurs upon the southwest corner of the Elizabeth Carroll headright, about three miles from the Sabine River. The deposit here covers an eliptical shaped hill about sixty feet high, and is mainly composed of broken laminated ore of the massive variety and ferruginous sandstones, the sandstones greatly predominating. Near Roseborough Springs, on the P. Lindsay headright, there is another deposit of thinly scattered fragments of ore lying upon a light brown sand, which in turn rests upon a stratified grayish white sand or sandy clay, with occasional red or brown strata lying among the grayish white sand. On the J. P. Townly headright, on the east side of the Sherrard Branch of Hagerty's Creek, there are two hills of about eighty and one hundred feet elevation, and rising precipitously from the bottom lands along the creek. These hills are covered with large blocks of ferruginous sandstone, but no iron of any class appears. Another deposit of the same character occurs on the north end of the Hamilton McNutt and Joel B. Crain headrights. This deposit consists for the most part of a thinly scattered layer of ferruginous sandstone, with a few nodules of concretionary ore.

Throughout the non-iron ore bearing portions of the county there are occasional thin deposits of ferruginous gravel, small pieces of ore, and sandstone. These deposits do not as a general thing exceed an inch in thickness, and are not more than a few yards square in extent. None of these deposits are of any economic value.

TOPOGRAPHY.

The ore region of Harrison County appears to form the remnant of an extensive plateau, which extended from the northern part of the State southward. This plateau-like region is cut off somewhat abruptly towards the south and northeast portions of the county, and also shows that a considerable amount of erosion has taken place in the northern part of the county. All that now remains is the narrow flat-topped ridge extending from the western boundary of the county eastward to about seven or eight miles north and east of the town of Marshall.

Along the southern margin the elevations of the ridge, as compared with the lower stage of the country, show some abrupt changes within short distances.

These elevations, secured from railroad profiles and barometric readings, give the northern side an average height of about two hundred feet above the bed of the Little Cypress Creek. The elevations shown by the levels of the Marshall and Northwestern Railway, and barometric readings through the region north of the Cypress, show the country to the south of the creek to have an average elevation of from eighty to one hundred feet above the northern part of the county.

These figures also tend to show the existence of a flat-topped ridge extending from the western line of the county eastward to some miles east of the town of Marshall, and having an average elevation of about eighty feet above the surrounding lower lands along the southern side, and gradually rising towards the northern side, where the average elevation appears to be about two hundred feet above Cypress Creek and in places from eighty to one hundred above the highest points of the northern part of the county.

This ridge at its widest part does not exceed eight miles, and narrows towards the western part of the county, where the width does not exceed four and a half or five miles. On the east, the ridge breaks into a succession of lower ridges, gradually losing its distinctive elevation until it merges into the general level of the lower lands. On the northern and southern sides the face of the ridge slopes gradually from the lower to the higher levels, except where the larger creeks flowing from the higher grounds, both towards the north and the south sides, have cut wide steep-sided channels. In some places there is an appearance of bench-like formation, but this does not appear extensively or continuously for any distance, and only where there is a difference in the material composing the beds or owing to the presence of beds of iron ore.

On account of the erosion due to the presence of numerous small streams and some large creeks, this southern ridge presents the appearance of a series of flat-topped, rounded and oval-shaped hills, having, with some few exceptions, the same general elevation. The higher hills, such as Hynson's Mountain, Barnes' Hill, Twyman's Hill, on the south side of the Clery Grillet, and the ridge stretching northwesterly through the John Deckert and Seth Sheldon headrights, owe their higher altitudes to a covering of sandstones and iron ores. On the same general principles, it may be said the rounded hills rising out of the lower plain to the south and east of the county owe their existence to their protective covering of sandstone and ore.

What might be considered the crest line of the region, or the divide between the drainage area of the Sabine River and the Little Cypress Creek, is extremely irregular, and in two places is almost cut through by the waters of the creeks. On the O. H. P. Bodine survey the Moccasin Creek flowing north and the Dufford's Creek flowing south, interlock, Dufford's Creek taking its rise between two prongs of the east branch of the Moccasin. The same thing occurs near the headwaters of Ray's Creek and the middle prong of Potter's Creek. On the eastern end of the ridge the different headwaters of the Eight-Mile, Haggerty's, and Watkins' creeks interlock with each other so as to present a complicated series of low rounded hills and deeply cut stream channels.

On the northern side, going west from Marshall, a series of creeks known as Potter's, Caney, Page, Moccasin, Panther, and Clear flow north into Cypress. These creeks have cut narrow, deep ravines through the sands and clays along their upper portions, and have formed tortuous channels through comparatively wide sandy bottoms as they near their respective points of junction with the Cypress. Most of these streams have their origin in springs and have deep, steep-sided, rounded heads, with occasional overhanging banks.

Numerous small streams exist throughout the region, having a tendency to form the country into the appearance of a double comb, having the back or main ridge extending in an easterly and westerly direction and the latteral spurs turning in a north and south or somewhat northeasterly and southwesterly direction. In many cases the latteral spurs have an elevation equal to the main ridge.

The part of the county lying to the north of the Little Cypress forms a plateau-like region, much broken by stream courses. This region lies at a much lower elevation than the country to the south of the creek.

Its southern side, along the Little Cypress Creek, rises somewhat abruptly from the bottom lands. At Jones' Crossing, near the Upshur County line, the difference of elevation between the creek bottom and the hills along the southern boundary of the plateau is ninety-six feet. At Allan's Crossing the upland shows an elevation of two hundred and sixty-two feet and the bottom lands two hundred and eleven, a difference of fifty-one feet. Coming eastward, at Sloan's Bridge the side of the table land rises from two hundred and ten feet to three hundred and forty feet in a distance of two miles. The levels of the Marshall and Northwestern Railway show an increased elevation of from two hundred and eight at the bridge over the Cypress Creek to two hundred and sixty-nine at the eastern side of the ore field. In the two last places the ascent is made by successive easy, bench-like grades, due probably to the presence of beds of laminated ore in the hills of gray sand peculiar to this northern section of the county.

Along the southern side of the plateau, going west, there are only three creeks of any size; Bear Creek, to the action of which is due largely the abrupt termination of the plateau in its eastern extension; Lick Creek, near the centre of the region, and Eagle Creek, in the western end.

To the south and east of these ridges the country is rolling and in places hilly, but with a general lowering of level until the flat bottom lands of the Sabine River and the region of the Caddo Lake system is reached. Throughout the lower region there are a few conical shaped hills protected from the general leveling process going on rapidly by a capping of ferruginous sandstones and broken fragments of ore.

STRATIGRAPHY.

For the division of the county into a northern (that lying north of the Little Cypress Creek) and a southern division (or that portion of the county lying southward of the same creek), there are other reasons beside the simple geographical fact that these two districts are separated by a large creek having a margin of broad bottom lands, or the question of altitude The two divisions are different from a stratigraphical point of view. In the southern field there is a considerable extent of country overlaid by a rich brown or dark orange-red sand, containing a considerable quantity of ferruginous gravels, siliceous pebbles, and fossil wood. To the north of the Cypress this brown or orange-red sand is not to be found anywhere. In the southern field the overlying sands generally lie upon sands having a lighter yellow or white color, and where these sands are wanting the upper brown sand rests immediately upon thinly laminated red and white sands or clayey sands, or their equivalents, the unstratified mottled red and white clayey sands. North of the Cypress the universal covering is a gray sand resting upon beds of laminated iron ore or upon a very heavy deposit of alternate strata of gray clay and gray sand. In this deposit, which appears to be somewhat similar to the borings from the deep well at Jefferson, the gray clay usually lies in strata from two to four inches in thickness and the sands in somewhat thicker strata. Occasionally the clay assumes a heavy bedded or even an unstratified condition, in which the deposit is frequently from five to seven feet in thickness. The total thickness of the deposit of gray clay and sand is not known. In one place it has been pierced to a depth of thirty-one feet without passing through it.

The following three sections show the structure of this part of the county:

I. Well at M. B. Alexander's house, on A. Dean headright. Altitude about 300 feet.

1.	Gray unstratified sand	10 feet.
2.	Laminated iron ore and sandstone	5 feet.
3.	White sand	5 feet.
4.	Alternate strata of grayish white sand and clay. The clay appears to be lying in strata of from 2 to 4 inches and the sand from 4 to 5 inches. At 45 feet the sand becomes thicker at the expense of the clay	31 feet.+
		51 feet.

II. Well at G. W. Cook's house, on the S. N. Hall headright, about five miles northwest of No. 1. Altitude, 382 feet (bar.).

1.	Gray sand	1 foot 6 inches.
2.	Gray clay	15 feet.
3.	Gray laminated clay	2 feet.
4.	Slaty clay	2 feet.
5.	Sandstone	1 foot 6 inches.
		22 feet.

III. Section from cutting in road at Mr. Allan's house, on the W. C. Allan headright, close to Little Cypress bottom lands and about three miles south of No. 1. Altitude of creek bottom, 212 feet.

1.	Brownish gray sand, seen a few yards back from edge of bluff	3 feet.
2.	Conglomerate ore in blocks measuring from 18 inches to 2 feet. This conglomerate is hard and solid and forms surface of bluff at edge	2 feet.
3.	White sand stained yellow in places. This sand is hard and compact	6 feet.
4.	Laminated iron ore, with thin overlying stratum of sandstone—iron of massive variety	4 inches.
5.	Greenish yellow spotted sand in a compact form, somewhat glazed on outer surface, but broken with numerous irregular fractures filled with iron, giving the face of the bed a reticulated or net-like appearance	10 feet.
6.	Laminated ore and ferruginous sandstone	2 feet.
7.	Greenish yellow sand spotted with round dirty white or gray spots. In other respects this bed resembles No. 5	10 feet.
8.	Soft, friable, very sandy conglomerate lying at base and probably a recent formation not belonging to above section.	

This section lies below the one at M. B. Alexander's well, but whether it discloses the state of affairs underneath the region in which the well lies can not be corroborated.

The southern division, or that part of the county lying south of Little Cypress, divides itself naturally into three sections: First, the high plateau-like region extending through the central portion of the county from the western boundary to a few miles east of the town of Marshall and upon which Marshall stands; second, a belt of land lying around the base of this ridge and within a 300 foot contour line, the chief characteristic of which is its dark brown or orange-red sands with their associated gravels and fossil woods; and, third, an area of gray sands and silts lying in a semi-lunar shape along the Louisiana State line, with projecting horns or extensions stretching along the lake region in the north and the Sabine River on the south, and beneath the three hundred foot line.

To this region belong the bottom lands around these waters as well as a large portion of the Little Cypress bottoms.

1. The structure of the plateau or ridge of ore bearing country of the county is shown by the following sections to consist of sands, clays, and ore deposits:

I. Well near Mr. J. B. Hall's house, on the Clery Grillet headright. Altitude, 550 feet.

1.	Soft yellow unstratified sand	27 feet.
2.	Dark brown laminated ore	6 feet.
3.	Coarse yellow sand	10 feet.
4.	Dark brown laminated ore. Thickness unknown.	

II. Section of east side of Hynson's Mountain, near Mineral Springs, on S. Wagley headright. Altitude of hill, 572 feet.

1.	Ferruginous sandstone blocks and fragments of laminated ore lying on side of hill and mixed with a brown sand and gravel	50 feet.
2.	Thin layers of a slaty dark blue color	10 feet.
3.	Light blue clay and sand with streaks of iron stains and ferruginous matter	10 feet.
4.	Clay ironstone	4 inches.
5.	Black micaceous sand in thin laminæ and containing casts of fossil shells	20 feet.
6.	Yellow sand	
	Total	90 feet 4 inches.

A section on the W. B. Brown headright shows the following:

1.	Yellow sand	6 feet.
2.	Hard yellowish gray sand	19 feet.
3.	White sand, with streaks of white clay, weathering yellow and having a tendency where exposed to break into irregular blocks	46 feet.
4.	Thin layer of laminated ore	2 inches.
5.	Bright yellow clay	8 inches.
6.	Black micaceous clay	8 feet. +

The elevation of the upper surface of this section is about 420 feet.

A hill on the northern side of the E. A. Merchant headright shows a section of

1.	Dark brown unstratified sand	5 feet.
2.	Ferruginous gravel	1 foot.
3.	Stratified white and red sand and sandy clay	6 feet. +

Altitude of hill, 442 feet.

On the road near Nesbitt's Spring, on the west side of the Francisco Calvillo headright, a cutting shows:

1.	Brown sand with ferruginous gravel	4 feet.
2.	Mottled sandy clay	6 feet.
3.	Stratified black clay in beds of about 2 inches	8 feet. +

In a cutting on the Marshall and Northwestern Railway, about a mile west of Marshall, the section is as follows:

1.	Surface soil of yellowish brown sand and gravel	6 inches.
2.	Red sand	1 foot 6 inches.
3.	Soft red sandstone, with patches of blue, dipping slightly to the west	10 feet.
4.	Sandy clay parting	2 inches.
5.	Sandstone like No. 3	3 feet.
6.	Stratified red and white sand and sandy clay	6 inches. +

The elevation of this cutting is 460 feet above tide.

The stratified red and white sand and sandy clay (No. 6) of this section is seen in various cuttings between this place and the centre of the town of Marshall, and also stretching north and east of the town.

At the pumping house of the Marshall City Water Works a section of the hill gives the following:

1.	Brown gravelly sand	5 feet.
2.	Laminated ore and ferruginous sandstone	1 foot 6 inches.
3.	Stratified red and white sand and sandy clays, with mottled sand in front	45 feet.
	Add to this, section of wells bored in valley of Walnut Creek:	
4.	Surface soil, brown sand and gravel, 12 to 15 feet (wash from hills on either side).	
5.	Blue clay	3 feet.
6.	White sand with some gravel, with increase of gravel towards bottom,	43 feet. +
	Total	97 feet 6 inches.

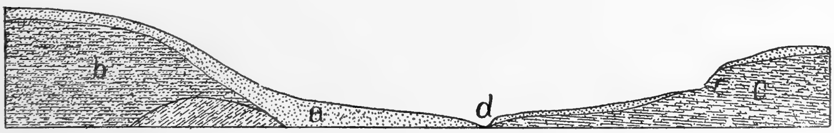
The elevation of the top of this cutting is about 387 feet above sea level.

Along the Marshall and Longview road going west from Marshall the cuttings made for drainage and other purposes, as well as the washouts, show a series of almost horizontal beds of brown unstratified sand, ferruginous matter, and stratified red and white sands and sandy clays, with occasional patches of mottled clay and sand for nearly four miles. At the hill on the S. P. Hall headright the level of the country suddenly falls about fifty feet. The cutting shows the following section:

1.	Brown unstratified sand, with fragments of laminated ore	3 feet.
2.	Stratified white and red sand and sandy clay	40 feet.
3.	White sand at base having a stratified appearance with an easterly dip of 20°	6 feet.

The brown sand (No. 1) overlaps the end of the white and red sand and clay and also covers the white sands. Half a mile farther west these white sands (No. 3) form the surface for a few yards, when they again disappear under yellow sands. In the western exposure the white sands have a slightly western dip. These sands are also seen on the Jose Sanchez headright. In this place, however, they are more of a clay than a sand.

Section of Hall's Hill, on S. P. Hall headright, four miles west of Marshall:



E Fig. 5. W

a, Brown sand. b, Stratified red and white sand. c, White sand. d, Creek.

From these sections it will be seen that the great bulk of the table land consists chiefly of an unstratified brown or yellowish brown sand overlying a regularly bedded, thinly laminated red and white sand or sandy clay. The unstratified sandy deposits appear to have a thickness ranging from one foot to sixty feet, and contain all the iron ore deposits found within the region. The stratified red and white sands and sandy clays attain a maximum thickness of about seventy feet. The stratified sands of Cass County become in Harrison more of a clayey nature and the strata generally appear thicker. In some sections of Harrison County the white strata attain thicknesses of two or three and even five and six feet. Wherever these beds outcrop in water courses the stream bed and banks are generally strewn with pellets of pure white clay in sizes ranging from that of a pea to that of an ordinary hen egg. These pellets are due to the breaking down of the beds and the washing away of the loose sands from their clayey matrix and the leaving of the clay to form the embryo nodules found.

Between these two deposits occurs a thin ferruginous parting ranging from one inch to a foot or even a foot and a half in thickness. This parting is invariably present in some one of its many forms of gravel, ferruginous sandstones, or laminated ore, and forms the lowest ore deposit.

The next lower member of these beds is what is known in the locality as soapstone. This is thinly bedded dark blue clay, frequently jointed and containing rarely partings of a dark colored sand. This clay extends beyond the plateau and underlies the brown sand of the next lower division of the county. So far as seen it appears to have a maximum thickness of eighteen feet.

Lignite occasionally appears underlying this clay, but not with any degree of certainty or regularity.

The fourth member of the series is a stratified blue clay, weathering to a pale blue color and having that tint towards the top, but darkening in color towards the bottom of the bed. Maximum thickness known, thirty feet. This deposit extends eastward as far as the third division, or gray sand area, and under it for a considerable extent.

The fifth member of the series appears to be a black clay, not exceeding eight feet and only found in the eastern portion of the county. Its place in the west and northern part of the county appears to be occupied by a white gravelly sand, which in the Marshall Water Works wells is at least forty-three feet thick.

The sixth member of the series is a micaceous black sand or clayey sand, thinly and irregularly laminated, showing a total thickness of eighteen feet. This is underlaid by a thin seam of lignite about one foot thick.

The seventh is a yellow or white sand, having a known depth of twenty-five feet.

The eighth and lowest deposit is a stiff black micaceous sandy clay, containing numerous deposits of iron pyrites. In the deep well at Marshall this clay has a thickness of nine hundred and fifty-four feet, and rests upon a blue limestone (probably one of the large bowlders of the Basal Clays).

2. The structure of the dark brown or orange-red sand covered area lying around the base of the ridge or plateau is shown by the following sections:

About a mile east of Marshall, on the Scottsville road, a cutting shows the following section:

1.	Brown sand and gravel	3 feet.
2.	Thin parting of gravelly ferruginous sandstone	1 inch.
3.	Stratified red and white sand and clayey sand	20 feet.

The elevation of this section is about three hundred and ninety feet.

At the second mile, on the same road southeast of Marshall, a section of the hill shows:

1.	Brown sand containing a considerable quantity of gravel	2 feet.
2.	Thin parting of ferruginous matter	2 inches.
3.	Stratified blue clay	10 feet.
4.	Dark blue stratified sandy clay	20 feet.
5.	Covered by a deposit of gravelly sand similar to the material lying on the top but comparatively free from gravel	20 feet.

The top of this hill is flat for nearly a quarter of a mile, and on the southeast side of the dark blue stratified sandy clay (No. 4) is replaced by a greenish brown unstratified sand, having numerous small rounded and oval whitish gray spots scattered through it. This sand has a tendency to glaze upon exposure. This deposit is underlaid by the thinly laminated, regularly stratified red and white sands. The elevation of this hill is about three hundred and ninety feet.

Six miles southeast of Marshall, on the same road, a cutting shows the following section:

1.	Dark brown unstratified sand, with a small deposit of greenish blue sand at base,	4 feet.
2.	Ferruginous parting, laminated	1 foot.
3.	Greenish hued sand, weathering to a gray, stratified in thin laminæ and having a slight dip to southeast.	1 foot.
4.	Dark blue stratified clayey sand, weathering to a lighter color; thickness unknown	2 feet.+

The elevation of this section is about three hundred and fifty feet.

Ten miles east of Marshall, on the Marshall and Shreveport road, a section taken from an opening gives the following:

1.	Cinnamon brown sand	8 feet.
2.	Thin bed of lignitic matter	10 inches.
3.	Dark blue sandy clay, breaking into irregular fragments	2 feet.
4.	Light blue sand	6 feet.

The dip of these beds is southeast, apparently about 5°, and the elevation of the cutting about three hundred feet.

On the J. Johnson headright, at the old Haggarty farm, a section taken from a washout gives the following:

1.	Dark brown or orange-red sand, with quantities of fossil wood	4 feet.
2.	Ferruginous gravel cemented together	10 inches.
3.	Brownish yellow sand	2 feet.
4.	White sand	3 feet. +

These sections are all from the lower terrace or belt of country lying at the base of the plateau-like ridge running east and west through the county and lying between this ridge, and the belt of gray silty sands having a still lower level along the courses of the Sabine River and Caddo Lake region and stretching across the county in a semi-lunar form between these two points, having the projecting horns stretching along these two water courses, while the center of the crescent reaches to near the Papaw Creek on the east side of the Lucinda Wallace headright.

The average elevation of this belt of brown sand is about three hundred and fifty or three hundred and sixty feet above sea level.

The upper sand of this area may be described as a dark brown, somewhat between an orange and a red color, changing in localities to a lighter hue or grayish brown and cinnamon brown color. This sand is somewhat coarse-grained, and among its chief characteristics are: (1) Its total disregard of the condition or form of the underlying beds. It covers all alike. Over the stratified red and white sands and sandy clays, unstratified mottled sands, and where these are absent lying upon the stratified dark blue clays or greensands, this brown sand lies like a mantle. It varies in its thickness according to the condition of the underlying materials. (2) The great quantities of gravel found in association with this sand. This gravel is chiefly derived from ferruginous sandstones, but considerable quantities of a white quartz stained yellow, and small rounded and waterworn pebbles of a grayish crystalline or metamorphic rock are found throughout the deposit. These gravels are found bedded in pockets and scattered throughout the sand, singly or in small numbers. In the darker browns the gravels when present are usually found bedded as in the dark brown sands on the Johnson, Townsend, and Payne headrights. Among the lighter browns and grays the pebbles are scattered in no uniform manner, but are generally found singly and at considerable intervals. Another circumstance worthy of note connected with the presence of these gravels is the fact that when the pebbles are scarce or sparsely scattered through the sand there is a total absence of the softer ferruginous pebbles and nothing but the harder crystalline materials are present. Whether the ferruginous gravels be derived from the thin beds lying in the higher ridges of the county (and they appear to be), it is true that the farther we get away from the breaks along the sides of these ridges or the lower lying hills along the plateau margin the fewer deposits of ferruginous gravel are to be found. Another circumstance connected with the existence of these quartz and other crystalline pebbles is their existence among the brown and yellowish brown sands frequently found capping the highest points of the central plateau and consequently above the sources of the ferruginous gravels.

The origin and movement of these ferruginous gravels may be illustrated by Section III, already given, and shown in Figure 6. In this section the brown sand overlying the summit of the hill to a depth of two feet contains so much ferruginous gravel derived from the weathering of the sandstone bed that the deposit might almost be considered a ferruginous gravel. The heavy deposit of brown sand lying at the foot of the slope shows comparatively few pieces of ferruginous matter. The sand as well as the gravel at both places are of the same nature and both are derived from the same source.

Diagram showing relative positions of ferruginous gravel and brown sand on hill two miles southeast of Marshall (Section III):

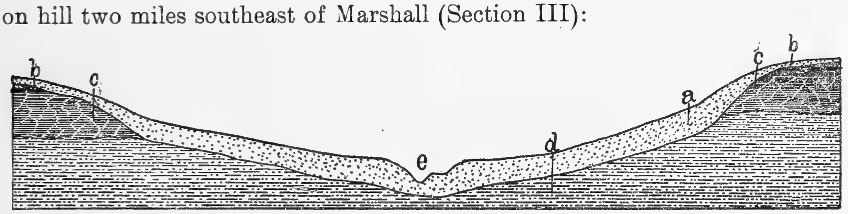


Fig. 6.

a, Brown sand. b, Ferruginous parting. c, Stratified blue clay. d, Dark blue stratified sandy clay. e, Creek.

3. The third characteristic of this brown sand, and the most distinguishing one, is the presence of fossil wood in large quantities. In size these fragments vary from two to ten inches in diameter and from six inches to ten feet in length. Some of the fragments indicate trees having a growth of from twenty-eight inches to three feet in diameter.

The wood is generally silicified and has a white or brown color. The colors, however, vary according to the prevalence of iron in the sand. Some of the fragments are stained a dark iron brown, and others have the molecules of vegetable matter largely replaced by a hydrate of iron. Some of the fragments are soft and chalky white, readily soiling the fingers, and others are hard and sonorous when struck with the hammer.

There does not appear to be any abrupt or sudden change between the region occupied by the brown sand and the area overlaid by the light gray silty sand, forming the third division and lying to the south along the Sabine River and eastward along the Louisiana State line. These gray sands occupy a generally lower level, having an average altitude of about two hundred and fifty feet. which gradually lowers towards the lake region in Louisiana. Greenwood having an elevation of two hundred and twenty-two and Shreveport one hundred and ninety-five feet.

Where the brown and gray sands meet in the vicinity of water courses the brown occupies the upper ground lying along the margin and the gray lies within the bottom lands—no brown being found in that area. From this position it looks as if the gray sands belong to a newer formation or a more recent period of the same age, and have been laid down since the present system of drainage had its origin.

The few sections obtained from this area show the gray sands to be underlaid by brown, gray, and mottled clays; the mottled clay being mostly unstratified, while the stratified brown and gray clays are frequently cross-bedded and irregular in their deposition.

Section of well on James Harkin headright, near the Louisiana State line. Altitude two hundred and eighty feet:

1.	Clay soil	1 foot.
2.	Brownish clay	4 feet.
3.	Hard, smooth, laminated clay with occasional strata of gravel	18 feet.
4.	Gravelly clay—gravel more abundant than clay	3 feet.
		26 feet.

In some places on this headright the sands and clays are twisted and broken and more or less cross-bedded.

At Robertson's Ford a section of the river bank gives:

1.	Gray sand	1 foot.
2.	Mottled, brown, blue, and yellow unstratified clay	45 feet.
3.	Lignite	6 feet.
4.	Dark blue sandy clay to water	3 feet.

IRON ORES.

The iron ore deposits of Harrison County consist mostly of laminated and conglomerate ores, with a small quantity of nodular concretionary ore. The laminated ores are found generally in a broken and fragmentary condition, mixed with ferruginous sandstone, capping many or most of the hills within the limits of the county or else lying buried under a superincumbent mass of yellow or gray sand and showing no outcrops beyond a broken and fringed end of the bed lying upon the surface of and protecting some bench-like extension of the sand hill. It is also frequently found in digging wells. This ore is found in extensive deposits in various parts of the county.

Along the margins of the streams and at a considerable height up the hills, lying close to the water courses and even capping the low lying hills in the same positions, the two grades of conglomerate ore are found scattered in the form of large irregularly shaped blocks. The lower and more recent of these deposits are frequently in a thinly bedded condition.

The geode or nodular concretionary ore, although sometimes found among the higher yellow and gray sands, belongs more essentially in this county to the dark brown and red sands belonging to the middle division of the county.

In thickness these deposits vary from the scattered deposits of a few inches to a maximum thickness of twelve or fourteen feet for laminated ore. For nodular, concretionary, and conglomerate ores no thickness can very well be given, as those ores are generally found in the form of nodules or bowlders. Probably the heaviest deposits of nodular ore are those found on the W. C. Crawford headright, where, mixed with a brown sand, it reaches a thickness of four feet. On the J. M. Dorr headright the same material is about seven feet. The conglomerate ores are generally found in the form of large irregular blocks or bowlders, and measure in places from $2\times2\times1$ to $6\times4\times2$ feet, and many are even larger—some on the north side of Little Cypress Creek having a size of over ten feet in length and from three to five feet in thickness. On the C. Grillet headright it forms a ridge of blocks for some distance and having an elevation of about fifteen feet.

In that portion of the county lying to the north of the Little Cypress Creek the ores found consist of laminated and conglomerate ores, the conglomerate greatly preponderating. At Oney's Mill, on Eagle Creek, on the S. B. Simpson headright in the western part of the county, the conglomerate ore lies upon both sides of the creek in the form of huge masses, some of which measure ten feet in length, eight feet in width, and over three feet in thickness. These huge blocks lie piled on the top of each other to a height of over twenty feet along both sides of the creek for more than two hundred yards. Further down the stream, and underneath these blocks, a bed of laminated ore of the massive variety about a foot thick appears in the breaks of the hill along the widening bottom connected with this stream. This is on the eastern bank of the creek, and along the western bank these ores appear in a similar relation to each other. Oney's mill is situated within a few yards of the crest of the divide between the two Cypresses and on the south side. On the north side of this divide a small stream, tributary to the Big Cypress Creek, flows through a region covered by similar blocks of ore. These ores are on the S. B. Simpson headright, and they also occur on the John Morton, Dan Jones, M. Redding, and other headrights in this neighborhood, at which places they have about the same thickness. On the H. Oney and J. Oney, two small headrights southeast of the S. B. Simpson headright, laminated ore in a very broken condition shows a probable thickness of three or four feet.

The estimated thickness of the ores in this region may be considered as not exceeding a maximum of fourteen feet.

Coming east from this place the ores on the B. Wilson and D. Maxwell headrights do not exceed two feet. These are laminated and lie too deep for practical purposes. On the north side of the John Beaty, near Montvale Mineral Springs, the thickness is about four feet. On the Wm. Beckwell headright a very siliceous ore in blocks ranging from four to ten feet or more in length and from five to six feet in thickness caps some of the hills near Lancaster's Mill, and also occurs surmounting some of the higher hills on the J. Petsick headright. To the south of this, on the Stinson lands and the W. C. Allan headright the ores are mostly a conglomerate, with thinly bedded laminated ore underneath. The conglomerate lies mostly in its usual position along the margin of the higher ground close to Little Cypress Creek bottom lands or along the edges of the ravines formed by the small streams flowing into these bottoms. The ore in these lands, including the conglomerate deposits and underlying laminated ore beds, does not exceed five feet.

Along the D. Bryan, M. Hunt, and Daniel McPhail lands, and where the higher lands approach the Cypress bottoms, laminated ore crops out in various thicknesses, culminating in a bed five feet thick found in a well on the A. Dean headright at M. B. Alexander's house.

On the south side of the Little Cypress the thickest ore deposits reach the maximum of fourteen feet and in some places may exceed this, though in the majority of the ore locations the ore does not exceed four or five feet, and in many not more than two or three feet. In the western part of the ridge, on the Robert Hightower land, the beds of laminated ore have a thickness of over ten feet. It is somewhat thicker on the Peter Pinchum headright, where a break across the headright near the northern side shows a bluff of nearly fifty feet covered with projecting blocks of a siliceous ore; the thickness is probably from eight to ten feet. The deposit gets thinner as it comes east, as on the J. Bowen and Dan Davis and northern side of the Wm. Nelson headrights it falls to two or three feet. On the Seth Sheldon and John Deckert headrights the ore hills reach an altitude of six hundred and twelve and six hundred and forty feet, and so far as could be seen the ore covering averages a thickness of about five or six feet. It may be thicker, but its lower division is very liable to be considerably mixed with a brownish yellow sand.

On the Clery Grillet headright the surface ore in no place exceeds four or five feet. A deposit of conglomerate ore on the east side near the W. C. Duffield headright shows a ridge of blocks measuring from five to six feet in length and from two to four feet in thickness. In the northern part of this headright the surface ore shows a thickness of five feet. Near the centre of the headright, at Mr. J. B. Hall's house, a well forty-three feet deep passed through a bed of laminated ore six feet thick at a depth of twenty-seven feet, and after passing through ten feet of yellow sand underlying the ore bed the well stopped at a lower bed of the same grade of ore. The thickness of this lower bed is not known, as it was not cut into more than a few inches.

On the S. Wagley headright, at Hynson's Mineral Springs, and a hill about three-quarters of a mile west, the three classes of ore occur, having a combined thickness of probably twenty feet. These ores lie in different positions on the hill, and their thickness is hard to arrive at with any degree of satisfaction.

On the Ephraim Tally headright Barnes' Hill shows a deposit of crumbly ore about six feet thick. Through the Francisco Calvillo, W. B. Rhea, and Samuel Jordan headrights the ore deposits do not exceed two feet. On the Henry Teal headright the ore deposit is not over two feet in thickness, of which one foot is a laminated ore of the massive variety. In the northeastern portion of the ore region, on the Thomas Gray and Lewis Watkins headrights, a ridge of laminated ore ten feet in thickness occurs. The upper division is broken, fragmentary, and associated with red sand. The lower, as exposed in the Marshall and Jefferson public road, lies in a solid condition two feet in thickness.

Following the methods employed in describing the iron ores of the other counties in East Texas, the ores of Harrison County may be divided into three classes: 1, Laminated Ore; 2, Geode or Nodular Concretionary Ore; and, 3, Conglomerate Ore. Of these the laminated and conglomerate ores are the most extensive in their development. The geode or nodular concretionary ores, although found more or less scattered throughout the yellow and brownish yellow sands of the higher ridge through the centre of the county, are more intimately connected with and best developed among the dark brown or orange-red sands belonging to the second or middle division, lying at a lower level around the base of the ridge. Although laminated and conglomerate ores occur associated with these sands, the occurrences are rare and the ores not of a sufficient extent, except in very few places, to be of any practical value.

In the detailed descriptions of these ores the localities given are those in which the ores are most prominently developed. The smaller deposits found outlying among the gray sands in the eastern portion of the county are not considered of sufficient value to be enumerated.

1. LAMINATED ORE.

As we come southward the deposits of laminated ore, which in Cass County, towards the northern boundary of the iron ore region of East Texas, were found only in a fragmentary condition, appear to thicken, and from occupying a very insignificant position among the iron ores of the northern region in Cass, gradually assume a more prominent position in coming south until in Harrison County the development of this class of ore is such that it occupies the position of being the most important iron producing ore in the county.

Keeping to the same general principle of the thicker the overlying sandy deposit the thinner the underlying bed of laminated ore, it is noticeable that wherever these beds approach the surface or become the capping of the hill they become thicker and heavier, reaching their greatest development when found as a surface deposit. Although this may be accepted as a general rule, it is not without many extensive exceptions. Thin beds as well as thick deposits frequently occupy a position close to or upon the surface, while comparatively thick deposits of the ore lie at depths of from ten to fifty feet. It is, however, usually the case that where thinly bedded ores occur at the surface they are in a broken and fragmentary condition and mixed with great quantities of ferruginous sandstones.

The laminated ores of Harrison County occur in beds made up of thin laminæ of a dark brown or chestnut brown color, interlaminated with thin laminæ of a bright yellow, and have a resinous lustre. The yellow laminæ are frequently absent, and the beds then become a segregation of dark brown, almost black, glossy laminated ore. Surface deposits where the yellow colored laminæ are absent assume a lighter brown tint. These laminæ rarely exceed half an inch in thickness and usually do not exceed one-fourth of an inch. This ore also occurs as a massive ore of variable thickness—from two inches to three or four and sometimes five feet. In color these deposits of massive ore vary from a dark chestnut brown to a lighter shade of brown specked with small irregularly disseminated patches of yellow. In the thinner beds, the partings or sides of the strata are frequently of a dark, almost black, glossy hue. Laminated ore also occurs in considerable quantities in a crumbly condition, the pieces being generally in a thin, scaly, or cuboidal form, having the blocks and scales somewhat mixed with clay. In color, this class of ore is usually of a dark chestnut brown and has a brownish red streak. The powdered ore also shows a brown color.

The most extensive developments of laminated ore occur in the western part of the county on the Robert Hightower, John Bowen, western portion of the Daniel Davis, and north side of the William Nelson headrights. The ore in this region lies in the form of a ridge in an almost due north and south direction. The ridge is nearly half a mile long and from two to three hundred yards wide. The ore is a dark brown with glossy black and yellow partings, and lies in layers of from six to eight inches in thickness, the whole body being about ten feet thick on the Hightower land. Across the Bowen and on the western end of the Davis headrights, the quality remains the same, but the thickness is not more than three or four feet, and on the Bowen it is broken and fragmentary. This irregularity of thickness is apparently due to the fact that a break occurs on the Hightower land and the Bowen and Davis lands are considerably lower. It is possible the ore on these last two headrights belongs to the lower division of the Hightower ridge.

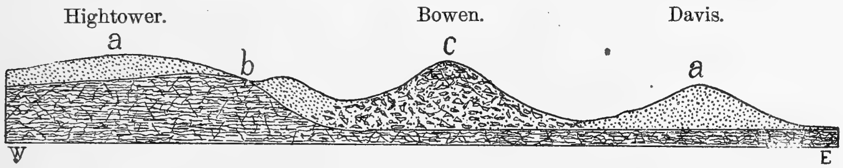


Fig. 7.

a, Yellow sand. b. Laminated ore. c, Fragmentary ore.

Due south of the Robert Hightower headright lies the Peter Pinchum headright. On this land, there is a ridge of siliceous ore or ferruginous sandstone, extending across the middle of the north half of the headright for nearly a quarter of a mile and from one hundred to two hundred yards wide.

This ridge has a face height of about fifty feet, which is covered with huge blocks, some of which measure ten feet in length and from six to eight feet in width and having an average thickness of three feet. It will probably be found fit for mining to a depth of thirty feet for some distance into the hill. This ore is too siliceous to be used alone for any iron work, but may be found suitable for mixing with some of the less siliceous ores.

Commencing on the south side of the John Decker headright, near the southeast corner, and extending in a northwesterly direction for nearly a mile and a half through the Decker and northern portion of the Seth Sheldon headright as far as the south side of the B. M. D. Burrows headright, there is a ridge of yellow sand covered with a heavy deposit of broken laminated ore of the massive and crumbly varieties, mingled with broken ferruginous sandstones. These pieces rarely exceed a foot in length, lie closely packed together, and form a solid iron covering for this ridge. The thickness of this ore covering averages from five to six feet.

On the hills around Hynson's Springs lies a covering of laminated ore of the siliceous and crumbly characters. These ores appear to lie on either side of the hill tops. Although not exclusively confined to any special location, the crumbly ore is found in greater profusion on the western than on the top or eastern side of the hills. The same peculiarity is noticed also on the Barnes hill, on the west side of the Ephraim Tally headright about a mile east of the springs. The eastern sides of these hills are mostly occupied by deposits of siliceous, massive, laminated ore and ferruginous sandstones. In these localities the laminated ore forming the cap covering the summits of these hills has a thickness of about eight or ten feet.

On the Thomas Gray and Lewis Watkins headrights, in the northeastern portion of the ore region, there is a ridge of laminated ore consisting chiefly of broken fragments or bowlders of laminated ore and ferruginous sandstone. This ridge lies upon a red sandy clay or sand, and has a thickness of about two feet. Underneath this red sandy clay there occurs another deposit or bed of ferruginous sandstone and massive laminated ore about two feet in thickness. The following is in a section of the region:

1.	Broken fragments of massive laminated ore and ferruginous sandstone	2 feet.
2.	Red sandy clay	3 feet.
3.	Ferruginous sandstone	1 foot.
4.	Massive laminated ore	2 feet.
5.	White and red sand and sandy clay stratified in thin laminæ.	

In the northwest part of the county, on Eagle Creek, beds of massive laminated ore occur in the form of large blocks from eight to ten or twelve feet in length and from one to three feet in thickness Similar deposits occur in many places in this region, but as a general thing the blocks have been broken into small pieces.

These are all surface ores, but in many places throughout the county the beds of laminated ore are found under heavy deposits of yellow, brown, and gray sands.

On the north side of the Little Cypress, on the A. Dean headright, a bed five feet thick lies under a deposit of gray sand ten feet thick. The following section shows its position:

1.	Gray sand	10 feet.
2.	Laminated ore	5 feet.

The broken edge of this deposit appears in the Coffeeville road about two hundred and fifty yards southeast of this place.

On the W. C. Allan headright a bed of laminated ore two feet thick lies beneath twenty-one feet of gray sand, conglomerate ore, and a greenish yellow spotted sand.

On the south side of the Little Cypress wells dug in several places show the presence of laminated ore in various thicknesses and at different depths. A well on the Clery Grillet headright shows a deposit of a dark brown thinly laminated ore six feet thick at a depth of twenty-seven feet. In this well another deposit is found ten feet deeper, but the thickness is not known.

On the south side of the John M. Clifton, James B. Chaffin, and Henry Teal headrights, thin deposits of laminated ore occur lying under a brown and orange-red sand at depths varying from five to twelve feet, and close to the town of Marshall beds of laminated ore occur in broken and fragmentary conditions at various depths beneath an orange-red sand. These beds, however, are thin and of no practical value.

Thinly scattered deposits of laminated ore in a broken condition or thinly bedded are also found at other places throughout the county; but while some of them may be of use, the greater proportion of these beds will be found of no practical value, many of them being mere shells not exceeding two or three inches in thickness.

TABLE SHOWING ANALYSES OF LAMINATED IRON ORES FROM HARRISON COUNTY, TEXAS.

No.	Peroxide of Iron.	Silica.	Alumina.	Magnesia.	Lime.	Sulphuric Acid.	Phosphoric Acid.	Water and Loss on Ignition.	Total.	Metallic Iron.
747†...	67.91	11.60	7.09	......	Trace.	Trace.	0.27	13.20	100.07	47.53
749†...	61.22	15.15	10.18	......	......	Trace.	Trace.	13.50	100.05	42.85
750†...	47.53	35.65	6.37	Trace.	Trace.	Trace.	0.56	9.90	100.01	33.27
752*...	64 03	16.70	10.77	......	Trace.	0.32	0.35	7.90	100 07	44.82
753†...	69.65	13.20	2.05	Trace.	Trace.	0.08	1.14	14.00	100.12	48.75
804†...	64.90	26.70	0.70	......	Trace.	......	0.07	7.81	100.18	45.43
806†...	67.75	16.80	5.45	Trace.	Trace.	0.10	0.26	9.60	99.96	47.42
807*...	44.07	39.70	8 33	Trace.	Trace.	0.33	0.15	7.20	99.78	30.84
808*.	63.95	13.40	8.30	......	Trace.	0.22	0.12	14.20	100.19	44.76

Analyses made in the Laboratory of the Geological Survey of Texas by †L. E. Magnenat, *J. H. Herndon.

Localities.

No. 747. Hynson's Mountain.
No. 749. E. Tally headright.
No. 750. C. Grillet headright.
No. 752. Six miles northwest of Marshall, near railway crossing.
No. 753. J. B. Hall, C. Grillet headright.
No. 804. Walnut Creek, near stand pipe of Marshall Water Works.
No. 806. R. Hightower headright.
No. 807. L. Watkins headright.
No. 808. J. Decker headright.

2. GEODE OR NODULAR CONCRETIONARY ORE.

The occurrence of geode or nodular concretionary iron ore in Harrison County is somewhat limited in extent, and although it is found scattered more or less over the entire county, it does not appear to be developed to any great extent upon the higher lands, but is almost exclusively confined to the region of dark brown or red sands, and even there, is only sparingly developed.

The nodular ore of Harrison County is usually found in small quantities lying near the base of the higher central region and among the brown sands, from which they appear to have been washed out by the extensive erosion going on within the area of their occurrence.

The geode or nodular concretionary ore occurs in the form of irregularly rounded nodules or concretions of varying sizes, ranging from two to eight or ten inches. Occasionally nodules of a foot or fifteen inches in their greatest extension are found, but nodules of this size are rare in Harrison County. In structure these nodules are usually formed of concentric rings or layers lying around a central piece of brown or yellow ochreous matter, frequently sand, and occasionally clay. Some are filled with a sand similar to the deposits in which the nodules are found, and others appear to have no central core, as they are found hollow. This may probably be due to the absorption of the central core by the inner ring, or probably due to some fracture in that ring allowing the loose sand to escape prior to the addition of the succeeding outer layers. From the analogous cases found in the structure of some clays and the manner in which accretions or nodules are formed, it might fairly be inferred that these concentrically ringed iron nodules were formed in a similar manner. Among recent clays, as well as among many of the clay shales belonging to the Lower Coal Measures, nodules or concentrically formed concretions occur. These concretions occur in rounded, oval, and other shapes and in all sizes, and appear to have been formed round a central core, sometimes a piece of wood or a shell, and very frequently of a harder piece of the same material as that forming the concentric layers of which the nodules are made up. On the Dan Davis headright, in Harrison County, many of the concretions found on the east side appear to have formed around a core of ferruginous gravel and to have the central gravel firmly cemented to the inner ring of the nodule. Extensive deposits of flat or slightly raised ore on the north side of the Peter Pinchum headright show the same tendency of the ore to concentrate upon and attach itself firmly to the underlying gravel.

In Harrison County nodular ore occurs chiefly scattered over the north side of the Clery Grillet headright and among the series of small rounded yellow sand hills in that neighborhood. It is also found in scattered quantities along the sides of the Hynson Mountain and on the hill to the west. On the southwest corner of the W. C. Crawford headright, about two miles west of Hallville, the summit of the ridge forming the termination of the central plateau in that region is covered with a broken mass of red sand and nodular ore to a depth of about five feet. A short distance north of this, at 'Squire Lynch's place, where the Marshall and Longview road crosses the same ridge, the nodular ore is found in thin scattering quantities.

The west end of the Dan Davis headright is occupied by deposits of a laminated ore lying close to the surface. The nature of the district changes near the center of the headright at Mr. Black's house, and from that point eastward through the Davis and partly across the Bailey Lout headright the country is covered with an orange-colored sand, amongst which nodular ore in considerable quantities is found. The nodules found here lie quite close to the surface and have a depth of about three feet. These nodules lie closely packed to each other in places, but eastward they become more scattered. These nodules are probably the largest seen in Harrison County, and are from twelve to fifteen inches in length, having a thickness of from two to six inches. They are concentrically ringed like most of the other nodular ore geodes, but have the peculiarity of having their centre or core filled with a fine gravel firmly cemented together in the form of a conglomerate and have this gravelly core attached to the inner layer of the surrounding bands.

On the banks of Walnut Creek, about two and a half miles north of Marshall, there is a mixture of nodular ore, ferruginous sandstone, laminated and conglomerate ores. The nodular ore is not very prominent.

On the Joel B. Crain, John Johnson, and Joseph E. White headrights scattered quantities of nodular ore are found in the different washouts common throughout the region. The surface soil is of a dark brown or orange-red color and contains a considerable quantity of ferruginous and other gravel, and fossil wood. The nodular ore found throughout the district is embedded in this sand in apparently great quantities. Nodules are found thinly scattered over the surface, embedded and projecting from the sides of the cuttings made by the streams and rain, from which those lying in heaps along the bottoms of these cuttings must have fallen. These nodules are dark rusty brown upon their exterior surface, but throughout the interior they are a dark steel blue, and many have a considerable play of color when freshly broken. While some are partially hollow and show concentricity of their laminæ, the greater proportion of the nodules have the interior rings so plicated as to show an almost solid body. The depth of the ore bearing gravel in this region is about six feet.

Small quantities of nodular concretionary ores are also found in the region lying to the north of Little Cypress Creek.

Although nodular concretionary ores of this class show a considerable percentage of metallic iron in their composition and are practically of easier access for mining purposes, those of Harrison County are not of sufficient importance in point of quantity to be extensively worked alone.

TABLE SHOWING ANALYSES OF CONCRETIONARY IRON ORES FROM HARRISON COUNTY, TEXAS.

No.	Peroxide of Iron.	Silica.	Alumina.	Magnesia.	Lime.	Sulphuric Acid.	Phosphoric Acid.	Water and Loss on Ignition.	Total.	Metallic Iron.
748*...	62.33	10.90	‡	‡	‡	0.43	0.38	....	74.04	43.63
751†...	61.34	11.85	16.26	Trace.	Trace.	0.25	Trace.	10.40	100.10	42.93
809*...	73.03	9.80	8.17	Trace.	Trace.	0.29	0.32	8.20	99.81	51.12
810*...	72.40	11.30	6.80	Trace.	Trace.	0.15	0.96	8.21	99.82	50.68
811*...	72.40	14.50	5.80	Trace	0.60	0.30	0.19	6.30	100.09	50.68

Analyses: *J. H. Herndon, †L. E. Magnenat.
‡Not determined.

Localities.

No. 748. Top of hill one mile west of Hynson's Springs.
No. 751. Top of hill at Hynson's Springs.
No. 809. Hardy Berry farm, J. Johnson's headright, northeast Harrison County.
No. 810. East side of Dan Davis headright.
No. 811. Hardy Berry's old field, J. Johnson's headright.

3. CONGLOMERATE ORES.

The conglomerate ores are not very extensively developed in Harrison County. Where found, these ores are generally associated with the streams, either, as in the case of the older deposits, lying high up on the bank or near the sources of the streams, or, as in the case of the more recent depositions, lying close to the present course of the water or within a very limited distance from it. In some places throughout the county these two deposits can be seen occupying their relative positions and within a few yards of each other. Numerous instances of this kind occur along the banks or margins of the higher lands lying along the Little Cypress Creek bottoms. In cases where the older conglomerate is absent, the newer deposit can be seen fringing the base of the mountain or bluff, while a stratum or bed of laminated ore or ore fragments is exposed in the face of the hill higher up.

Section of bluff at Mr. Allan's house, on the W. C. Allan headright:

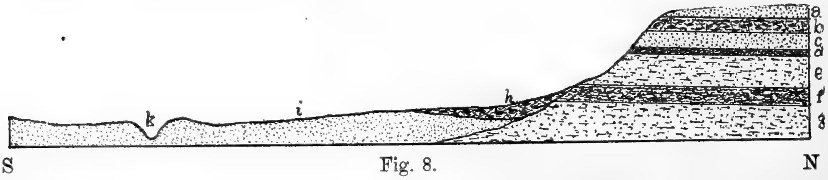


Fig. 8.

a, Gray sand. b, Conglomerate ore. c, White sand. d, Laminated ore. e, Greensand. f, Laminated ore. g, Greensand. h, New conglomerate ore. i, Bottom silt. k, Cypress Creek.

Some of the deposits of the older conglomerate ores sometimes occur in bowlder form high up the sides of isolated sand and gravel hills found over the surface of the central plateau.

The conglomerate ores of Harrison County may be divided into two divisions:

1. An older and higher deposit, in which the conglomerate consists of ferruginous pebbles from half an inch to an inch in diameter, sands, and gravels, with occasional siliceous or quartz pebbles. This deposit breaks with an even fracture and presents a firm, solid face.

2. A newer deposit of conglomerate, in which the material consists chiefly of a ferruginous gravel and sand, very closely held together by the same cementing material. Pebbles of any size or material are usually absent in this newer deposit. This deposit always lies close to the present stream beds or within a very short distance above them. From its composition, looseness of texture and materials, and its association with large quantities of gravel of a texture similar to that of which it is formed, it has the general appearance of being of recent origin, if, indeed, it is not at present actually in the course of formation. As a source of iron these newer deposits are of no value whatever. They might, however, probably be used in composition with coal tar or asphaltum, or even alone, as a material for road making purposes.

The older conglomerates are not, as a general thing, very rich in iron, and are not likely to be used in the presence of the great quantities of better and richer ores found throughout the county. The localities in Harrison County in which these ores have their greatest development are:

On the east side of the Clery Grillet and west side of the W. C. Duffield headrights there is a ridge of the older conglomerate ore lying in an easterly and westerly direction for nearly one hundred and fifty yards and having an elevation of about sixteen feet. This ridge lies upon the north bank of a prong of Potter's Creek, and the blocks into which the ore has been broken are tilted in the direction of the creek bed. This condition is no doubt due to the erosion of the underlying sand. These blocks are of large size, many of them measuring over six feet in length. Farther down the main stream of the same creek a deposit of the same grade of conglomerates occurs upon the S. P. Hall headright. This deposit is somewhat more pebbly than that on the Grillet headright and is associated with extensive deposits of gravel and sand.

Along the base of the mountain upon which Hynson's Springs are situated, and the mountain lying about a mile west, conglomerate bowlders occur, and on the west side of the hill near John Cole's house, on the Micajah Lindsay headright, the same class of ore is to be found in blocks of large size. It is also found upon the western sides of several of the small hills upon this survey in blocks, and is as a general thing a very poor pebbly conglomerate. This region is tributary to Page Creek. Conglomerate also occurs along the banks of Walnut Creek, in the James Chaffin headright.

In the region north of the Little Cypress conglomerate ore occurs in considerable quantities along the banks of Eagle Creek, Lick Creek, and the upper portion of Bear Creek. On Eagle and Lick creeks the ore occurs in large irregular masses, and is found in the same condition along the south side of this region from the western boundary line of the county as far east as the south side of the A. Porter headright.

On the W. C. Allan headright and at other places along the same line the newer conglomerates occur, forming a base or fringe to the higher lands.

Along the hills forming the southern margin of the Cypress bottom lands the newer conglomerate also crops out at various places. Of these the best developed deposit is seen near Mr. W. L. Sloan's house, on the J. W. Overstreet headright. In this place the conglomerate is scattered over the side of the hill in thin blocks or slabs of from three to four feet in length and width and about ten inches in thickness. A short distance up the hill a ten inch bed of the same material projects from beneath the light brown sand. The whole presents the appearance of having been formed at no distant date and afterwards broken up by change in the course of the creek, which is at present flowing through a flat piece of sandy land about one hundred yards away.

TABLE SHOWING ANALYSES OF CONGLOMERATE IRON ORES FROM HARRISON COUNTY, TEXAS.

No.	Peroxide of Iron.	Silica.	Alumina.	Magnesia.	Lime.	Sulphuric Acid.	Phosphoric Acid.	Water and Loss on Ignition.	Total.	Metallic Iron.
793* ...	48.79	39.40	......	......	......	......	......	......	......	......
794* ...	50.68	38.40	......	......	......	......	......	......	......	......
795† ...	62.37	25.90	0.63	Trace.	0.20	0.09	0.71	10.00	99.90	43.65
797† ...	52.87	33.60	......	......	......	......	......	......	......	......
798† ...	36.41	41.80	......	......	......	......	......	......	......	......

Analyses made in Laboratory of Geological Survey of Texas by *J. H. Herndon, †L. E. Magnenat.

Localities.

No. 793. Peter Pinchum headright.
No. 794. Thos. Gray headright, near Wade Scott's house.
No. 795. Near John Cole's homestead, M. Lindsay headright.
No. 797. W. C. Allan headright.
No. 798. South side of M. Lindsay headright.

ANALYSES OF HARRISON COUNTY IRON ORES.

Twenty analyses of the iron ores found in Harrison County have been made. Of these ten have been classified as laminated ore, five belong to the geode or nodular concretionary variety, and five of the analyses are made from conglomerate ores. These analyses have been made from specimens collected with the view of obtaining a fair average knowledge of the value of the ore banks. Picked specimens, which would represent a much higher grade of ore, might easily be obtained from the same localities, but samples which could be considered as of fairly representative character only were taken.

These analyses were made of the ore as brought from the banks, without any previous calcination or driving off water or carbon dioxide, and although they show a fairly good grade of ore, the methods of washing, calcining, and desulphurizing this class of ores, as practiced in their ordinary workings, would show them to carry a higher percentage of metallic iron than the analyses given.

In these analyses it is also assumed that under the present methods of working this class of ores, and the existing facilities in the shape of fuel, flux, transportation, etc., as well as the great quantities of higher grade iron ores being put upon the market, ores carrying less than forty per cent of metallic iron can not be profitably worked.

In the case of the conglomerate ores none of the samples analyzed show a sufficient value to be worked for their metallic iron. The best sample of this class of ores (No. 795) gives an analysis of:

Silica	25 90
Ferric oxide	62.37
Metallic iron	43.65

One hundred parts iron contain 0.71 of phosphorus.

The only means of working the conglomerate ores will be by crushing and concentrating, and until some cheap and efficient method of doing so can be found these ores may, although showing over forty per cent of metallic iron, be considered as non-productive ores.

The impurities found in association with the laminated and geode or nodular concretionary ores are generally of a very trifling character, and are mostly sulphur and phosphorus in small proportions. The proportions of sulphur are very low, ranging from a mere trace to 0.12 per cent among the laminated ores and increasing slightly in the geode or nodular ores, reaching 0.17 per cent in No. 748. These ores can readily be desulphurized by any of the ordinary methods of washing and roasting or calcining now in practice in the preparation of such ores for the furnace.

The percentages of phosphorus existing in the ores are very small, and some of them, such as Nos. 749, 804, and 808 among the laminated ores, and Nos. 751 and 811 among the nodular concretionary ores, contain so small proportions of this impurity as to entitle them to be ranked as Bessemer ores.

Of the geode or nodular concretionary ores Nos. 751 and 811 belong to the Bessemer class of ores, as shown by analyses.

The ores have been classified as Bessemer ores on the assumption that if smelted alone they would produce pig containing not more than 0.10 per cent of phosphorus.

The ores shown in the other analyses, Nos. 747, 752, 806 of the laminated class, and Nos. 748 and 809 of the nodular concretionary class of ore, show proportions of phosphorus to iron ranging from 0.238 to 0.27 per cent. That is, if smelted alone these ores would produce pig containing between two-tenths and three-tenths of phosphorus respectively.

No. 796 contains 1.02 of phosphorus and No. 810, 0.826 of phosphorus to one hundred of iron.

By the proper mixture of these ores with the harder and purer magnetites of the Llano district a good grade of iron may be produced.

By the open hearth process all these ores can be utilized for the manufacture of steel.

The silica in the Harrison County ores ranges from 9.80 to 16.80 per cent. In one case, No. 804, it reaches as high as 26.70 per cent. The whole of these ores are susceptible to a considerable lowering of these percentages by a thorough and judicious washing.

FERRUGINOUS SANDSTONES.

At various localities throughout the county there are somewhat extensive deposits of iron-bearing sandstones. These sandstones usually accompany and overlie the laminated iron ores, and are rarely if ever found continuous in this county, but usually occur in the form of broken fragments. The following table of analyses shows the composition of these sandstones:

TABLE SHOWING ANALYSES OF FERRUGINOUS SANDSTONES FROM HARRISON COUNTY, TEXAS.

No.	Peroxide of Iron.	Silica.	Metallic Iron.	Locality.
744†..	31.16	49.30	21.810	T. G. Twyman's farm, Clery Grillet headright.
746†..	32.11	60.90	22.477	East side of hill at Hynson's Springs.
799†..	52.87	33.60	37.009	Northeast corner of Richard Hooper headright.
800*..	36.20	58.40	25.340	North side of Peter Pinchum headright.
801†..	41.16	35.80	28.812	W. C. Allan headright.
802*..	53.20	26.80	37.240	Northeast side Sheldon headright.
803*..	25.81	60.20	18.067	Blalock's Ridge, Thos. Gray headright.
805†..	35.77	46.80	25.039	W. C. Allan headright, from fracture in sand.

Analyses made in Laboratory of Geological Survey of Texas by *J. H. Herndon, †L. E. Magnenat.

For further details, see under head of Building Stones.

CLAYS.

The clays of Harrison County are better developed and of more value from an economical point of view than those found toward the northern boundary of the State in the region of Cass County.

As we leave the Sulphur Fork and come southward the clay beds thicken and spread over much greater areas. The mixture of clays and sands which in Cass County lies in thin laminæ of alternate clay and sand becomes more of a clay and sandy clayey nature, the clay becoming more prominent. In some places the clayey strata belonging to the stratified red and white sand series of the Cass County beds show in Harrison a thickness of five or six feet.

In Harrison County there are several extensive deposits of clay suitable for manufacturing purposes. These clays range in color from a very dark blue to a pale shade of the same color, from a dark iron brown to a pale brick-red or a yellow, and from a drab gray to a pure white, and many beds also extend in color from a pure black to a grayish and rusty black. Many of the Harrison County clays are too sandy and otherwise impure to be of any use other than for the manufacture of the commonest and poorest grade of ordinary building bricks, and others are so free from sand as to be practically useless in their native state, and in order to bring them into the requisite condition for manufacturing purposes require a liberal admixture of a clean, pure sand. "Slick" clays when used without sand part with their contained water too slowly, and mostly go to pieces in the drying. The best clays for all practical purposes are those which contain a fair proportion of sand.

Some of the sandy clays of this county are to all outward appearances free enough from iron and presumably other impurities to form a medium grade of fire bricks and bricks suitable in every respect for the markets of the district. Some of the less sandy and more aluminous clays are suitable for the manufacture of drain tiling, a good pressed front or ornamental brick, and may probably be found by judicious mixing with other clays, all of which occur in the county, suitable for the manufacture of terra cotta ware. A clay for terra cotta ware requires to have the maximum of strength with the minimum of shrinkage in the drying and burning, a combination of conditions rarely found in clay from any one bed. In many portions of the county there are extensive deposits of a gray, pinkish gray or white, white, and pale lead colored clays, which lie near enough the surface for practical use, and which are all sufficiently aluminous and plastic to form all the classes of the ordinary earthenware of every day use.

The clays of Harrison County may be distributed according to their uses, as follows: 1, Brick clay or earth; 2, Fire clays; 3, Pottery clays; and 4, Miscellaneous clays.

1. BRICK CLAYS OR BRICK EARTHS.

Under this heading it is proposed to group all the ordinary clay products utilized in architectural or farming operations. These are ordinary building bricks, pressed and ornamental and front bricks, terra cotta ware, and drain tiling.

Extensive deposits of a brown, grayish brown, drab or gray, and yellowish brown sandy clay or brick earth, containing a greater or less proportion of iron nodules about the size of an ordinary pea or smaller, ferruginous pebbles, and other impurities, lie scattered over a great extent of Harrison County. These deposits are more or less suitable for the manufacture of a fair grade of ordinary building bricks. When burned these bricks are of a pale gray color, more or less spotted and disfigured by the presence of iron stains. Soft burned bricks assume a light red or yellowish brown when the firing has not been long enough continued. Bricks made of this class of earth when properly burned are hard and show a minimum of shrinkage both in air drying and firing. In the kiln they show but slight tendency to glaze or melt. On being thoroughly dried and then immersed in water for thirty-six hours these bricks show an absorptive power of fourteen ounces, or about one-sixth of its weight of water. In the manufacture of these bricks, when hand made, they require from two to three days to dry on yard and from three to four days to burn, and require from one-half to three-fourths of a cord of mixed oak and pine wood per one thousand to burn.

There is only one brick yard in operation in Marshall and no others within the limits of the county. This yard employs about twenty hands, and in 1890 made eight hundred thousand bricks, the greater proportion of which were shipped to points in Louisiana.

Although material suitable for the manufacture of a good grade of pressed front or ornamental bricks is very abundant within a short distance of Marshall, none have ever been made. For the manufacture of such bricks a clay must be procured and worked in such a manner that the iron or other coloring matter is evenly distributed throughout the mass, so that when the bricks are taken from the kiln they will present an even and uniform color. To succeed in the manufacture of pressed bricks the clay must be thoroughly worked, and in clays in which there is a probability of cracking or undue shrinkage owing to an insufficiency of sand, the clay must be "grogged" or sanded to an extent sufficient to prevent this taking place.

Good clay for the manufacture of this class of bricks can be found in the mottled brownish blue beds lying about a mile west of Marshall. The Texas and Pacific Railway hospital and buildings in that neighborhood, on West Burleson Street, stand upon heavy beds of this material. On West Houston Street, near the Boys' College, it is also found, having a thickness of about four feet.

In the manufacture of terra cotta ware clays of different grades exhibiting different properties are used. No such ware is made in Harrison County, and none has ever been used. Clays suitable, by proper admixture, for the manufacture of this material exist in the neighborhood of Marshall, and may also be found in the eastern portion of the county, but only in a limited extent.

Most clays suitable for the manufacture of bricks will make drain tiling. Care must be taken, however, to see that the clay or earth be not too sandy. Drain tiles made from sandy clay are, as a general thing, too weak to stand much handling.

The necessity for a good quality of drain tiles in Harrison County can hardly be over estimated. Extensive areas throughout the county, especially in the lower lying lands, would be materially benefited by a thorough system of drainage. Lands at present lying idle and subject to overflow could be brought into cultivation, and those at present cultivated would have their agricultural capabilities greatly increased. The market for such articles need not be limited to Harrison County alone, but might be found in other counties throughout East Texas, as well as in Western Louisiana.

Good clays for the manufacture of drain tiling are to be found almost as extensively distributed as the brick earths throughout the county. Great quantities can be procured in the neighborhood of Marshall. Both on the Marshall and Longview and the Marshall and Gilmer roads, within a mile of the town, a clay suitable for tiling is seen in almost every cutting. This clay averages from two to four feet in thickness, and is generally overlaid by a brown ferruginous sand.

The quality of this clay will be materially improved by winter tempering—that is, by digging the clay in the fall or early winter and allowing it to undergo the action of the rain and frost during the winter, spading it over occasionally to bring the whole of the material under the influence of the weather. By this means the clay will be mellowed and the summer's supply can be procured and tempered at a less cost than it can be obtained in any other manner. The brick earths of Harrison County will also be improved by such a course.

2. FIRE CLAYS.

A good fire clay is one which will for the longest period satisfactorily resist heat of the highest temperature, and to do this the clay must be free from any ingredient which will combine with any of the other materials and form a flux when exposed to a high degree of temperature. For this reason a clay intended for the manufacture of fire bricks or any article intended for resisting heat should be as free as possible from magnesia, lime, iron, and alkalies.

Clays, as found in the pit or natural state, rarely contain all the necessary conditions to fit them for the manufacture of first class fire bricks. They have to be mixed with some material which will allow for the expansion and contraction incident to an excessive heat and cooling, and at the same time hold both of these conditions in check. For this purpose burned clay of the same class, broken bricks, ground quartz, calcined flints, sand and gravel, and sometimes small coke or graphite are used.

Many of the clays found in Harrison County will be found to be suitable, when properly prepared, for the manufacture of a medium grade of fire bricks or other articles intended for positions where a fair resistance to heat is necessary. Some of these clays contain mechanical impurities, which by the proper course of treatment can be easily eliminated. Many of the siliceous white or gray sandy clays found in the county belong to the fire clays, and some of the darker colored blue and lighter shaded clays found underneath the lignite beds may also be used for fire purposes.

The light grayish yellow and almost white siliceous clay found overlying a bed of lignite on the north side of the Francis Wilson headright will be found suitable for fire purposes, but will not be found suitable for pottery purposes, as the clayey proportion is not in sufficient quantities. This clay lies under a heavy deposit of brown sand. The following is a section of the pit:

1.	Brown sand	6 feet.
2.	Sandy clay	4 feet. +

On the south side of the same headright, in a cutting on R. Huffman's farm, there is a deposit of light blue and black clays underlying a two foot bed of lignite. The upper clay, or that lying immediately under the lignite, may be utilized for fire clay purposes, and will also be found serviceable for pottery work. This clay, however, lies at too great a depth to be of any practical value for any length of time. At present it could only be economically obtained by taking it from the bed of the stream. The following is a section of this opening:

1.	Brown sand and gravelly ore, gravel about four inches	45 feet.
2.	Brown sand	5 feet.
3.	White sand, somewhat stained brown throughout the upper division, but a pure milky white from near the centre to bottom	26 feet.
4.	Lignite	2 feet.
5.	Grayish blue or black clay, becoming lighter in color and iron-stained in the upper two feet next to the lignite	6 feet.
6.	Blue clayey sand in strata of one inch, cross-bedded and dipping 60° northeast	9 feet.
7.	Light blue clay with lignitic partings	7 feet.
8.	Black clay in thin laminæ	3 feet.
9.	Yellow sand	5 feet. +
		108 feet.

The light blue clay with lignitic partings may possibly be used for earthenware manufacture.

Where the Marshall and Longview road passes through the upper part of the Jose Sanchez headright there is an exposure of a light colored, almost white, siliceous clay, overlaid by a mottled red and blue sand and divided from the overlying bed by a thin streak of ferruginous sandstone. This clay lies among the red and white stratified sands and evidently belongs to the same deposit. The following is a section of the cutting:

1. Mottled red and blue sand.. 4 feet.
2. White siliceous clay.. 2 feet.+

The material found here may be utilized for the manufacture of a fair grade of fire bricks. These bricks will necessarily be confined to positions in which comparatively low temperatures are held, such as household fire grates or for boiler settings around cotton gins, grist and saw mills. It can not be utilized for ware on account of its want of plasticity and generally sandy nature.

On the south side of the Peter Whetstone headright and about half a mile south of the town of Marshall there is a deposit of blue sandy clay, which is at present being used as a fire clay by the iron founders in Marshall for the purpose of lining their cupolas, and is said to be very well adapted for the work. The following is a section of the pit as it is open at present:

1. Brown sand, unstratified and containing nodules of iron ore.................. 4 feet.
2. Blue sandy clay.. 3 feet.

This blue clay is reported as being underlaid by a light colored yellowish white clay. The underlying bed is not visible in the present condition of the pit, but about one-fourth of a mile nearer the town a whitish yellow stained sandy clay is exposed in a deep cutting near the Firemen's Park, and which, from its dip and elevation, may be the equivalent of the bed found at the Adams pit.

This clay bank is of considerable extent, and may probably be, with more propriety, referred to the class of pottery clays. It is placed in this list from the fact that it is at present being used for fire clay purposes. Although used for cupola lining, it is extremely doubtful whether it will stand the extreme heat necessary to be used in the manufacture of fire clay goods. In the cupola it is used as a mortar in which to set the fire bricks forming the main body of the lining, and as a thin wash spread over these bricks. It consequently is not subjected in any body to the intense heat of the furnace.

The following is an analysis of this clay dried at 115° C.:

Silica	71.00
Alumina	20.20
Iron	2.20
Lime	Trace.
Magnesia	Trace.
Soda	6.16
Potash	1.24
	100.80

Lying amongst and apparently a member of the red and white stratified sands and sandy clays, on the south side of the Lewis Watkins headright, on the road from Marshall to Jefferson, there is a deposit of a highly aluminous clay showing a thickness of six feet. To the touch this clay is soft, and adheres strongly to the tongue. With care in selecting and cleaning, so as to free it from iron as much as possible, this clay may be utilized for the manufacture of a good grade of fire clay goods. It will, however, require to be mixed with some other material, such as sand or burned clay, to give it the requisite powers of expansion and contraction to stand any prolonged or excessive heating. This clay also belongs to the list of pottery clays.

The following is an analysis of this clay air dried:

Silica	68.90 per cent.
Alumina	21.83 per cent.
Iron	1.57 per cent.
Alkalies	2.00 per cent.
Water	5.60 per cent.
	99.90 per cent.
Sand	25.23 per cent.

The areal extent of this deposit is not known, but there is every probability that it extends over a wide area of this part of the county. The overlying material is about five feet where the exposure occurs, but will become deeper towards the east.

The gray clays lying beneath the gray sands throughout that part of the county lying to the north of the Little Cypress may be utilized for fire clay purposes. These clays are, by themselves, of too close a texture and too fine grained to be used as a fire clay without the addition of some opening material. Combined with the sands among which they lie these clays may be utilized with little or no extraneous matter. By burning this clay and grinding the burned clay and then mixing the product with the raw material a good quality of brick can be made.

These clays are very widely distributed and have probably a thickness of two hundred feet. In places they may contain thin seams of lignite, but these will be at a considerable depth.

At M. B. Alexander's house, on the A Dean headright, a well boring shows these clays with the associated sands to have a thickness of more than thirty-one feet. At this place they lie under twenty feet of sand and laminated ore. To the southward of this well, and on the same headright, these clays appear close to the surface and in places have a clear thickness of clean clay, free from sand, of seven feet. The same class of clays also occurs upon the S. N. Hall headright at Mr. G. W. Cook's house. At this place the clay lies beneath eighteen inches of gray sand and has a known thickness of over fifteen feet.

The following is an analysis of this clay dried at a temperature of 115° C.:

Silica	73.11
Alumina	17.77
Iron	2.83
Lime	0.40
Soda	3.02
Potash	2.76
Magnesia	0.28
	100.17

3. POTTERY CLAYS.

As compared with fire clays pottery clays are more plastic and adhesive on account of the greater proportion of contained alumina. Pottery clays have also a wider range in the proportions of their constituents, and generally contain more impurities, besides it is not necessary that these clays should contain such refractory properties as fire clays. Any plastic clay capable of withstanding a heat high enough to enable it to "frit" without actual fusion is suitable for pottery use, provided it does not contain too large a proportion of impurities.

Clays suitable for the manufacture of the ordinary grades of earthenware occur in great quantities in Harrison County. Some of these clays are highly aluminous, but the greater proportion of them contain considerable quantities of sand, either mixed throughout the body of the mass of clay or in thin strata or layers interlaminated with the clay beds.

The gray clays of the region north of the Little Cypress and the aluminous clays found on the Lewis Watkins headright may be utilized for the manufacture of a good grade of earthenware. The clays found in the Huffman section, especially Nos. 5 and 7, belong to the list of plastic clays and may be used for the manufacture of such articles as jugs, jars, churns, fruit jars, etc.

The clay found on the south side of the Peter Whetstone headright, and already described among the fire clays, may be utilized as a pottery clay if used in combination with some other more aluminous clay. This clay was used for the manufacture of earthenware some twenty-five years ago. The work was carried on for a year or two, and then abandoned on account of some difficulities connected with the firing or burning of the ware. The loss from this source was about twenty-five or thirty per cent. Judging from the numerous fragments still lying around the site of the kiln, the ware made was rather open in texture. This clay admitted of both a "salt" glaze and a glaze made from ashes. It will also admit of a black or "Albany slip" glaze. When salt glazed, the ware is a creamy white with a faint tinge of brown through it. Ash glaze gave the ware a greenish black hue.

This clay can be materially improved by the addition of a more aluminous clay, such as found on the Lewis Watkins headright, and by a proper course of working. By such operations the texture of the clay would be much improved and the ware closer bodied and better fitted to meet the requirements of the market. The loss in firing would also be lessened to such an extent as to render the clay profitable to work.

In the bank of a cutting on the Texas and Pacific Railway, on the south side of Walnut Creek, on the Daniel McGray headright, there is an exposure of a pale blue plastic clay. It is seen in the south end of the cutting, having a depth of exposure of one foot, but its real thickness or extent is not known. It probably, judging from the contour of the region, extends for a considerable distance both east and west of the railway track.

The following is a section of the cutting:

1.	Brown sand, containing bowlders of ferruginous sandstone, laminated iron ore, and gravel	1 foot.
2.	Horizontally lying stratified sand and clay, the clay partings and the sand beds having thicknesses of clay one inch, sand two to six inches,	4 to 6 feet.
3.	Dark blue, almost black, clay in more or less jointed condition, some of the pieces being spherical and concentrically formed, others cuboidal, and all having a tendency to stratification	3 to 6 feet.
4.	Grayish greensand	1 foot 4 inches.
5.	Pale blue or lead colored clay at south end of cut.	1 foot.+

This pale colored clay (No. 5) is covered by the brown gravelly sand (No. 1) of section.

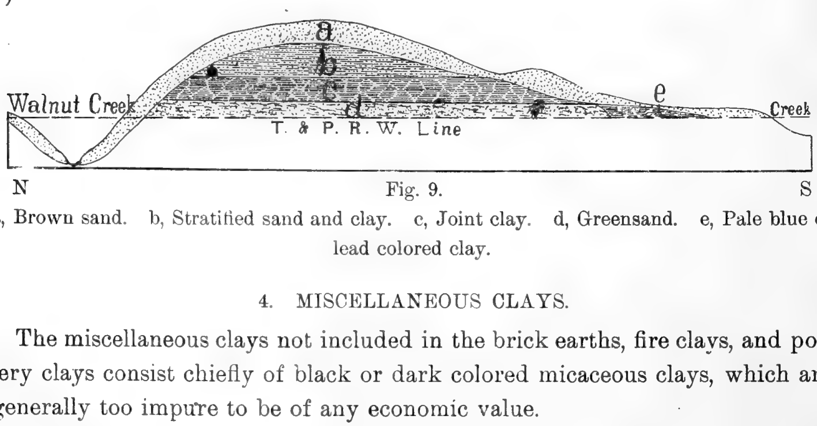


Fig. 9.

a, Brown sand. b, Stratified sand and clay. c, Joint clay. d, Greensand. e, Pale blue or lead colored clay.

4. MISCELLANEOUS CLAYS.

The miscellaneous clays not included in the brick earths, fire clays, and pottery clays consist chiefly of black or dark colored micaceous clays, which are generally too impure to be of any economic value.

A deposit of dark blue clay is bored through by the wells of the Marshall Water Works. This clay is strongly impregnated with sulphuret of iron and gives the water of the wells a strong smell of sulphureted hydrogen gas.

Throughout the eastern part of the county, but generally at too great depths to be of any economic use, there are several extensive deposits of clay or sandy clay, known in the region as soapstone.

The accidental constituents or impurities in these clays are iron, either as an oxide or sulphide in the shape of pyrites, mica, sand, alkalies, and lignite. The most of these can be removed or overcome by judicious working or by washing and grinding. Where pyrites occur in large pieces they ought to be removed by cutting out of the clay before grinding. In many of the blue clays iron pyrites occur disseminated through the clay in small seams or in balls, and frequently in such small particles as to render the cutting impracticable. Except for articles requiring a low temperature, or for the manufacture of alum, these clays are of no practical use. By the proper grinding and working of clay, lignite can be rendered serviceable in the production of heat while the ware is in the kiln. Its presence will render the bricks or other ware more porous than necessary, but in most cases this will not materially affect the brick. Mica must be got rid of by washing. As a source of potash this mineral is not desirable in clays of any description, especially those intended for pottery or refractory purposes.

TABLE SHOWING ANALYSES OF CLAYS COLLECTED IN HARRISON COUNTY.

No.	Silica.	Alumina.	Iron.	Lime.	Magnesia.	Soda.	Potash.	Water.	Total.
*812[1]	73.11	17.77	2.83	0.40	0.28	3.02	2.76	......	100.17
†814	74.15	14.11	4.09	(‡)	(‡)			......	....
†716	68.35	16.22	4.08	......	1.08	2.20		8.00	99.93
†813	....	....	....	......	......	2.90	3.20	......	......
†815	....	....	20.78	......	..	......	......	......	......
*817[1]	71.00	20.20	2.20	Trace.	Trace.	6.16	1.24	......	100.80
†818[2]	65.90	18.43	3.77	0.60	0.30	4.08	0.95	6.36	100.39
†622	82.10	14.24	1.56	1.16	......	1.00 Chl.		......	....
821[3]	68.90	21.83	1.57	......	......	4.00 Chl.		6.60	....
929	75.30	13.87	2.53	1.90	1.23	2.65	2.62	......	100.10

1 Dried at 115° C. 2 Fuses at white heat. 3 Silica in the form of sand, 25.23 per cent.

‡Not determined.

Analyses made in the Laboratory of the Geological Survey of Texas by *J. H. Herndon, †L. E. Magnenat.

Localities.

No. 812. A. Dean headright.
No. 814. J. Sanchez headright.
No. 716. F. Wilson headright.
No. 813. D. McGray headright.
No. 815. W. B. Burres headright.
No. 817. P. Whetstone headright.
No. 818. D. McGray headright.
No. 622. F. Wilson headright.
No. 821. Lewis Walkins headright.
No. 929. M. L. Rager headright.

BUILDING STONE.

With the exception of the ferruginous sandstones there are no good building stones within the limits of Harrison County. Many of the indurated brown and yellow sands may be utilized for foundations and chimneys, and some of the more ferruginous conglomerates and sandstones may also be used for the same purpose.

On the northeast corner of the Wm. Watkins survey the ridge running northwesterly through this survey into the Redin Mason headright is composed of a purplish brown ferruginous sandstone suitable for building purposes. This stone lies in layers varying from six to eight inches in thickness and breaks with a square fracture. It will not admit of a polish or even very smooth dressing, but for ordinary building purposes where the roughness of the surface will not form an objection this stone will answer all purposes. A similar sandstone occurs on the B. Cannon headright and on the Peter Pinchum and Robert Hightower headrights. On these headrights the stone exists in large blocks. North of the Little Cypress Creek a highly siliceous ore or ferruginous sandstone is also found scattered through several headrights in the neighborhood of Lancaster's saw mill on the Wm. Beckwell headright. This sandstone lies in a bedded form in several of the higher hills on the J. Petsick headright. It has been used for road making purposes, but appears to be too soft for such use upon any roads having heavy traffic.

In several places throughout the eastern portion of the county small knolls covered with blocks of a brown sandstone occur. These have no economic value beyond locally supplying the farmers with foundations for their buildings. The most extensive deposits of this sandstone are found on the J. P. Townsend headright, where there are two hills about eighty and one hundred feet high. The stone here is in the form of large irregularly shaped blocks, and some of it very soft.

No detailed locations of the indurated yellow or brown sands or altered greensand can be given. They are scattered extensively over the country. In many places these sands contain casts of fossils.

No regular quarries of any sort are open within the limits of the county, and very little stone of any kind is used.

GREENSAND MARL.

Deposits of greensand marl occur at several places throughout Harrison County. These deposits vary from a pure pale green colored sand to a drab or dirty white or buff gray colored clayey sand, spotted with light or pale gray rounded and oval shaped spots, and the whole having a greenish shade through it. This sandy clay is in many places indurated by exposure and presents a slightly glazed appearance upon the surface.

The areal extent of these sands is not known, as they generally lie deep and are only exposed in a few places throughout the county. The following sections, taken at the various places of exposure, show the greensands to have a thickness of at least twenty feet in some places.

At 'Squire Lynch's house, on the southwest side of the W. C. Crawford headright, there is an exposure of a pinkish brown indurated sandy clay, having numerous rounded and oval white colored spots. This pinkish brown color gradually fades to a pale yellowish brown, still retaining the white or gray spots, and the whole is pervaded by a light greenish shade.

On the W. C. Allan headright this same greenish hued brown or yellow colored indurated sand appears in a section of the bluff. (See Nos. 5, 6, and 7 of section on page 121.)

About two and a half miles southeast of Marshall, on the Elysian Fields road, there is a deposit of a clayey sand of a greenish brown or yellow unstratified appearance, having numerous oval shaped and rounded gray or grayish white colored spots, and having a tendency to glaze upon exposure. This deposit is also indurated through the action of the weather. It takes the place of the dark blue clay No. 4, of section III, on page 121, and is about twenty feet thick.

Another deposit of this green colored sand occurs in the cutting on the Texas and Pacific Railway on the Daniel McGray headright. This sand, No. 4 of section on page 150, is a grayish green black specked sand, showing sixteen inches in thickness in the cut.

The value of these greensands, from an agricultural point of view, depends upon their qualifications as a fertilizer, and that largely upon the quantity of phosphoric acid, carbonate of lime, or potash these sands may contain.

The soils of Harrison County are chiefly sand, and are rapidly becoming exhausted of all their agricultural qualifications. This is noticeable in great numbers of "old fields" at present out of cultivation and being allowed to grow up in young pine, and also in the ever increasing acreage of lands annually being abandoned.

LIGNITE.

The semi-lunar region of gray sands lying along the Sabine River, extending across the eastern side of the county and along the Caddo Lake and Cypress Bayou towards Jefferson, is generally underlaid by beds or deposits of lignite of varying qualities, extent, and thickness. As a general thing these deposits are thicker toward the southern side of the county than toward the north, and as far as could be judged from the well borings in which lignite occurs, the deposit thins out towards the western margin of the gray sand area. These deposits are also, from the same data, irregular in their distribution, and are altogether absent in some localities.

Lignite appears at several places along the Sabine River in thicknesses of from two to six feet. On the John D. Pinson headright it is said to have a thickness of between five and six feet. Towards the centre of the area wells dug deep enough to pierce the lignite beds show them to have a thickness of only from six to twelve inches. On the W. D. Ward headright the lignite lies under thirty feet of sand and clay, and the mean of three wells does not exceed two feet, and along the lake shore region around Port Caddo the bed has a general thickness of about three feet.

Outside of the gray sand region the lignite occurs at several places. In the deep well bored at Marshall lignite about one foot thick was passed through at a depth of one hundred feet. It was also struck in a well on the O. H. P. Bodine survey at a depth of thirty-two feet, and on the Francis Wilson headright it is seen in a stream bed to have a thickness of two feet at a depth of seventy-six feet.

The bed found on the O. H. P. Bodine headright is the upper or highest bed found in a boring made near the same place under the direction of Mr. Hoxie, when general manager of the Texas and Pacific Railway. The drill was carried down eighty feet, and in its course passed through three beds or deposits of lignite, showing thicknesses of twelve, six, and six feet. The lowest bed was not pierced through, owing to the quantity of water accumulating in the well and the inadequate means of pumping at hand. While this bed is known to have a thickness of six feet, its actual thickness may be much more.

Sections showing the positions of the lignite have already been given in the preceding pages. In one of the sections the lignite was found lying upon a white sand. The section shown on page 128 shows the lignite at Robertson's Ferry, on the Sabine River, to rest upon a dark blue sandy clay, and on the Francis Wilson headright, as shown by the section on page 146 the lignite rests upon a blue iron-stained clay.

At Rocky Ford, on the Sabine River, the lignite stretches across the river in the form of a bar, and disappears under a deep covering of gray sand. This bar of lignite has a width of about forty feet and slopes downward in its passage across the stream, being about three feet higher at its upper edge than at the lower. The lignite from this place is a dark black, devoid of lustre, and friable when exposed to atmospheric agencies. In burning it has an unpleasant odor and leaves a soft brown ash. The thickness of this bed is said to be four feet.

A section of the place gives the following:

1.	Light yellowish gray silty sand	20 feet.
2.	Lignite	4 feet.
		24 feet.

Except in very dry seasons this bed is always covered with water.

Near Carter's Ferry, on the Carthage road, there is another exposure of lignite about six feet thick. This deposit, like the one at Rocky Ford, also stretches across and is best seen in the river bottom. The water here has cut a channel through the lignite bed close to the Harrison County side, and leaves a wide stretch of the bed along the Panola County side of the stream perfectly dry This lignite is a dull black, with little or no gloss when freshly broken, and has a tendency to split into thin layers, and when broken across the strata breaks with a subconchoidal fracture.

In this deposit there are the trunks of two trees, measuring sixteen and twenty feet in length respectively, and from eighteen to twenty inches in diameter. The sixteen foot tree is silicified throughout its entire length, and the twenty foot tree is but partially so, having the butt and lower part of the trunk silicified and the top and upper part of the trunk perfectly lignitized. There does not appear to be any definite line of demarkation between the two conditions—the silicified and the lignitized—but they graduate from the one to the other almost imperceptibly. These trees are lying in such positions as they would take naturally had they floated down the river and sunk in the positions found. In this same bed there is a stump standing in such a position as to lead to the inference that it grew in the position it now stands, or was there prior to the deposition or formation of the upper three feet of the lignite. This stump is silicified, and the centre has apparently decayed and been removed before the process of silicification had commenced.

The following is a section of the river bank at this deposit:

1.	Gray silty sand, forming the banks of the river on both sides	25 feet.
2.	Lignite, dull and lustreless, thinly bedded and containing fossil trees	6 feet.
		31 feet.

The deposit found at Robertson's Ferry is six feet thick, and is of a harder nature than the two deposits described above. When freshly broken it shows a slight lustre, which it soon loses, and breaks into an irregular lump resembling bituminous coal. In burning this coal emits an offensive odor and leaves a small quantity of brown ash. This deposit appears upon the Harrison County side of the Sabine River and close to the water even in its lowest stage. It is said another deposit occurs from twelve to fourteen feet deeper. The deposit as seen in the bank of the river has a length of about one hundred yards, and in passing back into the country appears to thin out rapidly, as a well forty-four feet deep, about a mile north of the river, passed through only one or two inches of lignitic matter and into the blue sandy clay bed which underlies the lignite at the ferry.

The deposit on the Francis Wilson headright is only two feet thick and about seventy-six feet underground. This lignite has more the appearance and texture of lignitized wood. The grain and fibre of the wood are still visible and can be easily traced. In texture it has all the appearance of a member of the pine family.

This lignite does not burn so readily as the others, but acts very like a wet wood. The smell from the fire is not so strong, but in other respects, such as showing a red ash, it is the same as the other lignites of the district. In splitting and breaking it splits easily along the fibre, but breaks only with considerable difficulty, and then only with a square fracture.

Section of lignite bed in stream on O. Hendricks survey near Port Caddo:

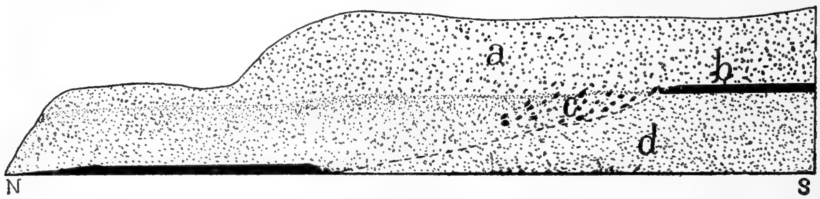


Fig. 10.

a, Gray sand. b, Lignites. c, Sandy pebbles. d, Rusty grey sand.

The lignites from the Lake Caddo region are a dull, lustreless black. They have not yet been examined with regard to their action under fire.

No specimens of the lignites from well borings were obtained, and consequently no definite particulars can be given.

The economical uses of these lignites are many, but so far nothing has been done with them. They may be utilized by sugar manufacturers as a clarifying medium, and by recent improvements in the formation of stoves can be cheaply and successfully used for such purposes as cooking, heating, and for steam or any other purpose in which long carriage or exposure to atmospheric changes will not be required. The main objection to the burning of these lignites will be the smell of the noxious gas arising from their disintegration and destruction by fire. No experiments have been made with the view of testing these lignites for furnace, foundry, or blacksmith purposes.

The more immediate economical uses to which the lignites of Harrison County can be put are· First, as fuel in the manufacture of bricks, both the common ordinary building bricks, pressed bricks, and fire bricks. In the manufacture of all these classes of bricks lignite might profitably be utilized as a fuel, particularly in the early stages of burning or "water smoking." Second, in mixing with the siliceous or the close textured aluminous clays of the county for manufacturing fire bricks. Ground lignite may be used in place of sawdust, which is frequently done, and so render the bricks lighter and more porous. The modus operandi of this process is thus: The clay and lignite are ground together in the mill before passing into the machine. When dry and placed in the kiln, the heat, at first low and steady, dries the clay and the lignite together, driving off the combined water of both, and when the kiln is "pushed" or raised to the highest stage of heat the lignite is consumed and leaves the brick in a porous condition. By this process the species of earthenware known as terra cotta lumber might also be made from the same materials, and many of the numerous light fire-resisting articles used in architecture made out of materials at present in a useless condition.

The peculiarities attending the firing of pottery will probably preclude the use of these lignites in that branch of the clay industries until some changes be made in the construction of the kilns commonly used.

It is probable some of the better grades may be found useful for gas purposes, but this is very doubtful in so far as the Harrison County lignites are concerned.

ANALYSES OF LIGNITES FROM HARRISON COUNTY, TEXAS.

No.	Water.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Total.
704†	14.850	38.520	39.605	6.175	0.850	100.00
707†	13.350	42.820	35.670	7.000	1.160	100.00
717†	16.400	35.950	44.750	2.300	0.600	100.00
952†	10.050	33.310	35.860	18.700	2.080	100.00

NOTE.—No. 717 is of the nature of lignitized wood.
†Analyses by L. E. Magnenat.

Localities.

No. 704. B. Anderson headright, Robertson's Ferry, Sabine River.
No. 707. J. T. Ramsdale headright, Rocky Ford, Sabine River.
No. 717. Francis Wilson headright.
No. 952. Port Caddo headright, McCathern Creek, Hendricks survey.

WATER SUPPLY.

The drainage of the county is divided into a northern and a southern basin, or the drainage area of the Cypress and that of the Sabine. A small portion of the northwestern part of the county is drained by Big Cypress, and the eastern lowlands belong to the area drained by the Caddo Lake system. The southern portion is drained by the Sabine River, and the central waters are carried off chiefly by the Little Cypress Creek and thrown into Ferry Lake, near Jefferson.

The crest line of the central plateau forms the divide between Little Cypress and the Sabine drainage area, and from its summit the streams tributary to these two flow north and south. There are no large streams within the area, and the main tributaries of Sabine and Little Cypress are mostly dry or only a series of pools throughout the greater portion of the year. The principal creeks tributary to the Sabine River are Mason's, Village, Dufford's, Potter's, Eight Mile, and Papaw creeks. On the north side of the central region the creeks flowing into Little Cypress are Watkins', Ray's, Caney, Page, Moccasin, Panther, and Clear creeks. On the north side of the Little Cypress the creeks tributary to that stream are Bear, Lick, and Eagle creeks.

For mining purposes these creeks would require to be dammed and the water stored; otherwise, with the exception of Sabine River and Little Cypress with its associated lake system, the water supply would be insufficient for the necessary work in connection with the manufacture of the iron ores of the county.

Good wells and many springs are found throughout the county. Wells descending as low as the micaceous black clays and greensands, as well as many entering the deep lying blue clays, have their waters impregnated with sulphate of iron. The wells belonging to the Marshall City Water Works are bored to a depth of sixty feet, and pass through a deposit three feet thick of dark blue clay. The water from these wells is charged with a small quantity of sulphureted hydrogen. The water when allowed to stand in the pipes smells strongly of this gas but has no unpleasant taste.

The only navigable waters in Harrison County are those of Caddo Lake and its extension to Jefferson, and the Sabine River. The latter is navigable for small river boats as far as Easton Ferry, in Gregg County, for probably four months in the year. No navigation has been carried on for some eight or ten years.

MINERAL SPRINGS.

There are numerous springs of chalybeate water scattered throughout the county, but only three of these are utilized either as health or pleasure resorts to any extent. These are Hynson's Springs, Roseborough Springs, and Montvale Springs.

Hynson's Springs have already been described by Dr. Penrose. (First Annual Report Geological Survey of Texas, p. 99.)

Roseborough Springs are a series of springs lying on the side and at the base of a small hill on the H. C. Lewis headright, about nine miles south of Marshall, and from eighty to one hundred feet (bar.) beneath the elevation of the town. The main spring has a flow of about ten gallons of water per minute. The water is a pale amber color, and when allowed to stand for some time throws down a dark colored sediment.

These springs are chalybeate, and contain chiefly iron and alumina with sulphates of calcium and magnesia. These springs have been recommended for skin diseases and are largely patronized.

The following is an analysis of the water from No. 1 spring:

Chloride of sodium	11.452
Sulphate of lime	36.617
Sulphate of magnesia	23.123
Sulphate of iron	16.497

Sulphate of soda	8.670
Sulphate of alumina	6.389
Silica and insoluble matter	5.481
Sulphate of potash	3 848
Total grains per water gallon of 231 cubic inches	112.077

Free carbonic acid gas 15.19 cubic inches per gallon.

Temperature at well 68°. Specific gravity not determined.

The water has a strong acid reaction and is of a pale amber color.

NOTE.—On reaching the Laboratory a large amount of the iron had become oxydized and precipitated. The jug containing the water was well shaken and portions taken for analysis, J. H. Herndon, analyst.

Montvale Springs is a newly organized place of resort, and lies on the line of the Marshall and Northwestern Railway, about sixteen miles from Marshall. The following is an analysis of this spring:

Bisulphate of potash	1.307
Bisulphate of soda	0.609
Sulphate of lime	1.516
Carbonate of lime	0.723
Carbonate of iron	0.844
Alumina	Trace.
Silica and insoluble matter	1.924
Chlorine	Trace.
Total grains per water gallon of 231 cubic inches	6.923

Free carbonic acid gas, 15.52 cubic inches per gallon.

Temperature at well 65°.

This water has a slight acid reaction.

Analysis by L. E. Magnenat.

TIMBER.

The total area of Harrison County is computed at eight hundred and ninety-nine square miles, or five hundred and seventy-five thousand three hundred and sixty acres. Of this, about three-fourths, or four hundred and thirty-one thousand five hundred and twenty acres, are covered with timber of various classes and different stages of growth. In the older timbered districts the growth consists of the different classes of oak—red, white, black-jack, post, and pin oak, with a quantity of bluejack oak on the sand hills; pine, hickory, walnut, ash, cypress, black and sweet gum, with the smaller growths of elm, holly, sassafras, and persimmon. The undergrowth in many places is dense. Cane grows upon the wet border lands of the streams.

In the newer timber lands, or lands thrown out of cultivation within the last fifteen or twenty years, pines greatly preponderate and are growing up rapidly, to the almost total exclusion of every other kind of timber. When cultivation ceases, and the land is thrown out, young sassafras and persimmon trees take possession and keep the lead for a year or two, then the pine begins to shoot up, and within a period of less than ten years the whole tract is covered with a dense growth of young pine trees, ranging from two to eight inches in diameter. Between the tenth and fifteenth years the greater number of these trees die, and the survivors, having more room to grow, increase their diameter measurements from ten to twelve inches. After the the twentieth year the growth is much slower. Under the present system of cultivation the acreage of land under timber is gradually increasing, or, at least, holding its own against the operations of the few saw mills and new clearings.

Of these timbers the oaks greatly preponderate and probably occupy one-half of the whole region. The older pine region of the county is almost ex-exclusively confined to the portion lying north of Little Cypress Creek. Detached portions of pine lands are found throughout the county, but not in extensive bodies. It is estimated that the total acreage of land occupied by pine timber, exclusive of the young growth unfit for saw logs, does not exceed sixty thousand acres.

Along Cypress Creek bottom lands, and also in some portions of the Sabine River bottom lands, cypress timber is found in considerable quantities, but the black and sweet gums are the more abundant. Small quantities of holly are also found in the lower bottom lands, but the trees are as a general thing of no practical value, and scarcely reach a growth much larger than the sassafras.

The timber lands may be divided thus:

Oak, including white, red, post, pin, blackjack, and bluejack oaks	215,760 acres.
Pine, including young growth	143,840 acres.
Cypress, gums, and other trees	71,920 acres.
Total	431,520 acres.

The average quantity of wood per acre suitable for fuel purposes is about forty-five cords. This will give a total of nineteen million four hundred and eighteen thousand four hundred cords.

CHAPTER IV.

GREGG COUNTY.

BY WM. KENNEDY.

PRELIMINARY REPORT ON THE IRON ORE DISTRICTS OF GREGG COUNTY.

During the month of October a few days were spent in Gregg County with the view of ascertaining and defining in a preliminary way the actual occurrence of iron ore within the boundaries of the county, and also in roughly ascertaining the areal extent of the ore regions. No attempt was made to make the survey as exact and final as has been done in the other ore bearing counties within the limits of the ore belt, and the questions relating to the stratigraphical and structural geology of the county, except in a very general way, have been left to be taken up next season.

STRATIGRAPHY.

The few cursory notes taken exhibit a similarity of structure with the other counties lying to the east and northeast. The higher grounds of the county are covered with a hetrogenous mixture of orange-red, yellow, and brown sands, fragments of ferruginous sandstones of irregular sizes and forms, and laminated iron ore with nodules of concretionary iron ore, many of which are broken into small fragments, and occasional bowlders of conglomerate ore. The lower, or grounds lying intermediate between the ridges and the river bottom sands, are covered by a yellowish or brownish colored sandy loam, containing occasional nodules of iron ore, and the river bottom lands are chiefly made up of a silt or fine gray colored sand.

In the northern portion of the county the underlying deposits exposed in many of the stream cuttings consist of thinly laminated dark blue or slate colored sandy clay, apparently belonging to the same series of lignitic deposits found exposed in the bank of the Sabine River at the International and Great Northern Railway crossing, and also on the C. A. Fraser headright a short distance east of the bridge on the Longview and Kilgore public road.

In the region around E. M. Cabbiness' gin and grist mill the section shown in a creek is as follows:

1. Brown or orange-red sand, with broken fragments of concretionary ore and siliceous pebbles.................................. 10 to 30 feet.
2. Dark blue or slate colored, thinly laminated, sandy clays, exposed...... 2 to 4 feet.

The same characteristic section is also seen at many other places along the road running west from this place to the Upshur County line, near the Omega Postoffice, with the exception that the unstratified orange colored and brown siliceous pebble bearing deposits become heavier towards the west, and also that the lower division of the deposit, as seen in the cuttings, assumes a more regular and somewhat roughly stratified condition, as well as becoming more like a soft sandstone or sand which has been consolidated and hardened by exposure. These deposits are also found extending into Upshur County.

Coming southward the country is so covered with brown and gray sands that no sections are exposed until near the line of the Texas and Pacific Railway, which runs in an east and west direction across the county. On the east side of the Isaac Skillern headright, about two miles west of Longview, a cutting in the course of a small creek crossing the Longview and Gladewater public road shows the following section:

1.	Brown sand, mixed with gravelly pebbles of quartz and other crystalline rocks and ferruginous sandstones	4 feet.
2.	Stratified white and red sands and sandy clays, the white sandy clay predominating, visible	4 feet.

At the crossing of the International and Great Northern Railway with the Longview and Kilgore public road, and lying to the east of the public road, the same series of stratified red and white sands (No. 2 of above section) and sandy clays, with their protective covering of ferruginous matter, is again seen.

The section is as follows:

1.	Ferruginous gravel, with crystalline pebbles, brown sand, and conglomerate iron ore in the form of bowlders	1 foot.
2.	Thin ferruginous partings	6 inches.
3.	Stratified red and white sands to bottom of cutting	6 feet.

The apparent dip of these beds is towards the south.

Another section of the same nature is also seen at Willow Switch, on the Texas and Pacific Railway, about three miles west of Longview.

A well twenty-two feet deep, on the south side of the Alexander Furguson headright, is reported to have the following section:

1.	Brown sand	6 feet.
2.	Thin layer of laminated iron ore	4 inches.
3.	Red clay	14 feet.
4.	White sand, containing large quantities of gypsum in a finely divided condition	2 feet.
		$22\frac{1}{3}$ feet.

Water was obtained in the white sand, and the thickness of the deposit is unknown.

The next section obtained was at the iron bridge, on the International and

Great Northern Railway, crossing the Sabine River. This section gives the following:

1.	Brown ferruginous sand, with siliceous pebbles and small quantities of nodular iron ore	20 feet.
2.	Dark greenish gray micaceous sands	10 to 15 feet.
3.	Thin seams of earthy lignite and alternate layers of dark colored sand (the thickest bed of lignite does not exceed ten inches at any point)	2 to 5 feet.
4.	Dark bluish or slate colored sandy clay to water	2 to 8 feet.

These strata have an apparent dip to the south (or with the course of the river, which is here a few degrees to the east of south), but are somewhat irregular and wavy in their form.

At the iron bridge on the Longview and Kilgore public road a bluff on the south side of the river gives the following section:

1.	Brown sand, with broken fragments of laminated iron ore and ferruginous sandstone with a few broken nodules of concretionary iron ore	5 feet.
2.	Brown sand with streaks of white sand	20 feet.
3.	Light colored, almost white, sand of same texture as No. 2 and apparently belonging to the same deposit	10 feet.
4.	Light blue micaceous sand	25 feet.
5.	Gray sand	20 feet.
6.	Blue sandy clay to water	10 feet.
		90 feet.

The next most prominent section is taken from a bluff on the south side of the Sabine River, at Iron Bridge Postoffice. This bluff follows the course of the river for nearly half a mile, and its wall-like face forms a formidable obstruction to the river's tendency to turn southward. The following is a section of this bluff taken at the bridge:

1.	Surface deposit of dark brown or coffee colored sand, with broken fragments of sandstone	6 feet.
2.	Heavy bed of yellowish brown sandstone, soft when freshly cut but weathering hard on exposure. (This bed has been quarried at different places farther down the river, as well as at this place, and used for building purposes.)	6 feet.
3.	Brown sand, similar to No. 1	6 feet.
4.	Brown or yellowish brown sandstone, similar to No. 2 but softer and more friable, with alternate strata of a similarly colored sand	10 feet.
5.	Brown or yellowish brown colored sand, containing occasional nodules of iron ore, to level of water. (This sand strongly resembles, in color and texture, the underlying roughly stratified sands in the northern part of the county.)	12 feet.
		40 feet.

The trestle supporting the south end of the bridge rests upon the upper side of No. 2.

The extent, position, and formation of these two bluffs—the upper one at the crossing of the Longview and Kilgore road and the other or lower one at the Iron Bridge Postoffice—are interesting in view of the peculiar tendency of all the Texan streams tributary to the Red River division of the old Mississippi system of drainage, after having traveled for many miles in a general southeasterly course to suddenly change to a nearly direct eastward flow. This course is maintained for a few miles and then the river resumes its normal southeasterly, or more generally a southern, direction towards the Gulf of Mexico. At this place the Sabine flows eastward, and apparently with the strike of the several deposits with which the river is associated.

These two bluffs are connected by a chain of lower bluffs lying about half a mile south of the river's present course, and the whole presents a semi-lunar appearance, having the two ends abutting on the river and the lower ground filled with river silt.

The bluffs appear on each side of the river in something like an alternate series, and where a bluff occurs on one side of the river the other bank lies mostly in the form of a low, flat, marshy, or silt filled bayou.

These alternate bluffs, with their accompanying silt deposits and marshes, seem to indicate the instability of the river and a series of oscillations in the course of the stream channel within a comparatively recent time. The exact condition or extent of these changes has not yet been studied.

IRON ORES.

The iron ores of Gregg County belong to the same classes of ores—the laminated, nodular or concretionary, and the conglomerate ores—found scattered throughout the other counties of Eastern Texas.

1. LAMINATED ORE.

Laminated ores are but sparingly represented in Gregg County. This ore is a brown hematite of a chestnut color and often of a highly resinous lustre. In structure it varies from a compact massive variety, showing no structure, to a highly laminated form, the laminæ varying from one-sixteenth inch to a quarter inch thick. The laminæ frequently show a black, glossy surface, though the interior is always the characteristic chestnut brown color.

The laminated ores of Gregg County are found mostly in a fragmentary condition. No deposits in situ of any extent or value were seen anywhere in the county. The only deposit of laminated ore occurring in Gregg is a thin deposit, not exceeding six inches in thickness, found exposed on the road and in the banks of a small stream known as Rocky Branch, on the east side of the Alexander Furguson headright, about two miles west by south of Longview. In addition to this deposit being very thin, it is also of a very low grade.

Small scattering fragments are found in places throughout the ore areas of the county, but are in most places in association with the ferruginous sandstones belonging to and overlying such ore deposits whenever they do occur in regularly bedded form.

2. GEODE OR NODULAR CONCRETIONARY ORE.

This ore is also a brown hematite and occurs in a great variety of forms. It generally occurs as nodules or geodes, or as honeycombed botryoidal, stalactitic, and mammillary masses. It is rusty brown, yellow, dull red, or even black in color, and has a glossy, dull, or earthy lustre. The most characteristic feature of the ore is the nodular form in which it occurs. These nodules or concretions have frequently a striated appearance, showing a brown and yellow alternation of laminæ when broken, and have been formed by the concretions of ore forming in thin deposits or layers around a nucleus of some other matter. This nucleus is frequently, from some cause or other, wanting and the nodule is found hollow when broken. In others the nucleus consists of a white or yellowish colored sand or a brown ochreous material.

These concretions are found loosely scattered throughout the brown and orange colored sand, sometimes in heavy deposits and lying so close together as to give them the appearance of a regularly bedded ore; but in most places in Gregg County this ore lies in scattered nodules or in very small deposits, both areally and in thickness.

A small deposit of this class of ore occurs among the brown gravelly sands on the David Hill headright and northward along the county line for a mile or two. Between Cabbiness' gin and grist mill and Omega Postoffice several small deposits of the same nature occur, and there are also some small deposits found scattered throughout the rest of the ore areas of the county. An ochreous form of this ore occurs on the Isaac Skillern headright, near the crossing of the Longview and Gladewater and the Longview and Gilmer public roads.

3. CONGLOMERATE ORES.

This variety of ore consists of a conglomerate of brown ferruginous pebbles, with some siliceous pebbles cemented in a sandy matrix. These beds are usually of local deposit, and are found along the banks and bluffs of almost all the streams in the iron ore regions.

These ores are found in Gregg County in association with both Grace and Hawkins' creeks, as well as in the form of bowlders scattered over the greater part of the county, but always in close association with the creeks and smaller streams. A poor grade of conglomerate forms the protective covering of the chain of low bluffs lying between Iron Bridge Postoffice and the Longview and Kilgore public road on the south side of the river.

Conglomerate ores are of a very low grade and can not be worked profitably. It is probable that by crushing, washing, and concentrating these ores might be used. By heating to a low red heat the contained iron becomes slightly magnetic, and in that condition might be separated by magnetic concentration. Owing to the cost attendant on these operations, the present condition of the iron markets of the world, and the existence of so many better ores, it is not likely that any use can be found for these ores for many years to come. They might, however, be profitably used as a material for the formation of wagon roads in the localities where the ores occur.

THE IRON ORE BEARING REGIONS OF GREGG COUNTY.

The high ridge of ore bearing sands and gravels found in Harrison County extends into Gregg for a few miles, having its termination near the west side of the David Hill headright. This western end of the great Harrison ridge somewhat resembles its northeastern end, in so far as it finishes in a succession of sloping steppes or benches, and consists of a brownish red or orange-red colored sand containing quantities of nodular or concretionary ore of an apparently fair quality, but in no place of sufficient quantity to render them available as working deposits.

Crossing the wide bottom lands accompanying the headwaters of Grace's Creek, we find the ore beginning near the southwest corner of the David Benton headright, and from that point extending in a northwesterly direction to the county line and for some distance into Upshur County. This ore deposit forms the division or "divide" between the waters of the Sabine River and Cypress Creek drainage areas, all streams flowing southward finding their outlet in the Sabine River, and those having northern flow passing into Little Cypress Bayou. Roughly this area may be considered as extending from the southwest corner of the David Benton headright in a northeastern direction to the northeast corner of the R. W. Crane headright, and a short distance in the same direction into the James F. Dixon headright. From this point the hill swings round somewhat sharply to the northwest, reaching the northeast corner of the W. H. Hart headright. It then passes in a somewhat semi-lunar form along the northern side of the W. H. Hart, across the James Price, C. P. Hertford headrights, and follows the west bank of a small creek through the David Meredith headright into the Rogers headright, crossing the county line near Omega Postoffice. The line from Omega turns in a westerly direction through Upshur County, but to what distance has not yet been determined.

The southern boundary of this area, beginning at the same point on the southwestern corner of the David Benton headright, crossing in a westerly direction along the south side of the James F. Dixon to the west prong or main stream of Grace's Creek, thence northward to the head of the creek, and then in a northwesterly direction through the James F. Dixon, H. H. Kirk, and M. Alexander headrights, and a little west of north through the Marshall Mann headright, crosses the county line into Upshur on the eastern side of the Meredith Chandler headright. The line then passes to the northeast corner of the William King headright in Upshur. How much further this ore extends into Upshur is not known, as the line has not yet been traced.

The total areal extent of this region is in the neighborhood of eight and one-third square miles.

The ore found in this region is a mixture of a highly ferruginous sandstone in the southeastern division, and a series of deposits of the nodular concretionary variety in the northwestern division and along the Upshur County line. Throughout the whole of the district the ore is thinly scattered, and in only a few places attains a sufficient thickness to be entitled to be considered as a workable deposit. Even in these it rarely attains a thickness of more than a few feet, probably not exceeding more than four feet at the greatest thickness, and then only over a few acres.

Along the Upshur County line the nodular ore is overlaid in many places by a considerable thickness of yellow or brownish yellow sand. The nodules are thin and scattering, and so far as observed are of no practical value.

In the area comprising the David Benton and James F. Dixon headrights the ferruginous sandstones are prevalent and appear in the form of a mound near the Judson Postoffice. In the north and east of the Dixon headright these sandstones lie in the shape of a ridge from ten to fifteen feet, and sometimes more, above the rest of the region. These sandstones have been quarried for building purposes, but with indifferent success.

About two miles north of Longview a thin deposit of ore and ferruginous sandstones occur in a short ridge extending in an easterly and westerly direction across the Hamilton McNutt headright. The ferruginous sandstones of this area have been largely employed as building stones—a purpose for which they appear to be very well adapted. As an iron producing source the materials of this deposit are of no practical value, although a small quantity of very good ore is to be found in association with these sandstones.

The next extensive tract of ore bearing lands lies upon the west side of Grace's Creek, in a somewhat irregular form and carrying small quantities of ore of different grades. The outline of this field may be defined as follows: Beginning at the crossing of the Kilgore and Longview public road and the International and Great Northern Railway, near the bridge across Grace's Creek, the eastern limit of the ore extends a little west of north through the Marshall Mann headright to the line of the Texas and Pacific Railway near Willow Switch. From this point it extends due north across the Isaac Skillern and David Furguson headrights and along the east side of the William Robinson headright to the northeast corner of this survey. The line then turns west to near the northeast corner of the Henry Hathaway headright, and thence southerly along Hawkins' Creek, through the W. H. Castleberry headright, to the south side of the same survey. It then turns east and northeast to the northwest corner of the Isaac Skillern headright, and from that point in an irregular line to near the Sabine, on the southwest corner of the Alexander Furguson headright, and then eastward through the Furguson and Marshall Mann headrights to the crossing of the public road and International and Great Northern Railway. This field comprises an area of about fourteen square miles.

The ore over the greater portion of this field is thin and scattering, and consists chiefly of conglomerate and nodular ore, with a great proportion of ferruginous sandstones. The only heavy deposits are those along Hawkins' Creek near the western boundary of the field, and these are chiefly of a siliceous variety of conglomerate ore.

Throughout this ore field all the various classes of ore found in East Texas are represented. On the east side of the Wm. Robinson headright, near the old Allison place, the ore is represented by a gray ferruginous sandstone. This sandstone is found in a fragmentary condition, scattered over the surface of the ground in pieces ranging from two or three inches to sixteen or eighteen inches or more in length, and although generally in flat pieces, many of the larger fragments present the appearance of having been formed around some central nucleus, which has since been removed, giving the sandstones the figure of a broken earthenware pot. Across the Isaac Skillern headright and on the west side of Grace's Creek the ore exposed in many places is in the form of a conglomerate, carrying not more than 32.61 per cent of metallic iron, and also as a highly ferruginated sandstone, which will probably carry in the neighborhood of twenty-five per cent of iron.

Crossing to the eastern side of the W. H. Castleberry headright, considerable deposits of a poor quality of conglomerate ore are found lying along both banks of Hawkins' Creek. On the west side of the Wm. Robinson headright, and through the central portion of the Isaac Skillern headright, small scattering deposits of nodular concretionary and an ochreous concretionary ore are to be found covering the surface of the ground, but in very few places were these nodules found to extend to more than a few inches in depth. An analysis of a sample of the ochreous variety of these ores found on the Gilmer and Longview road, near the junction of this road with the road to Gladewater, gives the following:

Silica	10.10
Ferric oxide	*75.42
Alumina	6.78
Sulphuric acid	†0.11
Phosphoric acid	‡0.44
Lime	0.10
Magnesia	Trace.
Loss	7.01
	99.96

One hundred parts of iron contain 0.363 of phosphorus.

* Metallic iron, 52.79. † Sulphur, 0.044. ‡ Phosphorus, 0.192.

The southern portion of this field in the Alexander Furguson and Marshall Mann headrights is occupied by a thin deposit of laminated ore and ferruginous sandstone. The ore and accompanying sandstone lie in the shape of large flat slabs, some of which measure from five to six feet in length and from two to four feet in width, but in no case do the combined thicknesses of the two reach six and most of them not more than four inches.

Throughout portions of the Skillern headright a deposit of laminated ore is reported as being struck in boring wells. This deposit is said to lie at a depth of about twenty feet. Its thickness is not known.

TABLE SHOWING ANALYSES OF ORES FROM THIS DIVISION OF GREGG COUNTY.

No.	Ferric Oxide.	Silica.	Alumina.	Sulphuric Acid.	Phosphoric Acid.	Lime.	Magnesia.	Loss on ignition.	Total.	Metallic Iron.
958	50.48	35.80	......	......	......	......	....	......	....	35.34
959	75.42	10.10	6.78	0.11	0.44	0.10	Trace.	7.01	99.96	52.79
960	66 98	11.60	......	......	......	......	....	.....	....	46.88
961	46.59	44.00	......	......	......	......	....	......	....	32.61

Localities.

No. 958. A. Furguson headright.
No. 959. I. Skillern headright.
No. 960. W. Robinson headright.
No. 961. On Gladewater road, two and a half miles west of Longview.

The only other portion of the county north of the Sabine on which iron ore was found to exist at all is on the western side, near where the Upshur County line crosses the H. H. Edwards headright. This ore deposit, with the exception of some ridges on the farm of Mr. Lewis Barnes, is very thin and scattering, and consists chiefly of a ferruginous gravel, with a few blocks or bowlders of conglomerate and laminated ores scattered throughout the gravel. The siliceous pebbles found associated with the gravel are abundant in this region. The ore on the ridges on the Barnes farm might more properly be designated as a highly ferruginated sandstone, and is found in large slabs forming the crests of the three ridges in several places, and also forming a debris of broken material along the sides of the intersecting creeks.

The total area of this ore region is not more than two square miles, and in no portion of the area can the ore be looked upon as of any economic value.

That portion of the county south of the Sabine River has only been examined partially, and even that only in the portion contiguous to the river. With the exception of one or two localities nothing definite is known about the region.

On the western side of the county, on the W. W. Avery headright, a deposit of iron ore is said to exist, but nothing is as yet known regarding its quantity, extent, or quality.

Where the Longview and Kilgore road crosses the Sabine the south bank of the river rises in a precipitous manner to a height of ninety feet. The upper portion of this bluff is composed of a brown sand, with fragments of laminated ore, ferruginous sandstones, and some broken nodules of concretionary ore, the talus on the side of the bluff being almost altogether made up of ferruginous sandstones in the form of large blocks and fragments. This bluff is the northern termination of a flat-topped ridge extending from the south bank of the Sabine River in a southwesterly direction towards the village of Kilgore, and occupying that portion of the country lying between Rabbit Creek and Winn's Bayou. In the immediate vicinity of the river small quantities of ferruginous sandstones, with some broken nodules of concretionary ore, are found as a surface deposit. Further south the sandstones predominate.

On the north end of the Elenor Bradley and Henry Hoover headrights a range of bluffs lying a short distance south of the river shows considerable quantities of the newer grade of conglomerate iron ores, and on the northeastern portion of the centre of the Bradley land, along Dutchman's Creek, small quantities of broken concretionary ore are found intermingled with the overlying brown sand and siliceous pebbles.

The iron ores of Gregg County, so far as they have been examined, may be considered as non-workable ores. Where any quantity exists the quality is not good, and can scarcely be ranked higher than a ferruginated sandstone, probably carrying about thirty to thirty-five per cent of ore. Where the higher grade concretionary and ochreous ores are found the quantity does not justify any attempt being made to operate them.

LIGNITES.

The lignitic series of sands, clays, and lignites appear in Gregg County at various places along the Sabine River. No deposits of lignite of sufficient thickness to be of any practical value were seen.

Some years ago shafts were sunk on the H. Frost headright for the purpose of mining the lignite deposits underlying the sandy deposits. Several tons were mined and used as fuel on the Texas, Sabine Valley and Northwestern Railway. No satisfactory tests were made, as this fuel was abandoned on economical grounds, lignite having been found a more expensive fuel than wood. The pits were deserted and are now filled up with sand and water.

Where the International and Great Northern Railway crosses the Sabine River the northern bank shows a section of thirty feet of sands, lignites, and clays, capped by about twenty feet of ferruginous and siliceous gravel, sand, and small nodules of iron ore.

The following is a section at this place:

1.	Brown ferruginous sands and gravels	20 feet.
2.	Dark greenish gray micaceous sands	15 feet.
3.	Thin seams of earthy lignite, with alternate strata of dark colored sand, the main seam of lignite one foot thick	5 feet.
4.	Bluish colored sandy clay to water	8 feet.
		48 feet.

The bluff at Iron Bridge Postoffice is made up chiefly of alternate strata of sand and soft yellowish brown sandstones or altered greensand. No lignites appear in this section.

Lignite is reported as being visible at different points along the river at low water.

BUILDING STONES.

The yellowish brown and dark brown sandstones or altered greensands found in the bluff at the Iron Bridge Postoffice, and scattered in profusion in the form of large blocks on the F. Thorn headright, have been used as a building material with considerable success. These sandstones, although soft when first quarried, have a tendency to harden when exposed to the action of the weather. They cut square and make a good joint, but will not admit of any great degree of fineness in dressing. The durability of these sandstones is very great.

The ferruginous sandstones accompanying the small deposit of laminated ore on the Hamilton McNutt headright have been used to a considerable extent for building purposes in the town of Longview, and as foundation material for houses and bridges along the lines of the Texas and Pacific and International and Great Northern Railways. These stones are obtained in irregularly shaped blocks of various sizes, and require considerable work before being fit for use. The ferruginous sandstones found on the H. H. Edwards headright may be used for building purposes in any position where not in immediate contact with heat or where fine dressing is required.

CLAYS.

The clays of the county were not examined with sufficient care to determine their relative value. No clays suitable for any of the finer uses were noticed, although some small deposits may occur interstratified with the lignitic sand and sandy clays.

Brick clays or earths occur in considerable quantities in the neighborhood of Longview. A kiln of brick was burned at Earpville several years ago, and in 1890 a small kiln was burned by a Mr. George Echolls on the Isaac Skillern headright. The bricks burn to a pale gray and are disfigured by dark blue iron stains when burned hard. Soft burned bricks made from this earth are a light shade of red or rust colored, according to their position in the kiln. When hard burned the brick is very hard and not easily broken or breaks with an irregular fracture. Great quantities of a yellow colored clayey sand or earth which might be utilized in the manufacture of bricks occur around the village of Gladewater. No use, however, is being made of these deposits.

SOILS.

The upland region of the county is covered by a light sandy loam, frequently changing to a sand. The color is alternating, with proportions of ore found in the vicinity, and is generally a brown, orange-red, or brownish yellow. The subsoils are mostly of a sandy or clayey nature. The land is generally poor. In the lower lying regions the soils are of a brownish yellow colored sandy clay, having spots of yellow colored sandy brick earth or clay. Extensive deposits of this class of material are found in the vicinity of Longview, where it covers the whole of the M. Greer, southern part of the Hamilton McNutt, and the whole of the Alexander Jordan headrights, as well as a part of the Avery Johnson headright. It is also found extensively developed in the district around Gladewater. The subsoil is a mottled clay in most places.

Throughout the bottom lands fringing either side of the Sabine River and along Grace and Hawkins' creeks, the soil is a light yellowish gray colored fine sand or silt, having a depth of from ten to twenty feet.

TIMBER.

The timber is mostly oak, hickory, and pine, with the different kinds of oak greatly preponderating.

CHAPTER V.

MORRIS, UPSHUR, WOOD, VAN ZANDT, AND HENDERSON COUNTIES.

BY WM. KENNEDY.

The counties of Morris, Upshur, Wood, Van Zandt, and Henderson mark the northwestern limit of the iron region of East Texas. A line drawn from the eastern side of Morris County, about four miles north of Hughes' Springs Station, on the Missouri, Kansas and Texas Railway, and running in a southerly direction through Morris County to a few miles west of the point where the Upshur County line intersects Big Cypress Bayou, thence in a southwesterly direction to about three miles north of Gilmer; from there in a westerly direction to near Quitman, in Wood County; thence southwest through Wood, crossing the Sabine near Mineola, and then in a southwesterly direction to near the centre of the south line of Van Zandt County, near Beaver Creek; crossing into Henderson and turning back in a southeasterly direction to near Brownsborough, and thence southwesterly into Anderson County, near the Trinity River, will give an approximate boundary to the western and northwestern edge of the brown hematite iron ore fields of East Texas.

The ore deposits lying along and within the boundary thus approximately given are not extensively developed in any of the counties named. In Morris they are found as extensions or outliers belonging to the Cass and Marion County deposits. In Upshur and Wood counties the ore deposits are found partly as extensions from other counties and partly as isolated deposits scattered over the eastern and southern portions of the counties; and in Van Zandt and Henderson the ore deposits occur altogether in isolated hills, in the southwestern portion of Van Zandt and northeastern and southeastern portions of Henderson.

The total area of these ore deposits does not exceed seventy square miles, and is distributed among the various counties as follows:

1.	Morris County	15 square miles.
2.	Upshur County	10 square miles.
3.	Wood County	25 square miles.
4.	Van Zandt County	1 square mile.
5.	Henderson County	19 square miles.
	Total	70 square miles.

The ore deposits found along the boundary line thus drawn are mostly of the nodular concretionary variety throughout Morris and Upshur counties.

Toward the southern end of the line in Van Zandt and Henderson counties, although nodular concretionary ores are present in considerable quantities, the lists of specimens obtained by Mr. Ladd and myself show a preponderance of laminated ores of the buff crumbly variety, with some ferruginous sandstones. Along the streams and watercourses crossing the line of ore deposits in the whole of these counties there are several considerable deposits of conglomerate ore.

The analyses of these ores show them to carry from forty-three to fifty-six per cent of metallic iron in the Upshur ores, and from thirty-nine to fifty-six per cent in the Henderson ores. The Wood County ores are, as a general thing, low in iron, only three of them touching as high as forty-five per cent.

Two analyses have been made of the Van Zandt ores, but the metallic iron in either does not exceed forty per cent. The ores found in these counties, which, from the content of metallic iron, would be considered as of sufficient value to work, contain the impurities sulphur and phosphorus in exceedingly small quantities, and many of them might be considered of sufficient purity to be ranked as Bessemer ores. The others are all within the limits necessary to rank them among the ores suitable for the manufacture of steel by the open hearth process.

Among the Upshur ores the sulphur ranges from 0.02 to 0.37 per cent, and in the same ores the phosphorus ranges from a trace to 0.38 per cent.

The best ore of the Wood County collections shows a trace of phosphorus only, and of the Henderson ores only two contain anything more than a trace of phosphorus. Of these one of the ores from near Fincastle shows an iron-phosphorus proportion of 0.22 per cent, and the other, an ore from Battle Creek, has a proportion of 1.15 per cent. The other ores from this county all belong to the Bessemer grade of ores.

The workable ores of Wood County show percentages of 0.29 and 0.34 per cent of sulphur, and in Henderson County sulphur appears as traces only in the whole of the ores analyzed, except one, in which that impurity amounts to only 0.17 per cent. These ores can easily and readily be desulphurized by washing, roasting or calcining as practiced in the ordinary methods of preparing such ores for the furnace. It will be noticed that every one of these ores contains lime in greater or less proportions, some of the Upshur ores showing as high as 2.30 per cent.

While these softer limonite ores, when worked by themselves, have all the characteristics of the East Texas iron ores, in that they produce a peculiarly tough, durable iron, suitable for the manufacture of car wheels and all the implements necessary for farming purposes, a judicious mixture of these limonites with the harder magnetites of the Llano region would improve the grade of pig iron and also steel which might be manufactured from these ores.

The suitable proportions can only be determined by the actual working of the ores, but in few cases will this be found to exceed forty per cent of magnetite.

MORRIS COUNTY.

IRON ORES.

The iron ore deposits found in Morris County lie altogether in the southeastern portion of the county, immediately adjoining the extensive ore deposits of Cass and Marion counties, of which they are apparently but an extension.

In Morris County the ore region comprises a series of hills, having a north and south course, and extends in the form of a narrow strip along the eastern boundary of the county from the north end of the Edward West headright as far south as the J. W. Body headright. The ore margin turns west through this survey to the east side of the David Sorrel headright, and then north again, extending in this direction to the south side of the B. Hamilton headright. It then turns southwest to the southeast corner of the J. B. Lilly headright, from which point the line runs in a southerly direction, following the course of Bruton, or Beaver, Creek to Holley Creek, on the south side of the Leander Kidd headright. On the south side of Holley Creek the trend of the ore is southeasterly along the southern end of the ridge to near the centre of the west side of the Wm. King headright, and thence southwest to the Marion County line, on the Samuel Johnson survey.

The ores of that portion of this field along the eastern side of the county belong to the nodular concretionary or geode variety, and exist in the form of irregularly shaped nodules of sizes varying from six to ten and twelve inches in diameter. These nodules are usually hollow or found filled with a yellow sand or brown ochreous matter. A few nodules of the glossy black radiated or fibrous variety of ore are also found in this region, but not in anything like sufficient quantities to make them a representative class. A few deposits of conglomerate ores are also found in connection with the creeks of the district, and scattered throughout the whole field there are large quantities of black glossy ferruginous gravel or sand. The pebbles of this gravel vary in size from that of a small pea to pebbles having diameters from half an inch to one inch. These gravels are mostly found in connection and mixed with a dark brown sand.

The ores found in the western portion of the main ore region of the county, as well as on the King, Cherry, and associated headrights, are chiefly of the concretionary class, in a segregated and botryoidal form, and are usually associated with a highly ferruginated sandstone. These ores lie in the form of large irregularly shaped masses, roughly pitted and mammillated on the surface, and have usually a dull, earthy, lustreless brown color. In places this dull brown gives place to a beautiful glossy black color, with a brilliant lustre. This black ore occurs generally in the form of thin streaks running through the brown, and sometimes occurs as broad patches, in which cases it always presents a mammillated surface and is rarely of any thickness. When broken the ores of this part of the field present a concretionary appearance, and the portions between the ore septa are usually filled with a dark brown ochreous matter, and although sometimes empty this condition is very rare.

This ore usually surmounts the hills forming the ridges in which it occurs, and with the exception of a few spots on the tops of the highest points of the ridge is wholly exposed. In some of the high hills the ore is covered by deposits of fine yellow sand from five to ten feet in thickness. The broken condition of the ore renders it difficult to measure the thickness of the deposit with accuracy, but it may be estimated about five feet. The maximum thickness of the deposits does not exceed eight feet.

Throughout the whole of the region immense deposits of ferruginous gravels and sands occur, lying around the base and well up on the sides of the ridges, and in some places reaching as high up the hill sides as the edges of the ore deposits from which they were evidently derived. These sands and gravels contain large quantities of ore in the form of nodules and broken fragments from the size of small peas to that of a man's head. The ores in these gravels are usually of a good quality, although more or less mixed with sandstone.

This forms the main body of the Morris County ores, but isolated fields occur in the vicinity of the town of Daingerfield, to the west of the town on the Henry Proctor headright, and another in a range of hills rising about one hundred and fifty feet above the level of the lower plain or bottom lands of the neighboring creeks. This ridge begins on the southwest of the J. N. King headright, passes in a southeasterly direction to near the northeast corner of the south J. N. King headright, then south to the northwest corner of the J. W. Duncan headright, and then, swinging around in a westerly direction to the middle of the east line of the J. V. Cherry tract, it assumes a southwesterly course to near the south side of this survey, where it terminates in a high round-topped hill. Passing around the base of this hill, the ore line turns northeasterly through the H. S. Proctor headright, and thence east to the J. N. King survey. A rounded isolated hill on the east side of the Ewing Ellison headright is also capped with ore, but is of no great extent. Ore is also reported to exist on the James Knolb headright.

The ores found on the Cherry and King headrights are similar to those found in the main ore field on the eastern side of the county, and may be considered a portion of the same field.

The following analyses are of specimens collected in this region:

ANALYSES OF IRON ORES FROM MAIN ORE DEPOSITS IN MORRIS COUNTY.

No.	Ferric Oxide.	Silica.	Alumina.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Loss on Ignition.	Total.	Metallic Iron.
1094† ...	81.60	6.10	1.20	......	Trace.	0.32	Trace.	10.80	100.02	57.12
1095† ...	84.98	7.40	1.42	......	Trace.	Trace.	0.17	6.00	99.97	59.48
1096† ...	76.54	6.90	3.06	......	Trace.	0.48	Trace.	13.00	99.98	53.58
1097† ...	73.72	7.80	5.48	......	Trace.	0.38	Trace.	12.65	100.03	51.60
1098*.	74.30	13.10	5.10	Trace.	Trace.	0.32	Trace.	7.08	99.90	52.01
1099* ...	76.50	7.80	4.50	Trace.	Trace.	0.36	0.12	10.70	99.98	53.55

Analyses by †L. E. Magnenat, *J. H. Herndon.

Localities.

No. 1094. Northwest corner of the J. W. Duncan headright.
No. 1095. From a different portion of same headright.
No. 1096. Dr. Bradfield's farm, James N. Gray headright.
No. 1097. James N. Gray headright, three and one-half miles south of Daingerfield.
No. 1098. Leander Kidd headright.
No. 1099. Leander Kidd headright.

These ores are very generally mixed in the banks, and it is very probable that every ton of ore mined in any portion of this field would contain more or less of each class here represented. An average sample of the whole combined would give the following analysis:

Ferric oxide	77.94
Silica	8.18
Alumina	3.46
Phosphoric acid	0.31
Sulphuric acid	0.04
Lime	Traces.
Loss on ignition	10.04
	99.97

Metallic iron, 54.56.

One hundred parts of iron contain 0.247 of phosphorus.

This ore if calcined would give from the above analysis 60.69 of metallic iron.

These ores compare favorably with the limonites of Alabama of the subcarboniferous metamorphic regions of that State, and the Tuscaloosa formations, which Dr. E. A. Smith ranks second in importance in the production of iron in Alabama.*

The ore field in the immediate vicinity of the town of Daingerfield consists of two high hills lying on the Henry Proctor headright and extending in an

* The Iron Ores of Alabama, in their Geological Relations, 1887.

easterly and westerly direction. The hill to the west has an elevation of one hundred and fifty feet (bar.) above the level of the rails of the Missouri, Kansas and Texas Railway at the Daingerfield station.* A section of the region in this neighborhood shows:

1.	Ferruginous gravel and iron ore found in well on top of hill	30 feet.
2.	Greensand in well, but not bored through. (This greensand appears in the form of a broken ledge of soft yellowish green sandstone along the face of the hill at an elevation which would indicate its having a thickness of at least twenty feet)	6 feet.
3.	Mottled yellow, brown, and white sand	15 feet.
4.	Thinly laminated bluish iron-stained sands or clayey sands	4 feet.
5.	Light bluish, white, or yellowish white clayey sand	4 feet.
6.	Micaceous black sandy clay, with thin streaks of lignitic matter	8 feet.
7.	Dark blue sandy clay, enclosing bowlders of red sandstone, containing imprints of leaves, visible	2 feet.
8.	White sand or sandy clay	50 feet.
	Total	119 feet.

Numbers 1 and 2 of this section are from a well on the top of the west hill; 3, 4, 5, 6, and 7 from a brook north of the town; and 8 from a washout in Dr. Bradfield's farm at the base of the east hill. The ore of this region is chiefly of the concretionary class in the form of a dark brown or black variety, and considerable quantities of the black nodules have a radiated or fibrous structure. The surface of this district is covered with a mass of ferruginous sand, gravel, and fragments of ore of varying sizes. Although the greater portion of these ore fragments do not exceed two to four inches in diameter, many of them range from two to four feet in their greatest length. These large bowlders are found mostly high up the sides of or on the summits of the hills. The line of the ore deposit is difficult to make out, and probably does not exceed two or three feet in thickness. The deposit itself forms a covering of the west hill, but on the hill next the town it is covered by a heavy deposit of sand.

The ferruginous sands flanking and running high up the hillsides are heavily charged with ore nodules and fragments of the same character as that of the bowlders on the tops of the hills. In thickness this sand varies from two to fourteen feet. The lower portion of the deposit is generally free from ore or gravel.

Masses of a soft greenish yellow colored sandstone or altered greensand occur throughout the whole ore and gravel along the lower portion of the hillsides, and a belt of this material ten or fifteen feet wide in the form of broken bowlders occurs about fifty feet from the tops of the hills. This belt forms a small bench, and the broken sandstone found along it appears to in-

* The elevation of the rails at this station is 398 feet above tide.

dicate the existence of a sandstone bed lying at the base of the greensand deposit found in the Rogers well on the top of the hill lying to the west. This would indicate that these greensands are at least twenty feet in thickness.

Fragments of a dark brown sandstone are scattered throughout the red sands and gravels lying around the base of these hills. These sandstones contain impressions of leaves. Three varieties of these leaves have been obtained, but they have not yet been determined.

Specimens of ores collected from this field give the following analyses:

No. of Analysis.	Ferric Oxide.	Silica.	Alumina.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Loss on Ignition.	Total.	Metallic Iron.
No. 1090	76.26	5.20	6.84	Trace.	Trace.	Trace.	11.60	99.90	53.38
No. 1091	79.07	5.70	5.73	Trace.	Trace.	Trace.	9.45	99.95	55.35
No. 1092	80.20	4.20	3.10	Trace.	Trace.	Trace.	12.50	100.00	56.14
No. 1093	80.20	4.35	5.50	Trace.	1.03	Trace.	9.00	100.08	*56.14

Analyses by L. E. Magnenat.

*Phosphorus, 0.449.

Locality.

Nos. 1090, 1091, 1092, 1093 from Henry Proctor league.

As these ores are more or less mixed throughout the whole of this field, an average analysis will best show the true worth of the ore. The following is an average analysis of the above ores:

Ferric oxide	78.93
Silica	4.86
Alumina	5.29
Lime	Trace.
Phosphoric acid	0.26
Sulphuric acid	Trace.
Loss on ignition	10.64
	99.98

Metallic iron, 55.25.

One hundred parts of iron contain 0.204 of phosphorus.

By calcining this ore the percentage of metallic iron will be increased to 61.87 per cent.

The total area of ore producing lands within Morris County has been computed at fifteen square miles. Much of this, however, may be found on careful examination to be too poor in ore to be of any practical value.

GREENSAND MARLS.

Deposits of greensand marls occur at various places within the county. These deposits have been particularly observed on the eastern boundary of the county in the neighborhood of Hughes' Springs, where the deposits noted in Cass County extend westerly into Morris, and in the immediate vicinity of the town of Daingerfield. The Daingerfield deposits occur on the Henry Proctor headright, immediately underlying the iron ore deposits of that neighborhood, and a short distance west of the town, and appear in the form of a greensand in a well dug some years ago. On the face of the hill the same deposit appears as a soft yellowish green sandstone. This deposit, No. 2 of general section on page 178, has a thickness of about twenty feet. These greensands can scarcely be utilized as fertilizers, as they only contain 0.4 per cent of soda and potash and 0.7 per cent of phosphoric acid, with a small proportion of lime In the event of the overlying iron ore being utilized these greensands will be easily obtained for any purposes to which they may be suited.

LIGNITES.

Deposits of lignite are reported as existing along the banks of Sulphur Fork on the northern boundary of the county, and at various other places lying north of Daingerfield. These have not yet been visited and examined.

On the Jonathan N. Bohonan headright, about five and a half miles south of Daingerfield, there are several exposures of a thin seam of lignite. At Mr. S. H. Pruitt's house an attempt has been made to develop this vein, and an opening has been made with a view to mining the lignite for local use. The vein at this place is only fifteen inches thick, and dips a few degrees south of east, and according to Mr. Pruitt, at the rate of one inch in three feet.

A section of the opening at this place shows the following:

1.	Yellow sand	7 feet.
2.	Lignite	1 foot 3 inches.
3.	Black or dark blue stratified sandy clay, mixed with lignitic matter, visible	5 feet

The lignite at this place, although reported as being of a fair quality, can not be worked.

The following is an analysis of the lignite:

Moisture	4.45
Volatile matter	52.05
Fixed carbon	15.15
Ash	28.35
	100.00

CLAYS.

Unless the dark blue clay associated with the lignitic beds can be utilized, there are no clays in this county, so far as have been observed, of any practical value. Analyses of this clay show it to have only traces of alkalies. It may probably be of a fairly refractory character and suitable for a low grade of fire clay goods.

Ordinary building bricks have been made in the neighborhood of Daingerfield, but these bricks are generally rough and rather weak. No regular brick yards exist, and the bricks made are only made at long intervals.

The following sections show the general relations of the various strata of this region:

Section of cutting on Missouri, Kansas and Texas Railway three miles west of Hughes' Springs.

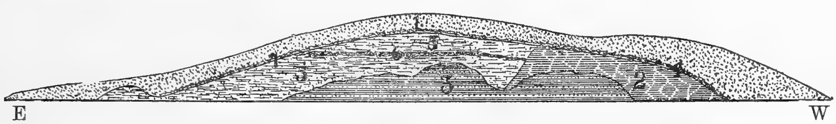


Fig. 11.

1, Brown unstratified sand and gravel. 2, Unstratified mottled clay. 3, Black or dark blue stratified clay with sandy partings. 4, Thin layer of ferruginous gravel. 5, Thinly bedded or laminated white and brown sands. 6, Thin irregular pavement or bed of conglomerate ore. 7, Thin beds of ferruginous sandstone.

Section of cutting on Missouri, Kansas and Texas Railway two miles east of Daingerfield:

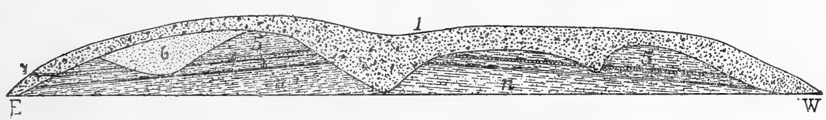


Fig. 12.

1, Brown unstratified gravelly sand. 2, Thinly bedded white and red sand. 3, Thinly bedded white and blue sand. 4, six inch layer of soft sandstone. 5, Same as No. 2. 6, Unstratified mottled sand. 7, Ferruginous sandstone.

The stratified red and white sands and black micaceous sandy clays of the lignitic group appear in the cuttings along the Missouri, Kansas and Texas Railway in this region as far as Daingerfield. A short distance north of the town these black micaceous sands are seen in a stream cutting, and show a thickness in this place of eight feet. Throughout the lower black micaceous clays nodules of iron ore occur, lying in the form of thin beds or pavements. These nodules are generally of large size and average from twelve to twenty-four inches in their longest diameter. These pavements are somewhat irregularly distributed throughout the cuttings, but are never superimposed upon each other, and as no more than one ever appears, even in the longest cuttings, it is presumed that they are continuous and all of the same horizon and formed at or about the same period of time

Beds of a sandy yellow ochreous clay also occur in these regions, but these are as a general thing too sandy to be of any practical value. These clays would require to be washed to free them from the intermixed sand before the ochre could be utilized, and this would entail cost far beyond anything they would realize if brought to market. Bricks have been made of this material in the neighborhood of Hughes' Springs, but they are not considered of a good quality.

UPSHUR COUNTY.

The next county south of Morris County, and lying within the ore boundary already defined, is Upshur County. From our present knowledge of the iron ore deposits of Upshur County, their mode of occurrence appears to be in the form of small patches, ranging from fifteen or twenty acres to thirty-eight hundred and forty acres in extent and somewhat scattering in their positions. From the specimens obtained these ores belong chiefly to the geode or nodular concretionary and conglomerate varieties, and the analyses made in the laboratory of the Survey give the following results:

ANALYSES OF IRON ORES COLLECTED IN UPSHUR COUNTY BY MR. G. E. LADD.

No.	Ferric Oxide.	Silica.	Alumina.	Sulphuric Acid.	Phosphoric Acid.	Lime.	Magnesia.	Loss on Ignition.	Total.	Metallic Iron.
319†...	61.57	22.32	6.03	0.10	0.16	Trace.	Trace.	10.04	100.22	43.09
325*...	80.78	4.30	2 22	0.02	0.38	0.88	Trace.	10.47	99.05	56.44
326†...	65.79	18.77	8.31	0.36	Trace.	2.30	Trace.	5.05	100.58	46.05
335*...	71.78	14.10	2.82	0.28	Trace.	Trace.	......	11.10	100.08	50.24
338*...	66.09	11.85	6.91	0.37	0.28	1.81	Trace.	12.40	99.71	46.23
341†...	48.65	26.07	12.65	0.26	Trace.	2.30	Trace.	10.30	100.23	34.05

Analyses made in the Laboratory of the Geological Survey of Texas by *J. H. Herndon, †L. E. Magnenat.

Localities.

No. 319. Ahira Butler headright, northeast corner Upshur County.
No. 325. Three miles southeast of Coffeeville, on the Wm. Hambright headright.
No. 326. Ahira Butler headright, in northeast corner Upshur County.
No. 335. Two miles southwest of Coffeeville, on the John Parker headright.
No. 338. Ahira Butler headright.
No. 341. Northeast corner Upshur County.

Beginning at the northeast corner of the county, the first deposit of ore is a straggling remnant of the conglomerate deposits found in the western end of Marion County and the northwestern portion of Harrison County, on the Wm. Murray headright.

Northwest of this deposit and about a mile from the village of Coffeeville a deposit of ore, extending in a general northwesterly direction for nearly four miles and having a width of about one and a half miles at its greatest diameter, occupies a large portion of the western side of the Ahira Butler headright, the whole of the J. Martin and N. S. Paymenter headrights, and portions of the east side of the E. Wilkerson and W. G. Holloway headrights, an area comprising nearly three thousand nine hundred square acres, or about six square miles.

The ores of this field consist principally of the laminated and nodular grades, with the accompanying ferruginous sandstones. Analyses of these ores show them to be of a moderate quality, carrying both sulphur and phosphorus in small quantities. See analyses Nos. 326 and 338.

About three miles south of Coffeeville, on the John Parker headright and near the centre of the survey, there is a small rounded deposit of concretionary ore, having an areal extent of about two hundred square acres. See analysis No. 335.

East of this last deposit and about three miles southeast of Coffeeville there is another small deposit of ore on the Wm. Hambright headright. This deposit appears from its position to be the terminal part of the extensive laminated and conglomerate deposits found farther east on the William Murray headright and extending thence into Harrison County. This deposit appears to be chiefly a concretionary ore of a good grade, very low in silica and sulphur, but carrying seventeen-hundredths of one per cent of phosphorus. The metallic iron is also over the average, being 56.45 per cent. See analysis No. 325. This ore also carries about 0.88 per cent of lime.

Going northeast from Gilmer, the public road to Fayette crosses a ridge of ore land about four miles northeast of Gilmer. This deposit, which is approximately three miles in length, has a width of about three-quarters of a mile and comprises an area of fourteen hundred and forty square acres. Beginning at the northeast corner of the Wm. C. King headright, the eastern boundary of the deposit passes in a southeasterly direction through the Benjamin Talbot, C. B. Teal, northeast corner of the Elias A. Burrell, and southwest corner of the James Wagstaff headrights, thence through the J. M. Clough and into the Alfred Hefner headrights. From this point it turns west for a short distance, and then in a northwesterly direction, in a line almost parallel to the eastern boundary, through the Ames W. Smith, E. A. Burrell, and C. Wright headrights and into the Wm. King headright, turning east to the place of starting.

Another deposit occurs in the vicinity of the town of Gilmer. There are several small deposits, the first and most extensive of which is in the form of two rounded hills lying on the south side of the John J. Hooper headright, comprising together an area of about thirty acres. The next deposits lie about two miles west of the town and on the north side of the J. B. B. Davenport headright, and have an area of ten or fifteen acres.

In the neighborhood of Omega Postoffice, and extending as far west as Glenwood Postoffice, and thence southwesterly to and including the West Mountain region along the Gregg County line, there are deposits of concretionary ore imbedded in the overlying orange colored and brown sands. These brown sands have a thickness ranging from four to fifty feet, and wherever cut through appear to overlie the thinly laminated dark blue micaceous sandy clays of the lignitic formations. The exact areal extent of this deposit of ore is not known, as the outlines have not yet been traced.

The total area of iron ore lands within the limits of Upshur County may be placed at six thousand four hundred acres, or about ten square miles.

WOOD COUNTY.

In Wood County the iron ores are found scattered in small bodies throughout the greater extent of the county. The Wood County ores are chiefly of the nodular concretionary variety of limonites, and a few deposits of the laminated class and some conglomerate ores found along the margins of the creeks. The heaviest deposits of these ores are found: First, on a ridge running north and south through the southern portion of the Philip Gonzales headright and extending south for a short distance into the I. Meredith survey. This deposit is mostly of the nodular or concretionary variety, and carries about 47.76 per cent of metallic iron, with 0.24 of phosphorus, 0.14 of sulphur, and 14.50 per cent of silica.

The next deposit of any size is an oval shaped hill on the east side of the Wm. M. L. Burnett and west side of the Joel C. Bradford headrights. The ore from this region is a poor quality of limonite or a clay iron stone, carrying only 34.27 per cent of metallic iron in association with 36.27 per cent of silica. This ore contains 0.31 per cent of sulphuric acid and a trace of phosphorus. It also contains 2.10 per cent of lime and 1.20 per cent of manganese.

Another deposit of laminated ore occurs about one-half mile east of Lake Fork and two miles north of the Texas and Pacific Railway—partly on the west side of the Simon Gonzales and partly on the J. Monteith headrights. This ore contains only about 29.98 per cent of metallic iron, with 40.60 per cent of silica, and is therefore of no practical value as a producer of metallic iron.

About three miles northeast of the village of Mineola there is a small deposit of concretionary ore on the G. Greer headright. The ore of this deposit only shows a percentage of 27.84 per cent of metallic iron.

In the neighborhood of the town of Quitman scattering deposits of iron ore occur. These deposits are mostly of the nodular concretionary and conglomerate varieties and occur in thinly scattered quantities, covering a district of from three to seven miles north and west of Quitman. Conglomerate ore also occurs on the Sulphur Spring road about ten miles north of the town.

The ores found in this region have from thirty-two to fifty-three per cent of metallic iron, the best ore being that found on the ridge extending from three to seven miles northwest of the town of Quitman.

An analysis of this ore gives:

Metallic iron	53.76
Silica	9.50
Sulphur	0.116
Phosphorus	Trace.
Lime	1.06
Manganese	0.83

A small quantity of clay ironstone is found on the J. B. Mansell headright about three miles west of Pine Hill, and a deposit of nodular concretionary or geode ore also occurs about two miles southwest of the same place.

The following table will show the analyses of the Wood County ores from specimens collected by Mr. G. E. Ladd:

ANALYSES OF IRON ORES COLLECTED IN WOOD COUNTY.

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Sulphuric Acid.	Phosphoric Acid.	Loss on Ignition.	Total.	Metallic Iron.
317*....	68.23	14.50	5.17	0.86	Trace.	0.34	0.57	10.20	99.87	47.76
328*....	76.80	9.50	Trace.	1.06	......	0.29	Trace.	12.30	100.78	53.76
329†....	54 76	25.05	7.64	Trace.	Trace.	0.51	1.12	11.20	100.28	38.33
336*....	39.78	40.40	8.42	1.06	Trace.	0.18	0.31	9.50	99.65	27.84
337*....	44.98	36.70	6.82	2.27	Trace.	0.02	0.16	9.70	100.65	31.48
339†....	42.84	40.60	7.86	2.10	Trace.	1.04	Trace.	6.10	100.54	29.98
340†....	48.96	36.27	4.54	2.10	Trace.	0.31	Trace.	7.25	100.63	34.27
353†....	45.14	41.50	7.16	Trace.	Trace.	0.18	0.35	5.95	100.28	31 59
355†....	46.98	39.95	4.12	Trace.	......	0.15	0.22	8.38	99.80	32.88
356*....	64.36	21.40	2.64	Trace.	......	0.30	1.54	10.10	100.34	45.05

Analyses by *J. H. Herndon, †L. E. Magnenat.

Nos. 328 and 340 respectively, 0.83 and 1.20 manganese.

Localities.

No. 317. Gonzales headright, three miles northwest of Pine Hill. Concretionary ore.

No. 328. Three to seven miles northwest of Quitman. Nodular masses.

No. 329. Three miles north of Quitman. Clay ironstone.

No. 336. Three and one-fourth miles northeast of Mineola, Greer headright. Concretionary ore.

No. 337. Two miles southwest of Pine Hill. Concretionary ore.

No. 339. One-half mile east of Lake Fork, two miles north of railway. Laminated ore.

No. 340. Three miles west and north of Pine Hill. Clay ironstone.

No. 353. West of Quitman. Clay ironstone, ochreous.

No. 355. Sulphur Springs road, ten miles north of Quitman. Conglomerate.

No. 356. Quitman. Conglomerate.

VAN ZANDT COUNTY.

The iron ore deposits of Van Zandt are confined to the eastern portion, and thin out and disappear before passing the centre of the county. The only iron ore deposits known to be of any extent occur in the southeastern portion. The main body of ore is in the form of a long narrow ridge extending from the northeast corner of the E. Arrington headright through the L. Buford headright, and northeast through the R. Crane and I. Piles headrights to near the center of the B. M. Boland survey. The ore found in this ridge belongs to the laminated grade, but so far as the present methods of working iron ores are concerned this ore is non-productive, an analysis showing only 32.88 per cent of metallic iron.

Small rounded isolated deposits of laminated ore occur in many of the surveys in this section of the county. The largest appear to be the deposit found on the A. S. Johnston survey. The total area of iron ore territory in Van Zandt has been computed at one square mile.

ANALYSES OF IRON ORES COLLECTED BY MR. G. E. LADD IN VAN ZANDT COUNTY.

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Sulpuric Acid.	Phosphoric Acid.	Loss on Ignition.	Total.	Metallic Iron.
344* ...	46.98	28.40	12.42	0.28	......	0.41	0.51	11.21	100.21	32.88
357† ..	58.25	14.80	12.85	Trace.	Trace.	......	0.48	13.50	99.88	40.77

Analysis by *J. H. Herndon, †L. E. Magnenat.

Localities.

No. 344. Buford survey, four miles northeast of Edom.

No. 357. A. S. Johnston's survey.

HENDERSON COUNTY.

IRON ORES.

Crossing the southeast corner of Van Zandt County, the western boundary of the East Texas iron ore fields enters Henderson County near its northeast corner. The first deposits found lie upon the north side of Battle Creek, on the Juan M. Martinez headright. On the south side of the creek, and on the same survey of land, another deposit of ore of the same quality occurs. This region consists of high, broad, flat-topped, steep-sided hills, having a general elevation of one hundred and forty feet above the level of Battle Creek. The general trend of these hills is northwest and southeast, or in the same direction as the creek. The whole area of this field does not exceed twelve hundred acres.

The next deposit of ore found lies in the neighborhood of Brownsboro Station, on the St. Louis, Arkansas and Texas Railway. This deposit occurs in a long narrow range of flat-topped hills, having a general course of from a few degrees west of north to southeast. The general elevation of these hills does not exceed one hundred and forty feet above the level of the bottom lands of Kickapoo Creek on the north and of Flat Creek on the south. This deposit begins on the south side of the Dickers Parker headright, and the east side runs east of south to near the center of the north side of the J. Carver headright, whence it turns east to the west side of the J. N. Gaines headright, thence south to near the southwest corner of the Gaines headright. From this the line turns west to the east side of the Susan Head headright, and from there turns west of north to the Dickers Parker survey. The area of this field comprises about eighteen hundred acres.

Crossing the broad flat bottom lands belonging to the Flat Creek drainage area, the next iron ore field, and by far the most extensive ore region in Henderson County, lies in the district between Mulberry Creek on the north and Caddo Bayou on the south. Towards the east this field is limited by the broad bottom lands of the Neches River, and on the west by a series of deposits of yellow sand. The boundary of this field, beginning at the southeast corner of the James McDonald headright, passes south through the Maria Trinidad Equis headright to the north side of the Juan Jose Martinez survey, then turns east to near the west side of the Thomas Chaffin headright. From this point the line curves around to the northeast corner of the E. Cazanova headright, and thence with a gentle curve southwesterly to the southeast corner of the A. H. Caldwell headright. From there the ridge turns southeastward and crosses the Anderson County line on the Alfred Benge headright. The western boundary of the field passes northwesterly through the A. Benge and D. M. Dickerson headrights into the east side of the Isaac Burton headright. Turning northeast it reaches the southwest corner of the Juan Jose Martinez headright, and thence southwest to the southwest corner of the W. L. Scott headright. From here the ore boundary passes north along the W. L. Scott and Simon Boon headrights to Boon Mountain, on the northwest corner of the A. K. Jones headright; thence northeast to the southwest corner of along the south side of the James McDonald headright to the southeast corner. The total area of this field is nearly fourteen square miles.

The region covered by this field presents a series of rounded, oval shaped, and long, narrow, steep-sided hills or ridges, having a general uniform elevation of from one hundred and forty to one hundred and sixty feet (bar.) above the bottoms of the creeks in the neighborhood.

The sides of the ravines cut by the creeks show a complicated series of benches, alternating in number according to the relative position of the hills and streams. Round Mountain, so called from its shape—an isolated flat-topped hill on the northwestern corner of the A. K. Jones headright—shows only one bench close up to the summit of the hill; and Pilot Hill or Buffalo

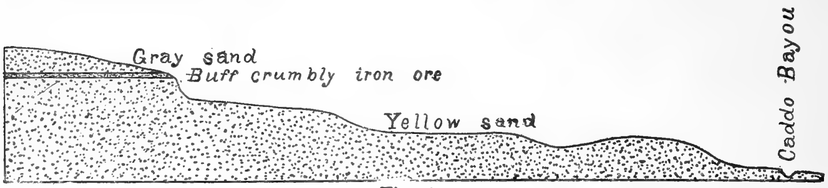


Fig. 13.

DIAGRAM SHOWING BENCHES BETWEEN PILOT HILL AND CADDO BAYOU.

Ridge, on the Alfred Benge headright, shows no less than four within the distance from Caddo Bayou to the summit. The intermediate hills, such as Pine Hill or Cooper Mountain, on the W. H. Watts headright, show four benches, while the hill on the Luke Gauntt headright, behind Mr. James Gauntt's house, shows only two.

The streams flowing through the ravines all have the V-shaped bottoms common to water-cut channels.

The deposits within the region and constituting the ridges are comparatively uniform in their positions, the ore deposit being found at a level of one hundred and forty feet, and where the elevation of the ridge does not exceed this height the ore covers the surface in the form of a flat cap, broken into large bowlders, frequently measuring from six to ten feet in length and four to six feet in width, and having a thickness equal to the whole depth of the ore deposit. Such points of the ridges as reach the higher elevations of one hundred and fifty and one hundred and sixty feet are covered with a light gray and yellow colored sand.

The benches found along the sides of these ridges are altogether due to the action of the streams flowing at their bases and to atmospheric agencies.

The beds underlying the iron ore deposits are of a yellowish colored sand, with a sandy clay lying close to the base. A section of the country at J. Gauntt's house gives the following:

1.	Gray sand	10 to 15 feet.
2.	Bed of buff crumbly iron ore	4 feet.
3.	Yellowish colored iron-stained sand	120 feet.
4.	Sandy clay	20 feet.
5.	Gray sandy clay	2 feet.
6.	Lignite (known to be over)	2 feet.

These yellow sands (No. 3) are easily eroded, and by their destruction the iron ore deposit is left unsupported. Blocks of ore are thus detached, fall or slide down the hillside, to accumulate and form a bench at a level lower than where they originated. These ore deposits when in place are covered with a thin deposit of ferruginous sandstone, and the blocks found covering the second and lower benches, besides being tilted and sloping downward, are frequently completely overturned, showing the ferruginous sandstone beneath the ore.

The iron ores found throughout the different ore fields of the county are all of the laminated variety of Dr. Penrose's classification, and belong to that division of the laminated ores known as buff crumbly ore. These ores have all a uniform appearance and thickness, and are overlaid throughout the whole of the region by a soft brown ferruginous sandstone. This sandstone thickens towards the northeast, and is found in greater quantities in the ore fields around Battle Creek than in the region around Fincastle and Boon Mountain, in the southern field.

The analyses of these ores show them to carry phosphorus in greater or less quantities, extending from a mere trace to 0.44 per cent, and sulphur exists only in exceedingly small quantities, all of the analyses made showing only traces of this material.

The local details of the most prominent portions of the southern fields give a thickness of ore about three feet.

At Round Mountain, on the Allen K. Jones headright, the hill has an elevation of one hundred and forty feet above the level of the creek, and is covered on the summit by large blocks of ferruginous sandstone and buff crumbly iron ore. Some of these blocks measure six feet in length by four feet in width, and are from two to four feet in thickness. The ferruginous sandstone found here in association with the ore does not exceed two or three inches in thichness. A narrow, deep, steep-sided ravine divides Round Mountain from Boon Mountain. Boon Mountain has the same structure as Round Mountain, and belongs to the same range of hills. Close to J. M. Gauntt's house, on the Luke Gauntt headright, another hill rises to an elevation of one hundred and fifty feet above the bottom lands. This hill is a long, narrow, flat-topped ridge, running in a northeasterly and southwesterly direction. The bench around the hill at an elevation of one hundred and forty feet is covered with broken fragments of buff crumbly ore and ferruginous sandstone, and the side of the hill is covered with a broken debris of the same character of material. The ore on this hill does not exceed three feet, and the associated sandstone two or three inches. The highest portion of this ridge is covered by a deposit of grayish colored sand about ten feet in thickness. A well twenty-two feet deep at Mr. Gauntt's house, close to the base of this hill, passed through a red and black clay into lignite.

Another isolated oval shaped hill, known locally as Pine Hill or Cooper

Mountain, is situated on the south side of the W. H. Watts headright. This hill has an areal extent of about three hundred yards in length and one hundred yards in width, and an elevation of one hundred and ten feet. The summit of the hill is covered with a deposit of buff crumbly ore and ferruginous sandstones, measuring from three to six feet in length, and widths varying from two to five feet. The deposits of ore on this hill do not exceed two and one-half to three feet in thickness. The otherwise precipitous sides of this hill are divided into four benches or steppes. These benches are covered with large blocks of ore which have apparently slipped or fallen down from the summit of the hill. Many of them have been completely turned over in their descent, and now lie in positions showing the sandstone which usually covers this class of ore lying underneath the block.

On the W. J. L. Scott headright the hill forms a broad, level plateau, the highest portion of which, near the Myrtle Head school house, is covered with a deposit of gray sand about twelve to fifteen feet in thickness. In ascending the hill on the west side, a broad bench is passed over before reaching the school house. This bench also appears on the road leading southeasterly towards the village of Fincastle. The bench on both sides of the hill is covered with blocks of broken buff crumbly ore, showing a thickness of a little over two feet. The uniform quality and elevation of these blocks of ore show them to be the broken outcroppings of a similar deposit of iron which passes through the plateau and underneath the gray sandy deposit crowning its highest points.

A series of small hills occurs on the Juan Jose Martinez headright around Fincastle Postoffice. These hills are all rounded in form and rise to sharp peaks. All of them contain iron ore of the same quality and thickness as the other hills already described.

Beginning a little to the south of Fincastle, on the E. Cazanova headright, and extending southwesterly through the southwestern portion of that survey and covering the whole of the A. H. Caldwell headright and part of the D. M. Dickerson and Alfred Benge headrights, the ore is contained in two almost parallel ridges. Near D. M. Dickerson's house the ridges unite and form one high ridge, terminating in Pilot Hill or Buffalo Ridge on the south side of the Alfred Benge headright, near the Anderson County line. Pilot Hill has an elevation of over one hundred and eighty feet above Caddo Bayou, and is covered with a deposit of over thirty feet of gray sand, which also covers the higher portions of these ridges. The ore deposits in these ridges appear in their relative positions of about one hundred and forty feet above the creeks which flow at the western and eastern bases.

The ore of this region is all of the buff crumbly variety and is overlaid with a thin deposit of ferruginous sandstone. Some large blocks surmount the ridges and lie scattered along their sides, but the greater portion of ore deposits in this region exist in the form of broken pieces of small sizes and coarse ferruginous gravel. From its generally broken condition it is difficult to estimate the thickness of the ore deposits in this region, but it is probable that about three feet of good workable ore will be found throughout the greater portion of the ridges. On Pilot Hill the ore when seen in place has this thickness.

While the quantity of ore found in the region forming this field may not show a thickness of more than three feet, and a great extent of the area may not exceed two and one-half feet, the sides of the hills all show a large quantity of debris from which vast quantities of workable ore may be readily and cheaply obtained. The enormous erosion which this region has undergone has been the means of removing the soft underlying yellow colored sands and allowed the ore blocks and fragments to fall down along the sides of the hills and ridges, until now these accumulated blocks form deposits of ore many feet in thickness, and which will require years of steady mining to remove before the ore beds now in place will require to be touched. It may be estimated that within this ore field each square mile of ore deposits carries in the neighborhood of seven million tons of ore.

Specimens of ore collected in this field give the following analyses:

ANALYSES OF IRON ORES COLLECTED IN HENDERSON COUNTY.

No.	Ferric Oxide.	Silica.	Alumina.	Magnesia.	Lime.	Sul[illegible]ur Acid.	Phosphoric Acid.	Loss on Ignition.	Total.	Metallic Iron.
255*(L)......	64.30	15.40	10.70	......	1.06	......	0.24	7.70	99.40	45.01
257*(L)......	59.20	16.20	11.20	......	Trace.	......	Trace.	13.45	100.05	41.44
347*(L)......	80.45	4.30	3.15	Trace.	Trace.	Trace.	Trace.	12.15	100.05	56.31
1077 †........	69.90	10.40	10.90	Trace.	Trace.	Trace.	0.35	8. 5	100.10	48.93
1078 †........	55.59	17.20	14.81	Trace.	Trace.	Trace.	1.10	11 5	100.05	38.91
1079 †........	67.14	14.00	7.46	Trace.	Trace.	Trace.	0.64	11.00	100.24	47.00
1080 †........	67.14	10.30	9.06	Trace.	Trace.	Trace.	0.54	13.20	100.24	47.00
1081 †........	63.02	14.30	9.58	Trace.	Trace.	Trace.	0.51	12.50	99.91	44.11

Analyses by *J. H. Herndon, †L. E. Magnenat. (L) Specimens collected by Mr. G. E. Ladd.

Localities.

Nos. 255 and 257. Juan J. Martinez headright near Fincastle.

No. 347. A concretionary ore found two miles west of Fincastle.

No. 1077. Pilot Hill, on Alfred Benge headright.

No. 1078. Round Mountain, on A. K. Jones headright.

No. 1079. Hill at J. M. Gauntt's house, on Luke Gauntt headright.

No. 1080. Near Myrtle Head school house, on W. J. L. Scott headright.

No. 1081. A. H. Caldwell headright.

The central or Brownsboro ore field consists of a number of flat-topped ridges, extending in a generally north and south direction, and covers an area of nearly two square miles. This field appears to be a continuation of the southern field, although it is separated from that region by the extensive bottom lands of Kickapoo Creek. The ore found in this area has the same general characteristics. It belongs to the same buff crumbly class of ore, has the same thickness of between two and four feet, and lies at about the same general elevation of about one hundred and forty feet above the creeks.

A specimen of ore collected in this region by Mr. G. E. Ladd gives the following analysis:

Ferric oxide	73.60	per cent.
Silica	10.06	per cent.
Alumina	9.89	per cent.
Phosphoric acid	Trace.	
Sulphuric acid	Trace.	
Lime	Trace.	
Water and loss	6.75	per cent.
	100.30	
Metallic iron	51.52	per cent.

The northern ore field, lying on the Juan M. Martinez headright along the banks of Battle Creek, comprises an area of nearly two square miles. This ore field consists of two flat-topped ridges, lying on both sides of the creek, and having an elevation above it of one hundred and fifty feet (bar.). The upper portion of the hills is covered with a heavy deposit of grayish yellow sand, under which the ore deposits appear as outcropping and broken fragments, many of which have fallen farther down the steep sides of the hills, and in numerous places have been the protecting covering of the small benches along the eastern and southern sides of the hills. The ores of this field are similar to those found at Brownsboro and in the southern portion of the county in the neighborhood of Fincastle.

On the south side of the J. M. Martinez survey there is a small ridge of ferruginous sandstone and concretionary ore in small fragments. In passing northwesterly this ridge increases in altitude until it reaches its maximum altitude of one hundred and fifty feet (bar.) above Battle Creek.

Near Mr. Chapman's house, and on Mr. D. Cade's farm on the same headright, the ore is of the buff crumbly variety, covered with the usual ferruginous sandstone.

The ore bed in this field appears to have a general or uniform thickness of two and one-half or three feet. Large quantities of broken fragments of ore are found as debris lying along the bases of the ridges. This debris is mixed to a considerable extent with the ferruginous sandstones overlying the ore.

These sandstones appear to increase in thickness in passing from the southwest to the northeast of the county.

The specimens obtained from this portion of the county give the following analysis:

Ferric oxide	58.24 per cent.
Silica	22.10 per cent.
Alumina	8.16 per cent.
Sulphuric acid	Trace.
Phosphoric acid	1.08 per cent.
Lime	0.29 per cent.
Loss on ignition	10.11 per cent.
	99.98 per cent.
Metallic iron	40.77 per cent.

The uniformity of the elevation of these ridges, together with their similarity of structure and general thickness to the ore deposits on the west side of Smith County, as well as those of the adjoining portion of Anderson County, lead to the inference that during the period in which the sand deposits from which these ore beds were afterwards derived were being laid down, the surface of this part of the sea bottom had a uniform level, sloping gently towards the southeast with a very uniform degree of dip, not much greater, if any, than the fall of the present stream beds, and that the broad bottom lands of the Kickapoo, Flat, and Caddo creeks, as well as the low lying, partially swampy lands along the Neches River, have all been formed by the action of these streams within comparatively modern times.

No faults, breaks, or dislocation of the strata are observable throughout the whole of this region, and all the beds maintain their uniformity of elevation; and the general southeasterly dip shows these deposits to be comparatively free from the minor undulations observable in many other places in East Texas.

The enormous amount of erosive work performed by these streams may be estimated from the fact that Flat Creek, a comparatively small stream, has cut through the ore bearing ridges to a depth of one hundred and fifty feet and formed a series of bottom lands nearly six miles in width, while the nearest ore deposit to the Neches River on the Henderson County side is that on Battle Creek, and is three miles distant.

The similarity and relative positions of the deposits on either side of Battle Creek show that this creek has divided the northern ore field into two divisions by cutting for itself a channel near the centre of the field nearly three-quarters of a mile in width, over a mile long, and one hundred and forty feet in depth.

BUILDING STONE.

The only building stones found in the county are the soft, friable, yellow and brown indurated glauconitic sands found everywhere throughout East Texas. Deposits of this sandstone occur a few miles north of the town of Athens, and also on the south side of the J. M. Martinez headright, half a mile north of Chandler Station. At this latter place the sandstone is a yellow, soft, easily cut stone, lying in strata from eight inches to two feet in thickness, the whole section presenting a face of about ten feet.

CLAYS.

Extensive deposits of clays of widely different characters occur throughout the western and central portion of Henderson County. Some of these deposits are at present being utilized for the manufacture of ordinary building bricks, ornamental and paving bricks, while the finer qualities of the clay deposits in the neighborhood of Athens are being utilized for the manufacture of fire bricks, earthenware, and drain and sewer pipes.

The most extensively developed deposits of clay within Henderson County are found in the immediate vicinity of the town of Athens. In this region alone five deposits of clay of varying characteristics occur, all of which have been worked at one time or another in a more or less desultory manner.

Bed No. 1, occurs on the T. Murchison farm, on the west side of the James B. Attwood headright, about one and a half miles north and a little east of the town. This clay bank lies on the north side of a small stream, and has a thickness of two feet where open, but apparently thickens towards the southeast.

This clay is thinly laminated and of a very pale lead color, drying almost to a white, and contains small crystals of what the potters call "tiff," or gypsum, in its lower division. A section of the bank at Mr. M. K. Miller's pit gives the following:

1.	Ferruginous gravel and yellow sand	2 to 10 feet.
2.	Pale lead colored laminated clay	2 feet.
3.	Lignitic sand or black sandy clay	......

From the dip of the beds in the region this clay appears to be the highest in the list of clay deposits in this neighborhood.

Half a mile further west, and on the same headright, Bed No. 2 occurs. This deposit dips slightly towards the east, and has the same light blue or pale lead color and is six feet thick. It was worked some years ago for the manufacture of earthenware, but with the exception of a few trial loads obtained by M. K. Miller, it is not now in use. A section of the pit gives the following:

1.	Ferruginous sand and gravel	5 feet.
2.	Pale lead colored clay	6 feet.
3.	Lignitic matter	......

From its elevation and its relation to the underlying black lignitic clay or sand, this deposit appears to be a western extension and outcropping of the deposit found in the Miller pit.

Bed No. 3 occurs in a brook on the Bishop farm, on the Boly C. Walters headright, about a mile north of Athens. This clay is a pale brown and blue color, and underlies a pavement of large ferruginous bowlders and has a thickness of over six feet. A section of the opening gives the following:

1.	Yellow sandy clay and sand	2 feet.
2.	Bowlder bed	6 to 10 inches.
3.	Brownish blue clay	6 feet.

This deposit appears to underlie the M. K. Miller deposit and overlie the deposits found close to the town of Athens. This clay has never been used for manufacturing purposes.

Bed No. 4 occurs about a quarter of a mile west of the town. This is the most extensively developed deposit of clay known in Henderson County. Outcroppings of this deposit are found in numerous places throughout the Thomas Parmer and B. A. Clark headrights, and underlies the whole of the town of Athens. The western edge of the bed so far as yet known is seen outcropping in two small cuttings on the St. Louis, Arkansas and Texas Railway, about a mile west of Athens. The bed has a slight dip to the east, or a little south of east, and a tendency to thicken in its easterly course. At the pit opened by the Texas Fire Brick and Tile Company's works this bed has a thickness of two feet at the western end of the pit, but rapidly thickens to eleven feet, and at Henry Morrison's pit on the Clark headright, one mile east of the town, it has a thickness of twelve feet. The clay is light, almost white in color, and overlies a fine white, even-grained siliceous sand. A section of the Texas Fire Brick and Tile Company's pit gives the following:

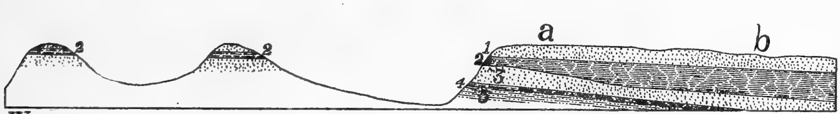


Fig. 14.

a, Texas Fire Brick and Tile Company pit. b, Henry Morrison pit.

1.	Yellowish brown sandy clay	5 feet.
2.	White colored fire clay	2 to 11 feet.
3.	Fine white sand	5 feet.
4.	White clay	1 foot.
5.	Pale blue sandy clay (known to be)	4 feet.

The section at Henry Morrison's pit gives the following:

1.	Yellowish brown sandy clay	5 feet.
2.	Light bluish white clay, containing small spots of bright red in the upper division, but becoming white in the lower	12 feet.
3.	Fine white sand	

The areal extent of this bed or deposit is not known, but the numerous openings which have been made indicate its having a workable area of nearly two miles in length and over a mile in width. An opening made in this deposit on Mr. B. Wofford's land, about three-quarters of a mile southeast of Athens, is reported as showing the clay to be thirty feet thick and to contain numerous leaf impressions in the lower divisions of the beds.

A deposit of a bright red colored clay occurs on the top of a hill on the south side of the J. B. Attwood headright. This deposit is four feet thick and is covered with a thin ferruginous, gravelly soil, and lies upon a red colored sand.

A deposit of dark blue lignitic clay occurs underneath a deposit of lignite on the southwest side of the C. M. Walters headright. This deposit is four feet, and possibly more, in thickness.

The clays of the county may be divided into three divisions, viz.: 1st. Clays suitable for building materials, such as the common building bricks, ornamental or front pressed bricks, and terra cotta ware. 2nd. Refractory clays, or clays suitable for the manufacture of furnace and cupola linings, fire bricks, fire backs for grates, etc. 3rd. Pottery clays, or those suitable for the manufacture of ordinary earthenware.

1. BRICK CLAY.

Extensive deposits of clay suitable for the manufacture of ordinary red building bricks form the surface deposits in many portions of the county. At the Texas Fire Brick and Tile Company's yard fine red colored pressed brick, suitable for frontal purposes, have been made from a mixture of the overlying brown sandy clay and the upper or stained part of the company's fire clay bed. Bricks made from this mixture and repressed by a Raymond press take a fine skin and clear red color. These brick burn very hard and solid.

A bright red clay found on the south side of the J. B. Attwood headright is used by Mr. Henry Morrison as a mixture with the upper lying division of his white clay bed for the manufacture of an ornamental brick. These bricks burn hard and have a strong tendency to glaze. The ornamentation on these bricks burns sharp and clear. Paving tiles and blocks are also made from this mixture and appear to serve this purpose very well. Some portions of the streets of Athens have been paved with these tiles for several years, and as yet do not show any signs of breakage.

Ordinary building bricks are made from the brown sandy clay overlying Mr. Morrison's white clay, but these bricks have a tendency to split in the burning.

Ordinary building bricks have been made by several parties around Athens, but with the exception of a few made by Mr. Morrison no continuous work in this class of building materials is carried on. Bricks made from mixtures of these clays when burned hard have a pale brownish gray color, spotted with iron stains, and are extremely hard.

2. REFRACTORY CLAYS.

The clays found in beds Nos. 1, 2, 3, and 4 are all suitable for the manufacture of refractory clay goods, such as fire bricks, furnace and cupola linings, fire backs for grates, etc. The clay obtained from Bed No. 4 is utilized by the Texas Fire Brick and Tile Company to make all the above classes of goods. The furnace linings manufactured by this company are used in the iron furnace at the State Penitentiary Iron Works at Rusk, and are highly commended by the superintendent of that institution. Cupola linings made by the same company are also used in the Kelly Plow Company's works at Longview with very satisfactory results. Large quantities of fire bricks are also shipped to Dallas, Fort Worth, and other places, with satisfactory results.

Bricks made from this clay burn hard and have a chalky white or creamy white color, according to their position in the kiln. When freshly burned these bricks weigh about six pounds, and their power to absorb moisture is about 0.6 per cent of their weight.

In the manufacture of these fire clay goods nothing but the clay itself is used. Dried lumps of clay are placed in the kiln and subjected to the same amount of firing as necessary to burn the brick. This material is afterwards withdrawn, ground, and mixed with the raw clay in the proportion of about thirty per cent of this calcined clay or "chamotte" to seventy per cent of the raw material.

An analysis of this clay dried at 115° C., made in the laboratory of the Survey, shows this clay to have the following composition:

Silica	68.55 per cent.
Alumina	26.00 per cent.
Ferric oxide	Trace.
Potash	Trace.
Soda	Trace.
Lime	Trace.
Magnesia	0.11 per cent.
Water and loss on ignition	6.00 per cent.
	100.66
Sand	4.20 per cent.
Specific gravity	2.18

3. POTTERY CLAYS.

No thoroughly first class reliable pottery clay has been yet found in the vicinity of Athens. Mr. M. K. Miller has been using a clay obtained from beds Nos. 1 and 2 with only partial success. The chief difficulty with these clays is their non-vitrifiable qualities. In burning the ware it is found to have a tendency to form too open a body in the time necessary to burn, and if the time be prolonged the ware shows a decided tendency to crack and break. These clays do not admit of a good glaze, in so far that the Albany slip used does not readily adhere to the ware, but scales off, leaving the open body exposed.

In the manufacture of open ware, such as milk jars, pans, churns, etc., or such articles as may not be required to retain liquids for any prolonged period, this clay will serve the purpose very well, and will make a strong, durable article suitable for everyday use. For jugs and other articles required to retain oils, liquors, etc., for a prolonged period the clay is not suitable without a mixture of a more alkaline or fusible clay.

The following is an analysis of an air-dried specimen of clay from bed No. 1, used by M. K. Miller in his pottery:

Silica	69.20	per cent.
Alumina	21.03	per cent.
Ferric oxide	1.37	per cent.
Potash	Trace.	
Soda	2.30	per cent.
Lime	Trace.	
Magnesia	0.94	per cent.
Loss on ignition	5.16	per cent.
	100.00	
Sand	8.50	
Specific gravity	2.04	

The following analysis is from an air-dried specimen of clay obtained from bed No. 3:

Silica	70.80
Alumina	18 56
Ferric oxide	1.04
Lime	Trace.
Potash	Trace.
Soda	5.35
Magnesia	1.58
Water and loss	2.60
	99.93

There is every probability that this clay, if properly worked, will be found to make a closer bodied ware and be more suitable for the manufacture of earthenware vessels than any of the other clays found in the vicinity of Athens. No tests have ever been made.

4. MISCELLANEOUS CLAYS.

There are several other classes of clays in the vicinity of Athens, all of which are suitable for the manufacture of the ordinary draining tiles, and some may by judicious mixture with other clays be suitable for sewer pipe uses. Owing to the open texture to which ware made of the other clays burn, none have been found upon experimentation to be suitable for the manufacture of this class of clay goods. The drain tiling made by the Texas Fire Brick and Tiling Company is of a good quality and will admit of transportation for long distances.

The following analyses are from clays dried at 115° C., obtained at the Henry Morrison pit and from a clay bank used by Mr. Morrison as a mixture in the manufacture of ornamental bricks and paving tiles:

HENRY MORRISON PIT.

Silica	72.30
Alumina	19.33
Ferric oxide	2.47
Soda	4.44
Potash	Trace.
Lime	Trace.
Magnesia	0.50
Loss on ignition not determined	.....
	99.04
Sand	5.85
Specific gravity	2.22

RED CLAY FROM J. B. ATTWOOD SURVEY.

Silica	61.90
Alumina	23.70
Ferric oxide	5.50
Soda	1.27
Potash	Trace.
Lime	Trace.
Magnesia	1.11
Loss on ignition	6.52
	100.00
Specific gravity	1.93

THE CLAY INDUSTRY.

There are four establishments for the manufacture of fire bricks, tiles, and pottery in the neighborhood of Athens, viz.:

The Texas Fire Brick and Tile Company.—This is the most extensive clay working plant in Athens, and devotes its whole attention to the manufacture of refractory goods, such as fire bricks, furnace and cupola linings, and grate backs. Drain tiles are also made by this company, and sewer pipes were also made for some time, but owing to the unsuitable quality of the clay for this purpose the manufacture of sewer pipes has been abandoned.

The clay used for the manufacture of these bricks after being taken from the pit is stored in a shed, where it is allowed to dry for some time. When required for use it is ground in a dry pan, at the same time being mixed with the necessary amount of "grog" or calcined clay. From the pan the mixture is raised by an elevator to the pug mill, where, after being thoroughly mixed and worked, it passes down through a funnel to the press. These bricks are made in a Bennett brick machine having a daily capacity of fifteen thousand bricks. After being taken from this press the bricks are repressed by a Raymond hand press and dried under cover, care being taken to allow as little handling as possible after repressing.

The fire bricks and linings are burned in a series of four round dome-shaped down-draft kilns, having a capacity of forty thousand bricks each. These kilns are set in the form of a square and united to a single smoke stack which rises from the center of the area between the kilns. In burning the bricks three days are allowed for water smoking and four days for burning off, and the whole burn is generally completed in seven or eight days. The fuel used is altogether wood, and half a cord is allowed for each one thousand bricks. Large quantities of this clay are dried and ground and shipped to various points, where it is used as a mortar for setting fire bricks, a purpose to which it appears to be admirably fitted.

The works are run by steam power, and when in full operation employ from twenty-four to thirty men.

THE ATHENS POTTERY COMPANY. — This is a small pottery recently commenced (July, 1890) by Mr. M. K. Miller. The clays worked are from a pit on the J. B. Attwood headright, and the articles made are mostly jugs, jars, churns, flower pots, and earthenware dishes. Most of the ware made is glazed with the "Albany slip" black glaze, and only a small quantity of salt-glazed ware is made. The machinery used for preparing the clay at this factory is very simple. The clays are placed in a small pug mill operated by a horse. From this mill it passes into a pit, where it is spaded over and taken into the factory as required. The newly turned ware is dried on an artificial dryer before slipping. The kiln is a round up-draft kiln and has a capacity of thirty-five hundred gallons.

In burning the ware twenty-four to thirty hours are allowed for completing the burn, and the ware is usually removed on the third day after the commencement of the firing. Longer burning, it is said, causes the ware to "craze," or air check, on being brought into the air, and often causes a considerable quantity of the articles to break in the kiln. Six cords of wood are usually required to burn a kiln, or about two cords to every one thousand gallons of ware.

This pottery employs five men.

SOUTHERN POTTERY, TILE, AND BRICK COMPANY.—This company has ceased work, owing to the unsuitable quality of the clay it was using. When in operation the clay used was obtained from the same bed as that of the Texas Fire Brick and Tile Company. The company's works have a capacity of producing one thousand gallons of ware daily.

HENRY MORRISON'S BRICKYARD.—This brickyard is situated about a mile southeast of Athens, and works a white clay in conjunction with the bright red clay found on the south side of the J. B. Attwood survey. The upper yellow or surface sandy clay is also utilized in the manufacture of ordinary building bricks. The section at this yard gives the following:

1.	Brown or yellowish brown clay or loam	5 feet.
2.	Light blue white clay	12 feet.
3.	White sand	

Ordinary building bricks, ornamental and frontal bricks, and paving tiles are made at this yard. The bricks are first made in a Penfold machine and afterwards repressed by a Raymond hand press. The ordinary bricks are usually dried on the yard, but the finer articles are dried under cover. The kilns (of which there are two) are oblong-shaped, up-draft, old-fashioned kilns, with a capacity of ten thousand bricks.

The paving tiles made at this yard are very hard and durable and of a good size and shape.

The yard does not work regularly, and the number of men employed is variable.

GLASS SAND.

The sections shown in the clay pits belonging to the Texas Fire Brick and Tile Company, at Henry Morrison's pit, and also at the base of the clay deposits on B. Wofford's land, show the existence of a fine white siliceous sand. This sand bed wherever cut through shows a uniform thickness of between five and six feet, and has an areal extent, so far as known, coextensive with the fire clay deposits, or nearly two miles in length and over a mile in width.

This sand is an angular, even-grained white sand, in every respect suitable for the manufacture of ordinary glassware, as well as for the manufacture of window glass. It contains a very small proportion of alumina and practically no iron, and will require very little preparation in the way of washing to fit it for the glassmaker's use.

This sand compares with the New Jersey glass sands in every respect and is much more cheaply obtained. In the New Jersey sand beds the stripping or top dirt, consisting of gravel and sand, is in some places seventeen feet thick.* At Athens the stripping is in a few places as deep as twelve feet, but

*Geology of New Jersey, 1868, page 691.

it consists of a clay which can also be sold at a price even higher than the sand.

Large quantities of this sand are shipped to Dallas and Fort Worth, where it is used for mixing with lime to make a fine grade of finishing plaster.

LIGNITES.

The greater portion of the central and western portion of the county is underlaid by lignitic deposits. These lignites outcrop at various places in the neighborhood of Athens. When first taken from the mines the lignite forms a solid block with a subconchoidal fracture and slightly coal-glossy lustre, but upon exposure to the air for a few days it loses its gloss and becomes a dead black and in a short time breaks into small cuboidal fragments.

The Texas Fire Brick and Tile Company mined and used as a fuel for steam purposes lignite from an outcrop on the southwest corner of the C. M. Walters headright. The following is a section of this opening:

1. Gray sand	6 feet.	
2. Yellow clay		2 inches.
3. Lignite	6 feet.	
4. Dark blue clay	4 feet.	
Total	16 feet	2 inches.

In mining this lignite the overlying sand and clay were taken off and thrown into the hole left by the extraction of the coal. The product obtained was used as a fuel for some time, and is reported as being a good steam producer when carefully watched, but the utilization of this coal has been abandoned.

ANALYSES.

The following analyses of these lignites made in the laboratory of the Geological Survey were made from two specimens from the same bed, No. 1 being a freshly mined specimen, and No. 2 from a specimen taken from the Survey Museum, in which it had been kept in contact with the air for more than two years:

Locality.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.
No. 1, C. M. Walters headright	6.80	50.65	37.00	5.55	0.52
No. 2, C. M. Walters headright*	5.70	57.45	29.85	7.00	0.87

Analyses by J. H. Herndon. *Collected by Dr. R. A. F. Penrose, Jr.

Lignite also occurs in a bluff on the north side of the S. Calderon headright. The following is a section of this bluff:

1.	Brown sand	10 feet.
2.	Thinly laminated sandy clay	14 feet.
3.	Black sandy clay	2 feet.
4.	Lignite	10 inches.
	Total	21 feet 10 inches.

On the Neches River, about two miles east of this place, lignite occurs in the bluffs of the river, extending southward for nearly a mile. Lignite is also found in wells throughout the southeastern portion of the county at depths ranging from twenty to forty feet.

TIMBER.

In addition to being on the western boundary of the iron bearing regions, Henderson County appears also to lie upon the extreme western edge of the pine growing area of the State. No pines grow in any portion of the county except in the extreme southeastern, where a few scattered trees or small groves are found close to the Anderson County line.

The timbered area of Henderson County is probably equal to about two-thirds of the whole extent of the county, or nearly six hundred square miles. The timber consists chiefly of the several varieties of oak—mostly post oak, blackjack oak, water oak, white oak—and hickory.

The growth of all these trees is small, and will probably not exceed an average of twenty-five or thirty cords of wood per acre.

CHAPTER VI.

SMITH COUNTY.

BY J. H. HERNDON.

PRELIMINARY STATEMENT.

Dr. R. A. F. Penrose, Jr., in his report on the iron ores of Eastern Texas, has devoted much research and time to studying their origin, modes of deposition, general character, and relations to each other and to the underlying and overlying formations, and has necessarily given the general geology of the Tertiary and later formations. His field of operations embraced the whole of Eastern Texas, including Smith County. This being the case, I have restricted my efforts to the thorough mapping out of the iron ores, clays, lignites, building stone, etc., paying especial attention to their economic features, leaving the general geology as properly belonging to him. It gives me much pleasure, however, to be able, after thoroughly investigating the same field, to add my endorsement and approval of his theories in regard to the origin of the iron ores of Eastern Texas.

GEOGRAPHY AND TOPOGRAPHY.

Smith County is in Eastern Texas, Tyler, its county seat, being in latitude thirty-two degrees twenty minutes north, and longitude ninety-five degrees ten minutes west. On the north it is bounded by Wood and Upshur counties, the Sabine River forming the boundary line; on the east side by Gregg and Rusk counties, on the south by Cherokee, and on the west by Henderson and Van Zandt counties, the Neches River being the boundary line for a great part of the distance. It has an area of nine hundred and fifty-seven square miles, and is well watered by numerous springs and streams and possesses a very elaborate drainage system. Village, Duck, Saline, Harris, and Mann's creeks drain the northern portion of the county and empty into the Sabine River. The Neches River drains the western portion, while Mud Creek, or the Angelina River as it is known further down, drains the southern and southwestern portion of the county.

The general surface of the country presents the usual characteristics of the iron ore regions of the Gulf Tertiary of Texas. It consists of a series of hills and plateaus, with narrow undulating valleys, the whole surface being cut by numerous streams and deep ravines. These divides are for the most part generally narrow, but occasionally broaden into wide and extremely level plateaus, sometimes several miles in breadth, and are capped by strata of iron ore of varying thickness, to the presence of which the ridges owe their very existence.

At a former period the whole county represented an old Tertiary sea bottom, or base level, and formed one extensive level plateau. The Neches and Sabine rivers have cut through this plain to a depth of two hundred to four hundred feet, the softer strata of which have been eroded and worn away, leaving as elevations those portions which are capped by iron ore or sandstone, thus giving rise to the present configuration of the county. This erosion has been upon a very extensive scale, and is still continuing its work of denudation at a rapid rate.

The iron ore ridges are covered by a dense forest growth of oak trees, hickory, pine, walnut, sassafras, mulberry, cottonwood, etc., and have generally an altitude of from three hundred and fifty to seven hundred feet above the sea level, and are from one hundred to two hundred and fifty feet higher than the main drainage grooves of the Sabine and Neches.

However, they are often represented by isolated hills one-half to one mile in length by two hundred to three hundred yards in breadth, which are heavily timbered and cut by innumerable tributary small streams and ravines.

IRON ORES.

LOCALITIES AND AREAS.

The main ore beds of this county lie at a distance of from one to six miles south of the Sabine River, and can be traced in broken areas across the entire northern portion of the county. In the southern portion are several small divides, capped with good ore, which are a continuation of the iron ore beds of Cherokee County. The bluffs east of the Neches River contain a very fair grade of limonite ore, though it is so broken that it is probably not sufficient in quantity for economic purposes.

There are six localities in the county where ore occurs in sufficient quantities to render it commercially valuable, the boundaries of which I traced carefully and have noted on the accompanying map.

The first of these is the Garden Valley bed. It begins on the F. B. Ragsdale survey and runs a little west of north through the western lines of the H. Cozzart, Wade, and Wm. McCary surveys, thence crosses near the southwestern corner of the R. G. Stewart, touches the J. Williams, thence turns east through the Casey Askew, and extends through the southeastern part of the San Antonio and Mexican Gulf Railroad Company survey; from there it turns southeastward, passes through the southwestern corner of the Thos.

Gardiner and the northern portion of the John P. Potter, touches the northeast corner of D. Brown headright, turns northeast again, passing through the centre of Jas. Bunch survey, thence northwest to the Wm. T. White, taking in the southwest corner of Peter Swanson survey; thence south again through the Bennet McNeely, and skirting the western line of the Ellison tract, and then taking in nearly the whole of the M. T. Hemphill and Sanders surveys; from the Sanders tract it turns northwest again through the McKnight, Caldwell, and Wm. Johnson surveys back to the F. B. Ragsdale, whence it started.

The second iron field is the Steen Saline or Lindale bed. It is three miles east of Lindale and five or six miles south of the Sabine River.

Its extreme northwestern point is in the Sam Stevens headright. From this point it runs a little south of east through the southern parts of the Dawson, John McCoy, and B. Jolley surveys, and breaks off in the northeastern part of the John Steen headright. Farther east, across Saline Creek, it begins again on the B. Yeargan survey, and runs south through the western corner of the C. Secrest, and extends in a southwesterly direction through the Estrada, and continues to about the centre of the Felix Flores league. From here it runs northwest, cutting off the northeast corner of Pedro Del Rio league, from thence through the southwestern portion of the Carmona league, thence north again to the starting point on the Stevens headright. A narrow ridge of ore runs southwest from the Pedro Del Rio league to the Frances Gilkeson headright, west of Swan's Switch.

The third bed is on Price's survey, still further east of Lindale, and embraces approximately the Wm. Price, S. M. Grace, Casey Green, Jas. T. Shepard, and Geo. W. Welsh headrights.

East of Winona and northwest of Starrville is another quite extensive bed of ore. It begins about a mile east of Winona and runs north along Harris Creek, through the Robert Walters survey, to within a mile of the Sabine River; it then turns east and extends nearly to the east line of the E. Newberry survey, then turns south, crossing half of the E. E. Lott survey, runs through the western portion of the I. Croom, touches the southwest corner of the Geo. M. Nichols survey, crosses the fork of Harris Creek, bends west, and begins again in the southeast corner of Eustacha Newberry survey, runs southeast through the corner of the L. W. Hall, takes in the Lagrove survey; thence turns west along the M. Mase, extends through the north corner of the M. Sewel to the southwest corner of the M. B. Clark survey; it then turns north again and skirts the eastern line of the M. B. Clark survey, back again to the starting point on the Eustacha Newberry.

Eight miles northeast of Tyler is another smaller outcropping of good ore. It embraces the southern portion of the Isaac Killough, J. M. Hall, and J. C.

Balger surveys and the western half of the John B. Wright and S. Hopkins, and nearly all of the Thos. Hays, Wm. McAdams, and all of the Geo. B. Chanceller and F. M. Draper headrights.

The last locality is that of the Gandy Mountain, between Bullard and Troupe.

Gandy Mountain is a narrow ridge about one-half to one mile wide, beginning on the E. Gandy and Wm. Bickerstaff surveys and running northwest through the Jordan, John Wagoner, John Chaube, John Vaughn surveys, passing through the corners of Wm. Luce and Manuel Gutierez leagues, and terminating in the Wm. Chancellor headright. The total area of the iron ore beds of Smith County is eighty-one square miles, divided as follows:

		Square Miles.
1.	The Garden Valley bed	30
2.	Lindale or Steen Saline bed	20
3.	Price's	3
4.	Winona and Starville beds	18
5.	G. B. Chancellor bed, eight miles southeast of Tyler	4
6.	Gandy Mountain bed	6
	Total	81

These figures are only intended to represent approximately the area of the iron ore deposits, for the ore beds are cut by innumerable ravines and creeks, and are by no means continuous over the whole area described.

OCCURRENCE OF THE ORES.

The iron ore may be seen cropping out in horizontal stratification around the edges and brinks of these hills, and has a thickness varying from six inches to three feet, and is in every instance overlaid by a thin stratum of angular quartz sandstone, and in some cases with from one to twenty feet of soil, while the ore is underlaid by from ten to thirty of altered greensand, which in turn overlies a series of red sandy clays. In some places the greensand is wanting. Where this is the case the iron ore is replaced either by a soft yellow sandstone, which hardens on exposure to the atmosphere, or by a dark colored hard ferruginous sandstone.

BENCHES.

Wherever good ore is seen in Smith County the hills which carry it show the typical bench structure. Mr. Penrose has described in a general way the benches in Smith, Anderson, and Cherokee counties.* He says:

"As has been stated by the writer, in a previous report, these benches can be formed in three different ways:

*First Annual Report Geological Survey of Texas, 1889, p. 8.

"1. By landslides, which have carried down a portion of the top bed to a lower level, often giving the appearance of a second bed of iron ore, when it is only the edge of the upper one.

"2. The alternation of hard and soft strata. The softer beds become eroded, and expose the harder iron ore, sandstone, or hardpan.

"3. By erosion in successive periods of elevation of the country.

"It is probable that each of these causes has formed some of the benches, but they are usually so heavily covered by detritus that it is often very difficult to determine which has formed any certain bench. In the iron ore region of Cherokee, Anderson, and Smith counties, however, they are very often, if not most often, due to landslides (2). At first it might appear that the great number of such benches on a hill side, their occasional regularity, and their universal occurrence could not be accounted for by this explanation, but an examination of the form of erosion now going on in the country tends strongly to prove that this cause has operated, at least in a great number of cases. As we go over any of the iron bearing highlands the ore bed is seen to be sunken as we near the brink of the hill, and this is especially true at the heads of ravines where springs gush out. It has already been stated that the iron ore is overlaid by sand and underlaid by a bed of greensand thirty to forty feet thick. Beneath this are interbedded sands and clays, all lying horizontally, or almost so. The springs rise sometimes above the iron ore bed, but more often between it and the greensand, and below the greensand. When the underground waters reach the outcrop of the bed along which they are flowing they appear as a spring, generally highly ferruginous, and giving rise to a small stream. In wet weather the flow from these springs is very strong, and besides carrying out the mineral matter in solution, they also transport in the state of mechanical suspension large quantities of sand from the beds through which the water has flowed before reaching the surface. This action gradually makes the sand strata porous and honeycombed, and the result is that it finally reaches such a stage of this condition that it gives way to the pressure of the overlying beds, sinks down, and causes the formation of a bench on the hill side. Of course more sand is carried from the part of the bed near its outcrop than back in the hill, and hence the reason that the benches generally slope toward the drop of the mountain, and also the reason of the downward slope of the ore on the edge of the summit.

"There are many facts that tend to prove that such an occurrence as this has gone on.

"1. There is generally found a cap of iron ore on the benches as well as on the top of the hill, and of the same nature and the same thickness in both places. Yet where a clean section of the deposit underlying the top ore bed is seen, it is very rare that lower beds are found, and when they do occur they are thin, discontinuous, and of a physically different ore than the main bed. This would tend to show that the ore bed found on the benches belonged at the level of and had once been part of the main bed.

"2. The greensand underlying the ore bed varies from thirty to forty feet thick, yet when there are several benches on the hill slope, and we measure the vertical thickness of the greensand from the upper ore bed to the base of the outcrop, it often appears almost a hundred feet thick. This can only be explained by supposing the edge of the hill to have slipped.

"The alternation of hard and soft strata doubtless causes the formation of many benches, but this generally occurs in the country north of the Sabine, where almost all the benches are due to it. The soft strata over a harder one are worn away, until the eroding agencies come to the hard floor, which temporarily arrests the denudation, and hence arises a bench. The number of benches that can be explained as sea beaches, or river and lake terraces, is exceedingly doubtful, and the want of contour maps, as well as the concealed condition of all the strata, makes it still more difficult to determine the extent to which this cause has operated. No satisfactory work can be done in the matter until good maps are obtainable."

Eight miles southeast of Tyler this structure is well represented. Here the benches are two in number. A section gives:

1.	Soil and sand	1 to 10 feet
2.	Angular sandstone	¼ to 1 inch.
3.	Black laminated ore	6 to 10 inches.
4.	Altered greensand	10 feet.
5.	Red sand clay, at base exposed	50 feet.

One mile west of Steen Saline and four miles east of Lindale, the same structure may be seen again. At this locality I counted no less than four benches, which are probably due to landslides. Good ore of the black laminated variety was seen in all four benches. In many other places in the county their structure is well illustrated.

DESCRIPTION OF THE IRON ORES.

The iron ores of Smith County may be classed as brown hematites, otherwise known as limonites. They have as a rule from five to twenty per cent of water, three to thirty-five per cent of silica, from two to twenty per cent of alumina, with small amounts of lime and magnesia. The metallic iron varies from twenty to fifty-six per cent. These ores are high in phosphoric acid, some of them having as high as one per cent, and the average being about four-tenths of one per cent. The sulphur is not so high, as many of the ores have only a trace of it.

An average of forty-three complete analyses of iron ores from Smith County gives the following results:

Metallic iron	40.56 per cent.
Alumina	10.13 per cent.
Silica	22.41 per cent.
Phosphorus	.24 per cent.
Sulphur	.07 per cent.
Water	9.97 per cent.

From the above figures it will be seen that the ores are of a very good grade. Several of the ores among those counted in making the above average were conglomerates very high in silica. This of course would raise the general average of silica and lessen that of phosphorus and other constituents.

In his report on the iron ores of Eastern Texas Mr. Penrose has divided and discussed the iron ores under three heads. First, Brown Laminated ores; second, Geode or Nodular ores; and third, Conglomerate ores. For the sake of clearness and convenience, I will follow his classification of the ores. All three varieties of these ores are well represented and pretty widely distributed over the county.

In the southern portion of the county are several very extensive outcroppings of the laminated variety, but by far the largest beds of this ore are seen in the northern part of the county. There the ores appear in broken areas, at from one to seven miles south of the Sabine River, throughout the whole northern portion of the county

Along the bluffs of the Neches River, in the south-western portion of the county, there occurs a very fine quality of limonite ore, though it is probably not in sufficient quantities to render it commercially valuable. (See Analysis No. 20 in tables.)

1. BROWN LAMINATED ORES.

Dr. Penrose describes these ores as follows: *

"The ore is a brown hematite of a rich chestnut color, and often of a highly resinous lustre. In structure it varies from a compact massive variety showing no structure, to a highly laminated form, the laminæ varying from one-sixteenth of an inch to one quarter of an inch in thickness, frequently separated by hollow spaces, and sometimes containing thin seams of clay. These often give it a buff color and a crumbly nature, and hence the name often applied to it of 'buff crumbly ore.' The laminæ frequently show a black glossy surface, though the interior is always the characteristic rich chestnut brown color. * * * The ores occur in horizontal beds from one to three feet thick, and average between eighteen inches and two feet in

* First Annual Report Geological Survey of Texas, 1889, pages 66 and 67.

thickness. It is flat on top, but is bulging and mammillary below, and lies at or near the summits of the highest hills in the region. In fact, it is to this protecting cap of hard material that the hills owe their existence, as it has saved the underlying strata from the effects of erosion, which otherwise would quickly have lowered them to the level of the surrounding rolling country. The iron ore bed is directly underlaid by a deposit of a soft yellow indurated glauconite (greensand) varying from thirty to forty feet thick. This bed is sometimes hardened into a soft rock, easily cut with a saw or an axe, and locally used as a building stone. The interior of the bed, however, where it has not been exposed to the atmosphere, retains the dark green color of the unaltered greensand. It contains considerable iron pyrites and numerous casts of fossils of the Claiborne Epoch, and represents the entire north extension of the Smithville beds of the Colorado River. This in turn is underlaid by a great series of sands and clays, for a description of which see the Timber Belt beds."

This description, which was intended for the whole area of Eastern Texas, fits admirably the ores of Smith County, hence I have given it in full.

LOCALITIES.—The first locality at which I examined the laminated ore was on the J. B. Chancellor headright, eight miles southeast of Tyler. Here the ore was seen in large quantities, covering an area of about four square miles. It is of the black and brown laminated variety, the laminæ on the surface preserving a resinous lustre, showing iridescent colors, but on breaking open a piece of the ore the rich characteristic chestnut brown color is seen. The ore crops out on the brink of the ridge, and is from six to ten inches in thickness.

The ridge itself is covered by a dense growth of blackjack oaks, hickory, etc., and is cut by numerous deep ravines and hollows. At this locality may be seen also the typical bench structure of the iron ore regions, which here are two in number. The ore is overlaid by from one to twenty feet of soil and sand, and has a thin veneering of sandstone from one-half to two inches in thickness on it. It is underlaid by from ten to twenty feet of soft indurated greensand, in which a few casts of fossils and calcareous concretions were occasionally seen. The greensand is in turn underlaid by a series of red sandy clays containing thin seams of iron ore and ferruginous pebbles. A section of the various strata gives:

1.	Sand and soil	1 to 20 feet.
2.	Siliceous sandstone	½ to 2 inches.
3.	Laminated iron ore	6 to 10 inches.
4.	Altered greensand	10 to 20 feet.
5.	Red sandy clays, at base exposed to view	60 feet.

About five miles southwest of this point, and seven miles west of Troupe, the same character of ore was again met with. The ridge at this place is known locally as "Gandy Mountain," and is covered by good ore—lying for the most part directly on the surface throughout its whole extent. Gandy Mountain is about one hundred feet higher than the surrounding country, and is from one-half to one mile in width and about three or four miles in length.

It begins on the Wm. Chancellor headright on the north and terminates abruptly on the Gandy and Bickerstaff headrights at its southern extremity.

The ore is of a rich chestnut-brown color of the laminated variety, and is seen lying directly on the surface of the mountain. It is underlaid by ten to twenty feet of greensand, which is in turn underlaid by red sandy clays.

In the northern part of the county, directly west of Swan's Switch, is a narrow isolated hill, one-quarter to one-half a mile in width by one mile in length, which is covered by a black massive iron ore, the laminæ in it being hardly perceptible. This ore is known locally as "black incinerated ore," and yields on analysis fifty-two per cent of metallic iron. This is the largest per cent of iron yielded by any ore in the county, but the value of this ore, I am sorry to say, is considerably lessened by the large per cent of phosphorus which it contains. (See No. 15, table of analyses.)

On the Carmona league, five miles east of Lindale and one mile west of Steen Saline, were seen large quantities of ore of the laminated variety, which varies in color from black to light brown. The laminæ of the ore is filled with a reddish clay, which accounts for the large amount of alumina found in it.

The ore at this locality covers an area of twenty square miles, and all phases and characters of the laminated variety may be seen. The bed of ore is discontinuous and much broken up. Large quantities of the ore as seen upon the surface often present a fantastical appearance. Bowlders of it may be seen varying from one foot to four feet in diameter, covered with protuberances which form clusters, the bowlders being sometimes flat on top, bulging or mammillary below, or perfectly round, though they have for the most part an oblong shape, presenting very much the appearance of a bunch of grapes. For this reason I have designated it as "botryoidal ore," though it is known locally as "buff crumbly ore" because the laminæ are filled with clay, and upon weathering or when struck with a hammer they are easily crumbled or shattered to pieces. The buff crumbly ores are very siliceous and are high in alumina.

North of Garden Valley buff crumbly ore of the same character as that described above covers an area of thirty square miles. In fact it is met with in patches and discontinuous beds south of the Sabine along the whole northern portion of the county.

2. NODULAR OR GEODE ORES.

These ores are not so well developed as the laminated variety, nor do they occur in such extensive deposits. They are always associated with sandy or sandy clayey deposits and rest conformably with them. The strata of sand and clay are always much cross-bedded and have thin seams of hard pan and thin ore running in every direction through them. The ore itself lies in discontinuous beds, which vary in thickness from a few inches to six feet, and occurs in perfectly rounded, honeycombed, or many chambered masses.

The last named variety, called septarious ore from its many chambers and partitions, is found in red sandy clay, and it nearly always has its chambers filled with red clay. While this ore occurs in the same kind of formation as the geode ore proper, its form points to a different origin. The clay and sand in which it is found are always much cracked and cross-bedded. Iron-bearing solutions have penetrated these cracks and along the planes of cross-bedding and deposited hydrated peroxide of iron, which forms the walls of the chambers, and the clay being thus incased in prison walls retains its original character.

LOCALITIES.—Two miles southwest of Starrville a very fair grade of geode ore was seen. It lies in discontinuous masses, the nodules varying from six inches to three feet in thickness. It is associated with red mottled clays and sandstone. (See ore No. 6 in table of analyses.) On the Eustacha Newberry survey, south of Winona, geode ore occurs on the surface, and still further south of Winona, on the Lawrence headright, a very good bed of geode ore was seen. This bed is about six feet thick, the geodes being about six inches in diameter.

Other localities are McNeely headright and north of Garden Valley and east of the Neches River.

3. CONGLOMERATE ORES.

The conglomerate ore is nearly always, though not invariably, found on the lower hills, in close proximity to running water. This ore is occasionally met with alongside of the laminated variety, which is found at an altitude of about one hundred feet above them, though this is rarely the case. Conglomerate ores owe their origin to the breaking up of the older deposits of iron ore, the detritus from which has been redeposited by running water; the detritus being composed of pebbles of iron ore, quartz, fragments of hard-pan, and occasionally pieces of silicified wood, all of them varying in size from a buckshot to several inches in diameter.

These pebbles are as a general thing cemented together by silica, though in some cases oxide of iron performs this function. Water, carrying in solution salts of iron, has percolated through the conglomerate bed, the iron being oxydized and deposited as red peroxide, which acts as a cement, binding the pebbles together in a coherent mass. Such is the case with the conglomerate ore found west of Winona. The ore having the oxide iron cement as a matter of course is very much richer in iron than those with the silicic acid, and sometimes carries as much as fifty per cent (though the general average is about twenty per cent) of iron. These ores could be very much improved by sorting, crushing, and concentrating them I found conglomerate ores of very fair quality on Price's survey, Eustacha Newberry survey, close to Garden Valley, eight miles northeast of Tyler, eight miles southwest of Tyler, and on several sections of the Seven Leagues.

UNCOMMERCIAL ORES.

Ores of poor quality, including highly siliceous conglomerates, very ferruginous sandstones, and thin seams of geode ore, may be seen in nearly every part of the county, and in places they are in close proximity to the laminated and buff crumbly ores, and possibly might be worked in connection with these with good results. These, even if they can be called ores, are not of commercial importance by themselves, and can only be utilized by working them in with richer ores.

The following is a table of analyses of iron ores of each character described from every locality where the ore is commercially valuable in Smith County:

TABLE OF ANALYSES OF IRON ORES OF SMITH COUNTY.

No. 1. Botryoidal iron ore. Carmona survey.
No. 2. Conglomerate iron ore. Price survey, ten miles east of Lindale.
No. 3. Conglomerate iron ore. Eustacha Newberry survey, one mile east of Winona.
No. 4. Segregated limonite ore. Robinson survey, three miles northeast of Winona.
No. 5. Limonite. Two miles southeast of Winona, Lawrence survey.
No. 6. Limonite. Lagrove survey, three miles southeast of Starrville.
No. 7. Limonite. Newberry survey, one mile west of Winona.
No. 8. Limonite. Newbery survey, one mile west of Winona.
No. 9. Limonite. Price survey.
No. 10. Massive iron ore. Section 27, Seven Leagues.
No. 11. Conglomerate iron ore. Five miles east of Tyler.
No. 12. Geode iron ores. McNeely headright, near Old Flora.
No. 13. Laminated ore. D. White survey, Garden Valley.
No. 14. Buff crumbly ore. Garden Valley.
No. 15. Massive laminated ore. Swan's Switch.
No. 16. Limonite. Four miles southeast of Tyler.
No. 17. Limonite. Felix Flores survey.
No. 18. Limonite. One mile west of Winona.
No. 19. Laminated ore. Mount Sylvan.

No. 20. Limonite ore. East of Neches River.
No. 21. Geode iron ore. Nine miles west of Tyler.
No. 22. Conglomerate. Eight miles northeast of Tyler.
No. 23. Brown laminated ore. Eight miles southeast of Tyler.
No. 24. Limonite. Mount Sylvan, Barcroft survey.
No. 25. Laminated ore. Five miles east of Lindale.
No. 26. Laminated ore. Gandy Mountain.
No. 28. Botryoidal ore. One mile north of Garden Valley.
No. 29. Buff crumbly ore. Garden Valley.
No. 30. Conglomerate iron ore. Eight miles southwest of Tyler.
No. 31. Brown laminated ore. Eight miles southeast of Tyler.
No. 32 Iron ore. From five miles south of Troupe.
No. 33. Laminated limonite. Just south of Steen Saline.
No. 34. Limonite. Price survey.
No. 35. Botryoidal iron sand stone. Near Steen Saline.
No. 36. Limonite. Price survey.
No. 37. Limonite. Three miles east of Tyler.
No. 38. Limonite. Seven miles west of Troupe.
No. 39. Limonite. Between Garden Valley and Lindale.
No. 40. Laminated limonite. East of Saline Creek.
No. 41. Laminated limonite. West of Saline Creek.
No. 42. Limonite. Garden Valley.
No. 43. Limonite. Starrville.
No. 44. Limonite. South of Sabine River.

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Sulphuric Acid.	Phosphoric Acid.	Water.	Total.	Metallic Iron.
1 *....	50.21	21.50	14.19	1.19	Trace.	.10	.22	13.10	100.51	35.47
2 *....	54.37	25.80	11.63	......	......	......	......	......	....	38.54
3 *....	34.93	23.60	20.67	......	......	......	......	......	......	24.64
4 †....	49.58	27.50	....	......	......	.09	Trace.	....	....	34.70
5 †....	56.75	18.85	12.05	Trace.	......	2.63	.18	9.60	100.06	39.72
6 †....	58.31	26.90	5.09	Trace.	Trace.	.07	.36	9.00	99.73	40.81
7 †....	71.40	14.50	6.10	Trace.	Trace.	Trace.	1.14	7.00	100.14	49.98
8 †....	49.26	36.50	5.74	Trace.	Trace.	.16	.83	7.60	100.09	34.48
9 *....	36.48	44.20	10.92	1.06	......	.12	.41	7.30	100.49	25.33
10 †...	43.65	53.50	....	......	......	.18	.41	......	....	30.55
11 †....	65.48	25.40	....	......	......	.28	.29	......	....	45.83
12 †....	62.98	16.40	8.02	Trace.	Trace.	.10	P1.49	12.10	100.10	44.08
13 †....	48.95	....	....	......	......	.10	.50	35.20	....	34.26
14 †....	44.28	37.70	10.52	.60	Trace.	.10	.66	6.40	99.85	30.99
15 *....	74.85	3.20	9.26	.45	......	.12	1.59	10.60	99.97	52.39
16 *....	49.90	33.30	6.30	.32	......	Trace.	.48	10.01	100.31	35.24
17 *....	61.65	21.65	5.55	.66	......	.03	.22	10.30	100.06	43.62
18 *....	73 60	5.60	10.40	1.25	......	.01	.36	8.54	99.76	51.99
19 *....	59.25	20.05	10.15	.98	......	.01	.70	8.75	99.89	41.86
20 †....	52.38	26.90	8.22	Trace.	Trace.	Trace.	.58	8.80	99.88	36.66
21 †....	57.05	16.00	14.35	1.80	Trace.	Trace.	2.08	8.80	100.08	39.93
22 †...	51.91	27.25	....	......	......	.36	.42	......	....	36.33
23 †....	57.05	11.65	20.35	Trace.	Trace.	Trace.	1.05	9.80	99.90	39.93
24 †....	79.82	3.00	....	......	......	......	......	......	....	55.87
25 †....	59.30	12.10	16.90	Trace.	Trace.	.24	.54	11.80	100.88	41.51

Nos. 33 to 44 inclusive were collected by G. E. Ladd.

Analyses marked * by J. H. Herndon; ‡ by L. E. Magnenat.

TABLE OF ANALYSES OF IRON ORES OF SMITH COUNTY—*continued.*

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Sulpuric Acid.	Phosphoric Acid.	Water.	Total.	Metallic Iron.
26 *....	59.25	16.55	13.65	.10	......	.34	.38	10.55	100.82	41.86
27 *....	61.75	16.80	9.85	Trace.	Trace.	Trace.	2.04	9.50	99.94	43.62
28 *. ..	42.10	39.50	8.70	.12	Trace.	Trace.	Trace.	10.01	100.43	29.74
29 *....	51.46	27.50	9.74	......	......	.24	1.47	9.48	99.89	36.34
30 †....	38.19	43 80	......	......	......	.27	.31	......	....	26.73
31 *....	57.25	8.18	30.63	1.23	.80	1.45	......	......	99.54	40.08
32 *....	20.46	......	......	......	......	......	......	......	....	14.32
33 † ...	68.68	12 05	6.12	Trace.	Trace.	.17	.18	13.00	100.20	48.07
34 †....	56.00	27.35	5.70	Trace.	Trace.	.32	.35	10.60	100.32	39.20
35 *....	32.48	58.90	2.32	Trace.	Trace.	Trace.	Trace.	5.40	99.10	22.73
36 *....	50.20	31.10	7.80	Trace.	Trace.	Trace.	.54	11.10	100.74	35.14
37 †....	65.96	11.20	8.83	.70	Trace.	Trace.	.62	13.50	100.81	46.17
38 *....	57.85	21.70	8.45	Trace.	Trace.	Trace.	.86	10.90	99.76	40.49
39 *....	64.36	16.90	7.44	Trace.	Trace.	......	.48	10.00	100.18	45.05
40 †....	59.71	22.25	7.39	Trace.	Trace.	Trace.	.80	10.00	100.15	41.79
41 *....	67.14	13.93	4.06	Trace.	Trace.	Trace.	.44	14.40	99.97	46.99
42 †....	58.89	21.20	8.61	Trace.	Trace.	......	.29	11.10	100.09	41.12
43 †....	63.73	14.80	14 67	Trace.	Trace.	......	.38	9.50	100.08	44.61
44 †....	53.83	30.90	4.47	Trace.	Trace.	.24	.025	10.40	99.86	37.68

Nos. 33 to 44 inclusive were collected by G. E. Ladd.

Analyses marked * by J. H. Herndon; † by L. E. Magnenat.

LIGNITES.

I have been asked so many questions while working up this subject about the origin and value of lignites, that I deem a short explanation of their origin would not be out of place at this time, when so little is known in regard to lignites in Eastern Texas.

When vegetable matter undergoes decay with exclusion of air, under water or in the earth, it undergoes certain chemical changes. These changes are aided by pressure and temperature. The vegetable matter or wood gives off water, carbonic acid, and carburetted hydrogen, thus becoming richer in carbon, and forming what is known as coal. Low swampy lands, lagoons, estuaries, and sand bars at the mouths of rivers afford the requisite conditions for the accumulation of vegetable matter.

In regard to the formation of coal, an eminent authority says: *

"The most generally received opinion is that much if not all coal results from the transformation of plants upon the site of their growth. The principal evidence in favor of such a supposition is afforded by the common occurrence of a bed of clay, the so-called 'under clay,' containing the roots of plants, representing the old soil, immediately below every coal seam—a fact that was first pointed out by the late Sir W. E. Logan in South Wales. * * * The action of the water in bringing down drift wood may also have contributed some material, but much less than the local growth. * * *

* Encyclopædia Britanica, vol. 4, page 47048.

The conditions favorable for the production of coal seem therefore to have been forest growth in swampy ground about the mouths of rivers and rapid oscillation of level, the coal produced during subsidence being covered up by sediment brought down by the river, forming beds of clay or sand, which on re-elevation formed the soil for fresh growths, the alternations being occasionally broken by the deposit of purely marine beds."

The lignites of this county belong to the Tertiary formation and are of more recent date than true coal. Those in Smith County were undoubtedly formed in small estuaries or lagoons on or near the coast. The materials, consisting of trees, leaves, and swampy plants, the same as the present growth, sometimes grew *in situ*, but for the most part were transported to their present resting place by rivers. This is shown by the cross-bedding of the inclusive strata of clays and sand.

In nearly every part of the county I found beds of lignite, varying in thickness from a fraction of an inch to ten feet. These beds are very numerous and lenticular in shape, having uniformly a dip to the south or southeast. The physical aspect of the lignite varies considerably. It differs in color from brown to black and from an amorphous mass to a hard glossy variety. From the great differences in their physical aspects, thickness, and the lenticular shape of the basins themselves, I am inclined to believe that these lignites were formed in estuaries and not in swamps and bogs.

I have personally inspected ten localities where lignite seams were exposed to view. In the northern part of the county it is developed in great abundance along the Sabine River, and may be seen cropping out in many places in its bed and bluffs. I also met with it in the southern portion of the county. On the Wm. Luce league a section of the strata gives:

Red sand	10 feet.
Blue clay, containing the seams of lignite and yellow sand	6 feet.
Sand, impregnated with lignite matter	5 feet.
Blue clay	6 feet.
Lignite exposed to view	3 feet.

The coal was brown in color and crumbled readily on exposure to the atmosphere. On section twenty-four of Thomas Quevedo survey the following section was seen:

Soil	3 to 5 feet.
Buff colored sandy clay	10 feet.
Red and white mottled clays, with streaks of sand	20 feet.
Blue sandstone	6 inches.
Lignite, brown in color	4 feet.

This specimen was very similar to the above, except that it contained inclusions of resinous matter.

Other localities are west of Lindale, three miles northeast of Lindale, sections 6, 24, and 40 of Seven Leagues, E. E. Lott headright, and in the Sabine River close to Belzora crossing.

The lignite beds are generally overlaid by from two to thirty feet of sand and clays, and can only be seen where the creeks and rivers have cut through the overlying strata.

As to the value of the lignites in Smith County, it is very small, from the fact that it has immense virgin forests which have hardly been touched, and a scarcity of wood will not be felt for a long time to come.

In their natural state the value of these lignites is quite small on account of the large amounts of ash, sulphur, and water which they contain, a great part of the heating power being lost in volatilizing the water, which varies from five to fifteen per cent of the whole. The difficulties in mining the lignites will be too great to render them of economic importance. The following is the analyses of five lignites made by Mr. Magnenat:

No. and Locality,	Water.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	
1. Eight and a half miles southwest of Tyler........	14.23	43.07	30.82	10.62	1 26	100
2. Three miles west of Lindale......................	9.83	32.45	16.10	40.22	1.70	100
3. Twelve miles southeast of Tyler, Wm. Luce survey..	11.70	43.57	27.76	16.38	.59	100
4. Lee Springs, six miles south of Tyler............	3.80	26.85	11.80	57.55	(*)	100
5. Three miles northeast of Lindale, Robinson survey..	11.40	40.90	35.50	14.20	(*)	100

*Not determined.

Nos. 1 and 5 are fair average samples of the lignites found in Smith County.

SOILS.

The soils in Smith County are of three different characters—the alluvial of the bottoms or chocolate soils, the gray sandy on a red clay foundation, and the red lands. The alluvial soils of the bottoms are best adapted for growing cotton, corn, and sugar cane. The light gray sandy soils are used nearly altogether for raising cotton and corn. The gray sandy or upland soils are not so productive as the other two kinds of soil, and they are probably deficient in potash, phosphoric acid, and lime, which are plant foods. I regret that the time was too short to have these soils analyzed for the purpose of ascertaining the nature of the defects and, if possible, the suggestion of a remedy.

The red colored soils, known as the red lands, are esteemed very highly by their owners, for they produce equally well cotton, corn, grain, and vegetables. They are especially adapted for fruit raising. Indeed, so salubrious is the climate and so excellent the soils that at no distant day we may hope to see the fruits of Eastern Texas rivaling in the markets of the East the far famed fruits of California. The people of Smith County are well aware of the importance of their fruit crop, and fine orchards and nurseries are springing up all over the county, and local capital has established in the last few years three canning factories, the capacity of each being twenty-five hundred cans of fruit daily.

CLAYS.

No deposits of the finest grade of procelain clays were found in Smith County, though in many localities clays were seen that would do for the manufacture of coarse pottery. Careful chemical analyses which I made of various samples of these clays show them to contain large amounts of free sands, iron, and alkalies, all of which are highly injurious to good pottery clays. While they can not be used for making procelain ware, with judicious selection and management they will make coarse pottery. This fact has been demonstrated by practical tests, and jugs, sewer pipes, churns, flower pots, and tiling have been manufactured from them.

In 1883 a jug factory was in operation on the E. B. Ragsdale headright, west of Garden Valley, which made a very good grade of pottery, though for some reason they suspended operations in a short time. The clay used in this factory is of a light gray color, which becomes nearly white when dry. It is very plastic, and is overlaid by from one to fifteen feet of red sandy and clayey strata. At the locality where I examined it about five feet of it was exposed to view. It is very similar both in physical and chemical properties to the pottery clays used in Henderson and Rusk counties. For the sake of comparison, I give below the clay from Garden Valley and also those used in Henderson, Rusk County:

No. 1.		No. 2.	
Silica	69.05	Silica	64.40
Alumina	22.60	Alumina	24.17
Iron (ferric oxide)	1.40	Iron	3.23
Potassa	2.03	Alkalies as chlorides	3.50
Soda	.99	Lime	Trace.
Sulphuric acid	Trace.	Magnesia	Trace.
Lime	Trace.	Sulphuric acid	Trace.
Magnesia	Trace.	Water	7.25
Water	4.12		

No. 1 is from Garden Valley and No. 2 from Henderson, Rusk County.

Three miles east of Lindale, one mile west of Tyler, three miles east of Tyler, and ten miles southwest of Tyler the same character of clay was again met with. The clay west of Tyler is on the land of W. L. Watkins, of Tyler. The bed is quite extensive, and is overlaid by from ten to twenty feet of soil and red sandy clay, though it is exposed to view in several places where ravines have cut through it. The sample which I obtained from this locality is quite sandy. Below is the analysis of it, made on the specimen dried at 115° centigrade:

Silica	85.40
Alumina	10.02
Iron	2.18
Lime	.10
Potash	Trace.
Soda	Trace.
Water	1.95
Total	99.65

Mr. Watkins, the owner of the clay, dug some distance into the bed and obtained a better sample of the clay, which he sent to Athens, Henderson County, and had it worked up into a small jug, which I saw. The clay burns to a light color and the jug made from it is of medium quality. This clay, by washing and careful management, could be utilized with good results for making flower pots, jugs, and coarse pottery of every description.

FIRE CLAY.

The clay found on the E. B. Ragsdale survey, which is very similar to the clay found in Henderson County, would probably make fire brick, though I think the per cent of fusible substances is a little too high to make a good quality. As a general thing the clays found in Smith County contain a large per cent of iron and alkalies, and these, on account of their easy fusibility, render the clays unfit for withstanding the degree of heat necessary in good fire brick.

BRICK CLAYS.

In nearly every part of the county may be found an excellent clay for making brick. This clay is found near the surface, being covered by only two or three feet of soil; consequently the cost of stripping is comparatively nothing. The clay is either of a red or light gray color. On burning, the bricks assume a beautiful red color, due to the iron in them. Sometimes the surface of the brick is glossy, with black spots. This is caused by the incipient fusion of the contained iron. The last named bricks are more brittle than the others. These bricks are very durable and make handsome dwellings. They are manufactured extensively in Tyler and on a small scale in several other towns in the county, and on account of the wide prevalence of the material and the small cost attending their manufacture the bricks are sold at very low figures.

BUILDING STONES.

The building stones of this county are of two kinds, viz.: A, sandstones; B, limestones.

A. SANDSTONES.

Sandstones are universally distributed over the whole county. Though these are of economic importance they are of limited extent. These sandstones have been formed in situ from beds of sand whose grains have been cemented together by ferruginous solutions depositing iron while percolating through them. The stone used for building purposes is generally soft when first dug or blasted, and can be easily cut with a saw or an axe into any shape desired. It varies in color from yellow to dark brown, although occasionally a pure white siliceous sandstone is found, and at places what is known as indurated greensand has become so hardened as to form an excellent building stone. Sandstones of this variety contain specks of glauconite, and often casts of fossils are met with. When the stone is first dug it is very soft, but hardens on exposure to the atmosphere It varies in thickness from several inches to twenty feet, and is used locally for building chimneys. At one place in a graveyard I saw several tombstones made of it which had stood for thirty years, and they were still in a perfect state of preservation.

Localities.—On "Rocky Mountain," on the J. H. Arendt survey, four miles east of Tyler, the sandstone is about fifteen feet thick, and covers an area of about six acres. It is yellow in color and quite soft when first dug, and has a local use for building chimneys.

On Todd Mountain, seven miles east of Lindale, a black sandstone ten feet thick covers the divide for several miles in vast quantities.

North of Garden Valley is seen a soft yellow sandstone containing specks of glauconite, which is used locally for building chimneys.

Other localities are six miles west of Tyler, east of Neches on the Bluffs of Sabine, and on the divides between the creeks in the southern part of the county.

B. LIMESTONE.

Limestone in Eastern Texas is quite rare, and Smith County is very fortunate in possessing two outcroppings of it, though they are limited in extent. The limestones occurring within the Tertiary formations are generally associated with salines, and such is the case in Smith County. Scott's quarry, five miles east of Lindale, is situated on Saline Creek and is associated with Steen Saline. The limestone of Scott's quarry is a bluish gray, highly siliceous limestone, of Tertiary age. It is very hard, receives a fine polish, and is an excellent building stone.

In the southwestern part of the county, on section forty-five of the Seven Leagues, occurs another outcropping of a whitish yellow fossiliferous limestone, which covers an area of two miles in length and one mile in width and crops out on both sides and underlies Brooks Saline. It is not a good stone for building purposes, but will make lime.

I am told that during the war large quantities of lime were made from it, the lime possessing hydraulic properties. In 1885 large quantities of this limestone were used at the State Penitentiary at Rusk for fluxing iron ores, and it was found to answer this purpose very well, though its use had to be discontinued on account of the cost of transportation.

Below are given analyses of the two limestones mentioned:

STEEN SALINE.		BROOKS SALINE.	
Lime	20.62	Lime	46.66
Carbonic acid	16.20	Carbonic acid	36.66
Magnesia	Trace.	Water	2.40
Silica	55.00	Silica	7.15
Iron and alumina	8.30	Iron and alumina	7.10

LIME.

The limestone from Steen Saline is too siliceous to make good lime, but the Brooks Saline limestone will make lime of an excellent quality. The lime made from this stone possesses hydraulic properties, which is due to the fact that it contains nearly ten per cent of silica. Immense deposits of clay occur in close proximity to the limestone, and it is probable that by mixing these clays with the limestone in proper proportions a good quality of cement could be made from it. The short time allowed me in which to write this report prevented me, much to my regret, from testing the hydraulic properties of this stone.

SALINES.

Smith County possesses two salines, both of which were quite widely known during the late war for the excellent quality of salt which was manufactured at them. One of them is situated in the northeastern and the other in the southwestern part of the county. Steen Saline is five miles east of Lindale, on the Carmona headright, and is situated on Saline Creek, just a little north of the point where it forks. Saline Creek runs through the Saline and empties into the Sabine River.

The Saline proper is a small prairie, about one-half to three-fourths of a mile wide by from one to two miles in length. The surface of the Saline is covered by incrustations of salt and is composed of black and lead colored clays. Like many other salines, it is associated with limestone, which may be seen cropping on both sides of it. The Saline is surrounded on all sides by a chain of low hills which are covered by a dense undergrowth. These hills are from thirty to sixty feet higher than the surface of the Saline. The limestone described above, under the head of Building Stones, crops out on both sides of the Saline and is overlaid and surrounded by lead colored and yellowish laminated Tertiary clays.

Large quantities of an excellent salt were made here during the war, by digging shallow wells and evaporating the brine thus obtained in huge iron kettles and boilers. It is said that employment was given to three thousand Confederate soldiers in making salt at that time, but now the whole place is being rapidly overgrown with underbrush, and only a few of the numerous wells remain to tell the story of past activity.

At Grand Saline, in Van Zandt County, about thirty miles northwest of Steen Saline, rock salt has been struck at a depth of nearly two hundred feet. Nearly the same conditions are met with at Grand Saline as obtained here, so it is not improbable that rock salt may underlie Steen Saline, but nothing can be known definitely as to whether rock salt is present until actual experiment is made and a shaft is sunk. Even if rock salt is not found, it has been proven that the supply obtained by evaporating the brine is comparatively inexhaustable.

BROOKS SALINE.

Brooks Saline is situated on Saline Creek, in the southwestern portion of the county. It is from one-half to three-quarters of a mile wide, and about two and one-half miles in length. On all sides it is surrounded by hills, just as is the case at Steen Saline. The surface of the saline consists of blue and black clays. Around its edges, however, a laminated yellowish clay is seen also. On both sides of the saline is seen the yellow fossiliferous* limestone above spoken of, which probably belongs to the Ripley beds of the Upper Cretaceous, and represents an old Cretaceous island in the Tertiary sea. Brooks Saline was worked during the war, but since that period it has not been utilized. Dr. Buckley, in his report, has preserved for us the record of the quality of salt made at these salines. He says:

"Brooks Saline is seventeen miles southwest from Tyler. This saline covers five or six acres of land. It lies in a valley surrounded by hills, in which are pockets of limestone. Seven furnaces were run at this saline during the war, making one hundred sacks of salt daily. It takes three hundred gallons of the water to make one bushel of the salt."†

* This formation is a Cretaceous inlier and contains fossils of the upper beds of the Upper Cretaceous. These fossils have been determined for me by Prof. Robt. T. Hill, and are as follows: *Plicatula*, *Gryphœa vesicularis*, *Ostrea sp. ind.*, and *Inoceranus sp. ind.*, and belong to the Marlbrook marls, for which see Arkansas Report, Vol. 2, page 85. Mention has been made of this Cretaceous island by Lawrence C. Johnson ("Report on the Iron Ore Regions of Northern Louisiana and Eastern Texas, 1888").

†First Annual Report of the Geological and Agricultural Survey of Texas. S. B. Buckley, Ph. D., 1874, page 126.

STEEN SALINE.

"The Steen Saline is fourteen miles north of Tyler. It covers about ten acres of land, and is surrounded by high hills, in which limestone is found. Twenty furnaces were run at this saline during the war, making twelve thousand sacks of salt daily. It takes one hundred and ninety gallons of the water to make a bushel of salt."*

Thus it is seen that a large quantity and excellent quality of salt can be manufactured at both of these salines, and it is to be hoped that intelligent capital will at an early date take hold of and develop them to their full capacity.

TIMBER.

Every part of the county is well wooded. Not only the bottoms along the creeks and rivers, but the uplands and highest divides are covered by a dense forest growth. The forests are composed of the short-leaf pine, hickory, maple, sassafras, walnut, cottonwood, persimmon, mulberry, black jack, pin oaks, post oaks, water oaks, white oaks, sweet gums, elms, etc. In the bottoms all kinds of creepers are seen, such as rattan and grapevines, which often make the forests a perfect jungle. The woods are utilized for all kinds of domestic purposes. The pine for making lumber; hickory and oaks for fuel; the various kinds of oaks are used for fencing posts, cross-ties, and for rail fences and cotton baskets; while quite recently a chair factory has been started in Tyler which utilizes several kinds of hard woods for making chairs and various small articles of furniture. At the present rate of consumption it will be many years before a scarcity of wood is felt.

WATER SUPPLY.

Good wells of the purest freestone water can be obtained at any point in the county at a depth varying from ten to one hundred feet, while running streams and mineral springs are met with every few miles. The mineral springs are generally chalybeate in character, though a few springs are met with which are very pure and almost free from mineral matter.

*S. B. Buckley, loc. cit.

CHAPTER VII.

PANOLA COUNTY.

BY JOSEPH B. WALKER.

INTRODUCTION.

The district composed of Panola, Shelby, Nacogdoches, and Rusk counties, lying between north latitude 31° and 32° 30′, and west longitude 93° 40′ and 95° (examined during the summer of 1890) is mainly between the Sabine River on the northeast and Angelina River on the southwest. The whole three thousand four hundred and ninety square miles is included in what is known as the "Timber Belt" of East Texas.

The most characteristic feature of the topography of this district is the enormous erosion, which has ploughed out extensive valleys, and left the high hills (buttes) and ridges, locally called "mountains," as imposing witnesses of that potent agency. These hills and ridges, covered with forest trees, when viewed from an elevation do indeed present the appearance of mountain ranges.

Fig. 15.

VIEW FROM BREWER'S MOUNTAIN, NACOGDOCHES COUNTY.

a, Mount Enterprise, Rusk County. b, Iron Mountain, formerly Elkin's Mountain, Rusk County.

For a general description of the geography and topography of East Texas, with notes on the literature of the Tertiary formation, the reader is referred to the preliminary report by Dr. R. A. F. Penrose, Jr., in the First Annual Report of the Geological Survey of Texas, 1889, and to the introductory chapter of this Report on the Iron Ore Districts of East Texas.

Panola County has an area of seven hundred and ninety-nine square miles, lying between north latitude 32° and 32° 30′ and west longitude 94° and 94° 40′. It was created by division from Shelby and Harrison counties in 1846.

Acreage.—The number of acres is five hundred and eleven thousand three hundred and sixty. The number of acres in field cultivation in 1889–90 was sixty-eight thousand two hundred and fifty-six, or 13.34 per cent.

The number of acres in timber is estimated at three hundred and fifty-seven thousand three hundred and eighteen.

DRAINAGE.

The county is drained by the Sabine River, which runs through the middle portion, from the northwest corner to the southeast corner. Its tributaries on the west are Williams Creek, Martin's Creek, with its forks, Corbet Creek, Williamson Creek, Twoomy Creek, Dillard's Creek; Iron Bayou, Hog Creek, with its principal fork, Roberts Creek; Six Mile Creek, or Cypress Bayou, with its north fork, Little Six Mile Creek, and its south fork, Big Six Mile Creek; Murvall's Bayou, with its principal forks, Nail Creek, Henderson Creek, Brushy Creek, Indian Creek, Taylor Creek; and McFadden's Creek. The tributaries of the Sabine on the east are Eight Mile or Cypress Creek, Caddo Creek, No Bottom or Jackson's Creek, Little Bottom Creek, Mill Creek, and Socagee Bayou. Near the bed of the Sabine River are several fresh water lakes, known as Hendrick's, Hill's, and Clear lakes. They seem to be fed by small springs, but are subject to overflow from the river. Numerous visitors resort to them during the fishing season.

SURFACE.

The general surface of this county is hilly and undulating. The highest plains, or remnants of the original Tertiary deposition, are in the northwest and southwest portions, where the buttes and ridges, having a trend from a little north of east to a little south of west, have been formed by erosion from the original Tertiary plains. The estimated height of these is from six hundred to seven hundred feet above the present sea level. Covered as they are with forest trees, they appear like mountain ranges, and are locally spoken of as the mountainous portion of the county.

SOILS.

The top soil of the buttes and ridges is very sandy, probably from the leaching action of rain water. The soil on the sides of these elevations partakes of the nature of the top, mingled with the under stratum of red ferruginated and mottled red and gray clay. The soil on the lowlands and alluvial bottoms is composed of a mixture of erosion and transportation of the finer particles of the other two. The best soil for agricultural purposes is therefore the sandy loam of the lowlands and the alluvial bottoms. Next to this in value for field cultivation is the ferruginous sandy clay soil on the rolling uplands, which in favorable seasons produces crops fairly well, but does not stand a long period of dry weather. The first to wear out is the sandy soil on the elevated buttes and ridges. The vast area of forest timber has a beneficial effect in the production of rainfall, furnishing moisture by evaporation to the atmosphere, from which it is condensed by cooler currents in the upper region. An instance of this was witnessed in Rusk County, on the road between Henderson and Pine Hill, in company with Mr. Moss, of Henderson. A cloud gathered above us, and in half an hour the rain fell sufficiently to run in the roadbed, but there was no storm, no surface wind, nor electric phenomena. Passing on a few miles and returning by another road, we observed that the rain was only local, not exceeding a strip of about three miles wide by several miles long. The moist, shaded surface also tends to cool the surface winds, which in consequence do not dry the field soil as rapidly as hot surface winds, which derive their temperature from contact and radiation of large barren areas.

To bring the soils up to the highest possible state of cultivation, there is needed a continual, systematic method of fertilizing. This could be perhaps most economically effected by restricting the area of tillable land and applying to the restricted area a liberal supply of compost consisting of leaves and pine straw with muck from the swampy places. This could be mixed if desired with gypsum or land plaster, of which there is such abundance in the north central part of the State. Some of the greensand marls would also add much to the permanent fertility of the soils by adding their constituents, alumina, potash, lime, soda, and a small percentage of phosphates. If the marls were roasted and ground or beat up fine their effect would be more rapid. Experience demonstrates that higher cultivation is more profitable, even with the added expense of fertilizing and an equal amount of labor.

TIMBER GROWTH.

Old field or short-leaf pine, *P. mitis*, and its congener, the loblolly pine, *P. tæda*, are the most abundant of the timber trees in this county. The different oaks, sassafras, locust, hickory, elm, gum, black walnut, willow, and cypress each have their representatives. In 1888 there were nineteen saw mills reported in the county. The total area in acres is 511,360, of which 70,228 were reported in cultivation, leaving 441,132 acres. If from this be deducted one-tenth for town sites, barrens, and streams, the remainder, 397,019 acres, would represent the timber region. If from this another tenth be deducted for timber already cut and in process of cutting by the mills, the remainder, 357,318 acres, would be an approximate estimate of the area of standing timber. The total value of this quantity is estimated as follows: One-fourth, or 89,329 acres, suitable for lumber, at an average of twenty-five hundred feet per acre, would yield 223,322,000 feet. The remainder, 267,989 acres, if cut into cord wood for charcoal, at an average of thirty-seven and one-half cords per acre, would yield a total of 10,050,587 cords. If the cord wood be burned into charcoal its value would be increased about one-fourth for manufacturing purposes.

IRON ORES.

In the northwestern part of the county, on the summits of the highest ridges and hills, there are remnants of the original iron ore deposits.

The Selman tract, Wesley Gooden headright, containing about two hundred acres, has several high ridges capped with ore, which is mainly siliceous conglomerate and iron sandstone. The conglomerate is cemented by the same material that forms the underlying and often adhering iron sandstone. The thickness is about three feet each. On the north and slightly west side of these ridges were seen ovoid limonite geodes, in no regular stratum, but yet in a somewhat definite horizon. Associated with these is a large quantity of iron gravel derived from the partial breaking up of the geode shells. These geodes afford a fair percentage of metallic iron, as will be seen from the analysis.

Near Tatum the conglomerate and iron sandstone have a similar large development, but the conglomerate has here been somewhat disintegrated, and therefore the iron sandstone appears to have the greatest development.

Fragments of iron sandstone and geodes appear as float on the rolling hills in almost every part of the county.

Laminated limonite and its congener, buff crumbly or bog limonite, was seen in quantity only in the southwestern part of the county, where it extends over into Shelby County. It occurs as usual in the iron capping of the main ridge, which was part of the original Tertiary plain, and was once connected with the aluminous iron bearing ridges of Mount Enterprise, Iron Mountain, Glenfawn, New Salem, and Quin Mountain, in Rusk County, Brewer's Mountain, in Nacogdoches County, and westward as at Rusk, in Cherokee County.

In all of these localities the ore exists in sufficient quantity for manufacturing purposes. The following table shows the composition of some of the specimens taken:

ANALYSES OF IRON ORES FROM PANOLA COUNTY.

No.	Sesquioxide of iron.	Silica.	Alumina.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Magnesia.	Loss on Ignition.	Manganese.	Total.	Metallic Iron.
665†	50.72	40.45	7.68	Trace.	0.25	Trace.	......	0.80	.....	99.90	35.50
666†	64.23	21.20	11.77	Trace.	0.80	......	Trace	1.80	.....	99.80	44.96
667*	32.74	10.90	41.96	1.40	0.09	Trace.	Trace.	13.40	.....	100.39	22.91
668†	60.80	24.50	....	......	....	......	......	.....	.....	......	42.56
675†	70.50	12.70	8.40	Trace.	0.10	a 2.42	......	1.00	b 4.80	99.92	49.35
677†	72.11	8.10	5.69	Trace.	0.25	0.28	......	8.50	b 5.00	99.93	50.47
678†	73.08	11.75	2.92	Trace.	0.15	0.63	......	8.10	3.50	100.13	51.15
679*	51.48	11.40	22.72	Trace.	0.16	0.01	Trace.	14.11	.....	99.88	36.03
680†	69.63	15.00	4.77	Trace.	0.43	0.33	......	9.90	.....	100.11	48.74
686*	45.25	15.00	25.36	0.45	0.44	0.12	Trace.	11.70	c 2.55	100.87	31.67

Analyses by *J. H. Herndon, †L. E. Magnenat.

a Sulphur. b Red oxide of manganese. c Sesquioxide manganese.

Localities.

No. 665. Buff crumbly ore, four miles north of Timpson, Shelby and Panola.

No. 666. Laminated iron ore, four miles north of Timpson, Shelby and Panola.

No. 667. Geode iron ore, four miles north of Timpson, Shelby and Panola.

No. 668. Conglomerate iron ore, five and one-half miles north of Timpson, Panola.

No. 675. Geode limonite with ochreous centre, near Mineral Spring Ridge, four miles north of Beckville, Panola.

No. 677. Septum iron ore with ochreous centre, near R. W. Kinard's house, Wesley Gooden headright, Panola.

No. 678. Geode limonite, Selman tract, southwest corner W. Gooden headright.

No. 679. Geode limonite, near R. W. Kinard's place, W. Gooden headright.

No. 680. Geode limonite, with clay iron stone centre, R. W. Kinard's place, Wesley Gooden headright.

No. 686. Clay iron stone centre of geode, one mile south of Tatum Station, in railway cut, Panola County.

CLAYS.

There are several beds of clay in this county which are capable of producing brick, drain tiles, and jug ware. In the manufacture of coarse pottery some difficulty has been experienced, caused by cracking of the ware in the kiln, thus involving considerable loss of labor and fuel. The remedies are: 1. To have the forms thoroughly dry before putting them into the kilns. 2. To fire up slowly. 3. To carefully stop all vents after burning, and allow the kiln to cool gradually. If these remedies do not correct the trouble, then the raw clay itself needs attention, and can be made to stand the furnace fire without cracking by mixing a portion of burned and powdered clay with the raw clay before forming on the potter's lathe, or by mixing several of the clays together in the requisite proportions. This will modify the tension produced by contraction in cooling.

The following table gives the composition of several clays selected for analysis:

ANALYSES OF CLAYS.

No.	Silica.	Alumina.	Iron.	Soda.	Potassa.	Magnesia and Lime.	Water.
823*..........	82.80	9.83	2.77	3.84	1.62	Trace.	....
825*..........	72.00	11.82	3.38	5.56	2.57	Trace.	5.70
826*..........	57.80	18.94	7.55	5.62	1.05	Trace.	9.01
827*..........	79.00	5.54	5.66	5.38	.66	Trace.	4.50
828*..........	83.40	6.45	4.40	3.87	1.33	Trace.	....
829*..........	73.60	....	....	4.75	2.33	Trace.	....
831*..........	79.20	6.12	2.51	6.09	1.33	Trace.	c 4.70

*Analyses by J. H. Herndon.

c Fusible at white heat.

Localities.

No. 823. White sandy clay, Carthage and Timpson road, two miles south of Carthage.

No. 825. Gray sandy clay, above the lignite shale, from Allen Baker farm, M. Payne headright, four miles east of Carthage.

No. 826. Plastic ferruginous clay, one mile east of Tatum Station.

No. 827. Red and gray mottled clay, under the iron bed, Six Mile Creek.

No. 828. Indurated sandy clay, Donnel field, one-half mile southeast of Carthage.

No. 829. Lignitic clay shale, lower bed, near Iron Bayou, Lagrone headright.

No. 831. Stiff, tenacious, sandy clay soil, light brown color, from lignite series in plowed field R. W. Kinard farm, Daniel Martin headright.

LIGNITE.

There is a large deposit of lignite in this county, the bed apparently varying in thickness in the different localities.

At Grand Bluff it was seen cropping out at the water line of the Sabine River, near the ferry, and in places forms the bed of the river.

On the Allison tract, six miles east of Tatum Station, it crops out at the base of a hill on a little stream fed by springs, which flow from the water bearing sand in contact with and overlying the lignite.

About four miles south of Carthage, on the M. Payne headright, Baker's subdivision, were seen specimens from a prospect hole then full of water. The bed was reported to be two feet thick.

The best exposure was seen at Mineral Spring Ridge, four miles northwest of Beckville, where a tunnel had been excavated nearly north and south one hundred and fifty feet in the lignite bed. The bed here is four and one-half feet thick. Several car loads of this lignite had been shipped to Longview, where it was burned in grates for domestic purposes. It was also tried in the fire box of a wood burning locomotive on the Texas, Sabine Valley and Northwestern Railway with some success. The two obstacles to its continued use were:

1st. The exhaust steam discharged into the fire box from the cylinders disturbed the arrangement of the coal.

2nd. The cheapness of wood, $1.75 per cord to the road, left no inducement to change the construction of the furnaces in the engines.

This lignite is typical of the formation in Panola County. A specimen taken from the end of the tunnel shows the following composition in an analysis by Mr. L. E. Magnenat:

Water	20.80
Volatile matter	52.08
Fixed carbon	22.67
Ash	3.97
Sulphur	0.48
Total	100.00

MINERAL PAINT.

ASPHALTUM BROWN. — In the west bank of a cut on the Texas, Sabine Valley and Northwestern Railway, one-fourth mile south of Tatum Station, was seen a stratum of black asphaltic clay, about ten inches thick, overlaid by stiff plastic yellow clay, and underlaid by a thin stratum (two inches) of blue clay, under which is a stratum (twelve inches) of yellow sandy clay, and beneath this lighter lignitic clay. This asphaltic clay when rubbed on the back of the hand, which was perspiring freely, developed a rich chestnut brown color. It could be purified and used as a pigment in fine oil painting. It was tested in a crude way by the roadmaster, Mr. Evans, by mixing with oil and painting a test sample for a black color. After exposure of several months he reported the color permanent. The composition of this clay as analyzed by Mr. J. H. Herndon is: Water, 14.40; volatile matter, 24.35; fixed carbon, 14.80; silica and ash, 46.45.

YELLOW OCHRE.—In several parts of the county, but more especially in the northwestern portion, various sized ovoid geodes of limonite, containing centres of yellow ochre, were observed. The analyses show these to consist of hydrated peroxide of iron, silica, and alumina as the chief constituents, in variable quantity.

RED OCHRE. — In the northwestern part of the county, on the Wesley Gooden headright, a local stratum was observed consisting mainly of limonite about two inches thick, with septa of the same material containing nuclei of both red and yellow ochre, in alternate divisions, as inclusions. One specimen, analyzed by Mr. L. E. Magnenat, shows a composition of silica, 8.10; sesquioxide of iron, 72.11; alumina, 5.69; red oxide of manganese, 5.00; water, 8.50; phosphoric acid, 0.25; sulphur trioxide, 0.28; lime, a trace.

RED HEMATITE.—A compact iron sandstone was seen in many places, but in larger quantities near the railway in the vicinity of Tatum Station, Jas. Reel headright. This material, by roasting in a kiln, would be converted from limonite into hematite, which after grinding (and washing if necessary and then drying) would produce a deep red pigment suitable for wagons, machinery, and even house paint. The analysis of this ore by Mr. J. H. Herndon shows its chief ingredients to be, sesquioxide of iron, 29.74; alumina, 12.06; and silica, 56.30.

In addition to these reds, there are surface red clays so highly charged with sesquioxide of iron that by suitable preparation they could be used for coarse work on fences, barns, tool houses, railway section houses, etc. Such a locality was observed on the hill at Dr. Sterrett's house, Elijah Morris headright, northeast of Beckville on the Grand Bluff and Harmony Hill road.

WHITE CLAYS. — Some of the white clays would in like manner yield a creamy white color when dried and ground in oil, and would then be suitable for fences, etc.

GREENSAND.

In crossing a little stream which flows from a chalybeate spring on the Menifee tract, Daniel Martin headright, at the waterline in the bottom of the gulley, about fifteen feet below the surface, was seen a small tongue of rusty color, about six inches thick, which on excavation proved to be greensand, having some dark glauconitic specks through it. A similar deposit was seen on the Alex. Carter place, Wm. McKnight headright. Both these specimens changed color on drying, becoming reddish yellow or orange in hue. A specimen taken for analysis gave:

Silica	48.30
Sesquioxide of iron	34.19
Alumina	8.81
Lime	2.06
Magnesia	1.44
Potash	2.48
Soda	1.58
Sulphuric acid	0.89
Phosphoric acid	Trace.
Total	99.75

No beds of the later calcareous greensand marls were seen in this county.

SILICIFIED WOOD.

Fragments of this material were seen in various parts of the county. On Mineral Spring Ridge, four miles north of Beckville, a portion of a large trunk of a tree was taken out of the lignite bed. It was partly silicified and partly lignitized, with incrustations of quartz crystals stained with carbon. Specimens were taken and are now in the State Museum.

OIL.

On the surface of several small ponds along the line of the Texas, Sabine Valley and Northwestern Railway were seen thin films of reddish brown oil. These were attributed to the lignite bed, which is apparently in close proximity.

FRESH WATER SILICEOUS LIMESTONE.

At several places this limestone was observed. On Six Mile Creek, or Cypress Bayou, M. Payne headright, at the waterline were seen two exposures; one shaly or laminated, with micaceous sand interstratified; bed about two feet thick. Within fifty yards, on the opposite side of the creek, were large pieces of the massive variety, but not in horizontal position. They were also about two feet thick An examination of the vicinity exhibited some evidence of faulting or sliding.

The laminated variety contained small blackened leaf impressions and other carbonaceous remains. The massive variety contained larger leaf impressions, which had become ferruginated. The same bed was afterward seen in an exposure on the Thos. F. Hull farm, about three miles west, under water in the same creek, and appeared to be about three feet thick.

At Grand Bluff, on the Sabine River, was noticed a ledge of this limestone in the west embankment, giving a distinct exposure of the two varieties *in situ.* The thickness of the upper laminated stratum is two to two and one-half feet, a parting of sandy clay six feet thick overlying the massive bed, which here has a thickness of three feet. The dip of the strata is west and rounding on the north down to the river bed, indicating disturbance. About five hundred yards below there has been a slide or a fault at the mouth of a little ravine, which has brought a large mass of the upper stratum to a lower level than the massive stratum, furnishing additional evidence of disturbance.

On the Menifee tract, southwest corner of Daniel Martin headright, was seen a surface exposure of over two feet of the massive variety. A sample from this locality was submitted to analysis by Mr. J. H. Herndon, who found it composed of lime, 23.06; magnesia, 0.79; sesquioxide of iron, 3.55; alumina, 8.85; silica, 47.00; carbonic acid gas, 17.70; phosphoric acid and sulphuric acid, traces. These beds, if ever deposited in a continuous sheet, have been eroded, so that that they now appear usually as local detached fragments and bowlders, and always waterworn.

SANDSTONE.

Underlying the deposit of iron conglomerate and iron sandstone in this county there are some localities where a thick bed of sand has been partly cemented by ferruginous solution, and where, undercut by local springs, the caving of the sands has exposed considerable bluffs of soft yellow and red sandstone. Such an exposure was seen at the headwaters of a little stream two miles north of Twoomy Creek and one and one-half miles southwest of Mineral Spring Ridge. The bluff here consists of fifteen to twenty feet of sandstone overlaid by about five feet of sandy soil of the plain, which is about seventy-five feet above the bed of the stream. On Daniel Martin headright, northwestern portion of the county, near the line of Rusk County, was seen a similar ledge of soft yellow sandstone bordering a little stream.

A similar formation was also seen in the northern part of Sabine County, six and one-half miles south of Patroon Postoffice, Shelby County, on the Stephen Matlock tract, in the Wm. Nethery headright. Here the soft ferruginous sandstone has a thickness of twenty feet, just above an extensive line of excavation which is known to the old settlers as the "Old Mexican Silver Mine." The yellow sandstone is here underlaid by a stiff plastic yellow clay. It was evident from inspection that the excavation had been made at some former time as a roadway for wagons loading the sandstone from the ledge above. Where the stone was carried. or for what purpose it was used, is no longer known. It was perhaps a quarry of the old Mission Fathers. A large white oak tree now standing in the middle of the roadway would seem to indicate that the work done here was not later than seventy-five years ago.

On the summit of a ridge, near the house of Alex. Carter, in the William McKnight headright, northwest corner of Panola County, are two large bowlders of hard iron sandstone—dimensions, about six feet long, five feet wide, and three feet thick. The stones are in remarkably good state of preservation. The name "Indian Rock" has been given to them from the tradition that the Indians used the upper surface for the purpose of sharpening *whang awls.* These were blunt pointed instruments of bone, later of iron, used for making holes in dressed skins for sewing with leather thongs, or *whangs* as they were called. The grooves left on the stone seem to corroborate the tradition.

GLASS SAND.

In several places in this county can be seen local deposits of white sand that could be made available for the manufacture of window glass, bottles, lamps, and the ordinary kinds of glassware. Such a locality was seen in crossing a little stream two and one-half miles northwest of Beckville, on the Harmony Hill road. Another extensive bank of white sand was observed about one mile above the ferry at Grand Bluff, on the Sabine River. The abundance of fuel and facility of getting soda ash from Galveston at comparatively low rates would favor such an enterprise, if the plant be located on or near a railway.

MAGNETIC SAND.

In the soil in nearly every portion of the county was observed a considerable percentage of magnetic sand and pebbles. The sand is in fine state of division, quite black and lustrous, and differing somewhat in composition from the magnetic pebbles. From dried and powdered soil the sand and pebbles can be easily collected by the magnet. A sample of this sand was taken from a gulley near the railway cut one-half mile north of Carthage. Its origin is yet uncertain, but possibly local. A preliminary analysis by Mr. J. H. Herndon gave sesquioxide of iron, 50.99; protoxide of iron, 27.76;

alumina, 13.99, leaving about seven per cent undetermined for want of more material. Some of the tests seemed to indicate titanium in association.*

The magnetic pebbles as a rule are not so black, and are associated usually with iron gravel, some of which is non-magnetic.

NOTES ON THE STRATIGRAPHY OF PANOLA COUNTY.

About four miles southeast of Carthage, on the Allen Baker farm, M. Payne headright, was seen the following section:

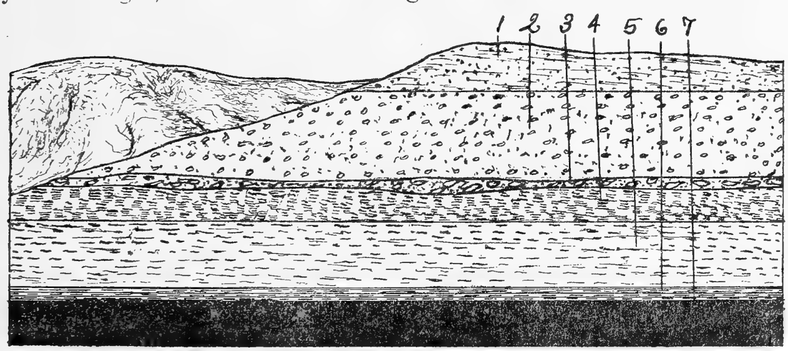


Fig 16.

SECTION FOUR MILES SOUTHEAST OF CARTHAGE.

1.	Sandy soil in cultivated field	2 feet.
2.	Drift in pocket, iron gravel, and magnetic pebbles	4 feet.
3.	Ochreous centres of iron geodes broken by cultivation	1 to 6 inches.
4.	Red and mottied red and gray clay	18 inches to 2 feet.
5.	Gray clay—plastic, but slightly sandy	3 feet.
6.	Lignitic clay shale, with plant fossils—very friable	8 inches.
7.	Lignite bed	2 feet.

On Six Mile Creek, or Cypress Bayou, at the waterline, were seen:

1.	Laminated siliceous limestone, with plant fossils	2 feet.
2.	Massive siliceous limestone	2 feet.

These had been disturbed by faulting and sliding, and the exposure was small. Observations afterwards made on the exposure at Grand Bluff fix their stratigraphic position with reference to each other, and their position with reference to the above section to be between Nos. 5 and 6, and belonging to the lignitic series.

On the road from Wood's Postoffice to Carthage, near the M. Payne headright, was noticed deep red and mottled red and gray clay, corresponding to No. 4 of the section, and denoting former presence of the iron bed above, now eroded down to the clay.

* The presence of titanium in these sands has since been confirmed.

About three miles south of Carthage, in the same road, this was verified by finding loose detached fragments of fine-grained iron conglomerate, apparently in line with the trend of the ridges. In the same road were seen fragments of silicified wood and ferruginated silicified wood. As a rule, the presence of silicified wood in the soil, or sometimes two or three feet under the soil, is a pretty good indication of a lignite bed underneath, at varying depths from eight to forty feet.

Descending the ridge, half a mile south by east from Carthage, on the Carthage and Timpson road, on the George Goodwin headright (trend of ridge east by north and west by south), was noted a bed of ferruginous sandy clay having an exposure in the road bed of one hundred yards and a thickness of twenty feet, containing a broken stratum of limonite geodes which did not exceed ten inches in thickness at any one place. The geodes often have a nucleus of yellow ochre and sometimes of white sand. The geode bed is here underlaid apparently by a few inches of warty stalactitic clay iron stone. The stratigraphic position of this formation corresponds with No. 3 of the Payne headright section shown in Fig. 16. In the fields on the right and left it is obscured by about two feet of sandy soil in cultivation.

Another section about two miles south of Carthage, in the same road, gives the following:

1.	Stratum of grayish white sandy clay, somewhat hard	5 feet.
2.	Red and gray mottled clay	20 feet.
3.	Bed of grayish white clay	4 feet.

to surface of the water in a tributary branch of Six Mile Creek, or Cypress Bayou. The upper bed was probably derived from the leaching of the soil by rain water. (See analysis No. 823.) The lower bed of grayish white clay corresponds with No. 5 and the bed of mottled red and gray clay with No. 4 of the Payne headright section. The mottling of the clay has been produced by the infiltration of ferruginous solution into the joints and cracks of the clay.

Some two and one-half miles south of Carthage, in the same road, was noted the following section:

1.	Sandy soil	2 feet.
2.	Red clay	5 feet.
3.	Geodes of limonite filled with red and yellow ochre	10 inches.
4.	Fine grained sand largely impregnated with black oxide of manganese (a pocket probably), in parted strata	3 inches.
5.	Red and grey mottled clay, with alternating thin crusts of aluminous iron oxide, to bottom of gulley	15 to 20 feet.

In the same locality was seen a fragment of a fine-grained sandy conglomerate, but no continuous stratum. A few pseudomorphs after iron pyrites, and detached fragments of silicified wood, partly ferruginated, were also seen.

In the bed of Six Mile Creek, or Cypress Bayou, some micaceous sandy shale was seen in contact with the lignitic siliceous limestone. The exposure as seen was about three feet thick on the Thos. F. Hull tract.

Detached and waterworn specimens, six to eight feet long, five to six feet wide, and about one foot thick, were afterward seen exposed on either side of the Texas, Sabine Valley and Northwestern Railway, two miles north of Beckville. This fresh water limestone has already been referred to its stratigraphic position. The number of fragments and bowlders seen in various localities point to the fact that it was once a stratified deposit of considerable extent, but afterwards eroded, displaced, and waterworn, so that it is now generally found partially preserved in detached masses.

On the summit of a ridge about one and seven-eighths miles north of Beckville, on the railway, was seen geode limonite associated with a very considerable quantity of iron gravel. These geodes here have a thickness from eighteen inches to two feet, and vary in composition and value from the ochreous clay iron stone centre, to the more compact concentric shells of limonite, which by fracture and weathering became the origin of the iron gravel in this locality.

In the southwest corner of the Wesley Gooden headright, near Riley W. Kinard's residence, in the road to Beckville, about half a mile south of the ford of a small branch, a tributary of Martin's Creek, was seen the following section:

1.	Iron sandstone	18 inches.
2.	Yellow vesicular ochreous sandy iron ore	3 feet.
3.	Heavier sandy iron ore	2 feet.
4.	A thin stratum of septum iron ore, with red and yellow ochreous inclusions,	2 inches.

This arrangement seemed to be a local variation in the deposition of the iron series.

A tendency to the formation of septum ore was afterwards seen in several places. The ore on the summit of Mineral Spring Ridge is somewhat of this character. Portions of it were sometimes seen elsewhere as nuclei of geodes.

Near this locality, in the southeast corner of the Daniel Martin headright, Selman tract, on the summit of a ridge, was noticed the following section:

1.	Conglomerate iron ore, iron sand cement	2 feet 6 inches.
2.	Iron sandstone, often adhering to No. 1	2 feet 6 inches.
3.	Geode bed, mingled with iron gravel, covering the northwest side of the hill	Displaced.
4.	Sandy ferruginated clay, with iron pebbles from disintegrated conglomerate	To base of hill.

The conglomerate and iron sandstone outcrop on the summit occurs in large boulders, some of which would weigh several tons. While they show evidence of former stratification, they are not now as a rule horizontal, but are tumbled one upon another and lying inclined at different angles. This may have been caused by local vibrations of the earth's surface, or possibly by sub-erosion of the strata and gravitation after the deposition of the iron, or probably the close of the Tertiary period.

In crossing a little stream fed by chalybeate springs, on the Menifee tract, southwest corner of Daniel Martin's headright, near the water line in the gulley, some fifteen feet below the surface soil, was seen a tongue of rusty colored material about six inches thick, which on excavation proved to be greensand mixed with clay. Specimens which were sent to Austin changed in transitu to a yellow or orange color by oxidation of the protoxide to hydrated peroxide of iron. A similar exposure was also seen on the Alex. Carter tract, in the Wm. McKnight headright.

Within half a mile of Riley W. Kinard's house, on another small stream, was noted in the south bank of the gulley two distinct layers of asphaltic clay, about three inches each, separated by about twelve inches of light colored clay. This, with a deposition of chocolate colored micaceous shale in the same neighborhood, has been referred to the lignitic series.

On the Menifee tract, in the southwest corner of the Daniel Martin headright, was seen an outcrop of massive siliceous limestone over two feet in thickness. The stratigraphic position has already been given. Similar exposures at various localities have been noted. A test for hydraulic properties was not successful.

On the summit and sides of the hill at Dr. Sterrett's house, Elijah Morris headright, Grand Bluff and Harmony Hill road, was seen a large quantity of iron gravel overlying a deep red clay soil. At Mahon, on the same road, were seen small bowlders of iron conglomerate and iron sandstone. These bowlders also occur in the southeast corner of the Wm. Hamilton headright, three miles from Beckville.

On the east bank of the Sabine River, at Pulaski Ferry, was seen the following section:

1.	Surface pebble drift	2 feet.
2.	Iron sandstone	6 inches.
3.	Orange sand	3 feet.
4.	Shaly iron ore on surface of incline	8 feet.

On the ledge below, within twenty feet of the water, the following section was obtained:

5.	Orange to red sand	4 feet.
6.	Coarse white pebbles cemented by iron and silica	1 foot.

7. Interstratified sand and clay shale. The dark stratum (three inches) of shale looks bituminous, or at least organic........................ 5 feet.
8. Cross-bedded gray sand.. 5 feet.
9. Shaly clay, with nodules of clay stone, to water line.

At a second bluff, about one and one-half miles up the river, the ledge dips to the southwest, and the section appeared to be:

1. Soil.. 8 feet.
2. Hardpan clay.. 2 inches.
3. Shaly clay on the incline.................................... 20 feet.
4. Hardpan clay.. 1 inch.
5. Shaly clay on the incline.................................... 25 feet.

Going down the ridge road on the east of the Sabine River, several miles from Pulaski Ferry, the following section was noted on Big Rocky Hill and vicinity:

1. Sandy soil.. 2 feet.
2. White and colored drift pebbles.............................. 2 feet.
3. Pebble conglomerate and adhering iron sandstone.............. 2 feet.
4. Red clay, changing to yellow sandy clay, or orange formation.. 20 feet.

From the foregoing observations it would seem that the character of the iron deposit depended on local conditions at the time of sedimentation and cementation, and the following working hypothesis may be stated:

That the buttes and ridges were once connected and are now but the remnants of an elevated Tertiary plain.

That this elevated plain was once lacustrine, as shown by the successive depositions of beds of clay and sand, the stratified material of the lignite series, and the stratified iron series.

That the quantity of iron in solution probably varied at different times, but the total was nearly the same for the northwest and southwest portions of the county.

That the buff crumbly or aluminous bog ore resulted from the iron solution penetrating and cementing the lacustrine deposit of clay in the southwest portion of the county.

That the overlying contact of laminated iron ore resulted from a simultaneous deposition and cementation of iron sediment and clay.

That a subsequent drifting of fine sand was in like manner cemented by sedimentation from the iron in solution, forming the iron sandstone.

That afterward the drift sand included small rounded iron pebbles and gravel, which in like manner was cemeted by deposition of the iron in solution, to form the iron conglomerate.

That during this time a similar amount of iron was deposited by sedimentation in the northwestern portion of the county, but the drift sand was largely in excess of the clay, consequently the iron sandstone was largely increased in thickness, while the buff crumbly was diminished in the same ratio, the conglomerate remaining nearly the same.

QUATERNARY.—The orange sand formation is not so noticable in this as in other counties of this district, and will receive further consideration in the description of the formation as seen in its best development.

RELATION OF STRATA.

From the foregoing sections the following general section is made, to show the relation of strata to each other; it being understood that the entire section is never seen complete in any one locality, and that some of the minor variations in alternating beds of sand and clay are omitted.

1. Sandy soil on the summits of hills and ridges.................. 2 feet.
2. Conglomerate iron ore (cemented iron pebbles and iron gravel), Selman tract, Wesley Gooden headright.................. 3 feet.
3. Iron sandstone (siliceous and iron sand) cemented by ferruginous sedimentation. (The 2 inches in the southwest and the 3 feet in the northwest.).................. 2 inches to 3 feet.
4. Laminated iron ore (wavy limonite), the first near Grand Bluff, the latter in the southwest.................. 2 to 6 inches.
5. Buff crumbly or bog iron ore. (Traces of the first near Grand Bluff, the latter in the southwest.).................. 2 to 3 feet.

The two last mentioned varieties, 4 and 5, usually together in contact when seen in mass, but both are sometimes wanting, and sometimes replaced by fossiliferous iron sandstone.

6. Soft to moderately hard yellow to red sandstone. (In the northwestern portion of the county. This corresponds with the position of typical or upper bed of orange sand, sometimes changing to orange loam, and probably was originally greensand, but now altered by oxidation of the protoxide to hydrated peroxide of iron.).................. 15 feet.
7. Geode limonite, with yellow ochre or orange loam centers, sometimes sand centers. (This horizon is included in the orange loam formation, and usually occurs near the top of the upper bed of orange sand or orange loam.).................. 1 to 2 feet.
8. Iron gravel, resulting from the breaking up of geode shells, crumbling of the buff crumbly iron ore, mixed with iron pebbles from the partial and sometimes entire disintegration of the iron conglomerate. (This has no definite vertical section, being found as float on the sides of the hills and ridges, and in the valleys as drift).
9. Red iron clay. (This has resulted from the ferrugination of the entire bed to this depth.).................. 4 to 5 feet.
10. Mottled red and gray clay. (This has resulted from partial ferrugination by infiltration into joints and cracks.).................. 5 to 10 feet.
11. Greensand. (Only two small exposures seen in northwest portion of this county.).................. 6 inches.

12.	Gray sandy clay and bluish sandy clay. (This is the source of the potter's clay.)	6 to 8 feet.
13.	Siliceous laminated limestone. (Frequently micaceous and sandy between the laminæ, with carbonized plant remains. Usually found near the water line of streams.)	2 to 2½ feet.
14.	Sandy clay	6 to 10 feet.
15.	Compact siliceous limestone	2 to 3 feet.
16.	Lignitic clay shale. (Usually of brownish color and sometimes containing plant fossils.)	6 inches to 2 feet.
17.	Compact lignitic clay. (Sometimes replaced locally by asphaltic clay with bluish sandy clay parting.)	1 to 2 feet.
18.	Lignite bed, varying in thickness and somewhat in quality, with partings of lignitized clay	2 to 4½ feet.
19.	Shaly clay with hardpan partings	20 to 40 feet.
20.	Burned and metamorphic clay, as seen at Twoomy Creek and Beckville	1 to 2 feet.

TWOOMY CREEK METAMORPHIC DISTURBANCE.

At a point about two and one-fourth miles above Beckville, where the Texas, Sabine Valley and Northwestern Railway cuts through an embankment just south of the trestle over Twoomy Creek, a tributary of Martin's Creek, there is a peculiar formation in the west side of the railway cut. The linear exposure north and south is about three hundred feet, having the following section:

d.	Surface red clay soil (subsequent deposit)	2 to 4 feet.
b.	Clay stratum, changing from nearly white on the south to yellow, red, bluish quartzite, and scoria toward the north, at squeeze	1 to 8 feet.
a.	Red earthy clay to bed of railway, except at the break and squeeze	4 to 6 feet.
c.	Squeeze.	
e.	Twoomy Creek.	

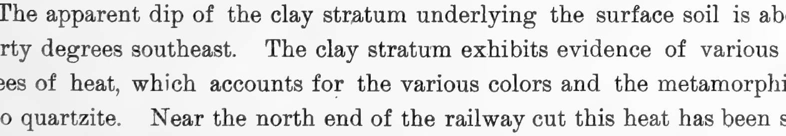


Fig. 17.

TWOOMY CREEK DISTURBANCE.

The apparent dip of the clay stratum underlying the surface soil is about thirty degrees southeast. The clay stratum exhibits evidence of various degrees of heat, which accounts for the various colors and the metamorphism into quartzite. Near the north end of the railway cut this heat has been sufficient to fuse the quartzite into scoria or cinder. The baked clay, quartzite, and scoria have been used successfully as ballast for the road. An analysis of the cinder by Mr. L. E. Magnenat shows its composition to be silica, 34.45; sesquioxide of iron, 37.83; alumina, 14.17; lime, 10.00; magnesia, 0.43; alkalies, as chlorides, 6.26; manganese dioxide, undetermined; phosphoric acid and sulphur, traces. Some two miles south, or within five hundred feet of the depot at Beckville, the same burned and disturbed clay was seen without scoria in a road bed; strike apparently northwest and southeast; dip at one place sixty degrees southwest, but within one hundred and fifty feet the dip changes to north by east and disappears under the surface soil and under a ridge on the north. On the summit of the ridge under which the burned clay disappears were seen fragments of silicified wood, with adhering crystals of quartz; also fragments of iron sandstone. A well forty feet deep from the top of this ridge passes through alternating beds of sand and clay, and through the lignite bed, which is here about four feet thick. (It has been before remarked that the water bearing sand overlies the lignite bed. This was conspicuous in the Mineral Spring lignite bed, where the water forms dripping springs in the tunnel, carrying down considerable quantities of fine white sand into the crevices of the lignite on the sides of the tunnel.) The wells are often dug into or through the bed of lignite to form catch basins for holding a supply of water.

Three miles southwest of Mineral Spring Ridge is another ridge, rising from Twoomy Creek or one of its tributaries, in which was reported a cave from which specimens were taken by early prospectors and reported to have assayed silver. The locality was visited and proved to be a prospect hole (then full of water) on the side of the ridge, from which a quantity of metamorphic clay quartzite had been thrown out at the time of the digging. This was similar material to that of the Twoomy Creek railway cut. An assay in the laboratory showed no silver except that usually found in the oxide of lead used in making assays. This may have misled some former assayer in making the analysis.

The stratum of baked and burned clay having been observed at three different points of a triangle having sides several miles long, indicates a considerable area of disturbance accompanied with metamorphism. Its character, even where least burned, is quite different from the ordinary clays of the Tertiary, while its stratigraphic position, as seen dipping under the lignite at Beckville, shows that its deposition and disturbance was prior to the formation of the lignitic series, and must belong therefore either to the earlier Tertiary, or possibly to the later Cretaceous. The large percentage of lime (ten per cent) from the analysis of the scoria or cinder would rather point to a close connection with the latter. The least burned, or yellow baked clay, however, contains only one and two-tenths per cent of lime, combined with its equivalent of silica as silicate of lime.

GRAND BLUFF DISTURBANCE.

East of Beckville, on the eastern part of the Lagrone headright, near the old Dixon place, in the Grand Bluff road, was seen evidence of an apparently later disturbance, and as part of the iron series is involved it must have occurred after its deposition.

The red and gray mottled clay, its superimposed red clay, and the overlying thin stratum (two inches) of iron sandstone have been displaced. Instead of being horizontal, as when deposited, the series is now tilted and twisted, having in some places a dip varying from fifty to ninety degrees. In addition to this, the iron sandstone in places has on one side distinct grooves, which indicate great lateral pressure and simultaneous sliding motion. Several specimens of crusty and botryoidal limonite, which no doubt were the local representative of the buff crumbly ore, were seen mixed up with the disturbance. A few fragments of wavy laminated limonite were found, some of which were still adhering to the thin iron sandstone, confirms the opinion.

Returning to Beckville on the Grand Bluff and Harmony Hill road, two miles northwest from Grand Bluff, on the W. N. Lee place, Antoine Duboise headright, in the bed of Dillard Creek, a tributary of Martin's Creek, an upturned outcrop of siliceous limestone was seen. Strike, east by north and west by south. Dip about forty-five degrees, nearly south.

At Grand Bluff, on the Sabine River, about a mile above the ferry, a fault or slide involving the two beds of laminated and massive siliceous limestone already described under "Fresh Water Siliceous Limestone" was seen. The fault occurs at the mouth of a little ravine on the west side of the river, and shows the laminated limestone out of place, the throw being about twenty feet. This, in connection with the foregoing observations, has been named "the Grand Bluff Disturbance," to distinguish between what appears to have been a later without metamorphism and an earlier disturbance accompanied with metamorphism as shown on Twoomey Creek.

CHAPTER VIII.

SHELBY COUNTY.

BY JOSEPH B. WALKER.

This county, lying between north latitude 31° 35′ and 32°, and west longitude 93° 50′ and 94° 30′, has an area of eight hundred and two square miles.

From a municipality named Teneha it was renamed Shelby County, in honor of Gen. Isaac Shelby of Kentucky, by the Executive Council in 1835.

ACREAGE.—The number of acres is five hundred and thirteen thousand two hundred and eighty. The number of acres in field cultivation in 1889–90 was forty-six thousand two hundred and eighty-six, or 9 per cent, and in fruit and garden, seven hundred and fourteen acres.

DRAINAGE.

This county is watered and drained on the east by the Sabine River, which forms its eastern boundary, and also the boundary between the State of Texas and the State of Louisiana. The tributaries on the west are Teneha Bayou and its forks, Cedar Creek, Slough Bayou, Plum Creek, Prairie Creek, Huana Bayou; Granie Creek; Siepe Bayou and its forks, Siepe Branch, Bayou Blue, South Fork; Stone Bayou and its four forks, including Sanders Creek, Marbinel Creek; Patroon Bayou and its several forks, including Running Fork, Mill Creek, and Buckley's Creek.

The western and southwestern portions of the county are watered and drained by the Attoyac Bayou, which forms the western boundary of the county.

The tributaries on the northern and eastern side are Caney Branch; Bear Bayou; Stockman's Branch; Lion's Branch; Sandy Creek, formerly Hooper's Creek; Arenoso Creek and its forks, Dillard Creek and Boggy Creek. The Attoyac is a tributary of the Angelina River. The Angelina, a tributary of the Neches, and the Sabine empty separately into Sabine Lake, and this, by Sabine Pass, into the Gulf of Mexico.

SURFACE.

The high ridges, originally part of the elevated Tertiary plain, extend, as remnants, from northwest corner to the central southern boundary, forming the water shed between the tributaries of the Sabine River on the east and the tributaries of the Attoyac Fork of the Angelina River on the west.

The remainder of the county is broken rolling upland, and alluvial bottom land as valleys along the streams.

SOILS.

The top soil on the ridges is sandy from the leaching action of rain water. The soil on the sides of the ridges is sand mixed with a greater proportion of clay. On the rolling uplands the soil is mainly red ferruginated sandy clay. In the bottoms the soil is a mixture of the others from transportation, forming the fertile sandy loam of the valleys.

The principal products are cotton, corn, sweet potatoes, and sugar cane.

CLAYS.

On the rolling uplands are often seen beds of red and gray mottled clay four to six feet thick, overlaid by thin sandy soil and underlaid by gray sandy clay two to ten feet thick, and under this a parting of sand underlaid by bluish clay. The red and gray mottled clay is now used in the raw state for the manufacture of brick, but in this condition it usually contains pebbles and iron gravel which produce ugly spots and a different rate of expansion and contraction, resulting in cracks. These troubles can be partially remedied by the weathering of the clay during the winter, by drying and screening before dumping into the pug mill, or by washing the clay and using only the lighter material from mechanical suspension and subsequent sedimentation. The lower hardpan gray clay, by weathering, screening, and thorough working in the pug mill, will make a strong, compact, semi-vitrified brick, admirably adapted for lining of cisterns, street and sidewalk paving in cities, etc. By washing and taking the lighter parts from mechanical suspension and sedimentation it becomes suitable for yellow pottery and jug ware.

At the brickyard of Mr. J. J. Gibson, one mile south of Teneha, on Houston East and West Texas Railway, was observed the following section from the excavation made for brick material:

1.	Surface soil	1 foot.
2.	Yellow sand	2 feet.
3.	Sandy clay, somewhat ferruginated	3 feet.
4.	Mottled red and gray clay to bottom of cut.	

Here the bricks were made from the raw clay and used for local building. They are also shipped in carload lots to Houston. The selected bricks are of a fair quality, but there is considerable loss from warping, shrinking, and cracking, etc., in burning. A great improvement in quality could be made by some attention to the remedies given above. Burning in clamps or properly constructed permanent kilns would insure a more evenly distributed heat and a more uniform product, with less loss from warping, cementing, and cracking.

Near the brick kiln, south of Teneha, was observed some local change in the sandy clay overlying the mottled red and gray clay, as seen in the west bank of the railway cut, as will appear from the following section:

1.	Light sandy soil	6 inches.
2.	Yellow sand	2 feet.
3.	Yellow sandy clay, to bottom of cut	2 feet.

No. 3 contained a belt or pocket of small nodules one-half inch to one and one-half inches in diameter, having dark nuclei of bluish black color, which afterward proved to be mainly black oxide of manganese, associated with ferric oxide and alumina.

FRESH WATER SILICEOUS LIMESTONE.

About seven miles south of Timpson, near the crossing of Bear Bayou, on both sides were seen ledges of this limestone, similar to those seen in Panola County, but somewhat denser and of a deeper blue color, indicating more lime and less silica. The ledge on the north side was of considerable extent.

At the residence of Mr. C. Silas Baines, eight miles south of Timpson, in the J. A. Rodrigues headright, are found large ovoid nodules of this limestone several feet long by four to five feet wide, with radial cracks which have been filled with crystal calcite.

Near this locality it was also seen as an outcrop on the side of a hill, and again in a gully between the hills on the A. C. Thornbery headright.

About five miles south of Patroon, on the Matlock place, in Wm. Nethery headright, both yellow and blue siliceous limestone bowlders were seen near the top of a hill, or at a higher elevation than it had been observed before.

An outcrop was also seen on a hillside bordering a fork of the Attoyac Creek, on the Bryant Humphrey headright, in the western part of the county.

LIGNITE.

About seven miles south of Timpson, in the northeastern portion of the W. J. Crump headright, at the falls of a small stream, a tributary of the Attoyac Creek, in a gully about eleven feet deep, a bed of lignite apparently four or five feet thick was seen. It formed the bed of the gully and was similar to the lignite bed of Panola County

No other exposures of the lignite bed were observed in this county, but it is probable that it is of considerable extent.

TIMBER GROWTH.

The total area is 513,280 acres, of which 47,000 represents the total field, fruit, and garden area in cultivation, leaving 466,280. If from this be dededucted 46,628 acres for town sites, barrens, and streams, and from the remaining 419,652 be deducted 41,965 acres for timber already cut and in process of cutting by the sixteen saw mills, then 377,687 acres would approximately represent the present area of standing timber.

The total amount of timber would be approximately represented by the following figures: One-fourth, or 94,422 acres, suitable for lumber, at an average of 2500 feet per acre, would be 236,055,000 feet. The remaining, 283,265 acres, if cut into cord wood for charcoal, at an average of $37\frac{1}{2}$ cords per acre, would make a total of 10,622,437 cords.

The most abundant timber trees in this county are the pines, *Pinus mitis* and *Pinus taeda.* Both are varieties of the short-leaf or old field pine.

The other trees include the different oaks, sassafras, locust, hickory, elm, gum, black walnut, willow, cypress, and in the northern part of the county, on McFadden Creek, the *Magnolia grandiflora.*

IRON ORES.

The country between Carthage, in Panola County, and Teneha, in Shelby County, is for the most part gently rolling. The summits of the ridges, of moderate elevation, show remnants of the iron ore bed, either as fragments of iron sandstone or as deep red clay, underlaid by the mottled red and gray clay, with scattered shells or crusts and yellow clay stone centres of former iron geodes.

The country between Teneha and Logansport, Louisiana, as seen along the line of the Houston East and West Texas Railway, exhibits similar conditions. The general dip is apparently about five to eight degrees east by south.

The remnant of the iron ore deposit is seen on top of the hills and ridges extending from the extreme northwestern to the central southern boundary, or crossing from Panola County in the northwest and into San Augustine and Sabine counties southeastward.

In the road at Timpson, at Center, and elsewhere a quantity of siliceous iron pebbles were observed in the sandy soil. These pebbles are probably derived from the disintegration of the iron conglomerate, and are associated with iron gravel in angular pieces, resulting from the breaking up of the former bed of aluminous buff crumbly iron ore, and the concentric shells of iron geodes. Some of this material was magnetic and easily separated from the non-magnetic portion by a common horse shoe magnet.

On a trip to the south of Timpson, crossing Bear Bayou about seven miles from Timpson, on a ridge one mile south of the Whiteside residence, was seen a remnant of the iron ore bed consisting of a bench of about twenty-five acres, on the top of which is a bed of iron sandstone which had been nearly four feet thick, as ascertained from a bowlder which had fallen from the bench. The bed of conglomerate iron ore belonging above and in contact with the iron sandstone was gone, by disintegration and transportation. Underlying the compact iron sandstone is a bed (of undetermined thickness) of modified ferruginated sand, with a tendency to concentric structure similar to geodes, and having their centres filled with loose sand.

In the road from Timpson to San Augustine, about four miles from Timpson, was seen a thin stratum of clay ironstone, part of which had jointed square fracture and yellow ochre nuclei. This corresponds with the septum iron ore already described from Panola County.

Near a small bridge over Tadlock Branch, an eighth of a mile south of Timpson, were seen a number of tumbled bowlders of iron conglomerate resting on a few feet of clay, which was underlaid by about one foot of lignitic clay shale to the water line. Some of these iron conglomerate bowlders would probably weigh as much as two thousand pounds.

On another trip southward, about eight miles from Timpson, on the A. C. Thornbery headright, was seen a ridge locally known as Wolf's Mountain, the top of which is covered by about two feet of soil sand. Underlying this is two feet of compact iron sandstone resting upon four feet of ferruginated sand, the bottom of which is cross-bedded and resting on a seam of harder ferruginous sand. This in turn is underlaid by about four feet of softer ferruginous sand. See section, Fig. 19, p. 253.

On one of the adjoining hills was seen quite an assemblage of iron sandstone nodules and "potleg" siliceous iron ore.

On other hillsides in the neighborhood of Mr. C. S. Baine's residence, in the J. A. Rodrigues headright, were seen iron geodes of considerable size, many of them two and one-half feet by eighteen inches, with yellow ochre centres. Some exhibited evidence of slight burning by local forest fires. In these localities occur a large quantity of iron pebbles and iron gravel, a portion of which was magnetic and separated by the magnet. Similar pebbles and gravel were observed at Patroon Postoffice in the southeastern part of the county.

Crossing Iron Mountain, on the road from Patroon to San Augustine, the conglomerate iron ore seems to have been disintegrated and removed. The iron sandstone, much broken, remains. Some of it has a little laminated iron ore adhering to it, and some of a lower horizon shows a tendency to geodiform structure.

On the road from San Augustine to Center the iron pebbles were seen in abundance, associated with a very deep red clay soil. About three and one-half miles north of San Augustine a small quantity of iron conglomerate was seen.

The best iron ore seen in Shelby County was in the extreme northwestern portion of the county, about four or five miles north of Timpson. Near the Bettie A. Allen tract is a ridge capped with the iron ore deposit, from which the following section was made:

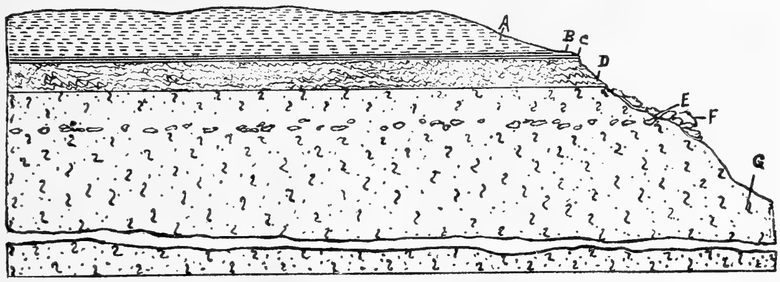


Fig. 18.

SECTION OF IRON ORE DEPOSIT FOUR MILES NORTH OF TIMPSON.

A. Soil sand with timber growth.......... 6 feet.
B. Iron sandstone.......... 6 inches.
C. Laminated iron ore.......... 6 inches.
D. Buff crumbly iron ore.......... 3 feet.
E. Geode iron ore.......... Variable.
F. Fragmental bowlders from No. 1, on hillside.
G. Sandy clay to base of hill.

CHEMICAL ANALYSES OF IRON ORES.

No.	Sesquioxide of iron.	Silica.	Alumina.	Phosphoric acid.	Water.		Metallic iron.
665†	50.72	40.45	7.68	0.25	0.80	*a* Trace.	35.50
666†	64.23	21.20	11.77	0.80	1.80	*b* Trace.	44.96
667*	32.74	10.90	41.86	0.09	13.40	*a b* Trace.	22.91
669*	71.14	16.50	9.36				49.80
832*	58.23	22.90	10.77	Trace.	7.35	*a b* Trace.	40.76
833*	51.94	33.70	10.46				36.25
834*	58.86	25.30	5.14		10.13	*a b* Trace.	41.20
835*	42.49	13.90	30.31				29.74
836*	45.96	34.00	10.90				32.17
837*	40.29	42.80	14.31				28.20

Analyses by †L. E. Magnenat, *J. H. Herndon.
a Lime and sulphur. *b* Lime and magnesia.

Localities.

No. 665. Buff crumbly iron ore, four to five miles north of Timpson, Shelby and Panola counties.

No. 666. Laminated iron ore, four to five miles north of Timpson, Shelby and Panola counties.

No. 667. Geode iron ore, four to five miles north of Timpson, Shelby and Panola counties.

No. 669. Magnetic iron pebbles, from road in town of Timpson, Shelby County.

No. 832. Laminated iron ore, seven miles south of Timpson, Shelby County.

No. 833. Geodic iron sandstone, eight miles south of Timpson, Shelby County.

No. 834. Geodic crumbly iron ore, eight miles south of Timpson, Shelby County.
No. 835. Concretionary iron ore, four miles south of Timpson, Shelby County.
No. 836. Conglomerate iron ore, one-eighth mile south of Timpson, Shelby County.
No. 837. Iron sandstone, partly hematized, seven miles south of Timpson, Shelby County.

SANDSTONE.

About five and one-half miles north of Timpson is a little stream taking its origin from springs which issue from the water bearing sand. Overlying this sand is an extensive deposit (twenty-five feet) of soft sandstone, slightly impregnated with iron, giving it generally a yellow color, except where the iron was stronger and has stained it a reddish brown color. The water flowing from the springs carries with it a considerable quantity of loose white sand, and this has so undermined the soft sandstone that it has "caved," forming an escarpment or bluff. The under part of the bed has gradually released a portion of its material and thereby formed a hollow pit-like opening, from which it has derived its name—Cave Spring. The sandstone is soft and friable, and therefore not sufficiently strong for building purposes.

The only other bed of sandstone observed in this county is on Wolf's Mountain, eight miles south of Timpson, where the top layer is indurated, partly from cementation, and thus protected a bench having now only a small outcrop. This exposure shows a distinctly stratified condition, the lower portion being cross-bedded. A second bench of softer material, also of small extent, was protected by the overhanging upper ledge until it broke, and a portion of it rolled as bowlders to a lower position on the hillside. See Fig. 19, p. 253.

GLASS SAND.

The only exposure of an extensive bed of soft white sand noted in this county is that already described at Cave Spring, about five and one-half miles north of Timpson, where a portion of it is stained yellow and red by the trickling of an iron solution from above. The thickness of the bed is about twenty-five feet. In mining it for glass sand the stained portion could be rejected. If the alumina be sufficient to become detrimental it could be washed out, as there is sufficient water at hand for the purpose. Fuel is also abundant in the neigborhood.

There are probably other beds of white sand in this and other portions of the county, at present covered by surface soil.

SILICEOUS IRON PEBBLES AND IRON GRAVEL.

In the soil of nearly every portion of the county, more or less of small rounded iron pebbles associated with angular fragments of aluminous iron gravel were seen. A considerable portion of these are magnetic and separable by the permanent magnet.

MANGANESE NODULES (WAD).

About one mile south of Teneha, on the Houston East and West Texas Railway, was seen an irregular belt of warty nodules in the yellow sandy clay on the west side of the railway cut. The exterior of these nodules is of the same color as the sandy clay. On fracture they exhibit a dark bluish black color, and the nucleus found to consist mainly of black oxide of manganese associated with ferric oxide and alumina (bog manganese).

BROWN SPRINGS.

About eight miles north of Timpson, in the southwestern portion of Panola and as near as could be ascertained on the McWilliams headright, there is a spring from which issues a brownish colored water. As it is more conveniently reached from Timpson, it is treated of here instead of being included in the description of Panola County.

The stream, issuing from two places a few yards apart, is not bold. The water has a deep amber color, not unlike the color of whisky, is not styptic in taste, makes no rusty deposit, and therefore has little if any iron in solution, and there is no indication of any other metallic salt. When taken into the stomach the heat of the body deprives it of a portion of its carbonic acid gas, producing eructation, but no feeling of constriction, as with some other waters.

The place has been noted as a neighborhood resort for about thirty-five years, and recently a few temporary cabins have been erected for the accommodation of visitors.

The color of the water is no doubt due to its contact with some member of the lignitic series. A slight faulting would have thrown the asphaltic clay, with its soluble carbonaceous matter, into a position to be traversed by the water before reaching the surface.

This clay has already been described under "Asphaltum Brown" in the description of mineral paints of Panola County.

NOTES ON THE STRATIGRAPHY OF SHELBY COUNTY.

The following section, taken from the ferry road on the Louisiana side of the Sabine River, at Logansport, Louisiana, shows a probable rearrangement by transportation of the members of the section above No. 7.

1.	Gray sandy soil	2 feet.
2.	Mottled yellow and gray clay	10 feet.
3.	Yellow and blue clay interstratified	4 feet.
4.	Geode iron formation (nonconformable)	1 foot.
5.	Sandy clay	3 feet.
6.	Iron sandstone (irregular)	1 foot.
7.	Lignitic shale to water line	2 feet.

Passing from Logansport to Timpson the surface is gently rolling. In the railway cuts through the ridges the strata are clay and sand interstratified, with occasional thin crusty seams of ferruginated material near the top and projecting about an inch from the weathered incline of the cuts. The capping of the ridges is usually red sandy clay, with some small fragments of iron sandstone remaining. The dip of the strata is generally east by south about 5° to 8°. In one cut, about three miles northeast of Timpson, was seen a siliceous limestone slab six inches thick and two feet exposure.

At Teneha, at Timpson, at Center, at Patroon, and elsewhere, as already stated, magnetic iron pebbles and magnetic iron gravel were seen, associated with similar pebbles and gravel which were non-magnetic.

The iron pebbles were derived from the disintegration of the iron conglomerate, and the iron gravel from the breaking up of the laminated ore, the buff crumbly ore, and concentric crusts of the geode ore.

The partial magnetization of the iron pebbles and iron gravel is attributable to the action of local forest fires, causing dehydration, partial reduction of the sesquioxide to protoxide of iron.

In the dump from one of the public wells at Timpson a few small fragments of bright lemon-yellow ochre were seen.

In the road, five and one-half miles north of Timpson, one mile west of Cave Spring Hill, were seen bowlders of iron conglomerate about two feet in thickness.

A similar conglomerate was seen at a little bridge an eighth of a mile south of Timpson.

The Cave Spring Ridge section of the iron ore deposit has already been given.

Iron sandstone was seen on ridges seven miles south of Timpson, and on

Wolf's Mountain, eight miles south of Timpson, one and one-half miles south-east of C. Silas Baine's residence, on the A. C. Thornberry headright. (See Fig. 19).

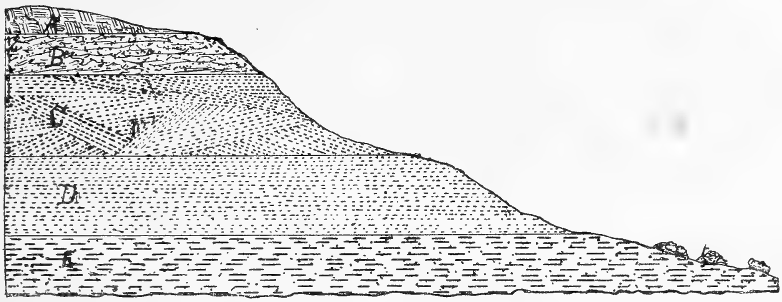


Fig. 19.

WOLF MOUNTAIN SANDSTONE.

A.	Soil, sand	2 feet.
B.	Iron sandstone	2 feet.
C.	Cross-bedded ferruginous sandstone	4 feet.
D.	Soft ferruginated sandstone	4 feet.
E.	Sandy clay to base.	
F.	Fragments fallen from B.	

Some of the iron sandstone material in this vicinity is porous, and has a tendency to geodic structure. Iron geodes of large size were found at a lower horizon, on the sides of the adjacent hills.

"Potleg" iron ore was seen in one locality in the neighborhood. The material is similar to that of the iron sandstone, and in form these potlegs are generally elongated thick-walled tubes with branches. The hollow is usually small and axial. They were probably formed around small roots and stems as nuclei. The gossamer-like remains of such stem were seen on breaking a fragment afterward in another county. In this case the small potleg was included in orange loam.

A fragment of wavy laminated iron ore was found seven miles south of Timpson. It was possibly a float specimen, as no exposure of it was observed in connection with the iron sandstone.

DISTURBANCE.

Aside from the tumbled condition of the iron conglomerate and the iron sandstone, no other evidence of disturbance in this county was noted, except that of the lignite bed, already referred to, in the northeast corner of W. J. Crump's headright, near the headwaters of a small tributary of Attoyac Creek. The little stream has cut through a considerable portion of the bed. The peculiarity of this bed, partly exposed, is the exhibition of numerous parallel fault lines, running east by north and west by south, indicating great latteral pressure from the direction north by west, with an apparent slight upward sliding. The exposure is unequal in the two banks of the stream. In the bank on the eastern side it is covered by about two feet of soil. On the western side it is covered by about six feet of valley drift. The difference is probably the result of a previous erosion of the lignite bed, before the deposition of the valley drift.

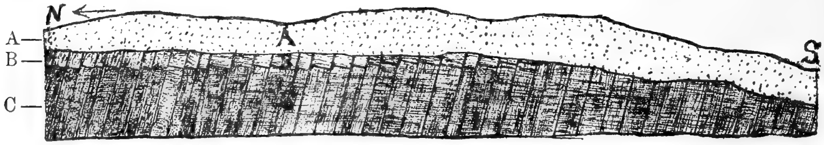


Fig. 20.

FAULTED LIGNITE BED, SHELBY COUNTY.

A.	Sandy soil	2 feet.
B.	Lignitic shale	1 foot.
C.	Lignite bed	4 feet.

Across the southern boundary of Shelby, in Sabine County, the bowlders of siliceous limestone already described as occuring near the top of the hill, and therefore out of their usual horizon, were probably carried upward by a similar sliding motion.

RELATION OF STRATA.

The relation of strata in Shelby County is similar to that of Panola County, from Nos. 1 to 19 of the section.

CHAPTER IX.

RUSK COUNTY.

BY JOSEPH B. WALKER.

The area of this county is 917 square miles, lying between north latitude 31° 51′—32° 25′ and west longitude 94° 25′—94° 58′. It was formed from Nacogdoches County, and organized in 1843, being named in honor of Thomas J. Rusk.

ACREAGE.—The number of acres is 586,880. The number of acres in field cultivation in 1889–90 was 101,585, or 17.3 per cent. The number of acres in fruit and gardens was 2677.

DRAINAGE.

This county is watered and drained in the northern and northeastern portion by the Sabine River and its tributaries: Caney Creek; Rabbit Creek, with its east and west prongs; Cherokee Bayou and its fork, Towiska Creek; Corbet Creek and Williamson Creek, forks of Martin's Creek; Iron Bayou; Attoyac Creek; Murvall's Bayou, and Golondrina Creek.

The middle and southwestern portions by the tributaries of the Angelina River: Bowles Creek; Johnson's Creek; Striker's Creek; Mud Creek; Scoober Creek; Big Shawnee Creek; Anadarco Creek; Barnhart's Creek, and the East Fork of the Angelina River.

SURFACE.

The highest elevations are the iron-capped ridges, more particularly in northern, northeastern, and southern portions of the county. The remainder is hilly and rolling, except the valleys which form the margins of the streams.

SOILS.

The top soil of the ridges is sandy. The hillside soils are loamy, with a considerable mixture of sand. The valley soils are a mixture of the finer particles derived from the weathering and gradual erosion by rains of the hillsides. They contain more or less organic matter, obtained in the same way, and are therefore fertile sandy loams.

The principal products are cotton, corn, oats, sweet potatoes, peas, and sugar cane.

Horticulture has also made some progress in this county, and the peach here, as in California, is the leading orchard fruit.

CLAYS.

This county, like the preceding counties, has an abundance of clay suitable for bricks, tiles, etc. It also has extensive pockets of washed clay, derived from the lignitic clay shales, which, with proper tempering, are admirably adapted to the production of coarse pottery, such as jugs, milk crocks, sewer pipe, etc. Such a bed exists near the town of Henderson, and was extensively worked by a pottery enterprise as far back as forty years ago. About one-half mile northeast of the court house is now the Henderson Pottery Works, organized in February, 1890, and chartered in March of the same year. The plant consists of one brick dome kiln about thirty feet high and sixteen feet diameter; one wooden factory building, ninety feet by forty feet, containing one pug mill, six potter's lathes, and one slip machine for glazing the ware. The manager is using for the best ware the pinkish gray, clay from the bed formerly used by the older pottery. He is also using a yellow mottled clay, mixed with sand, for producing a furnace brick. Also, a grayish white clay for making a semi-vitrified brick for walling in cisterns, street paving, etc. The writer is indebted to him for specimens of ware for the State Museum.

About two miles east of Mount Enterprise, or fifteen miles west of Garrison, is a bed of red clay ten feet thick, overlying a bed of orange loam five feet thick, under which is a bed of red and yellow mottled clay eight feet in thickness. (See section on page 263.)

About fifteen miles southeast of Henderson, in the Minden road, is a bed of red clay eight feet thick, overlying six feet of orange loam. (See section on page 264.)

About two or three miles northeast of Henderson, on the Alma, Beckville and Grand Bluff road, is a bed of mottled red and grayish white clay underlying the orange loam. This mottled clay, by the weathering of the red and white, often imparts a pinkish hue to the washed exposures of the clay.

On the northern exposure of the hillside at Millville is a bed of red clay eight feet thick, overlaid by typical orange sand and underlaid by a six feet bed of mottled red and gray clay. (See section on page 264.)

At Sulphur Spring, eighteen miles south of Henderson, is a bed of clay four feet, and a bed of yellow sandy clay eight feet. (See Fig. 21, under Stratigraphy.)

About six and one half miles west of Henderson, on the Larissa road, is a bed of deep red clay, overlying the lower bed of orange loam.

About eight miles west of Henderson, on the same road, there is a pocket deposit of dark clay, slightly magnesian, overlaid by mottled red and gray clay and underlaid by a bed of soft plastic clay to bottom of gully.

About a quarter of a mile northwest of Henderson, on the Belleview road, there is a bed of gray plastic clay fifteen feet to bed of branch.

ANALYSES OF CLAYS.

No.	Silica.	Alumina.	Sesquioxide of Iron.	Lime.	Magnesia.	Soda.	Potassa.	Phosphoric Acid.	Water.	Sulphur Trioxide.	Total.
755†.....	64.40	24.17	3.23	Trace.	Trace.	a 3.50		Trace.	7.25	......	....
766*.....	7.40	55.40		6.58	8.28	5.26	2.57	Trace.	13.50	.73	99.72
767†.....	73.00	6.91	5.69	Trace.	.50	2.50	2.62	......	b 9.00	......	100.22
782*.....	62.00	12.12	8.08	......	......	.....	.....	......	......	......	....
788†....	71.25	18.58	1.62	Trace.	.60	a 4.00		......	5.50	Trace.	....

Analyses by *J. H. Herndon, †L. E. Magnenat.

a As chlorides. *b* Organic matter.

No. 755. Gray clay, lignitic series, used at the Henderson Pottery Works, one-half mile north of the court house.

No. 766. Indurated glauconitic clay, greensand marl series, near Sulphur Springs, eighteen miles south of Henderson.

No. 767. Micaceous sandy lignitic clay, eighteen miles south of Henderson.

No. 782. Mottled orange loam, lower orange sand formation, hillside, northern exposure, at Millville.

No. 788. Dark clay, slightly magnesian, pocket bed, lignitic series, Larissa road, eight miles west of Henderson.

SILICEOUS LIMESTONE.

About four miles east of L. D. Stephens' house, at Sulphur Spring, on a little branch tributary to East Fork of Shawnee Creek, March Brothers tract, in the Thomas Williams league, near Dave Morris' house, was seen an outcropping ledge of siliceous limestone, belonging to the lignitic series, two feet eight inches thick.

LIGNITE.

At or near Sulphur Spring no exposure of the lignite bed was observed, but the siliceous limestone above noted, as well as the remarkable development of micaceous sandy lignitic clay shale in a little branch just west of Sulphur Spring Church, would indicate its presence below. The running water in this branch, as well as a similar one just east of the church, has cut ravines in this material several feet deep. At Sulphur Spring is a fault exhibiting a portion of this lignitic deposit. (See section on page 264.)

Lignite has been reported as existing near Henderson, but was not seen by the writer. There is no reason to doubt it, however, because part of the lignitic series is shown by the derived potter's clay. Lignite is found also near the school house at Millville.

At Graham's Lake, twelve miles west of Henderson, in the hillside some twenty feet above the water, there is a bed of lignite.

A sample of this lignite analyzed by Mr. J. H. Herndon exhibited the following composition:

Moisture	16.55
Volatile matter	43.90
Fixed carbon	25.40
Sulphur	0.08
Ash	14.15
	100.08

MINERAL WATER.

Sulphur Spring, about eighteen miles south of Henderson, was in former times somewhat noted as a place of resort for invalids and others. The water is, however, chalybeate, and not sulphur water as its name would indicate. Its mineral character is derived from the partial decomposition of iron ore in contact with organic matter, possibly that contained in the micaceous sandy lignitic clay shale. A similar spring was observed about a mile east of L. D. Stevens' residence. The water is cool and rather pleasant in taste, though slightly styptic, and deposits a rusty sediment on standing.

OIL.

The only mineral oil seen in this county was a thin film which covered about one hundred square feet of the surface of the water in Graham's Lake, twelve miles west of Henderson. This was afterwards driven to the shore by a light breeze which produced a rippling of the water. It was an exudation from the lignite.

GREENSAND MARL.

From Sulphur Spring southward to the intersection of the tributaries of the East Fork of Shawnee Creek is a fine development of greensand marl.

About two miles east of Mount Enterprise, in the bed of a small stream, a tributary of the East Fork of the Shawnee Creek, is a deposit of greensand shell marl.

In the bed of a branch, also a tributary of Shawnee Creek, about one-fourth to one-half mile south of L. D. Stevens' residence, southeast corner of Martinez league, was seen a bed of slightly altered greensand marl twenty feet thick, under which, separated by recemented iron ore, is a second bed of altered greensand marl ten feet; under this, separated by thin iron seams, is a bed of green marly clay, with pyrite, two feet; dark greensand marl, without pyrite, six feet; indurated glauconitic clay, six inches; greensand marl, very dark green when fresh, three feet, to sandy bottom of valley. (See section on page 265.)

A similar outcrop on the same stream, some three miles southwest, near an old mill, was seen by Mr. Moss, of Henderson, a companion for this trip, but was not visited by the writer.

ANALYSES OF GREENSAND MARLS.

No.	Silica.	Protoxide of iron.	Sesquioxide of iron.	Alumina.	Lime.	Magnesia.	Potassa.	Soda.	Phosphoric Acid.	Water.	Sulphur trioxide.
762*	25.20		58.68		2.96	4.68	4.15	4.04	Trace.	......	1.33
764*	30.40		52.60		2.46	3.92	2.28	4.97	Trace.	3.11	0.51
765*	16.60		67.00		4.11	4.75	2.48	3.63	1.27	......	0.72
766*	7.40		53.40		6.58	8.28	2.57	5.26	Trace.	13.50	0.73
768† ..	32.10	20.39	12.71	15.54	1.98	5.20	3.62	2.37	Trace.	5.20	0.98
759*a	20.70	......	44.62	7.40	1.31	0.57	Trace.	0.42	4.79	16.10	0.12
770†	26.30	.....	29.59	27.81	0.90	1.60	3.29	4.66	0.22	5.00	0.38

Analysis by *J. H. Herndon, †L. E. Magnenat.

a Manganese, 1.40 per cent; Carbonic acid, 2.90 per cent.

Localities.

No. 762. Greensand marl, upper bed twenty feet. Stevens' Branch, Sulphur Spring.

No. 764. Greensand marl, bed six feet, under pyrite, Stevens' Branch, Sulphur Spring.

No. 765. Greensand marl, middle bed six feet, Stevens' Branch, Sulphur Spring.

No. 766. Indurated glauconitic clay, between strata of marl, Stevens' Branch, Sulphur Spring.

No. 768. Greensand marl, lower bed, three feet exposed, Stevens' Branch, Sulphur Spring.

No. 759. Altered greensand marl, or fossiliferous orange loam, Sulphur Spring.

No. 770. Altered greensand marl, one mile east of L. D. Stevens' house, near Sulphur Spring.

TIMBER.

The total area of this county is 586,880 acres.* After deducting the amount in field, fruit, and garden cultivation, 109,764 acres, and for barrens, town sites, and streams, 68,159 acres, and for timber cut and in process of cutting by the ten saw mills at work in the county, 58,422 acres, then the final remainder, 350,535 acres, would approximately represent the area of standing timber.

The total value of this area of timber would be approximately represented as follows: One-fourth, or 87,633 acres, suitable for lumber. The remainder, 262,904 acres of standing timber, if cut into cord wood, would probably average 37½ cords per acre.

* Report of Commissioner of Agriculture for 1888–89.

The character of timber trees is similar to that of Nacogdoches County, except the noted absence of long leaf yellow pine, *Pinus australis.*

IRON ORES.

At Mount Enterprise, on the northeastern and northwestern exposures, representatives of iron pebble conglomerate, iron sandstone, wavy laminated and buff crumbly iron ores were seen covering an area of about two hundred acres.

About two miles east from Henderson, on the Pine Hill road, were seen some large geodes of iron ore, not in continuous bed, but extensive. Two and one-fourth miles from Henderson, on the same road, is a remnant of a bed of iron pebble conglomerate on the summit of a ridge. Four miles east of the town, on the same road, is a ledge of sandy ferruginated geodes. Five miles east on the same road is another remnantal bed of iron pebble conglomerate on the summit of a ridge.

About three and one-fourth miles northeast of Henderson, on the Millville road, large bowlders of iron pebble conglomerate were seen. Seven miles from Henderson, on same road, fragments of iron ore, including buff crumbly ore, were noted.

In a field at Howard Williams' place were collected fragments of a stratum of fossiliferous iron sandstone containing casts of shells, *Cardita planicosta*, etc.

About seventeen miles south of Henderson, at Gould Postoffice, is the northeastern exposure of Iron Mountain, formerly Elkins Mountain. On this ridge there is an extensive remnant of the iron series. The iron pebble conglomerate has been disintegrated and eroded, but a few tumbled bowlders, as seen in the vicinity of the fault at Sulphur Spring, escaped disintegration by being covered with local drift until uncovered by gully washing, and now attest its former presence.

The iron sandstone, only a thin stratum of which now remains, was partly eroded, but what is left has served to protect a portion of the wavy laminated and underlying buff crumbly iron ore, which here rests upon an extensive local drift deposit of altered greensand marl of the Eocene epoch. The upper portion of this marl or orange loam is fossiliferous, containing casts of Eocene shells, *Cardita planicosta*, etc.

In front of L. D. Stevens' house, at Sulphur Spring, faulted and tilted strata of iron ore were observed. Some portions of the limonite are compact and glossy black. The wavy laminated and buff crumbly varieties are also represented. The orange loam is here rich in fossiliferous casts of Eocene shells.

One-half mile east of the Sulphur Spring church and school house is a remnant of wavy laminated and buff crumbly iron ore, including fragments of iron sandstone.

On the summit of Iron Mountain, formerly Elkins Mountain, also known as Bagley Mountain, two and one half miles from Glenfawn, seventeen miles south of Henderson, and three miles south by east to Gould Postoffice, was noted the following section:

1.	White sandy soil	2 feet
2.	Iron sandstone	1½ inches.
3.	Wavy laminated iron ore	7½ inches.
4.	Buff crumbly iron ore	34 inches.
5.	Orange loam to base.	

Width across the ridge, one-half mile; length, three and one-half miles.

At Glenfawn there is a ridge two hundred yards wide, and six hundred yards long. The crest of the ridge, near Mr. Blanton's house, is covered with broken fragments of laminated and buff crumbly iron ore.

About half a mile from Glenfawn, on the Douglass road, at the Nunnelly place, now owned by Mr. McBelk, on the northwest slope of the ridge was seen a considerable exposure of laminated and buff crumbly ore. A similar exposure was seen two to three miles from Glenfawn, on the W. F. Allison headright.

Similar exposures were observed near the village of New Salem, on the W. H. Walters headright, and further on in the road to Quin Mountain, Sanchez headright, and at Uriah Quin's place, eighteen miles southwest of Henderson, Robert D. Marlow headright. Quin Mountain is four miles long and one mile wide.

About twelve miles from Henderson, on the New Salem and Henderson road, at Scoober Creek, were noticed a few rounded geodes with septa and filled with ferruginous sand.

On the Larissa road, six and one-half miles west of Henderson, are a few bowlders of iron pebble conglomerate and small fragments of the former underlying bed of iron sandstone. In the same road, west of W. T. Brewer's house, were seen similar bowlders of loosely aggregated iron pebble conglomerate.

On the road from Belleview to Monroe, two and one-half miles from the latter place, is a remnant of the iron pebble conglomerate bed, partly disintegrated. The hillsides are thickly strewn with iron pebbles from this source.

On the road from Monroe to Henderson, two and one-half miles from the latter place, is a remnant of the iron pebble conglomerate bed overlying a thin broken stratum of fossiliferous iron sandstone, which rests upon orange loam.

On the same road, seven miles north of Henderson, is a remnant of a bed of iron pebble conglomerate about three feet thick.

ANALYSES OF IRON ORES.

No.	Sesquioxide of iron.	Silica.	Alumina.	Phosphoric Acid.	Sulphur trioxide.	Lime.	Magnesia.	Manganese oxide.	Water.	Total.	Metallic Iron.
682*	51.46	......	33.60	......	......	......	....	......	......	......	36.35
683*	29.74	56.30	12.06	......	......	......	......	......	......	......	20.81
756†	49.88	7.90	27.92	0.39	Trace.	0.60	......	......	13.10	99.99	34.91
757†	47.08	35 00	11.62	Trace.	0.26	Trace.	......	......	5.60	99.76	32.95
758†	69.53	15.10	6.67	Trace.	0.28	......	......	5.60	3.20	100.38	48.67
760†	71.79	7.45	5.01	0.25	2.11	Trace.	......	......	13.50	100.11	50.28
761†	73.73	8 50	7.17	0.66	0.10	Trace.	......	Trace.	9.90	100.28	51.61
769*	69.85	7.60	8.55	0.51	Trace.	Trace.	Trace.	......	13.20	99.71	48.89
771†	72.11	14.10	6.69	[a] 1.41	0.10	Trace.	......	......	5.50	99.91	50.48
772†	74.38	10.20	6.02	[b] 1.15	0.12	Trace.	Trace.	......	8.50	100.37	52.06
773†	68.28	8.75	17.32	[c] 1.58	0.37	Trace.	Trace.	......	3.60	99.90	47.78
774†	54.56	16.50	19.44	Trace.	0.40	0.20	......	......	8.60	99.90	38.19
776*	71.14	10.40	7.06	0.89	0.02	Trace.	Trace.	......	10.58	100.09	49.79
777†	78.26	6.00	6.74	0.48	0.12	Trace.	......	......	6.20	99.60	54.78
778*	50.48	8.80	......	......	......	......	......	......	......	......	35.39
779†	56.51	29.80	......	......	......	......	......	......	......	......	39.55
783*	35.57	49.90	6.83	......	......	......	......	......	......	......	24.89
784*	......	39.00	6.72	......	......	......	......	......	......	......	34.62
785*	35.57	55.50	5.63	......	......	......	......	......	......	......	24.89
786*	62.09	24.90	6.31	......	......	......	......	......	......	......	44.03
787*	......	29.40	10.12	......	......	......	......	......	......	......	37.58
790*	45.27	42.40	6.33	......	......	......	......	......	......	......	31.69
791*	42.04	36.30	5.36	......	......	......	......	......	......	......	36.90
792*	21.66	61.40	12.59	......	......	......	......	......	......	......	15.16

Analyses by *J. H. Herndon, †L. E. Magnenat.

a Reduced to phosphorus=0.61. *b* =0.48. *c* =0.69.

Localities.

No. 682. Conglomerate iron ore, two hundred yards west of Tatum Station, James Reel headright.

No. 683. Iron sandstone, one-fourth mile west of Tatum Station, James Reel headright.

No. 756. Agate banded limonite, between buff crumbly ore and orange loam, Iron Mountain.

No. 757. Buff crumbly iron ore partly altered to hematite, Mount Enterprise.

No. 758. Iron geode, central fragment, two miles east of Henderson, Pine Hill road.

No. 760. Ferruginous tufa, overlying orange loam, Iron Mountain, at Gould.

No. 761. Laminated wavy iron ore, Iron Mountain, at Gould.

No. 769. Limonite, in contact with orange loam, Iron Mountain, at Gould.

No. 771. Laminated wavy limonite, one-half mile east of church, near Sulphur Spring.

No. 772. Compact laminated iron ore, Iron Mountain, at Gould.

No. 773. Compact laminated iron ore, front of L. D. Stevens' house, Sulphur Spring.

No. 774. Buff crumbly iron ore, Quin Mountain, eighteen miles southwest of Henderson.

No. 776. Botryoidal laminated limonite, Stevens Branch, Sulphur Spring.

No. 777. Laminated limonite, west side of Iron Mountain, two and one-half miles east of Glenfawn.

No. 778. Orange yellow loam, in contact with buff crumbly iron ore, Mount Enterprise.

No. 779. Iron pebble conglomerate, three and one-fourth miles northeast of Henderson.

No. 783. Fossiliferous iron sandstone, overlying orange sand, Millville.

No. 784. Iron pebble conglomerate, six and one-half miles west of Henderson, Larissa road.

No. 785. Iron sandstone, six and one-half miles west of Henderson, Larissa road.

No. 786. Iron pebble conglomerate, two and one-half miles south of Monroe.

No. 787. Iron pebble conglomerate, seven miles north of Henderson.

No. 790. Buckshot pebbles and iron gravel, overlying lower orange loam, Millville.

No. 791. Soft iron conglomerate, recemented, twelve miles west of Henderson, Cherokee County.

No. 792. Pebbles from orange sandy loam, two miles east of Mount Enterprise.

GLASS SAND.

While no extensive deposits of pure white sand were observed, the top soil sand of the ridges could be washed in vats filled with running water, by frequent agitation to allow the clay and other impurities to flow off and the sand to deposit as sediment. It could then be used to advantage for the production of bottles and other coarse glassware.

ORANGE SAND.

At Millville, on the northern slope of the hillside, is an exposure of typical orange sand ten feet thick, underlying two and one-fourth inches of fossiliferous iron sandstone. This sand very probably was originally white sand It was afterward saturated with a solution of the protoxide of iron, which, uniting with a portion of the silica, became greensand, and this by oxidation became orange sand. On analysis a specimen afforded Mr. J. H. Herndon the following composition: Sesquioxide of iron, 3.23; alumina, 1.77; silica, 94.60. Another specimen from one-half mile northwest of Henderson gave the same analyst the following composition: Sesquioxide of iron, 2.58; alumina, 0.72; silica, 95.65.

The bed at Millville becomes somewhat loamy near the base, and rests upon six feet of red clay, and this upon a stratum of mottled red and gray clay also six feet thick, under which is a bed of orange loam five feet. The chief constituents of this lower bed are: Silica, 62.00; sesquioxide of iron, 8.08; and alumina, 12.12.

STRATIGRAPHY.

About fifteen miles west of Garrison or two miles east of Mount Enterprise is the following section (Eocene? to No. 5):

1.	Red clay, with overlying scattered iron pebbles and iron gravel	10 feet.
2.	Orange yellow loam, with similar pebbles and gravel	5 feet.
3.	Mottled red and yellow clay	8 feet.
4.	Sand and clay, interstratified	8 feet.
5.	Greensand shell marl, Miocene? or recent basin deposit in creek bed.	

About fifteen miles southeast of Henderson, on the Minden and Henderson road, is the following Eocene? section:

1.	Red clay, with overlying scattered iron gravel	8 feet.
2.	Orange loam	6 feet.
3.	Sand bed	15 feet.
4.	Lighter orange yellow loam	6 feet.
5.	Mottled red and gray clay	5 feet.
6.	Gray clay to bed of creek.	

At Millville Postoffice, on the northern slope of the hillside, is the follow-Eocene? section:

1.	Sandy soil	2 feet.
2.	Hard stratum of fossiliferous iron sandstone containing *Cardita planicosta*, *Turritella* sp. ind	$2\frac{1}{4}$ inches.
3.	Orange sand, typical (see analysis)	10 feet.
4.	Red clay, with overlying scattered iron pebbles and iron gravel, some of which are magnetic	8 feet.
5.	Mottled red and gray clay	6 feet.
6.	Under bed of orange loam	5 feet.
7.	Washed soil, from all the above, to bed of creek	3 feet.

At the chalybeate spring (so-called Sulphur Spring), eighteen miles south-east of Henderson, is a fault showing disturbance. The following is the section:

A.	Reddish sandy clay soil	5 feet.
B.	Local pebble drift	2 feet.
C.	Clay	1 foot.
D.	Lignitic micaceous clay shale to bed of creek	3 feet.

A section seventy feet further up the stream shows the following:

A.	Red sandy clay soil	5 feet.
I.	Clay	4 feet.
F.	Local drift pebbles of iron clay stone to bed of branch	4 feet.

Another section fifty feet further north shows the following:

A.	Reddish sandy clay soil	5 feet.
J.	Yellowish sandy clay	8 feet.
K.	Gray sand, with interstratified crusts of ferruginated shale, to bed of branch	5 feet.

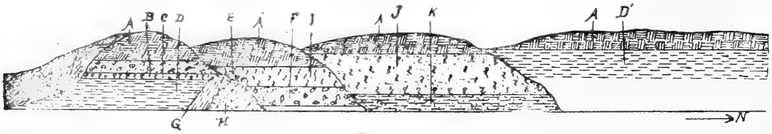


Fig. 21.

SECTION AT SULPHUR SPRING, RUSK COUNTY.

A.	Reddish soil	5 feet.
B.	Pebbles, drift	2 feet.
C.	Clay	1 foot.
D.	Micaceous sandy shale (lignitic series).	
E.	Conglomerate bowlders.	
G.	Fault in sandy shale.	
H.	Hard gray sand.	

I.	Clay	4 feet.
F.	Pebbles	4 feet.
J.	Yellow sandy clay	8 feet.
K.	Hard gray sand, with crusts of ferruginous shale, to bed of creek	5 feet.
D′.	Lignitic micaceous sandy shale to bed of branch near church or school house	5 feet.

On the hillside, and in the bed of a small branch tributary to the East Fork of Shawnee Creek, one-fourth to one-half mile south of L. D. Stephens' house, was noted the following section:

1.	Sandy soil on summit of ridge	2 feet.
2.	Fragments of iron sandstone and buff crumbly iron ore on the hillside.	
3.	Fossiliferous altered greensand marl, Eocene?	10 feet.

At this place a new set of deposits appears to come in. A continuation of the section shows:

4.	Slightly altered greensand shell marl	20 feet.
5.	Iron sandstone conglomerate derived from summit bed, and recemented with iron pebbles from the pebble conglomerate during the deposition of the shell marl	18 inches.
6.	Hard stratum of iron sandstone	6 inches.
7.	Loosely aggregated crusty iron (irregular laminæ)	6 inches.
8.	Altered greensand marl	10 feet.
9.	Iron sandstone crust	3 inches.
10.	Shaly iron crust	3 inches.
11.	Green marly clay with pyrite	2 feet.
12.	Dark greensand marl without pyrite	6 feet.
13.	Indurated glauconitic clay	6 inches.
14.	Very dark greensand marl to sand in bottom of the valley	3 feet.

About thirteen miles west of Henderson, or three miles across the line of Cherokee County, and one and one-half miles northward from Grissom's gin house, in a little gully was noted the following local stratification:

1.	Soft iron conglomerate of argillaceous pebbles, no definite bed.	
2.	Ferruginated orange sand with stem holes. (In breaking one piece the gossamer-like remains of the cellular tissue of a stem were observed.)	12 inches.
3.	Orange sandy loam, with casts of *Cardita planicosta* and *Turritella*, sp. ind.,	6 inches.
4.	Argillaceous shale and iron sandstone crust, interstratified	3 inches.
5.	Soft ferruginated sandstone	12 inches.
6.	Shaly micaceous iron sand and clay, interstratified	12 inches.
7.	Stratified micaceous iron sandstone	3 inches.
8.	Red sandy clay and crusty iron shale	12 inches.
9.	Micaceous iron sandstone	2 inches.
10.	Micaceous iron sandstone with green stain	1½ inches.
11.	Argillaceous iron sandstone	3 inches.
12.	Mottled, red and gray clay to bottom of gully.	

About one-fourth of a mile northwest of Henderson, on the Belleview road, is the following section:

1.	Gray sandy soil	18 inches.
2.	Fragments and bowlders of iron sandstone	1 foot.
3.	Orange sand, upper bed, about	15 feet.
4.	Orange sandy loam	5 feet.
5.	Gray sandy soil or clay drift in road bed	6 feet.
6.	Lower bed of orange sand, changing at base to orange loam	10 feet.
7.	Gray plastic clay to bed of stream	15 feet.

RELATION OF STRATA.

In the northeastern portion of this county, the relation is similar (being a continuation) to the section in northwestern Panola, from No. 1 to the lignite, No. 18, the wavy laminated and buff crumbly iron ore excepted, as noted in the description of that locality. These, if ever deposited, were eroded before the deposition of the iron sandstone and the overlying iron pebble conglomerate.

In the central portion of the county, as at Millville, the sand underlying the iron series becomes distinctly typical orange sand in the upper part of the bed, but somewhat loamy at base, where it rests upon red clay. The absence of fossils in the base, middle, and upper part of the bed indicates that it was local drift in agitated water. The Eocene fossils, *Cardita planicosta*, etc., in the thin overlying stratum of iron sandstone two and one-quarter inches, indicate a period of more quiet water.

In the southern part of the county the sand bed is replaced by orange loam, which is fossiliferous, containing Eocene fossils only in the upper portion at and near the line of contact with the overlying buff crumbly iron ore.

The parting of recemented angular fragments of iron sandstone and iron pebbles derived from the summit capping of the ridges, now found between the layers of greensand marl in Stevens Branch, near Sulphur Spring, is confirmatory evidence of the greensand marl having been deposited after the deposition of the iron ore which caps the ridges.

The fault in the lignitic micaceous sandy shale at Sulphur Spring indicates that the disturbance which produced it was of course after its deposition.

The tumbled bowlders of iron pebble conglomerate near by, as well as the disturbed fossiliferous orange loam in front of L. D. Stevens' residence, indicate that the disturbance was after the deposition of the iron ore.

In the upper exposure of the greensand marl, on Stevens Branch, near Sulphur Spring, are pressure cracks, having the direction east 10° to 15° north, and west 10° to 15° south. There is no reason to doubt that these were made at the time of the disturbance, as they are within half a mile of it. If we accept the Miocene hypothesis of the calcareous greensand shell marl, the disturbance must have occurred after the deposition of the Miocene strata, or at least a portion of it.

The direction of the pressure cracks in the marl, the direction of the pressure cracks in the lignite in the western portion of Shelby County, and faulting disturbance at Grand Bluff, on the Sabine River, are nearly if not quite in parallel lines, and not many miles apart. The inference may fairly be drawn that they were closely connected phenomena and belong to the same time.

This inference becomes more important in consideration of the probability that the Eocene epoch ended with the formation of the iron pebble conglomerate which now caps or has capped the hills and ridges of highest elevation, and that a period of grand erosion, accompanied with a land elevation or sea subsidence, intervened between the formation of the iron pebble conglomerate and the estuary deposition of the calcareous greensand shell marl.

The writer is indebted to Dr. W. D. Holleman and Esquire L. D. Stevens for courtesies received during several trips in this region.

CHAPTER X.

NACOGDOCHES COUNTY.

BY JOSEPH B. WALKER.

The area of this county is 974 square miles, lying between north latitude 31° 15′—31° 50′ and west longitude 94° 20′—94° 55′.

It was one of the original municipalities, and became a county under the same name in 1837.

ACREAGE.—The number of acres is 623,360. The number of acres in cultivation for field crops is 61,382, or 9.84 per cent. Acres in fruit and garden, 1455.*

DRAINAGE.

This county is watered and drained by the Attoyac Bayou (forming the eastern boundary) and its tributaries on the western side: Golondrina Creek; Naconiche Bayou and its forks Wandes Bayou and Caney Creek; Guajalate Creek; Terrapin Creek; Arroya Amaladero; and Sandy Creek. On the north by Beech Creek, East Pen Creek, West Pen Creek, Bills Creek, tributaries of Shawnee Creek, which is itself a tributary of the East Fork of the Angelina River. On the west and south by the Angelina River, forming the western and southern boundaries. Its eastern and northern tributaries from these boundaries are: Shawnee Creek and its southern fork, Indian Creek; Rusk's Creek; Bayou Loco; Little Loco; Bayou Moral and its fork Bayou Alaza; Lamana Bayou; Dorr's Creek; Bayou Carrizo and its forks Puentemia Creek, White Oak Creek, Red Creek; Arroyo Visitador and its fork Aguzitas Creek; La Vacca Creek; and Durazno Bayou.

The Attoyac Bayou, at the southeastern extremity of this county, empties into the Angelina River, which, after making the boundary between San Augustine and Angelina counties, passes through the northwestern portion of Jasper County and empties into the Neches River, which empties into Sabine Lake, and the lake, by Sabine Pass, into the Gulf of Mexico.

SURFACE.

The highest elevations are in the northwestern and eastern portions of the county, and were originally part of the elevated Tertiary plain, but now eroded into ridges. The remaining portion of the county is mainly broken and rolling upland, except the valleys along the streams.

* Commissioner of Agriculture Report of 1888–89.

SOILS.

The soil on the high ridges is sandy. On the sides of the ridges it is a ferruginous loam mixed with sand. The upland soil is frequently covered with extensive stretches of gray sand, having often a depth of four or five feet. The underlying stratum is usually red or orange sandy clay. The valley soil is a fertile sandy loam.

CLAYS.

This county has extensive deposits of clay suitable for making bricks and tiles.

Within two miles of the town of Garrison is a brick yard, where, in addition to building brick from the ordinary clay, is made a semi-vitrified cistern and paving brick of excellent quality, from the gray clay of the lignitic series.

On the Houston East and West Texas Railway, about a quarter of a mile north of Fitze Station, in the railway cut, is an exposure of a bed of sandy clay shale ten feet thick. (See section under Stratigraphy.)

A similar exposure was seen in the railway cut about an eighth of a mile southwest of Fitze Station, overlaid by five and one-half feet of yellow sandy clay, and this in turn overlaid by two feet of soil derived from the mottled red and gray clay. (See section under Stratigraphy.) The same bed, eight feet thick, was seen in a railway cut on the same road, two and one-half miles northeast of Garrison.

On the southern edge of the town of Nacogdoches, on the road to Melrose, was seen a drift section containing a bed of ferruginous sandy clay about five feet thick, overlaid by sandy ferruginous soil three feet, and underlaid by one foot of iron pebble drift, under which is an irregular bed of bluish clay one foot thick; under this is irregular drift and cross-bedded sand. (See section under Stratigraphy.)

Across the little stream is a brick yard, making a fair quality of brick, used mainly for building in the town of Nacogdoches. The material is taken from a bed of sandy clay corresponding with the five-foot bed of above section.

Going up the hill beyond the brick kiln, on the plateau half a mile southeast, was seen a bed of mottled sandy clay, overlying a five-foot bed of white sand, with interstratified ferruginated streaks.

In the same road, four miles northwest of Melrose, at Simpson's Hill, was seen a bed of red clay sixty feet thick.

At Aaron's Hill, just west of the town of Nacogdoches, on the Douglass road, is a bed of mottled clay six feet in thickness, underlying two feet of soil sand.

A bed of red clay, giving an exposure about one mile in length, was observed in the same road, five to six miles west of the town of Nacogdoches.

About eight and a quarter miles west of the town, in the same road, was seen a bed of stratified clay several feet thick, overlaid by iron sandstone and remnants of iron conglomerate. Under the clay is a bed of hardpan grayish sandy clay, which rests upon mottled red and yellow sandy clay.

About eight miles southwest of Nacogdoches, in the old San Antonio road, there is a considerable bed of red clay, from which projects a stratum of calcareous ferruginated shell rock. This clay bed is an extension of that seen at Simpson's Hill.

SILICEOUS LIMESTONE.

On a tract of land adjoining W. J. Peterson's on the north, near Fitze Station, there is an exposure of this rock, close to which was observed some of the upper shaly strata of the lignitic series. Other exposures of this limestone were seen in the railway cut about two and a half miles northeast of Garrison. A few scattered nodules of the material were observed on the hillsides near Cherino.

LIGNITE.

Except a streak of asphaltic clay near Fitze, no exposures of the lignite bed were seen in traveling through this county, but it probably exists in the eastern portion, forming an irregularly serrated line southward. In passing from the office of the Lubricating Oil Company to Cherino, on the north side of the road between a saw mill and the latter, is a well recently dug on a ridge, which, judging from the dump, had penetrated the lignitic shales.

MINERAL WATER.

Within the limits of the town of Garrison is a spring which is frequented by persons who believe they derive benefit from the use of the water.

The property has been recently improved by excavating about seven and one-half feet and building a circular wall about three feet in diameter, capped with a heading of hydraulic cement. Over this is an octagonal pavilion of wood, about thirty feet in diameter. A company has been formed with a project for building a $5000 hotel, with half the capital subscribed in the town. The water is from the main water bearing sand, which overlies the lignite.

The water belongs to the chalybeate class, and judging from its taste apparently contains iron, magnesia, alumina, carbonic acid, and perhaps a little free sulphuric acid derived from the decomposition of iron disulphide (pyrites).

Sulphur Water.—There is fine sulphur water fourteen and one-half miles southeast of the town of Nacogdoches. The property has been improved by

OIL WELL, NACOGDOCHES COUNTY.

the building of a pavilion and a wall of masonry around the spring to form a catch basin. It has been a place of resort by persons of the vicinity. Visitors formerly came in wagons with their families and camped out for several days. There is quite a little settlement (Oil City) located on the property, the houses having been built for the accommodation of the work people employed by the Petroleum Prospecting Company. The peculiarity of this spring is that when the sediment is stirred bubbles of red-brown oil will rise, spread on the surface of the water, and flow off at the spout of the spring. This fact it is believed led to the discovery of the oil of this region.

MINERAL OIL.

The oil bearing sulphur water spring above described is located on one of the two tracts of land owned and operated by the Petroleum Prospecting Company. The water with traces of oil flows into the little stream adjacent known as Oil Spring Branch, a tributary of Bayou Visitador. In the valley of the stream are the present oil bearing wells, some thirty in number.

From Mr. B. F. Hitchcock, the manager in charge, the following particulars were obtained: "The Petroleum Prospecting Company was organized in 1887. Since then forty wells have been drilled, about thirty of which are oil bearing. In drilling they get oil between seventy and one hundred feet. The wells have been drilled generally to a depth of one hundred feet. The plant consists of the office in the spring lot; a storage house containing four wooden tanks of two hundred and fifty barrels capacity each, set up; four wooden tanks of the same capacity not set up; two iron tanks of a capacity of one thousand barrels each, now full of oil; one engine house, with stationary engine; one pipe line three inches in diameter, fourteen and one-half miles long, leading to an iron shipping tank having a capacity of two thousand barrels, located on Aaron's Hill, on the west side of the town of Nacogdoches; several large well derricks, and portable engines for drilling."

The object of the stationary engine was to heat the oil by means of coils in the iron tanks, with the view of rendering it temporarily lighter and more fluid, in order that the heavier siliceous matter mechanically suspended might be deposited in the bottoms of the tanks. Another object in view in locating the stationary engine was the pumping of the oil through the pipe line to the shipping point at Nacogdoches, but up to this date no oil has been pumped through the line, and no oil has been shipped from the wells for the past two years. The company at present is only bailing out the wells semi-weekly and storing the oil.

In the valley of Bayou Visitador, about three or four miles northeast of the oil spring property, is the plant and property of the Lubricating Oil

Company. The plant of this company consists of a receiving or "dump" tank; five storage tanks; one iron evaporating pan three by twenty feet, with steam chest underneath; steam filter pump; boiler house, with portable boiler and engine; one iron shipping tank; stock of iron drums for shipping and return; portable derricks and portable engines for drilling; manager's office and dwelling; stables and outhouses; store house, with stock of piping, fittings, and well tools.

Several wells were drilled on this property before it came into possession of the present company, and about twenty-five since.

The method of operation consists in bailing the water and oil semi-weekly from each oil bearing well by means of a cylindrical galvanized iron bored well bucket ten to fifteen feet in length, a little less in diameter than the bore of the well, with a dart valve in the bottom. The water and oil are discharged into a separating barrel (by allowing the dart valve to strike the bottom of the barrel), which is provided with two plugs or bungs, one for water, the other for oil. From the separating barrel the oil is drawn into carrying barrels in a wagon, which conveys it to the receiving or dump tank, into which it is emptied. This tank is located on a hillside overlooking the storage house with its tanks, into which the oil runs through an iron pipe by gravitation. From the storage tanks the oil is fed by iron pipes into the iron evaporating pan, provided with a steam chest below, which heats the oil and drives off the remaining water and the small amount of naptha. While still hot the oil is forced by steam through a specially woven filter cloth to remove any particles of grit, and the oil discharged through a pipe into the iron shipping tank, from which it is run off into iron shipping drums provided with wrought iron tires for rolling. The capacity of each drum is about one hundred gallons. They are conveyed by wagon to the town of Nacogdoches for shipment by railway.

The writer is indebted to Mr. H. H Sawyer, formerly of East Hampton, Massachusetts, mining engineer, now postmaster at Nacogdoches, and general manager of the Lubricating Oil Company, for courtesies and the following facts in reference to the history of the oil industry in this county: "The first authentic prospecting for oil in this region was by Emory Starr, now of Maysland, and Peyton F. Edwards, now of El Paso. About twenty years ago they visited what is now known as the Oil Spring, fifteen miles southeast of the town of Nacogdoches, while on a hunting excursion. They dug a few holes with spades in the sandy soil on the margin of Oil Spring Branch, and left them during the night. On returning next day they found that oil and water had collected in the holes while they were absent. Some of this oil was secured and brought to the town of Nacogdoches, where it was tested on shoe leather, harness, and for other domestic purposes.

"Subsequently John F. Carlee, now of the State Geological Survey of Pennsylvania, operating for himself and others, drilled a well four miles northeast of Oil Spring, on Caney Creek, Skillern tract; also one on the land now belonging to Dr. Leak, one mile west of the village of Melrose. They found but little oil in the first well, and not reaching oil in the second at a depth of eighty feet, the work was abandoned, probably from want of capital.

"The next work was done by B. F. Hitchcock, now manager of the Petroleum Prospecting Company. He succeeded in interesting E. H Farrar, of New Orleans, in the enterprise. Mr. Farrar organized a company. with capital stock fixed at $100,000, for the purpose of drilling wells at Oil Spring, sending to Pennsylvania for expert drillers and machinery. The management of the company in the field was placed in the hands of J. E. Pierce, of New Orleans. The first well, eight-inch casing, found oil at about seventy feet, the drilling being entirely in sand and apparently drift. It was a flowing well, and the first day some two hundred fifty or three hundred barrels of oil went to waste before it was brought under control and capped. It ceased to be a flowing well after the first day. Subsequently the oil was pumped into tanks. This company continued drilling wells, with some intermission, until the spring of 1889, since which time they have been bailing oil, say twice a week, from some of the wells and storing it in tanks.

"Five different companies have at different times been organized and operated for oil well boring since 1887, the total number of wells drilled up to date being about ninety. Of these companies the Petroleum Prospecting Company and the Lubricating Oil Company alone remain in the field. The Lubricating Oil Company is making a business of bailing, preparing, and marketing oil. Forty wells have been drilled on this property, and twenty of these are now oil bearing."

The receptacle of mineral oil is apparently accidental, the oil having been reported from nearly all geological periods from the Lower Silurian up, including limestones, sandstones, shales, and sands. The transporting agency was water, and with the water it was often collected in caverns as reservoirs, or absorbed by any porous material with which it came in contact. From these receptacles it either exudes and floats as a film on ponds, lakes, and streams, or flows from fissures as springs, or from bored wells.

If an oil bearing cavity or porous stratum be penetrated by a well boring the first product would be gas, the next oil, and finally water.

In the Tertiary lignitic regions of Texas the conditions of vegetation, decomposition, and retention have been of the latter character. The formation, consisting of interstratified beds of clay and sand, has offered no opportunity for any extensive caverns, and whatever oil is now found absorbed has been transported until it met with a retentive absorbent, such as the greensand marl in the valleys of the lower part of Nacogdoches County, which is overlaid by only a light covering of detritus from the adjacent hillsides. When no such absorbent lay in the course of the oil it was carried by the rivers to the sea. Ex Governor O. M. Roberts' "Description of Texas" calls attention to floating oil on the Gulf of Mexico near Sabine Pass, the natural outlet of this region.

The origin of this oil appears to have been in the lignite bed, for similar oil may now be seen exuding in small quantity from the lignite and floating as film on adjacent ponds and streams. The writer is of the opinion that it has been produced by the gradual decomposition of vegetable matter alone. This seems to be supported by the fact that no animal fossils were observed in immediate association with the lignite bed. No doubt that the decomposition of animal remains have in other formations contributed their quota of oil, as claimed by Dufrenoy (Min., iv, 602, 1859), J. S. Newberry (Ohio Agric. Rep., 1859), and T. Sterry Hunt (Can. Nat., vi, 241, 1861; Amer. Jour. Sci., ii, xxxv; Chem. News, 1863).

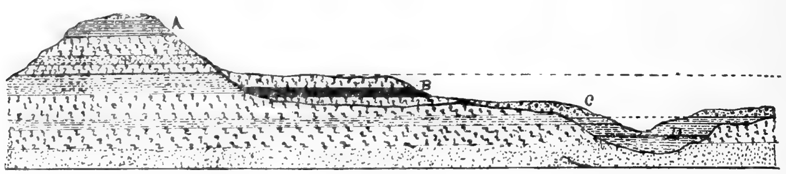


Fig. 22.

IDEAL SECTION OF OIL BEARING REGION IN NACOGDOCHES COUNTY.

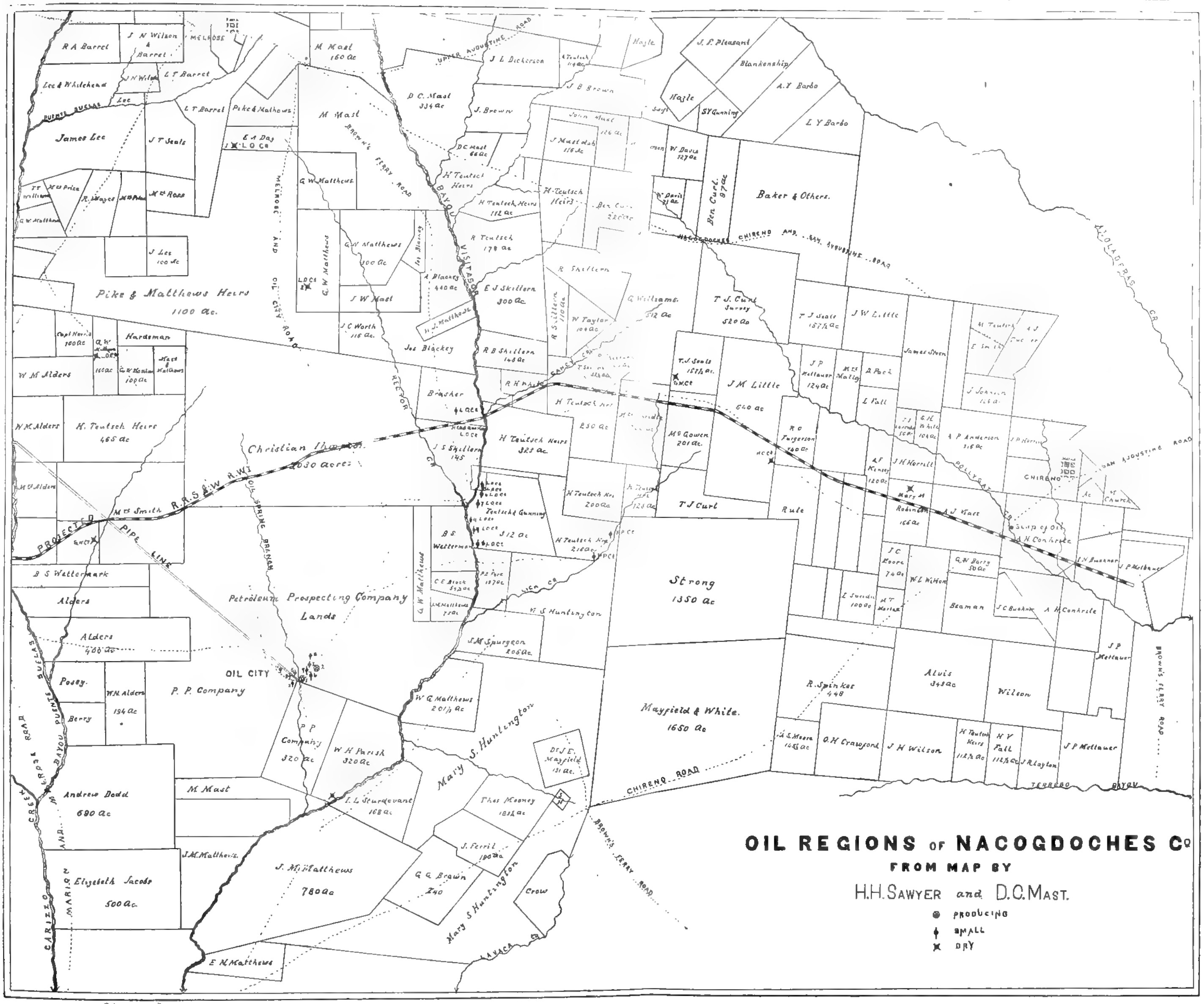
a, Iron ore hill. b, Lignite bed. c, Detritus. d, Oil bearing greensand marl.

The oil is of brown color, similar to oil of tar, and contains a mixture of several liquid parafins. It has been exposed and transported some distance from its source by the agency of water, which will account for the loss of nearly all the naptha and probably all solid paraffins.

Both liquid and solid paraffins are produced by the oxidation and distillation of organic matter, such as wood, brown coal, peat, bituminous coal, bituminous shale, fatty oils, resin, and animal matter. Richenbach, in 1830, discovered in wood tar a mixture of the paraffin series, and on account of its little affinity for other substances he gave the solid members the name (from *parum* and *affinis*). By fractional distillation he obtained a mixture of the liquid members, which he named *eupion*.

Most carbon compounds yield some member or a mixture of the members of the paraffin series when heated with an excess of hydriodic acid. (Berthelot, Ann. Chem. Phys. (4), xx, 392.) Cast iron when dissolved in acid produces a hydrocarbon containing paraffins. (Cloez, Compt. Rend., lxxxv, 1003.)

Pennsylvania mineral oil consists mainly of the normal paraffins with a


OIL REGIONS OF NACOGDOCHES Co
FROM MAP BY
H.H. SAWYER and D.C. MAST.
PRODUCING
SMALL
DRY
OIL CITY
CHIRENO
Pike & Matthews Heirs
1100 Ac.
Christian Ihompson
2030 acres
Petroleum Prospecting Company
Lands
P. P. Company
Strong
1350 Ac
Mayfield & White.
1650 Ac
Andrew Dodd
690 Ac
Elizabeth Jacobs
500 Ac
J. M. Matthews
780 Ac
Mary S. Huntington
Baker & Others.
James Lee
H. Teutsch Heirs
465 Ac
CHIRENO ROAD
BROWN'S FERRY ROAD
SAN AUGUSTINE ROAD
UPPER AUGUSTINE ROAD
PROJECTED PIPE LINE
OIL CITY ROAD
MELROSE AND
Alvis
Wilson
J H Wilson
O H Crawford
J P Mettauer
R. Spinks

small mixture of other hydrocarbons, which are not yet definitely determined. (Schorlemmer, Phil. Trans., 1871, vol. clxii, part 1, p. 111; Chem. Soc. Jour., 2, viii, 216; Warren, Silliman's Am. Jour., xi, 89, 216; Pelouze and Cahours, Compt. Rend., liv, 1241; Ann. Chem. Phys. (4), i, 5; Ann. Chem. Pharm., cxxiv, 289; cxxvii, 190; cxxix, 87.)

The solid members of the series are sometimes found as minerals in regions of brown coal and bituminous shale, and are known under the name of ozocerite, hatchettite, mineral tallow, and mineral wax.

The tarry product from distillation of such shale, brown coal, and peat has been used as a source of naptha, illuminating oil, lubricating oil, and solid paraffin.

Some years ago, when visiting the abandoned plant of the Cannel Coal and Oil Company, at Cloverport, Kentucky, the writer saw a large quantity of solid paraffin in the residuum of oil which had been left for a few years in the large cast iron retorts. Schorlemmer (Chem. Soc. Jour., xv, 419, 1862) has shown that the paraffins produced by the distillation of cannel coal are similar to those of other mineral oils.

Under direction of Dr. Edgar Everhart, Professor of Chemistry, University of Texas, Mr. P. H. Fitzhugh submitted this oil from Nacogdoches to some tests in the laboratory. (Bulletin No. 4.) The following facts were reported: "The oil has a brownish red color. The odor is peculiar, but not so offensive as the crude petroleum of Pennsylvania. At ordinary temperature the oil is mobile, but not so much so as ordinary petroleum. Submitted to extreme cold the oil still retains its liquidity, but naturally becomes less mobile. The temperature of the oil was reduced to less than zero (Fahrenheit) without losing its flowing qualities. At no temperature attainable in the laboratory by artificial means could any solid paraffin be separated. The oil does not gum on exposure to the air. It is not adapted to the production of illuminating oil; its value consists in its use as a lubricant. About four pounds of oil was subjected to distillation over the naked flame in a retort connected with proper condensers. The temperature was carried up to 680° F. At intervals of 45° each distillate was removed and its weight determined. The results of the distillation were as follows:

1.	Below 300° F. the distillate amounted to	0.04 per cent.
2.	300° to 345° F. the distillate amounted to	0.37 per cent.
3.	345° to 390° F. the distillate amounted to	1.38 per cent.
4.	390° to 435° F. the distillate amounted to	2.09 per cent.
5.	435° to 480° F. the distillate amounted to	3.14 per cent.
6	480° to 525° F. the distillate amounted to	6.25 per cent.
7.	525° to 615° F. the distillate amounted to	7.07 per cent.
8.	615° to 680° F. the distillate amounted to	5.63 per cent.
	Remaining in the retort	74.03 per cent.

"A consideration of the above figures shows in the first place that the crude petroleum of Nacogdoches is practically free from naptha, which distills off below 250° F. Four pounds of this oil carried to a temperature fifty degrees higher yielded only a few drops of a light oil, amounting to 0.04 per cent of the total amount taken. In the Pennsylvania crude petroleum the illuminating oil comes off between 250° and 500° F., and it on an average amounts to about fifty-five per cent. The Nacogdoches petroleum between the same degrees of temperature yields only a little over seven per cent. Three-fourths of the oil does not boil until a temperature above the boiling point of mercury is reached. Above 400° F. and even lower the distillate is not pure white, but is somewhat colored. This color deepens on exposure to to the atmosphere. The distillate exhibits a beautiful fluorescence. Attempts were made to render the distillates colorless by refining them with oil of vitriol, etc., as is done with the ordinary petroleum, but the results obtained were not satisfactory. Some of the crude oil was subjected to distillation until but a small residue was left in the retort. This residue had the consistency of thick pitch, and was of black color.

"The density of the petroleum at 62.6° F., is 0.9179, compared with water as unity. The density of Pennsylvania petroleum is usually about 0.794–0.840. The coefficient of cubical expansion, as determined by Mr. Fitzhugh, is 0.02568. Its weight, its high boiling point, its non-solidification by cold, and its property of not gumming make it a splendid lubricating material. The practical tests that have been applied to it confirm this opinion."

GREENSAND MARLS.

In the bed of the road from Nacogdoches to Melrose, about four miles northwest of the latter, is an exposure of five feet of *indurated* greensand shell marl, under which is four feet of *very friable* greensand shell marl. Under this is a shaly marl two feet, with a middle parting of very hard indurated green clay, two inches. Underlying this is a bed of altered greensand marl, three feet.

On Aaron's Hill, just west of the town of Nacogdoches, is an exposure of greensand shell marl twenty feet thick. A lower portion of the same bed is exposed at the crossing of Bayou Lamana, in the same road, on the west side of the town of Nacogdoches.

In the road bed on the hill just south of the brick yard, in the southern limits of the town of Nacogdoches, is an exposure of several feet of greensand marl with fossil casts. (See Fig. 24.) South of Melrose, in the oil regions along the valley of Bayou Visitador and its tributaries, is a large deposit of oil bearing greensand marl. (See Map of the Oil Regions.)

At the falls on the headwaters of Caney Branch, about one mile northeast of the office of the Lubricating Oil Company, is an exposure of twenty-four feet of greensand shell marl, the upper layers of which are oil bearing. (See Fig. 25, under Stratigraphy.)

On the Day farm, now the property of the Lubricating Oil Company, is oil well No. 1, bored to a total depth of two hundred and fifty four feet. The record of this well shows a surface drift of nine feet of red clayey earth, under which is a bed in two layers of one hundred and eight feet of greensand marl, of which the upper layer consists of fifty-nine feet of *light bluish* greensand shell marl, and under this is the second layer (in contact) of forty-nine feet of *dark bluish* greensand shell marl. At a depth of two hundred and nine feet another bed of dark bluish greensand shell marl twenty-nine feet was drilled.

About eight miles southwest of Nacogdoches, in the old San Antonio road, is an exposure of calcareous shell rock, indurated by ferruginous infiltration. The bed is about two feet thick and similar to the upper stratum seen at Simpson's Hill, four miles northwest of Melrose, and was deposited at the same time.

About one-third of a mile east of the office of the Lubricating Oil Company is an exposure of the upper stratum of shell rock overlying the greensand marl and containing small white shells of *Cardita*, sp. ind., *Ostrea sellæformis*, etc.

About one mile southwest of the town of Cherino, at Fall's old saw mill on Polesoto Creek, is an exposure of about sixteen and one-half feet of greensand marl, consisting of altered greensand, ten feet; shell rock, two feet; indurated green sandy clay, two feet; oil bearing greensand marl, twenty inches, and shell rock, ten inches to water-line of the creek.

ANALYSES OF GREENSAND MARLS.

No.	Silica.	Protoxide of Iron.	Sesquioxide of Iron.	Alumina.	Lime.	Magnesia.	Soda.	Potash.	Sulphur Trioxide.	Phosphoric Acid.	Loss by Igniiton.
688†	30.50	24.47	4.93	14.49	2.31	3.66	Trace.	2.05	.31	41	17.00
689*	32.00	54.60			5.18	6.22	Trace.	Trace.	.78	.83	.....
690*	20.10	[a] 1.55 [l] 5.90	32.34	9.86	11.20	Trace.	2.66	1.90	.37	.75	13.50
691*	.....	....	.....	.....	.....	......	4.89	.66	.....	Trace.	.....
692†	15.30	24.40	17.14	12.26	6.30	4.32	[c] 5.10		[b] 11.20 Trace.	.29	5.70
693*	.....	[a] 1.85	.....	.....	.....	......	4.45	.76	.. ..	.32	.....
694*	15.30	[l] 17.60	18.75	6.85	24.25	.82	2.83	Trace.	.13	.19	12.01
695*	.....	....	....	.....	.....	.. .. ..	2.96	.76	..	Trace.	.....
696†	33.45	20.39	5.36	15.69	1.65	5.05	1.14	2.05	.74	Trace.	14.55
697†	34.10	14.58	2.06	14.94	8.28	3.68	2.03	.68	55	Trace.	19.00
698†	47.10	4 66	21.43	2.60	6.83	2.81	3.52	2.62	.69	Trace.	7 90

Analyses by * J. H. Herndon; † L. E. Magnenat.
a Manganese. *b* Carbonic acid. *c* As chlorides.

Localities.

No. 688. One-fourth mile southeast of Nacogdoches, Nacogdoches County.

No. 689. Roasted sample, one-fourth mile southeast of Nacodoches.

No. 690. Altered calcareous greensand marl, Simpson's Hill, four miles northwest of Melrose.

No. 691. Roasted sample, altered calcareous greensand marl, Simpson's Hill, four miles northwest of Melrose.

No. 692. Indurated calcareous greensand marl two inches, Simpson's Hill, four miles northwest of Melrose.

No. 693. Roasted sample, indurated calcareous greensand marl, Simpson's Hill, four miles northwest of Melrose.

No. 694. Altered calcareous greensand marl two feet, eight miles southwest Nacogdoches.

No. 695. Roasted sample, altered calcareous greensand marl two feet, eight miles southwest of Nacogdoches.

No. 696. Oil bearing greensand marl, fifteen miles southeast of Nacogdoches.

No. 697. Oil bearing greensand marl, one mile southwest of Cherino, twenty-inch bed.

No. 698. Calcareous greensand marl one mile southwest of Cherino.

TIMBER.

The total area of this county is 623,360 acres. If from this amount be subtracted 62,837* acres in field, fruit, and garden cultivation, and from the remaining 560,523 be deducted 70,065 acres for town sites, barrens, and streams, and from the remainder, 490,458, be deducted 61,307 acres for timber already cut and in process of cutting by the fifteen sawmills, then the final remaining 429,151 acres will approximately represent the area of standing timber, of which one-fourth, or 107,288 acres, is suitable for lumber, and the remaining 321,863 acres of standing timber if cut into cord wood would probably average thirty-seven and a half cords per acre.

The most abundant timber trees are three species of the pine family, which stand in the following order with reference to number: Old field, short leaf, *Pinus mitis;* bottom loblolly, short leaf, *Pinus tæda;* and long leaf yellow pine, *Pinus australis*, M., or *Pinus palustris*, L. The long leaf pine exists in small areas or patches in the southern part of the county.

The *cupuliferæ*, or oak family, is represented by blackjack, *Quercus nigra;* post oak, *Quercus obtusiloba;* swamp Spanish or pin oak, *Quercus palustris;* white oak, *Quercus alba;* Spanish oak, *Quercus falcata;* chinquapin, *Castanea pumila;* beech *Fagus feruginea;* and horn beam or iron wood, *Caprinus Caroliniana.*

The *juglandaceæ*, or walnut family, by black walnut, *Juglans nigra;* and white hickory, *Carya tomentosa.* The *rutaceæ*, or rue family, by prickly ash, or tooth ache tree, *Zanthoxylum Carolinanum.* The *cornaceæ*, or dogwood

*Commissioner of Agriculture Report, 1888–89.

family, by dogwood, *Cornus Florida;* and black gum, *Nyssa multiflora.* The *ulmaceæ,* or elm family, by white elm, *Ulmus Americana.* The *salicaceæ,* or willow family, by swamp willow, *Salix nigra;* and gray willow, *Salix tristis.*

IRON ORES.

On the W. J. Peterson tract, Castro headright, near Fitze Station, on the Houston East and West Texas Railway, was seen on the top of the ridge a remnant of the iron ore deposit, consisting of broken strata *in situ* and detached fragments of iron sandstone which had been tumbled. In this locality the only remains of the overlying bed of iron pebble conglomerate consist of a limited number of scattered siliceous iron pebbles. The wavy laminated, buff crumbly, and small nodular or geode iron ore have no visible representatives.

On the ridge west of the station a similar condition exists.

About two hundred yards north of the station is a new modification of large nodular or iron sandstone geode ore. Here this material exists in almost a continuous local bed, consisting of very long geodes, some of them twenty feet or more in length by three feet in width, and about eighteen inches in thickness. The structure is represented by lenticular layers, more or less argillaceous, the outer layers frequently sandy and the nuclei yellow sand.

About six miles southeast of the town of Nacogdoches the remnant of the iron ore deposit is represented by fragments of iron sandstone two inches thick, and fossiliferous orange loam, from which was taken a specimen containing a cast of a large shell, *Cardita planicosta.* It is probable from the amount of iron present that the wavy laminated, or at least the buff crumbly, iron ore existed locally, but is now disintegrated and forms the red soil of the drift.

In a gully on the roadside adjacent was seen a considerable number of what appeared to have been very large nodules or geodes. They now form a part of the bed of the gully, the upper portion of the geodes being worn away by the water.

At Simpson's Hill, four miles northwest of Melrose, the large deposit of of deep red clay indicates the former presence of iron ore. One fragment of iron pebble conglomerate was seen. A few miles north of this locality, on same ridge apparently, was seen a portion of a bed of this material.

About eight and one-fourth miles west of Nacogdoches, on the Douglass road, the summit of the ridge has a stratum of iron pebble conglomerate two and one-half feet thick. On the same ridge were observed detached iron pebbles and iron gravel, some of which are magnetic, and a sample was collected by means of a magnet.

Twelve miles west of Nacogdoches, on the same road. were seen on both sides of the road iron pebble conglomerate bowlders, two to three feet long by two to two and one-half feet thick.

Thirteen miles west of town, on the same road, is a remnant of the bed of iron sandstone, protruding through the soil. The upper stratum is firm, but the under stratum is water-worn, being of much softer material, showing the process of disintegration during erosion.

On the old San Antonio road, thirteen miles from the town of Nacogdoches, was seen a bed of conglomerate, consisting of iron pebbles, with adhering white siliceous pebbles, the cement consisting mainly of iron and sand. Underlying the hard iron sandstone is a softer stratum of ferruginated yellow sandstone. From this point to within five miles of town the hilltops are capped with the remnant of the iron ore, consisting of iron pebble conglomerate, partly disintegrated, leaving the iron pebbles scattered in the soil. In some localities fragments of iron sandstone are found, but the thickness is only a few inches.

Near the bridge, nine miles west of Nacogdoches on the Douglass road and near the Looneyville fork of the road, is a narrow neck of iron pebble conglomerate, associated with iron sandstone and yellow loam. The position of this remnant indicates sliding and subsequent covering by drift until the valley erosion of the little stream again exposed it. The bowlders are not horizontal, but more or less tumbled.

About thirteen and a half miles west of the town, in the Looneyville road, is a bed of soft ferruginated sandstone underlying the hard iron sandstone.

About fifteen and a half miles west by north of the town, on the same road, were seen detached pieces of iron sandstone, adhering to the underlying laminated iron ore, associated with fragments of the under bed of buff crumbly iron ore.

About sixteen and a half miles northwest of Nacogdoches, on the Looneyville road, were seen fragments of more compact buff crumbly iron ore. Some of these are slightly altered, and rendered magnetic by forest fires.

At the seventeen-mile post, on the same road, is an open field, in which the soil is covered with a bed of buckshot iron pebbles derived from the disintegration of the iron pebble conglomerate. The quantity of these pebbles is sufficient to be used as a source of ore for a limited time. On the north side of this hill or ridge are fragments of iron sandstone mingled with fragments of buff crumbly iron ore. No bed is now visible, but it may be covered by the drift soil.

About twenty miles northwest of Nacogdoches, on the road from Looneyville to Linn Flat, is a bed of iron sandstone, the under portion of which is amygdaloidal; the small lenticular kernels are orange loam.

On the same road, five miles from Looneyville, on the M. J. Cook tract of land, A. Oliver headright, is a bed of wavy laminated and buff crumbly iron ore. This bed is capped with the usual thin crust, about two inches, of compact iron sandstone. This locality is within the Brewer's Mountain bed, and extends about five miles nearly east and west by two and a half miles north and south, making about fifteen miles in circumference. From the northeast end of Brewer's Mountain can be seen Elkin's Mountain, now called Iron Mountain, in Rusk County, which is seven miles distant and was once in connection as part of the elevated Tertiary plain.

Returning to Nacogdoches by the Indian Creek road, some two miles before its intersection with the Tyler road, or about ten miles northwest from the town of Nacogdoches, was passed the site of an old forge, locally called "foundry," established during the Civil War, and successfully worked for the production of malleable bar iron in 1863–64 by R. W. McLain, and after by McLain and Highter. The quality of this iron was reported to be excellent by a blacksmith who had used it, and who still had a sample of it.

The nearest railway to Brewer's Mountain is the Houston East and West Texas, and the shipping point Nacogdoches. Sterne Station is a few miles nearer, but from this point there is no direct established public road.

ANALYSES OF IRON ORES.

No.	Sesquioxide of Iron.	Silica.	Alumina.	Phosphoric Acid.	Sulphur Trioxide.	Lime.	Magnesia.	Water.	Metallic Iron.	Phosphor's in 100 p'rts Met. Iron.
670 *	60.47	21.80	12.93	......	......	......	......	......	42.31	......
671 *	60.81	19.80	13.19	......	......	......	......	......	42.56	......
672 †	65 79	22.70	......	......	......	......	......	......	46.05	......
673 *	59.56	20.30	11.64	1.27	.01	Trace	Trace.	7.20	41.69	1.33
674 †	48.33	34.90	7.27	Trace.	......	Trace.	......	9.45	33.83	......
699 †	39.45	36.95	13.65	.83	Trace.	1.20	.60	7.00	27.61	1.31

Analysis by * J. H. Herndon; † L. E. Magnenat.

Localities.

No. 670. Conglomerate iron ore, eight and one-fourth miles west of Nacogdoches.

No. 671. Conglomerate iron ore, twelve miles west of Nacogdoches.

No. 672. Conglomerate iron ore, twelve miles southwest of Nacogdoches.

No. 673. Laminated (wavy) iron ore, Brewer's Mountain, seventeen miles northwest of Nacogdoches.

No. 674. Buff crumbly iron ore, Brewer's Mountain, seventeen miles northwest of Nacogdoches.

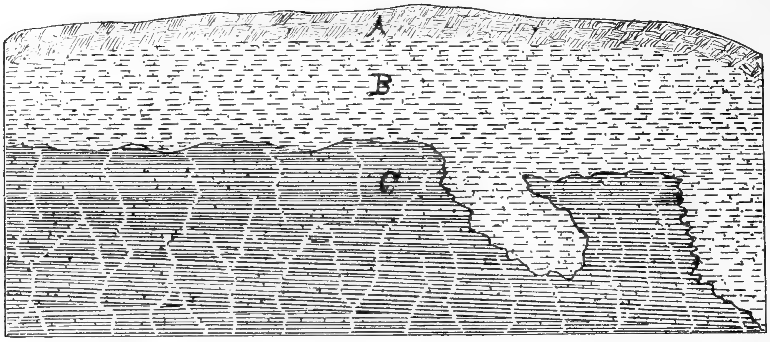
No. 699. Ochreous iron ore, fifteen and one-half miles north by west from Nacogdoches.

NOTES ON THE STRATIGRAPHY OF NACOGDOCHES COUNTY.

About thirteen miles southwest of Timpson and a quarter of a mile north of Fitze Station, on the Houston East and West Texas Railway, in the railway cut, is an exposure showing dislocation in the bed of sandy clay shale.

The flexure has a dip 20° southeast for forty feet, afterward bending and cutting upward through the soil, indicating motion of the surface with a slide and squeeze.

About one-eighth of a mile southwest of Fitze Station, in another railway cut, is a second exposure of the same bed showing irregular water erosion.



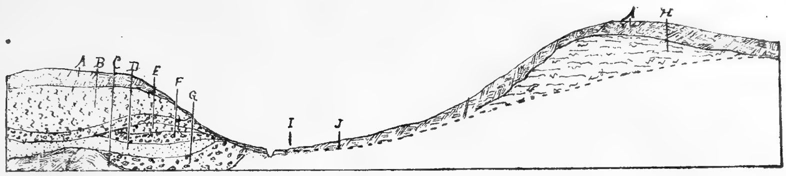
N.E. Fig. 23. S.W.

SECTION ONE-EIGHTH MILE SOUTHWEST OF FITZE STATION, NACOGDOCHES COUNTY.

A.	Soil from mottled clay	2 feet.
B.	Yellow sandy clay	5 feet.
C.	Sandy clay shale to bottom of railway cut	10 feet.

About two hundred yards north of Fitze Station is a stratum of yellow sand ten feet thick, overlying the long ferruginous geodes described under Iron Ores. This interposition of sand is wanting in most localities, but the general inference from this and other localities where it does exist fixes the horizon of the geodes as underlying the sand, which in some localities has become partly indurated to form the soft sandstone before described as underlying the regular iron sandstone.

Going from Nacogdoches to Melrose, within the southern limits of the former place, is an exposure of drift material by the roadside, consisting of soil, ferruginous sandy clay, iron pebbles, clay, and cross-bedded sand. On the opposite hill just beyond the brick yard, across the little stream, is an exposure of greensand marl.



W. Fig. 24. E.

SECTION NEAR BRICK YARD AT NACOGDOCHES.

A.	Sandy red soil	3 feet.
A'.	Sandy soil with altered greensand	3 feet.
B.	Ferruginous sandy clay	5 feet.
C.	Cross-bedded sand	2 feet.
D.	Sand.	
E.	Clay	1 foot.
F.	Drift	18 in.
G.	Drift	3 feet.
H.	Greensand marl with fossiliferous casts	4 feet.
I.	Brickyard.	
J.	Wagon road bed.	

In the same road, about four miles northwest of Melrose, at Simpson's Hill, is an exposure of red clay sixty feet; indurated greensand shell marl five feet, containing shells of *Scutella subrotunda?*, *Cardita*, sp. ind.?, etc.; very friable greensand shell marl four feet; shaly marl, with a two-inch parting of hard glauconitic clay, two feet; altered greensand shell marl three feet.

On the road from Marion to Nacogdoches, eight miles southeast of Nacogdoches, is an exposure of greensand shell marl, probably a continuation of the bed just described.

On Aaron's Hill, just west of the town of Nacogdoches, was observed the following section in the cut made for the public road:

A.	Soil (sandy clay)	2 feet.
B.	Mottled clay	6 feet.
C.	Gray sand	8 feet.
D.	Greensand shell marl	20 feet.
E.	Red clay bottom soil	2 feet.
F.	Greensand shell marl to bed of creek.	

About one-fourth of a mile north of the office of the Lubricating Oil Company was seen a stratum of greensand marl in the bed of a small stream. When the marl was chopped with a hachet the red-brown oil exuded and floated off on the surface of the water. On the hillsides adjacent are remnants of the iron sandstone material.

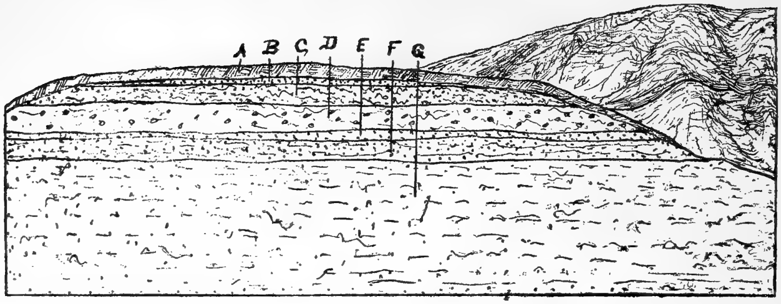


Fig. 25.

OIL BEARING GREENSAND MARL.

A.	Sandy soil.	
B.	Hard greensand	3 to 12 inches.
C.	Soft greensand and trace of oil.	2 feet.
D.	Softer greensand, with grains of glauconite containing nodules of iron sandstone and some globules of oil	3 feet.
E.	Softer greensand shell marl, containing a large percentage of oil	1 to 12 inches.
F.	Close textured glauconitic green clay with less oil	2 feet.
G.	Aluminous fossiliferous greensand marl (no oil)	15 feet.

In the railway cut, on the Houston East and West Texas Railway, two and one-half miles northeast of the town of Garrison, is the following section:

A.	Red sandy clay soil	3 feet.
B.	Yellow gray sandy shale eight feet to bed of road, with parting seam of iron oxide one-half inch, and projecting nodule of siliceous limestone.	

The dip of this section is northeast about 15°, and the beds show a slight flexure.

About one hundred yards northeast of the last locality, in another railway cut, is a section similar to the upper part of the last, but in which the iron seam has been folded and pushed up out of its usual place, nearly cutting in two the upper thirty-inch exposure of yellow gray sandy shale.

About five miles southeast of Nacogdoches, in the Melrose road, was seen dark red clay mixed with nodular masses of orange colored clay.

About six miles southeast of Nacogdoches, on the same road, was seen on the roadside a bed of orange loam, considerably broken and crumbled by extensive erosive agency. There is evidence that at least a portion of this bed is fossiliferous. A specimen of this material was secured which contained a cast of *Cardita planicosta*, diameter about one and one-half inches, with broken casts of several other shells which could not be identified, as only small portions of the casts were visible.

On Simpson's Hill, four miles northwest of Melrose, the sixty feet of red clay is overlaid by five feet of orange loam, and this in turn by twenty feet of red clay to the summit of the hill. In both these localities small fragments of iron sandstone two inches thick are found at intervals. From Simpson's Hill was taken also a small fragment of iron conglomerate.

RELATION OF STRATA.

To avoid repetition, it may be stated that the general section is similar to that described under Panola County from Nos. 1 to 19, with the following exception:

In the southern portion of this county the lignitic boundary seems to have been either an irregular serrated line at some distance from the Angelina River, having the same general course of the stream; or, if the lignitic series was deposited continuously, the material was cut and carried away by erosion, and a newer estuarine deposition, possibly lacustrine in part, took its place. Apparently the newer deposition was afterward covered by drift of sandy clay until again partly exposed by valley erosion.

There are some facts which indicate that the calcareous greensand shell marl was of more recent deposition than the Eocene strata. In the altered greensand of the Siliceous Eocene—i. e. above the lignite bed and its associate series of siliceous limestone, clays, micaceous shales, etc.—the fossil shells of *Cardita planicosta*, *Turritella*, sp. ind., etc., are without exception, so far as the writer observed, only brown ferruginated *casts* in the orange loam, while in the calcareous greensand shell marl of the oil regions along the valley of the Bayou Visitador the *white shells* are themselves intact and tolerably well preserved. The calcareous greensand shell marl was observed between ridges only, while the altered siliceous greensand or orange formation (interior often green) of the Eocene is coeval with the buff crumbly iron ore deposit.

Near the office of the Lubricating Oil Company is an abundance of a bivalve shell of the Cardita type, but only about one-fourth the size of the planicosta found in the Siliceous Eocene. The *Ostrea sellæformis* is also well represented. The *Turritella carinata* exists mostly in fragments. The *Astarte Conradi* and a shell resembling the *Crassatella alta* were tolerably well preserved. In the greensand shell marl at Simpson's Hill, four miles northwest of Melrose, a section of which has been given, was found a scutella similar if not identical with the *Scutella subrotunda*, Lam., which is recognized in Europe as of the Miocene Tertiary.

The writer is aware that these fossils have been figured and described as belonging to the Claiborne group in the Gulf States, and have been assigned to a place or horizon just above the lignitic series in the Eocene epoch, but believes that after closer investigation they will be accepted as part of the Miocene Tertiary.

The depth of the calcareous greensand shell marl is approximately shown by the following section, sectionalized from the boring or drilling of well No. 1, Day farm, now the property of the Lubricating Oil Company, about eighteen miles southeast of Nacogdoches. The section is figured on "Henry W. Sawyer and D. C. Mast's map of oil lands in Nacogdoches."

1.	Derrick flooring timbers	2 feet 10 inches.
2.	Red clayey earth	9 feet.
3.	Bluish green calcareous shell marl	61 feet.
4.	Dark green calcareous shell marl	49 feet.
5.	Dark drab clay	20 feet.
6.	Light drab clay, with iron pyrites	16 feet 6 inches.
7.	Sand and iron pyrites, with "slush oil"	2 feet 6 inches.
8.	Dark drab clay	35 feet.
9.	Calcareous marl with sand streakings	6 feet.
10.	Sandstone	3 feet.
11.	Clay with sand streakings and iron pyrites	7 feet.
12.	Dark bluish green shell marl	29 feet.
13.	Dark drab clay	11 feet.
14.	Marl	3 feet.
	Total depth of well	254 feet 10 inches.

The geographical altitude of the lignitic series, as appears from the dump of a recent well dug for water on a ridge between this locality and Cherino, is above No. 1. and to the bottom of the oil well section, which is far below the usual horizon of the lignitic series, there is no indication of lignite. The inference is either that the Eocene lignite does not exist below the bottom of the oil well, or that there has been an abrupt dip of the strata, which is not sustained by other observations. There are other facts, such as the diotamaceous earth, etc., in Angelina and adjoining counties, which harmonize with the Miocene hypothesis. but the other details are reserved for future description, as they require further investigation.

CHAPTER XI.

CHEROKEE COUNTY.*

BY JOSEPH B. WALKER.

The area of this county is 1008 square miles, lying between north latitude 31° 25′—32° 7′ and west longitude 94° 52′—95° 25′.

ACREAGE.—The number of acres is 645,120. The number of acres in field cultivation in 1888 was 95,197, or 14.75 per cent. Fruit and garden 2335 acres.

DRAINAGE.

This county is watered and drained in the north central portion by the West Fork of the Angelina River and its tributaries; on the southeast by the Angelina River and its western tributaries, Beaver Creek, Mud Creek, Roark's Creek, and their tributary branches. The Neches River forms the western and southern boundary. The tributaries of the Neches within the limits of the county are Owl Creek, Copes Creek, Gum Creek, One Arm Creek, Bull Creek, Bean's Creek, Bowles Creek, Larrison's Creek, Devil's Creek, and their tributary branches.

SURFACE.

The surface of this county consists of elevated plains, ridges, hills, rolling upland, and valleys. The elevated plains form a watershed, dividing the waters of the Angelina River from the waters of the Neches River, and extend from Larissa in a southeasterly direction, including Jacksonville, Rusk, Alto, to the middle of the southeastern boundary of the county.

SOILS.

The soil on the elevated plains and summits of ridges and hills is sandy and easily cultivated.

The hillside soil is marly, mixed with sand from the summit soil and disintegrated aluminous iron ore.

The valley soil is a mixture of the finer washings of the upper soils and organic matter.

About one-half the area of the county has been estimated as susceptible of cultivation.

*NOTE.—The general features and distribution of the ores of this county were so fully described by Dr. R. A. F. Penrose, Jr., in the First Annual Report (pp. 31, 67, etc.), that the following is only intended as supplemental to his work.

CLAYS.

The lignitic clay shales, gray hardpan clay, and blue marly clay are in sufficient quantity for the manufacture of bricks, tiles, and coarse pottery. Several brick yards have been established, and merchantable brick have been made and used in Rusk and New Birmingham. At Miller & Fuqua's brick yard is made a brownish gray pressed brick called "iron brick" for facing. They will make the brick needed for buildings and foundation of the new Star and Crescent furnace. This yard began January 1, 1890, and uses red surface clay; also gray sandy soil clay. The product during the past year was two million bricks. The plant consists of four pug mills, one Thaison brick press, having a daily capacity of fifteen thousand, and one Raymond hand press.

MINERAL PAINT.

Yellow Ochre.—In the iron series, underlying the buff crumbly iron ore, is an extensive drift deposit of altered greensand of marly consistence, in which the green protoxide of iron has become yellow from oxidation to the hydrated peroxide of iron. A purer yellow is often found as nuclei or centres of the iron geode ore.

Brown Ochre.—In many localities the wavy laminated and buff crumbly ores are of dark brown color. These ores, when ground and sifted, will give a yellowish brown pigment.

Red Ochre.— This is sometimes found as inclusions in iron geodes and in septum iron ore. In some localities, where the siliceous ores, such as the iron pebble conglomerate and iron sandstone, have been exposed to the action of forest fires, the brown hydrated oxide of iron has been partly altered to the anhydrous red oxide of iron (hematite). This material, if ground and sifted, will give a red pigment. Some of the red clays owe their color to this source.

LIGNITE.

In a little branch tributary to Bean's Creek, three miles north by west of the town of Rusk, E. M. Priest's tract, in the John M. Furgison headright, was seen an outcrop of lignite underlying a twelve-inch stratum of lignitic clay shale. Overlying the clay shale is six feet of soil drift, including small nodules and fragments derived from the iron series which caps the ridges. Along the same branch are tumbled bowlders of iron conglomerate, or breccia, consisting of cemented angular fragments of iron sandstone and aluminous iron ore, with a few small rounded iron pebbles from the older disintegrated iron pebble conglomerate.

A sample of the lignite from this locality, submitted to analysis by Mr. L. E. Magnenat, afforded the following composition: Water, 9.12; volatile matter, 30.32; fixed carbon, 34.22; ash, 22.98; sulphur, 3.36.

The lignite outcrops in several other localities in this county which were not visited by the writer, but the character of the lignite, as it belongs to the same deposition, is probably similar.

The following specimens of lignite, submitted to analysis for this report, were collected by Dr. R. A. F. Penrose, Jr., more than a year ago, which will account for the difference in percentage of moisture, etc.:

ANALYSES OF LIGNITES.

No.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Total.	Sulphur.
1109*	7.00	53.70	32.55	6.75	100.00	0.89
1110*	4.40	34.65	27.70	33.25	100.00	1.33
1111*	8.15	43.55	42.50	5.80	100.00	3.37

* Analyses by J. H. Herndon.

Localities.

No. 1109. Brown lignite, six miles south of Alto.

No. 1110. Lignite, near Jacksonville.

No. 1111. Lignite, McBee school.

On the west bank of a little branch tributary to the one above mentioned, J. W. McCord's place, John H. Furgison headright, was seen ten feet of micaceous lignitic sand of creamy color above and brownish at base near the water. Overlying this deposit is the surface soil drift, about two feet thick. The position of the micaceous sand is above the lignitic clay shale.

MINERAL WATER.

Chalybeate Springs.—Wherever the disintegrated iron ore has drifted into contact with organic matter the access of water by infiltration gives origin to chalybeate springs. The carbonic acid gas derived from the slow oxidation of the organic matter is held in suspension by the water, which coming in contact with the iron ore dissolves a portion of the iron. On reaching the open air the carbonic acid gas is gradually given up and the iron, no longer soluble in the water alone, is deposited as a rusty sediment. When this sediment is deposited on a bed of small iron pebbles and iron gravel, which usually line the margins of streams in this region, the pebbles and gravel are cemented into a soft iron conglomerate. This was seen in process of formation in a little stream in the northern limits of the town of Rusk and elsewhere.

Sulphur Springs.—Several springs of sulphur water have been reported in the eastern portion of the county on the tributaries of the Angelina River. (First Annual Report, page 100.)

MINERAL OIL.

In the grassy valleys between Rusk and New Birmingham traces of oil were seen oozing through the soil, causing dark spots. Films of oil can be seen in shallow water holes or post holes after a rainy season. This oil is derived from the lignite bed, which, as appears from the lignitic clay shales, is in close proximity.

It is possible that the oil may be found absorbed in quantity along some of the tributaries of the Angelina River in the southeastern portion of the county.

GREENSAND.

Underlying the buff crumbly or aluminous bog iron ore is usually an extensive deposit of altered siliceous greensand. In some localities the alteration to yellow ochre or orange loam has not been entire, and the interior of the deposit still exhibits its characteristic green color. A sample of the green clay stratum of this county (First Annual Report, page 94) on analysis gave the following composition: Silica, 25.8; alumina, 42.20; oxide of iron, 19.75; lime, 0.90; magnesia, 0.80; phosphoric acid, 0.49; sodium oxide, 2.5; potash, 0.26.

In certain localities, as at Dial's Station, the siliceous glauconite has become sufficiently indurated to be useful as building stone. The capstones of the brick wall enclosing the State Penitentiary were obtained from this quarry. A specimen of this stone submitted to chemical analysis by Mr. L. E. Magnenat gave the following composition: Silica, 14.40; sesquioxide of iron, 30.27; protoxide of iron, 25.96; alumina, 2.07; lime, 3.05; magnesia, 5.00; potash, 4.61; soda, trace; phosphoric acid, 0.54; sulphur, trace; water, 14.00.

The more recent deposit of calcareous greensand shell marl will probably be found in the southeastern portion of the county, near the Angelina River.

TIMBER.

The total area of this county is 645,120 acres. If from this be deducted 97,532, the number of acres in cultivation for field crops, fruit, and garden, and from the remainder, 547,588 acres, be subtracted one-eighth for barrens, town sites, and streams, one-tenth for timber cut and in process of cutting by the fifteen saw mills, the number of acres cleared for charcoal by the "Old Alcalde Furnace," 2500, and 250 acres by the "Tassie Belle Furnace" to January, 1891, then the final remainder, 428,476 acres, would approximately represent the area of standing timber.

One-fourth of this amount of timber, or 107,119 acres, would be suitable for saw logs. If cut into boards, at an average of 2500 feet per acre, this would make 267,797,500 feet. The remaining 321,357 acres of timber, if cut into cord wood and burned for charcoal, would probably produce an average of 1000 bushels per acre.

IRON ORE.

This county has a large and valuable remnant of the iron ore deposit. The old elevated Tertiary plain, originally covered with the "blanket deposit" of iron ore, has since been eroded into hills and ridges. A vastly greater amount of ore has been disintegrated and washed out from its original place of lacustrine deposition than now remains, but the remnant is still of great commercial value. The ore is found capping the highest hills and ridges, covered usually by two to ten feet of sandy soil. The iron pebble conglomerate, the top stratum of the iron ore series, has here been disintegrated and drifted before the deposition of the sandy soil, but enough of the pebbles and fragments of the conglomerate are still found in and along the streams to show that this stratum once existed as a top stratum. Many of these small iron pebbles have been recemented, in association with other fragments of iron ore, to form a new conglomerate on the margins of the streams where the chalybeate water exudes. The capping of the iron ore on the elevated ridges, as now found, is usually hard iron sandstone one to two inches in thickness, and underlaid by the black-crusted wavy laminated ore six to seven inches thick. These two varieties adhere with considerable tenacity. In contact with and underlying the wavy laminated ore is the stratum of buff crumbly ore, usually twenty to thirty inches thick, with botryoidal and mammillary surface beneath, as stated by Dr. R. A. F. Penrose, Jr., in the First Annual Report, page 96.

ANALYSES OF IRON ORES OF CHEROKEE COUNTY.

No.	Sesquioxide of iron.	Silica.	Alumina.	Magnesia.	Lime.	Sulpuric Acid.	Phosphoric Acid.	Water.	Total.	Metallic Iron.
7†	60.35	25.13	4.25	Trace.	0.33	......	0.26	9.24	99.55	42.25
25* a	59.74	.....	23.41	1.18	0.51	1.86	....	12.00	99 13	41.82
28* b	44.80	18.42	18.49	4.41	0.56	4.40	....	8.73	100.00	31.36
30* c	43.67	11.40	....	.....	.....	0.02	......	.....	....	30.57
31*	20.46	...	.....	.....	.....	......	....	..	......	14.32
A..	......	d 17.53	....	.....	.....	.....	P .153	......	....	46.55
B....... ..	......	d 17.67	......	.....	.....	.. ..	P .069	13.09	....	45.65
C..........	......	d 20.36	.....	. .	.....	S.038	P .062	15.25	....	45.17
D..........	......	d 23.84	.. ..	....	.....	S.01	P .315	15.76	....	40.63
E..	......	d 16.62	......	....	.....	S.027	P .284	13.71	....	48.31
F..........	64.52	d 20 36	......	....	.....	S.038	P .062	14.25	99.23	45.17
G..........	69.00	d 16.62	......	.....	.....	S.027	P .284	13 71	99.64	48.31
1107*......	63.84	18.90	5.76	......	0.18	0.20	0.09	11.03	100.00	44.68
1108*......	66.05	10.65	10.35	......	0.25	0.11	0.49	12.10	100.00	46.23

Analyses * by J. H. Herndon; † by L. E. Magnenat.

a MnO, 0.42. *b* MnO, 0.17. *c* Insoluble, 33.50. *d* Silica and insoluble.

From No. 7 to E, inclusive, collected by Dr. R. A. F. Penrose.

Localities.

No. 7. Limonite.

No. 25. Brown massive iron ore, five miles west of Jacksonville.

No. 28. Fossiliferous iron ore, four miles north of Jacksonville.

No. 30. Brown hematite.

No. 31. Poor ore, five miles south of Troupe.

No. A. Raw ore, penitentiary ore bed; analysis made for John Birkinbine, 1885.

No. B. Raw ore, penitentiary ore bed; analysis made for John Birkinbine, 1885.

No. C. Raw ore, penitentiary ore bed; analysis made for John Birkinbine, 1885.

No. D. Raw ore, penitentiary ore bed; analysis made for John Birkinbine, 1885.

No. E. Raw ore, penitentiary ore bed; analysis made for John Birkinbine, 1885.

No. F. Solid brown hematite, penitentiary ore bed. Analysis by Regis Chauvenet & Co., St. Louis.

No. G. Black laminated ore. Analysis by Regis Chauvenet & Co., St. Louis.

No. 1107. Wavy laminated ore, one mile north by west of State furnace, Cherokee County.

No. 1108. Compact buff crumbly iron ore, one mile north by west of State furnace, Cherokee County.

THE IRON INDUSTRY AT RUSK AND VICINITY.

Through the courtesy of Captain E. L. Gregg, of Rusk, who was secretary of the committee appointed to find suitable locations for the State Penitentiaries, the writer obtained the following particulars, the original report having been filed in the State archives, and lost in the fire which destroyed the old Capitol building.

The committee appointed by Governor Richard Coke in 1875 consisted of W. W. Lang, of Marlin, chairman; Thomas Dwyer, Ed. Burleson, of San Antonio; B. W. Brown of Longview, and E. L. Gregg, of Rusk, secretary.

The object was to locate two penitentiaries—one northeast of the Trinity River, in East Texas, for the manufacture of iron; the other in West Texas, for the manufacture of woolen goods.

In making the examination for the location of the eastern penitentiary the committee traveled through Grayson, Marion, Gilmer, Titus, Smith, and Cherokee counties. At the suggestion of Governor Coke an expert, Mr. G. A. Kelley, was appointed by the committee, who accompanied them, except in Grayson County.

After careful examination of the iron fields the committee recommended Rusk as the best location for the eastern penitentiary, on account of the quantity and quality of the iron ore.

Before the completion of the report and the consummation of the contract with the builders of the prison two vacancies occurred in the committee, one caused by the election of the chairman, W. W. Lang, as a member of the Constitutional Convention in 1876, the other by the death of Thomas Dwyer, of San Antonio. These vacancies were filled by the appointment of Judge

J. M. Hurt, now of the Court of Appeals, and Judge D. E. Thomas, of Austin, who assisted in the completion of the report and the contract with the builders of the prison cells at Rusk.

This committee also recommended the location of the western penitentiary at San Marcos, for the manufacture of woolen goods, but no contract was carried into effect, on account of the failure of the Legislature to make an appropriation for that purpose.

The official report of this committee was made to the Governor, delivered to the Secretary of State, and destroyed, as before stated, by fire in the old Capitol building.

Through the courtesy of Major Thomas J. Goree, Superintendent of Penitentiaries, the following particulars were obtained by the writer:

The principal object in establishing the penitentiary at Rusk was the development of the iron industry in East Texas. The cell building was built with that object in view, but fearing that the manufacture of iron (without railway facilities) would be unsuccessful, the first Board of Directors, consisting of Governor O. M. Roberts, Treasurer Lubbock, and Attorney-General McCormick, directed that the walls be completed around the cell building and brick workshop.

Under the law reorganizing the penitentiary in 1879, a State Board of Directors was created, consisting of the Governor, State Treasurer, and Superintendent of Penitentiaries. By direction of that board Major Thomas J. Goree, Superintendent, made an examination of the iron ores with the view of manufacturing iron as first contemplated. His report was favorable, and resulted in a contract for the construction of the State furnace, which was named "the Old Alcalde" in honor of Governor O. M. Roberts.

E. C. Darley, of St. Louis, became the contractor, and the work was done under the immediate supervision of his agent, Mr. R. A. Barrett, by convict labor. While in course of construction, in 1883, this Penitentiary, with a number of convicts, was leased to Comer & Fairis, who took charge of the same January 1, 1884, the furnace being finished about that time. Under their management the "Old Alcalde" furnace went into blast in February, and ran a few weeks under the direction of Mr. Veach, of Alabama, as superintendent, making seven to ten tons of pig iron per day. On the representation to the State Board that the cause of their ill success was a faulty construction of the bosh—that iron could not be made to the full capacity of the furnace with such a steep bosh—the contractors got permission to take out the bosh and put in the old style flat bosh, which being in place the furnace went into blast again, making the highest yield in any one day fifteen tons of pig iron.

In September some of the tuyeres were burned out, the contractors claiming that the water supply was insufficient to run with; and finally, one month later, to save themselves from loss, they surrendered their contract.

Soon after this, in the early part of 1885, the Board secured the services of an expert, Mr. John Birkinbine, of Philadelphia, to examine thoroughly the furnace plant and stack for an opinion as to whether the stack was of faulty construction or whether the fault was in the operation of it. After making a thorough examination, he approved the lines of the furnace construction, and recommended that the flat bosh be removed and replaced by such an one as had been originally constructed.

Mr. R. A. Barrett, who had superintended the original construction, was employed to make the change and to operate the furnace. He had charge of it from 1885 to January 1, 1891, running it very successfully, making from twenty-five to thirty-nine tons per day when in full blast.

Since the establishment of the plant the State Board have acquired, at various times and of sundry persons, by purchase $8773\frac{4}{10}$ acres timber lands in Cherokee County and $2951\frac{5}{10}$ acres timber lands in Angelina County for coaling purposes; also $2860\frac{6}{10}$ acres ore and other lands near the prison, and the mining privilege on $800\frac{5}{10}$ acres ore lands; the right of way on the prison spur railway, one and one-fourth miles; the right of way for ore bed road, one and one-half miles; tramway from furnace to ore bed, one mile; the right of way for water pipe line, about half a mile; and other facilities for manufacturing purposes.

The facts pertaining to the addition of the water pipe foundry and architectural castings have been enumerated in this volume, and need not be repeated here.

The writer is indebted to Mr. R. A. Barrett, late superintendent of prison industries at Rusk, for courtesies received.

The following particulars of furnace operations were partly in answer to interrogatories and partly from personal observation.

"The Old Alcalde" hot blast furnace and pipe foundry, under control of the State Board of Penitentiaries, was designed and built (1884) for twenty-five tons daily capacity.

The lines of the furnace are as follows: Height of stack, sixty-seven feet; internal diameter at top, six feet six inches; bosh, nine feet six inches; crucible, four feet ten inches; height of mantel, thirteen feet six inches; height of tuyeres, five feet six inches.

The average charge or burden of the furnace is thirty bushels of charcoal, thirteen hundred pounds of raw ore, two hundred and fifty pounds of limestone.

The average blast is thirty-eight hundred to four thousand cubic feet of hot air per minute.

The heated gases arising from the ore, limestone, and imperfect combustion of the charcoal are utilized by conducting them from the top of the furnace through the "down-take" or iron pipe to the gas oven, where the occasional addition of a stick or two of cord wood serves to keep the gases ignited, thus communicating the heat to a multiple section of pipes, through which the air is driven from the blowing engine to the tuyeres.

A portion of the gases from the "down-take" is conveyed by a branch pipe to the boilers, where it is similarly used for heating, to make steam for the engine. The blowing engine is of the Weimer type, manufactured by the Weimer Machine Works Company, of Lebanon, Pennsylvania.

GRADES OF PIG IRON.

This furnace usually produces two grades of *hot blast* pig iron, known in commerce as No. 1 foundry pig iron and No. 2 foundry pig iron. Other grades of *warm blast* pig iron are made to order for the manufacture of car wheels, known in commerce as No. 4 car wheel iron (best), and a cheaper grade, No. 1 car wheel iron. To produce the warm blast iron, the temperature of the air blast is reduced to between 350° and 400°, but this reduction in blast temperature causes a reduction in the daily output of the furnace, and to that extent increases the cost of the product.

The following table exhibits the daily average product of pig iron for the months in blast, from the time the State Board resumed control of the furnace, to December, 1890.

AVERAGE DAILY PRODUCT IN TONS.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1885..........	....	....	.....	.....	....	..	.....	.....	.....	.....	.....	25½
1886.	28⅔	....	.....	.....	.....	.....	23½	27½	24⅙	24½	.....	....
1887..........	.....	28	26½	24¾	....	.....	.. .	.. .	.....	31½	33	24½
1888..........	.....	....	25½	29	22½	19½	20	.	24½	25	28	27
1889..........	.....	25	23½	.....	20	20	23½	26	22⅓	22¾	23	....
1890..........	.....	..	20	23⅗	24⅕	25⅓	24¼	22⅖	23½	25½	27⅓	....

The total product from December, 1885, to January 1, 1891, is about 24,000 tons of 2240 pounds each, or 53,760,000 pounds.

ANALYSIS OF THE PIG IRON.

Made by Chouteau, Harrison & Valle Iron Company, St. Louis, October 21, 1886.

Phosphorus	0.477
Silicon..	2.250
Sulphur..	0.005
Metallic iron...	94.000

ANALYSES OF LIMESTONE.

(Used as flux) from Coryell County. Chemists: Regis Chauvenet & Bro., St. Louis.

	Sample No. 1.	Sample No. 2.
Silica	0.12	0.10
Oxide of iron	Trace.	0.28
Carbonate of lime	99.75	99.60
	99.87	99.98

ANALYSES OF FURNACE SLAG.

From "The Old Alcalde Furnace." Chemists: Regis Chauvenet & Bro., St. Louis.

	B† Sept. 5, 1888.	A* Sept. 22, 1890.	C* Oct. 12, 1886.
Silica	39.87	42.46	41.90
Alumina	22.90	25.94	27.02
Lime	36.33	30.64	30.37
Magnesia	....	0.87	0.70
Metallic iron	1.14	....	....
	100.24	99.91	99.99

†"The greater part of the iron is in the form of metallic granules, caught in the slag, and is therefore returned as iron rather than sesquioxide."

*"The absence of iron is a remarkable feature in the above, and shows good work."

COST OF MATERIALS.

Iron Ore.—The cost of mining with convict labor and transporting the raw ore to the furnace on tramway cars, including the crushing necessary to make it ready for the furnace, is estimated at fifty cents per ton. The ore was at one time roasted. The water having been evaporated, and some of the sulphur volatilized, there was some improvement in the working of the furnace and in the quality of the pig iron, but this has not been enough to justify the extra expense of roasting. Some of the ore would be improved by washing, and this would have been tried but for the scarcity of water.

Limestone. — The limestone is obtained near Leon Junction, formerly Pecan Grove Postoffice, in Coryell County, and is transported some two hundred miles by railway to the furnace. The average cost of rough stone, delivered at the furnace, is $2.70 per ton, to which is added the cost of crushing, ten cents per ton.

Charcoal. — As the distance to the coaling ground is increased by the cutting of timber on the lands nearer to the furnace, the cost of transportion becomes greater. The estimated average cost of charcoal delivered at the furnace during the year 1890 is seven cents per bushel.

THE TASSIE BELLE FURNACE.

The Cherokee Land and Iron Company was organized in 1888 by Mr. A. B. Blevins, promoter, under the laws of the State of Texas, as a joint stock company, with an authorized capital of $1,000,000 in shares of $1 each. The officers were: H. H. Wibirt, of New York City, president and treasurer; R. L. Coleman, of St. Louis, first vice-president; J. C. Reiff, of New York City, second vice-president; Henry T. Kent, of St. Louis, secretary and general attorney; John C. Meyers, of St. Louis, assistant secretary; A. B. Blevins, of New Birmingham, Cherokee County, manager for Texas; John Birkinbine, C. E. and M. E., of Philadelphia, designer of furnace; Nathan F. Barrett, of New York City, landscape engineer; Chas. E. Jacques, of New York City, architect; T. Howard Barnes, of New Birmingham, civil engineer. The capital was raised principally in New York.

LOCATION.—The property of the company is within Cherokee County, and consists of ore and timber lands, town lots, and buildings, including the furnace, in the town of New Birmingham, which is laid out about two miles south of the town of Rusk (the county seat), on the line of the St. Louis, Arkansas and Texas Railway.

DESIGN OF THE FURNACE.—The furnace was built after designs made by Mr. John Birkinbine, iron expert and engineer, of Philadelphia, Pennsylvania. It is of the hot blast type, with a working capacity of fifty tons per day, although its full capacity has not yet been reached. The furnace is equipped with two down-takes—one leading part of the heated gases from the top of the furnace to the boiler furnace, for generating steam; the other conducting the remainder of the heated gases from the top of the furnace stack, through an intervening dust cylinder, to the gas oven, where the gases are kept ignited to heat the multiple section of air pipes for the production of a hot air blast. The form of oven is known as "Weimer's new patent pipe oven." The blowing engine is of the Weimer type, made by Weimer Machine Works Company, Lebanon, Pennsylvania. The pumping engines are of the Knowles pattern; the small one is used for feeding the boilers, the large one for general purposes and for extinguishing fire in case of accident.

REORGANIZATION.—The company has recently been reorganized and the capital increased to $3,000,000. Mr. R. L. Coleman, first vice-president, promoted to president; Mr. A. S. Mahoney, of New York city, made treasurer and chemist; Mr. David Carson, of St. Louis, made superintendent of the furnace. The lands now owned and controlled for ore and timber amount to about twenty thousand acres. The company has expended on lands and buildings, up to date, about $450,000.

LINES OF THE FURNACE.—Through the courtesy of Mr. David Carson, superintendent of the furnace, the writer was permitted to examine the working drawing of the furnace, from which the following notes were made: Base of hearth, eleven feet; inside diameter of crucible, six feet six inches; bosh, eleven feet; six tuyeres, height above hearth, six feet; hearth to bosh, fifteen feet three inches; inside stack, from bosh to "down-takes," thirty-one feet ten inches; diameter of the two down-takes, thirty inches; inside diameter of stack at top, eight feet eight inches; outside stack, from hearth to top, sixty-three feet six inches; height of mantel, eighteen feet.

Product.—To Mr. R. L. Coleman, president, the writer is indebted for samples of the product (No. 1 and No. 2 foundry pig iron) for the State museum, and the following particulars: The furnace was put in blast November 8, 1890, and went out of blast January 10, 1891, for alteration of boiler furnace. The product for the time in blast was a little over two thousand tons of two thousand two hundred and forty pounds each, or about four million four hundred and eighty thousand pounds.

THE STAR AND CRESCENT FURNACE.

This furnace is located between Rusk and New Birmingham, on the St. Louis, Arkansas and Texas railway, just outside the southeastern limits of Rusk.

Organization.—This company was organized in November, 1890, as a joint stock company, with a capital of $500,000. The stock is partly owned by local stockholders, but most of it is held by capitalists in New Orleans. The officers are as follows: Mr. A. Britton, of New Orleans, president; Mr. E. C. Dickinson, of Rusk, vice-president; Mr. E. S. Maunsell, of New Orleans, secretary and treasurer; Mr. R. A. Barrett, of Rusk, formerly superintendent of prison industries at the State penitentiary at Rusk, general manager.

Property.—The property owned and controlled by this company at present consists of about fifteen thousand acres of timber land, and about three thousand acres of ore land.

Furnace under Construction.—The ground was broken for the foundation of this hot blast furnace in the early part of January, 1891. Through the courtesy of Mr. R. A. Barrett, general manager, the writer was permitted to examine the working drawing of the stack, from which notes were made of the principal lines. It will be built from these drawings, designed and prepared by Mr. Barrett himself. Height of stack inside, sixty-five feet; bosh, eleven feet in diameter; crucible, six feet in diameter; diameter inside stack at top, eight feet six inches; six tuyeres, four and one-half inches in diameter; height of tuyeres, six feet.

The capacity of the furnace is estimated at fifty tons per day. A new feature in construction is suggested by experience in the life of boshes. This furnace will contain a circular "water brick" constructed of hollow casting, which will be laid with the bosh brick. A circulation of water through the casting will prevent the too rapid destruction of the fire brick lining, which is exposed to the intense heat of the fuel under blast.

Blowing Engine.—The blowing engine will be of the Weimer type, made by the Weimer Machine Works Company, Lebanon, Pennsylvania. Steam cylinder, thirty inches in diameter; blowing cylinder, seventy-two inches in diameter; stroke of both, forty-eight inches.

Steam Boilers. — The boiler house will contain three batteries of two boilers each; diameter, fifty-four inches; length, thirty feet. Each boiler will have two eighteen-inch flues.

Buildings.—The ore stock house and the coal stock house will be built of wood. Every other building on the place will be of brick and iron.

Products. — Besides the production of foundry and car wheel iron, this company will probably add as rapidly as possible a water and gas pipe foundry, a machine shop, a rolling mill, and a nail factory.

Additional Transportation. — This company has faith in the idea that, with these added industries, this region must soon of necessity have another railway, and that the building of this road will solve the fuel question.

GENERAL SUGGESTIONS.

Economy in the Use of Iron Ores.—As a matter of public or State economy the best results in the production of pig iron would be obtained by shipping a portion of the hard refractory iron ores of Central Texas to the furnaces of East Texas, and mixing them with the soft aluminous ores of that region, which would result in a mutual benefit to the working qualities of both ores and a mutual benefit to both sections of the State.

The hard igneous ores of Central and West Texas are located in districts which are as yet without a known fuel supply, and must therefore remain useless until fuel can be obtained or until a market can be found for the ore. The smelting of these ores alone is attended with considerable disadvantage. Furnace experts claim that the refractory magnetites and red hematites injure the fire brick lining of the boshes, from their weight and hardness in passing downwards. On the other hand, the hydrated ores (limonites) of East Texas contain such a large percentage of alumina that they, when used alone, tend to clog the furnace by crumbling and impeding the blast or draft through the mass of ore.

The mixture of the igneous and aqueous ores would therefore greatly aid the working qualities of both ores. While the quality of the iron as now manufactured in East Texas is excellent for pipe, architectural work, and by reducing the temperature of the blast for car wheels, it would, by the proper admixture of the ores, be greatly improved for general castings, such as machinery, etc.

Such a policy steadily pursued would extend the time of usefulness of the furnaces now established and to be established in East Texas; for while the ore deposits are sufficient for a good many years to come (dependent upon the number of furnaces), they are nevertheless superficial, and therefore can not be considered inexhaustible. The igneous ores, on the contrary, are true fissure veins of great depth, and are therefore capable of contributing a large quota of ore to enable the furnaces of East Texas to continue their operations much longer. Such a policy would also be of great benefit to Central, and in the future, West Texas, because it would open up a ready market for a large natural product which is now valueless except for speculation.

The limestone for flux now used at the furnaces is transported from Leon Junction, some two hundred miles, at low rates of freight. To carry the iron ores from Central Texas to the existing furnaces in East Texas would require the building or extension of a railway from the town of Lampasas to the town of Llano. From the town of Llano tram roads could be built to the largest outcrops of the iron ore, a little northwest of the town. At Lampasas connection would be made with the "Cotton Belt System," or St. Louis, Arkansas and Texas Railway, which at present transports the limestone used in the furnaces from Leon Junction. The distance for this iron ore would only be eighty-six miles further. The railway would have freight traffic both ways, transporting the iron ore in one direction and lumber from the saw mills in the other direction.

Uses for Furnace Slag.—The furnace slag, which at present is a waste product, could be utilized for the manufacture of two commercial articles, with very little additional expense: 1st. Paving blocks for sidewalks. This would require suitable cast iron molds with pressure plungers for giving shape to the material; an annealing oven for gradually cooling the blocks. This could be heated by part of the furnace gases from the down-takes. An endless chain, with platform links, would be necessary for rapidly delivering the blocks into the annealing oven. Such blocks, being unaffected by atmospheric changes and being of harder material, would resist wear longer than clay paving blocks. 2nd. Polishing powder. The fine white porous slag produced when the slag runs out over wet surfaces, if pulverized and sifted, being of similar consistency, would make a good substitute for powdered pumice stone as a polishing powder.

THE RECENT EARTHQUAKE.

Under the direction of the State Geologist, the writer made some investigations to determine the facts of a reported recent earthquake at Rusk. After careful investigation the conclusions reached are as follows: The time of reported occurrence was midnight, when few observers were awake. It was also during the prevalence of a storm, hence there was much diversity of opinion expressed by citizens. An examination of the strata in the vicinity revealed slight faulting due to previous earthquakes, but no faulting was observed that was of recent origin.

The following paragraph was seen by the writer in the Houston Post, copied from the Cherokee Herald:

"Rusk Treated to Two Genuine Earthquake Vibrations. *Rusk, Texas,* January 8. — Last night at 12 o'clock this town and immediate vicinity experienced two well defined shocks of an earthquake. Each paroxysm was accompanied by a detonation loud and long, as of thunder rolling from south to north. Several chimneys were leveled with the earth, and sleepers in various portions of the town were awakened. J. W. McCord, in charge of the county jail, a very strong structure, declares that for fully one minute he apprehended a collapse of the building, and Theo. Miller says the Acme Hotel was shaken to its foundation. There was no wind, though there was a slight rain falling and some electrical force prevailing, but not of sufficient strength to produce the shocks. A few parties here who were through the Charleston, South Carolina, shocks of 1887, pronounced the phenomenon last night a genuine earthquake."

The chimney which fell was visited. The material was old and the mortar had been partly washed out by atmospheric agencies in the past; it may, however, have fallen during the reported vibration of the earth. The county jail exhibits no external cracks such as might be produced by severe earthquake vibrations. No cracks were observed in the outer wall of the Acme Hotel, but in the room occupied by the writer there are cracks where the front wall joins the partition walls that may have been produced by the vibrations described.

The Austin Statesman of January 9th contained the following Associated Press dispatch:

"Earthquake in Ohio.—*Toledo, O.*, January 9.—Just at noon a shock of earthquake was felt here that shook houses, rattled windows, and frightened horses. The shock came apparently from the south, and a slight rumble accompanied it. The shock was about the same in its effects at all points within a radius of forty miles from here."

In the Galveston News of January 16 appeared the following foreign dispatch:

"Algiers, January 15.—Reports from interior points show that an earthquake was felt throughout an extended region. The shocks were severe at Gourza, near Cherchell. Part of the buildings of the village were demolished and many persons buried in the ruins."

Allowing for the time necessary for the news to get from the interior to

Algiers, the earthquake mentioned must have occurred about the same time as those above described, from which it may be inferred that the centre of disturbance was in the eastern hemisphere, and the vibrations observed in the western hemisphere were simply due to reaction.

CONCLUDING REMARKS.

The writer desires to express his thanks to public spirited citizens of Rusk and New Birmingham for courtesies during his short stay in their midst. Among others, he met Mr. A. Jackson, who at a Democratic convention held at Jacksonville, in 1856 (which was addressed by Rusk, Wigfall, and others), introduced a resolution, framed by Mr. M. H. Bonner, calling for legislative action to organize a State Geological Survey. To Mr. Jackson and Mr. Bonner therefore belongs the credit of probably the first public action looking to the establishment of a State survey.

The writer is indebted to Mr. N. F. Drake, Assistant Geologist, for his aid in preparing the map of the oil regions of Nacogdoches, and the various figures accompanying this report, for the photo-engraver.

CHAPTER XII.

ANDERSON COUNTY.

E. T. DUMBLE.

GEOGRAPHY AND TOPOGRAPHY.

Anderson County comprises the country lying between the Trinity and Neches rivers, bounded by Henderson County on the north and Houston County on the south, an area of one thousand and eighty-eight square miles.

Of the two rivers the Trinity is the larger, and its drainage system cuts more deeply into the former plateau than that of the Neches, although the tributaries of the latter stream stretch fully half way across the county in places. This causes the drainage divide to lie near the centre of the county, which it crosses in an almost north and south direction; but the general elevation of the eastern half is somewhat greater (probably fifty to one hundred feet) than that of the west. The county for the most part is generally rolling, but when the ridges of iron-capped hills are reached they take on all the appearance of mountains, although in fact seldom over one hundred feet in height above the surrounding level. This variety of contour is largely due to the combined erosion of the two rivers and their drainage systems, which has sculptured a topography of diversified character from the ancient table land that formerly occupied this region in common with much the greater part of Eastern Texas and portions of Arkansas and Louisiana. Of this table land a few remnants still remain, forming a rude semicircle of iron-capped hills, which has for its diameter the Neches River. Here, as elsewhere in this region, it is only the highest points on which the iron ore deposits are found, and to its protection their present eminence is due. To the south of Palestine the country becomes lower and the hills more scattering.

To the east this plateau breaks into small hills, extending to the Neches River; and on the west it gradually disappears in the same way in the watershed of the Trinity. This iron region thus forms the divide between the Neches and Trinity, just as in Cherokee County the Selman range forms the divide between the waters of the Angelina and the Neches. In this range, as in Cherokee, springs give rise to many creeks, which flow down the steep slopes of the plateau, come together in the lowlands, and finally discharge into the muddy waters of the main rivers.

From the divide a number of streams flow through the county, either southeasterly to the Neches or southwesterly into the Trinity. Among the principal tributaries of the Neches are Caddo, Brushy, Walnut, Hurricane, Still's, and Jones' creeks, while on the Trinity side are Wild Cat, Catfish, Springer, Lata, Keechi, Tour or Saline, Camp, Parker's, and Box creeks.

From this it will be seen that the county is well watered, and the usual accompaniment of iron ores of this region, abundant springs, are also numerous; consequently there is no scarcity of water anywhere in the county. Well water is secured in almost any portion of the county at depths varying from twelve to forty feet.

In 1888 there was less than fifteen per cent of the total area of the county under cultivation, the leading products being cotton, corn, oats, peas, sweet potatoes, fruit, etc.

There are some prairie lands in the northern and western parts of the county, aggregating in all perhaps one-fifth of its total area. The remainder of the county is well timbered with short leaf pine, oak, hickory, etc., the pine greatly predominating in the eastern part of the county.

These prairies doubtless represent the southern extensions of the Basal Clays of the Tertiary and the Ponderosa Marls of the Cretaceous, both of which occur in that region.

STRATIGRAPHY.

The rock formations of Anderson County comprise representatives of at least three systems: The Cretaceous, Tertiary, and Quaternary. The details of the entire stratigraphy of each system have not yet been worked out, but the following broader characters have been determined:

System. (Period.)	Division.	Beds.
QUATERNARY.		The sands and sandstones capping the iron ore hills.
TERTIARY.	TIMBER BELT BEDS.	The iron ores. The greensands and accompanying beds of clays and sands.
UPPER CRETACEOUS.	SALINE LIMESTONE. PONDEROSA MARLS.	

CRETACEOUS.

The representatives of this system in Anderson County are confined to the Ponderosa clays and the overlying or included masses of limestone designated as the "glauconitic" beds. In some places it would appear that the limestone occurs as masses in the clays themselves, while at others their extent seems to prove them the remnants of an overlying deposit of limestone. One of the latter is the deposit which surrounds the Saline, six miles west of Palestine. This limestone, as first stated by Dr. Penrose, is found in a ring of hills reaching sixty feet or more above the level of the Saline, not continuously, but outcropping in many places on the north, west, and east sides.

A few low outcrops were also seen on the south side. In appearance it greatly resembles the Austin chalk, except that it contains specks of greensand. On subsequent examination I found just below the top a glauconitic seam with numerous shells, among them an oyster,* of distinctively peculiar form. The outcrops are cut irregularly by seams of calcite. These seams vary in width from one-half inch to twelve inches, and many of the fragments which lie scattered over the hillside so closely resemble silicified or agatized wood that it is readily mistaken for it. Some of the calcite is fibrous, the crystals running at right angles to the crevice. In other instances there is no such regularity of arrangement, but one set of crystals is attached to the next at various angles.

The Saline itself is a flat irregular depression, longest from north to south, being possibly a mile in length, but not more than one-half mile in width. During the winter months it contains some water, but in the summer it is dry, and there are small patches scattered here and there on which an incrustation of salt appears. The soil of the Saline has the same appearance as that of the "black waxy" or Ponderosa clays soil. The timber appears to be encroaching on it gradually. The drainage from the surrounding hills builds delta-like formations further and further outward, and the trees push out to the edges of these.

About six miles north of this the Ponderosa clays were observed. They are in the northward extension of the valley in which the Saline occurs. Here the soil has its characteristic black waxy appearance, and the exposed clays their yellow color. They contained yellow calcareous nodules and many fine specimens of *Exogyra ponderosa*, Roemer, accompanied by *Gryphœa vescularis*, Lamark. The highest beds were found to contain a decided intermixture of limestone in small fragments, below which was an arenaceous bed containing fragments of a small thin-shelled oyster of which no specimens could be secured sufficiently perfect for identification.

The clays themselves are yellow on exposed surfaces, showing lamination in places. Where they are dug into they are of a slaty blue color. The included limestone nodules and bowlders are septarious and semi-crystalline, and often contain fossils. In one place an almost vertical dyke of limestone, some five or six inches in thickness, was observed cutting the clays, and quantities of calcite similar to that occurring in the drift at the Saline were found in the drift at this place also. In addition to this a few fragments of clay ironstone were found. To the north this is overlaid directly by the lignites and clays of the Timber Belt beds in such manner as would suggest the existence of this Cretaceous inlier as an elevated land area at the time of their deposition.

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* *Ostrea salinensis*, Dumble, sp. n.

TERTIARY.

With the exception of the ores the highest bed of the Tertiary which is exposed here is the bed of the greensand immediately underlying the iron ore beds. This varies in thickness from ten to forty feet, and "is composed of glauconitic grains with more or less green clay, the latter often occurring in the form of interbedded seams or lenticular patches. This bed is usually rusted upon the surface from the combined decomposition of the glauconite and iron pyrites which it contains, but the interior preserves its green color. It contains many fossils of the Claiborne forms, generally as casts, but sometimes well preserved Oblong and kidney-shaped calcareous nodules, varying in size from one-half inch to three inches in diameter, are sometimes found, but are somewhat rare." This bed forms the divide between the Trinity and Neches rivers, and occupies some of the highest points in the northern part of the county. Immediately underlying this bed there is a series consisting of interbedded and interlaminated sands and clays, often cross-bedded, stained by decomposed iron pyrites, and containing numerous small beds of lignite. "These sands are frequently indurated by a ferruginous or siliceous cement into beds of sandstone varying very much in hardness, color, and thickness. Such beds vary from one to twenty feet in thickness and are of very limited extent. They generally cap knolls and hills, and forms a protecting cover which saves the underlying strata from erosion."

At the base of these sands are found purplish and chocolate colored sands, stratified horizontally, and containing specks of mica and gray sandy clays with fragments of lignite. Crystals of selenite are found in many parts of them. These beds are exposed by erosion of the upper greensands and by various wells that have been dug or bored on the east and south, and correspond in their general features very closely with the beds of the same horizon described in other localities of this East Texas region.

One peculiarity worthy of note in the greensand marl is the occurrence of lines of the material in indurated concentric nodules. These are present in many places, and an analysis shows a much larger percentage of ferric oxide in them than in the massive material in which they occur, and they are seemingly continuations of the processes by which some of the iron ores have been formed.

The following special sections will serve to illustrate more fully the general stratigraphy of the Tertiary.

The Oil Wells Section.—Ten miles east of Palestine, in the neighborhood of Still's Creek, several borings were made for oil in 1887. The road from Palestine to the wells shows, first the greensand bed underlaid by the white, red, and other lignitic sands and clays. Below these were found purplish and chocolate colored sands, stratified horizontally, and containing mica. These are partly indurated by bituminous matter on the surface, which is present, however, in too small quantity to burn. The deepest well gives a section of three hundred and ten feet.

OIL WELL SECTION. J. L. MAYO.

1.	Soil	15 feet.
2.	Red sandstone, some oil	3 feet.
3.	Chocolate colored stone	6 feet.
4.	Alternate strata of sand and clay	34 feet.
5.	Sand impregnated with oil	14 feet.
6.	Clay	6 feet.
7.	Hard stone	1 foot.
8.	Sand	8 feet.
9.	Stone	1 foot.
10.	Alternating sand and joint clay	27 feet.
11.	Quicksand and water	6 feet.
12.	Blue lignitic clay	159 feet.
13.	Sand, loose and firm, blue color	30 feet.
14.	Blue sandstone	
	Total	310 feet.

The Elkhart Wells Section.—These wells are one mile southeast of Elkhart and thirteen miles south of Palestine. The surrounding country is very flat, and is fully one hundred feet below the railroad level at Palestine. Between the two localities were seen the greensand bed with its underlying sands and clays. Six miles from Palestine the descent begins, and beyond that the hills are rare, and seldom rise high enough to be capped with the yellow indurated greensand. The following section is made from the surrounding exposures and the wells at that place.

ELKHART WELLS SECTION.*

1.	Brown and black clays, plastic, containing iron pebbles, silicified wood, and calcareous nodules	10 feet.
2.	Gray and yellow-brown plastic clays in thin laminæ	5 feet.
3.	Dark brown altered greensand, fossil casts	1 foot.
4.	Gray laminated plastic clay	3 feet.
5.	Greensand, hard for eight to ten inches and full of shells, interbedded with greenish black clay	4 feet
6.	Gray clay like No. 4	
7.	Gray and mottled clay	8 feet.
8.	Gray and light chocolate laminated sand, scales of hardpan, gypsum crystals, coating of sulphur sometimes appearing between laminæ and often in the gypsum	10 feet.
9.	Gray clayey sand, fine	5 feet
10.	Dark gray stratified clay with fine mica	10 feet.

*As stated in the introduction, much of the matter here given is taken from the report and notes of Dr. R. A. F. Penrose, Jr.

11.	Gray sand, fine in texture, with much pyrites	5 feet.
12.	Black clayey sand	12 feet.
13.	Gray sandy clay, with broken fragments of lignite sometimes making up one-half the mass	10 feet.
	Total	83 feet.

These two sections, in connection with the various similar sections of the adjoining counties, give an idea of the rock materials of the region. The Elkhart section represents a part of the upper portion of the Oil Wells section, No. 8 of the Elkhart section being possibly the No. 3 of the Oil Wells section.

The amount of dip is very small. In places it appears to be as much as three to five degrees, but this is only local and usually due to sub-erosion. No accurate determination can be made until more detailed work is carried on, lines of levels run, and the various separated beds mapped and correlated.

QUATERNARY.

The extent of the Quaternary modifications of the underlying materials and the deposits directly referable to that period have not yet received sufficient study to enable us to do more than indicate their existence and designate some of the members. A part of the iron ores are possibly of this period, while the overlying quartzitic and quartzose sandstone and gray, yellow, or buff colored sands, together with some of the mottled sands or sandy clays and gravel, certainly belong to it.

THE IRON ORES.

The deposits of iron ore in Anderson County, like those of the entire district, are found capping the highest hills, or, in the case of some of the conglomerate ores, along the water courses, either at their present level or more often at that of some time prior to the erosion of its present channel. As has already been stated, these deposits are found cresting a rude semicircle of hills having for its diameter the Neches River, and are in fact the western extension of the deposits of Cherokee County.

"Going north from Palestine the main iron bearing range is met at about three miles from the town, and extends in a great plateau, often broken up into separate flat-topped hills, from here northerly towards Beaver, Brushy Creek, Kickapoo, and the Henderson County line.

"The ore found here is continuous over large areas and maintains a very steady thickness of from one to three feet. To the south of Palestine the same ore is found, but here the bed is generally thinner and less continuous, and the ore bearing hills more scattered." Therefore, the iron range in the great highland region to the north of Palestine comprises most of the ore of the county. What adds still more to its value is its nearness to the pure white limestone in the Saline. This is excellently adapted for a flux in smelting iron ore, and on that account of the greatest practical importance.

The ores are of the brown laminated, concretionary, and conglomerate varieties found elsewhere in the district, the former greatly predominating. The stratigraphic position of the ores has been described so often as to need no repetition here, where they present no features differing from those of Cherokee and other counties. The analyses will show that the ores of this county are of excellent quality, some of them being adapted even for the manufacture of steel, on account of the small amounts of sulphur and phosphorus contained in them and their high percentage of metallic iron.

IRON ORE AREAS.

Just northwest of Palestine the first of the great range of iron bearing hills begins. Its longer axis extends nearly northwest, and it has a length of five miles by a width of about two miles. an area of nearly ten square miles. Its boundary begins in the northern part of the J. Snively survey, runs north through the western part of the S. G. Wells, crossing into the Wm. Kimbro near the northwest corner of the Wells tract. Following a general northwest course through the Kimbro tract it crosses the southwest portion of the S. Hopkins and G. W. Ford surveys into the M. Salisar tract. Its extreme northern limit is near the centre of the tract, where it turns south to near the southern boundary of the survey, and then sharply east to the corner of the Geo. Hanks, at which point it again crosses into the Kimbro tract. From here it follows an irregular line, crossing the J. P. Burnet, G. W. Gatewood, and Jno. Shirley tracts, back into the J. Snively and to the place of beginning. The ore is of the laminated variety with some concretionary ore in places.*

Just east of this a much smaller area of similar ore is found, beginning in the northeast corner of the W. Kimbro, crossing the Peter Hinds and David Faris surveys into the southwest corner of the H. Hunks tract. This deposit has a length of about two miles and is not more than one-half mile in width. The ore is similar to that just described (laminated) and has an average thickness of more than two feet.

The third area of high grade ore lies to the north of the two just described and is more extensive than either. On its eastern side the headwaters of the Mount Prairie Creek have cut deeply into it, giving it a very irregular outline. Its southeast corner is about the southwest corner of the Jno. McCrabb survey, and the line bounding it passes northward through the western part of that tract into the J. B. McNealy, of which the deposit covers probably about

* Analyses 4 and 5, Laminated Ores.

one-third (the western) part. The line is very irregular here, and crosses into the Elizabeth Grace league, of which it covers an area of about one square mile in the southwestern corner. The line then passes north and northwest through the J. Hendry, F. D. Hanks, and P. O. Lumpkins tracts to its most northern point, on the Jno. Chase survey. From here it passes south through the Lumpkin tract and the eastern edge of the Geo. Andring league to its southeast corner, where it turns east through the Levi Hopkins, Danl. Parker, Jno. Wright, and S. A. Mays tracts to place of beginning. Its area is nearly fifteen square miles. The ore is similar to that of the other localities mentioned.

MASSIVE IRON ORE FROM ANDERSON COUNTY, TEXAS.

Specimen collected by E. T. Dumble north of Palestine. Analysis by L. E. Magnenat.

Ferric oxide	69 50
Silica	11.35
Alumina	8.00
Phosphoric acid	.55
Loss by ignition	10.50
Lime and magnesia	Traces.
Total	99.90
Metallic iron	48.65

Lying to the northeast of this are found two areas forming divides on the waters of Walnut Creek. One of these is on the James Hall survey, the other on the Adolph D Latlin. The two together may aggregate one square mile.*

Six miles east we find another series of hills in the neighborhood of Kickapoo. The largest of these has probably an area of three to three and one-half square miles, lying principally in the Jose Peneda grant, but covering also the southern portion of the Jose Chireno.

South of Kickapoo, on the W. F. Pool survey, is a large hill capped with laminated ore. Northeast of that town are two others on the Goss survey and one on the Timmons, and three miles east another hill is found, also on the Goss survey.

Just north of Nechesville are two small hills containing excellent ore. (Analysis 3, Laminated Ores.) With the exception of a few areas too small to be of economic value these are all the localities at which high grade ores exist north of the railway. South of the railway two areas of similar ore are mapped. These are, however, not very extensive. One of them is on the W. S. DcDonald tract, the other on the H. Anglin.

There is, however, good ore on the high divide between Still's and Ionie creeks. It has a length of thirteen miles and an average width of a mile

*Analysis 1, Laminated Ores.

and a half, giving an area of say nineteen square miles. The ore on this is of a good quality, but it is not as thick nor as continuous as the beds north of the railroad. The boundary of this bed, beginning in the western part of W. Frost league, passes in a direction northeast by east through the northern portions of the P. Martin, R. Erwin, and Geo. Clewis surveys, crosses the Fien Roberts, G. Killion, W. C. Carter, W. Foreman, and S. Yarborough tracts to the T. Pate survey, where it has its eastern point. From here it returns to the place of beginning by a line passing west through the Yarborough league, the Webb and Bennett surveys, and thence southwest through the W. E. Huddlestone, Neville, Killion, Webb, Thos. Hill, J. E. Palmer, Jno. Swearingen, J. W. Humy, T. H. Hamilton, J. H. Gillespie, and Wm. Frost surveys. (Analyses Nos. 3 and 4, Siliceous and Conglomerate Ores; 2 and 6, Laminated Ores.)

In addition to the areas described there are several others which, on account of the thinness and siliceous character of the ore, are not of as great economic importance. One of the largest of these areas is of rectangular shape and lies between the greater high grade ore areas at the head of Mount Prairie Creek and those of Walnut Creek, and forming the divide between these creeks. It embraces parts of four surveys, the Elizabeth Grace, James Hall, J. B. McNealy, and John Little. Two other similar areas occur between the first two high grade areas described and the third, lying east and west of Beaver Postoffice respectively.

On the Stephen Crist survey, south of Palestine, there is another area of this siliceous ore, covering more than a square mile; and just south of Ione Creek are two other hills capped with similar ore. The most westerly of these covers parts of the Wm. R. Wilson, A. Killough, J. Gibson, C. Grigsby, and Jose M. Mora surveys, and the other, beginning in the southeastern portion of the Mora survey, covers parts of the Kennedy, Jno. Blair, C. Adams, R. Walker, B. H. Adams, and W. W. Pharr tracts. It is hardly probable that these ores, if they can be called such, will be utilized at present. (Analyses 1, 2, and 5, Siliceous and Conglomerate Ores.)

ANALYSES OF LAMINATED IRON ORES FROM ANDERSON COUNTY.

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Loss by Ignition.	Total.	Metallic Iron.
1*....	68.80	13.36	3.40	Trace.	Trace.	.12	......	13.70	99.38	48.16
2*....	64.32	8.70	13.18	Trace.	......	Trace.	Trace.	14.10	100.30	45.02
3†....	67.84	9.64	8.16	Trace.	......	Trace.	......	14.69	100.33	47.49
4†....	59.53	11.40	18.27	Trace.	Trace.	1.00	Trace.	9.60	99.80	41.67
5†....	68.54	10.95	8.76	Trace.	......	1.25	Trace.	10.25	99.75	47.97
6†....	68.86	12.75	7.04	Trace.	......	.70	Trace.	10.70	100.05	48.20

*Analyses by J. H. Herndon. †Analyses by L. E. Magnenat.

Localities.

No. 1. Fosterville.
No. 2. Eight miles southeast of Palestine.
No. 3. One-half mile north of Nechesville.
No. 4. North of Palestine.
No. 5. North of Palestine.
No. 6. South of Palestine.

ANALYSES OF SILICEOUS AND CONGLOMERATE ORES FROM ANDERSON COUNTY.

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Loss on Ignition.	Total.	Metallic Iron.
1 †....	38.29	53.45	3.71	Trace.	......	Trace.	Trace.	4.50	99.95	....
2 *....	60.05	24.48	....	......	......	......	......	......	....	42.04
3 †....	62.42	17.00	7.78	Trace.	......	Trace.	Trace.	13.10	100.30	43.69
4 †....	60.17	15.95	17.03	.45	.29	Trace.	......	6.60	100.49	42.11
5 †....	37.00	54.00	2.80	Trace.	Trace.	Trace.	Trace.	6.10	99.90	25.90

*Analysis by J. H. Herndon. †Analyses by L. E. Magnenat.

Localities.

No. 1. South of Palestine.
No. 2. Five miles south of Palestine.
No. 3. South of Palestine.
No. 4. South of Palestine.
No. 5. South of Palestine.

LIME.

The scarcity of limestone existing in the counties of Eastern Texas tends greatly to the enhancement of the value of deposits of even limited extent, and the siliceous character of those of Tertiary age still further limits the supply really suitable for lime. For these reasons, the limestone which has been mentioned in the description of the Saline in Anderson County has an exceptional value. It is of yellowish white color and is cut by numerous seams of pure calcspar or carbonate of lime. Although no analysis has been made of it as yet, it is certainly suited to the manufacture of lime of good quality, and as a flux for the rich iron ores of the region, so soon as smelters are erected for their utilization. It is probable, if we may judge from the extent of the outcrop of this stratum, that there is a considerable body of it; enough for the supply of the immediate vicinity for many years.

GREENSAND MARLS.

The greensand marls, as has been shown in the general section, are usually from thirty to forty feet in thickness, underlying the iron ores and overlying the gray clays and white sands. In many places, however, the bed has not its average thickness, owing to the great amount of erosion which has taken place. Thus, east of Palestine, on the road between that city and the oil wells, it is in places not more than one foot in thickness. It is found here, as at many other places in the county, as the yellow indurated variety, which is used in places for building stone.

South of Palestine the greensand marls are of similar character, although the undecomposed material, with many shells, is found in the Elkhart section below the upper indurated variety.

North of Palestine the same greensands occur for a distance of three miles, while on the west unaltered greensands with calcareous shells are found.

The soils resulting from the decomposition of these greensand marls, where they form the surface of the ground, are of red or brownish red or mulatto color, and are the most productive of all the soils of the region except those of the river bottoms.

The value of the greensands as fertilizers for the more sandy soils of the region has been stated. Even the yellow or altered greensands contain sometimes as much as four per cent of potash and ten per cent of lime, both of which are valuable ingredients for the sandy soils; the first supplying available plant food, while the lime acts upon the other mineral matters and prepares them for the use of the plant.

The special adaptability of the soil and climate of Anderson County for the raising of fruits, melons, and vegetables has been most fully proven by actual experiment. To this success the greensand soils have contributed largely, and the great extent of this formation over the county, which renders it easy of access to almost every section, and its perfect applicability as a fertilizer for the sandy fruit soils, renders the future of agriculture and fruit raising in this county one of the most magnificent possibilities. All that is required to develop this great field is the intelligent use of the materials provided so lavishly by nature.

BUILDING STONES.

The building stones of this county are confined to the indurated altered greensand marls and other sandstones.

These were fully described under the title of Building Stone in the First Annual Report of this Survey. "The greensand bed varies from thirty to forty feet thick, but it is only in parts of it that the hardening process has gone on to a sufficient extent to make it available for building purposes. These indurated places vary from one to ten feet thick. It is of a chalky or waxy consistency, dense and compact in structure, and easily shaped into the desired form. On the ease with which it can be cut, and also a certain toughness which it preserves in spite of its softness, depends its universal use wherever it can be found. It is locally known as "yellow rock," "yellow sandstone," or "gumstone." Sometimes the greensand has become hardened without losing its green color, and in such cases we have a green rock of very similar nature to the yellow one just described. Such a material is found in Doyle's Gap and on the slope of the Mount Selman iron range in Cherokee County. The glauconite in this green rock is generally mixed with a large amount of clay of the same color, and in some places the clay almost entirely replaces that mineral. This presence of clay probably accounts for the hardening of the bed, as it has acted as a cement in indurating the glauconite. Sometimes also finely disseminated carbonate of lime is the cementing material in such rock.

"The other sandstones are more limited in extent and only locally valuable, being due to the action of ferruginous solutions on the loose sands which covered the beds of ore and lie along the hillsides."

THE OIL SANDS.

"Ten miles east of Palestine is seen a series of black and chocolate colored sands, lying horizontally and containing specks of mica. They are impregnated with bituminous matter, sometimes in the form of stiff sticky asphalt and at others as mineral oil. In this neighborhood six wells were bored for oil by a Palestine syndicate in 1887, but little or no oil was found. The following two sections of borings from data collected by Mr. J. L. Mayo, contractor, show the associations of the oil bearing strata:

1.	Soil	15 feet.
2.	Rusty sand (some oil)	3 feet.
3.	Chocolate colored hardened sand	6 feet.
4.	Alternate strata of sand and clay	34 feet.
5.	Sand impregnated with oil	14 feet.
6.	Clay and sand	43 feet.
7.	Quicksand and water	6 feet.
8.	Blue lignitic clay	159 feet.
9.	Loose sand	30 feet.

1.	Rusty clay	15 feet.
2.	Quicksand	15 feet.
3.	Light colored clay	22 feet.
4.	Sand impregnated with oil	36 feet.

"Oil bearing sands were passed through in all the borings, and oil is occasionally seen in the creeks and springs of the neighborhood, but in none of the borings was it found to flow in any quantity. The reason of this is doubtless due to the fact that the oil bearing stratum has been cut through by numerous creeks, and the oil, if indeed it ever did exist in any quantity, has been drained off.

"The asphalt is probably due to the oxidation of the residuum of oil left in the sand. In many places the summer heat has softened it and caused it to run out of the sand, forming small pools on the hillsides.

"This is especially true where the bitumen bearing bed has been exposed on the surface (as it often is) and subjected to all the atmospheric influences. The amount of asphalt which could be obtained in this locality is not very large, and the asphalt bearing sand is apt to run into oil bearing sand, so that the quantity in any one spot is very uncertain. There is, however, enough of the material to be used for paving in the surrounding towns of Palestine, Jacksonville, New Birmingham, Rusk, and other places, and if the asphalt sand was used in its natural state on the streets and pavements it would greatly increase the welfare and comfort of these towns."

CLAYS AND LIGNITES.

These materials exist in quantity and of excellent quality in Anderson County, but the Survey has not yet made any detailed investigation of them.

MINERAL SPRINGS.

"Elkhart Wells are one mile southeast of the town of Elkhart, in Anderson County. They vary from thirty to sixty feet in depth, and have been sunk for the sake of the mineral waters they contain. A hotel is being built here and a health resort started. Some of the waters are comparatively free from mineral matter, while others are strongly impregnated with iron, alum, and sulphur. Some of the old wells here are said to have smelled so strongly of sulphur as to have been obnoxious, and were filled up. The surrounding country is flat, low, and underlaid by sand and clay. These are brown from the presence of vegetable matter, and contain iron pyrites, lime, gypsum, and sulphur. It is doubtless to the mutual decomposition of these materials that the mineral matter in the water owes its origin. Some of the waters have a strong sulphur taste and others have the pungent effects of alum and iron salts."

THE ANDERSON COUNTY SALINE.

The description of this saline was given in the First Annual Report, page 33, and another statement of it will be found in the description of the stratigraphy of the county at the beginning of this paper.

It is only one of a series of these deposits of salt which seems to extend in two or more lines from northeast Texas in a southeasterly direction toward the Gulf.

The existence of other salines at different localities in Eastern Texas has been noticed several times in the publications of this Survey and of those which have preceded it, as well as elsewhere.

The principal salines so far described in East Texas are:

Grand Saline, Van Zandt County.

Steen Saline, Smith County.

Brooks Saline, Smith County.

Saline, Anderson County.

Saline, Freestone County, two miles east of Butler.

The conditions surrounding these salines are very nearly the same in all instances. There is generally a depression surrounded by wooded hills in which are found limestones of white or gray color. The depression is sometimes marshy, or during the winter months holds a body of water of greater or less extent, which evaporates as the summer approaches and leaves an incrustation of salt on the ground.

The limestones are white to grey in color, and are sometimes quite siliceous, and sometimes they are glauconitic. They are characterized especially by the seams of calcite they contain, and are proved by their fossil contents to be the equivalents of the Ripley group (Cretaceous) of Mississippi. The underlying clays belong to the Ponderosa Marls, numbers of this oyster being found at different places in them.

Surrounding these salines on every side we find strata of Tertiary age, and the salines themselves are therefore in the nature of Cretaceous inliers in that formation. They represent islands in the Tertiary sea formed by projecting eminences of the underlying strata of Cretaceous age.

These salines occur also in Louisiana, where they have been studied by E. W. Hilgard and F. V. Hopkins.* "The only known exposures of the limestones are at Winfield and near Chicot, in St. Landry's parish. The same strata, however, come very near the surface at all the various salt wells in Bienville and Winn parishes, and is the formation to which the sulphur of Calcasieu and the rock salt of Petit Anse belong."

Hilgard regards the series of Cretaceous inliers "which traverse Louisiana from the head of Lake Bistenau in a south southeast direction, terminating probably in the great rock salt mass of Petit Anse" as representing "summits of an (more or less interrupted) ancient ridge, a kind of backbone to the State of Louisiana, whose resistance to denudation has measurably influenced the nature and conformation of subsequent deposits."† The connection between these salines and the strata containing them and the deposits of oil, sulphur, and gypsum existing in southwestern Louisiana is well worthy of notice.

* First Annual Report Geological Survey of Louisiana, F. V. Hopkins, M. D., p. 206.

† Geol. Hist. of the Gulf of Mexico, A. J. S., vol. 2, Dec. 1871, pp. 209, 210.

At the sulphur mine in Calcasieu Parish the boring of a well twelve hundred and thirty feet deep showed oil for the first three hundred and eighty-three feet.

"The evidence of oil consists in a number of black banks of hardened bitumen on the northern border of the marsh prairie and on its surface; also quite a number of bubbling springs, emitting an inflammable gas; and crude petroleum may be found by walking over the marsh. So abundant is this natural discharge of crude oil that the log haulers for miles around obtain their only supply of lubricating material from these springs. And yet the boring made in one of the most promising spots, to obtain a more abundant flow of oil, was almost entirely unsuccessful. The oil was at one stage of the boring, obtained in considerable quantity, but was soon exhausted. The well was continued still further down into the bowels of the earth, and instead of more oil the marvelous deposit of sulphur now so well known throughout the State was discovered."* The sulphur is of unequaled thickness and purity, and the gypsum, which is over five hundred feet thick, is also pure.

The existence of similar areas and conditions in East Texas, and the discovery of rock salt underlying Grand Saline, in a deposit nearly a mile in length, and over two hundred feet thick, are ample encouragement for the expenditure of the money necessary to sink trial wells in every such locality known in the State.

* Second Annual Report Louisiana State Geological Survey, F. V. Hopkins, M. D., p. 39.

CHAPTER XIII.

HOUSTON COUNTY.

BY E. T. DUMBLE.

Lying immediately south of Anderson County, and situated like it between the Trinity River on the west and the Neches on the east, is Houston County. This county, which has a total area of eleven hundred and seventy-six square miles, is bounded on the south by Trinity County, and is the most southwestern county of the iron ore district, as far as we were able to ascertain during the past field season.

Its topography somewhat resembles that of Anderson County, particularly in the northern portion, where the formations are a continuation of those described in that county. In the south, however, beds of a newer formation appear, and with different conditions a somewhat different topography exists.

The divide between the Trinity and Neches rivers is an elevated ridge or backbone running approximately north and south through the centre of the county, and the general surface of the country is rolling, and even becomes quite broken and hilly in the northern portion. There are several small lakes in the county, and the creeks, which are slowly cutting into the dividing ridge, flow southeast and southwest respectively to the rivers which bound it. Many of these creeks are well supplied with fish and differ from the streams further west in that they are never-failing. The principal tributaries to the Neches are Cochino, Hickory, Camp, Piney, and San Pedro creeks, while on the west we have the Big Elkhart, Little Elkhart, Hurricane, Caney, Negro, White Rock, and Tantobrogue flowing into the Trinity.

About one-fourth of the entire area of this county is prairie land, scattered here and there in small bodies, while the balance is covered with timber, some parts of it being heavily wooded with various kinds of oak, pine, ash, and hickory, with some pecan along the Trinity River.

According to the report of the Department of Agriculture for last year there was only eight per cent of the total acreage of the county under cultivation. Corn, cotton, sorghum, oats, and sweet potatoes are the principal crops, but orchards are being planted, and the entire suitability of the soils of certain localities for this purpose, and the presence of greensand marls for fertilizing, offer every condition of success for this industry.

The soils of this county, depending as they do on the varied underlying geological horizons, are of considerable diversity. The soil of the prairies varies from a sandy to a clayey loam. The timbered lands in the valleys vary from light brown to chocolate loams and clay soils, while the uplands are principally covered with gray sand. Probably the larger portion may be classed as sandy, although considerable areas exist of black, red, and gray loams. With the exception of soils resulting directly from the weathering of the greensand marls themselves, which are the very best of soils, the sandy soils fertilized with the greensand are best adapted to fruit culture.

IRON ORE AREAS.

The only iron ore areas so far examined in this county are found in a series of oval shaped hills which extend in a northeast and southwest direction across the county north of Crockett.

GENERAL GEOLOGY.

In this county, so far as our investigations have shown, we have represented only strata of the Tertiary and Quaternary age.

The general section is:

QUATERNARY	Orange Sands.
TERTIARY	Iron Ores. Fayette Beds. Timber Belt Beds.

QUATERNARY.

The gray sands, the mottled and sandy clays, and the yellow sands, which in so many places are the surface formation of the county, are of Quaternary age. Too little study has been done on them as yet to enable us to fully define them, or to distinguish in every instance between these and some beds of very similar appearance and composition which are earlier.

THE IRON ORES.

It is very possible also that a part of the deposits of iron ore which are found capping the hills or scattered along their sides belong to the same period. Part of them might possibly be assigned to the Fayette beds, making them the equivalent of the sandstones of that formation. The grounds for such a reference are, however, seemingly entirely insufficient, and unless future investigations add stronger reasons for this correlation than have yet been brought forward it will hardly be tenable. The principal reason for even suggesting such a correlation is the occurrence of a belt of ferruginous material at the contact of the clays and sands of these beds which closely resembles some of the conglomerates and siliceous ores of this region. The greater part of them are probably remnants of the Tertiary deposition.

FAYETTE BEDS.

The Fayette beds, which consist of thinly stratified clays of light colors (watery green, light blue, cream color, and nearly white, rarely chocolate), and frequently showing thin coatings of sulphur where they are exposed in cuts or washes, cover about two-fifths, the southern portion, of the county. The line of contact between these beds and the underlying Timber Belt strata crosses the International and Great Northern Railway at or near the station of Paso.

The difference in the character of the two divisions of the Tertiary is so strongly marked as to be recognizable at a glance. In addition to the difference in color and in general appearance, the presence of silicified wood in quantities is a marked feature of these Fayette beds. These beds, so far as they have been examined, present no difference worthy of note from the description given of them by Dr. Penrose in the First Annual Report of this survey, page 47, *et seq.*

TIMBER BELT BEDS.

The materials comprising the different strata of this division, although they are covered in many places to a less or greater depth by deposits of a later date, extend over the greater part of the county. They are:

Gray and brown laminated plastic clays. Dark brown, greenish gray, and lead black plastic clays with white limestone concretions. These concretions are soft and jelly like when freshly exposed but crack on drying, and in some cases the cracks are filled with calcspar. This bed also contains some silicified wood.

Greensand marls. These beds of greensands, which are glauconite mixed with green clay, often altered to brown by oxidation of the iron, contain many masses filled with fossil shells. In some instances the original calcareous matter of the shell is still preserved, although in a somewhat decomposed condition, while at others there is nothing remaining but casts of the shells.

White plastic clays.

This succession of strata corresponds very closely with the section observed and described at and near Elkhart, in Anderson County, beginning with No. 1 of that section.

THE IRON ORES.

The ores of Houston County, so far as they have been examined, belong to the class of "Conglomerate Ores" described by Dr. Penrose in the First Annual Report of this Survey. The few specimens which were secured in the very hasty trip I made into the county are rather siliceous, and range from thirty-five to about forty per cent of metallic iron in the different samples taken. Other ores, seemingly of better quality, were sent me after my return to Austin, and it is probable that the more detailed investigation to be made during the coming field season will show ores of workable purity. In order to bring ores of such quality as are here shown by analysis to a workable grade (compared with the massive and laminated ores of other counties of the district) it would be necessary to crush and wash them, in order to get rid of the excess of silica, which should not be more than ten or twelve per cent. So far as the other deleterious substances, such as sulphur and phosphorus, are concerned, these ores compare very well with the general average of Texas ores, even if they are not a little above it.

The following table of analyses, made in the laboratory of the Survey, of specimens collected by myself from localities northwest and northeast of Crockett, represents the character of the ores so far as examined up to this time.

ANALYSES OF CROCKETT COUNTY IRON ORES.

No.	Silica.	Ferric Oxide.	Alumina.	Lime.	Sulphuric Acid.	Phosphoric Acid.	Loss on Ignition.	Total.	Metallic Iron.
1062*	36.75	51.46	5.24	0.82	0.40	0.49	4.90	100.06	36.02
1063	32.60	55.04	4.56	0.60	0.19	0.20	6.70	99.89	38.53
1064	37.10	50.91	4.09	1.15	0.47	0.17	6.10	99.99	35.64
1065	33.92	54.21	4.19	1.00	0.59	0.28	6.10	100.29	37.94

*Analysis by J. H. Herndon.

Localities.

No. 1062. Twelve miles northeast of Crockett.

No. 1063. Near Davis' Creek.

No. 1064. Twelve miles northeast of Crockett.

No. 1065. Eight miles northwest of Crockett.

SOILS.

Houston County has a variety of soils, as has already been stated. They can, however, be divided into four general classes:

Gray sandy soils .... Upland soils.
Mulatto soils .... Lowland soils.
Red sandy and red clayey .... Lowland soils.
Chocolate soils .... River bottom soil.

"The river bottom soils, or chocolate lands, are found along all the rivers, and are alluvial. They vary from the clayey to the sandy class, but generally belong to the former, differing a little in color according to the local presence or absence or iron. They are frequently highly calcareous, especially along the larger rivers, which having previously flowed over vast areas of calcareous rocks in the prairie region, have become highly charged with carbonate of lime. When the rivers rise in the wet season they overflow this bottom land, leaving a sediment of rich calcareous clay, which adds greatly to the fertility of the soil. The red clayey, the red sandy, and the 'mulatto' soils are extensively represented in East Texas, and form some of the richest lands of the region. They are not sharply divided from each other, but gradually blend together. They are underlaid by the clay and sandy strata of the Timber Belt beds, and owe their color to the decomposition of glauconite and other iron bearing minerals.

"The 'mulatto' soils are of a brownish red color, and are generally the result of the decomposition of the large glauconite beds of the region, and as they contain the fertilizing ingredients of that mineral they are very productive. Next to the river bottom lands, they are the most productive soils of East Texas, and are extensively developed in Anderson, Smith, Cherokee, Rusk, Gregg, Harrison, and other counties.

"The upland soils or gray sandy lands cap the high plateau country. They are of a gray or buff color on the surface, but one-half to two feet below the sand becomes much more mixed with clay, and is often stained red by iron. The gray surface soil blends into and is doubtless derived from the red subsoil, but has lost its iron by the leaching action of carbonic acid solutions. The clay has also been carried away on the surface by the action of rain water. The early settlers avoided these high sandy lands, as they were considered barren and worthless. But with an increase of population came an increase in the value of land, and a corresponding necessity to use all available soils. Then it was that these uplands were tried and found especially well adapted to the cultivation of fruit."

The following analyses of gray sandy upland soils and subsoils from this region give a fair idea of their composition. They are taken from analyses published by Dr. Loughridge, in the Tenth Census Report, on "Cotton Production in Texas:"

ANALYSES OF GRAY SANDY UPLAND SOIL AND SUBSOIL.

	Soil.	Subsoil.
Insoluble	92.943	79.954
Soluble silica	1.009	1 251
Potash	0.111	0.069
Soda	0.093	0.060
Lime	0.147	0.168
Magnesia	0.077	0.012
Brown oxide manganese	0.051	0.170
Peroxide of iron	1.614	8.478
Alumina	1.470	6.078
Phosphoric acid	0.193	0.194
Sulphuric acid	0 020	0.006
Water and organic	2.201	4.109
	99.929	100.547

ANALYSES OF GRAY SANDY SOILS (UPLAND).

	Wood County. Soil.	Smith County. Soil.	Subsoil.
Insoluble silica	93.051	94.350	93.458
Soluble silica	3.364	0.525	1.820
Potash	0.114	0.111	0.148
Soda	0.074	0.105	0.080
Lime	0.031	0.076	0.090
Magnesia	0.061	0.061	0.031
Brown oxide manganese	0.111	0.040	0.121
Peroxide iron	0.611	2.050	2.337
Alumina	0.908	0.303	0.779
Phosphoric acid	0.169	0.237	0.295
Sulphuric acid	0.012	0.031	0.105
Water and organic	0.611	2.035	0.911
	99.117	99.926	100.175

Taking Professor E. W. Hilgard's determinations as to the amounts of potash, phosphoric acid, and lime which are necessary to secure fertility and lasting qualities to a soil, we find that in these soils (second table of analyses) the percentage of potash is quite low, being barely above the lowest limit needed in fertile soils. The lime, which if present in sufficient quantity would in some measure make up for the deficiency in potash, is present in such small amounts as to be insufficient to even render available for plant food the phosphoric acid which exists in the soil.

This ingredient (phosphoric acid) is, however, in rather larger quantity than usual, and to its presence and amount is largely due the fertility and durability that the soils do possess.

But these are not the only soils which do not contain these essential ingredients in such quantities as will secure the durability so desired. This will be readily seen by an examination of the red sandy and clayey soils. This soil, which was taken as characteristic of this class by Dr. Loughridge, is described by him as "a dark loamy soil near Palestine, Anderson County, subsoil eight to twelve inches."* (First table of analyses.)

Both the soil and subsoil are deficient in the amounts of potash they contain, although they have fair percentages of phosphoric acid and lime. Not sufficient, however, to make up for the small amount of potash.

The mulatto soils are more nearly the ideal in composition, although they vary considerably, as will be seen by the analyses given below, which were made at the Survey labratory at the Agricultural and Mechanical College by Mr. P. S. Tilson.

*Page 25 Cotton Production U. S.

[NOTE.—Heading of analyses of page 322 should be "Red sandy and clayey."]

ANALYSES OF MULATTO SOILS.

	Soil.	Sub-soil.
Moisture and volatile matter	6.10	10.39
Soluble silica	0.23	0.25
Insoluble silica	72.09	59.14
Oxide of iron	16.39	25.73
Alumina	2.78	3.14
Phosphoric acid	0.23	0.44
Lime	0.28	0.16
Magnesia	0.22	0.30
Sulphuric acid	1.54	0.31
Chlorine	0.10	0.11
Potash	0.103	0.23
Soda	0.39	0.46

These soils were selected by Dr. Penrose as typical of the mulatto soils of East Texas. Their fertility as virgin soils is largely due to the percentage of phosphoric acid they contain. The percentage of potash is very fair.

This class of soils is probably the best of the county, outside those of the river bottoms, and as they are the result of the decomposition of the underlying beds of greensand marls will prove very lasting as well as fertile. Deep plowing is the best thing that can be done to increase their fertility or renew it in case of its decrease.

These soils, however, are not the prevailing ones of the county, and it is therefore most important that means be found to increase the fertility of the two other classes described, and to add to their durability.

Our analyses show us that the phosphoric acid, one of the most needful elements, is present in sufficient quantity in all these soils; that it is lime and potash in which they are deficient. If, therefore, these elements can be supplied in proper quantity at a reasonable outlay, we will be able to correct the inequalities and secure a soil fully up to the ideal, which will be both fertile and durable. Such a source of supply exists throughout the northern portion of the county in the deposits of greensand marls which are found exposed in the various creek valleys and on the hillsides. It is not all equally valuable. Parts of it have been more altered than others, and the potash, if present originally in large quantity, has been removed by solution. Other portions contain few shells and are low in the percentage of lime. There are localities, however, where in the unaltered greensand marls we find as much as four, five, and even six per cent of potash, and up to ten and twelve per cent of lime. The following analyses, by Mr. L. E. Magnenat, of greensands from Houston County only represent two localities, and were not selected on account of their probable value, but for their proximity to the place at which it was desired to use them.

ANALYSES.

	No. 556.	No. 1058.
Silica	13.77	42.10
Ferric oxide and alumina	35.40	37.02
Lime	19.93	5.80
Magnesia	3.78	0.86
Carbonic acid	13.30	......
Phosphoric acid	0.51	0.32
Sulphuric acid	0.49	......
Potash	......	2.14
Soda	3.54	......
Ignition	9.40	11.80
	100.12	100.04

The first of these, owing to the amount of lime it contains, is well adapted for use on the sandy soils wherever it can be hauled at the rate of three or four trips per day. At a greater distance it would hardly be profitable to haul it.

The use of this greensand on the gray sandy and the red sandy or clayey soils must be attended with the greatest benefit. The amount of lime contained in it will not only act as a fertilizer itself, by making up for the deficiency of potash, but will help to render available the abundance of phosphoric acid present in these soils. While the percentage of potash in the marls analyzed is not large, other localities will probably furnish beds richer in this important constituent.

The manner of applying this marl and its action on the soil has been explained both by circular and in the first part of the present Report, and it is therefore hardly necessary to repeat it here.

Too much stress can hardly be laid upon the availability of this marl for the purpose desired. It is true that it is not equal in some respects to the famous greensand marls of New Jersey, but on the other hand the soils for which it is wanted are different also, and it does contain just those elements of fertility that are lacking in these soils.

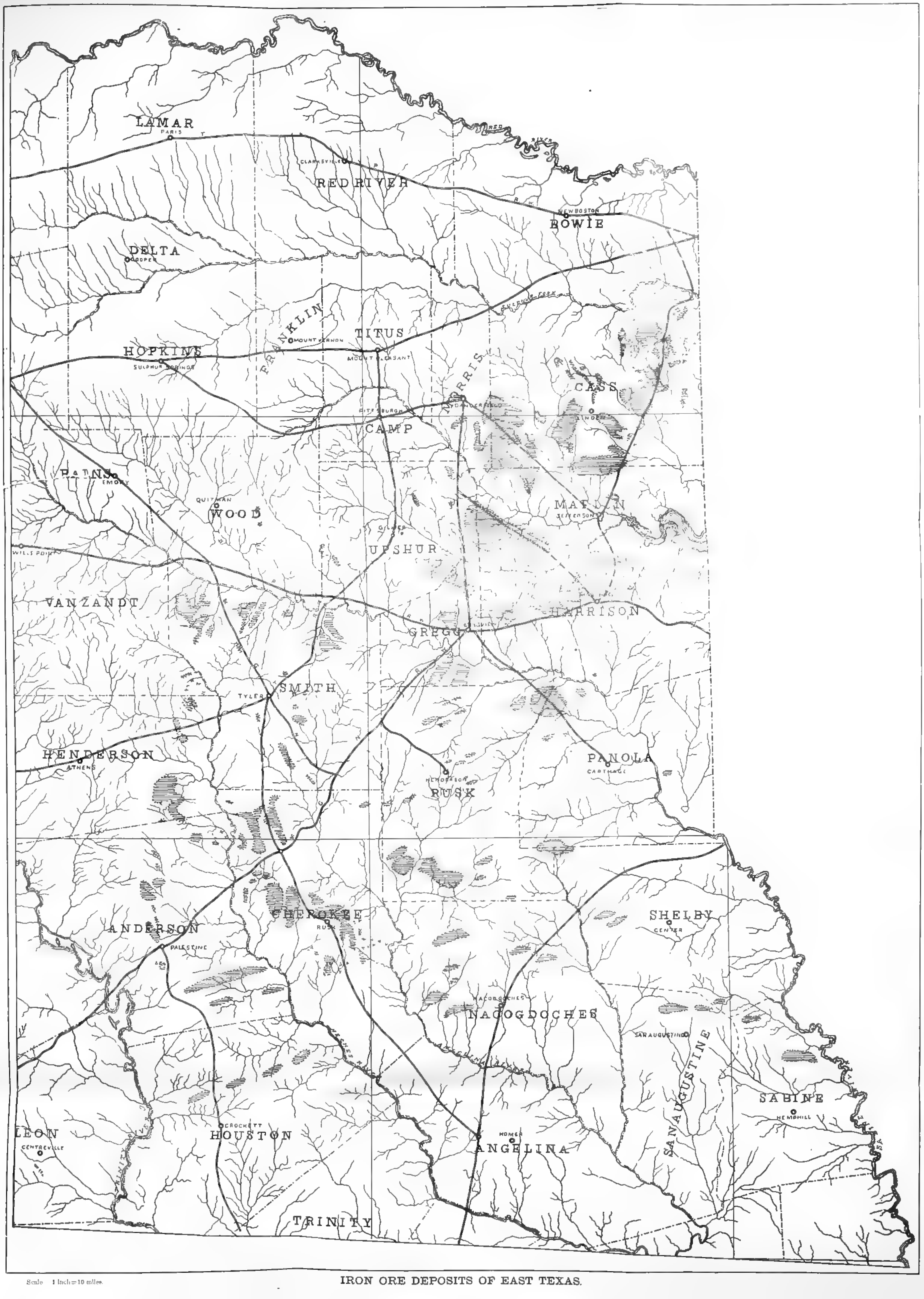
Taking into consideration the widespread deposits of the greensands, which secures their existence within hauling distance of almost all the localities requiring them, their perfect adaptability for increasing and renewing the fertility of the soils most needing them, and finally the fact that the entire cost necessary is that of digging and hauling and applying them, it would seem that there must be an immediate effort on the part of the East Texas farmers to reap the benefits that will so surely follow upon their use.

BUILDING STONES.

The indurated greensands and some of the later Quaternary sandstones yield excellent building material in this county. Some of it is of good color, and it has been successfully used in many buildings in and around Crockett.

MINERAL WELLS.

Like all other sections covered by the strata of the iron ores and lignite formations, Houston County has its share of mineral springs and wells. Some of these have already secured some reputation as medicinal waters, and it is probable that when they are properly studied and reported on they will become more fully appreciated even than they now are.



Scale 1 Inch = 10 miles.

IRON ORE DEPOSITS OF EAST TEXAS.

CARBONIFEROUS CEPHALOPODS.

BY

ALPHEUS HYATT.

CARBONIFEROUS CEPHALOPODS.

BY ALPHEUS HYATT.

The following descriptions, accompanied by figures in outline, were taken from a collection forwarded by Mr. E. T. Dumble, State Geologist of Texas, and other fossils which were in my possession as loans from the National Museum and various persons referred to in the text. These forms being extremely limited in their chronological distribution, and therefore very helpful in distinguishing the age of the rocks in which they are found, it was thought best to have them all published in one treatise. This proceeding also enabled the author to make more satisfactory comparisons, and as these comprise a larger number of species than has yet been got together in a single publication it will be more satisfactory to working geologists.

NAUTILOIDEA.

Temnocheilus Conchiferous, n. s.

Loc. Texas.

Coll. Geol. Survey of Texas.

Figs. 23, 24, natural size.

Figs. 23, 24.

This is a small species having an exceedingly thick shell. The sides are decidedly convex and ornamented with short, thick, heavy-looking, fold-like pilæ, which are prolongations of the thick, heavy, but not very prominent nodes on the edges of the abdomen. The shell is so thick that in some casts of the interior, as in the figure given above, these nodes are not visible, and in others they are only slightly indicated. The surface appears to have been smooth with the exception of these nodes and pilæ, but this could not be observed satisfactorily. The increase by growth in the transverse diameters is exceedingly rapid, whereas the vertical diameters increase slowly by growth. The abdomen is much depressed, almost flattened along the centre, becoming strongly convex only near the outer edges or sides. The sides, as in all the species of this genus, converge very rapidly towards the umbilici.

The living chamber expands very rapidly and continuously outwards to the aperture in its transverse diameters, and varies from somewhat more than one-fourth to somewhat less than half of a volution in length. The aperture has a very shallow broad ventral, and lateral sinuses. The impressed zone on the dorsum is well marked, but the involution covers only the central part of the abdomen, leaving the whole area of the sides and the edges of the abdomen exposed.

The sutures have broad and very short ventral and lateral lobes, and corresponding saddles at the angles of junction of the abdomen and sides; dorsal sutures were not observed. The siphuncle is of medium size and somewhat above the centre. The figure is approximately natural size.

TEMNOCHEILUS FORBESIANUS.

Nautilus Forbesianus. McChesney, Trans. Chicago Acad., I, Pl. 3, Fig. 4a–b.

Loc. Texas.

Coll. Geol. Surv. of Texas.

The fossil No. 289a has exactly the form in section of the whorl, the large nodes, and sutures of this well known Carboniferous species. Its other affines are also Carboniferous. It resembles the *Nautilus Acanthicus*, Marie Tzwetaev,* from the Upper Carboniferous in Russia, but from this it differs in the sutures, which are less sinuous on the sides, more closely arranged, and it is supposed that they do not have an annular lobe, which is a minute acute or V-shaped dorsal lobe in the centre of the larger dorsal lobe, although this fact was not ascertained. The sutures also resemble those of *Nautilus Coxanus*, Meek and Worthen,† but the nodes are larger and less numerous, the ventral (outer side) is broader in proportion and also not so evenly and prominently convex. It differs from *Temnocheilus latus*, and *Winslowi*, Meek and Worthen,† in having a whorl less depressed in proportion to its breadth—that is, the abdomino-dorsal diameter is longer in proportion to the broadest transverse diameter of the whorl in adults, and the nodes are less prominent. Otherwise it approximates so closely to *Temnocheilus latus* of the Carboniferous of the Illinois Survey, and also of the Belgian Survey, that it might be readily mistaken for the young of that species.

TEMNOCHEILUS LATUS, Meek and Worthen.

Loc. near Oswego, Kansas.

Coll. National Museum.

This is a much compressed and distorted fossil in shaly limestone, having a

*Cephalopods de la Section Superieure du Calcaire Carbonifere de la Russie Centrale, Mem. de la Comite Geologique, V, No. 3, 1888, Pl. 1, Fig. 1–2.

†Geol. Survey of Illinois, V.

line of huge tubercles and an aspect similar to that of *Temnocheilus latus* or *Winslowi*. This in common with a number of others here described from this locality were collected and presented by Dr. W. S. Newlon.

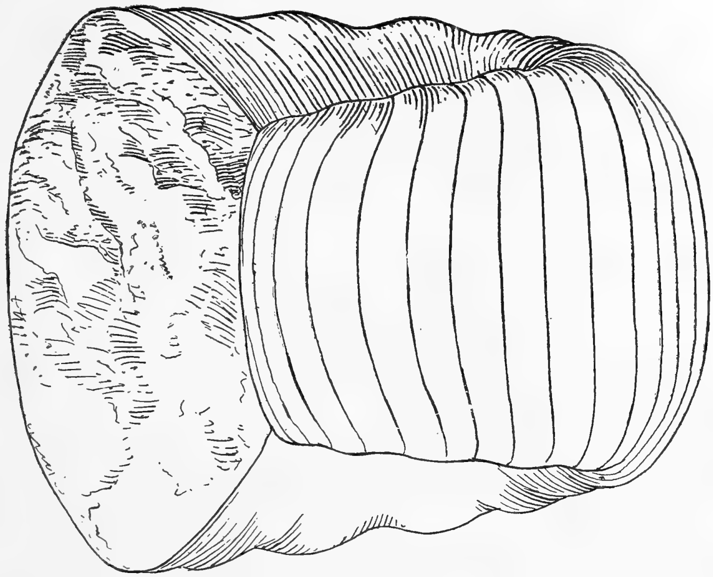


Fig. 26.

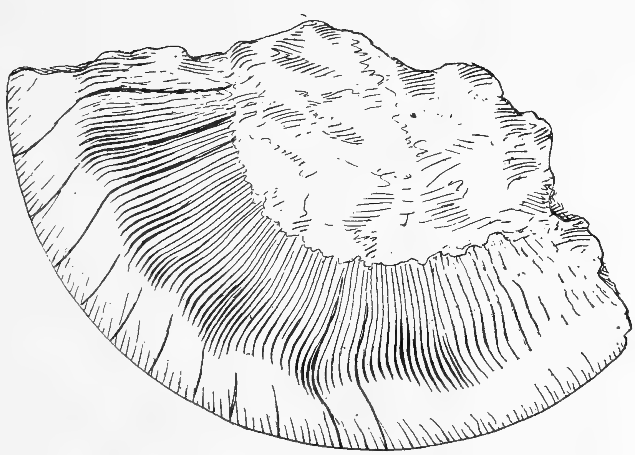


Fig. 25.

TEMNOCHEILUS DEPRESSUS, n. s.

Near Oswego, Kansas.

Coll. National Museum.

Figs. 25, 26, natural size.

The young of this fossil was not visible, the whole umbilical area being concealed on both sides by matrix. The sides are very narrow, convex, and very abruptly convergent to the umbilici. Their junctions with the abdomen are subangular, with a row of obscure elongated nodes, which are more marked on the shell than on the cast, and better marked on one side than on the other. The shell has fine striæ of growth almost straight or only slightly concave on the sides and bending backwards on the abdomen to form broad and apparently deep sinuses. These sinuses are, however, much broader in proportion and not as deep apparently as those in the striæ on the abdomen of *Tem. crassus.*

The sutures are only slightly concave on the sides and have very broad and extremely slight lobes on the abdomen. They are numerous, and the interspaces of the air chambers quite narrow. The tubercles are more obscure than in other species on the cast and also less prominent on the shell; the air chambers are also narrower than usual in species of similar proportions. It is similar to *T. conchiferus* in the slight character of the nodes and transverse section of whorl, but the increase by growth is less, in *T. conchiferus* the nodes extend internally across the longitudinal axis of the whorl, whereas in this species they extend parallel with that axis, and the shell is thicker in *conchiferus.*

It is closely similar to *Temnocheilus coronatus* as figured by De Koninck* in his Calcaire Carbonifere; but our species has an abdomen somewhat more depressed and very much broader in proportion to the abdominal and dorsal diameter at the same age, and the nodes are less prominent. It is similar to *Tem. latus* and *Winslowi* in the transverse section of the whorls and umbilici, but the nodes are more numerous and much smaller. It differs from *Tem. Forbesianus* in having a much broader whorl at the same age and much deeper and more funnel-like umbilici, the nodes are not so heavy and are closer together, but the sutures are similar in both. No living chamber was observed. Position of siphuncle is unknown. Fig. 26 is in part restored.

* Ann. du Mus. d'Hist. Nat. de Belgique, II, Pl. 24, Fig. 2.

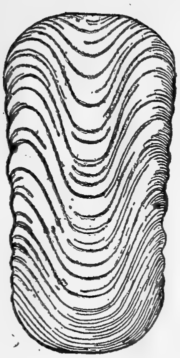


Fig. 27.

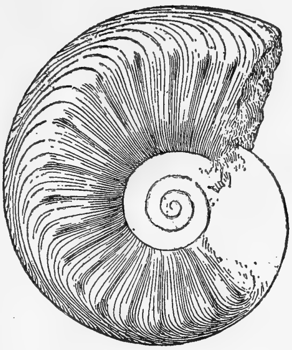


Fig. 28.

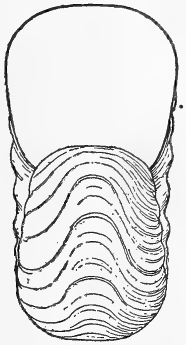


Fig. 29.

Temnocheilus crassus, n. s.

Loc. near Oswego, Kansas.

Carboniferous. Coll. National Museum.

Figs. 27–29. Magnified one-third.

This species is represented only by a fragment, but the characteristics are so peculiar that there is apparently little doubt of its being the representative of a distinct form.

The sides are convex and do not converge towards the umbilici so abruptly as in most forms of this genus. They are covered by numerous well defined straight pilæ, terminating in small nodes at the edges of the abdomen. The abdomen is convex, with a narrow slightly depressed zone along the centre. The shell is ornamented by prominent striæ of growth, and at regular intervals one of these is more prominent than the neighboring striations, showing frequent short arrests of growth. These striæ are straight upon the sides, but upon the abdomen bend suddenly posteriorly, forming wide sinuses of great depth; doubtless the aperture was similar. The sutures are almost straight on the sides and have a very broad and slight ventral lobe. Siphuncle unknown.

This shell is very similar to *Nautilus falcatus*, L. de C. Sowerby,* in so far as they both have ribs. The Coalbrookdale specimen, however, has no tubercles, or at least none are given, and the sides of the whorl are figured as concave. *Naut. Nikitini*, Tzwetaev,† is also very similar, but the ribs are less numerous and the sutures quite different. *Nikitini* has saddles and lobes as in *Tainoceras*. Living chambers were not observed. Position of siphuncle is unknown.

Figs. 27 and 28 show the fragment, and Fig. 29 is therefore in part a restoration.

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* Prestwich, Geol. Coalbrookdale, Trans. Geol. Soc. London, V, Pl. 40.

† Op. cit., Pl. 1, Fig. 5.

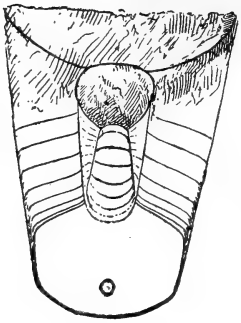

Fig. 30.

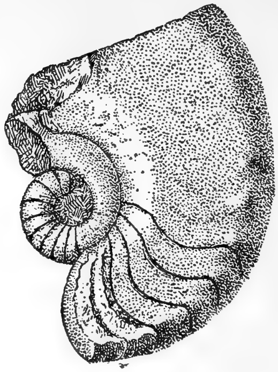

Fig. 31.

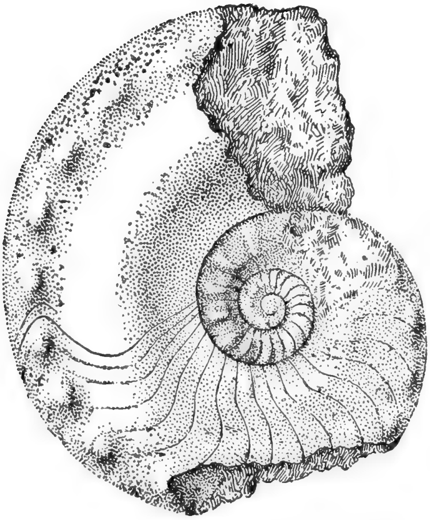

Fig. 32.

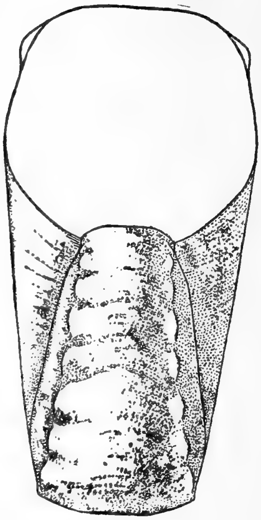

Fig. 33.

METACOCERAS CAVATIFORMIS, n. s.

Near Kansas City, Mo.

Coll. A. Hyatt and Dr. J. S. Newberry.

Figs. 30–33, natural size.

The flat sides in *M. cavatiformis* incline outwards very slightly, the umbilical shoulders are rounded, and the abdomen narrower than the dorsum. There is a row of elongated nodes along either edge of the abdomen and the central zone of the abdomen is depressed. There are slight swellings or crests on either side of the central depressed zone along the abdomen of the casts examined, but these did not have tubercles.

The whorls differ markedly from other species of this genus, and in fact it resembles *T. cavatum* closely in general aspect. It differs from this, however, in the proportionally narrower abdomen, and the umbilical shoulders are also narrower and more abrupt. The great differences are of course in the absence of abdominal tubercles and in the sutures, the peculiar broad abdominal saddles of *T. cavatum* being absent. There is a shallow abdominal lobe on the impressed zone of the dorsum. The involution does not extend beyond the lateral lines of nodes. The living chamber is probably not much over one-fourth of a volution in length, judging from the length of that in the original specimen in my collection, which has the chamber complete on the venter. The siphuncle is situated above the centre. There is also a specimen in Prof. Newberry's collection at Columbia College, New York, from Kansas City, Missouri, with an entire living chamber which is even slightly shorter than one-fourth of a volution in length.

The young as shown above in the figure of a specimen (Figs. 30, 31) from Dr. Newberry's collection, reported to have come from Miami County, Illinois, is of an entirely different appearance from the later stages, with an almost round whorl, sutures nearly straight or with only a slight abdominal saddle, shell smooth and umbilical perforation large, showing that they were true cyrtoceratites throughout the first whorl, which was not completed until the shell had reached a considerable size. The amount of involution of the younger whorls by the living chamber is exaggerated in the side view of this specimen (Fig. 31), and is better indicated in the front view of the same. The resemblance of the young whorl in outline to that of the genus Temnocheilus can be readily seen in the last figure in which the front view of the first part of the second whorl is shown. On this second whorl a single row of tubercles appears on either side, and these complete the resemblance to Temnocheilus.

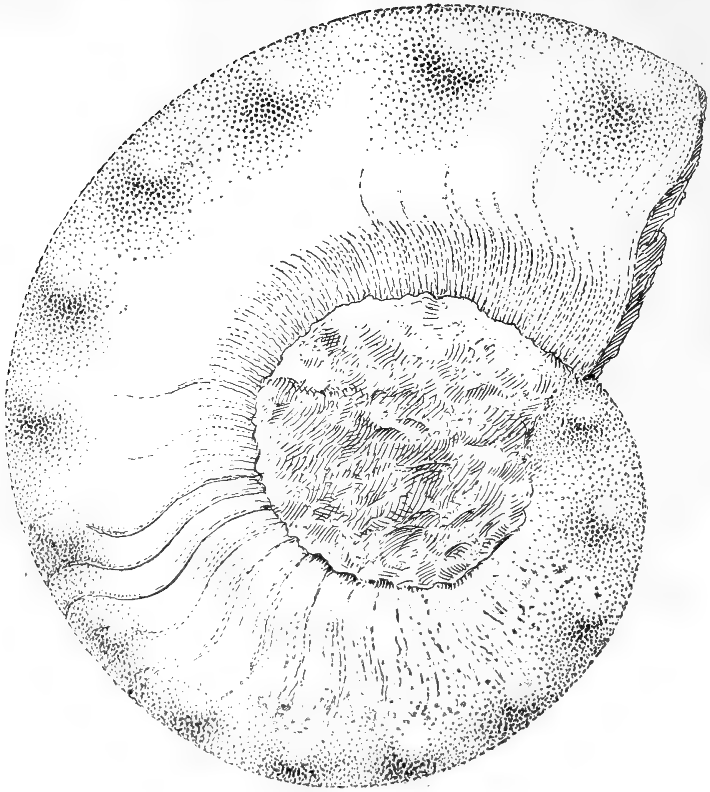

Fig. 34.

METACOCERAS DUBIUM, n. s.

Loc. Kansas.
Coll. R. Hay.
Figs. 34, 35, natural size.

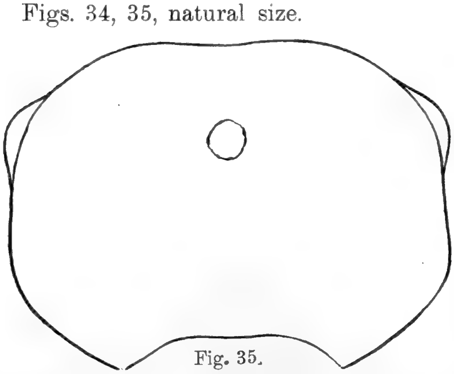

Fig. 35.

There are no lines of abdominal tubercles, only low, broad, longitudinal swellings on either side of the depressed central zone of the abdomen, and the nodes on the sides are large and prominent, as in other species of this genus. The sides, however, are narrow and slightly concave, and internally a ridge is formed on account of the suddenness with which they incline to the umbilicus at the dorsal shoulders, and inside of this there are two broad, smooth, only

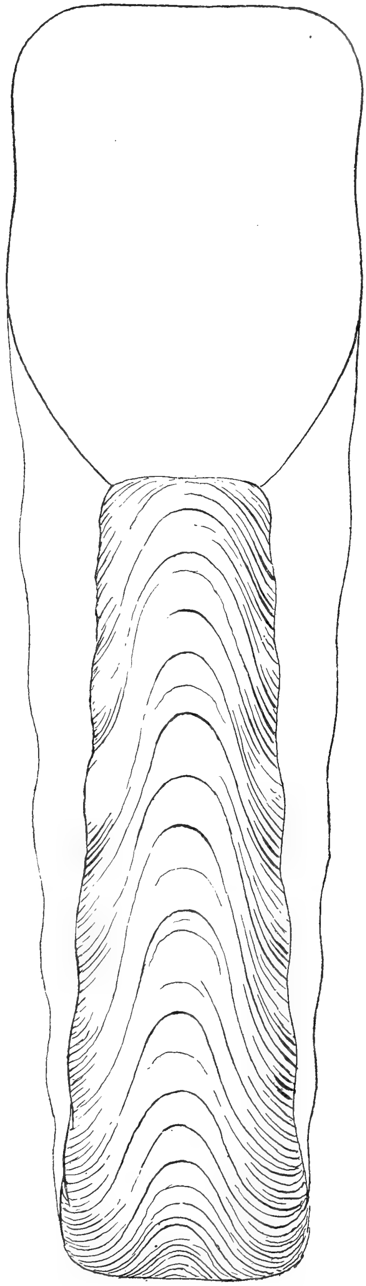

Fig. 36.

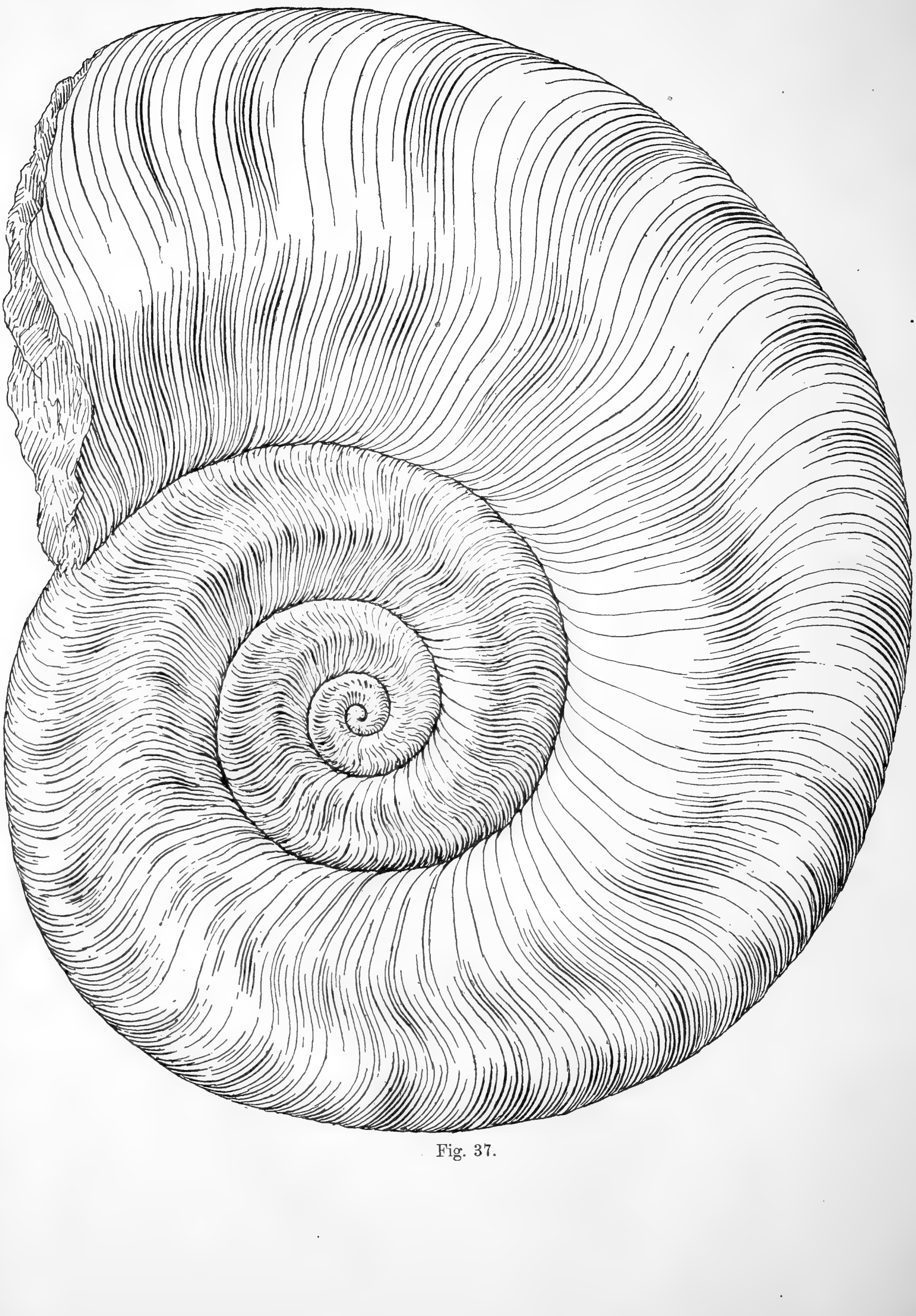

Fig. 37.

slightly convex zones on either side of the umbilical shoulders. The umbilical shoulders or crests may be slightly nodular in some specimens. There is an impressed zone on the dorsum, the involution embracing the surface of the abdomen but not covering the nodes. The transverse diameter through the umbilical shoulders is greater than that measured through the dorsal part between any two nodes in a full grown shell which has not been distorted by compression. Fig. 35.

The sutures are nearly straight or slightly concave on the inside of the umbilical shoulders, with a shallow lobe on the dorsal zone, slight lateral lobes on the sides, and small saddles at the junction (genicular crest) of sides and abdomen. On the abdomen there are only very shallow broad lobes.

Siphuncle above the centre. Living chamber somewhat over one-half of a volution in length and still imperfect.

METACOCERAS WALCOTTI, n. s.

Loc. San Saba County, Texas.

Coll. National Museum. Collected by Dr. Newberry.

Figs. 36, 37, natural size.

This species is remarkable for the rapid increase of the abdomino-dorsal diameter of the whorl by growth. The diameter of the largest specimen is 167 mm. The dorso-abdominal diameter of the whorl at the beginning of the last quarter of the last volution is about 52 mm., and the same diameter of the corresponding part of the proximate inner whorl does not appear more than half as great, 22 mm. The transverse diameter through the large outer row of tubercles is apparently about the same as that through the umbilical shoulder in the last part of the last whorl. At younger stages the whorl is evidently much less heavily tuberculated and the transverse section is probably a more or less flattened oval, with the longest diameter transverse instead of vertical as it finally becomes at older stages. It seems doubtful whether the dorsum and abdomen change much in their relations, except in so far as they are altered by the rapid growth of tubercles and umbilical shoulders. The living chamber is above one-half and may have been three-quarters to nearly a full volution in length. The shell is thick, measuring 2 mm. in thickness on the abdomen and somewhat less on the sides. Situation of siphuncle unknown. The abdomen is evenly flattened or convex, and the tubercles are on the edges of the abdomen. The elongation, prominence, and linear arrangement of these form nodose ridges. The sides are concave between these and the umbilical shoulders. The umbilical shoulders are very prominent, and form continuous broad ridges with occasional, though very obscure, nodosities where ribs springing from the genicular nodosities (outer row) cross the sides of the whorls. Between these shoulders and the impressed zone of the dorsum are broad, smooth, slightly concave zones, which are correlative with the prominence of the shoulders, and are therefore found only in the later stages. The zone of impression along the area of contact between the whorls is narrower and shallow, and probably confined to the later stages of growth; such facts, however, were not determinable with certainty.

The sutures had saddles at the umbilical shoulders, lateral lobes with slight saddles at the angles of the sides and abdomen, and a deep lobe on the abdomen. The side view (Fig. 37) is a restoration so far as the internal parts of the umbilicus are concerned, and it makes the young whorls probably flatter on the sides and more like those of the adult than they really were. The front view is in a measure also a restoration, all specimens being more or less impressed. A specimen from Texas exists in Prof. Newberry's collection which gives the sutures.

It is like *Metacoceras Sangamonensis*, Meek and Worthen,* from the Coal Measures of Illinois; but that species had very nearly the same form as the adult of this species at an age when this still had an embryonic rounded whorl. It may be the same as the *Discites tuberculatus*, Owen,† but the figure given of this last is too imperfect to admit of comparison. It resembles also the unnamed nautilus described by McChesney,‡ but this shell is much broader transversely and like *Sangamonensis* matures much earlier, and the abdomen is also hollow like the *Metacoceras tuberosus*, McCoy.‖ This last species is more like our *M. Walcotti* than any other, but differs in the hollowness of the abdomen and the less prominence of the umbilical shoulders.

There is a compressed specimen from the coal measures of Kansas, collected by Dr. W. S. Newlon, in the Coll. National Museum, which although much compressed has similar nodes and lateral ridges and is probably a variety of the same species.

The species differs from *M. Dubium* in the earlier stages, the adult characteristics being developed very late in the life of the shell, the interior whorls being rounded at a stage when in *M. Dubium* the full adult characters have been developed. *M. Dubium* is also broader transversely, and the lines of growth have only a shallow abdominal sinus, whereas in *Walcotti* there is a sinus of great depth, as in *Temnochelius crassus.*

The resemblance to *Metacoceras* (*Nautilus* (*Gyroceras*)), *subquadrangularis*, Whitefield,§ are more remote. This shell is distinctly gyroceran in its mode of coiling and the umbilical perforation is much larger and young whorls more

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* Geol. Ill., II, p. 386, Pl. 29, Fig. 3.

† Geol. Wis., Iowa, and Minn., p. 581, Pl. 5, Fig. 14.

‡ Trans. Chic. Acad., I, Pl. 3, Fig. 6.

‖ British Pal. Rocks, Pl. 3?, Fig. 15.

§ Amer. N. Y. Academy Science, II, No. 8, p. 232, Paleontology Ohio, III, vol. II, p. 16.

slender and tapering. The nodes are less prominent in *M. quadrangularis* and these disappear in adults, in which also the shell is thinner than in *Walcotti*. We have had the type of this last mentioned species for examination through the kindness of Prof. Newberry.

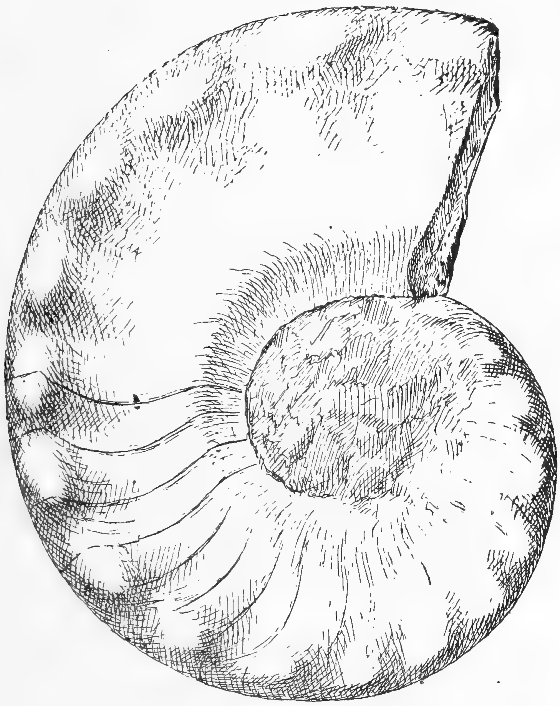

Fig. 38.

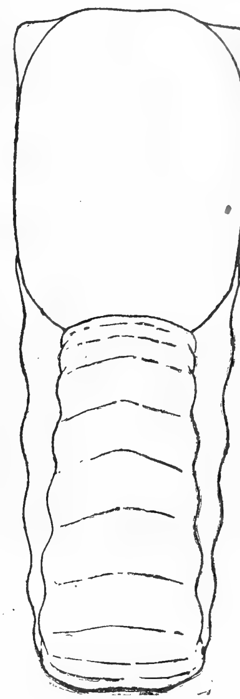

Fig. 39.

METACOCERAS HAYI, n. s.

Loc. Kansas.

Coll. R. Hay.

Figs. 38, 39, natural size.

This cast has broad flattened sides, having angular umbilical shoulders where the sides descend abruptly to the umbilici. There is an outer row of tubercles on the edge of the abdomen. These are elongated longitudinally and the depressions between them are often very distinct; the surface of the cast is otherwise smooth. The sutures have short and very broad lateral lobes with saddles at the umbilical shoulders and on the abrupt edges of the abdomen. The abdominal lobe is short and broad. It has a slight angle or V-shape in the specimen, but this is probably due to compression. The sutures just inside of the umbilical shoulders appear to be nearly straight on the nearly vertical narrow zones on either side of the outer whorl, but there is probably a shallow dorsal lobe on the impressed zone. The living chamber is about one-fourth of a volution in length and still incomplete. The specimen is much narrowed by compression, and making due allowance for this the abdomen is slightly broader than the dorsum, measuring through the umbilical shoulders, and it has been so represented in the drawing. The amount of involution is slight, the whorls being in contact only along the surface of the slightly convex abdomen, and there is consequently only a shallow impressed zone in the dorsal surface of each whorl. Nevertheless the increase by growth in the dorso-abdominal diameter of the whorl is evidently rapid.

Specimens of this and some other species were received through the courtesy of Captain George E. Pond, of Fort Riley, Kansas.

The front view (Fig 39) is in large part restored from a much compressed specimen.

Its nearest ally occurs in the Carboniferous in Russia. It differs from *Metacoceras* (*Nautilus*) *Tschernyschewi*, Tzwetaev,* in having somewhat broader sides and a narrower abdomen at the same age, and fewer tubercles. These also are elongated longitudinally, whereas in *Tschernyschewi* they are elongated transversely forming a series of rib-like folds.

METACOCERAS INCONSPICUUM, n. s.

Loc. Kansas.

Coll. R. Hay.

Figs. 40, 41, natural size.

This cast has an aspect which at first sight leads one to think it is a species of Tainoceras, but the abdominal sutures are deficient in the pair of saddles distinguishing that genus, and there are no lines of abdominal tubercles. The whorl increases in abdomino-dorsal diameters faster than *Metacocoras cavatiformis*, but not in the transverse diameters; the whorl is consequently more compressed. The umbilical shoulders are not so angular as in that species, and the sides broader and less convergent outwards, and the tubercles upon the outer border of

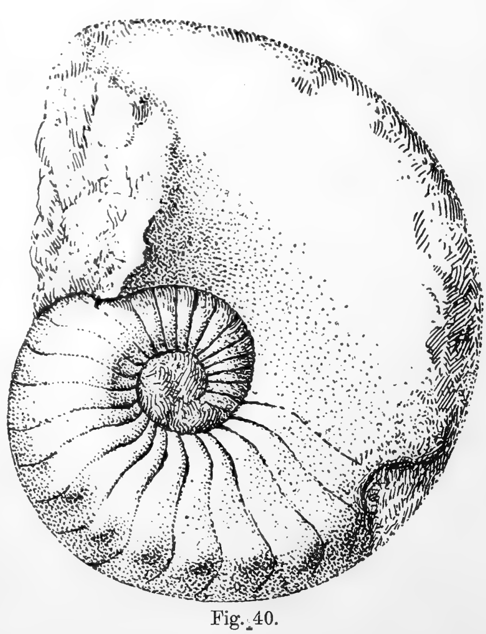

Fig. 40.

*Ceph. du Calc. Carbonifere de la Russie Centrale, Mem. du Com. Geol., V, No. 3, Pl. 2, Figs. 7–9.

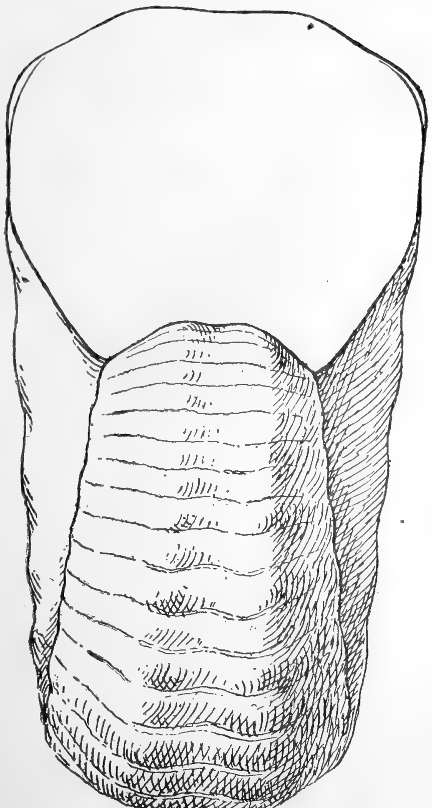

Fig. 42.

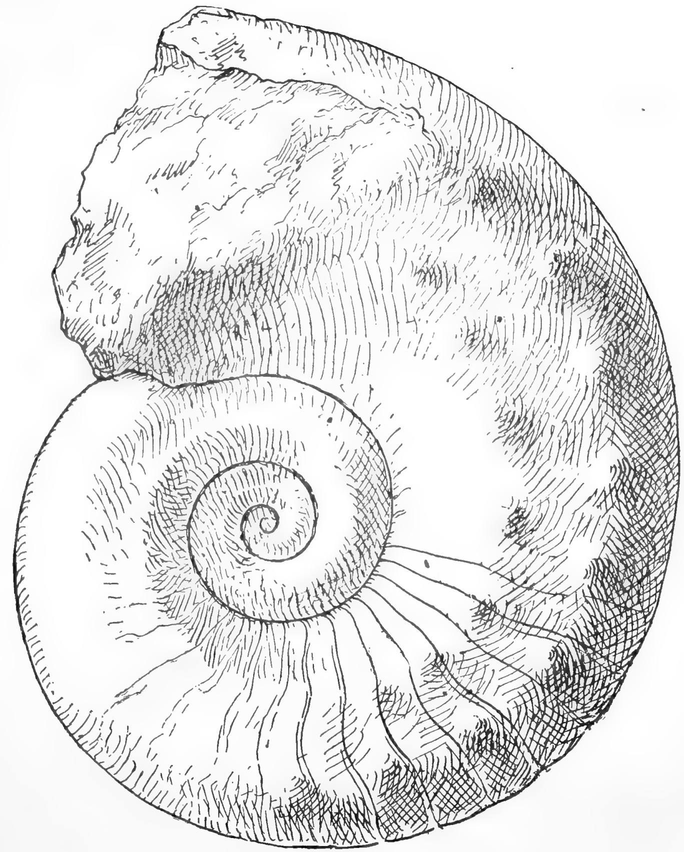

Fig. 43.

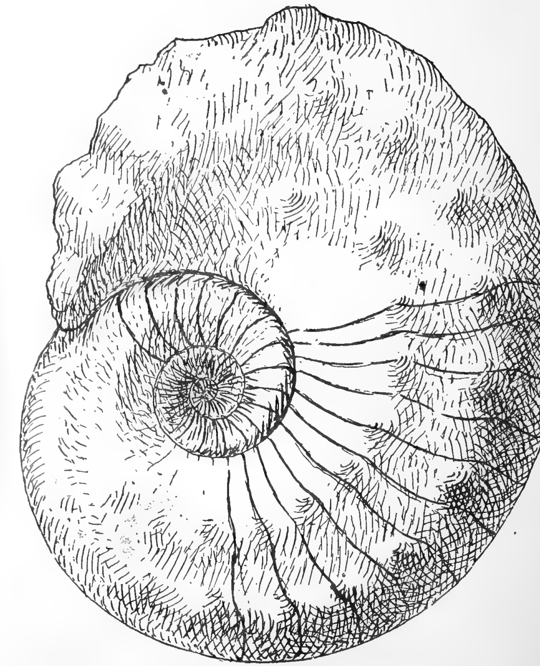

Fig. 44.

the sides are less conspicuous upon this cast. The sutures have about the same general contour as in the nearest ally just mentioned, but the lateral lobes are broader and shallower and the saddles at the umbilical shoulders are not so prominent.

The young do not seem to have the pilæ so plainly shown in the umbilicus of *Metac. cavatiformis*, but the cast may deceive the observer in this respect.

Fig. 41 represents a section of the adolescent whorl without tubercles.

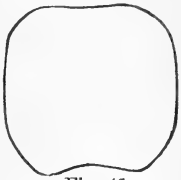

Fig. 41.

TAINOCERAS CAVATUM, n. s.

Loc. Texas.

Geol. Surv. of Texas.

Fig. 42–44, natural size.

The cast of this shell has distinctly marked lines of nodes, two on each side and two on the abdomen (outer side). The umbilical shoulders of the whorls are very broad but slightly convex and divergent. The umbilici are consequently deep and broadly coniform. The sides are flat, narrow, and not as broad as the umbilical shoulders of the whorl. The abdomen is very much broader than the dorsum and consists of three longitudinal divisions, a smooth zone on either side lying between the outer lateral and the proximate abdominal row of nodes. These two internodal zones are only very slightly convex, have no ribs, and the median zone lying between them is also free of ribs and decidedly concave. No shell was seen. The sutures are moderately closely set. The living chamber, of which the larger part is preserved, was probably, judging from markings on the cast, not less than half a volution in length. The increase by growth in the lateral transverse diameters is much more rapid than in the dorso-ventral diameters of the whorl, and the last whorl therefore grows broader quite rapidly. Siphuncle was not seen.

The smaller specimen of the two under examination is also a cast, but it shows the umbilicus quite plainly. This is deep, and the narrow, flattened sides of the later stages arise on the latter part of the second or the first quarter of the third volution.* The second volution has a very broad abdomen and convex sides dipping steeply towards the funnel-shaped umbilici as in Temnocheilus. Whether the sides had one row of tubercles along the crests at the junctions of the abdomen and sides before these began to spread out to form the flattened sides of the latter stages could not be determined—none were present on the cast. (Fig. 44.) But it is probable that the other row

*Number of volutions are estimated; the beginning of the first volution is destroyed in the fossil.

appeared before the inner lateral row during the Temnocheilus-like stage. The side view (Fig. 44) has the lower part or outer whorl much too broad, and the umbilicus consequently too narrow, but the depth is better shown than in the other figure (Fig. 43), where it is a restoration. The notable fact is the late stage at which the Temnocheilus form still characterizes the whorl and the rapidity with which the sides become flattened and assume the Tainoceran outline.

This species differs from *Tainoceras quadrangulum*, McChesney, in having a stouter whorl in all its diameters and in the sutures, especially on the abdomen (outer side). The abdominal lobe is as broad as the outer side in *quadrangulum*, whereas in this species it occupies only the longitudinal concave zone between the two rows of abdominal tubercles. It is more closely allied to *Nautilus tuberculatus*, Sow., as figured by Trautschold,* from the Upper Carboniferous of Russia, but the shell has whorls broader in proportion to the abdomino-dorsal diameter, and the nodes of the outer lateral ridges are closer together and larger. *Nautilus tuberculatus* as figured by Sowerby apparently differs in the same characteristics, but the figure is poorly executed, and I have no English specimens of this species for comparison.

This species might be supposed to be a close ally of *Solenoceros* (*Nautilus*) *Canaliculatus* as figured in the Kentucky Geological Survey,† but the sutures and all characteristics differ essentially in the adult stage, although the young are quite similar. The *Nautilus decoratus* of the Kentucky Survey‡ may also be the young of an allied species of this genus, but is evidently not very closely allied, since the abdominal depression is not very well marked in the drawing.

DOMATOCERAS, N. G.

The species representing this genus is more closely allied to forms of *Centroceras* than to those of any other genus, but these so far as known have very peculiar and distinct characteristics. Although resembling this species in the external parts of the transverse section of the whorls and in the sutures, they differ in many ways. This is a true Nautilian form, the impressed zone being a marked characteristic affecting the dorsal outlines of the sutures in this species, whereas the typical Centroceran forms are gyroceran, having the impressed zone present only in the advanced stages of growth of some forms. The nealogic stages in Centroceras remain similar to the adults of Temnocheilus for a prolonged period, and the tubercles remain prominent, even on the casts throughout the later nealogic (adolescent) and earlier ephe-

*Kalkbruche von Miatschkowo, p. 28, Pl. 3.

†Maps and Illus. of Vols. II and III, 1857, Pl. x, Fig. 3 and Fig. 3a.

‡Ibid, Pl. ix, Fig. 4.

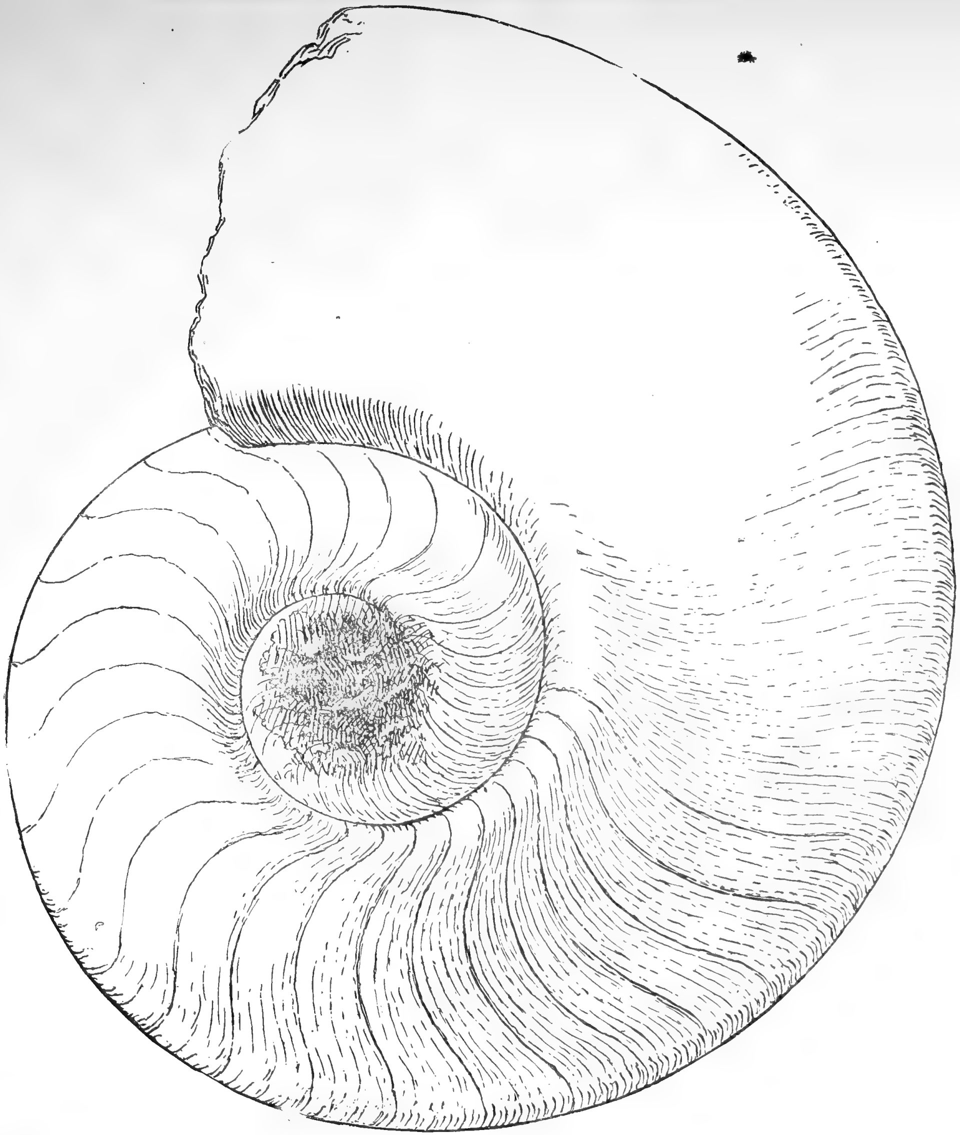

Fig. 45.

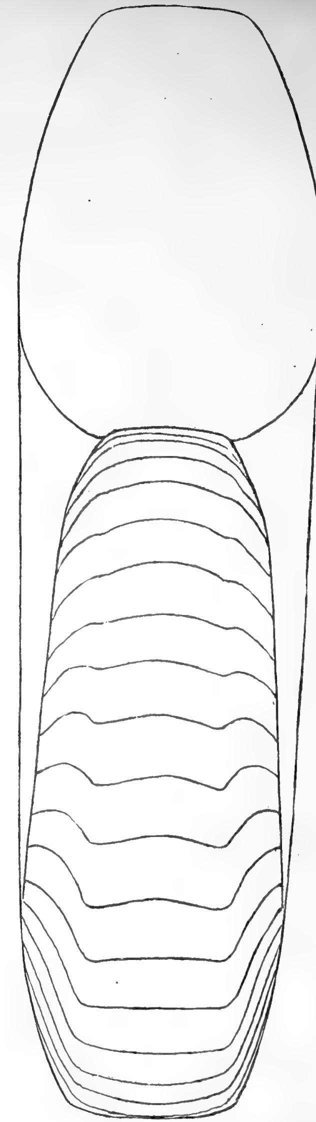

Fig. 46.

bolic (adult) stages. No tubercles were observed in *Domatoceras umbilicatum*, although it was sufficiently well preserved to have shown them had they existed. They might have been present in the earlier nealogic stages which were not visible. In Centroceras the young whorl throughout the later nealogic stages is tetragonal, but the sides are divergent, the abdomen being broader than the dorsum. In this species during the same stages the sides are nearly parallel or only slightly convergent, and the abdomen nearly equal to or somewhat narrower than the dorsum.

Centroceras (*Temnocheilus*) *Scottense* (sp. Worthen*) is a good example of the genus Centroceras, having all the characteristic markings and form of that genus.

Domatoceras umbilicatum, n. s.

Loc. Oswego, Kansas. Lower Coal Measures.

Coll. Nat. Museum, by Dr. Newlon.

Figs. 45–47, enlarged one-third. Fig. 47, natural size of living chamber at first septum.

This species reaches a considerable size, the specimen here described being about 217 mm. in diameter.

The living chamber is incomplete, and is a trifle over one-fourth of a volution in length. The narrowing of the abdomen with increase of age is very marked on the living chamber in this specimen. It measures 192 mm. in length along the abdomen, 73 mm. in the abdomino-dorsal diameter at the last septum, and about 52 mm. in the transverse diameter at the umbilical shoulders, and 34 mm. near the venter. The sides of the whorls are flattened and converge outwardly, so that the abdomen is considerably less in breadth than the dorsum in the large full grown stage. There is a shallow impressed zone upon the dorsum, which occupies about one-third of its width and is due to the slight rotundity of the abdomen and the small amount of involution in the coiling of the whorls. The umbilical shoulders stand out abrupt and broad, giving a depth to the wide umbilicus which is a marked characteristic. The sutures have shallow ventral lateral lobes. The saddles at the umbilical shoulders are broad and extend inwards to the edges of the impressed zone, and then the sutures bend toward the apex, forming a shallow dorsal lobe. There are no annular lobes in the centre of the dorsal sutures. The siphon is above the centre and is apparently nummuloidal. At the diameter of 95 mm. the whorl has the following measurements: Abdomino-dorsal diameter, 41 mm.; transverse through the umbilical shoulders, 32 mm.; and breadth of the abdomen was 25 mm.

Domatoceras (*Nautilus*) *complanatum*, sp. Sow. Min. Conc., Pl. 261, from

*Geol. Surv. Ill., VIII, Pl. 27, Fig. 3.

Isle of Man, from Carboniferous, is another form of this genus having a very slight form of involution, with a compressed whorl and sub-acute abdomen. The involution is very slight in this species, exposing all the internal whorls, but in the transverse section of the outer whorl and in the sutures it is unquestionably related to the species described above. The living chamber is over one half of a volution in length, but it is not certain from the drawing that it is completed.

The species differs from (*Discites*) *Highlandense*, Meek and Worthen,* in being much larger, in having stouter whorls. The sutures are, however, evidently very similar. *Highlandense* is described as having a narrow periphery, whereas this shell when about the same size as the specimen figured in the Illinois survey has an abdomen almost as broad as the dorsum and very much broader proportionately than in its own adult whorl. It differs from (*Naut.*) *planovolve*, Shumard,† in size and in having whorls with more rapid growth, and probably a wider and deeper umbilicus than in that species.

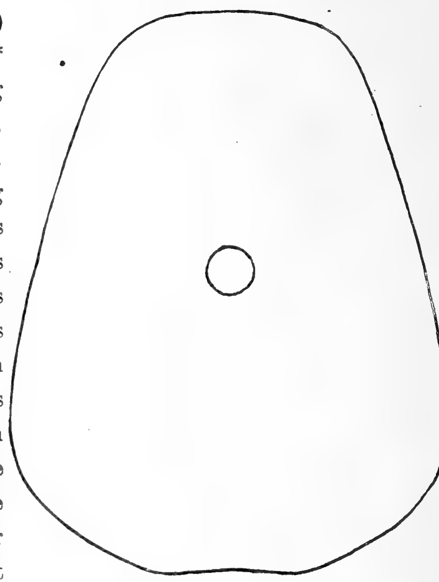

Fig. 47.

It differs from the nearest European congener, *Kon. infundibulum*, as figured by De Koninck,‡ in having a narrower abdomen and a more compressed form of whorl in the adolescent and adult stages; also in the sutures, which have a more marked abdominal lobe. It differs from *Kon.* (*Nautilus*) *podolskense*, Marie Tzwetaev,‖ in the young. This is similar to the adult in the proportions of the parts, but in *K. podolskense* the young whorl has an abdomen broader than the dorsum. The adult of this species also has a broader abdomen than the adult of our shell. The species evidently stands just between the genus represented by such species as *Kon. ingens*, *implicatum*, described by De Koninck, and *K. podolskense*, all of which have stout whorls with broad abdomens, and whorls similar to those of the young of *K. umbilicatum*, and

* Geol. Illinois, VI, p. 531, Pl. 33, Fig. 2.

† Trans. St. Louis Acad., I, p. 190.

‡ Calc. Carb., Pl. 24.

‖ Ceph. du Calc. Carb. de la Russie Centrale, Pl. 3.

those species of the same genus having more contracted abdomens, like *mosquensis* (sp. Tzwetaev), *planotergatum* as figured by De Koninck, and *Highlandense* (sp. M. and W).

The last whorl was considerably altered by compression on one side, and the drawings of the section and front view (Figs. 46, 47) are in a measure restorations.

ASYMPTOCERAS.

The *Cryptoceras Springeri*, White and St. John,* is the type of Meek's genus Solenocheilus described in the Invertebrate Paleontology,† and we quote from this volume the following: "The group for which Prof. Worthen and the writer [Meek] used the name Solenocheilus is almost entirely the same for which d'Orbigny proposed the name Cryptoceras in 1850; but d'Orbigny's name can not stand, because Barrande had used it for a genus of Cephalopoda in 1846. It is true that Barrande subsequently changed the name of his genus to Ascoceras, because Latreille had in 1804 used Cryptoceras for a genus of insects. If this was a sufficient reason, however, for changing Barrande's name, Latreille's Cryptoceras would be equally in the way of d'Orbigny's Cryptoceras; and if not, then Dr. Barrande's genus would have to retain his original name, which would render d'Orbigny's name equally untenable."‡

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*Trans. Chic. Acad., I, p. 124.

†U. S. Geol. Sur. Terr., IX, p. 491.

‡The genus *Cryptoceras* was first described by d'Orbigny in his Prod. Stratigraphique (Vol. I, p. 114), *Naut. dorsalis*, Phill. (Geol. Yorks., Vol. II, Pl. 17, Fig. 17, Pl. 18, Fig. 1-2) having been cited as the type. The name of the genus had, however, already been quoted on page 58 of the same volume, and *Naut. subtuberculatus*, Sandb., mentioned below as a member of the genus. This species would, therefore, according to a very strict interpretation of the laws of priority, have to be considered the type. D'Orbigny, however, evidently meant his description on page 114, and the species there mentioned should be accepted, and considered the first mention on page 58 as a quotation.

I followed the first course in my Genera of Fossil Cephalopods (Proc. Bost. Soc. Nat. His., XXII, 1883, p. 283, and note, p. 297), reducing Cryptoceras consequently to a synonym of *Temnocheilus*. I brought together under this name, having *Tem. coronatus*, McCoy (Syn. Carb. Foss. Ireland, Pl. 4, Fig. 15) as the type, all the Nautiloids having ventral and dorsal lobes in their sutures, the siphon close to the venter, tuberculated shells, etc. There were, however, in reality, two groups of species included under this name in the essay alluded to, Asymptoceras in part and Temnocheilus as a whole. Temnocheilus should be limited to those species having discoidal whorls and open umbilici, in which the increase of the whorl by growth was slow along the abdomino-dorsal diameter and much more rapid along the lateral or transverse diameter, especially near the angular junction of the sides and abdomen, the venter being consequently much broader than the dorsum, and the sides necessarily divergent, the umbilici deep. These also have large blunt tubercles along the angular junc-

In the Genera of Cephalopods I used the name of Ryckholt's Asymptoceras* for this same group, of which the type was *Naut. cyclostomus*, Phill. If Meek's reasoning holds good it seems to us that both the name Cryptoceras and Solenocheilus should be dropped in favor of Asymptoceras. The whorls increase very rapidly in all their diameters, and the living chambers are corellatively short. The sides and venter are usually gibbous; the dorsum has either no impressed zone or only a very narrow zone of depression, showing how recent was the derivation of this group from the parent gyroceran forms. The siphon is so near the venter that it interrupts the suture in most species. So far as I have been able to see, however, it is to be noted that the edges of the suture do not bend backwards to form a siphonal lobe similar to that of an Ammonoid. The siphon may become central in some adults, as in *Asympt. crassiventer.* The elliptical form of the young whorl, the large umbilical perforation, the simple, fine, smooth longitudinal ridges of the whorl in the young, and the presence of abrupt umbilical shoulders, indicate derivation from the open whorled form, Aipoceras. The sutures have broad ventral, lateral, and dorsal inflections or lobes, and small annular lobes.

The European species so far as now known to me are *Asympt. dorsale*, sp. Phill., *crassiventer*, sp. De Kon., *normale*, sp. De Kon., *latiseptatum*, sp. De Kon., *cyclostomum*, sp. Phill. and all of them are from the Carboniferous. *Asympt. Springeri*, sp. White and St. John, *capax*, sp. Meek and Worthen, and the following, are all that are known to me in this country, all three being also Carboniferous, Coal Measures.

ASYMPTOCERAS NEWLONI, n. s.

Loc., Oswego, Kansas, Coal Measures.

Coll. Nat. Mus., Dr. Newlon.

Figs. 48, 49, natural size.

The species in hand is a fragment very similar to *As.* (*Cryptoceras*) *capax*, Meek and Worthen.† There are three air chambers incompletely preserved in the cast. The last two sutures are 17 mm. apart on the venter. The increase in size is very rapid, being as much as 46 mm. in the greatest transverse diameter to 68 mm., a difference of 22 mm. in a distance of only 51 mm., as

tions of the sides and abdomen, and the sutures have broad ventral, lateral, and dorsal lobes. The Devonian forms of Temnocheilus, so far as known, have no annular lobe in the centre of the dorsal suture, but this is present in some Carboniferous species like *Tem. latus*, De-Kon. (Calc. Carb., Pl. 24, Fig. 2). The siphon, also, is near the venter in Devonian forms, but shifts nearer to the centre in some Carboniferous species, like *Tem. latus.* This organ, however, does not approach the periphery near enough to interrupt the line of suture on the venter in any species.

*Notice sur le Asympt. et Vestin, 1852.

† Geol. Ill., VI, p. 532, Pl. 33, Fig. 1.


Fig. 48.


Fig. 49.

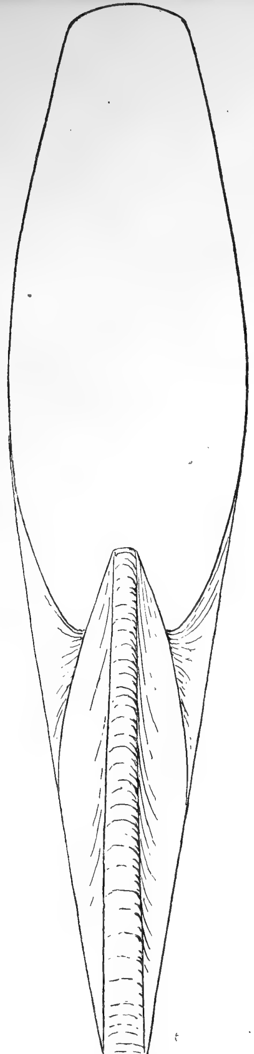
Fig. 50.

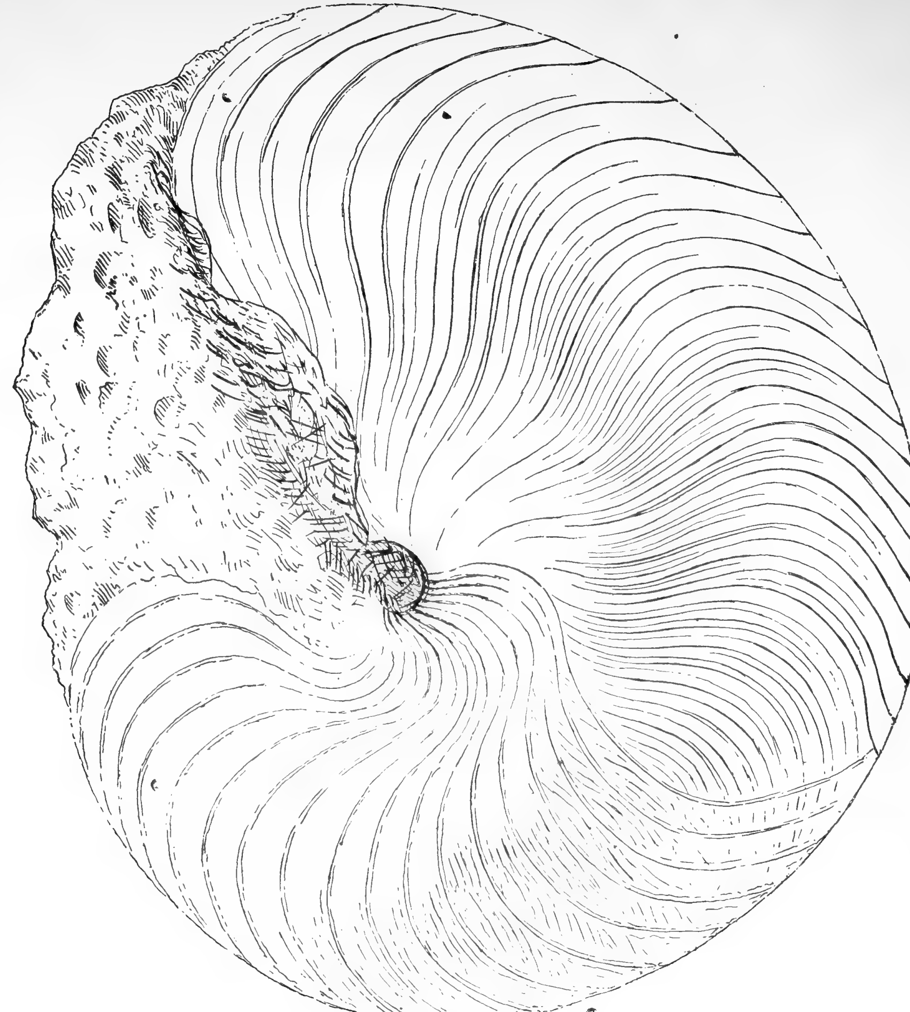
Fig. 51.

measured along the centre of the venter, and only 35 mm. as measured along the side of the whorl.

These measurements show a more rapid increase than in the whorl of *Asympt. capax.* The sutures are not only wider apart than in that species, but the form of the whorl also differs. In the figure of *As. capax* the greatest diameter of the living chamber is above or external to the umbilical shoulder, whereas in this species it is at the umbilical shoulder. The sides converge outwards from these shoulders and are not gibbous as in *capax*, and in the living chamber, which is evidently very nearly complete on one side, the whorl becomes flatter or more depressed on the abdomen than in *capax*, and the flaring of the aperture at the umbilical shoulders carries the lateral angles out with great rapidity. The diameter through the widest part of the whorl at the last suture is 68 mm., at a point about half way between this and the aperture about 82 mm., through the wings themselves not less than 120 mm., and perhaps a little more in perfect specimens.

The sutures have a distinct but very shallow broad lobe on the venter, which is irregularly interrupted by the siphon, and there are also shallow lateral lobes. In some specimens the sutures are very likely continuous, as they are in the figure of *capax.* If the side view of the sutures in the figure of *capax* is correct, these differ decidedly from those of this species. This shell differs from *Asym. Springeri* in having less angular umbilical shoulders, a more depressed abdomen, and more convergent sides. In fact, *Springeri* and *capax* resemble each other more than either of them resemble this species.*

The comparative length of living chamber can not be given, since the inner whorls were not visible.

PHACOCERAS DUMBLI, n. s.

Texas. Coll. Geol. Surv. of Texas.

Fort Riley, Kansas. Coll. R. Hay.

Figs. 50, 51, natural size.

The extraordinarily large size of this shell, its involute form, its compressed whorls, and the attenuated character of the outer part of the whorls in proportion to their transverse diameters, combined with the comparatively smooth and ribless shell, makes this species interesting.

The umbilici are very narrow and small, the involution being almost complete. The increase of the vertical diameters by growth is extremely rapid, whereas the transverse diameters have increased very slowly, leaving whorls very much compressed or axe-shaped. The broadest transverse diameters

*The species has been dedicated to Dr. W. S. Newlon, of Oswego, who found and sent the specimen, with some others described in this paper, to the National Museum.

are near the umbilici, and from this part the whorl is slightly concave on both sides towards the periphery or abdomen. This although very narrow is flattened or slightly convex, even in the largest specimens.

The living chamber in one specimen was about one-half of a volution in length. The lines of growth* indicate that the aperture probably had very broad lateral saddles and a single deep, narrow median abdominal lobe.

The sutures are near each other or slightly crowded in aspect. They have a narrow abdominal saddle, deep, broad lateral lobes, comparatively narrow lateral saddles near the umbilici, and a pair of shallow lateral lobes internally on the shoulders of the whorls.

The shell is thin and it is marked by fine lines of growth. The siphuncle is probably situated near the abdomen, but was not clearly seen.

A specimen sent me by Mr. Hay from Fort Riley is the most perfect specimen of this remarkable species that I have yet seen. It has an almost entire living chamber about one-half of a volution in length, the sutures show well, and it is not as much compressed as specimens from Texas. All the specimens are reported as coming from Carboniferous, as do all species of the genus so far found.

The sutures may have a slight lobe on the hollow of the narrow abdomen, where compression has affected them; where they are unaffected by compression they are absolutely straight or very faintly concave. In Mr. Hay's cast the outer part of the living chamber presents the abdomen as slightly convex, and leads one to think that the slight hollowness of the abdomen often present in younger whorls is due to compression. In fact the whorl is broken along a line parallel with and near to the edge of the abdomen and is concave from compression on the right hand (morphologically left) side until near the end of the living chamber. Here, where the abdomen presents a very flat convex surface, both sides of the whorl are unbroken and have the normal proportions. Figure 28 is therefore in part a restoration.

This is the largest and finest species of the involute shells of this group yet found in the Carboniferous. The principal differences between it and *Nautilus Rouilleri*, the adult of which was described and figured by Trautschold † under the name of Oxystomus, ‡ and the young by Marie Tzwetaev, ‖ consist in its size. The principal difference between the European and American is,

* The lines of growth in the drawing have the first lateral saddles or inflections too prominent and the second pair not prominent enough, the lobe between being too deep.

† Kalbruche von Miatschkowo, p. 28, Pl. 3, Fig. 7.

‡ The name Rouilleri was given to this as the type in De Koninck's Calcaire Carbonifere, p. 124, in his description of *Nautilus Oxystomus*, which last was afterwards taken by the writer as the type of his genus Phacoceras in Genera of Fossil Cephalopods. (Proc. Bost. Soc. Nat. Hist., XXII, 1883, p. 292.)

‖ Op. cit., p. 53, Pl. 6, Figs. 33–34.

that the former retains throughout life—that is to say, on all parts of its largest whorl, which is much larger than that of the European species—the peculiar but flattened abdomen which is found only in the young of *Phacoceras Rouilleri.* This character is of genetic importance, and, together with the longitudinal ridges and form of the young in this species, and in *P. oxystomum,* show that these acute involute shells were derived by descent from more discoidal shells like those of the genus Discitoceras. This also serves the purpose of explaining the occurrence in the Carboniferous of their apparently anachronic forms and structural characteristics. The aspect of the adults and the sutures in this genus are like Triassic species such as *Grypoceras* (*Nautilus*) *galeatus,* Mojsisovics, and at first they appear to have occurred before their proper geologic period. When, however, their young are studied, it is plain that their shells at early stages have the ordinary characteristics of normal members of the Carboniferous faunas, and that the peculiarities of later stages were evolved from purely Carboniferous forms. Their mimicry of Triassic shells in later stages must therefore be regarded simply as good examples of parallel progressive complications arising independently in different genetic series during different periods of time. In *Rouilleri* the flattened aspect of the crest of the abdomen is retained much longer in the course of the growth than in *Phacoceras oxystomum.* The American species, with its truncated abdomen existing in the adult, is therefore the most immature form of the group yet discovered, and although it is as yet impossible to come to any conclusion, this fact at present points to the fauna of this country as the place of origin or aldainic fauna of this series. *Rouilleri* is probably genetically connected with *P. Dumbli,* or some equivalent species, and *P. oxystomum* is similarly connected with *P. Rouilleri.* In both of these, however, it is superseded in the subsequent stages of shell growth by an acute abdomen.

EPHIPPIOCERAS.

This genus has been sufficiently described in Genera of Fossil Cephalopods.*

EPHIPPIOCERAS DIVISUM.

Nautilus divisus, White and St. John, Descrip. Fossils, etc., Trans. Chicago Acad. Sciences, I, p. 124.

Loc. Kansas, near Oswego. Coll. Nat. Mus. from Dr. Newlon.

Texas, in Coll. Geol. Survey, and from Kansas City, Mo., in Coll. Dr. Newbery, N. Y. Lower Coal Measures.

Fig. 52–54, one-third of the natural size.

The fragment in hand is so much larger than any other specimen of this genus yet found that its size alone is characteristic. The length of the incomplete living chamber is 195 mm. measured along the centre of the abdomen; the breadth of the same at the larger end is about 200 mm. through the umbilical shoulders, and at the smaller end through the second septum about 118 mm. About two air chambers are left upon this fragment and a part of a third. The whorl is kidney shaped in transverse section when looked at from the surface of the septa. The abdomino-dorsal diameter on the side

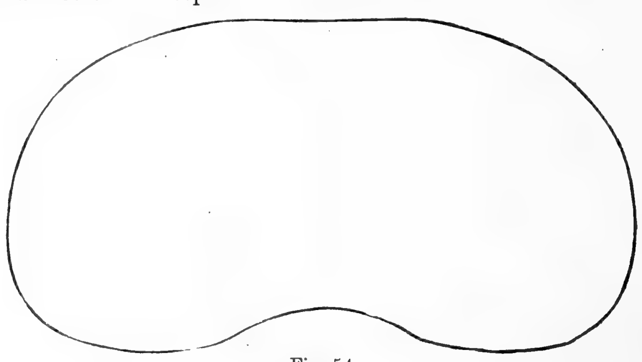

Fig. 54.

through the umbilical shoulder is 59 mm., while the same diameter taken through the centre of the whorl is only 48 mm., the transverse diameter being, as noted above, 118 mm. Notwithstanding the large size of the living chamber the form is quite as flattened as it is in the specimen of *Ephip. bilobatum* figured by DeKoninck in his Calcaire Carbonifere,† and there is also a similar depressed area, or broad shallow zone, running longitudinally along the venter. It is probable that no other species of nautiloid increases laterally more rapidly by growth than this one. The transverse measurements as given above are so large and the aspect from behind is such as to lead people to speak of these fossils as petrified skulls. The dorsal impression

*Op. cit., p. 290.

†Ann. du Mus. Roy. de Belgique, II, Pl. 9, Fig. 1.

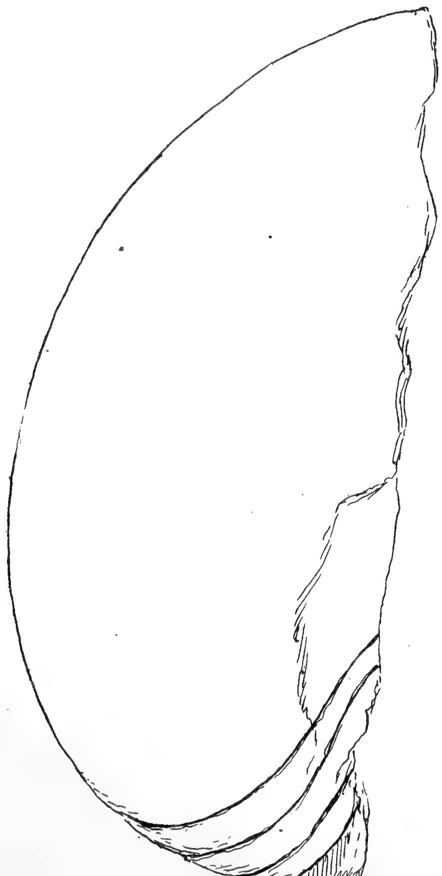

Fig. 52.

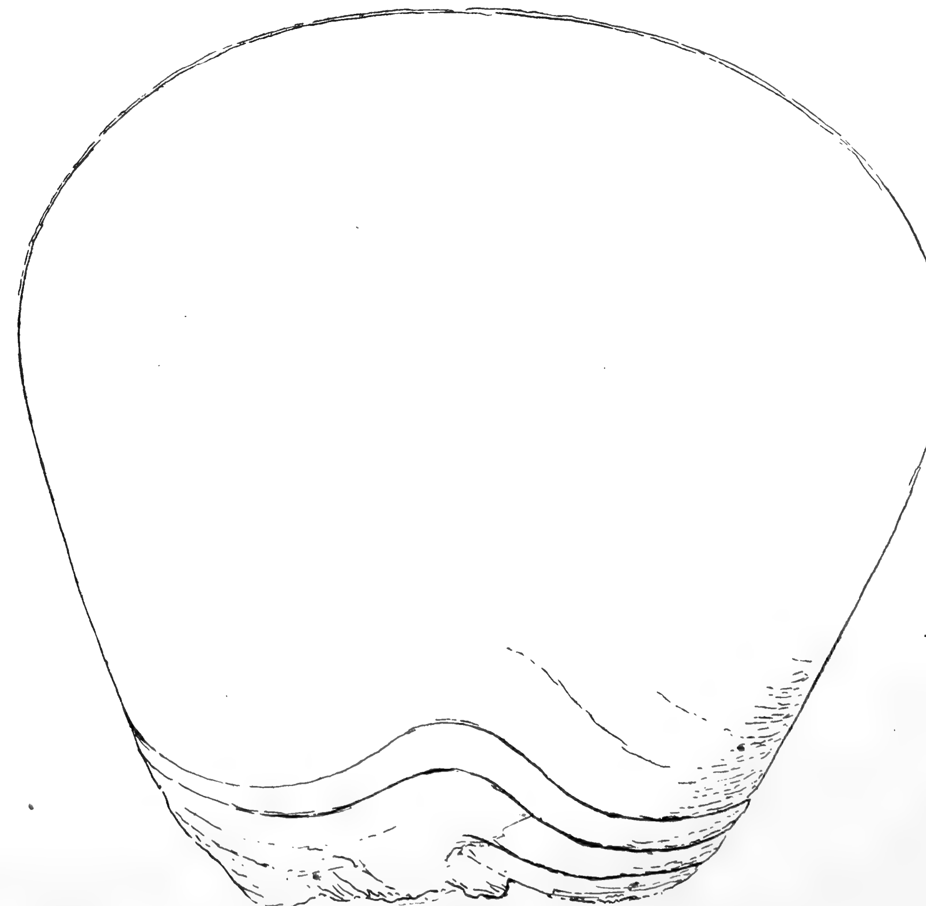

Fig. 53.

or dorsal zone is only 35 mm. in diameter, showing that the next internal whorl must have been very small compared to the outer one. The sutures have the typical form, with narrow, angular ventral saddles. The septa are divided by a median ridge internally, as in other forms of this genus.

The principal differences between this species and its nearest congener, *Ephip. bilobatum* of Europe, lies in the extraordinarily rapid increase of the lateral diameters of the whorls by growth and the enormous breadth of the last whorl. The lateral lobes are not so long, and the saddles at the umbilical shoulders not so deep in the specimen described, but this may be more a matter of age. Fragments of the shell still remain on the cast of the living chamber, and these are smooth.

The *Nautilus clitellarius*, as figured by De Verneuil*, is a small shell with open umbilici not at all similar to the fossil described above or to the true *Epiph. bilobatum* or *clitellarium* and we propose to call this *Ephippioceras Vernuili*. The *Naut. clitellarius*, Trautschold, also from Russia,† is a fragment, and may be the same, since although a fragment and considerably larger the sutures are similar to those of the last named. *Nautilus divisus*, as described and figured by White and St. John, is a closer ally than the Russian species, but their figure differs in not having the depressed zone along the abdomen, and the abdomen is apparently not so broad and depressed. The sutures are similar, having similar shallow lobes and not very prominent ventral saddles. The drawing is, however, in perspective, and the appearance of the sutures may be deceptive. While awaiting more evidence it has been thought best to adopt the name given by White and St. John for the Kansas and Texas fossils.

Epiph. (*Nautilus*) *clitellarius*, as first figured by J. de C. Sowerby,‡ is very like the adult of the Kansas fossil, if the drawing is accurate. This shell had, however, probably reached its maximum, or was nearly full grown; and if it were projected to the size often attained by the Kansas form would perhaps have a much broader and larger whorl. Accurate comparisons of good examples of these shells are needed before it can be positively decided that *clitellarius*, J. de C. Sowerby, *bilobatus*, Sow., and this form are not identical. The cast of a little shell figured by Fischer de Waldheim,‖ under the name of *Goniatites ovoideus* is similar to *biblobatum*, Sow., as figured by De Koninck, but the figure, unless it is inaccurate, is not like what the young of *E. divisum* must have been. *Cyrtoceras Fahrenkohli*, figured by the same author on the same plate, may be identical with this, as claimed by De

* Russia and the Ural Mts. Pal., Pl. 25.

† Nouv. Mem. de la Soc. Imp. de Nat. de Moscow, XIII, 1874, Pl. 30, Fig. 4.

‡ Bull. Soc. Nat. de Moscow, 1848, Part III, p. 132, Pl. 5, Fig. 3.

‖ Prestwich, Geol. Coalbrookdale, Trans. Geol. Soc. London, 2d ser., V, p. 492, Pl. 34, Fig. 5.

Koninck, but there can be no certainty in the comparison of figures, which are mere sketches. The latter is, however, less involute than the former, and this suggests comparison with De Verneuil's *clitellarius.*

Comparative length of living chamber can not be given because of the absence of the inner whorls.

There are two specimens of *Ephippioceras* in Prof. Newberry's collection at Columbia College, New York, coming from near Kansas City, Missouri, which may be the young of this species. One of them exhibits a living chamber, complete above on the abdomen, which is over one-fourth of a volution in length.

The specimens of *Ephip.* (*Naut.*) *ferratum* from Kentucky, in Coll. Museum Comp. Zool. at Cambridge show that this shell has a rounded very gibbous sided whorl with the central parts of abdomen also rounded, as in Fig. 2a on Pl. X of the Atlas of volumes II and III of Report Geological Survey of Kentucky. The increase in the transverse diameter is slower in this species than in *E. divisum* at any age.

A fragment in Coll. Geological Survey of Texas belongs to a specimen of this species and exhibits the same very prominent abdominal saddles in the sutures and rounded abdomen. The size of this is intermediate between the two above described and the large one from Kansas.

Ephippioceras (*Nautilus*) *Montgomeryensis*,* (sp. Worthen) differs from this species and all others, if accurately figured, in the tongue-like outlines of the neutral saddles. The umbilical shoulders are also peculiar.

ENDOLOBUS.

This genus has been sufficiently described in Genera of Fossil Cephalopods.†

The species described has not at the latest stage of growth in the single specimen observed yet acquired the ventral saddles found in other species. The slight ventral lobes are retained apparently even in adults. Figure 33 is taken from the young whorl after the removal of the living chamber. Fig. 34 shows a section of all the whorls observed in the same specimen, with an outline of the internal part of the suture, exhibiting the annular cone in section.

Endolobus (*Solenocheilus*) *Indianense*, if correctly figured, has the siphuncle nearer the abdomen than is usual in this genus, and the whorl in section has a very peculiar helmet-like shape, owing to the depression of the sides and the consequent narrowing of the abdomen.

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*Geol. Surv. Ill., VIII, Pl. 26–27.

† Op. cit., p. 288.

ENDOLOBUS GIBBOSUS, n. s.

Loc. Colorado River, San Saba County, near Bend. Texas.

Coll. Nat. Museum.

Figs. 55, 56, natural size.

This is a good sized, smooth shelled, nautilian form, the largest specimen not less than 130 mm. in diameter. The shell has broad, depressed whorls,

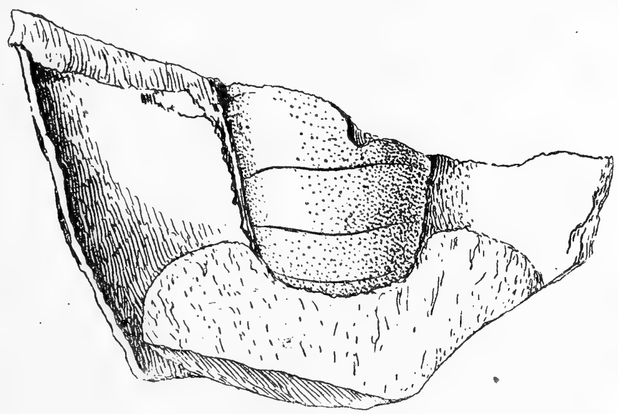

Fig. 55.

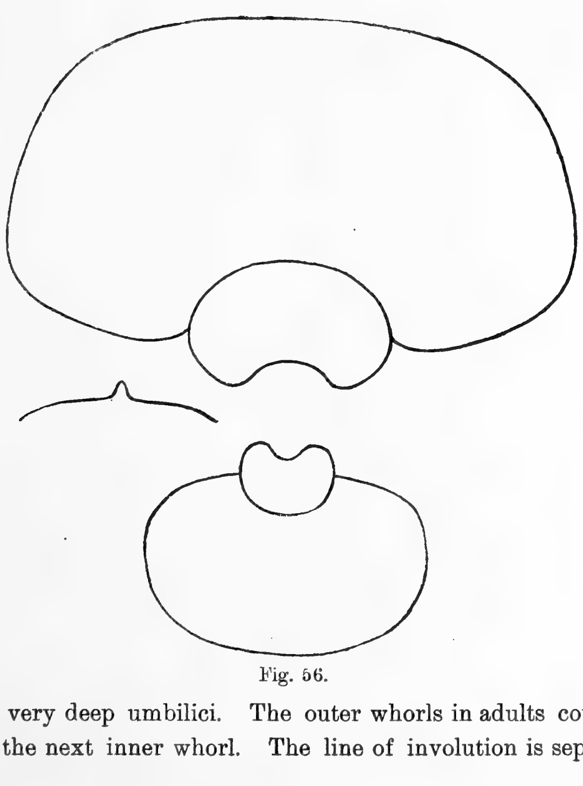

Fig. 56.

narrow and very deep umbilici. The outer whorls in adults cover in about one-half of the next inner whorl. The line of involution is separated from the abrupt and prominent umbilical shoulders by narrow uncovered zones. The young have whorls with transverse diameter more than twice as broad as the abdomino-dorsal, at least in the nealogic stages. At diameter of 37 mm. the whorl is as 13 mm. in abdomino-dorsal diameter to 27 mm. in transverse. The umbilical shoulder stands out from the side of the next inner whorl fully 8 mm. at this same diameter. In consequence of the large and subangular umbilical shoulders and the excessive rate of increase in the transverse diameter a whorl is produced which resembles that of Asymptoceras in general aspect. It can be at once distinguished, however, by the position of the siphuncle and the invariable continuity of the ventral suture.

The living chamber is considerably longer than one would expect in such a broad shell. It is, though incomplete, considerably over one-fourth of a volution in one specimen and in another somewhat longer. It is when complete probably in the neighborhood of one-half of a volution in length. The aperture was not clearly seen, but in the largest specimen there is what seems to be wing-like saddles on the sides as continuations of the prominent umbilical shoulders. These increase the resemblance of the terminal or living chamber portion of the whorl to Asymptoceras.

The sutures are widely separated, being 9 mm. apart at diameter of 27 mm. This extreme width of the air chambers is not maintained in full grown specimens, but the sutures are approximate only in outgrown specimens. The sutures have very shallow ventral and lateral lobes with correspondingly slight saddles at the junction of the sides and abdomen (and probably at the umbilical shoulders), but these are mere inflections, the outlines being almost straight. The sutures at the umbilical shoulders and inside of these were not seen except in section of the dorsal area. The impressed zone on the dorsal area is deep, and in a section which strikes obliquely across the septa a distinct annular cone and small annular lobe are exposed. This cone was well developed in the nealogic stage before the whole shell had reached the diameter of 27 mm.

GONIATITINAE.

GASTRIOCERAS.

The species of this genus have very broad depressed whorls with open and very deep umbilici, but the outlines of the sutures are the tests of affinity, the form of the whorl being the more variable quantity among shell-covered cephalopoda. As I have frequently pointed out, two shells may closely resemble each other in form and in external characters and yet belong to distinct groups, genera, families, or sub-orders; and it is even possible to make

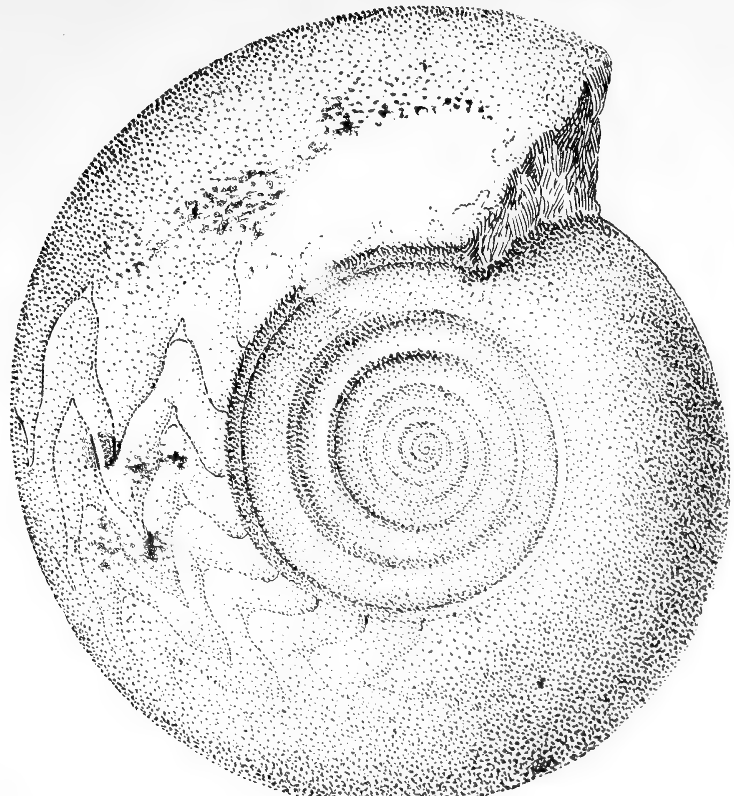
Fig. 57.

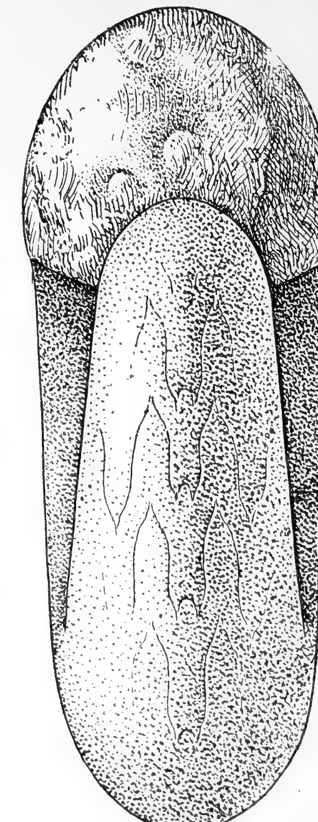
Fig. 58.

mistakes between casts of Nautiloids and Ammonoids, if the sutures and the young are entirely hidden. The species described below illustrates the constancy of the sutures and the variability of the form.

I wish also to call attention here to a characteristic not before noted in the genus Paralegoceras. The second lateral lobes or divisions of the great magnoscellarian saddles occupy the umbilical shoulders in Gastrioceras, whereas in Paralegoceras these same lobes are situated on the sides of the whorls. This distinction was noted in Gastrioceras in the description of this genus,* but not in Paralegoceras. The latter also has shallower umbilici and more rounded umbilical shoulders than in Gastrioceras, the third pair of saddles appearing also partly on the sides. We are now able to cite another species as belonging to this interesting genus. *Paralegoceras* (*Gastrioceras*) *Russiense* of Marie Tzwetaev has a form very like *Gast. compressum* as figured by the authoress,* but the outlines of the sutures and umbilical shoulders show that we are here dealing with a form of Paralegoceras. This is less compressed than *Paral. Iowense*, Meek and Worthen, and shows closer affinity with Gastrioceras in the form of the whorl.

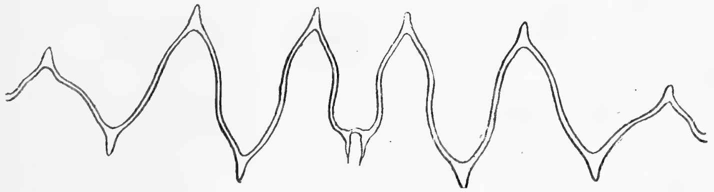

Fig. 59.

GASTRIOCERAS COMPRESSUM, n. s.

Loc. Colorado River. San Saba County, near Bend. Texas.

Coll. National Museum.

Fig. 57–59, natural size.

The form of the whorl is helmet-shaped and at the diameter of 109 mm. in a cast the greatest transverse diameter was 42 mm.; the distance in a straight line from umbilical shoulder to centre of abdomen 38–39 mm.; the abdomino-dorsal diameter 23 mm. The increase by growth in both diameters is slow and the umbilici consequently shallow. The involution covers more than two-thirds of next internal whorl at the diameter of 109 mm. and in another specimen at diameter of 68 mm. it is just two-thirds. The still younger whorls are numerous and visible from the sides at the centres of the umbilici, and doubtless the amount of involution is correspondingly less. Constrictions appear in the smaller specimen measured and in the younger stages of another flattened example.

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*Foss. Ceph., Proc. Bost. Nat. Hist., XXII, p. 327.

*Ceph. du Calc. Carb. de la Russie Centrale, Pl. VI, pp. 30–32.

The ventral lobe is divided by a large bottle-shaped siphonal saddle divided by a siphonal lobe at the extremity; the lateral branches of the ventral lobes are very long and acutely pointed, as are also the first lateral lobes which are of the same length as these branches of the ventral. The first lateral saddles are hastate and acutely pointed and second lateral saddles are, as is usual in this genus, sub-hastate. The inner outlines of these last are concave near the points, then suddenly convex internally where the lobe of the umbilical shoulder begins. These last mentioned lobes are also acutely pointed but much more abbreviated than the other two pairs. The shell is strongly striated, but it is not pilated or otherwise marked, except when constrictions occur.

REPORT

ON THE

GEOLOGY OF NORTHWESTERN TEXAS.

BY

W. F. CUMMINS.

REPORT

ON THE

GEOLOGY OF NORTHWESTERN TEXAS.

BY PROF. W. F. CUMMINS.

INTRODUCTION.

The following report is a statement of the work done in the field by myself and assistants during the past two years. In order to make a full report upon the different subjects it will be found necessary to repeat some things that have been given in previous reports, but this will only be done where it is important to a full understanding of the matter, and where it is necessary to have all the facts presented together.

In Part I, I have given a detailed statement of the general geology, stratigraphy, and paleontology of the district.

Part II is devoted to a review of the economic geology and agriculture.

Part III contains a brief description of the several counties in which coal seams No. 1 and No. 7 occur. This is given for the purpose of directing especial attention to the localities where the workable beds of coal may be found.

PART I.

STRATIGRAPHIC GEOLOGY.

The following table will show the formations in this portion of Texas, as I have observed them, as compared with the table taken from Dana's Manual of Geology, which will give a definite idea of what I intend to represent by the various divisions and subdivisions:

DANA.	TEXAS.
Recent	Recent.
Tertiary	Tertiary.
Cretaceous	Cretaceous.
Jurassic	?
Triassic	Triassic.
Permian	Permian.
Carboniferous	Carboniferous.
Sub-Carboniferous	?
Devonian	
Silurian	Silurian.

The above table gives the geological formations of the northwestern part of the State as I now understand it. I have confined my work largely to the Permian and Carboniferous formations, giving only such attention to the other members of the section as was necessary to determine the relation of the Permian and Carboniferous formations to the overlying and underlying series, and to enable me to determine with accuracy the extent of these two formations in this part of the State.

On Plate VI, I have given a columnar section of the strata (higher than the Devonian) in northwestern Texas, with the provisional divisions which I have made of them.

SILURIAN.

The Silurian lies along the southwestern border of the Carboniferous, the boundaries of which will be given in another place in this Report. It also occurs on both sides of the Wichita Mountains in the Indian Territory. This formation will be reported upon by Prof. Theo. B. Comstock, and needs no further notice from me in this connection.

DEVONIAN.

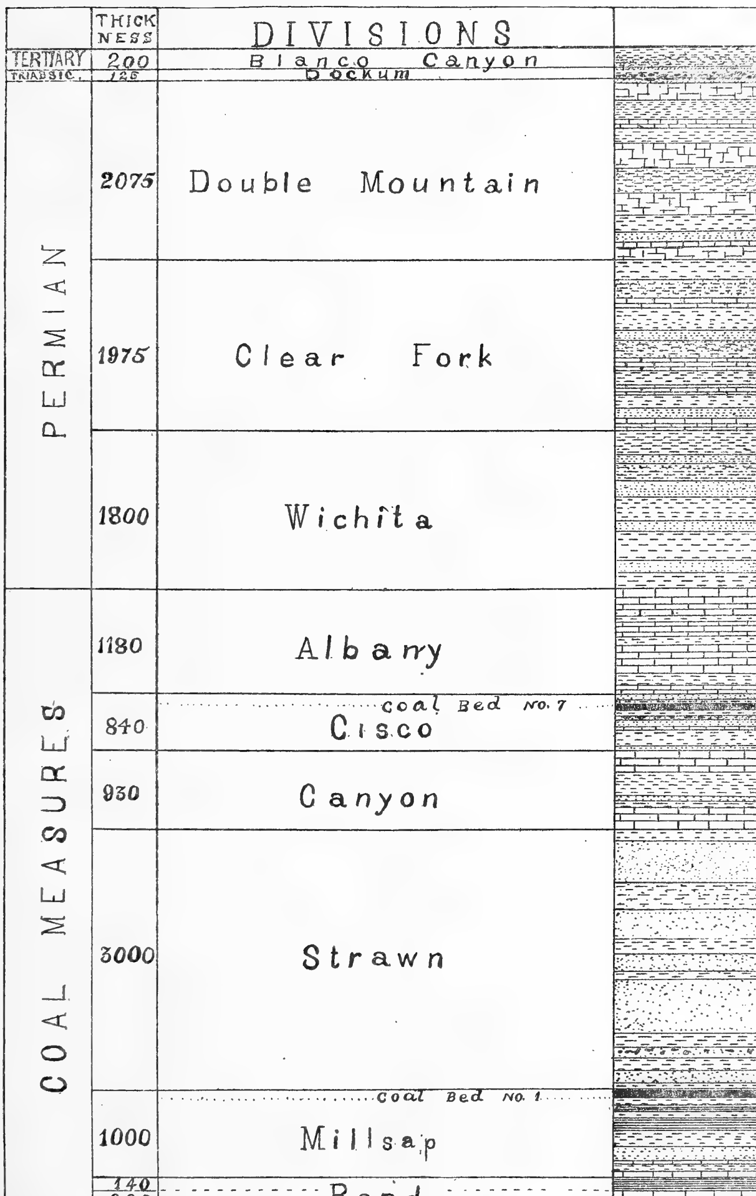
The Devonian is entirely wanting along all the lines of contact between the Carboniferous and the older rocks, so far as I have been able to determine. I have not seen this formation anywhere in the State, yet it may exist.

SUB-CARBONIFEROUS.

In 1879 Mr. Chas. D. Ashburner made a report to some capitalists, which by permission was read before the American Institute of Mining Engineers, at the Philadelphia meeting in February, 1881, and afterwards published in in their proceedings, entitled "Brazos Coal Field, Texas." This paper was a report made after personal examinations in Young and Stephens counties by himself. He makes the thickness of the true Coal Measures in Texas three hundred feet, and below that he says he found a limestone one hundred and fifty feet thick that belonged to the Sub-Carboniferous, and made it the equivalent of the Chester Group. He gives as his reason for so believing that he found a conglomerate above the limestone that belonged to the Millstone Grit or the base of the Coal Measures. As there is more than one thousand feet of the Coal Measures below the bed of conglomerate mentioned, and below the limestone which he calls Sub-Carboniferous, there is no possible chance for these limestones being Sub-Carboniferous.

In 1885, in his report on the Mineral Resources of the United States, published in 1886, Washington, he reiterates his former assertions in reference

PLATE VI.



VERTICAL SECTION OF THE STRATA IN NORTHWEST TEXAS.

to the Sub-Carboniferous in the vicinity of Fort Belknap and Crystal Falls, in Young and Stevens counties. He says: "The Brazos Coal Field is the southwestern limit of the Missourian or fourth bituminous coal basin of the United States. The Coal Measures of Stephens and Young counties belong to the Carboniferous age. The coal strata proper are eighty-five feet thick, and are included between an upper sandstone and conglomerate representative of the Millstone Grit, or Pottsville conglomerate No. 12 of the Pennsylvania Series, and a lower gray limestone, representative of the mountain limestone or Chester and St. Louis limestone of the Mississippi Valley."

That Mr. Ashburner was mistaken in supposing the conglomerate to be the equivalent of the Millstone Grit of the Pittsburg beds and the limestone below it, belonging to the Chester Group, is very readily seen by reference to the general section made from the northeastern part of the Coal Measures to the southeastern part thereof, or from the highest beds to the lowest, passing through Belknap.

As he finds the Coal Measures in the western edge of Parker County, which is at least one thousand feet below his Chester limestone stratigraphically, and free from any serious faulting, it is useless to give very serious attention to his suggestions about the Sub-Carboniferous being in Young and Stevens counties.

The characteristic fossils of the Coal Measures are very abundant and will be given in another place in this Report; and the most of them were found below the limestone thought by Mr. Ashburner to be Sub Carboniferous.

The following fossils were found at one locality near Graham, and the stratum from which they were taken is below the limestone thought to be Sub-Carboniferous by Mr. Ashburner:

Allorisma subcuneata, Meek and H.
Bellerophon percarinatus, Conrad.
B. carbonarius, Cox.
Euomphalus rugosus, Hall.
Lophophyllum proliferum, McChesney.
Pinna peracuta, Shumard.
Pleurotomaria sphærulata, Conrad.
P. tabulata, Hall.
Productus cora, d'Orbigny.
P. costatus, Sowerby.
P. nebrascensis, Owen.
Schizodus wheeleri, Swallow.
Spirifer cameratus, Morton.
Spiriferina kentuckensis, Shumard.
Zaphrentis spinulifera, Hall.
Productus longispinus, Sowerby.
Hemiphrontes crassus, Meek and Hayden.
Nucula ventricosa, Hall.
Rhynchonella uta?, Marcou.
Spirifer lineatus, Martin.
Myalina subquadrata, Shumard.
Chœtetes milleporaceus, Haines.
Orthoceras rushensis, McChesney.
Conocardium obliquum, Meek and W.
Aviculopecten occidentalis, Shumard.

Mr. Ralph S. Tarr, after studying that portion of the district lying along the Colorado River, came to the conclusion that there existed a considerable thickness of Sub-Carboniferous between the Coal Measures and the Silurian in the counties of Lampasas, San Saba, and McCulloch. He says:*

"The older Paleozoic rocks of Llano and Mason counties were the chief land areas from which the sediments composing the Carboniferous strata were derived. Resting unconformably upon these rocks is a limestone, which is also unconformable with the true Carboniferous. These beds appear as a narrow strip, separating the Carboniferous from the Silurian, and consist almost entirely of crystalline limestone with beds of shale. The beds of the Lower Carboniferous series were formed mostly in rather deep water off the shore of an old Silurian land area, and the beds of the sea shore may yet be seen in the form of shales, and rarely conglomerates, in the bays and on the headlands of the old shore line, which may be plainly traced. The dip of the beds is somewhat variable, but the average is gentle, from one to two degrees northwest. In one place the dip is twenty degrees in the same direction. There are small anticlinals and synclinals much more numerous than in the Upper Carboniferous, where they are very rare. Unless carefully mapped and studied over a considerable area, this formation might be overlooked and classed as a portion of the Upper Carboniferous. The fossils resemble those found in the true Carboniferous, though upon closer study some will undoubtedly be found to be quite different. One specimen of *Goniatites* has been pronounced by Prof. Alpheus Hyatt to be a distinctive Lower Carboniferous form.

"The deceptive resemblance of fossils would at first lead to a decision that these beds are a part of the Upper Carboniferous, and this deception is increased when an actual contact occurs between the strata of the two formations. At two places east of San Saba the limestone seems to dip conformably beneath the sandstones. In both these places the dip of the strata of each series is the same. It is only when we see the section as a whole that the true relation of the two series is discovered. The San Saba River, from just above its mouth nearly to the mouth of Richland Creek, is the dividing line between the Upper and Lower Carboniferous, and this line of division is continued westward up the valley of Richland Creek. On the north side of this line is the true Upper Carboniferous, consisting at this place of a great thickness of sandstone. South of this line is the Lower Carboniferous, composed in this region entirely of limestone and limy shales. As a person crosses the region for the first time there are three possible explanations of such a relation of beds. The first is that the limestones and sandstones are interstratified; but this is quickly disproved, since in the sandstone areas there are no limestones, and in the limestone regions no sandstones. This and abundant other

*Preliminary Report on the Coal Fields of the Colorado River, Ralph S. Tarr. First Annual Report of the Geological Survey of Texas, Austin, 1890, p. 201, *et seq.*

field evidence proves that the limestone is beneath the sandstone; and then the problem is narrowed down to two possible solutions—the two series are either conformable or unconformable. There are two proofs that they are not conformable. The dip of the limestone averages at least two hundred feet to the mile, and with such a dip any bed of limestone, as for instance the bed on the Colorado below Red Bluff, would soon dip under the sandstone if followed a few miles to the west, and the overlying sandstone would cover it and extend to the Silurian. But such is not the case. The belt of limestone extends continuously for nearly thirty miles. In this series there are many different beds of limestone and shale, one above the other, each one of which strikes up to the sandstone and there stops.

"We have therefore an upper sandstone formation, composed of various beds, striking southwest and overlapping a great thickness of limestone. There is therefore no explanation, to my mind, but unconformability; a fact which necessarily proves a different age from that of the overlying coal measures. That they are Lower Carboniferous rather than Devonian is shown by the close resemblance of the fossils of the lower beds to those of the Upper Carboniferous. The field evidences thus seem to prove that these beds are not a part of the true coal bearing series, but belong to an older formation—the Lower Carboniferous. The Lower Carboniferous extends from near Lampasas to some distance west of Brady, with an average width of not more than ten miles, and is the formation on which the towns of San Saba and Brady are situated."

His reference of these deposits of shales, limestones, and rarely conglomerates, to the Sub-Carboniferous, is based upon:

1. Unconformability with underlying Coal Measures strata.
2. Paleontology.

My investigations, made both before and after those recorded by Mr. Tarr, do not seem to me to warrant the reference of these beds to any period earlier than the Coal Measures themselves.

That there is non-conformity between the limestone and the sandstone beds in places there is not the slightest doubt, and the non-conformity is probably even greater than Mr. Tarr states it to be. He only claims difference of degree of dip, while in fact there is also difference in direction.

I think that it will be readily apparent that given the old Silurian shore line which Mr. Tarr describes, with its headlands and bays, having a general trend east and west, the dip and strike of the strata at its foot would naturally be governed more or less by the contours of its eroded surface and the shore. That this is the case is evidenced by the carefully prepared maps of the area made by Mr. Tarr, now in the possession of the Survey. These show in several places the strata in question dipping away—northeast, north, northwest—

from the Silurian headlands, and this corresponds fully with my observations. The point I desire to make is that the strike of this series of strata is not southwest but more nearly east and west, corresponding to the old shore line, and that the beds of limestone and shales which extend from the eastern edge of San Saba County to the town of Brady are no more than ten miles wide, and instead of being a series of beds of limestones and shales there is but one bed of shale; and one can start from Bend, in the southeast corner of San Saba County, and travel on the same black shales to the town of Brady.

From the base of the sandstones to the Texas marbles, which is below the blue limestone in question, at no place has the strata a thickness of five hundred feet, and instead of the limestones "striking up against the sandstone and there ending," they simply pass beneath the sandstone.

An examination of the completed sections of the Carboniferous of Texas shows that this unconformability is no greater than exists in other portions of the system.

That there exists slight unconformity between the upper and lower members of the same period is not to be wondered at when we take into consideration the fact that there was a general subsidence of the whole strata during the entire time, and which was at times more rapid than at others. There would be times when the general submergence would stand still for awhile until the limestone seas would fill up by the silt brought down from the lands surrounding. The seas would become more shallow until the waters would no more deposit limestone material, but the heavier clays, and they in turn would be followed by sandstones deposited along the sea coasts. There were doubtless also oscillations in the strata during these times—emergence as well as submergence. Where there is a continuity of sedimentation there has been no unconformability observed, and while it is a fact that the higher we get in the geological series in Northwest Texas the less is the dip of the strata, it is also a fact that at the place of contact between the different divisions there is no unconformity observable.

That there is a lapse of time between the deposition of the limestone and shales found in the San Saba County and the overlying sandstone is a fact that is easily understood by any one who has examined the Coal Measures in Texas. Below the same sandstones where they occur in the northern part of the Carboniferous formation, along the Brazos River, are several beds of limestone that are undoubtedly Coal Measures, but which are different from the limestones characterized by Mr. Tarr as Sub-Carboniferous, and which are so connected by sedimentation that there is certainly no break in the formation in that region; and besides, the limestones contain the well known characteristic fossils of the true Carboniferous series, as may be seen by the list of fossils given of that locality in another place.

Just how much time there was between the deposition of the limestones and the sandstones we do not know. But we do know that there are hundreds of feet of strata below the sandstone along the Brazos (which is the equivalent of the sandstones in San Saba County) and the limestones found in this district. A diamond drill taking out a two inch core has been put down one thousand feet, beginning at Coal Seam No. 1, at Thurber. The entire distance has been through blue slate, thin beds of gray sandstone, and blue limestone, all of which evidently belong to the Coal Measures, and that belong in the series between the Richland sandstone of Mr. Tarr and the blue shales of the Bend Beds.

A comparison of the Colorado and Brazos sections, as illustrated on Plate VII, shows that the unconformity at this place is caused by the absence of the entire Millsap series, including Coal Seam No. 1, from its rightful position between the shales and limestones of the Bend series and the Strawn (Richland) sandstone.

No list of fossils is given by Mr. Tarr as the basis of his reference of the Bend series to the Sub-Carboniferous The following is a list of those taken by myself and assistants from these beds:

LIST OF FOSSILS FOUND IN THE BEND DIVISION.

VERTEBRATES.

Edestus minor, Newberry.

INVERTEBRATES.

Hadrophyllum aplatus, sp. nov., Cummins.
Chætetes radiens, ———.
Spirifer cameratus, Morton.
Pleurotomaria turbiniformis, Meek and Worthen.
Bellerophon crassus, Meek and W.
Spiriferina kentuckensis, Shumard.
Productus nebrascensis, Owen.
Platyceras nebrascensis, Meek.
Euomphalus rugosus, Hall.
Myalina subquadrata, Shumard.
Synocladia biserialis, Swallow.
Bellerophon carbonarius, Cox.
Productus semireticulatus, Martin.
P. punctatus, Morton.
Nuculana bellistriata, Stevens.
Chonetes mesoloba, Norwood and Pratten.
Productus costatus, Sowerby.
Zaphrentis gibsoni, White.
Nunstroceras parallelum?, Hyatt.

These fossils seem to me to fully warrant the retention of the Bend series in the Coal Measures.

Professor George G. Shumard, Assistant State Geologist, in a report written in 1855 and 1856, but not published until 1886, says he found the Sub-Carboniferous in Texas. He says: "On the San Saba River, at a point about midway between Fort Mason and Fort McKavett, the rocks of the group are seen cropping out extensively from beneath thick strata of the Cretaceous Period. At this locality the thickness of their exposed edges was estimated by myself at about two thousand five hundred feet;" but in his Journal, published in the same book, he says of the same locality, "We came to an extensive outcrop of hard, granular limestone, belonging to the Upper Division of the Carboniferous system, which is here to be seen emerging from beneath the Cretaceous strata." *

It will be seen from the above that he calls it Sub-Carboniferous in one place, and puts it in the Upper Division in another; and as the fossils he gives as coming from the beds are similar to a collection made near Brady by myself from the Upper Division of the Carboniferous, I conclude his reference to the Sub-Carboniferous was a mistake, and therefore need not be further noticed.

It has been thought that the limestones of Palo Pinto and other counties belonged to the Sub-Carboniferous, because of its great extent and thickness, under the mistaken notion that the Coal Measures did not anywhere contain such extensive beds of limestone.

The same mistake was made in the early explorations of Iowa. Dr. C. A. White, in speaking of this matter, says: † "We find the formation in Iowa to be as fully characterized by limestones as any of formations of the Sub-Carboniferous group are."

From all the evidence I have been able to secure in the course of my work in this district I am forced to the conclusion that up to the present no Sub-Carboniferous rocks have been discovered.

CARBONIFEROUS.

By the term Carboniferous I intend in this report to designate the Coal Measures as the name was first applied by the miners in England to the coal bearing strata of that country, and to say when speaking of the Coal Measures, that it occupies the same relative position in the geological horizon as that applied to the locality where the name was first used, and as is given generally in the text-books.

I have not attempted to subdivide the strata into Upper Coal Measures, Middle Coal Measures, and Millstone Grit, as has been done in other States, nor to correlate the Texas divisions with other localities, for the lack of time to study the fossils of the measures, but have adopted provisional divisions of the formation, and hope to be able at a future time to correlate the strata

* A Partial Report on the Geology of Western Texas, Dr. Geo. G. Shumard, Austin, 1886.
† Geology of Iowa, 1870.

with like beds in other localities. The provisional subdivisions are shown in Plate VI, page 361, in this Report.

The Carboniferous area of Texas is an irregular belt of country stretching from Red River on the north southward to and below the Colorado, a distance of over two hundred miles, and having an average breadth of not more than seventy-five miles, with its longer axis approximately in the line of the strike of the formation.

The Carboniferous formation in Texas is overlaid on the eastward by the Trinity Sands along the entire eastern border. A line representing the eastern contact between the two formations would begin at a point on Red River near the northeastern corner of Montague County. Thence passing through Wise County, between Decatur and Bridgeport. Thence to a point on the line of the Texas and Pacific Railway three miles east of Millsap. Thence crossing the west branch of the Houston and Texas Central Railway at Carbon. Thence near the northwest corner of Comanche County. Thence by a line almost parallel with the west line of Comanche and Hamilton counties, but a few miles west of them, passing near Nix Postoffice, in Lampasas County, and reaching the Silurian a few miles south of that place.

The Carboniferous is bounded on the south by the Silurian. A line between these two formations on the south would begin at a point a few miles south of the town of Nix. Thence crossing the Colorado River a few miles south of Bend, and crossing Cherokee Creek a few miles above its mouth, and passing two miles south of the town of San Saba, and crossing the San Saba River near the mouth of Brady's Creek. Thence up that creek to its source. Thence westward to Kickapoo Creek in Concho County. At this place the Carboniferous formation is overlaid on the westward by the Permian.

The line between these two formations on the west would begin at a point on Kickapoo Creek, in Concho County, about where the main road from Brady to San Angelo crosses that creek. Thence down Kickapoo Creek to its mouth. Thence passing a few miles east of the town of Ballinger. Thence to Buffalo Gap. Thence crossing the Texas and Pacific Railway between Abilene and Elmsdale. Thence down Dead Man's Creek east of Fort Phantom Hill to the Clear Fork. Thence down that stream to a point opposite the town of Throckmorton. Thence by a line passing west of that town to a point on the Brazos River near the mouth of Spring Creek. Thence passing near the southeast corner of Archer County, Buffalo Springs, and to Red River near the mouth of Belknap Creek.

The northern boundary in Texas is Red River. In giving these boundaries it is not intended to say that a straight line drawn between any two given points would represent the exact contact between the two formations, for such would not be the case. In places along the eastern boundaries the Carboniferous would be east of such a line, while at other places the Cretaceous would be west of it. At the point where the Brazos River crosses that line it has cut down into the strata until the Carboniferous can be traced in the valley of the river as far southeastward as the line of Hood County. Again there is an extension of the Cretaceous strata forming a high ridge, between near Carbon and the southwest corner of Comanche County, extending to the westward almost to the Permian border at Elmsdale; and then again the Carboniferous is found along the Lampasas River from its source to the town of Lampasas. This strip of Carboniferous is confined entirely to the valley of the river. Again there is a small strip of Carboniferous near Marble Falls, and in Honey Creek Cove in Llano County.

Along the southern line the Cretaceous comes down on the north almost to the west line of San Saba County and extends along parallel with that line and finally crosses it near the head of Brady Creek. The Brady Mountains are Cretaceous and are cut through by erosion, showing the Carboniferous only in one place, at Cow Gap, on the road between Brady City and Coleman.

The following is a list of the counties which are in whole or in part Carboniferous: Montague, Wise, Jack, Parker, Palo Pinto, Young, Throckmorton, Stephens, Eastland, Erath, Callahan, Coleman, Brown, San Saba, Lampasas, McCulloch, Concho, Runnels, Taylor, and Shackelford.

The Carboniferous formation in Texas belongs to the Western Interior Coal Producing Field, composed of Missouri and the States adjoining on the north, west, and south, and reaching through, with some interruptions, into Texas. (Dana's Manual of Geology, p. 309.)

It is directly connected with the Carboniferous beds of the Indian Territory.

The area in Texas is subdivided into two fields by the overlying Cretaceous rocks which extend entirely across the formation just south of the Texas and Pacific Railway. We have called the northern division of these beds the "Northern or Brazos Coal Field," and those on the south the "Central or Colorado Coal Field."

The upper strata of the two fields are the same, but there is a great lapse of time between the lower sandstones in the Central Coal Field and the limestone immediately below them, as seen at the junction of these two beds in the vicinity of Lynch Creek and elsewhere along the line of contact between the two. The thickness of the formation in Northern Texas is about three thousand seven hundred and forty feet, by actual measurement on a line run from the upper part of the measures at the northeast corner of Throckmorton County, to the west line of Hood County.

The thickness of the beds in the Central Coal Field is about six thousand and nineteen feet, on a line run from the head of Pecan Bayou to the town of San Saba. Detailed sections along these lines are given beyond.

The formation includes all kinds of sedimentary rocks, with shales, clays, and seams of coal. There is no regular order in which these various beds occur. In the northern part of the formation in the State there are no limestones. In the southern part of the northern field there are first limestones, then sandstones, then beds of limestones, and at the base heavy beds of blue clay and limestones.

In the central district there are first limestones, and then heavy beds of clay and sandstones, and at the base beds of blue limestones.

There is no evidence whatever that the border formations on the southward of the present Carboniferous were ever overlaid by the Cretaceous Measures. All the evidence is directly to the contrary. It is evident that the present Silurian fields constituted the dry land during the whole of the Carboniferous Era. There was, in all proability, at the southern part of the Coal Fields in Texas an island in the Carboniferous sea, the extent of which it is now impossible to determine, for the reason that all the country south of the older rocks are covered by those of a later period than the Carboniferous.

There is no reason to suppose that the eastern shore line of the Carboniferous sea was anywhere in the region of the present eastern border of the Carboniferous formation in Texas. The great interior of the continent, from the Appalachian region to the western borders of Kansas and Nebraska, was slowly emerging from the waters during the era of the Coal Measures. At that time the Coal Fields were probably one vast forest, with here and there lakes of fresh water, and the deep water was farther to the southward than has ever been discovered.

Although the era was one of comparative quiet, with very slow emergence and submergence of the continental area, yet at the close of the Carboniferous period there had been formed a shore line extending from the northeastern part of the continent to the older formations in Llano County, cutting off a large area in which there was an interior sea in which the strata of the Permian and Triassic were afterward deposited. That barrier was probably formed not only by the deposition of material from the waters, as was the case over the entire region, but was probably assisted by a fold making an anticlinal and giving a northwestward dip to the Carboniferous strata that it has retained until now.

It is probable that the Cretaceous sea, that came on at a later date, did not cover up the entire area of the Carboniferous and Permian, but was rather in deep seas off the shores of these land areas. The erosion of the Cretaceous over large areas since that time has obscured the evidences of the extent of the Cretaceous seas, but I am inclined to think the Cretaceous seas extended in a narrow belt across the southern border of the Carboniferous, but doubt if the sea extended as far north as the Wichita River.

It has been thought that the Cretaceous formation at one time covered the entire area from the New Mexico country to Kansas, and the whole of the northwestern part of Texas and the Indian Territory, the same as the Cretaceous now covers the middle part of Texas, but I do not think the facts justify such a conclusion. There is certainly no evidence of the fact in the region of the Wichita Mountains. If the Cretaceous formation had been formed around the Wichita Mountains and afterwards destroyed by erosion, there would have been some portions of it left to show that fact. There are no remnants of the Cretaceous anywhere in Texas north of the Wichita River to the Canadian River, and beyond in the Indian Territory.

Professor Jules Marcou found the Cretaceous north of the Wichita Mountains, and again at the foot of the Llano Estacado, about two hundred miles west of that place, and there it was very thin.

I expected to have found the Staked Plains at the head of the Salt Fork of the Brazos Cretaceous, but the Tertiary rests directly upon the Triassic, and no evidence whatever that the Cretaceous ever existed there.

The condition for forming heavy beds of coal appears to have been wanting, and only thin seams will be found in the Texan strata.

All the coal seams of economic value will be found above the blue clay and limestones of the Bend series, and above the blue clay and hard limestones found south of the Brazos River, near Millsap, which are below Coal Seam No. 1, of the general section, and which I call the Millsap division in this Report.

THE SECTIONS.

The sections Nos. 1, 2, and 3, on Plate XVI, were made from actual lines run by instrumental measurement across the formation at different places.

Section No. 1 was made across the Permian, beginning at the Clear Fork of the Brazos River, near the western edge of Shackelford County, and ending at the top of the Staked Plains, near Dockum, in Dickens County. This section is intended also to show the relation of the Triassic and Tertiary Beds with the Permian, and also shows a part of the underlying Albany Beds of the Carboniferous.

The description of the divisions of the Permian have been given at another place in the report on the Permian.

SECTION NO. 1. (PLATE XVI.)

a. Clear Fork of Brazos River, the beginning of the section.
b. California Creek.
c. Paint Creek.
d. Salt Fork of Brazos, east of Kiowa Peak.

e. Salt Fork of Brazos, near mouth of Salt Croton Creek.
f. Salt Croton Creek.
g. Dove Creek.
h. Salt Croton Creek.
i. Big Duck Creek.
j. Red Mud Creek.
H. Haskell.
D. Dockum.
K. Kiowa Peak.
1. Upper part of the Albany Beds of the Carboniferous.
1 to 2. Clear Fork Beds of the Permian.
2 to 3. Double Mountain Beds of the Permian.
3″. Triassic.
3 to 4. Triassic.
4. Tertiary.

The local sections going to make up this general section are also given in the general report on the Permian.

The provisional subdivision of the Carboniferous as given on Plate VII is made up of the several beds as I found them in the Northern and Central areas of the Carboniferous formation in the State, and are as follows, beginning at the base:

1. Bend Division.
2. Millsap Divison.
3. Strawn Division.
4. Canyon Division.
5. Cisco Division.
6. Albany Division.

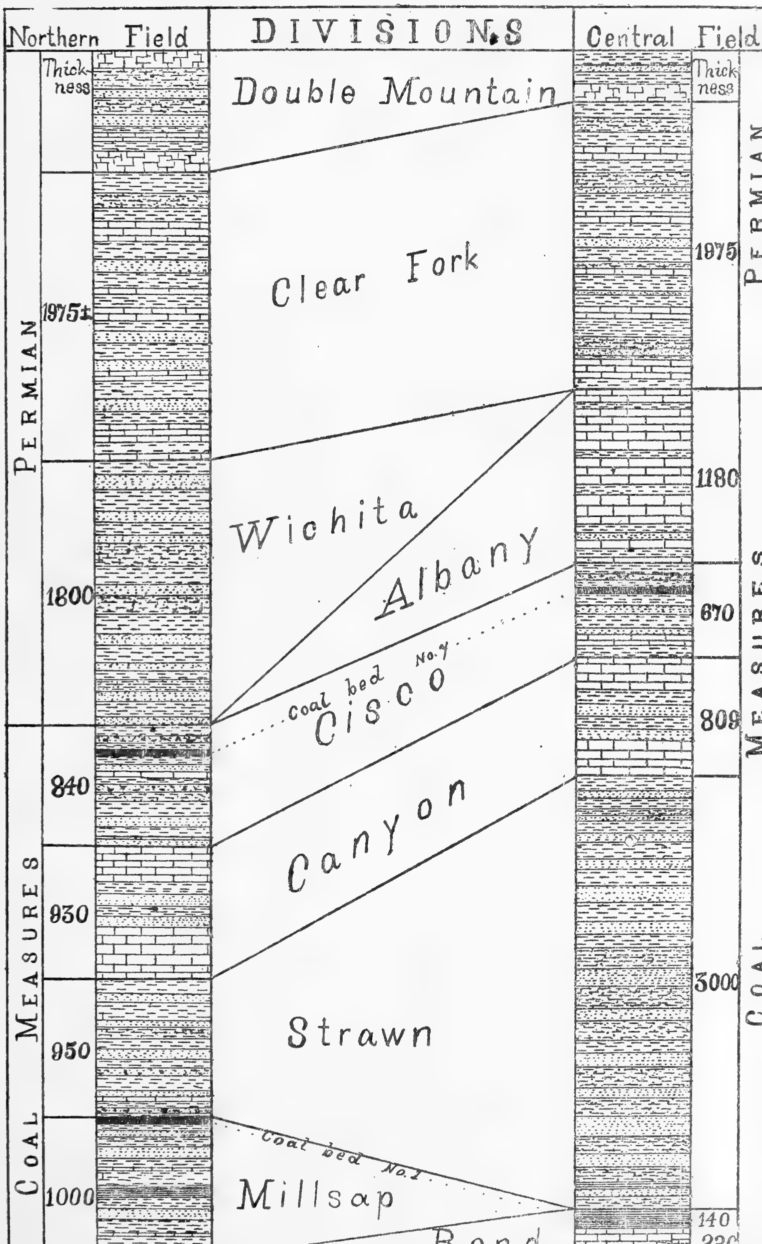
The following is a brief description of these various divisions:

Bend Division.—This division is found only in the Central Field, and lies along the edge of the Silurian, dipping away from it in almost every direction. It is composed of hard blue limestones and blue and black shales. This division is very readily distinguished from the overlying sandstones of the Strawn division. It is that part of the strata which was referred by Mr. Tarr in the First Annual Report to the Sub-Carboniferous, and has been already noticed at some length in this Report, so that no further description of the contacts between it and the other strata need be made at this place.

Millsap Division.—This division is found only in the Northern area, being entirely missing in the Central area. It embraces all the strata in the Northern area below Coal Seam No. 1. It is mostly composed of blue and black clays, with an occasional sandstone and limestone, and an occasional bed of sandy shale. The limestones are generally very hard and break with sharp edges. This is the material used for macadam on the streets of Dallas.

The strata of this division are well developed in the vicinity of Millsap, on

PLATE VII.


Northern Field
DIVISIONS
Central Field
Thickness
Double Mountain
Clear Fork
Wichita
Albany
Coal bed No. 7
Cisco
Canyon
Strawn
Coal bed No. 1
Millsap
Bend
1975±
1800
840
930
950
1000
PERMIAN
COAL MEASURES
1975
1180
670
809
3000
140
220

the line of the Texas and Pacific Railway, in the western part of Parker County. It was also found in a deep well at Thurber to be at least one thousand feet thick. The drill used there brought up a two-inch core which gave a very good idea of the section passed through, which was principally bluish clay, or as the miners call it slate, with a few seams of sandstone and limestone. Near the base of the section, at the Brazos River, in Parker County, there is a bed of limestone with many *fusulina.*

All the strata below the Coal Seam No. 1 in the Northern area are placed in this division.

The gas and salt water at Gordon and Thurber are found in this division.

Strawn Division.—This division is so named because of the fine and extensive presentation of the strata in the vicinity of that town. It occurs in both the Northern and Southern areas. In the section made across the Northern area it is shown in the vicinity of Mineral Wells, and in the Central section it is shown from south of Brownwood to the San Saba River. In the Northern area it rests conformably upon the Millsap division and its base is Coal Seam No. 1. In the Central area its lower portion is missing, as is also the Millsap division, and the middle part of the Strawn division rests unconformably upon the Bend division. This division is composed of shales and sandstones and some conglomerates. Coal Seam No. 1 is at the base of the division. It is intended to include in this division all the strata in the Northern area above Coal Seam No. 1 and the heavy beds of limestone of the division above. In the Central area it is intended to include in this division all the strata above the Bend division to the heavy beds of limestone near Brownwood.

Canyon Division.—This division occurs in both the Northern and Central divisions of the Central Carboniferous area. It is so named from the prominence with which some of the strata are seen at Canyon, in the western part of Palo Pinto County, along the the line of the Texas and Pacific Railway. This division is composed very largely of massive limestones, and may be seen at Rock Creek, in the western edge of Jack County; at and near Palo Pinto and Canyon Creek, in Palo Pinto County, in the Northern area, and on Jim Ned Creek, in the Southern area. The beds of limestones are not quite as thick in the Central area as they are in the Northern, but the thickness of the division is nearly the same in both. In this division occur most of the large springs to be found in the Carboniferous formation in Texas. This division is characterized by the heavy beds of limestone found in it, and is easily recognized by this fact, the limestones in the other divisions being much thinner bedded.

Cisco Division.—This division is well exposed at Cisco, on the line of the Texas and Pacific Railway, and to it I have given the provisional name of that town. It is composed mostly of conglomerates, sandstones, and limestones, as well as clays and sandy shales. In it occurs Coal Seam No. 7. This is the most extensive and continuous division in the entire series. It begins at the most northern extension of the Northern area and continues to the most southern extremity of the Central area. There is only one small area where it is covered by the overlying Cretaceous, and that is a few miles south of the line of the Texas and Pacific Railway, opposite to the town of Putnam, in Callahan County. This division usually extends to the western border of the "Upper Cross Timbers," and in the Central area it extends beyond their western border. The conglomerates in this division very much resemble the conglomerates found in the Strawn division, and were supposed by Mr. Ashburner to be the same beds, and were by him put in the Sub-Carboniferous and made equivalent with the millstone grit. The sandstones are much the same as those in the Strawn division but are harder. This division can best be determined by its stratigraphic position—below it is always found the heavy beds of limestone of the Canyon division.

Albany Division.—This is the upper division of the Carboniferous series in Texas. It is named Albany division for the reason that in the vicinity of Albany, in Shackelford County. the strata are well developed. The strata of this division are largely composed of limestone and shales, there being very little sandstone except at the base of the division. The division does not occur in the area north of the Brazos River, but is continuous as far south as the southern extremity of the Southern area. It is overlaid along the entire western border by the Clear Fork Beds of the Permian. This division is all west of the western boundary of the "Upper Cross Timbers." A small area only is overlaid by the Cretaceous, and that occurs a few miles south of the town of Baird, in Callahan County.

This division embraces all the strata above the sandstones of the Cisco division to the base of the Permian. The boundary between the Permian and Carboniferous is determined largely upon paleontologic grounds, and will be discussed more at length in another place in this Report. The limestones of this division are generally in thin beds, but in places they are massive, being four or five feet thick.

SECTION NO. 2. (PLATE XVI.)

This section was made from San Saba River, near the town of San Saba, to Brownwood, and thence to the head of Pecan Bayou, in the western edge of Callahan County.

a. San Saba River.
b. Colorado Civer.
c. East Comanche Creek.
d. Middle Comanche Creek.
e. West Comanche Creek.

f. Willis Creek.
g. Jim Ned Creek.
h, h, h, h, h, h. Pecan Bayou at various places.
i. Paint Creek at Byrd's old store.
j. Manties Creek.
k. Middle Fork Pecan Bayou.
l. Rough Creek.
m. North Fork Pecan Bayou.
S. San Saba.
B. Brownwood.
C. Cretaceous.
1 to 2. Bend Division.
2 to 3. Strawn Division.
3 to 4. Canyon Division.
4 to 5. Cisco Division.
5 to 6. Albany Division.
●. Coal Seam No. 7.

SECTION NO. 3. (PLATE XVI.)

Made from the western edge of Hood County northwestward, passing through the towns of Millsap, Mineral Wells, Graham, and Fort Belknap, to the northeast corner of Throckmorton County.

a. Kickapoo Creek.
b. Brazos River at the west line of Parker County.
c. Grindstone Creek.
d. Rock Creek, Parker County.
e. Little Keechi.
g. Rock Creek, Jack County.
h. Dry Creek.
i. Salt Creek.
j. Jim Anderson Creek.
k. Whisky Creek.
l. Skid Creek.
m. California Creek.
n. Wild Cat Creek.
o. Camp Creek.
M. Millsap.
M″. Mineral Wells.
F. Finis.
G. Graham.
B. Belknap.
1. Cretaceous.
1 to 2. Millsap Division.
2 to 3. Strawn Division.
3 to 4. Canyon Division.
4 to 5. Cisco Division.
●. Coal Seam No. 1.
x. Coal Seam No. 7.

LOCAL SECTIONS, NORTHERN COAL FIELD.

In order to secure an accurate knowledge of the entire Coal Measure section of Texas, two lines of levels were run entirely across them and the section constructed by actual observation of the formation, stratum by stratum. The following local sections will show in detail the character of the formation, and the plate of cuts No. XVI will give, on a reduced scale, the sections themselves. The location of the line of levels and locality of each section given will be found properly designated on the map accompanying this Report.*

The following sections were made along the line of levels that we ran across the Carboniferous formation from the northeast corner of Throckmorton County in a southeasterly direction to the line of Hood County:

SECTION 17, CISCO DIVISION.

This section was made about three-fourths of a mile east of where the Seymour and Graham road crosses Skid Creek, about eight miles west of Belknap.

1.	Blue Clay	4 feet.	
2.	Coal and shale, Seam No. 7	2 feet.	
3.	Yellow sandstone, shaly	3 feet.	
4.	Blue and yellow clay	15 feet.	
5.	Coal		4 inches.
6.	Blue Clay	10 feet.	
7.	Carbonaceous shale	3 feet.	
8.	Sandstone	4 feet.	
	Total	41 feet	4 inches.

SECTION 18, CISCO DIVISION.

At mouth of Whisky Creek, three miles west of Belknap.

1.	Shale	3 feet	
2.	Coal	1 foot	2 inches.
3.	Limestone	2 feet.	
4.	Sandstone, shaly	25 feet.	
5.	Coal Seam No. 7	1 foot	8 inches.
6.	Sandstone and shale	8 feet.	
7.	Coal	1 foot.	
8.	Conglomerate	40 feet.	
9.	Soil	2 feet.	
	Total	83 feet	10 inches.

*See Plate XVIII.

SECTION NO. 19, CISCO DIVISION.

Two hundred yards above the mouth of Whisky Creek.

1.	Bluish clay with selenite	6 feet.
2.	Coal	1 foot.
3.	Shale with limestone concretions	1 foot 6 inches.
4.	Shaly sandstone and clay	3 feet.
5.	Fine-grained sandstone	1 foot 6 inches.
6.	Sandstone, ripple marked	3 feet.
	Total	16 feet.

In the limestone nodules in No. 3 of the above section there occur the following fossils: *Productus punctatus*, Martin; *P. nebrascensis*, Owen; *Nuculana bellistriata*, Stevens; *Spirifer cameratus*, Morton; *Myalina subquadrata*, Shumard; *Aviculopecten occidentalis*, Shumard; *Nuculana ventricosa*, Hall; *Synocladia biserialis*, Swallow.

SECTION NO. 20, CISCO DIVISION.

Two miles east of Belknap.

1.	Limestone	2 feet.
2.	Blue clay	20 feet.
3.	Sandstone, ripple-marked and in places massive	20 feet.
4.	Yellow clay	7 feet.
5.	Shaly limestone, nodular fossiliferous	3 feet.
6.	Yellow clay	6 feet.
7.	Red clay	4 feet.
8.	Limestone	1 foot 6 inches.
9.	Blue clay with selenite	4 feet.
10.	Coal	9 inches.
	Total	68 feet 3 inches.

SECTION NO. 21, CISCO DIVISION.

At the falls of Salt Creek, one-half mile west of Graham.

1.	Conglomerate	4 feet.
2.	Sandstone (the Falls)	3 feet.
3.	Blue clay with calamites	50 feet.
4.	Sandstone	3 feet.
5.	Limestone, *Allorisma*	2 feet.
6.	Yellowish and blue clay	30 feet.
7.	Conglomerate	15 feet.
	Total	107 feet.

In the clay of No. 6 of the above section I found the fossils given on page 362 of this Report as being below the limestone called Sub-Carboniferous by Mr. Ashburner.

SECTION NO. 22, CISCO DIVISION.

On Weatherford road, ten miles east of Graham.

1.	Yellow clay	8 feet.
2.	Sandstone	2 feet.
3.	Blue clay, fossiliferous	10 feet.
4.	Yellow limestone, fossiliferous	2 feet.
5.	Yellow clay	30 feet.
6.	Sandstone, massive	20 feet.
7.	Yellow clay	30 feet.
8.	Conglomerate	20 feet.
	Total	122 feet.

In No. 3 of the above section the following fossils were found: *Bellerophon crassus*, Meek and Worthen; *B. carbonarius*, Cox; *B. nodocarinatus*, Hall; *Chonetes granulifera; Euomphalus rugosus*, Hall; *E. pentagulatus?; Loxonema rugosa*, Worthen; *Lophophyllum proliferum*, McChesney; *Macrocheilus primogenius*, Conrad; *Macrocheilus*, sp. ind.; *Nuculana bellistriata*, Stevens; *Orthoceras rushensis*, McChesney; *Orthis pecosi*, Marcou; *Pleurotomaria tabulata*, Hall; *Productus semireticulatus*, McChesney; *Spirifer cameratus*, Morton; *Zaphrentis spinulifera*, Hall.

SECTION NO. 23, CANYON DIVISION.

Two miles north of Finis, in Jack County, beginning at Rock Creek.

1.	Limestone	40 feet.
2.	Yellow clay	15 feet.
3.	Sandstone	20 feet.
4.	Yellow clay	28 feet.
5.	Thin-bedded sandstone	8 feet.
6.	Yellow clay	30 feet.
7.	Limestone	10 feet.
8.	Blue and yellow clay	30 feet.
9.	Mottled sandstone	4 feet.
10.	Hard sandstones, thin-bedded	6 feet.
11.	Yellow and blue clay	40 feet.
12.	Limestone, thin-bedded	25 feet.
13.	Sandstone	18 feet.
14.	Yellow clay	22 feet.
15.	Sandstone	30 feet.
16.	Conglomerate	20 feet.
	Total	340 feet.

The following fossils were taken from the massive limestone No. 1 of the above section: *Athyris subtilita*, Hall; *Productus longispinus*, Sowerby; *P. semireticulatus*, Martin; *P. cora*, D'Orbigny; *Spirifer cameratus*, Morton.

SECTION NO. 24, CANYON DIVISION.

On the Weatherford and Graham road, at Little (or East) Keechi Creek.

1.	Limestone	4 feet.
2.	Yellow clay, fossiliferous	25 feet.
3.	Sandstone	2 feet.
4.	Yellow clay, with clay ironstone	30 feet.
5.	Sandstone, massive	8 feet.
6.	Bluish clay, ironstone concretions	10 feet.
	Total	79 feet.

The following is a list of the fossils taken at this place:

Athyris subtilita, Hall; *Bellerophon carbonarius*, Cox; *B. percarinatus*, Conrad; *Chonetes*, sp. ind.; *Conularia crustula*, White; *Discina convexa*, Shumard; *Lophophyllum proliferum*, McChesney; *Productus cora*, D'Orbigny; *P. costatus*, Sowerby; *P. nebrascensis*, Owen; *P. symmetricus*, McChesney; *P. longispinus*, Sowerby; *Pleurotomaria sphærulata*, Conrad; *Spirifer lineatus*, Martin; *S. cameratus*, Morton; *Terebratula bovidens*, Morton.

At this place I found traversing No. 2 of above section what appeared to be a dyke, but upon closer inspection proved to be a seam of fossiliferous limestone. The seam is about two inches thick, and has a course of north 60° west. We sunk a pit by the side of the seam, and found it to be almost vertical, and the clay undisturbed on both sides of it. It is broken in pieces which are very uniform in size. The material is very compact and is not stalactitic, yet it does not resemble any other limestone in the vicinity. I was unable to account for the position of this limestone. The seam runs in about the same direction of the fracture in the surrounding strata.

SECTION NO. 25, STRAWN DIVISION.

Made at Mountain Springs, five miles east of the last section.

1.	Yellow and bluish clay	40 feet.
2.	Yellow limestone	2 feet.
3.	Yellow clay	22 feet.
4.	Limestone, water bearing	6 feet.
5.	Yellow clay	30 feet.
6.	Limestone, cherty	3 feet.
	Total	103 feet.

The cherty limestone in the above section is the same as was found in the bed of East Keechi Creek and at the base of the preceding section. The massive water bearing limestone is the same bed as is found at Palo Pinto and at Canyon.

SECTION NO. 26, STRAWN DIVISION.

Mineral Wells.

1.	Blue clay, fossiliferous	80 feet.
2.	Shaly sandstone	25 feet.
3.	Limestone	1 foot 6 inches.
4.	Yellow clay	44 feet.
5.	Sandstone	6 feet.
6.	Conglomerate	4 feet.
	Total	160 feet 6 inches.

The fossils collected at this place have been given on another page of this Report.

SECTION NO. 27, MILLSAP DIVISION.

At Powell's Ferry, on the Brazos River.

1.	Limestone in thin layers	4 feet.
2.	Sandstone	3 feet.
3.	Yellow limestone	1 foot 6 inches.
4.	Blue clay	20 feet.
5.	Limestone	4 feet.
	Total	31 feet 6 inches.

In No. 5 of the above section we found *Productus semireticulatus*, Martin; *Spirifer lineatus*, Martin; *Athyris subtilita*, Hall; *Spirifer plano-convexus*, Shumard. And in No. 1 of the above section the following fossils occur: *Spirifer lineatus*, Martin; *S. plano-convexus*, Shumard; *Fusulina cylindrica*, Fischer; *Zaphrentis gibsoni*, White; *Athyris subtilita*, Hall.

This section embraces the lowest division of the Carboniferous in the northern part of the State. Overlying this are the Trinity sands of the Cretaceous.

LOCAL SECTIONS, CENTRAL COAL FIELD.

We also ran a line of levels across the Central region of the Carboniferous, beginning at the head of Pecan Bayou near the western line of Callahan County and running thence in a southeasterly direction to the town of San Saba. I made a complete section of the formation along this line. The following local sections will give the principal features of this general section:

SECTION NO. 28, ALBANY DIVISION.

At the center of the north line of section No. 21, made for the Buffalo Bayou, Brazos and Colorado Railway Company.

1.	Shaly limestone in several beds, fossiliferous	3 feet.
2.	Yellow clay	4 feet.
3.	Limestone	10 inches.
4.	Clay	6 feet.
5.	Limestone, shaly at base, weathering in rounded masses at top	4 feet.
6.	Clay	10 feet.
7.	Limestone in beds	6 feet.
8.	Clay	2 feet.
9.	Limestone, with Nautilus and Orthoceras	1 foot 6 inches.
10.	Clay	10 feet.
11.	Limestones with iron seams	3 feet.
	Total	50 feet 4 inches.

The following fossils were found in No. 1 of the above section: *Productus semireticulatus*, Martin; *Myalina subquadrata*, Shumard; *Pinna peracuta*, Shumard; *Euomphalus pentagulatus?; Nautilus?.*

SECTION NO. 29, ALBANY DIVISION.

One and a half miles southeast of Section 28. The top of this section begins about twenty feet below the base of the previous section.

1.	Hard limestone	1 foot 6 inches.
2.	Yellow clay	10 feet.
3.	Yellow limestone, weathered into holes	13 feet.
4.	Yellow clay	4 feet.
5.	Limestone, fossiliferous	6 inches.
6.	Yellow clay	20 feet.
7.	Limestone, Nautilus?	
	Total	49 feet.

In the limestone of No. 5 of the above section I recognized *Nuculana bellistriata*, Stevens.

SECTION NO. 30, ALBANY DIVISION.

At the north line of Section No. 5, made for Buffalo Bayou, Brazos and Colorado Railway Company and about five miles southeast of the previous section:

1.	Limestones with beds of yellow clay	20 feet.
2.	Yellow clay	10 feet.
3.	Limestone	2 feet.
4.	Yellowish clay	4 feet.
5.	Limestone	2 feet.
6.	Yellow clay	20 feet.
7.	Limestone	3 feet.
8.	Limestone	2 feet.
9.	Limestone	1 foot 6 inches.
	Total	64 feet 6 inches.

In No. 1 of the above section there are *Bellerophon*, *Pinna*, *Allorisma*, and *Nautilus?*. From between the upper beds of limestones of this section there issues a bold, running spring, that flows into Rough Creek.

SECTION NO. 31, ALBANY DIVISION.

About one-half mile southeast of the previous section. The top of this section is about twenty feet below the base of the preceding section. Beginning at the top:

1.	Limestone, with thin seams of clay	4 feet.
2.	Shaly limestone	2 feet.
3.	Yellow limestone	1 foot 6 inches.
4.	Reddish limestone	8 inches.
5.	Gray limestone	1 foot 6 inches.
6.	Clay	2 feet.
7.	Limestone	1 foot 6 inches.
8.	Limestone	6 inches.
9.	Limestone	2 feet.
10.	Limestone	6 inches.
11.	Clay	6 feet.
12.	Yellow limestone	8 inches.
13.	Yellow clay	4 feet.
14.	Yellow limestone	1 foot.
15.	Yellow limestone	20 feet.
16.	Striped limestone	6 inches.
17.	Yellowish clay	10 feet.
18.	Limestone (building material)	1 foot.
	Total	59 feet 4 inches.

Some of the limestones in this section would make excellent building material when there shall be a demand for it. The formation here very much resembles that just west of the town of Baird, and is probably the same. It is the beds I have elsewhere called "Albany Beds," and is the same as seen at the head of North Hubbard Creek, in Shackelford County, northwest of Albany. The coral *Syringapora multattenuata* is very abundant, occurring in large masses in the clay and limestones. There were also *Synocladia*, *Macrocheilus*, *Aviculopecten*, and *Myalina*.

SECTION NO. 32, ALBANY DIVISION.

In McCoy's pasture, on the south side of Pecan Bayou, and below the forks of the bayou. The top of this section is eighty feet below the base of the previous section.

1.	Limestone	1 foot.
2.	Clay	20 feet.
3.	Limestone	1 foot 6 inches.
4.	Clay	10 feet.
5.	Limestone	1 foot 2 inches.
6.	Clay	15 feet.
7.	Limestone	1 foot 4 inches.
8.	Clay	20 feet.
9.	Limestone	1 foot 6 inches.
10.	Clay	10 feet.
11.	Limestone	8 inches.
	Total	82 feet 2 inches.

SECTION NO. 33, ALBANY DIVISION.

Polecat Hill, at Station No. 112 on our line:

1.	Red and blue clay	20 feet.
2.	Sandstone	6 inches.
3.	Blue clay	12 feet.
4.	Yellow limestone	2 feet.
5.	Yellow clay	10 feet.
6.	Yellow limestone	1 foot 6 inches.
	Total	46 feet.

At this section is the first sandstone we have found on this line. It is here in a thin bed, and is probably not persistent. It very much resembles the bed of sandstone found at Baird, and on North Hubbard Creek, near the town of Albany.

SECTION NO. 34, ALBANY DIVISION.

At one-half mile south of the previous section.

1.	Limestone	1 foot.
2.	Yellow clay	3 feet.
3.	Limestone, shaly	2 feet.
4.	Clay	4 feet.
5.	Limestone	8 feet.
	Total	18 feet.

SECTION NO. 35, ALBANY DIVISION.

At one-half mile southeast of the preceding section, and at Station 118.

1.	Bluish clay	40 feet.
2.	Limestone, large slabs	8 feet.
3.	Yellow clay	1 foot 6 inches.
4.	Limestone	3 feet.
5.	Limestone, shaly, same as No. 3 in Section 34	2 feet.
	Total	54 feet 6 inches.

Between Stations Nos. 119 and 120 is a bed of limestone, with thin seams of clay, thirty feet thick, containing a great number of *Allorisma subquadrata*, and weathering into round, biscuity masses when exposed to the weather.

SECTION NO. 36, ALBANY DIVISION.

On Pecan Bayou, one and a half miles southeast of the previous section.

1.	Shaly limestone	6 feet.
2.	Yellow clay	8 feet.
3.	Yellow limestone	1 foot 6 inches.
4.	Limestone	1 foot 3 inches.
5.	Yellow and blue clay	20 feet.
6 and 7.	Sandstone and bluish clay	15 feet 6 inches.
	Total	52 feet 3 inches.

SECTION NO. 37, ALBANY DIVISION.

One mile southeast of previous section.

1.	Sandstone in thin seams	2 feet.
2.	Blue clay	4 feet.
3.	Sandstone	8 inches.
4.	Yellow clay	12 feet.
5.	Limestone	1 foot 6 inches.
6.	Clay	40 feet.
7.	Sandstone	6 inches.
8.	Clay	20 feet.
9.	Limestone	2 feet.
	Total	82 feet 8 inches.

SECTION NO. 38, CISCO DIVISION.

On Pecan Bayou, one-half mile east of the county line between Callahan and Coleman counties.

1.	Yellow clay	25 feet.
2.	Slaty limestone	2 feet.
3.	Blue clay	20 feet.
4.	Limestone	1 foot 6 inches.
5.	Yellow clay	4 feet.
6.	Limestone	1 foot.
7.	Blue clay	4 feet.
8.	Limestone, *Fusulina*	2 feet.
	Total	59 feet 6 inches.

At this place are the first *Fusulina* I have collected on this line.

SECTION NO. 39, CISCO DIVISION.

One mile southeast of previous section and near the southwest corner of the McClung Johnson survey.

1.	Red clay	20 feet.
2.	Sandstone	2 feet.
3.	Blue clay	15 feet.
4	Sandstone	1 foot 6 inches.
5.	Yellow clay	30 feet.
6.	Greenish sandstone	6 inches.
7.	Yellow clay	15 feet.
8.	Yellow limestone	2 feet.
9.	Yellow clay	20 feet.
10.	Yellow limestone	2 feet.
	Total	108 feet.

At this place the following fossils occur: *Schizodus wheeleri*, Swallow; *Productus semireticulatus*, Martin; *Pinna peracuta*, Shumard; *Hemipronetes crassus*, King.

SECTION NO. 40, CISCO DIVISION.

On the Mark Izard survey, near the public school house.

1.	Black slate	4 feet.
2.	Limestone	8 inches.
3.	Blue shale	2 feet.
4.	Limestone	1 foot.
5.	Sandstone	2 feet.
6.	Slate	4 feet.
	Total	13 feet 8 inches.

About one mile east of this section, near the northeast corner of the George Eubanks survey, in a well that was being dug on Mr. Gould's place, the most of the way for thirty feet is through a shaly limestone and blue clay that has a great many *Aviculopecten* imbedded in it. One-half mile southeast of that is a hill showing the yellow limestone at the top that was first seen in Section 39 and elsewhere along the bank of the bayou; below that was the sandstone seen at the school house, as mentioned in the previous section.

On the top of the hill mentioned, and resting directly upon the yellow limestone, is a bed of conglomerate. I have not seen it elsewhere, and it is probably local.

SECTION NO. 41, CISCO DIVISION.

On bayou, three miles east of previous section, near the town of Burkett. Beginning at the top.

1.	Yellow clay	20 feet.
2.	Limestone	2 feet.
3.	Yellow clay	25 feet.
4.	Limestone	1 foot 3 inches.
5.	Yellow clay	8 feet.
6.	Limestone	1 foot 6 inches.
7.	Yellow clay	10 feet.
8.	Sandstone	4 feet.
	Total	71 feet 9 inches.

At this place we reached the first bed of coarse-grained massive yellow sandstone.

SECTION NO. 42, CISCO DIVISION.

At county line between Brown and Coleman counties and on the White league.

1.	Yellow clay	10 feet.
2.	Sandstone, massive	4 feet.
3.	Sandstone, hard	1 foot.
4.	Conglomerate	2 feet.
	Total	17 feet.

SECTION NO. 43, CISCO DIVISION.

At three miles east of previous section and on the Victoria County school land.

1.	Yellow clay	20 feet.
2.	Massive limestone	4 feet.
3.	Yellow clay	6 feet.
4.	Limestone, massive	3 feet.
	Total	33 feet.

This section very much resembles the strata on Sandy Creek, in Eastland County, three miles northwest of Cisco, and I judge it to be at the same geological horizon.

SECTION NO. 44, CISCO DIVISION.

At Mrs. Smith's, on the Jesse Williams survey.

1.	Black bituminous shale	10 feet.	
2.	Coal		4 inches.
3.	Blue clay	8 feet.	
4.	Sandstone, ripple marked, thin bedded	4 feet.	
5.	Yellow clay	30 feet.	
6.	Greenish sandstone		8 inches
7.	Yellow clay	40 feet.	
8.	Conglomerate	8 feet.	
	Total	101 feet.	

The coal seam in the above section is probably No. 7 of the general section, but being exposed in only one place, and that at the top of a small anticlinal, I was unable to determine. There are in places a small seam of coal above Seam No. 7, and it may be that this is that thin seam.

SECTION NO. 45, CISCO DIVISION.

Two miles west of Bird's store, and near the mouth of Paint Creek.

1.	Yellow clay	18 feet.
2.	Sandstone, cross-bedded, ripple marked	3 feet.
3.	Red clay	20 feet.
4.	Limestone	2 feet.
	Total	43 feet.

SECTION NO. 46, CISCO DIVISION.

At mouth of Paint Creek.

1.	Sandstone, ripple marked	4 feet.
2.	Yellow clay	20 feet.
3.	Conglomerate	4 feet.
	Total	28 feet.

SECTION NO. 47, CISCO DIVISION.

Beginning one mile east of the mouth of Paint Creek, at the top.

1.	Limestone, shaly, with coral	3 feet.
2.	Clay	30 feet.
3.	Sandstone	2 feet.
4.	Yellow clay	20 feet.
5.	Limestone, concretionary	2 feet.
6.	Yellow clay	6 feet.
7.	Limestone	1 foot 3 inches.
8.	Limestone	2 feet.
9.	Yellow clay	30 feet.
10.	Sandstone	3 feet.
11.	Yellow clay	20 feet.
12.	Limestone	1 foot 6 inches.
13.	Yellow clay	6 feet.
14.	Limestone	1 foot 8 inches.
	Total	128 feet 5 inches.

In No. 1 of the above section I found a coral, abundant and very large, that I I have seen at only one other place—on Mukewater Creek, near the town of Trickham. This is at about the same geological horizon, and I take it to be the same beds. The coral very much resembles *Campophyllum?* Some of the specimens are two inches in diameter and eight inches long.

SECTION NO. 48, CANYON DIVISION.

At the crossing of Pecan Bayou, and on the Wm. Eldridge survey.

1.	Massive sandstone	6 feet.
2.	Yellow clay	10 feet.
3.	Limestone	2 feet.
4.	Yellow clay	8 feet.
5.	Limestone, *Campophyllum? Fusulina*	3 feet.
	Total	29 feet.

SECTION NO. 49, CANYON DIVISION.

On the right of the road, opposite the twelfth mile post from Brownwood.

1.	Yellow clay	20 feet.	
2.	Limestone		10 inches.
3.	Sandy clay	20 feet.	
4.	Sandstone	6 feet.	
5.	Yellow clay	10 feet.	
6.	Limestone	1 foot	6 inches.
7.	Yellow clay	15 feet.	
8.	Rotten limestone, with fossils	2 feet.	
	Total	75 feet	4 inches.

At this place I collected the following fossils: *Athyris subtilita*, Hall; *Productus prattenanus*, Norwood; *P. nebrascensis*, Owen; *Pleurotomaria sphærulata*, Conrad; *P. tabulata*, Hall; *Productus semireticulatus*, Martin; *Spirifer cameratus*, Morton; *Orthoceras rushensis*, McChesney; *Macrocheilus ventricosus*, Hall; *Fusulina cylindrica*, Fischer; *Campophyllum?* sp.

SECTION NO. 50, CANYON DIVISION.

At Jim Ned Creek.

1.	Limestone	8 feet.
2.	Yellow clay	12 feet.
3.	Sandstone	2 feet.
4.	Yellow and blue clay	15 feet.
5.	Limestone	3 feet.
6.	Limestone	1 foot.
	Total	41 feet.

The limestones at this place are the same as are found on Rock Creek, in the western edge of Jack County, and numbered Section 23.

SECTION NO. 51, CANYON DIVISION.

Eight miles north of Brownwood.

1.	Yellow clay	10 feet.	
2.	Sandstone		10 inches.
3.	Yellow clay	20 feet.	
4.	Sandstone	2 feet.	
5.	Limestone	3 feet.	
6.	Yellow and blue clay	10 feet.	
7.	Blue limestone		10 inches.
	Total	46 feet	8 inches.

SECTION NO. 52, STRAWN DIVISION.

At Willis Creek, two miles south of Brownwood. Beginning at top.

1.	Limestone	25 feet.
2.	Clay	15 feet.
3.	Limestone	1 foot.
4.	Clay	
	Total	41 feet.

SECTION NO. 53, STRAWN DIVISION.

At and south of Colorado river, on West Brownwood and San Saba road. Beginning at the top.

1.	Sandstone	8 feet.
2.	Shaly sandstone	35 feet.
3.	Sandy clay	35 feet.
4.	Shaly sandstone	12 feet.
5.	Sandy clay	25 feet.
6.	Shaly sandstone	18 feet.
7.	Sandy clay	10 feet.
8.	Shaly sandstone	45 feet.
9.	Sandstone	5 feet.
10.	Shaly sandstone	5 feet.
11.	Sandstone	10 feet.
12.	Sandy clay	80 feet.
13.	Sandstone	25 feet.
14.	Sandy clay	15 feet.
	Total	328 feet.

SECTION NO. 54, STRAWN DIVISION.

Five to six miles south of Colorado River, on Houston and Texas Central Railway 89 and H. B. Williams 371 surveys, San Saba County.

1.	Sandstone	15 feet.
2.	Sandy clay	60 feet.
3.	Sandstone	5 feet.
4.	Sandy clay	50 feet.
5.	Sandstone	2 feet.
6.	Sandy clay	40 feet.
7.	Sandstone	7 feet.
8.	Sandy clay	35 feet.
9.	Sandstone	11 feet.
10.	Clay	15 feet.
11.	Sandstone	3 feet.
12.	Sandy clay	20 feet.
	Total	263 feet.

SECTION NO. 55, STRAWN DIVISION.

Eight or ten miles northwest of San Saba. Beginning at the top.

1.	Sandstone	5 feet.
2.	Sandy clay	25 feet.
3.	Sandstone	4 feet.
4.	Clay, somewhat sandy	95 feet.
5.	Sandstone	6 feet.
6.	Clay	7 feet.
7.	Sandstone, with clay partings	15 feet.
8.	Sandy clay	20 feet.
9.	Shaly sandstone	15 feet.
10.	Sandy clay	100 feet.
11.	Sandstone	2 feet.
12.	Sandy clay	13 feet.
13.	Sandstone	3 feet.
14.	Sandy clay	8 feet.
15.	Sandstone	6 feet.
16.	Sandy clay	55 feet.
17.	Sandstone, with some clay partings	16 feet.
18.	Sandy clay	30 feet.
	Total	428 feet.

A description of the rock material forming the Bend division was given in my report on "The Southern Border of the Central Coal Field," in the First Annual Report of this Survey, pages 147 to 150, and it is unnecessary to repeat it here.

PALEONTOLOGY.

The fossils of the series are generally quite numerous and ordinarily well preserved. The conditions for their preservation seem to have been very favorable.

VERTEBRATES.—Very few fragments of vertebrates have been collected in the strata, and they have generally been of such a fragmentary character that nothing could be made of them.

Edestus Minor.—A single specimen of this rare fossil was found in the black shale about one mile west of the town of Bend, in the southeast corner of San Saba County.

This species has never been found anywhere except in the Coal Measures. Professor Newberry says, after giving the locality of several specimens: "Thus it will be seen that all the specimens known, now quite numerous, are from the Mississippi Coal Field, that is, the coal area of Illinois and Missouri, once continuous but now separated by the erosion of the immediate valley of the Mississippi." *

It has been stated elsewhere in this Report that the Texas Coal Field is a part of the Mississippi Coal Field, and the conclusion that Dr. Newberry reaches, that it was a fish peculiar to the Western Coal Field, is not contradicted by the finding of this specimen in Texas.

ARTICULATES —Two species of Trilobites have been found belonging to the genus *Phillipsia.* They are not abundant, and have only been found at a few localities. Some of them are well preserved.

MOLLUSKS.—This sub-kingdom is well represented by the several classes, *Cephalopoda*, *Gasteropoda*, *Lamellibranchiata*, *Brachiopoda*, and *Bryozoans.* The Cephalopods are numerous in genera and species. Some of these are described for the first time in this Report by Prof. Alpheus Hyatt.

The Gasteropods are represented by several species in well preserved specimens. The families of *Bellerophon* and *Pleurotomaria* are most numerous.

Lamellibranchs are numerous, represented by the families *Aviculopecten*, *Allorisma*, *Myalina*, and others.

The Brachiopods are abundant everywhere, being represented by *Spirifer*, *Productus*, *Chonetes*, and other families.

RADIATES.—These are numerous, and are represented by *Zaphrentis*, *Campophyllum*, *Axophyllum*, and *Syringopora* of the corals, and several species of the Echinoids and Crinoids.

The Protozoans are represented by *Fusulina cylindrica* in very great abundance, and are found from the bottom to the top of the Measures. If there are more than one species—and that fact is to be determined by the sizes—then there are more than two species in the formation in this State, for they vary very much in size in different horizons.

There are several undescribed species of fossils occurring at different localities, the description of which will have to be deferred to another time.

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* Paleozoic Fishes of North America, P., p. 217, 1880.

The following is a complete list of the fossils of the Coal Measures that have been identified, collected in the State.

Allorisma subcuneata, M. and W.
Athyris subtilita, Hall.
Aviculopecten occidentalis, Shumard.
Arca carbonaria, Cox.
Bakevellia? parva, Meek and Hayden.
Bellerophon carbonarius, Cox.
B. crassus, M. and W.
B. percarinatus, Conrad.
B. nodocarinatus, Hall.
B. marcouianus, Geinitz.
Campophyllum torquium, E. and H.
Chonetes mesoloba, N. and P.
C. granulifera, Owen.
C. platynota, White.
C. verneuiliana, N. and P.
Conularia crustula, White.
Conocardium obliquum, M. and W.
Discina convexa, Shumard.
D. nitida, Phillips.
Dentalium obsoletum, Hall.
Edmonia aspinwallensis, Meek.
Euomphalus rugosus, Hall.
E. pentagulatus,
Ephippioceras divisum, Hyatt.
Endolobus gibbosus, Hyatt.
Fusulina cylindrica, Fischer.
F. robustus, Meek.
Fenestella, sp. ind.
Fistulipora nodulifera, Meek.
Gastrioceras compressus, Hyatt.
Hemipronites crassus, M. and H.
H. crenistria?, King.
Hadrophyllum aplatus, Cummins.
Lophophyllum proliferum, McChesney.
Loxonema rugosa, Worthen.
Lingula umbonata, Cox.
Lingula, sp. ind.
Lima retifera.
Meekella striata costata, Cox.
Michelina placenta?, White.
Myalina subquadrata, Shumard.
M. swallowi, McChesney.
M. recurvirostris, Meek and Worthen.
Macrocheilus ventricosus, Hall.
M. fusiformis, Hall.
M. medialis, Meek and Worthen.
M. primogenius, Conrad.
M. paludinaeformis, Hall.
Metacoceras walcotti, Hyatt.
Naticopsis nana, M. and W.
N. pricei? Shumard.
Nautilus winslowi, M. and W.
Nucula ventricosus, Hall.
Nuculana bellistriata, Stevens.
N. obesa, White.
Nunstroceras paralellum, Hyatt.
Orthoceras rushensis, McChesney.
Orthis pecosi, Marcou.
Pinna peracuta, Shumard.
Platyceras nebrascense, Meek.
Pleurotomaria turbiniformis, M. and W.
P. brazosensis, Shumard.
P. tabulata, Hall.
P. coxana, Meek and Worthen.
P. sphaerulata, Conrad.
P. newportensis, White.
Productus cora, D'Orbigny.
P. pertermis, Meek.
P. costatus, Sowerby.
P. longispinus, Sowerby.
P. nebrascensis, Owen.
P. punctatus, Martin.
P. semireticulatus, Martin.
P. symmetricus, McChesney.
Platyceras prattenianus, Norwood.
Phacoceras dumbli, Hyatt.
Retzia mormoni, Marcou.
Rhynconella uta, Marcou.

R. mutata, Hall.
Spirifer cameratus, Morton.
S. planoconvexus, Shumard.
S. lineatus, Martin.
S. rockymontanus, Marcou.
Spiriferena kentuckensis, Shumard.
Syntrielasma hemiplicata, Hall.
Synocladia biserialis, Swallow.
Schizodus wheeleri, Swallow.
Syringapora multattenuata, McChesney.
Terebratula bovidens, Morton.
Tainoceras cavatum, Hyatt.
Zaphrentis gibsoni, White.
Z. spinulifera, White.

PERMIAN.

It is intended to include in the Permian all the Red Beds in Texas which lie between the upper part of the Albany Beds of the Coal Measures and the Dockum Beds, or the lower part of the Triassic as recognized here.

The rocks of the Permian series comprise limestones, sandstones, shales, red and blue clays, and beds of gypsum. There has heretofore been a great deal of confusion in regard to the "Red Beds" of Texas and other localities in the northwest, and they have been sometimes referred to one series and sometimes to another, depending upon the locality at which they were observed.

The strata seen by Marcou in 1853 did not embrace much of the Permian of Texas, as his route was entirely north of the northern extension of the great body of these beds. He saw the upper part of the formation and recognized it as Permian. What he calls Trias in some of his later publications is what I have described as the Dockum Beds (Trias), and is not included in the Permian. What others have seen in Kansas and New Mexico and called Triassic is no doubt correctly designated; but these beds are not the same as the Permian of Texas, which is here so clearly marked by well defined horizons that there is no occasion to be mistaken in relation to its extent when seen upon the ground. The Permian Beds are so referred on stratigraphic and paleontologic grounds, as will be seen elsewhere in this Report.

BOUNDARY.

The entire boundary of the Permian has not yet been definitely determined in Texas. I have traced (and stated elsewhere in this Report) the line of contact between it and the Coal Measures on the east. On the south it is overlaid by the Cretaceous, and there the formation is found to be not more than thirty miles wide. The southern and western line between the Cretaceous and the Permian, beginning at a point on Kickapoo Creek, in Concho County, near where the road from Brady to San Angelo crosses that creek, passing along a few miles south of San Angelo to the mouth of Spring Creek; thence northward along the Cretaceous hills three or four miles west of the city of San Angelo. From here its western boundary lies along the foot of the Staked Plains, probably to the north line of the State. No attempt has been made to trace the western boundary fully, but it has been found at Big Springs; at Dockum's Ranch, in Dickens County; at Mobeetie, in Wheeler County, and as far north as the Canadian River. The rocks of this formation also lie on all sides of the Wichita Mountains, in the Indian Territory.

RELATION TO ADJACENT STRATA.

It seems to be still an open question whether the Permian Beds shall be placed with the Paleozoic or with the Mesozoic group. There has been an effort on the part of some to place it in the Mesozoic, while there has been an equal effort on the part of others to retain it in the Paleozoic.

Professor Jules Marcou says: "I include the Permian in the New Red Sandstone formation. I know that good reasons, based exclusively on paleontological grounds, have been advanced by geologists desirous to place the Permian in the Paleozoic; but I think the old classification a better one; and more, I think the term Permian, at least as given by Murchison for the strata of the government of Perm, a very improper one. There are strong suspicions that Murchison has put in his Permian of Russia a part, if not the whole, of the Trias; and I am certain that if geologists accept the Russian Permian, as Murchison has defined it, as a type, the Trias will disappear from classification in Asia, Africa, America, and Australia."*

On the other hand, Dr. C. A. White says, "All the hitherto recognized or reputed Permian of North America is far more intimately related, both paleontologically and stratigraphically, with the Paleozoic than with the Mesozoic."†

The International Congress held at Berlin left the matter still undetermined.

I shall not enter into the controversy in this Report, but as a matter of convenience place the Permian in the Paleozoic group. As stated, I intend to include in the Permian all the strata that shall be found to lie between the top of the Coal Measures and the base of the Triassic, as defined in American Geology.

That there is a hiatus between these two formations as defined in North America is a well known fact. By evidence that will be given hereafter, I wish to show that the series of strata that I here call Permian is different from either the Triassic above or the Carboniferous below, as they have been formerly identified. In discussing the question I shall not confine myself to

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* American Geology, Zurich, 1858.

† Proceedings American Association for the Advancement of Science, p. 212, 1889.

any one kind of reason, but shall use all the evidence I have collected. I shall notice the lithological character of the material, the stratigraphic relations, and the paleontological facts bearing upon the question, as I have observed them in this district, premising that the relative importance and value of the different kinds of evidence are in my estimation here named in ascending order.

We need not expect to find as great differences between the Carboniferous and Permian or Triassic and Permian as there is between the Carboniferous and the Triassic, for the former are necessarily more closely related in every respect than the latter, the Permian being the transition period between the two.

It is very often the case that stratigraphic evidence is the only kind that can be obtained for determining the age of a series of strata. If we find a great difference between the dip of adjoining sedimentary rocks, we naturally conclude that some considerable time has elapsed between the time of their deposition. Such is not always the case, however, for great cataclysms occurred sometimes in the midst of a period, causing unconformity between the rocks of the same period. And again, the fact of conformity does not necessarily prove that the two formations are of the same age. Lithological evidence is much more satisfactory, yet is not as conclusive as one would desire, when unsupported by other evidences. Profs. Fontain and White say upon this very subject:* "Thus, in ascending from a known Carboniferous horizon, if we find the coal in abundance in the lower beds and disappearing in the upper, while great masses of limestone and fine-grained red shales come in, surely this would be weighty evidence to show that Carboniferous conditions had changed to Permian."

The evidence from paleontological sources is to me always more satisfactory when the fossil forms are sufficiently abundant than the evidence from any other source. In a transition period like the Permian we will always find a decadence of old forms and an introduction of new ones. I doubt not that if the geological record was complete we should be able to trace the different steps by which the different species have been evolved, and that as these gaps in the geological history are filled up the transition periods will show these intermediate forms between the old and the new. The most that can be expected at the present is to show the commingling of these two forms in the same strata, and their presence thus commingled proves the strata to be neither the Carboniferous proper nor the Triassic, but the transition period between the two, which is the Permian.

It is a well known fact that certain forms which are abundant in the Triassic did not exist in the time of the Carboniferous, and that certain forms

* Second Geological Survey Pennsylvania, p. 111.

which were abundant in the Carboniferous are not found in the Triassic. I claim therefore that any strata that contain both of these characteristic or peculiar forms ought to be put in the Permian.

CONFORMABILITY.

The conformity of the dip of the Permian Beds with that of the Coal Measures in Texas has everywhere been observed, and this is in striking contrast to the unconformity between the Permian and Triassic. At places where the lower beds of the Permian lie in immediate contact with the Coal Measures it is almost impossible to determine the line of contact. This boundary is rather arbitrary than otherwise, since both are either sandstones or clay beds, and it is only after passing away from this line that one is certain that he has left the one and is upon the other. I doubt not that if the Permian had first been studied at this locality it would have been put with the Coal Measures; but being first studied in Saxony, where an unconformity exists and where it is impossible to trace a gradual passage from one to the other, a different series was established. Again, at the contact between the Coal Measures limestone and the middle beds of the Permian there is such a conformity between the two that no one would suspect but that they were a continued sedimentation; and the break is known only by the character of the material composing the strata, and the faunal life. A gradual submergence of the strata is the only movement that seems to have taken place during the time of the Coal Measures and Permian in Texas.

When I say there is no unconformability between the Permian and Coal Measures at this contact, I mean to say that there is no greater unconformability between them than there is between the different divisions of the same series. We find in Texas, in both the Permian and Coal Measures, that the earlier divisions dip at a slightly greater angle than those of a later date, so that if the top of the Coal Measures should be found resting upon the lower part of the series there would be a slight unconformability; and so of the contact between the Permian and Carboniferous. South of the Brazos River, at the contact between the Clear Fork division of the Permian and the Albany Beds of the Coal Measures, which are the highest division of the Coal Measures in Texas, a period of time intervened which is represented in Texas by the Wichita Beds of the Permian.

Again, at the line of the contact between the Wichita division of the Permian and the Cisco division of the Coal Measures, on the north side of the Brazos River, there is a period of time intervening which is represented in Texas by the Albany Beds, and therefore at this contact there is a slight nonconformity, which can only be discovered by actual measurements. By casual observation of the strata one could be very easily led to conclude that there was continued sedimentation.

The changes that were taking place in the geological history of the world at that time were unfavorable to the production of a heavy growth of vegetation and the deposition of material for making coal beds. This in itself would not be of much importance in determining the change from the Coal Measures to the Permian, but only shows that a change of some kind was taking place; and when one has passed up into the overlying beds but a short distance the difference is so apparent that the most casual observer can see that he has left the Coal Measures behind and has come upon something entirely different.

THICKNESS.

For quite a while it was thought that the Permian was merely the rounding off of the great Paleozoic area, and that it would only be found in narrow strips along the edge of the Carboniferous formation, but such can no longer be said to be the case, for the Permian has been found in the United States extending over a vast region, and is more than two thousand feet thick. In Texas the whole of the beds placed in the Permian are at least five thousand feet thick. These beds must have required a long period of time for their deposition, and the formation is entitled to be represented as a series in geological nomenclature.

LITERATURE.

In considering the Permian in Texas it may be well enough to state what has been written of this formation by others who have visited the region heretofore.

The first report of the Permian in this country was made by Prof. Jules Marcou, who traveled across the country from Fort Smith, Arkansas, to Los Angeles, California, between June, 1853, and March, 1854. In his resumé of that trip, published in 1854 in "Report of Explorations for a Railroad Route near the 35th Parallel of Latitude," Washington, he says: "Immediately after crossing Delaware Mount * * * we met with horizontal beds of red and blue clay that belong to another geological epoch. This new formation corresponding to that which European geologists have agreed to call the Trias."

In a paper published in 1858 he says of his name Trias, given to this locality: "I have always strongly suspected that the New Red Sandstone between Delaware Mount and Beavertown was of Permian age. Having found no fossils, and being the first geologist to enter these regions, I was not able when in the field to declare exactly the age of those strata. All that I knew then was, that after having left the Carboniferous limestone of Delaware Mount I entered upon strata belonging to another and younger formation;

and it was only after having passed Beavertown that I saw clearly I was upon the New Red Sandstone. Since the discovery of Permian in Kansas I am still more inclined to the belief that the strata between Delaware Mount and Beavertown are Permian. Thus you see I include the Permian in the New Red Sandstone formation." *

Again, in another report on notes furnished Prof. Marcou by Capt. John Pope, of a survey made from El Paso to Preston, on Red River, he says: "The upper part and the headwaters of the Rio Brazos are situated on the rocks of the Trias," and says in a note below, "I have since used the more general expression of New Red Sandstone formation to designate all the strata in America that lie between the Carboniferous formation and the Jurassic rocks."

I understand that while Marcou put all the Red Beds in Texas, from the Coal Measures and well marked Carboniferous strata at Fort Belknap to the foot of the Staked Plains at Big Springs, in the Triassic, he did not intend to say thereby that there were no beds in that district that might not properly be placed in the Permian. On a trip which he made across the same beds from Mount Delaware westward, as quoted above, he did not hesitate to place some of the beds in the Permian. He made no personal examination of the line between Fort Belknap and Big Springs, but made a report from notes and material collected by Capt. Pope, United States Topographical Engineer. Marcou says he called the Red Beds Trias on lithological and stratigraphical grounds alone, not having found any fossils by which he could determine their true geological horizon. The only fossils found were trees or petrified wood.

Doctor William DeRyee, formerly State Chemist, visited Archer County in 1868, in the interest of the Texas Copper Mining and Manufacturing Company. In a report made to that company and published by them he says:

"After traversing the Lias and Carboniferous series northward of Weatherford, I was agreeably surprised by a grand panorama of the outcropping Permian formation. This system is extensively developed in Russia between the Ural Mountains and the river Volga, in the North of England, and in Germany, where it is mined for its treasures of copper, silver, nickle, and cobalt ores. It has not heretofore been known to exist in this State, or has been mistaken for the Triassic system, which is overlying the former to the northwest."

Prof. Jacob Boll, formerly of Dallas, Texas, in an article entitled "Geological Examinations in Texas," published in the American Naturalist, Vol. XIV, pp. 684, 686, September, 1880, says these Red Beds of Texas are undoubtedly Permian.

* American Geology, Zurich, 1858.

Prof. C. G. Broadhead, who visited Colorado City, refers the beds in the vicinity of that place to the Permian.

Prof. E. D. Cope has described in the American Naturalist and other publications quite a number of vertebrate fossils as Permian, and while he has not entered into the discussion of the question of the position of the beds, he does not hesitate to call them Permian.

Dr. C. A. White visited the formation in Baylor, Wichita, and Archer counties, making a collection of the invertebrate fossils, a report of which was published in the American Naturalist, Vol. XXIII, pp. 109, 128, February, 1889. In that paper he says, after having stated several reasons for so thinking: "For these and other reasons yet to be stated, I have little or no hesitancy in designating this Texan formation as Permian."

Prof. Edward Hitchcock, in a report on the geology of this country, made upon the notes of Capt. Marcy's exploration of Red River in 1852, says, on page 156: "Upon the whole, I rather lean to the opinion that these strata may belong to the Cretaceous formation;" but without definitely determining the question, gives a provisional name to the beds of "Red Clay Formation and Gypsum Formation." No fossils were collected from these beds during that expedition, and the determination was made on lithological grounds alone.

Mr. Robert Hay, in Bulletin No. 37, United States Geological Survey, 1890, has attempted to synchronize the formation in Southern Kansas with that of the section on Red River made by Dr. Shumard and published in Marcy's report. He says: "Neither gypsum nor any other of the red rocks or shales or clays have hitherto yielded any fossils. The constant evidence of the litoral formation, however, suggests the expectation that some time reptilian or other tracks may be found in this formation that will serve to synchronize it with undoubted Mesozoic formations." He further says, after stating his reasons for so believing: "And although the evidence is not sufficient finally to demonstrate the age of the rocks, it is sufficient to warrant the provisional application to them of the name Triassic."

DIVISIONS.

I have separated the strata of the Permian into three divisions, under the names of Wichita Beds, Clear Fork Beds, and Double Mountain Beds.

These divisions have been made more for the sake of convenience than for any other reason, especially the last two.

WICHITA BEDS.

The Wichita Beds, which are the lowest in the series, are easily distinguished from the others by their peculiar characteristics. These beds are composed of sandstones, clay beds, and a peculiar conglomerate. There are no limestones in it from bottom to top. The sandstones are of various colors. The clays are red and bluish. In places the clay is copper bearing, yet this is not entirely peculiar to these beds, as the same thing occurs in the Clear Fork Beds. In the red clays are iron concretions that exist in places in great abundance. The peculiar Permian conglomerate which is found in this connection is composed of clay, or clay ironstone, in a ferruginous matrix.

The fossils occurring in these beds will be mentioned in another place in this Report.

The boundary between the Wichita Beds and Clear Fork Beds begins at a point on the Brazos River a little west of the mouth of Mule Creek, near the southeast corner of Baylor County, and extends by a direct line nearly north to Red River. The southeastern border would be the line between the Coal Measures and the Permian as given in another place. The Wichita Beds do not extend south of the Brazos River. These beds are heaviest along the Big Wichita River, where they attain a thickness of about two thousand feet.

The Albany Beds of the Coal Measures not occurring north of the Brazos River, the Wichita Beds rest directly upon and are conformable with the Cisco Beds. At first glance in passing over the country one would conclude that there had been a continuous sedimentation between these two beds, but upon closer inspection, and by taking a wider view, it is seen at once that this is not true. The Albany Beds of the Coal Measures are, at the point where we measured them, one thousand one hundred and twenty-five feet thick, and the whole of this division is lacking between the Cisco Beds of the Coal Measures and the Wichita Beds of the Permian.

CLEAR FORK BEDS.

The Clear Fork Beds is the name given to the middle division of the Permian strata, and they lie immediately west of the Wichita Beds for their entire length, and are then found resting upon the Albany Beds of the Coal Measures for the balance of their extent to the southward.

These Clear Fork Beds are composed of limestones, clay and shale beds, and sandstones.

The limestones are mostly magnesian and carbonaceous, some of them being so largely impregnated with carbonaceous matter that when struck with a hammer they give off a peculiar odor, which has given such stones the name of "stinkstone." These limestones carry an abundant and characteristic fauna.

The sandstones are not so abundant as in the Wichita Beds, and are not so massive, but are generally thin bedded.

The clays are blue and red, the red occurring in thick, heavy beds. The blue clays are in places copper bearing. The conglomerate is similar to that found in the Wichita Beds, but is not so abundant and is less compact.

Towards the top the sandstones become more shaly and the clays more sandy. There are also some beds of gypsum, but not in such great abundance as is found in the Double Mountain Beds. These beds lie conformably, or nearly so, upon the Albany Beds of the Coal Measures. They appear to be entirely conformable, and might be taken as one continuous bed of sedimentation, were it not that the position of the Wichita Beds is between them, and, as we have seen elsewhere, these Wichita Beds are two thousand feet thick, so a considerable lapse of time must have intervened between the times of their deposition.

DOUBLE MOUNTAIN BEDS.

These beds lie directly in contact with the Clear Fork Beds throughout the whole length, and no attempt has been made to determine a definite line of division between the two divisions. The beds are composed of sandstones, limestones, sandy shales, red and bluish clays, and thick beds of gypsum. The limestones are generally of an earthy variety, and in places have many casts of fossils, the newer types being more largely represented than those of the older. The gypsum beds are numerous and many of them very thick. All the clays and shales are impregnated with gypsum, and many of them carry a large per cent of common salt.

The sandstones are generally very friable, and are of various colors, red, white, and spotted.

The strata have a very uniform dip to the northwest until near their western border, where they are much distorted and crumpled, as though there had been a heavy pressure from the northwestward, compressing the strata into short folds. These beds have a thickness of about nineteen hundred feet. Toward the western extremity of the beds the red clays are transected in every direction with seams of fibrous gypsum, making a perfect network. These seams of gypsum range in thickness from that of a sheet of paper to ten inches.

THE SECTION.

The following sections, the line and localities of which are given on the accompanying map, were made of the Wichita Beds along the south side of the Big Wichita River, beginning four miles west of the east line of Baylor County:

SECTION NO. 28, WICHITA BEDS.

1.	Red clay	30 feet.
2.	Limestone	2 feet.
3.	Blue clay	4 feet.
4.	Limestone	1 foot.
	Total	37 feet.

The beds of limestone in the above section belong to the Clear Fork Beds, while the red clay is at this place at the top of the Wichita Beds.

SECTION NO. 29, WICHITA BEDS.

Two miles east of previous section.

1.	Red clay with nodular concretions with fossils	30 feet.
2.	Bone conglomerates	1 foot.
3.	Blue clay	4 feet.
4.	Conglomerate (iron ore)	2 feet.
	Total	37 feet.

This is one of the localities given in Dr. C. A. White's description of the fossils of the Permian. (Amer. Nat., Feb., 1889).

SECTION NO. 30.

One mile west of Corn Hill.

1.	Red clay	30 feet.
2.	Thin bedded sandstone	4 feet.
	Total	34 feet.

SECTION NO. 31.

Corn Hill, or Tit Mountain.

1.	Red clay	6 feet.
2.	Conglomerate, fossiliferous	8 feet.
3.	Red clay	30 feet.
4.	Thin bedded sandstone	4 feet.
	Total	48 feet.

At this place I got several specimens of vertebrate fossils which were described by Prof. E. D. Cope, and are embraced in the list of vertebrate fossils from the Permian, given elsewhere in this Report.

SECTION NO. 32.

Hills about twelve miles west of Wichita Falls.

1.	Red Bed clay	20 feet.
2.	Conglomerate, fossiliferous	1 foot.
3.	Red clay, with iron nodules	20 feet.
4.	Sandstone, thin bedded	4 feet.
	Total	45 feet.

It must be remembered that the conglomerate mentioned in these sections is the peculiar Permian conglomerate—composed of small round pieces of iron ore and clay cemented together by iron.

SECTION NO. 33.

Two miles west of Wichita Falls.

1.	Red clay, with nodular iron ore	30 feet.
2.	Sandstone, thin bedded	4 feet.
	Total	34 feet.

Another general section was made across the Permian strata, beginning at the contact between the Carboniferous Beds and the Permian near the line between Haskell and Shackelford counties, or the divide between the Clear Fork of the Brazos and California Creek. The contact here is between the Clear Fork division of the Permian and the Albany division of the Carboniferous.

The exact line of contact between the two formations at this place can not be definitely determined, as the strata are entirely covered by drift. In the rocks at the Clear Fork there were found only fossils of the Coal Measures, while at California Creek the fossils of the Permian are abundant. The texture of the rocks was observed to have changed, as well as the colors of the clays. The dip of the strata is very nearly the same.

Section No. 10, made about one mile northwest of the northeast corner of Swenson's pasture, and the northeast corner of a survey for the Buffalo Bayou, Brazos and Colorado Railway Company. Beginning at the top.

1.	Bluish clay	4 feet.	
2.	Gray limestone	1 foot.	
3.	Bluish clay, with *Syringapora*	4 feet.	
4.	Thin seam sandstone		2 inches.
5.	Reddish clay	6 feet.	
6.	Fossiliferous limestone	2 feet.	
	Total	17 feet	2 inches.

SECTION NO. 11.

The following section was made one mile east of California Creek, and to the east of our line:

1.	Blue clay	3 feet.	
2.	Limestone, much fractured	1 foot.	
3.	Blue clay	3 feet.	
4.	Sandstone, cross-bedded		6 inches.
5.	White and red clay	20 feet.	
6.	Gray limestone	2 feet.	
7.	Bluish clay	8 feet.	
8.	Dark fossiliferous limestone	1 foot	6 inches.
9.	Red clay	8 feet.	
10.	Limestone	1 foot.	
	Total	48 feet.	

SECTION NO. 12.

Made west of California Creek, near our line.

1.	Blue clay	2 feet.
2.	Argillaceous limestone	2 feet.
3.	Blue clay	6 feet.
4.	Red clay	8 feet.
5.	Limestone	1 foot.
6.	Thin bedded limestone, *Pleurophorus*	3 feet.
7.	Limestone	1 foot 6 inches.
8.	Rotten limestone	2 feet.
	Total	25 feet 6 inches.

Above the last section and to the west of it there is a broad, level plateau extending three miles to the breaks on Paint Creek. On this plateau the prairie dogs have brought up from their holes clay of a deep red color, and as soon as the bluffs on Paint Creek are reached it is seen that there is a complete change in the character of the strata. East of California Creek the rocks were all limestones and the clays were all blue. On the west side of the creek the rocks are all sandstones and the clays deep red.

The sandstones are thin-bedded and many of them cross-bedded, and the bedding dips at various angles and in different directions. In this thin-bedded sandstone are a great many tracks of insects.

At this locality are two beds of the conglomerate that is peculiar to the Permian, which is found at different localities and positions in the strata.

In the conglomerate and red clays of this place a number of vertebrate fossils were found, and it is in this section that the second bed of copper clay occurs. The following section was made at this place:

SECTION NO. 13.

1.	Dark red clay, with vertebrates, bottom not seen	10 feet.	
2.	Conglomerate		6 inches.
3.	Red clay	4 feet.	
4.	Thin bedded sandstone, with insect tracks		10 inches.
5.	Red clay	4 feet.	
6.	Blue clay, with copper concretions	4 feet.	
7.	Sandstone, concretionary		10 inches.
8.	Red clay, with clay concretions	8 feet.	
9.	Thin-bedded sandstone		8 inches.
10.	Cross-bedded sandstone		10 inches.
11.	Conglomerate, with remains of vertebrates		6 inches.
	Total	34 feet	2 inches.

The country from this point in a northwestern direction has a gradual rise until the breaks of the Double Mountain Fork of the Brazos is reached. Just before reaching the river there is a line of sand hills running parallel with the river. They are simply sand dunes caused by the drifting sands from the surrounding level country.

The hills in the vicinity of the Double Mountain Fork are composed of red clay and a thin seam of impure bluish limestone. The clays are a lighter red than those farther east. The following section was made three and one-fourth miles southeast of Kiowa Peak and below the junction of the Double Mountain Fork and the Salt Fork of the Brazos River:

SECTION NO. 14.

1.	Red clay, with seams of fibrous gypsum	40 feet.
2.	Greenish gypsiferous sandstones	10 feet.
3.	Blue clay, with thin seam of copper.	4 feet.
4.	White cross-bedded sandstone, with worm borings	12 feet.
5.	Conglomerate, in thin seams at top, and slanting back to top of hill	20 feet.
	Total	86 feet.

At this place we have the beginning of the great gypsum fields that extend to near the foot of the Staked Plains. The waters are all impregnated with salts and are not palatable.

The following section was made at the copper mine about one mile south of Kiowa Peak:

SECTION NO. 15.

1.	Gypsum and sandstone, thin bedded	10 feet.
2.	Red clay	20 feet.
3.	Blue clay, with copper	4 feet.
4.	White thin-bedded sandstone	3 feet.
	Total	37 feet.

The base of this section is about two hundred feet above the top of the previous section. The entire distance is a succession of sandstones and gypsum, with only one thin bed of impure limestone.

The copper clay mentioned in the above section is the upper copper bearing bed in the Permian in the State, and is found in several places north of this locality. The bed at the smelter west of Benjamin, in Knox County, is at the same geological horizon, as is also the bed of copper on Raggedy Creek, in Hardeman County. The country west of Kiowa Peak is very rough, the hills high, and the gulches very deep.

The following section was made at Kiowa Peak:

SECTION NO. 16.

1.	Gypsum and clay	60 feet.
2.	Red clay	20 feet.
3.	Gypsum	20 feet.
4.	Red clay	35 feet.
5.	Gypsum	15 feet.
6.	Gypsum, alabaster	4 feet.
	Total	154 feet.

The peak is a remnant of the higher tablelands left standing out from the main uplands. It can be seen for a long distance from every direction.

SECTION NO. 17.

Made four miles west of Kiowa Peak.

1.	Seams of gypsum and greenish gypseous clays	60 feet.
2.	Red clay	15 feet.
3.	Limestone	30 feet.
4.	Red clay	30 feet.
5.	Gypsum	55 feet.
6.	Bluish clay	15 feet.
7.	Limestone, in several layers	8 feet.
	Total	213 feet.

SECTION NO. 18.

Made at the "Z" ranch, about eight miles west of Kiowa Peak, on the Salt Fork of the Brazos River.

1.	Bluish clay and gypsum	3 feet.	
2.	Red clay	2 feet.	
3.	Bluish gypsum, hard	1 foot	6 inches.
4.	Red and blue clay, in seams	4 feet.	
5.	Bluish gypsum	4 feet.	
6.	Blue clay	2 feet.	
7.	Limestone, in thin layers, fossiliferous	6 feet.	
8.	Red clay	30 feet.	
9.	Blue clay	4 feet.	
10.	Limestone, in layers	3 feet.	
	Total	59 feet	6 inches.

The country is quite broken along the river, but broad plateaus extend from the breaks both north and south. The hills and valleys along the river are covered with a thick growth of cedar timber. The gypsum beds are cut into by deep canyons, and springs are to be found in all the gulches. The water is all impregnated with gypsum.

About one mile above the confluence of the Salt Croton Creek with the Salt Fork of the Brazos are the falls of Croton Creek. The water has a fall of about six feet. At the time of our visit there was as much water in Croton Creek as there was in the Salt Fork of the Brazos, and it is said to run about the same amount the entire year.

The following section was made at the falls:

SECTION NO. 19.

1.	Blue clay	4 feet.
2.	Limestone in layers, fossiliferous	8 feet.
3.	Massive white gypsum	30 feet.
	Total	42 feet.

The fossils recognized were two species of *Ammonite*, *Orthoceras*, and *Pleurophorus*. The upper part of No. 2 of the above section was almost entirely composed of *Ammonites?*

Three miles above this place is Salt Flat, a place where the water at times spreads out over a broad flat, which on evaporation leaves a heavy incrustation of salt. The water comes from a spring that breaks up through a spotted clay. The flat embraces about two hundred acres in area.

SECTION NO. 20.

Made at Salt Flat.

1.	Spotted red clay	3 feet.
2.	White massive gypsum	10 feet.
3.	Red clay	30 feet.
4.	Gypsum	1 foot.
5.	Red clay	30 feet.
6.	Gypsum	6 feet.
7.	Red clay	20 feet.
8.	Limestone	1 foot.
	Total	111 feet.

All the lateral streams flowing into Croton Creek for several miles are very salty. The hills are high and are composed of gypsiferous red sandy clays, and disintegrate rapidly. From Dove Creek to the top of the hill one mile north there is a difference of two hundred and sixty feet by barometric measurement.

SECTION NO. 21.

Made near the mouth of Dove Creek, three miles above Salt Flat.

1.	Gypsum	10 feet.
2.	Red sandy clay	20 feet.
3.	Limestone	1 foot.
4.	Red sandy clay	30 feet.
5.	Gypsum	8 feet.
6.	Red and white spotted sandstone, water-bearing	20 feet.
7.	Gypsum	3 feet.
	Total	92 feet.

The hills on the south side of Dove Creek are high and are composed of red sandy clays that disintegrate very rapidly, so that it was impossible to get a complete section.

SECTION NO. 22.

Made on South Croton Creek, five miles southwest of section No. 21.

1.	Red sandy clay with white spots	40 feet.
2.	Massive gypsum	3 feet.
3.	Red sandy clay	10 feet.
4.	Massive gypsum	4 feet.
5.	Red sandy clay	10 feet.
	Total	67 feet.

SECTION NO. 23.

Made on South Croton Creek, two miles southwest of the locality of Section 22.

1.	Red clay	20 feet.
2.	Gypsum	1 foot.
3.	Red sandy clay	30 feet.
4.	Gypsum	3 feet.
5.	Red sandy clay	40 feet.
6.	Gypsum	4 feet.
7.	Red sandy clay	25 feet.
	Total	123 feet.

The country from the top of this section slopes gradually to the west to Duck Creek, and is covered with drift. From Duck Creek to the Salt Fork of the Brazos is a high rolling prairie, with an occasional small ravine or creek. The country is covered with drift sand and pebbles from the disintegrated strata at the foot of the Staked Plains.

SECTION NO. 24.

Made at a bluff on Salt Fork, on section 8, block 1, Houston and Texas Central Railway surveys.

1.	Red sandy clay	4 feet.
2.	White gypsum	3 feet.
3.	Red clay, with thin seams of gypsum	10 feet.
4.	Mottled sandstone	6 feet.
5.	Red clay, with seams of mottled sandstone	20 feet.
6.	Mottled sandstone	4 feet.
7.	Red clay and mottled sandstone	5 feet.
8.	White gypsum	3 feet.
9.	Red clay	10 feet.
10.	Gypsum, alabaster	1 foot.
11	Red clay	4 feet.
	Total	70 feet.

The strata at all places heretofore have been very regular, with a slight dip to the nortwest, but at the above section and everywhere else to the foot of the Plains the strata are very much distorted.

The beds of gypsum very often present a crumpled appearance, the folds not being more than one or two inches across. The dips or foldings do not appear to be in any particular direction. The general dip of the formation is still toward the northwest.

SECTION NO. 25.

Made in a gulch north of Section No. 24.

1.	Mottled sandstone	3 feet.
2.	Mottled sandstone and clay	4 feet.
3.	Gypsum	2 feet.
4.	Red sandy clay	10 feet.
5.	Gypsum	1 foot.
6.	Mottled clays	20 feet.
7.	Gypsum	3 feet.
	Total	43 feet.

Deep gulches are washed into the strata, many of them miles in extent, with perpendicular walls.

SECTION NO. 26.

Made about two miles west of Section No. 25.

1.	Red clay	20 feet.
2.	Massive gypsum	4 feet.
3.	Red clay	20 feet.
4.	Massive gypsum	3 feet.
5.	Red shale, with seams of fibrous gypsum	30 feet.
	Total	77 feet.

In No. 5 of the above section the seams of the fibrous gypsum form a perfect network, traversing the bed of clay in every direction, ranging in thickness from that of a knife blade to ten inches.

The massive gypsum of No. 4 in the above section is composed of round concretions an inch in diameter, and has the appearance of pudding stone. The matrix is white and the concretions are of various colors. This form of gypsum I have seen at several places along the foot of the Plains.

SECTION NO. 27.

Made on Big Red Mud Creek west of the Colorado and Dockum road.

1.	Red clay	20 feet.
2.	Red sandstone	4 feet.
3.	Red shale with seams of fibrous gypsum traversing in every direction	20 feet.
	Total	44 feet.

A hill near the mouth of Little Mud Creek is capped with Triassic conglomerate. Near Section No. 27 is another hill with pieces of conglomerate on the top. From this point to Dockum, fifteen miles, the strata are made up of Permian and Triassic. The Permian was much eroded in places before the deposition of the Triassic.

These sections give almost a complete succession of the strata from the contact between the Albany division of the Coal Measures Series and the Clear Fork division of the Permian to the overlying Triassic. The sections of the Wichita division are given in another place.

DETERMINATION OF THE AGE OF THE STRATA.

That there has been difficulty in proving positively the existence of the Permian in the United States, any one at all familiar with the geological history of the country knows very well. This has resulted very largely from the fact of the scarcity of fossils in the beds thought to be Permian, and from the further fact that those who have attempted to determine the question have undertaken to do so by trying to find fossils in the American Permian similar to those found in the Permian in Europe, and because the fossils found in the American beds were not identical with those of Europe, the age of the strata has been in dispute. In reference to the occurrence of fossils in these beds there has been but one expression, and that is that they were very rare. The conditions necessary for their preservation did not exist except at rare intervals during the entire time of the deposition of the strata. That the life of that period was abundant there is no doubt, for where the conditions were favorable to their preservation they are very abundant. At one place in Texas I found at least twenty species in an area of five square yards in a bed eighteen inches thick.

In regard to the difficulty of identifying the Permian formation in the United States Prof. Endlich, in his report on the geology of the Wind River Range, in 1877, says: "The determination of the strata has been made with great difficulty, owing to the lack of characteristic fossils in the formation. At that locality the beds of Permian are composed of yellow and red sandstones and shales, with some dolomite, resting directly upon the hard blue limestone of the Carboniferous, and are overlaid by the Red Beds of the Mesozoic Group. The formation is conformable with both the Carboniferous below and the Mesozoic above. The inclination is nearly east and west, and in many places has both anticlinal and synchlinal folds. There is great uniformity of thickness and lithological character."

In a section made by St. John of the Pierris Mountain he gives two fossils, *Lingula* and *Pleurophorus*, which he says are similar to the *Pleurophorus* found in the lower Missouri regions, and probably identifies that horizon with the one further to the east.

Capt. C. E. Dutton, in a report on the Physical Geology of the Grand Canyon District, in 1882, page 64, says: "After the Carboniferous, came the Permian Age, in which were laid down from eight hundred to fifteen hundred feet of sandy shales. The stratification was wonderfully even and everywhere horizontal. The Permian beds are often ripple marked, and betray many evidences that they accumulated in shallow waters."

He also says that the same state of affairs continued through the Trias, which lies immediately upon the Permian. Again, on page 9, he speaks of the Permian lying immediately below a band of pale sandstone of very coarse texture, often becoming a conglomerate. This is the same conglomerate that Major J. W. Powell calls the Shinarump, and which Mr. C. D. Walcott places as the divisional line between the Permian and Triassic.

I have already adopted this horizon as the line between the Permian and Trias in this part of Texas.

In studying the fossils of the Permian of Texas I have not attempted to correlate them with the fossils found in the Permian in Europe, nor do I think it necessary to have them so in order that the beds in Texas should be placed in that division. It is a well known fact that some fossils that are characteristic of a division in Europe are not found in the same division in America, but are found in other divisions, and become characteristic of the formation where found.

Take for instance the *Fusilina cylindrica*, Fischer, which in Europe is found nowhere except in the Sub-Carboniferous, while in America it is not found in any place except in the Coal Measures, and the attempt to correlate strata in America with that of Europe by the fossils alone has led to some grave mistakes.

PALEONTOLOGY.

The value of the paleontological evidences of the age of a formation, when rightly interpreted, is acknowledged by every one to be of the highest importance. The life history of the globe is one, and the development from the lowest to the highest orders went on from age to age. The forms that were characteristic of one system gradually became extinct, and other forms came in and took their places. The older forms gradually became extinct and the newer as gradually came in. Some of the forms were much longer lived than others, and would pass through an entire system, and sometimes even longer, while others would be restricted to a single series. The old Paleozoic forms that had come of from the deep past were gradually giving place in the Permian to the Mesozoic forms that were to be so abundant as the time went by. The Permian was a period of transition. So greatly blended are the two forms—the old and the new—that it is still an open question as to whether it should be placed with the Paleozoic or with the Mesozoic groups. At places the older forms predominate, and when that is the case it is contended that it ought to be placed with the Paleozoic group. At other places the newer forms are more numerously represented, and then it is contended that the series should be placed with the Mesozoic.

Dr. White, who described the invertebrate fossils taken from the Wichita Beds and lower part of the Clear Fork Beds, found the older forms largely predominating, and did not hesitate to refer the Permian to the Paleozoic group. He says, however, that if two of the fossils found therein had been submitted to any paleontologist he would not have been warranted in referring them to an earlier period than the Trias, if he had followed the usually accepted standard of reference; and that without these two fossils the others might with equal propriety have been referred to the Coal Measures. The very fact that the two types occur in the same strata is the reason I insist on calling the beds Permian; and whether it shall be referred to the Paleozoic or the Mesozoic is a matter that will not be discussed in these pages. Some writers have evaded the issue by calling certain strata Permo-Carboniferous. If one would make special selections from the fossils of the Permian in Texas he could with equal propriety refer the strata from which they were taken to either the Coal Measures, Permian, or Triassic; but when they are taken together there can be no other conclusion reached than that the strata belong to the Permian. They can not be referred to the Carboniferous, because they contain not only the Carboniferous fauna, but also the forms found in the Triassic. They can not be referred to the Triassic, because they contain forms that belong to the Coal Measures, as well as forms that are characteristic of the Permian. Therefore the only reasonable reference is to the Permian as the transition period between the two others.

Dr. Newberry stated before the International Congress of Geologists at at Berlin that no Permian had been found in the United States, and gave as a reason for so stating that the fossils found in the so-called Permian Beds were all types of the Coal Measures. That was before the Texan field had been explored to any extent. He could not now repeat the assertion, for there are fossils in the Texas strata that could not with any propriety be said to belong to the Coal Measures. By reference to the list of fossils described by Dr. White, given in another place, it will be seen that out of the thirty-one species described fully one-half are common characteristic Coal Measure species, but the other half can not with any degree of propriety be referred to that series.

Since Dr. White's article was written I have collected fossils at different places at the same geologic horizon, and have found other forms both of the Coal Measures and Permian. At Ben Ficklin, in Tom Green County, at the extreme southern edge of the Clear Fork Beds, I found in the same stratum *Productus*, *Murchisonia*, *Aviculopecten*, and *Medlicottia.* Heretofore I had not found a single specimen of Productus in the Permian Beds.

Prof. E. D. Cope has described the vertebrate fossils from the Permian Beds of Texas, a list of which appears in another place in this Report. This list embraces upward of fifty species collected from the same beds as those from which the invertebrates were taken that were described by Dr. White, some of them a little higher in the series. By reference to this list it will be seen at a glance that the beds could not be referred to anything else than the Permian. Of this reference Prof. Cope says:

"The Texan genera of this group, so far as yet known, are about equally related to the Ural and South African types. The age of the former deposit is the Permian, which includes, according to Murchison, the Todtliegende and Zechstein of Thuringia. The age of the South African Beds is uncertain, but is suspected by some authors to be Triassic, and by Owen to be Paleozoic. In discussing the age of the clepsydrops shales of Illinois, which had been referred to the Coal Measures by all previous investigators, I left the question open as to whether they should be referred to the Permian or Triassic formations.* The evidence now adduced is sufficient to assign the formation, as represented in Illinois and Texas, to the Permian. Beside the saurian genera above mentioned, the existence of the ichthyic genera Janassa, Ctenodus, and Diplodus in both localities renders this course necessary."

The following is a list of the fossils described by Dr. White, American Naturalist, February, 1889, pp. 109, 128:

*Proceedings Philadelphia Academy, 1875, p. 405.

PERMIAN FOSSILS.

		Camp Creek.	Godwin Creek.	Military Crossing.
1.	*Goniatites baylorensis*, n. s	....	....	x
2.	*Ptychites cumminsi*, n. s	....	....	x
3.	*Medlicottia copei*, n. s	....	....	x
4.	*Popanoceras walcotti*, n. s	....	....	x
5.	*Orthoceras rushensis*, McChesney?	....	....	x
6.	*Nautilus winslowi*, Meek and Worthen	....	....	x
7.	*N. occidentalis*, Swallow	....	....	x
8.	*N.* ———?	....	....	x
9.	*N.* ———?	....	x	....
10.	*N.* ———?	....	....	x
11.	*N. endolobus?*	....	....	x
12.	*Naticopsis remex*, White	....	x	x
13.	*N. shumardi*, McChesney	....	x	....
14.	*Euomphalus subquadrata*, M. and W	....	....	x
15.	*E.* ———?	....	....	x
16.	*Murchisonia?*	....	x	x
17.	*Patella?*	....	x	....
18.	*Bellerophon crassus*, M. and W	....	x	x
19.	*B. montfortianus*, Norwood and Pratten	....	x	....
20.	*B.* ———?	....	....	x
21.	*Sedgwickia topekaensis*, Shumard sp	....	x	....
22.	*Pleurophorus* ———?	....	x	....
23.	*Clidophorus occidentalis*, Geinitz	....	x	....
24.	*Yoldia subscitula*, Meek and Hayden	....	x	....
25.	*Myalina permiana*, Swallow	x	x	x
26.	*M. aviculoides*, M. and H.	....	x	....
27.	*M. perattenuata*, M. and H	x	x	x
28.	*Gervillia longa*, Geinitz	....	x	....
29.	*Aviculopecten occidentalis*, Shumard.	....	....	x
30.	*Syringapora* ———?	x	x	x
31.	*Spirorbis* ———?	....	....	x
32.	*Cythere nebrascensis*, Geinitz	....	....	x

SUMMARY.

Mollusca.

Cephalopoda .... 11 species.
Gasteropoda .... 9 species.
Conchifera .... 9 species.

Articulata.

Vermes .... 1 species.
Crustacea .... 1 species.

Radiata.

Polypi .... 1 species.

Total .... 32 species.

The following check list of the vertebrate fossils taken from the Wichita and the lower part of the Clear Fork Beds of the Permiam in Texas was kindly furnished me by Prof. E. D. Cope for publication in this Report, giving the publications in which they were described by him. Many of these fossils were collected by myself before the Texas Survey was organized:

PISCES.

Selachii.

JANASSA, Munster.
J. ordiana, Cope.
CTENACANTHUS, Agass.
C. amblyxiphios, Cope, MSS.
DIDYMODUS, Cope; Proc. Acad. Phila., 1883, p. 108; Proc. Amer. Phil. Soc, 1884, p, 572.
D. texensis, Cope; *D.? compressus*, Cope; l. c.
D. platypternus, Cope; l. c.

Dipnoi.

CTENODUS, Agass.
C. periprion, Cope; Proc. Amer. Phil. Soc., 1878, p. 527.
C. porrectus, Cope; l. c.
C. dialophus, Cope; Proc. Amer. Phil. Soc., 1878, p. 528.
GNATHORHIZA, Cope; Proc. Amer. Phil. Soc., 1883, p. 629.
G. serrata, Cope; l. c.
CERATODUS, Agass.
C. favosus, Cope; Proc. Amer. Phil. Soc., 1884, p. 28.

Teleostomata.

ECTOSTEORACHIS, Cope; Pal. Bull. No. 32, 1880, p. 19.
E. nitidus, Cope; l. c.
E. ciceronius, Cope; Proc. Amer. Phil. Soc., 1883, p. 628.
BENEDENIA, Traquain.
B. palmaris, Cope, MSS.

BATRACHIA.

Ganocephala.

TRIMERORCHACHIS, Cope; Proc. Amer. Phil. Soc., 1878, p. 524; 1880, p. 54.
T. insignis, Cope; l. c., p. 524.
T. bilobatus, Cope; l. c., 1883, p. 629.

Rhachitomi.

ZATRACHYS, Cope; Proc. Amer. Phil. Soc., 1878, p. 523, et infra.
Z. serratus, Cope; l. c. et infra.

Eryops, Cope; l. c., 1877, p. 188.

E. megacephalus, Cope; l. c. *Rhachitomus valens*, Cope; l. c., 1878, p. 526.

E. erytholiticus, Cope; l. c., 1878, p. 515 (Epicordylus); Trans. Amer. Phil. Soc., 1886, Pl. I, Fig. 1.

E. ferricolus, Cope; l. c., 1878, p. 521 (Parioxys).

Acheloma, Cope; Proc. Amer. Phil. Soc., 1882, p. 455.

A. cumminsi, Cope; l. c., 456.

Anisodexis, Cope; l. c., 1882, p. 459.

A. imbricarius, Cope; l. c.

Microsauri.

Diplocaulus, Cope; Proc. Amer. Phil. Soc., 1877, p. 187; 1882, p. 541.

D. magnicornis, Cope; l. c., 1882, p. 453.

Embolomeri.

Cricotus, Cope; Proc. Acad. Sci., Phila., 1876, p. 405; Proc. Amer. Phil. Soc., 1884, p. 29.

C. crassidiscus, Cope; Proc. Amer. Phil. Soc., 1884, p. 29.

C. heteroclitus, Cope; l. c., 1878, p. 522; Amer. Naturalist, 1884, p. 39.

C. hypantricus, Cope; Proc. Amer. Phil. Soc., 1884, p. 30; Trans. Amer. Phil. Soc., 1886, p. 253, Pl. I, Figs. 2 and 6.

REPTILIA.

Theromorpha.

Clepsydropidæ.

Clepsydrops, Cope; Proc. Acad. Phil., 1876, p. 404.

C. natalis, Cope; Proc. Amer. Phil. Soc., 1878, p. 509.

C. macrospondylus, Cope; l. c., 1884, p. 35.

C. leptocephalus, Cope; l. c., 1884, p. 30.

Dimetrodon, Cope; Proc. Amer. Phil. Soc., 1878, p. 512, l. c., 1880, p. 42, et infra.

D. gigas, Cope; l. c., 1878, p. 513; l. c., 1880, p. 44.

D. incisivus, Cope; l. c.

D. rectiformis, Cope; l. c., p. 514.

D. semiradicatus, Cope; Bull. U. S. Geol. Survey Terr., 1880–81.

Naosaurus, Cope; Amer. Naturalist, 1886, p. 545, et infra.

N. cruciger, Cope (Dimetrodon cruciger); Proc. Amer. Phil. Soc., 1880, p. 44; Amer. Naturalist, 1878, p. 830.

N. claviger, Cope; Amer. Naturalist, 1886, p. 545, et infra.

N. microdus, Cope; l. c., 1886, p. 545. Edaphosaurus microdus, Cope; Proc. Amer. Phil. Soc., 1884, p. 37.

Theropleura, Cope; Proc. Amer. Phil. Soc., 1878, p. 519; 1880, p. 40.

T. retroversa, Cope; l. c.

T. uniformis, Cope; l. c., 1878, p. 519; 1880, p. 40.

T. triangulata, Cope; l. c., 1878, p. 520.

T. obtusidens, Cope; l. c., 1880, p. 41.

Embolophorus, Cope; l. c., 1878, p. 518.

E. fritillus, Cope; l. c., Texas.

E. dollovianus, Cope; Proc. Amer. Phil. Soc., 1884, p. 43, Pl. I., Figs. 4–5, Texas.

Edaphosaurus, Cope; Proc. Amer. Phil. Soc., 1882, p. 448.

E. pogonias, Cope; l. c., 449, Texas.

Pariotichidæ.

Pariotichus, Cope; Proc. Amer. Phil. Soc., 1878, p. 508.

P. brachyops, Cope; l. c.

P. megalops, Cope; l. c., 1883, p. 630.

Ectocynodon, Cope; l. c., p. 509.

E. aguti, Cope; l. c., 1882, p. 451.

E. ordinatus, Cope; l. c.

E. incisivus, Cope; infra.

Pantylus, Cope; Bull. U. S. Geol. Sur. Terr., 1881 (80).

P. cordatus, Cope; l. c.

Bolosauridæ.

Bolosaurus, Cope; Proc. Amer. Phil. Soc., 1878, p. 506.

B. striatus, Cope; l. c.

Chilonyx, Cope; l. c., 1883, p. 631.

C. rapidens, Cope; l. c.

Incertæcedis.

Metarmosaurus, Cope; Proc. Amer. Phil. Soc., 1878, p. 516.

M. fossastus, l. c.

Diadectidæ, Cope.

Pal. Bull. No. 32, 1880, p. 8.

Diadectes, Cope; Proc. Amer. Phil. Soc., 1878, p. 505.

D. sideropelicus, Cope; l. c.

Empedias, Cope; Proc. Amer. Phil. Soc.

EMPEDOCLES, Cope; Proc. Amer. Phil. Soc., 1878, p. 516; 1880, p. 634 (pre occupied).

E. phaseolinus, Cope; Pal. Bull. No. 32, 1880, p. 9.

E. alatus, Cope; l. c.

E. latibuccatus, Cope; l. c.

E. molaris, Cope; Pal. Bull. No. 32, 1880, p. 10.

E. fissus, Cope; Proc. Amer. Phil. Soc., 1880, p. 634.

HELODECTES, Cope; Pal. Bull. No. 32, p. 11.

H. paridens, Cope; l. c.

H. isaaci, Cope; l. c., p. 12.

Synopsis of the Species.

	Gen.	Species.
Pisces.—		
Selachii	3	4
Dipnoi	3	5
Teleostomata	2	3
Batrachia.—		
Ganocephala	1	2
Rhatchitomi	4	6
Microsauri	1	1
Embolomeri	1	2
Reptilia.—		
Theromorpha	15	34
Total	30	57

DIFFERENCE BETWEEN PERMIAN AND CARBONIFEROUS.

The highest beds of the Coal Measures have an abundant and varied invertebrate fauna. The fossils are well preserved and there is no doubt about the horizon to which they belong. They are *Productus semireticulatus*, Martin; *Myalina subquadrata*, Shumard; *Bellerophon crassus*, Meek and Worthen; *Pinna peracuta*, Shumard; *Syringapora multattenuata*, ————; *Macrocheilus ventricosus*, Hall; *Aviculopecten carbonareous*, Shumard; *Hemipronites crassus*, Meek and Worthen; *Schizodus wheeleri*, Swallow; *Allorisma subcuneata*, Meek and Worthen, etc. Immediately above these beds come the beds of the Clear Fork Division of the Permian with an entirely different character of fossils. When we take into consideration that the Wichita Beds in point of time come between these two series, and that the Wichita Beds are two thousand feet thick, it will be understood at once that there need be no hesitancy in pronouncing the two beds different, and no matter of wonder that the fauna of one should be so different from that of the other.

In the northern part of the State, where the Wichita Beds rest upon the Cisco Beds of the Coal Measures, there is as great a difference in the fauna as there is at the other locality. The Cisco Beds are principally sandstones and yellow clays with a characteristic Coal Measure fauna. Immediately upon these beds come the bluish sandstones and red clay beds of the Permian with its fauna. It must be remembered here also there is no continuous sedimentation, for the Albany Division of the Coal Measures comes between these beds in time, and these Albany Beds are about eleven hundred feet thick. The stratigraphic evidences that these two formations are different is very strong in Texas. If we take the Wichita Division of the Permian, which are entirely composed of sandstones and red clay beds, and place them where they rightly belong in point of time, upon the Albany Division of the Coal Measures, which are composed almost entirely of limestones and yellowish clay beds, the contrast between them will be much more apparent than it now appears, with the Clear Fork Division, whose bases are limestones and bluish clay beds, resting directly upon the limestone and clay beds of the Albany Division.

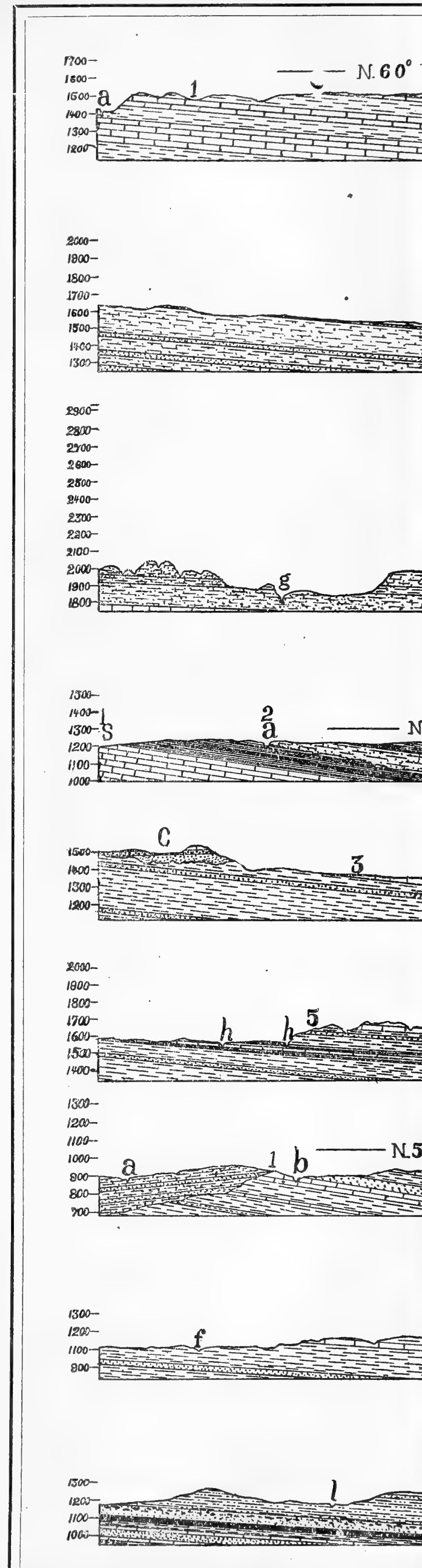
So far in this Report I have been considering the question whether the beds I have called Permian are capable of being separated distinctly and definitely from those of the Coal Measures, and I think that it has been shown that such can very readily be done in Texas, both on stratigraphic and paleontologic grounds, and I think that it is entirely safe to say that the beds do not belong to the Coal Measures series.

DIFFERENCE BETWEEN THE PERMIAN AND TRIASSIC.

The next question to be considered is as to how much of the Red Beds in Texas ought to be included in the Permian series. In other words, where ought the line between the Permian and Triassic be placed. I have placed all the strata, as I say in another place, between the Albany Division and the Dockum Beds in the Permian. The Albany Division is the highest part of the Coal Measures in Texas, as I understand it, and the Dockum Beds are the lowest Triassic, as the facts indicate to me.

Dr. White saw only the Wichita and lower part of the Clear Fork Beds, and from my description of the country thought that my Upper or Double Mountain Beds might be Triassic, but says:

"Along the western boundary of the Texas Permian, as it has been indicated in a previous paragraph, a series of strata about two hundred and fifty feet in maximum thickness, now generally known as the 'gypsum bearing beds' and thought by many to be of Triassic age, rests conformably upon the Permian. In general aspect, in a prevailing reddish color, and in general lithological character, except in the prevalence of gypsum in many of the lay-



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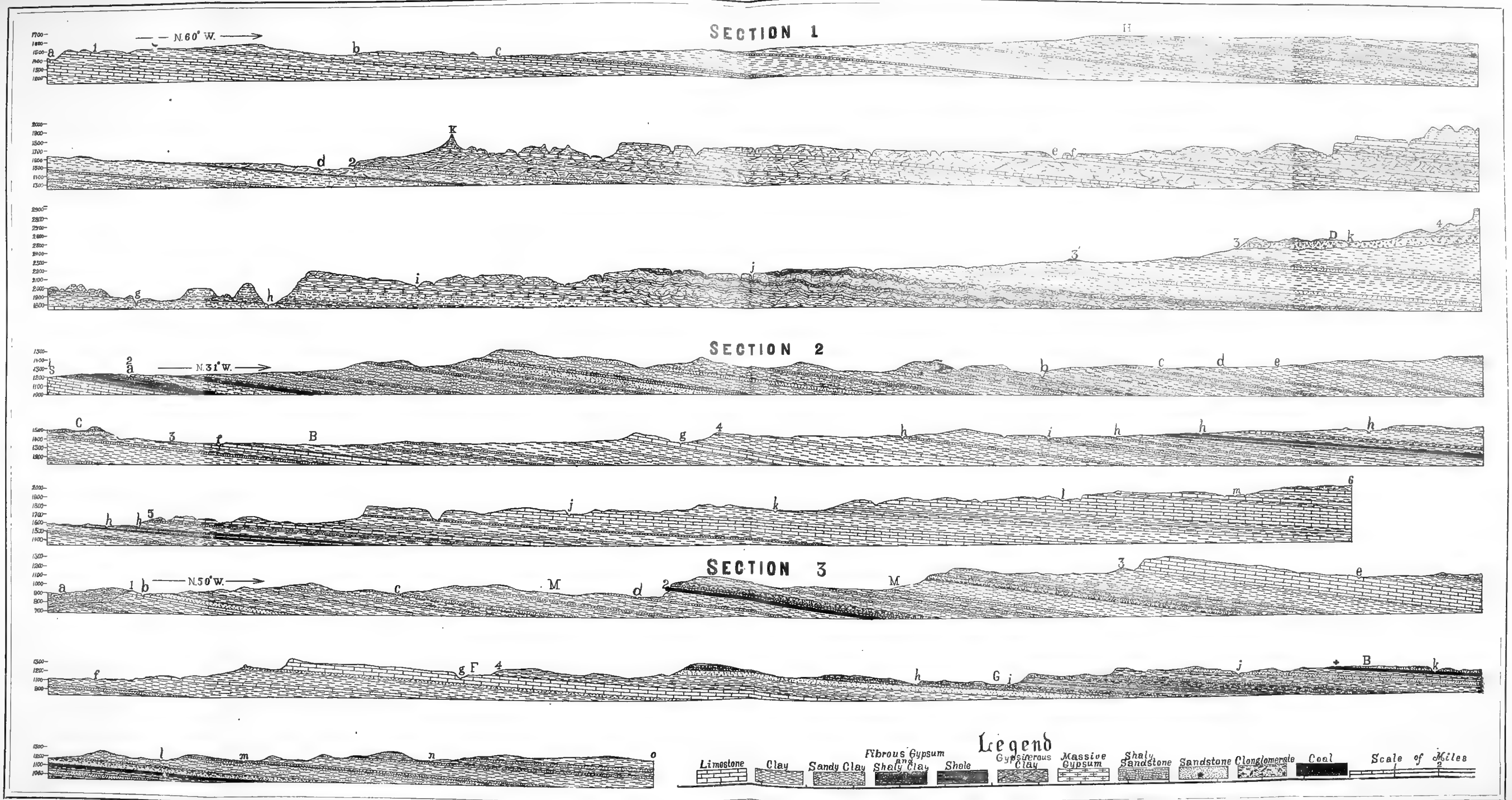

W. F. Cummins, Geologist for Central Texas.

SECTIONS ACROSS CARBONIFEROUS AND PERMIAN.

ers and somewhat greater prevalence of clayey material, these overlying beds resemble the Permian strata upon which they rest. With only one known exception, these gypsum bearing beds have furnished no fossils. The exception referred to is the discovery by Mr. Cummins, in Hardeman County, in an upper stratum of these beds, of a thin magnesian layer containing numerous casts of a species of Pleurophorus. This being a characteristic genus among Permian molluscan faunas, and a prevailing form in the Permian strata beneath the gypsum bearing beds, the question is suggested whether the latter ought not to be regarded as constituting an upper portion of the Permian. If these beds are not separable from the Permian, it seems to be doubtful whether the Trias has any representation in Texas."

Since that article by Dr. White was written, I have collected from numerous places in the beds referred to a great many characteristic fossils of the Permian, and am therefore confident Dr. White would give up his reference of the upper part of the strata to the Triassic.

Prof. Jules Marcou passed north of the Wichita Mountains on his trip across the continent in 1853, and probably saw only the Double Mountain Beds of the Permian; and while he did not find any fossils, he gave it as his opinion that that part of the strata was Permian. Where he refers to strata as Trias, in contradistinction to Permian, I have no doubt that it was the same as that to which I have given the provisional name of Dockum Beds, which are Triassic. I doubt if the Wichita Division occurs north of the Wichita Mountains. I am also of the opinion that only a part of the Clear Fork Division occurs west and north of the mountains, leaving only the Double Mountains Division exposed. I have gone as far north with my examinations of the strata as the Canadian River north of Mobeetie, and thence down that river to a point opposite the lower end of the Wichita Range, and have seen only the Double Mountain Beds. The older beds of the Permian may have been exposed farther northward in Kansas, but I am of the opinion that southwestern Kansas has only the uppermost beds, which Mr. Hay has synchronized with the strata near the mouth of the North Fork of Red River. This I judge from Mr. Hay's description of the strata. He gives it the provisional name of Jura-Trias "until paleontological evidence shall set it aside." The following summary is given by Mr. Hay as his reasons for so naming the strata, and which I quote here for the purpose of showing that the reasons given must give place to the paleontological evidences found in the Texan strata, and not for the purpose of controverting its application to the Kansas strata. He says:

"Several of the features described above suggest that the formation represents the Jura-Trias. These may be summarized as follows:

"(a) The formation is lithologically quite distinct from the subjacent Carboniferous strata.

"(b) The pevailing color of the formation is a dark red, brown, and sometimes a brighter red, like the Triassic generally is in Europe and America.

"(c) The lithified layers alternate with beds of clay and clay shale, as do the stony layers in the Triassic of the Atlantic slope and in much of the Jura-Trias of the west.

"(d) A massive layer of gypsum and numerous seams of selenite and satin spar appear in the formation, in which respects it corresponds with deposits further southwest, which have been referred to the Jurassic or Triassic on both petrographic and paleontologic grounds.

"(e) There are frequent shore marks, ripple marks, and rain drops, in which the formation simulates the Triassic of the Atlantic slope and many other regions.

"(f) There is a marked absence of fossils, a characteristic of the Triassic generally.

"(g) The formation is continuous to Red River, and appears to be stratigraphically connected with similar rocks beyond, which have already been referred to the Jurassic or Triassic on various grounds.

"(h) The surface of the formation was deeply eroded before the deposits of the Dakota or other Cretaceous formations were laid down.

"In brief, the lithological characters, in so far as they may be regarded as criteria in the correlations of formations, and the stratigraphy alike, suggest that the red rocks of Southern Kansas represent the group of strata elsewhere found between the base of the Cretaceous and the summit of the Carboniferous; and although the evidence is not sufficient finally to demonstrate the age of the rocks, it is sufficient to warrant the provisional application to them of the name Triassic."

The following comments may be made upon this summary in its application to the Texas strata:

(a) It is certainly different from the underlying Carboniferous, as has been shown elsewhere in the Report.

(b) The mere color of a rock would not distinguish between the Triassic and the Permian.

(c) The lithified layers alternate with beds of clay and clay shale in the lower Red Beds of the Permian in Texas, and would go as far to prove these upper beds Permian as would conclusions drawn from Triassic rocks in another part of the United States prove these Triassic.

(d) The occurrence of massive gypsum and seams of selenite does not prove anything, for the reason that they may occur in any of the strata since the

Carboniferous. In Arkansas the gypsum occurs in the Trinity Sands or Lower Cretaceous.*

(e) "There are frequent shore marks, ripple marks and rain drops" in other formations than that of the Triassic.

(f) This is no reason to refer strata to a distinct horizon because in other places certain strata have no fossils. But such is not the case in Texas, because fossils have been found in all the strata I have called Permian to within a short distance of the top, and will no doubt be found there upon proper investigation.

(g) The Jurassic and Triassic of Texas are not the same as the gypsum beds of Texas. The Triassic lies entirely west of the gypsums in Texas, and is so understood by Marcou and White, if Dr. White concedes the fact that the Pleurophorus and other Permian fossils determine the question, which he has already done. The Red Beds now referred to are those that occur in connection with the heavy beds of gypsum in Texas, and not the Red Beds of the Triassic that I have called Dockum Beds.

(h) The surface of the Upper Permian was deeply eroded before the Triassic was laid down in Texas, and so were the Triassic beds deeply eroded before the Blanco Canyon beds were laid down; so the question of erosion does not definitely show the strata to be either the one or the other.

The entire beds of the Texas Permian are conformable, having a small dip to the northwest, while the Dockum Beds (Triassic) dip to the southeast.

To summarize the reasons for saying all the strata from the Wichita division to the Dockum Beds are Permian, the following may be stated as true:

(a) There is a continuous sedimentation from the bottom to the top.

(d) The conglomerate of the Dockum Beds has been placed by Hayden elsewhere as the line between the Permian and the Triassic.

(b) The occurrence of Permian fossils in the strata from the bottom to near the top of the Wichita, Clear Fork, and Double Mountain Beds.

(c) The Albany Beds are characterized by a distinctively Coal Measure fauna.

(e) The Dockum Beds contain fossils of distinctively Triassic age, as determined by Prof. Cope.

There will be no difficulty in understanding why the Red Beds of Texas have been referred to the Triassic, if it will be kept in mind that there are Triassic beds in Texas that very much resemble in general appearance the Permian beds below them, although they would not be confounded with the Permian where the two are seen together. Dr. Newberry thus describes the beds which he correctly calls the Triassic:†

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*Arkansas Report, Vol. 2, p. 119.

†Monograph, U. S. Survey, Vol. XIV, p. 13.

"The Triassic strata underlying the Indian Territory, Northern Texas, New Mexico, etc., are peculiarly barren of fossils. They are generally reddish sandstones, conglomerates, and shales below, with a series of highly colored indurated marls or fine grained calcareous sandstones above, frequently charged with salt and sometimes including extensive sheets of gypsum, etc."

This description is an excellent one of the Dockum Beds (Triassic) in Texas, but is not applicable to the Permian beds below. There is not a single bed of conglomerate in the entire strata, as that name is generally used. The conglomerate bed that I have mentioned in the Wichita division is a peculiar stratum composed of rounded masses of clay ironstone cemented together by iron. In Texas I have placed the base of the Triassic just where Dr. Newberry has put it in the description above.

TRIASSIC.

In the First Annual Report, 1889, under the head of Dockum Beds, I mentioned the occurrence of a formation composed of beds of clay, sandstones, and conglomerates situated immediately above the Red Beds of the Permian and below the beds of the Tertiary, which constitute the Plateau of the Llano Escatado at this place. These beds occur probably along the entire base of the plains on the eastern side from Big Springs to the Canadian River. The great amount of petrified wood in the conglomerate is one of its chief characteristics. Prof. Jules Marcou, in 1853, found the Triassic along the Canadian River, and thus describes it along his route:

"In this group of Triassic rocks numerous remains of petrified wood, even whole trees, are often met with. On the western declivity of the Sierra Madre, between Zuni and the Rio Colorado Chiquito, there is really a petrified forest of trees thirty and forty feet long, divided in fragments from six to ten feet long, with a diameter of three to four feet, some being still upright, enclosed in the sandstone. These beds and remains of petrified wood belong nearly all to the family of the Conifers and some to that of the ferns with arborescent stems and to the Calamodendron."*

The formation was seen by Dr. Shumard at the head of the North Fork of Red River, in 1852, during Marcy's expedition. Captain Marcy saw it at the head of Prairie Dog Town River, and in his report of the expedition gives a glowing description of it. Although Marcy put it with the marly clays group of the Cretaceous, yet it is easily recognized by his description as the same beds as are seen at Dockum.

The formation is found on the west side of the plains, and is described by both Marcou and Shumard; yet it lacks the peculiar feature in that part of

*Geology of North America, Zurich, 1858.

the State of the fossil wood so abundant east of the plains. and should evidently be placed at a different horizon.

The beds that I designated under the provisional name of Dockum Beds are so similar to the Shinarump Beds, as described in "Geology of the High Plateaus," by Powell, that I here give an extract from that report, page 147:

"Within these shales there often appears a singular conglomerate. It consists of fragments of silicified wood embedded in a matrix of sand and gravel. Sometimes trunks of trees of considerable size thoroughly silicified are found, to which the Piute Indians have given the name 'Shinarump,' meaning the weapons of Shinav, the Wolf God."

Again, Mr. C. E. Dutton says: "Whenever we encounter a cliff which discloses the upper Permian Beds we find at the summit of the escarpment a band of pale brown sandstone of very coarse texture, often becoming a conglomerate. Its thickness is usually from forty to seventy-five feet."*

This conglomerate was found in that region resting upon strata known to be Permian, but there was no break in the deposit and the exact line of demarcation between the Permian below and the Triassic above had never been determined. Such, however, is not the case with the beds in this locality. The dip of the Permian is to the northwest, while these beds dip to the southeast, in the same direction as that of the Cretaceous further to the southward.

The thickness of these beds in the vicinity of Dockum is about one hundred and fifty feet. Of this about ten feet is made up of this peculiar conglomerate. At places, however, this conglomerate is over fifty feet thick.

The following section was made about three miles north of Dockum. Beginning at the bottom:

1.	Red Clay	20 feet.
2.	Sandstone, cross-bedded	10 feet.
3.	Conglomerate	20 feet.
4.	Red and blue clay	30 feet.
	Total	80 feet.

In the red and blue clay (No. 4) of the above section I found the fossil remains of a part of a large saurian (Belodon?), and in the same clay found the cast of a unio which I have called *Unio dockumensis.*

The sandstones and conglomerate are very persistent in character throughout this entire district. In places there is a large amount of mica in the sandstones in scales one-sixteenth of an inch square.

The following section was made at the falls of White River, in Blanco Canyon, about twelve miles below Mount Blanco. Beginning at the bottom:

*United States Geological Report, Vol. III, 1880.

1.	Red Clay	4 feet.
2.	Sandstone and conglomerate, cross-bedded	20 feet.
3.	Yellowish sandstone	6 feet.
	Total	30 feet.

White River pours over these beds at this place with a fall of twenty-two feet in one hundred feet distance. The amount of water flowing over these falls is about 13,000,000 gallons per day at time of low water. The top of the plains at a distance of two miles to the westward is two hundred and sixty feet above the bottom of the section at the falls.

The following section was made six miles below the falls. Beginning at the bottom:

1.	Red clay, with thin white seams	40 feet.
2.	Cross-bedded coarse micaceous sandstone, yellowish	20 feet.
3.	Iron ore conglomerate	1 foot.
4.	Soft, friable sandstone	30 feet.
5.	Conglomerate	30 feet.
	Total	121 feet.

The conglomerate of the above section is composed of water worn siliceous pebbles, and disintegrates very rapidly, leaving large beds of gravel at the base of the precipices.

In the conglomerate are impressions of the limbs and trunks of trees, but at only one place in this vicinity did I find the fossil wood preserved.

The beds of sandstone and conglomerate dip to the southeast, at nearly the same rate as the fall of the river below the falls. None of the sandstone or conglomerate are found above the falls, and at the falls are the first siliceous pebbles to be found in descending the canyon. Above the falls there is an entirely different formation, which I have called the Blanco Canyon Beds, and which are described in another part of this Report. The following section, made about six miles northeast of Dockum, will show the relation of the Dockum and Blanco Canyon Beds. Beginning at the bottom:

1.	Red and blue clay	20 feet.
2.	Conglomerate	12 feet.
3.	Sandstone, cross-bedded	10 feet.
4.	Conglomerate	6 feet.
5.	Red clay	30 feet.
6.	Conglomerate, containing *Unio dockumensis*	1 foot.
7.	Sandstone	8 feet.
8.	Cross-bedded sandstone	30 feet.
9.	Reddish sandy clay	180 feet.
10.	Reddish clay	10 feet.
11.	Hardened clay, top of Staked Plains	10 feet.
	Total	317 feet.

No. 8 of the above section is the top of the Triassic, while that of Nos. 9, 10, and 11 belong to the Blanco Canyon Beds.

In No. 6 I found a number of unios that appear to be of the same species as the *Unio dockumensis*, yet these are in a higher stratum than where I obtained the other specimens. The shells are covered with calcareous matter, and it was difficult to see the markings on the outside of them.

The following section at the head of Hades Creek, a prong of North Croton Creek, and about three miles east of the above section. This section will show the connection between the underlying Permian beds and the Triassic:

1.	Gypsum, with small round crystals, "plum pudding"	3 feet.
2.	Red clay	10 feet.
3.	Massive white gypsum	2 feet.
4.	Red clay, with seams of fibrous gypsum traversing it in every direction	55 feet.
5.	Red sandstone	2 feet.
6.	Red clay	60 feet.
7.	Sandstone and conglomerate, with fossil wood	20 feet.
	Total	152 feet.

The fossil wood in No. 7 of the above section is very abundant and some of the pieces very large. One tree at this place is about two feet in diameter and sixty feet long.

Pure fresh water is found everywhere in the sandstone and conglomerate, but as soon as the strata below are reached the water is highly impregnated with gypsum. The erosion of the red clay has been very great, both of the Permian and Triassic, before the deposition of the conglomerate of the last section. The red clay that is found elsewhere below the conglomerate has been entirely carried away.

The following section made near the Headquarter Ranch of the Espuela Cattle Company will show this bed of Triassic clay and its relation to the conglomerate. Beginning at the bottom:

1.	Red clay, with thin white seams	6 feet.
2.	Blue clay, with seam of white sandstone in the middle two inches thick	1 foot.
3.	Red clay, with seams of blue clay one-half inch thick	2 feet.
4.	Blue clay, with seams of white sandstone	1 foot.
5.	Red clay, with thin seams of red sandstone	8 feet.
6.	Blue clay, with thin seams of sandstone	1 foot.
7.	Red clay, with seams of sandstone	6 feet.
8.	Bluish clay, with seams of sandstone	2 feet.
9.	Conglomerate, with petrified wood	.....
	Total	27 feet.

In No. 1 of the above section the seams of white are sometimes not more than one-half of an inch thick, yet they show along the whole length of the face of the exposure, a distance of at least two hundred feet. The dip of the strata is to the southeast at a very small angle until near the extreme eastern end of this exposure, where it suddenly turns down at an angle of at least thirty degrees.

Another section was made at Soldier Mountain, about four miles southeast of Espuela Headquarters, and the last of the beds of conglomerate in this direction. Beginning at the bottom:

1.	Red clay	30 feet.
2.	Blue clay	8 feet.
3.	Conglomerate, with petrified wood	3 feet.
4.	Sandstone in thin layers	10 feet.
	Total	51 feet.

A few miles west of the mouth of the Blanco Canyon I found some pieces of trees that had been changed into lignite imbedded in the sandstone of the conglomerate. The impression among people who have seen these trees was that they were probably the outliers to a bed of coal, but such is not the case. There is no probability that anything more than a few isolated pieces of lignite will be found there, and that, too, of very poor quality.

It is more than probable that this formation has a very extensive outcrop along the base of the Staked Plains, between the Plains proper and the Permian. The conglomerate and sandstone are found in Potter County at the falls of Palo Duro Creek, a few miles east of Amarillo.

The fossil wood from this formation lies scattered all over the Permian. I have seen it along the Big Wichita, Pease, Red, and the Canadian rivers in great abundance. It is doubtless the source of all the gravel found scattered along these rivers from their sources to their mouths.

From the time the Red Beds of the West were first discovered until now there has been a great deal of confusion in regard to them. The absence of fossils, or very nearly so, rendered it impossible to determine the true horizon of the Red Beds by the paleontology. And when fossils were found the localities were so very remote from each other that the beds could not be correlated with any degree of certainty.

At one place and by one man they would be put in the marly clay of the Cretaceous. Another person at another place would put the beds in the Triassic, and in that would be included the Permian. Another at still a different locality would put them in the Triassic, denying that there was any Permian in the United States. Others would call the beds at still another locality Jura-Trias; and so the confusion went on. Each party would bring forward the few fossils found by him to support his theory and discredit the reference of others, and where fossils were entirely wanting that fact has been given as proof that the strata belonged to a particular series.

Another reason for the confusion was in trying to refer all the Red Beds of the West to the same horizon; and as they were in beds of continuous sedimentation, or apparently so, and were conformable in deposition, it was hard to give the dividing line between any of the beds.

The fact is, no doubt, that the Red Beds of the west when properly understood will be found to consist of beds belonging to all the subdivisions from the Coal Measures to the Cretaceous. In Texas the beds are very easily identified on stratigraphical and paleontological grounds. The Permian is very easily distinguished from the Carboniferous below, as between the contact of the beds there is a great hiatus in time, and when the whole contact is under consideration, is very different in sedimentation or stratigraphy. The Permian is well represented by both vertebrate and invertebrate fossils. The Triassic has also an abundant and characteristic fauna and flora, and between the Permian and Triassic in Texas there must have elapsed a considerable period. The upper part of the Permian was deposited in a shallow sea, where waters were highly charged with sulphate of lime and chloride of sodium; while the Triassic beds were deposited in a shallow fresh water sea, where a great deal of fresh water poured in from the mountains, containing a great many pebbles and much timber. The Permian has a continuous sedimentation of sandy clays, sandstones, and gypsum with no conglomerates, and with a regular dip to the northwest at a small angle; while the Triassic is entirely free from salts of any kind, and in the bottom part is largely composed of conglomerates and fragments of petrified wood, and dips towards the southeast at as small an angle, or in the opposite direction from that of the Permian. So there is no trouble in determining the line between the Permian and Triassic.

Only the upper part of the Permian is found north and west of the Wichita Mountains and along the Canadian River, and in that there are fewer fossils than elsewhere in the Permian strata, so that any one visiting that part of the formation might not find fossils sufficient to determine the horizon definitely or satisfactorily, and the mistake might very easily be made of calling all of the beds Triassic; while to the south and southwestward of the Wichita range no such mistake need to be made, because the fossils are numerous and distinctive.

Sufficient data has not been obtained to determine the exact horizon to which the Triassic beds on the eastern side of the Staked Plains should be referred in the series, but I do not think they will be found to be the lowest part of that division in the northwest. It is very evident, however, that there was not a continuous sedimentation between the Permian and Triassic.

DIP OF THE TRIASSIC, PERMIAN, AND CARBONIFEROUS STRATA.

The following summary of the dip of the strata, estimated by actual measurements along long lines, will give an idea of the inclination of the strata at different localities. There are places where the dip will be greater than that given, and there will be places also where it will be less. It will be observed that the dip of the strata becomes less as we go northwestward, or on the direction of the dip.

The dip is given as a general average of the various divisions mentioned elsewhere in this Report:

TRIASSIC.

Dockum Beds.

The approximate dip is southeast twenty-five to thirty feet to the mile.

PERMIAN.

Double Mountain Division.

The approximate dip is a little west of northwest, and averages about thirty feet to the mile. The upper part of the division is much folded, and the dip in amount or direction is not uniform.

Clear Fork Division.

The approximate and average dip is northwest forty feet to the mile.

Wichita Division.

The approximate and average dip is northwest thirty-five feet per mile.

CARBONIFEROUS.

Albany Division.

In the Northern Field the approximate and average dip is northwest forty feet to the mile.

In the Central Field the approximate and average dip is a little west of northwest thirty feet to the mile.

Canyon Division.

In the Northern Field the approximate and average dip is northwest seventy-five feet to the mile.

In the Central Field the approximate and average dip is north 50° west fifty feet to the mile.

Strawn Division.

In the Northern Field the approximate and average dip is north 30° west ninety feet to the mile.

In the Central Field the approximate and average dip is northwest seventy feet per mile.

Millsap Division.

This division only occurs in the Northern Field. The approximate and average dip is northwest eighty feet per mile.

Bend Division.

This division occurs only in the Central Field. A general average was not made, but the following measurements were made at the localities given:

At five miles west of Lampasas Springs the dip is north $21\frac{1}{2}°$ east one hundred and five feet per mile.

At Lampasas, north 30° east one hundred and five feet per mile.

At Bend, north 23° west one hundred and fifty-eight feet per mile.

At Cherokee Creek, north $84\frac{1}{2}°$ east one hundred and fifty-eight feet per mile.

These last estimates were made on short distances, and are very much in excess of what the strata would show on an entire section across the field.

TERTIARY.

BLANCO CANYON BEDS.

Above the Triassic formation, and resting conformably upon conglomerate, are the beds I have designated the Blanco Canyon Beds, which are possibly the equivalent of the "Green River" Beds of Hayden.

They constitute the upper beds of the Staked Plains, and are so well presented at Blanco Canyon that I have given this name provisionally to these beds.

They are composed of sands and clays. The clays and sands are indurated in places until they are as solid as stone. Their thickness at this place is about two hundred feet, with a gentle dip to the southeast.

The following section was made of a hill at the foot of the Plains four miles north of the town of Dockum. Beginning at the bottom:

1.	Reddish sandy clay	150 feet.
2.	White clay (chalk)	4 feet.
3.	Purple clay	3 feet.
4.	White clay (chalk)	3 feet.
5.	White sandy clay	6 feet.
	Total	166 feet.

This section rests directly upon those beds I have called "Triassic." From the point where this section was made the Plains stretch away to an unknown distance to the westward without break or change for hundreds of miles, except here and there where some stream has cut its way through, forming a deep, narrow chasm a mile or less in width, with perpendicular walls on both sides, often to the depth of the entire formation.

In No. 6 of this formation I found the fossil remains of a small turtle about six inches across and fragments of a large mammal.

I made the following section about one mile south of Mount Blanco. Beginning at the bottom:

1.	Reddish clay	30 feet.
2.	Red clay	2 feet.
3.	Sandy greenish clay	30 feet.
4.	Chalk	8 feet.
5.	Packsand	20 feet.
6.	Chalk	4 feet.
7.	White sandy clay	30 feet.
8.	White calcareous sandstone	4 feet.
9.	Stalactitic limestone	4 feet.
10.	Sandstone	3 feet.
11.	Limestone, hard	2 feet.
12.	Soil	8 feet.
	Total	145 feet.

The reddish clay (No. 1) of the above section looks very much like it had been deposited in a fresh water lake. In the packsand (No. 5) of the section are remains of large mammals. I found the tooth of a fossil horse. There is not much uniformity in any of the beds at this place except that of the reddish clay and the stalactitic limestone, which everywhere form the base and top of the Plains.

The following section was made one-fourth of a mile northwest of H. C. Smith's house and one mile north of Mount Blanco:

1.	Red clay (same as No. 1 of previous section)	130 feet.
2.	Stalactitic limestone	10 feet.
3.	Limestone	2 feet.
	Total	142 feet.

North of this there is no chalk along the canyon, but the stalactitic limestone lies directly upon the heavy beds of red clay. At the base of this formation there is a bed of sand that furnishes an abundance of water. About four miles above Mount Blanco there are two large springs that come up from this sand and give a large amount of water at all times. Wherever wells have been put down to this sand on the plains an abundant supply of good water has been obtained. Along the canyon below Mount Blanco at various places large springs are found. A fine flow comes from a spring on Crawfish Creek, about one mile south of Mount Blanco. In the vicinity of the falls, ten miles below Mount Blanco, there are numerous springs. Nearly all the gulches that come into the main canyon from the westward have running streams in them of clear, pure water. There is water enough in the canyon to irrigate large amounts of land if it was utilized in that way. At places below the falls the water comes from the conglomerate found every where below the sands of the Blanco Canyon Beds, but I think it is only where there are fissures in the sandstone and conglomerate that such is the case. Along the foot of the plains in the vicinity of Dockum there are several springs of pure, clear water.

I shall not attempt to determine the exact geological horizon of these beds for the present, as sufficient data has not been obtained to enable me to do so with certainty.

LLANO ESTACADO.

It has been supposed that the Staked Plains were of the same formation from one side to the other, and from the northern extremity at the Canadian River to the Pecos. When one attempts, however, to correlate the various reports that have been made from time to time, he will see at once that either the observers were not competent to determine the question, which is not so, or that the formation must be very different at different localities.

Marcou saw the Llano Estacado on the north, and the upper beds of the Plains he unhesitatingly pronounced Jurassic. Several parties have seen it at Big Springs, and have called it Cretaceous. I have seen it in Tom Green County, and am certain that it is Cretaceous there. I have also seen it at Dockum, and am sure it is Tertiary. I have had fossils from Palo Duro Canyon, and it is Tertiary there. I have traveled westward along the line of the Texas and Pacific Railway from Big Springs, and am sure it is Tertiary after getting upon the Plains west of Big Springs as far west as Dead Man's Cut, where I think it is Cretaceous, the rocks there being almost entirely composed of a small *Gryphœa* which has generally been referred to the species *pitcheri*, yet it may be Jurassic. At the top of the Plains at Quito, the first station east of the Pecos River, the strata are Triassic. Along the Pecos River, southeastward as far as Devil's River, Shumard calls the upper part of the Plains Creteceous; but it must be remembered that he put in the Marly Clays of the Cretaceous the whole of the Red Beds of both the Permian and Triassic, and it is only where he gives the fossils that are found in the strata that one can be certain that his reference to the Cretaceous was correct. A line of levels from the highest point on the Plains along the Texas and Pacific Railway shows a regular dip to the eastward of about eight and three-fourths feet to the mile in that direction, between Duro and Big Springs. Big Springs, however, is at the base of the Cretaceous, and Duro is at the highest point of outcrop of the Cretaceous rocks. The distance between these two points on a straight line is about eighty miles north 64° east.

From Duro to the western edge of the Plains at Quito, a distance of about fifty miles south 70° west, the dip of the surface is about ten feet to the mile; and to the Pecos River, a distance of about sixty-five miles, the dip of the surface is about the same, and the line is in the same direction. The highest point of the Staked Plains along the line of the Texas and Pacific Railway is at Duro, which is thirty-two hundred feet above sea level. Big Springs is twenty-four hundred feet, and the Pecos River is twenty-five hundred and eighty-five feet above sea level.

At Duro the dip of the surface is across the upper part of the Cretaceous, at Quito it is on the Triassic, and at the Pecos it is on the Red Beds that have not yet been determined. From the Pecos River westward along the line of the railroad the surface of the country rises very rapidly in a distance of seventy miles, or from the Pecos River to Boracho, the elevation being twenty-three hundred feet, or thirty-three feet to the mile. At Boracho the formation is Cretaceous, which dips to the southeast. It has been thought that the artesian water at Pecos City was in the Cretaceous and had its source to the westward along the base of the mountains, and that the same bed of water bearing sands would be found under the Staked Plains, but it will be seen at a glance that such could not be the case. If a line be drawn from the base of the Cretaceous at Big Springs to Duro, and that line protracted across the Pecos, it will reach the base of the Cretaceous in the vicinity of Boracho, but Pecos City would be over fourteen hundred feet below that line; or if a line be drawn with the line of the dip of the country from Boracho to the Pecos River, and that line protracted eastward, it will pass beneath the Cretaceous beds on the eastward. And then it is known that there is no Cretaceous strata from Quito to the Pecos Valley, but the Triassic comes in; so any water that might be in the Cretaceous formation west of the Pecos would not be found west of the Staked Plains, because the Pecos River has cut entirely through the Cretaceous strata.

More recently I have thought that the artesian water at Pecos City was confined probably to the valley of the Pecos, and was probably found in the deposits of a more recent age than the Cretaceous.

The following is a section of a well in Pecos City, given to me by Mr. Cox, who drilled the well in his own yard:

1.	Soil	1 foot.
2.	White clay	20 feet.
3.	Quicksand	2 feet.
4.	Soft sandstone	50 feet.
5.	Stiff yellow clay	20 feet.

6.	Quicksand	10 feet.
7.	White and blue clay	20 feet.
8.	Open space	5 feet.
9.	White sand	5 feet.
10.	Brownish clay	125 feet.
11.	Sand and gravel	7 feet.
	Total	265 feet.

It will be seen from the above that the strata do not correspond with the Cretaceous formation in other parts of the same district.

A deep well was put down at Odessa. The following section was furnished me by Mr. B. K. Brant, of Pecos City, who was at Odessa when the well was put down, and who was in a position to know the facts in the case:

1.	Soil	4 feet.
2.	Rotten limestone	16 feet.
3.	Conglomerate	4 feet.
4.	Sandstone, gravel, and sand	99 feet.
5.	Red clay	707 feet.
	Total	830 feet.

In passing through the material before reaching the red clay, three strong bodies of water were passed through.

In the above section I think No. 2 belongs to the Tertiary, while Nos. 3 and 4 are Triassic, while the red clay is more than probably Permian. The Triassic is the only formation in which I have seen any conglomerate and pebbles in this part of the State, and the conglomerate beds elsewhere lie at the base of the Triassic and immediately on top of the Permian. It might be that the conglomerate, sand, and gravel were a part of the Trinity Sands. In either case the Red Beds in which the last seven hundred feet of the well passed are Permian, and there would be little hope of getting water in them.

That the conglomerates are not Tertiary in the above section, I judge for the reason that no siliceous pebbles have been found anywhere in the Tertiary in the northwestern part of the State. The Carboniferous strata, and probably the Permian, are seen on both the eastern and western sides of the Plains; on the eastern side they dip to the northwest, while on the western side they dip to the southeast. There is therefore a great interior Carboniferous basin in which the newer formations have been deposited, and when the the entire district shall have been examined it will probably be found that all the observers have been correct in the reports made of the Staked Plains, and all the formations from the Carboniferous to the Tertiary will be found to exist in the localities from which the reports have been made, and that there will be no conflict between the various reports.

PART II.

ECONOMIC GEOLOGY.

COAL.

THE AREA OF WORKABLE COAL.

The two workable seams of coal, Nos. 1 and 7, have a general course of outcrop from northeast to southwest. Seam No. 7 is in the Cisco division, and lies toward the top of the Coal Measures. Seam No. 1 is in the Strawn division, and lies toward the bottom of the Coal Measures. Each one of these seams has been traced from place to place along the line of outcrop, so that there is not a mile of the line that has not been passed over and had special examination.

Local sections and maps have been made at various localities to show the exact relation of the Coal Seams to the surrounding strata. Wherever it was possible the names of the surveys upon which the outcrop appeared was given. Lines of triangulation and levels were run with as long lines as possible, in order to get the true dip of the seams at quite a number of places. The maps showing this work are given on plates at different places in the Report.

The outcrop of Coal Seam No. 7 begins on the north, near the town of Bowie, in Montague County, and runs thence southwestward through Jack County, crossing the West Fork of the Trinity River near the mouth of Lodge Creek. Thence by the town of Gertrude. Thence through Young County, by Flat Top, the mouth of Coal Creek, Belknap, and crossing the south line of Young County near the town of Carbondale. Thence through Stephens County, passing Crystal Falls, Coal Mountain, the mouth of Sandy Creek, and up Sandy Creek to Cisco, in Eastland County, where a few miles to the south the seam passes under the Cretaceous strata. It appears again on Pecan Bayou, near Byrd's Store, in the northwestern corner of Brown County; thence crossing into Coleman County, on the Wofford survey; and from thence crossing Home Creek, on the Scurlock survey, and to the mouth of Bull Creek, on the Colorado River; and passing Waldrip, in McCulloch County, where a few miles to the southwestward it passes below the higher part of the strata.

This gives about one hundred and ninety miles of outcrop on a direct line for this seam. It can safely be calculated that for a distance of ten miles to the northwestward of the line of outcrop this coal seam may be made available. This would give an area of nineteen hundred miles under which a workable bed of coal may be found at a convenient depth for economical purposes.

THURBER COAL MINE, SHAFT NO. 1. T, & P. RY.

[illegible]

The outcrop of Coal Seam No. 1 is first seen on the north, near the town of Bridgeport, in Wise County, and passes thence through the western edge of Parker County, between Millsap and Mineral Wells, and through Palo Pinto County, passing Gordon, and into Erath County, passing Thurber, to a point about ten miles south of Strawn, where it passes beneath the newer strata and does not appear again anywhere to the southward. This gives a line of outcrop about eighty miles long; and if the same calculation is made as in the case of the other seam it would give an area of eight hundred square miles of available coal lands of this seam, making the whole area of available coal lands in this part of the State twenty-seven hundred square miles.

AMOUNT OF COAL IN A GIVEN AREA.

The usual mining estimate of the productive capacity of a coal seam one foot thick is about one million tons of coal to the square mile. The coal seams of Texas will average two and a half feet thick, which would give two million five hundred thousand tons per square mile, or per section of land, in the coal area. It would take a plant producing six hundred tons per day, with two hundred working days in a year, over twenty years to take out the coal on a single square mile. The lands under which the coal seams are situated have no greater intrinsic value at the present than other lands in the vicinity, for the reason that most of them are distantly situated from lines of transportation, and a further fact that it requires a large investment of capital to carry on mining operations. Coal will not bear rehandling before reaching the lines of transportation because of the increased expense attached, but when our at present undeveloped industries are well established they will create a demand for fuel, and then the means of transportation will be provided and lands become more valuable.

SELECTION OF COAL LANDS.

The selection of coal land should always be made by an expert; one who is not only a judge of coal, but one who can also judge from the surrounding strata whether the country belongs to the true Coal Measures, and whether the seam is likely to be of uniform thickness.

I have endeavored to trace the only two seams in the State that are likely to furnish coal in paying quantities, which are No. 1 and No. 7, so that anyone can tell whether any coal outcrop he may find, or that may be found in sinking wells, belongs to either of these seams. By reference to the map showing the outcrop of coal in the State anyone can tell where profitable prospecting for coal may be done. Each of these seams has some peculiar characteristic by which it can be recognized at different localities.

Coal Seam No. 7 north of the Clear Fork of the Brazos River lies entirely above the massive limestone; while Coal Seam No. 1 lies entirely below all the massive limestone beds. A trained geologist would be able to trace the horizon of either of these seams by the accompanying rocks, whether he could see the outcrop or not, and would be able to indicate where a shaft would reach the seam, though it might be at some distance from an outcrop, with reasonable certainty. There are areas in which each of these seams are too thin for practical purposes, but these localities can only be determined by actual experiment.

In prospecting for coal it is only necessary to drift a few feet on the outcropping seam, so as to see the seam in its normal condition, away from where it has been subjected to the influences of the atmosphere. A drift of ten feet is generally sufficient to determine the thickness and quality of a coal seam at a given locality. Where there are sufficient outcrops to show the seam in several places in the same vicinity, several such openings should be made, so as to determine the general thickness of the seam and to furnish data for an estimate of the amount of coal a given area would furnish. It is also important that a shaft or drill be put down some distance from the outcrop, that the thickness of the seam may be known in that direction. I prefer a shaft to a drill, for the reason that it is not an easy matter to get a correct report from the driller of the exact strata passed through. Where a drill is depended upon, every piece of the core should be taken out and washed and preserved, and a correct record made of it. There is a general disposition to overestimate the thickness and quality of a coal seam found by boring. No reliability is to be placed upon the work of any kind of drill except one that brings up a core just as it occurs in the strata. Drop augurs for prospecting purposes are worthless.

KINDS OF COAL.

The only kind of coal found in this coal field is what is known as bituminous. It is high in volatile matter, and burns with an abundant yellow flame.

COAL ANALYSIS.

The importance of the analysis of coal is to show its value as a heat producer. It may be said in a general way that the more moisture a coal contains the less value it has, because the moisture prevents the combustion and must be driven off before complete combustion takes place. Part of the heat generated by the other material of the coal must be taken up to drive out this moisture. Again, it takes up a part of the weight that would otherwise be occupied by combustible material. Thus, if a coal has five per cent of moisture, that would be one hundred pounds in every ton that might be occupied by combustible material, and then it would take as much more to drive out the moisture, so at least two hundred pounds out of every ton would be unavailable on account of that percentage of water.

The greater percentage of ash a coal contains the less valuable does it become. The more fixed carbon a coal contains the greater its commercial value. The more volatile combustible material of a certain character a coal has the greater is its value, at least to a limited extent.

COKE.

A coal is increased in value by having good coking qualities. Coke is the solid portion of the coal after the volatile matter has been driven off. The coke retains the carbon and ash of the coal, so that a coal that has a high percentage of ash and volatile matter will be poor in carbon and in the coke it produces. The coal loses none of its bulk in the process of coking, but loses considerable in weight—at least one-half. The bulk of coke varies with the method of obtaining it.

Each kind of coal should be treated in making coke according to its own peculiarities. A coal that will give a good coke under one system of treatment might give a poor quality of coke under a different treatment. It is never advisable to send a coal away to some distant place to be tested in a coking furnace where they have been coking an entirely different coal. The result is very seldom satisfactory. The better plan is to build a small coking furnace at the mines and make the test in several different ways in order to get the best results. A small furnace could be built for a few hundred dollars, and the proprietors of the mines could have the work done by their own men, and let the coal be treated according to its own peculiarities, and not by some one whose interest might be subserved by producing a poor quality of coke in the test.

Tests as to the coking quality of a coal made in a laboratory are never satisfactory, because by rapid heating the small quantities used for analysis a much larger proportion of volatile matter may be driven off than by the slower process used in coking coal in a large way.

The principal object in coking, outside of concentrating its carbon and preventing its becoming pasty in the furnace, is to free the coal from sulphur, as the sulphur ruins the malleability of the iron.

So far as laboratory tests can determine, the coals of Texas have good coking qualities, and tests of the coal for coking purposes made in ovens where other coals are being coked have proven only partially satisfactory. The body of the coke was good enough, but the sulphur it retained was too high. This could be remedied by different treatment in the coking ovens. If the coal is piled into an oven with a sand floor, kept moist, and fired slowly the sulphur will escape, but if a dry heat is applied at once the sulphur combines with the carbon and is as injurious to the iron as if the coal in its original condition had been used. A simple test for detecting sulphur in coke is to throw water on red hot coke, and if it gives off a smell like rotten eggs it proves that it has not lost its sulphur in coking.

I am of the opinion that our coals will make good coke upon proper treatment in the ovens. Good coking qualities in a coal always render it more valuable, because such extend the demand for it.

ECONOMIC VALUE OF COAL.

The economic value of a coal bed does not depend so much upon the amount of fixed carbon or gas it may contain as upon its nearness to the consumer and the cheapness with which it may be mined. A bed of coal might be high in value in the heat units which it is capable of producing, yet could not be mined because of the competition with other coals and the high rates of transportation to market.

The Texas coal will have to come into competition with the coal from the Indian Territory and from the East, if it seeks a market in the cities in the eastern part of the State, and it will probably never be a successful competitor in these places.

The demand for Texas coal will be in the country west and south of the coal fields in the State. If the prices of coal that now prevail could be maintained the Texas coal could go into market in the eastern cities of the State and be sold at a lower rate than the Indian Territory coal now sells, and pay the mining company a handsome profit; but in order to sell the Texas coal in the same places with the Indian Territory coal it must be put on the market at a lower figure than the Indian Territory coal, because it is not supposed to be as high in heat units as that coal. Recent extensive tests on the Texas and Pacific Railway, however, refute this idea completely. As soon as this coal would be offered at a lower rate there would be a corresponding reduction in the price of coal from other localities, and the Texas coal would finally be driven out of the market in the eastern cities. The first cost of mining the Texas coal is greater per ton than that of the other coals, because the seams are thinner. The demand for fuel west and south of the coal fields in Texas is sufficient to consume all that these fields will produce, and will ever be on the increase, with the settlement of the country and the opening up of new enterprises. The immense fields of iron in Llano and adjacent counties will require large amounts of coke for the reduction of their ores as soon as railroads are built to them. These railroads, with others which will be built across the coal fields, will consume large quantities of coal, and it will be so close to the consumer that it can be sold to them at a lower rate than other coals can possibly be put down. New towns and cities will grow up, with their demand for fuel, which must all come a long distance or from these Texas beds.

There is really only one railroad that now creates a demand for the Texas coal, and that is the Texas and Pacific. It is true the Fort Worth and Denver crosses the coal fields and goes through the Panhandle country, but it crosses only one seam of the coal, and no attempt has been made to develop the coal there except in a small way. The northwestern branch of the Houston and Texas Central crosses the extreme southern part of the coal field, and at a place where the seam is not good, and where it would be difficult to work on account of the thinness of the bed.

The Texas and Pacific is using about six hundred tons per day from the mine at Thurber. With their increasing business they will have an ever increasing demand for this coal.

What is most needed to develop the coal of Texas is means of transportation to the west and south. And that the coal beds will be developed to their fullest extent does not admit of doubt, even if the seams are not as thick as they are in some other localities, nor the coal as free from impurities as the best article from other places.

There are nine seams of coal in the Northern Coal Fields, only two of which are of any economical value. These are No. 1 and No. 7. The others are only a few inches thick at any place I have seen them.

NATURAL GAS.

The demand and necessity for cheap fuel in the State makes it important that attention be given to every probable and possible supply. The use of natural gas has been shown to be the cheapest, where it can be obtained, of any other material, both for domestic use and for manufacturing purposes.

I have therefore given the subject such attention as it was possible in connection with my other duties, and will give the results of my observations in the bounds of the district to which I was assigned.

It will be necessary, in order to a proper understanding of the matter, that some general statements be made with regard to the supply of natural gas in other States, and of the conditions of the geological structure of a country in order that it may be a gas producing region.

Natural gas is used in a number of States and at different localities in them, and the cheapening of fuel in these States has been so great that whenever possible the manufactories have given up the use of coal, and have adjusted their machinery to the use of the new fuel. Many cities are now entirely lighted by natural gas, and in some places it is largely used for domestic purposes.

The most noted place for the use of natural gas is Pittsburg, Pa. There the matter has been fully tested and has proven every way satisfactory. The supply of gas for that place is obtained at a distance of twenty-four miles and less, and is conducted into the city by pipes ranging from thirty to five inches in diameter. The wells vary in depth from fifteen hundred to two thousand feet, and range from three to eleven inches in diameter. The amount of gas obtained from a well varies greatly. It has been found that all wells of the same size and same pressure are not equal gas producers. Therefore the amount of gas that the different wells give in the same district varies considerably. It has also been found that an occasional "dry hole" has been struck in localities in the immediate vicinity of good gas producers. The average number of dry holes in the Pittsburg district is about one in ten. The cause of this is that there are places in the gas bearing stratum that are impervious to the gas, and when such a place as that is passed through there will be no flow of gas. This can sometimes be remedied by blasting or breaking up the stratum at the place, but such is not always the case.

GAS BEARING STRATA.

A few necessary conditions must exist before it is possible for a stratum to be gas bearing. No gas can be found in the oldest strata. Nothing can be gas bearing below the Silurian. There can be no gas where the rocks have been greatly disturbed by upheavals, and where the rocks stand at a great angle. Even if there ever had been any gas in them, it has long since escaped.

Where the formation is very nearly flat over extensive districts of country, there is a possibility of finding gas, no matter to what period the strata may belong.

There is a popular notion that the Trenton limestone is the only bed in which gas or oil can be obtained, and I have received several communications asking if that formation was to be found in the State. The fact is, that oil and gas are not confined to any formation, and have been found all the way from the bottom of the Silurian to the glacial drift.

Gas is produced by the decomposition of animal and vegetable substances, and has been stored up in caverns, cracks, and porous beds, awaiting the prospector's drill. Whether the gas is still forming might be a question that would admit of dispute, yet it is thought that the supply in a gas bearing stratum, when once penetrated, will be practically inexhaustible for a great number of years.

GAS IN TEXAS.

There has been no effort to obtain gas anywhere in the part of the State to which this Report refers. Yet at numerous places holes have been put down searching for water and for other purposes which have penetrated a gas bearing stratum.

I am of the opinion that the gas in this part of the State will be found only in the Carboniferous formation, yet that formation may be overlaid by some of the newer formations at places where it may be possible to reach it by deep boring.

No deep wells east of the Carboniferous area in Texas have gone below the Cretaceous strata. It is not known what lies below the Cretaceous strata in the middle portion of Texas. The deep wells that have been put down at Fort Worth, Dallas, Waco, and other places that have given a fine flow of water have only penetrated the lower beds of the Cretaceous.

With the lights before me, I am now of the opinion that the entire Cretaceous area of middle Texas is underlaid by the Carboniferous. Every fact that I am in possession of leads to that conclusion.

If that be the case, then there is no reason why the same Carbonaceous shales that produce the gas in the Carboniferous regions would not exist under the Cretaceous, and would in all probability be equally if not more productive of gas than in the other regions of the State, and might be reached at a reasonable depth by boring.

The lower beds of the Cretaceous are reached at Dallas at about eight hundred feet. These beds along the line of outcrop where they have been measured are about two hundred feet thick. Placing, then, the Cretaceous strata at one thousand feet at Dallas, if the next formation below that is the Carboniferous, it would not take many hundred feet to reach the gas bearing shales. A hole put down to the depth of two thousand feet or less would determine the whole matter.

This matter is well worth the expense of the experiment. In case such a flow of gas was reached, which is probable, as was found in the Dalton well in Palo Pinto County, it would at once solve the fuel question of that city. This matter can not be predicted with the same degree of certainty as was that of the artesian water, for gas supplies are not subject to the same laws as that of water; yet there are indications sufficient of supply of gas existing there to warrant me in making the suggestion that the test be made.

Now that it is demonstrated that a fine flow of water can be obtained at a given depth, and that the city will put down other wells, when that work is commenced let the drilling continue for a few hundred feet further and determine the question of the possibility of finding natural gas, and if the matter should prove a failure there would only be a few hundred feet of work lost, for the casing could be taken up and the water allowed to come in and flow from the top.

The last part of the drilling ought to be in charge of a practical geologist, who would be able to tell the geological formation through which the drill was passing by the material brought up by the augur, otherwise the desired practical results might not be obtained.

What is here said of Dallas would apply with equal force to any other locality in the Cretaceous area except as to depth. At Dallas the Cretaceous is about one thousand feet thick, while at Waco it is two thousand and at Fort Worth probably about eight hundred.

The following is a list of wells, their locality and depth, where natural gas has been found in the Carboniferous strata in Texas.

Locality.	No. wells.	Depth.
Gordon	2	370 feet.
Thurber	1	480 feet.
Canyon	1	500 feet.
Dalton	1	384 feet.
Trickham	2	100 feet.
Waldrip	1	80 feet.
San Angelo	2	80 feet.
Fish Creek, Young County	2	120 feet.
Belknap	1	800 feet.

SALT.

Common salt or chloride of sodium contains sixty per cent of chlorine and forty per cent of sodium. The common article is very seldom free from other minerals, such as calcium and magnesium. The material from which salt is manufactured occurs as rock salt and saline water either in springs, lakes, or wells.

The origin of the material is much the same as gypsum, i. e., it is a precipitate from an enclosed sea. At present salt lakes and superficial accumulations of salt occur in various parts of the world, and these have furnished data for reasoning as to the saliferous deposits of earlier times. Salt lakes are derived from salt springs and the remaining portion of water cut off from the open sea, and when the evaporation of water occurs by the action of the sun and winds only fresh water is taken up by the process of evaporation. Now as water can only contain a certain amount of salt in solution, when the process of evaporation has gone on until the water has decreased so that it is completely saturated with salts, then as farther evaporation goes on the salt will be precipitated to the bottom, and in time beds of rock salt are the result. It often happens that during the process of evaporation water will flow into the lakes either from the ocean or from inland sources, and the process of the precipitation will be delayed for awhile, and beds of sand or clay will be deposited on top of the salt already precipitated, and after awhile salt will be again precipitated on the top of the clay or sand beds. As the result we find beds of salt interstratified with beds of clay and sandstone.

Sea water is generally composed of:

Chloride of sodium	2.50
Chloride of magnesium	0.35
Sulphate of magnesia	0.58
Carbonate of lime and carbonate of magnesia	0.02
Sulphate of lime	0.01
Water	96.54
Total	100.00

with generally traces of iodide and bromide of magnesia.

The following table is taken from the First Annual Report Animal Industry, 1884, Washington, D. C., p. 490, showing the composition of the different salts in the market, and will serve for comparison with Texas salts:

	Description.	Sodium Chloride.	Calcium Chloride.	Magnesium Chloride.	Sodium Sulphate.	Calcium Sulphate.	Magnesium Sulphate.	Insoluble Matter.	Water.
1.	Turks Island sea salt	96.760	.....	0.140	0.640	1.560	.....	.....	0.900
2.	Syracuse, New York, solar salt	96.004	0.092	0.089	.....	1.315	.....	.....	2.500
3.	Saginaw, Michigan, solar salt	95.831	0.356	0.140	.....	0.316	.....	.....	3.344
4.	Lincoln, Nebraska, solar salt	98.130	.....	0.080	0.390	0.250	.....	.....	1.200
5.	Kansas solar salt	93.060	.....	0.240	0.350	1.220	0.180	.....	4.950
6.	Hocking Valley, Ohio	97.512	0.234	0.089	.....	.....	.....	.....	2.130
7.	Petit Anse, Louisiana, rock salt	98.882	0.004	0.003	.....	0.782	.....	.....	0.330
8.	Syracuse, New York, "factory filled dairy"	97.832	.....	0.037	0.026	1.263	0.023	0.120	0.700

"In 1887 the production of salt in the United States was 7,831,962 barrels of 280 pounds each. Of this the value was estimated at $4,093,846.

"Michigan produced 3,944,309 barrels; New York, 2,353,560 barrels; Ohio and West Virginia, about 600,000; Kentucky, Tennessee, and Virginia, about 200,000; or about 7,000,000 barrels in all produced from the evaporation of brine. In addition, Louisiana praduced 225,000 barrels from quarries of rock salt at New Iberia; Utah, 325,000 barrels, mostly from the waters of Salt Lake, but a small portion from the quarries of rock salt in Jaub and Sevier counties. California produced in former years over 200,000 barrels, chiefly from the evaporation of sea water in San Francisco Bay, but in 1887 the production was only 28,000 barrels.

"In Kansas a discovery of rock salt has recently been made which promises to be an important addition to the resources of the State. The Salt Beds lie near the base of the Trias, and occupy a large area in the southern portion of the State, extending into Texas. In seven localities cited by Mr. Robert Hay, in the Biennial Report of the Kansas State Board of Agriculture, the rock salt lies at depths varying from four hundred and fifty to nine hundred and twenty-five feet, and the thickness is from seventy-five to two hundred and fifty feet.

"The production in 1888 was about two thousand barrels."*

In the Carboniferous and Permian formations in Northwestern Texas are numerous salt springs and wells, and at Colorado City, at a depth of eight hundred and fifty feet a bed of rock salt was found in boring for water.

The condition for the deposition of salt seems to have been peculiarly favorable during the latter Permian period. There was evidently an enclosed continental sea that followed the Carboniferous epoch, and that was for a long time very shallow. The red saliferous clays are in places several hundred feet thick and extend over large areas.

All the rivers and streams that have their origin in these clays and sandy shales, or that pass through them, are highly impregnated with salt, and many springs and small lakes in the region are completely saturated with it.

The Colorado, Salt, and Double Mountain Forks of the Brazos, Big Wichita, Pease, Prairie Dog Town, and Salt Forks of Red River all have their source in or pass through the Red Beds of the Triassic and Permian, and with their lateral streams are more or less impregnated with salt, the Salt Fork of the Brazos and the Salt Fork of the Red River carrying more than any of the others.

From the confluence of the Salt Fork and the Double Mountain Fork of the Brazos River the Salt Fork is, at a low stage of water, almost brine. The least evaporation of the water along the margins of the river results in the precipitation of the salt. For miles and miles at such times the brinks of the river are as white as a bank of snow. About one mile above the junction of Salt Croton Creek with the Salt Fork of the Brazos there is a fall of four feet in Croton Creek. At this place the rocks above the falls and along bluff are all incrusted with salt. Some of the party went bathing in the deep pool below the falls, and such was the density of the water they found it almost impossible to sink in it without great effort. A few miles above that is Salt Flat, an open, level piece of land, caused by the erosion of the overlying strata, about two hundred acres in extent. In the midst of this level area is a bold running spring of several thousand gallons of water per hour. This water carries so much salt that at the least evaporation of the water the salt is precipitated, and lies in sheets along the banks of the stream below in such quantities that it is easily gathered up in masses sometimes an inch or two thick. It has been the custom of the stockmen and other persons within reach of this place to send their wagons there during a dry time and in a day or two collect a load of the salt left by solar evaporation. There is no place in the State where salt could be so cheaply manufactured as at this place, and it only awaits the advent of cheap transportation to make this a great salt producing locality.

* J. S. Newberry in Transactions of the New York Academy of Science, November, 1889.

There are several other places in the vicinity where there are springs of less magnitude which would be good salt producers. There are large quantities of cedar timber in the vicinity that could be used for fuel, if it should be thought necessary to evaporate the water by the steam process; but with such a dry atmosphere as exists at that locality during most of the year there could be large quantities made by solar evaporation alone.

In the western edge of King County, on the Big Wichita, is a bold spring near the bank of the river that is very salty, and the same could be said of nearly all the springs along that river in that part of the county.

Along the Salt Fork of Red River there are many places where salt lies in thick incrustations, and this part of the State might get her supply from these points if some one had the enterprise to inaugurate the project of manufacturing it.

In the vicinity of Double Mountain there is a creek known as Salt Creek which at a time of low water is thick with salt. No doubt upon proper examination a place might be selected in that locality where salt could be profitably produced.

The same thing could be said of hundreds of places throughout the Permian formation in Texas, and it is only a question of cheap transportation when this part of the State will be famous for its salt works.

There are many salt wells in the Carboniferous formation. At Graham, in Young County, a few years ago, a large quantity of salt was produced from shallow wells. For a description of these wells, see the description of Young County, in another part of this Report.

The flowing wells at Gordon and other places in Palo Pinto County are all salty.

The flowing well near Waldrip, in McCulloch County, is salty.

The deep wells near tbe town of San Angelo, in Tom Green County, are salty.

In the examinations of water to be used in the manufacture of common salt there are only two principal things to be observed. The first is as to the amount of chloride of sodium (common salt), and the amount of sulphate of lime (gypsum) the water contains. If the water contains but a small percentage of salt the expense of evaporation will be too great to allow the economic production of that material. Gypsum is the only obnoxious ingredient that need be feared in the waters of Northern Texas. The gypsum is the first to be precipitated on the evaporation of the water, and generally forms in hard crusts on the bottoms of the evaporating pans. It is almost impossible to get rid of the gypsum from the brine by any cheap process. It would not matter so much if a small per cent of gypsum did precipitate with the salt, but as has been said above, it precipitates first and forms a hard crust on the bottoms of the evaporating pans, and they must be scaled occasionally, for this coating is a non-conductor of heat, and so much fuel is wasted in keeping up the amount of heat necessary that it is found economical to take up the pans and by an expensive process take the scale off. A good deal of the gypsum may be gotten rid of by heating the brine before it goes into the evaporating pans.

The chlorides of calcium and magnesium do not precipitate as readily as the common salt, and remain in the water left in the pans after all the salt has been precipitated. The only ill effect of the continued boiling of the water with these ingredients is that there is more or less hydrochloric acid turned loose, which attacks the iron of the pans and causes them to rust. The presence of chloride of magnesia in common salt is not an objectionable feature in a southern climate, where it is desirable in preserving meats that the salt should dissolve as soon and rapidly as possible.

From the analysis of the water at Colorado City, as given elsewhere, it will be seen that there is a very small percentage of gypsum in that water, and a part of that will be lost by evaporation, so if the whole remaining salts be precipitated it will yet be a first-class material.

The Texas Salt Company, of which Mr. George E. Briggs is president, are at Colorado, Texas. Their works are situated two miles east of that place on a high plateau overlooking that town. They get their water from four wells of about one thousand feet depth. The water is pumped from these wells by windmills thirty feet in diameter. In sinking these wells at a depth of about eight hundred and fifty feet a bed of rock salt was reached, and within the next two hundred and fifty feet one hundred and forty feet of rock salt was passed through.

The water in the wells rises to within about one hundred and fifty feet of the surface, and it has been found impossible to exhaust the supply of water in any of them by pumping. There has been no change in the character of the water since the company first began operations. The wells are cased to the depth of eight hundred and fifty feet, or to the first bed of rock salt. Fresh water was found in the wells both above and below the beds of salt. This company manufacture the salt by solar and steam evaporation, and produce seven hundred and fifty tons per month. This salt is sold in various parts of the State.

The following is an analysis of the water from these wells made by Mr. L. E. Magnenat, Chemist for the Survey:

	Parts per 100,000.	Grains per Gal.
Bicarbonate of soda	279.17	162.7655
Chloride of sodium	30,830.29	17,979.6143
Chloride of magnesia	470.27	274.2695
Chloride of calcium	55.64	32.4248
Sulphate of lime	522.82	304.8865
	32,158.19	18,753.9606

Saline water contains 32.16 per cent of salts.

Specific gravity, 1.1980.

COPPER ORE.

Copper ore has been known to exist in the Permian formation of Texas since 1852. It was first reported by Capt. R. B. Marcy in that year. It was reported to have been found on the north side of Red River, near the mouth of Cache Creek. He says: "In the course of the march to-day we met with numerous detached pieces of copper ore, mixed with volcanic scoria. This scoria is found in large masses in the ravines we have passed and extends back several miles from the creek." An analysis made of these ores at the time showed them to consist of a "calcareous amygdaloid, through which is interspersed black oxide of copper and stains of malachite."

In 1864 Col. J. B. Barry, then stationed at Fort Belknap, Young County, Texas, in command of Texas State troops, sent a scouting party into Archer and Wichita counties, furnishing them with Tonkawa Indians as guides, who conducted the party to the centre of Archer County and showed them the deposits of copper in that vicinity. Samples of the ore were carried to Austin to Gov. Pendleton Murrah, who had the same assayed by Prof. Wm. De Ryee, State Chemist, who found the samples to contain 70.68 per cent of copper. Some of the ore was smelted and made into percussion caps for the use of the Confederate army.

After that a company was formed and a charter obtained for mining the ore in Archer County. The company located 12,275 acres of land, and at various times have made attempts to develop their property. They mined many hundred tons and shipped the ores to the smelters of Philadelphia, Pa., and Baltimore, Md., after having hauled it overland to the railroads in some instances a distance of over two hundred and fifty miles. Only the high grade ores could be thus used, and all the low grade material was thrown into the dump.

The following statement made by Dr. F. A. Genth in 1882 will show the quality of the ore shipped from this land in 1874:

"UNIVERSITY OF PENNSYLVANIA,
"DR. F. A. GENTH, CONSULTING AND ANALYTICAL CHEMIST,
"WEST PHILADELPHIA, March 3, 1882.

"The following are the results of assays made by me of samples marked:

"1. Sixteen sacks Texas ore received at Schuylkill Copper Works, 20th February, 1874, by M. Veale, contained sixty-one (61) per cent of copper.

"2. On March 13, eleven sacks and two deer skins Texas copper ore—two thousand six hundred and ninety (2690) pounds—contained fifty-eight and ninety-four hundredths (58.94) per cent of copper.

"3. Two thousand three hundred and forty-two (2342) pounds Texas ore, etc., 21st April, 1874, contained sixty-two and thirty hundredths (62.30) per cent of copper.

"4. On April 29, 1874, Texas copper ore No. 4 contained fifty-seven and fifty-nine hundredths (57.59) per cent of copper.

"5. Six sacks of Texas copper ore—one thousand four hundred and sixty (1460) pounds—July 18, 1874, contained fifty-eight and forty hundredths (58.40) per cent of copper.

"These are all the assays which I have made.

"F. A. GENTH."

Since that time nothing has been done to develop the property.

A few years ago Gen. McClellan organized a company in New York for the purpose of developing the copper in the Permian in Texas. Gen. McClellan had been with Capt. R. B. Marcy in his exploration of Red River in 1852, and had seen the copper deposits found at that time. He came to Texas in these later years with an outfit for exploring and prospecting the copper region of Texas. They prospected the country through Haskell, Knox, Hardeman, and Wilbarger counties. They were equipped with diamond drills, and a smelter was erected in Hardeman County. Many holes were put down and much work done in the way of prospecting. The death of Gen. McClellan put a stop to the enterprise. No attempt had been made to make a geological examination of the country and to determine the relations of the copper deposits found in various counties in that part of the State until the work of this Survey was begun.

The country was known to belong to the Permian formation, but the relation of the copper beds and the nature of their occurrence had not been studied.

Capt. Marcy made the mistake of calling an indurated water-worn clay volcanic scoria, and nearly every geologist who has visited that field since has gone with the idea that there would be found veins of metaliferous material traversing the country rock in various directions, and that the best deposits of copper would be found at a lower depth than the outcrops.

The origin of the copper is not from volcanic sources. It is not a vulcanite, but it is a neptunite, and was precipitated from the sea water at the time of the deposition of the strata. There is no evidence anywhere in this entire region of volcanic upheavals since the time of the depositions of the Permian beds. These beds lie almost horizontal against the Wichita Mountains on the north, and no veins of igenous material have been found traversing the country in any direction.

The copper lies in beds parallel with the strata, which dip at a small angle to the northwest. It lies generally in beds of blue clay, which are themselves highly impregnated with copper. There are three distinct horizons of this copper in the formation, separated by several hundred feet of intervening strata. The lowest is found in the Wichita Beds of the Permian, which are the lowest beds in the formation. It is found in greatest abundance in Archer County, and extends in a northeast direction, crossing Red River near the mouth of Cache Creek, the locality where Capt. Marcy first made the discovery of the copper.

Another deposit is in the lower part of the Clear Fork division of the Permian formation, and is found on California Creek, in Haskell County; at Table Top Mountain, in Baylor County, and other places in a northeastern direction. The farthest point south at which I have seen this bed of copper clay is a few miles east of Buffalo Gap, in Taylor County, near where the Permian beds pass beneath the overlying beds of the Cretaceous.

The other horizon of the copper beds is in the Double Mountain division of the Permian, and occurs at Kiowa Peak, in Stonewall County; Buzzard Peak, and Cedar Mountain, in Knox County; at the head of Raggedy Creek, in Hardeman County, and on the north side of Pease River in the same county. The ore at all these places has much the same general appearance and much the same mode of occurrence.

At the centre of Archer County the principal part of the ore occurs in two forms. One that of pseudomorph after wood and the other in round nuggets.

The pseudomorph ore lies embedded in a blue clay in the form of logs of wood, and may at one time have been wood, but now has been transformed into copper. Six thousand pounds of that material taken out of the mines at one time averaged sixty per cent of copper.

That this material was once logs of wood and other vegetable material I judge from the fact of having found logs of petrified wood that were partly iron, partly silica, and partly copper. I have found many leaves of ferns in the sandstone that were transformed into copper. At one place I found a small petrified vertebrate animal that had been transformed into copper.

The nugget ore lies also in the blue clay, and is obtained by digging into the clay where they occur like digging potatoes. The miners for that reason gave one place the name of "Potato Mine." This class of ore will run as high as seventy-eight per cent metallic copper. The blue clay is impregnated with copper to such a degree that it can be profitably worked for the copper it contains, as will be seen from the following statement regarding the material taken from this locality. The clay bed at this place is four feet thick. I make the extract from a report made by Prof. Gustaf M. Westman, an eminent Swedish mineralogist, who visited this property with me in 1889 for the purpose of making a thorough examination thereof. We collected the clays from beds only a few inches from the surface. He says:

"At the excavation (Isbel lead) we found three separate veins of copper of a width, respectively, twelve by six inches, eight by three inches, and four by two inches, and besides, immediately below the lower sandstone a stratum of cupriferous marl extending the entire width of the tunnel, eight inches thick, yielding fifteen per cent of copper. The cupriferous marl situated below the sandstone, containing fifteen per cent of copper, can be estimated to be worth at the place ten dollars per ton."

Prof. Westman, in speaking of another place in the same vicinity, says:

"Although almost all the ore scattered on the surface in nuggets had been taken away, I only had to remove one foot of earth from the surface on the three spots mentioned already in order to find large deposits bedded in the clay. After washing this clay was found to contain ten per cent of copper ore."

The second stratum, running through the lower part of the Clear Fork division, has much the same appearance and the ore is very much the same. On California Creek, in Haskell County, the principal part of the copper found is the pseudomorph after wood. No prospecting has been done for copper in this part of the country, and the only thing that could be seen was at the outcrop.

The following section was made at a hill on Paint Creek, in Haskell County, near the old McKinzie Trail:

1.	Dark red clay, containing vertebrate fossils	10 feet.	
2.	Conglomerate (bean ore)		6 inches.
3.	Red clay	4 feet.	
4.	Thin bedded sandstone, with tracks of insects		10 inches.
5.	Red clay	4 feet.	
6.	Blue clay, with copper	3 feet.	
7.	Sandstone, concretionary		10 inches.
8.	Red clay, with clay concretions	8 feet.	
9.	Thin-bedded sandstone		8 inches.
10.	Cross-bedded sandstone		10 inches.
11.	Conglomerate, with vertebrate fossils		6 inches.
	Total	33 feet	2 inches.

This same bed of copper is found on the Big Wichita River north of Seymour in the vicinity of Table Top Mountain. A few years ago several thousand pounds of ore was taken from this locality, and several deep shafts were sunk, hoping to find a continuance of the copper ore at a lower depth, but none was found.

The following section was made of Table Top Mountain, beginning at the bottom:

1.	Red clay	30 feet.
2.	Conglomerate	6 inches.
3.	Red clay	20 feet.
4.	Thin-bedded sandstone	4 feet.
5.	Red sandstone	2 feet.
6.	Red sandy clay	18 feet.
7.	Red sandstone	2 feet.
8.	Red sandy clay	20 feet.
9.	Shaly fine grained argillaceous limestone	4 feet.
	Total	100 feet 6 inches.

The following section was made three miles northwest of Table Top Mountain and three-fourths of a mile west of the Clemmon shaft, beginning at the bottom:

1.	Red shaly sandstone	4 feet.
2.	Red clay	2 feet.
3.	Conglomerate	1 foot.
4.	White thin-bedded sandstone	1 foot.
5.	Red clay	4 feet.
6.	White sandstone	3 feet.
7.	Red clay	20 feet.
	Total	35 feet.

In No. 3 of the above section were found copper nodules, and in the red clay of No. 2 of the section were many remains of vertebrate animals. I traced this bed of copper ore to the north side of the Big Wichita River north of the mouth of Coffee Creek. It occupies the same relation to the limestone of the Clear Fork division as it does at Paint Creek in Haskell County.

The upper bed of copper occurs in the Double Mountain Beds of the Permian. I first saw it at our crossing of the Brazos River, a few miles below the confluence of the Double Mountain and the Salt Fork, and a few miles east of Kiowa Peak in Stonewall County. The following section was made at that place:

1.	Red clay, with seams of fibrous gypsum	40 feet.
2.	Greenish gypsiferous sandstone	10 feet.
3.	Blue clay, with seam of copper	4 feet.
4.	White cross-bedded sandstone with worm borings	12 feet.
5.	Conglomerate in thin seams and slanting back to top of hill	20 feet.
	Total	86 feet.

About one mile south of Kiowa Peak I made the following section:

1.	Gypsum and thin bedded sandstone	20 feet.
2.	Red clay	20 feet.
3.	Blue clay with copper	4 feet.
4.	White thin-bedded sandstone	3 feet.
	Total	47 feet.

At this place considerable work has been done prospecting for copper. There have been several tunnels driven into the hill, and two shafts have been sunk from the top of the hill to the copper clay bed. The entire seam of clay is impregnated with copper. In the clay are many pieces of charcoal that are mixed with the clay in confused masses, showing that the wood had been charred and broken before it was deposited in the clay. Some of these pieces of charcoal are covered with an incrustation of copper. This material was analyzed and gave 20 80 per cent of copper. It is very abundant at that place. The copper clay, which is four feet thick, gave 4.10 per cent of copper.

Another locality where this bed of copper appears is about nine miles west of Benjamin, in Knox County. At this place a company organized for the purpose a few years ago did a great deal of work prospecting for copper. They took out hundreds of tons of a material which they supposed could be reduced by smelting, which now lies at the mouth of the tunnel. They also erected a small smelter and attempted to reduce the copper clays, but found the plan impracticable. The clays are all impregnated with copper and carry a sufficient percentage to make the mining of it practicable, but the reduction will have to be by a different method than that of separating the copper from the clay by smelting in a furnace. Some of the copper taken from this place could be very easily reduced by the smelter, but the clays will have to be treated in a different manner.

The following section was made at this place:

1.	Red clay	20 feet.
2.	Blue clay, with seams of fibrous gypsum, pieces of charcoal, and copper	10 feet.
3.	Red clay	3 feet.
4.	Massive gypsum	2 feet.
5.	Red clay	25 feet.
6.	Bluish limestone, thin-bedded, with a great many *pleurophorus*	5 feet.
7.	Red clay, gypsiferous	20 feet.
8.	Limestone	1 foot.
	Total	86 feet.

I have seen this same bed of copper in Hardeman County, at the head of Raggedy Creek, and on the north side of Pease River opposite the mouth of Canal Creek.

At all the places mentioned in this report there is an abundance of low grade material, and if this kind of material has sufficient copper to pay for its reduction I do not see why they could not be successfully mined. The mining could certainly be done at a much cheaper rate than where a shaft has to be put down and the work carried on in the hard igneous rocks.

This clay could be lixivated and the copper precipitated or concentrated and in this manner get it in condition for the smelter. While there is a good deal of high grade ore at the different localities, yet I doubt that the mining of them alone could be made to pay. The seams of clay are continuous, but that can not be said of the high grade ores. They are in pockets and are very rich when found, but they can not be relied on as constant ore producers.

IRON ORE.

The iron ore of the Permian formation is principally a carbonate of iron of low grade. It occurs in the red clay of the Wichita division in concretionary form, the masses from the size of a pea to several hundreds of pounds in weight. The disintegration of the clays have caused these masses to accumulate at the base of the precipices in places in large quantities, and in convenient form if the ore shall be found rich enough in metallic iron to make it valuable for smelting purposes.

The red color of nearly all the clays in this division is due to the oxidization of the iron contained in them. The oxidization took place at the time of the deposition of the strata. The amount of iron in the clay that forms the coloring matter is very small.

It is not probable that there is any other iron ore in the Permian series except those already mentioned.

The tests made of these ores have not shown them to contain a sufficient amount of metallic iron to make the smelting of them profitable.

GYPSUM.

There are two sources of gypsum. One is where the beds are formed after the strata are deposited, by the action of sulphuric acid upon the carbonate of lime. The sulphuric acid acting upon the carbonate of lime, common limestone, drives off its carbonic acid and makes sulphate of lime, or gypsum. This was evidently the mode of its formation in New York. In that State the gypsum does not constitute regular layers in the strata, but is in lenticular masses in the formation. Sometimes the lines of stratification pass through the masses of gypsum. This is the case where the original beds of limestone were interbedded with seams of clay. The limestones on both sides of the clay would be changed into gypsum by the action of the sulphuric acid, but the clay would be unaffected by it and remain in its original form.

The other source of gypsum is by the deposition of material from sea water in enclosed seas. All sea water contains many materials dissolved out of the soil and carried down to the sea in solution. This material would only be precipitated by evaporation of the solvent. Common salt and gypsum are of this class. When the sea becomes enclosed so that there is no inlet from the ocean, and not enough fresh water flowing into the sea from the rivers and creeks to keep up the supply of water, at a certain stage of evaporation the various materials will be precipitated to the bottom, and if the evaporation continues for any length of time, heavy beds will be formed. Sulphate of lime, or gypsum, will be precipitated at one stage of the evaporation and common salt at another. The clay beds, sandstones, and limestones will be interbedded with these as the material is brought into the sea from the adjoining land. Thus in one place we find beds of gypsum pure and white, and in another rock salt, and in others limestone, sandstone, and clay beds without any admixture of either of the others.

The gypsum found in Western Texas was formed by this latter process. At one time the Permian sea was cut off from the main ocean, and as the waters of that sea became exhausted from time to time by evaporation, the beds of gypsum were deposited. At other times the sea would receive an amount of water, either from the open sea or by an influx of fresh water from the surrounding country, heavily laden with other material. Thus we have clay beds, limestones, and sandstones interbedded with the gypsum and salt.

The gypsum fields of Texas and the Northwest are the most extensive of any such formation in the United States. In Texas it reaches from the north line of the State to the line of the Texas and Pacific Railway on the south, and is from twenty to fifty miles wide. The beds are of varying thickness, from that of a knife blade to twenty feet. The east line of the deposit begins on Red River near the mouth of the North Fork, and thence by a line to Sweetwater, on the line of the Texas and Pacific Railway.

The western boundary is at or near the foot of the Staked Plains. The entire thickness of the bed containing gypsum about the middle of this district is about nineteen hundred feet. I have placed the gypsum beds in the Permian. There are various forms in which the gypsum occurs, but it all has the same chemical ingredients, the forms differing only in the manner of crystalization.

Selenite.—This is a clear, transparent variety, and has the quality of being split into thin sheets like mica or isinglass, and is very often taken for that material by persons not acquainted with the two minerals. This form of gypsum was used in ancient times for window glasses. It is said that Nero's house at Rome had windows of this material which had the peculiar quality of permitting things to be seen without from within, but did not permit things to be seen in the house from the outside. This form is found in many places, but generally in small crystals. At the head of Canal Creek, in Hardeman County, and not far west of the Eight Ranch, in King County, are some fine crystals. It is very easily distinguished from isinglass or mica by heating it. If it is gypsum it turns white at once and falls to pieces, while mica is not affected by heat.

RADIATE.—Is a kind of gypsum that has a radiated structure. It occurs in round balls in places, having great specific gravity.

FIBROUS.—This variety is also known as Satin Spar. It occurs in white or delicately tinged fibrous masses. It occurs in beds of the red clay in seams traversing the clay in various directions. It seems to have been formed by precipitation in cracks in the clay, crystalizing from the centre outward. Very few of the seams are more than two inches thick. At one place in Kent County, near the Salt Fork of the Brazos, I found a seam twelve inches thick. This is the thickest seam I have seen in the formation of this form of gypsum.

ALABASTER.—A compact snowy variety, sometimes tinged with various colors. It is cut into vases and ornaments, and receives a fine polish; it owes its beauty to its color and translucent structure. It is found in many places along the Salt Fork of the Brazos and other localities throughout the gypsum belt.

ROSE GYPSUM.—A peculiarly beautiful form of gypsum at Sweetwater, in Nolan County. It is called by the people there "petrified roses." It is a peculiar form of selenite in rounded masses of thin rose-like leaves that give it the appearance of roses. These masses are colored red by the clay and iron, and when freed from the surrounding clay are very beautiful, and make excellent and beautiful specimens for the cabinet.

MASSIVE.—The greater part of the gypsum in the district is the heavy-bedded, massive white and bluish beds. They occur in beds of various thickness. There is also a great deal of gypsiferous marls and clays, as well as heavy beds of gypseous sandstones.

A few sections from different localities will give an idea of the quantity of gypsum to be found in this district and its mode of occurrence. The following is a section of Kiowa Peak, in the northeastern corner of Stonewall County, beginning at the bottom:

1.	Gypsum	60 feet.
2.	Red clay	20 feet.
3.	Gypsum	20 feet.
4.	Red clay	35 feet.
5.	Gypsum	15 feet.
6.	Gypsum, alabaster	4 feet.
	Total	154 feet.

Another section at Salt Flat, in Kent County, beginning at the bottom:

1.	Spotted red clay	3 feet.
2.	White massive gypsum	10 feet.
3.	Red clay	30 feet.
4.	Gypsum	1 foot.
5.	Red clay	30 feet.
6.	Gypsum	6 feet.
7.	Red clay	20 feet.
8.	Limestone	1 foot.
	Total	101 feet.

The following section was made on the Salt Fork of the Brazos, in Kent County, on section 8 and block 1 of the Houston and Texas Central Railway surveys:

1.	Red sandy clay	4 feet.
2.	Massive white gypsum	3 feet.
3.	Red clay, with thin seams of gypsum	10 feet.
4.	Mottled sandstone	6 feet.
5.	Red clay, with seams of mottled sandstone	20 feet.
6.	Mottled sandstone	4 feet.
7.	Red clay and mottled sandstone	5 feet.
8.	Massive white gypsum	3 feet.
9.	Red clay	10 feet.
10.	Gypsum, alabaster	1 foot.
11.	Red clay	4 feet.
	Total	70 feet.

The following section was made three miles northwest of the smelter, in Knox County:

1.	Red clay	20 feet.
2.	White sandstone	10 feet.
3.	Red clay, with gypsum	30 feet.
4.	Massive bluish gypsum	2 feet.
5.	Red clay	20 feet.
6.	Massive white gypsum	4 feet.
7.	Red clay	20 feet.
8.	Massive gypsum	1 foot.
9.	Red clay, with seams of gypsum	30 feet.
10.	Limestone	2 feet.
	Total	139 feet.

ECONOMIC USES OF GYPSUM.

Gypsum is used for making plaster of Paris, which is used for making casts, making models, and for giving a hard finish to inside walls.

It is also used as a fertilizer for the improvement of soils.

There was used in the United States in 1886, the latest date of which I have the information, over one hundred and two thousand tons of land plaster, and ninety-eight thousand tons of calcined gypsum, or plaster of Paris, worth in the aggregate over one million dollars. The most of this came from foreign countries, and from beds that are much inferior to the gypsum of this district.

There are only two railroads that now penetrate this gypsum district from the south and east. That of the Texas and Pacific Railway reaches the beds in the vicinity of Sweetwater, in Nolan County, where there are fine beds of gypsum. The Fort Worth and Denver Railway reaches the gypsum in the vicinity of Quanah. At either of these places there is enough of the material to supply any demand that could be made upon it for ages to come.

Just what effect gypsum has upon soils by being strewn upon them has not been fully determined, but that it produces a decidedly salutary effect upon vegetation is not to be questioned. Prof. Lupton says: "As a fertilizer it furnishes lime and sulphur to the plants, and is thought to have the power of absorbing ammonia from the air and supplying it to the plant." To this important property Liebig ascribes much of its wonderful effect upon young grasses and wheat. "It has no caustic properties like quick-lime and guano, and therefore seeds are not injured by being placed in immediate contact with it. The vigorous, healthy start which it gives to the young plant is very desirable for both corn and cotton, since weak, sickly plants are almost sure to suffer from insects or perish from other causes. This is one of the cheapest of fertilizers, and should be used by farmers or planters who desire an increase of production by a moderate outlay of money."

The fertility of the river bottoms and valleys of Texas are in a measure due to the fact that these rivers have their sources in these gypsum beds.

BUILDING STONES.

In determining the quality of a building stone there are several things to be taken into consideration, three of which are of paramount importance. These are durability, texture, and color. The more satisfactory these things are in one stone the more desirable it is as a building material.

A stone that is granular will decompose more easily than the crystalline rocks, yet if the grains composing a stone, as the sandstones, are cemented together by a material that is inclined to harden on exposure it may be very durable. In selecting building stones or a place to open a quarry much information may be obtained by visiting the locality and seeing what effect the weather has had upon the stones exposed to the action of the atmospheric influences. The rocks that are thus exposed have been subject to these influences for thousands of years, and will show what may be expected of the stones when quarried and put into buildings. If the bed of stone is entirely hid from observation by the material of its own destruction it will prove to be a stone that will suffer greatly on exposure, but if it stands out in bold escarpment while the other parts of the strata are decomposed, it shows that it has a strong power to resist the atmospheric influences. It must be remembered, however, that the most obdurate material will show some effects of weathering; even the hardest granites have been decomposed by the relentless hand of time.

The color of a stone to be desirable must be uniform and permanent after weathering. Very few stones, if any, will retain the same color as when first quarried, and it is very desirable that there should be no nodules of pyrites that will cause streaks across entire walls below where such a nodule may occur.

It is always desirable that a stone that is to be used in a large building should be subjected to all the tests that have been adopted for determining these matters, such as the chemical constituents of the stone, its crushing capacity, its power to resist the action of carbonic acid, its ability to absorb moisture, as well as the facility with which it can be dressed under the hammer of the workman.

For testing the crushing weight of a stone cubes should be prepared two inches square, in duplicate, so that its resistance both in the direction of the bedding and in a line across the bedding may be tested. Many stones are much more durable and will stand much more pressure if put into a wall in the same way they were bedded in the quarry than if set up on edge.

No tests of the stone in this part of the State have been made by the Survey except some very brief and simple tests to determine some of the qualities of some of the limestones, and they were not made with a view of determining their value as building material.

CARBONIFEROUS BUILDING STONE.

In the Carboniferous formation in Texas, from the bottom to the top of the series, there are beds of excellent building stones, both of sandstones and limestones. Mention is made in the description of the several counties, elsewhere in this Report, of a number of places where these stones have been brought into use.

LIMESTONES.

In the Albany Beds, which occur at the top of the series everywhere in Texas south of the Brazos River, are the best limestones for building purposes in the formation. These limestones are generally blue when first taken out of the quarry, but after long exposure to the atmosphere change their color to a whitish-gray or buff, according to the different beds used and the different localities from whence they are taken. These beds furnish the building stones of Coleman, where several of the buildings have been constructed of this material. It lies in beds from a few inches to two feet thick, and is very even-bedded, is easily quarried, and receives an excellent finish under the workman's hammer. The uniformity of texture throughout an entire bed makes it a very desirable building stone.

Baird, in Callahan County, is another locality where this building stone has been used extensively, and has given general satisfaction. It has been used both for finished and rough work, and has proven equally satisfactory for each.

At Albany, in Shackelford County, there have been several beds opened and used extensively in that town for buildings. It lies in beds generally about eighteen inches thick, and gives slabs as large as the quarryman desires to handle. The best quality there is bluish on first being taken from the quarries, but changes to a lighter color on being exposed to the action of the atmospheric influences. The mention of these localities is sufficient to call attention to these beds, which are just as good at other localities occupying the same geological horizon, a mere mention of the beds being all that can be done at the present.

There are limestones in other divisions of the Carboniferous strata besides those of the Albany Beds that make good building material and have been extensively used. Mention of the quarry at Jacksboro is made in another part of this Report. The beds in the vicinity of Crystal Falls are excellent, but have not been used very largely, for the reason that there has been no local demand for them.

The limestones in the vicinity of Palo Pinto are good and very abundant, and have been used with satisfaction in that town.

The hard blue limestones along the line of the Texas and Pacific Railway in the vicinity of the Brazos, in the south side of Palo Pinto County, are being used as macadam on the streets in the City of Dallas. These stones are very hard, and when broken and compacted with sand and gravel make very desirable material for street improvement. The limestones in the vicinity of Brownwood would make excellent building material, and have been used to some extent in that place.

The limestones of the carboniferous would propably have been used more extensively than they have but for the fact that at almost every locality where they occur, and where there is a demand for building material, there are also beds of sandstones that work much more easily than do the limestones, and as a consequence have been used in preference to them; and not from any inferiority in the material for durability or color, but because the thin texture rendered them more difficult to put into the desired shapes.

SANDSTONES.

The sandstones of the Carboniferous are abundant, and are found in all the beds of the formation. They have been used more extensively than any other stones in this part of the State. For their great uniformity of texture and color, and for their known durability, they are very desirable for building purposes. They are easily quarried and admit of a good finish. The facility with which they can be dressed is another quality that has added to their value.

It would be a matter of impossibility to even mention the beds where good quarries of this stone could be opened, and the quality of the different beds is almost the same. As a matter of course some of the beds will be different in quality from that of others, and there will be changes in the quality of the sandstone in the same bed, but by proper selection good stone may be found in all of them.

The following localities are some of the places where the sandstones of the Carboniferous have been used: The quarries that have been worked most are in the southern part of Palo Pinto County, along the line of the Texas and Pacific Railway, near the Brazos River. Stone taken from this place was used in constructing the United States government building and the Grand Windsor Hotel in the city of Dallas. Stone from the same quarry was used in the construction of the large Joe Brown grocery house as well as others in the city of Fort Worth. The stone is there in unlimited quantities, and is within easy reach of the railroad. This stone was thoroughly tested by the United States architect before it was allowed to be used in the building at Dallas, and determined to be a very superior stone for building, as has been mentioned elsewhere. The court house in the town of Montague is built of sandstone from a quarry a few miles west of that town. At Bowie, in the same county, some of the business houses are built of the same material.

At Mineral Wells some of the business houses are built of sandstone found in the vicinity. At Ranger, along the line of the Texas and Pacific Railway, is a stone that has been used extensively not only for building houses but for construction of piers for the railway bridges.

At Eastland is a bed of stone that furnishes a good building material.

RED SANDSTONE QUARRY, QUITO T. & P. RY.

Some of the houses at Cisco are built from sandstone found in the vicinity. Just north of the town of San Saba a few miles is a bed of sandstone that has furnished good building material for various purposes in that town.

From Brownwood to San Saba are many beds of sandstones that will make first-class building material when there shall be a demand for it. The time has not yet arrived in the history of this part of the State when men build large and commodious houses out of the most durable material, but have devoted all their capital to investments that will yield a revenue, and have been content to live in houses built of lumber or inferior material. The time will come, however, when the average citizen will make improvements as though he had come to stay a while, and then the immense quarries of building stones found so abundantly in all this part of the country will be brought into use.

RED SANDSTONE.

About one mile southwest of Quito, a station on the Texas and Pacific Railway, twelve miles east of Pecos City, a quarry has been recently opened of red sandstone, which is probably one of the finest building stones in the State of that kind of material. The proprietors have secured the necessary transportation rates over the Texas and Pacific Railway. It is their intention to ship large quantities of stone to the eastern part of the State.

It is not definitely determined what geological formation is at that locality, but it is not later than the Triassic, and very probably belongs to that series. The stone lies in thick beds of even structure and uniform color and in unlimited quantities. It admits of a fine finish and retains its color well on exposure to the weather. The quarry is the most extensive in the State, and it is the intention of the owners to increase their working force as the demands for the stone increases.

PERMIAN BUILDING STONES.

There are three kinds of building stones in the northwestern part of the State—the dolomite, calcite, and sandstones.

LIMESTONES.

The dolomitic limestones are found principally in the Clear Fork Beds of the Permian. The calcite or common limestone is found in beds throughout the entire Carboniferous strata.

The dolomitic limestone is very durable as building material, for the reason that from its very composition it will stand the atmospheric influences better than the other stones. Rain water carries a good deal of carbonic acid, and as carbonate of lime has a much greater affinity for that acid than does the carbonate of magnesia, it will not be so easily affected by the weather.

These limestones lie in beds varying in thickness from an inch to three feet. The beds are generally separated by thin beds of clay, making it very easy to get out the stone in the quarry. The beds are generally very regular in thickness, and the rocks may be taken up and put into a wall in the same manner in which they were bedded, rendering no dressing necessary except the exposed edges that show in the wall. The color is quite uniform throughout a layer for long distances, and such is the texture that in weathering the color will still be uniform. The localities where this stone occurs are so numerous that it would be an impossible thing to mention all of them. It begins a few miles south of San Angelo, at the old town of Ben Ficklin, and extends continuously to the north line of Baylor County, a distance of one hundred and fifty miles, and in some places is several miles wide.

Wherever this stone has been used it has given the best satisfaction.

A quarry has been opened at the old town of Ben Ficklin, and the stone used very extensively in the city of San Angelo in the construction of some of the largest public and private buildings. It was also used for building the piers for the bridges across the Concho River in that county.

The houses at Fort Concho are built of this limestone, and have been erected for thirty years, yet they show no effect from weathering except that they are a little whiter than when they were first built.

The beds of limestones are in several layers and are easily quarried. The thickness of the beds vary from six inches to three feet.

At Ballinger a quarry has been opened at the top of the hill on the south side of the river, and one north in the north edge of the town; they are both of the same stratum of limestone. This limestone has been used extensively in the town of Ballinger for building purposes. The court house is built from material from this quarry, as are also the piers for the railroad bridge across the Colorado River west of the town of Ballinger, and across Elm Creek east of the town.

The limestone at the top of the hill where the quarry has been opened is in a regular bed three feet thick. It has two lines of fracture, one due north and the other north 45° east, with the magnetic variation at $9\frac{1}{2}$° east. The hill is eighty feet high, and a section made at this place shows the entire hill composed of alternating beds of limestone and clay.

On the north side of town a quarry has been opened on the same bed which will give equally as good stone. The convenience of these quarries to railway transportation ought to make them very desirable.

At the old town of Reynolds, five miles north of Ballinger, a quarry was opened, and when that town was the county seat of Reynolds County the principal building material was of the limestone from this place. It has very much the same appearance as the stone at Ballinger, and is probably a part of the same bed. At the town of Seymour, in Baylor County, a quarry has been opened that has furnished the principal building material for that town for several years. The stone was so easily quarried and wrought that it was cheaper to build of stone than to haul lumber from the railway; and then a stone house was so much more desirable. Now that they have a railway to the town all the principal buildings are still made of this material.

The principal quarry is in the bluff of the river one-half mile west of the town.

The following section made at the quarry will give an idea of the manner of occurrence of the limestone and clay beds at this place. Beginning at the top:

1.	Limestone		10 inches.
2.	Clay bed		2 inches.
3.	Limestone		10 inches.
4.	Blue clay	10 feet.	
5.	Limestone		10 inches.
6.	Blue clay	20 feet.	
7.	Limestone		8 inches.
8.	Blue clay	20 feet.	
9.	Limestone	1 foot.	
10.	Blue clay	8 feet.	
11.	Limestone	1 foot.	
	Total	63 feet	4 inches.

The clay bed between No. 1 and No. 2 of the above section is wanting in places, and the two beds of limestone are compacted into one bed making a stratum twenty inches thick, and is the best stone found in this quarry. The stone can be taken out in any sized pieces desired. It breaks with a smooth, even surface that requires very little dressing. The court house, jail, and nearly all the other buildings in the town are built of this material.

I merely mention these localities to show the extent of the beds, not that they are better at these localities than at hundreds of other places along the line of the outcrop indicated.

SANDSTONE.

This class of stone is very abundant throughout all the beds of the Permian, but more so in the Wichita and Clear Fork Beds

Its color is generally a gray or pale blue that changes to a brown on exposure by the oxidization of the small amount of iron they contain. Some of the beds are red and some are red and white spotted and some have a mottled appearance.

The beds about three miles southwest of San Angelo are a bluish gray. They are very homogenous throughout both in color and structure. These stones are in regular layers from six inches to four feet thick, are easily quarried, and are soft and easy to work when first taken out, but harden on exposure. There are several buildings in the city of San Angelo made of this stone. It is used in building chimneys, and stands the heat of an ordinary fire well.

At Buffalo Gap a red sandstone quarry has been opened by Mr. Haynes, and the material was used in the construction of the college building at that place. It is an excellent building material, retaining its color admirably, and becoming very hard on exposure to the atmosphere. The bed is not very extensive, but it is in sufficient quantity to supply any demand that may be made for it.

On the southeast of the town of Buffalo Gap about one mile and a half a quarry of bluish, fine-grained, thin-bedded sandstone has been opened that furnishes a good building stone. The stone ought to be laid in a structure in the same position that it occupies in the quarry, otherwise it is liable to scale in weathering, but if placed in the wall in the same position as it has in the quarry it will weather very slowly.

At Cedar Mountain, about six miles east of the town of Benjamin, in Knox County, a quarry has been opened of gray sandstone, which occurs there in heavy beds. The stone is easily quarried and dressed and becomes very hard on exposure. It changes color very little on weathering. The county jail in Benjamin is built of stone from this quarry.

All these places mentioned are in the Clear Fork Beds of the Permian, and are mentioned to give an idea of the extent of the sandstone in that part of the State.

In the Wichita Beds of the Permian there are no limestones suitable for building purposes, but there is a great abundance of sandstones everywhere. A few places only can be mentioned in this Report where these stones have been used.

At the town of Archer this stone is abundant, yet it has been used only to a limited extent, but where used has given entire satisfaction. Its color at that place is a bluish gray, rather soft when first taken from the quarry, but becomes hard on exposure, and stands the weather excellently.

At Wichita Falls there has been quite an amount of sandstone used for various purposes. The piers for the bridge for the wagon road across the Big Wichita River are built of this stone. The stone can be selected from quarries in this vicinity that will be of the same color throughout, but the most of it is inclined to be variegated. Some of the beds are light yellow and some of them are reddish.

Several quarries have been opened near Henrietta that have proven to be good. The stone is even-bedded and uniform in color, is very easily quarried and works well under the hammer, does not color on exposure to the weather, is free from nodules of pyrites, and is a very desirable building stone.

The court house, jail, and many other buildings in the town of Henrietta are constructed of this material.

At a great many other places there are beds of fine sandstone that can be used where there is a demand for such material.

BUILDING MATERIAL.

CLAYS.

The clays in this part of the State may be divided into two classes; first, that which occupies its original position in the formation and has been broken down on exposure to the atmosphere; second, the residual clays, more or less mixed with other material, which has been deposited in its present position by the action of the water during the time of the erosion, and more lately by the rivers and creeks.

The most of the bricks manufactured at present in this district are from this residual clay. That this clay should vary very much in different localities is to be expected from the very mode of its occurrence. It differs in value as a brick making material, owing to composition, texture, and different degrees of fusibility. That there should be failures sometimes in making good bricks is not to be wondered at; but the failure can generally be traced to the want of skill in the manufacturer rather than to the composition of the clays. Different clays require different handling, from the mixing to the final burning.

Pure clay will not make brick by itself, nor will clay and sand, even of proper proportions, unless there is some material to act as flux when they are burnt in the kiln.

Pure clay must furnish the largest part of the material for brick making and give body to the brick; yet by itself it would crack and crumble in drying, would shrink and melt and warp in burning, and be too hard to be broken by a stroke of the trowel, which is often necessary in building. Sand prevents the brick from cracking when drying and shrinking when burning. Lime, magnesia, and the metallic oxides, acting upon the other material, cause sufficient fusion in burning to cement the whole in a compact mass. The most of the clays in this district contain a sufficient amount of peroxide of iron to color the bricks a beautiful red.

A great deal depends upon the mixing of these elements in proper propor tion, and where that is not already done the material for this proper admixture is nearly always convenient. Chemical tests of the clays will determine very nearly what element would be lacking and how it could be supplied at any given locality.

In selecting clays for making bricks there are a few things to be considered. The material should be such as to give sufficient hardness to enable it to withstand heavy pressure and to stand the weather. It should be such that the brick will be of uniform size, to secure uniformity in the settling of the building, and to add to its beauty. It should have some material that would cause the whole mass to agglutinate and form a compact mass. When these matters are properly looked into and provided for there is no reason why good bricks may not be made at almost any locality in this part of the State.

FIRE CLAY.

This term has been used in this Report to designate a peculiar clay underlying the beds of coal. Fire clay for making the quality of brick known as "fire brick," which have a due admixture of clay and silica with the silica in excess, with no material that will act as flux when burning or when exposed to great heat thereafter, have been found in other coal fields and called fire clay, and in calling the clay "fire clay" in this district I have simply called it so from its position and not from its chemical properties.

POTTER'S CLAY.

The clays of the Coal Measures are excellent clays for making pottery, but have not been utilized for that purpose at any locality so far as I know.

MARBLE.

At several localities my attention has been called to beds of limestone that were supposed to be marble, but in no place has there marble been found. Hard limestones capable of receiving a high polish occur in places, but it is doubtful if any of them will be of any economic value.

Two miles and a half east of Graham, east of Salt Creek, is a bed of this marble. On first examination it appears to be sandstone on the outside, caused by the harder grains of the stone having resisted the weathering, giving the outer surface the weathered appearance of sandstone. This bed is very compact and has been slightly metamorphosed, yet not enough to destroy the forms of the fossils, but sufficiently to make it very solid. It takes an excellent polish, and could be used for articles of furniture that would not require much handling.

GRINDSTONES.

It would seem that the people of Texas ought to be able to make the grindstones they use, instead of importing them from a foreign country, as is very largely done. The same kind of sandstones are to be found in our Coal Measures as are found at other places where large quantities are produced.

There was imported into the United States in 1886, the latest date at which I have a statement, $45,713 worth of stones. Most of these came from England and Nova Scotia. The stones are manufactured there by hand with chisel and hammer, and then shipped to this country and sold at a less price than the stones can be made here.

The value of grindstones manufactured in the United States in 1886 was $250,000. A large part of the product is manufactured by machinery.

The sandstones of the Carboniferous in Texas would make a very good article if properly selected. There are only two places where any attempt has been made to develop this kind of an industry, and that was on Grindstone Creek, in the western part of Parker County, and at the stone quarry on the line of the Texas and Pacific Railway, near the Brazos River, in Palo Pinto County.

The locality on Grindstone Creek has been known almost ever since the settlement of the country. The old settlers utilized the stones for the purpose of grindstones before any could be brought from a distance. Only a few at a time have been made at this place on any occasion.

At the other place a few years ago a great number were made and met with a ready sale, but the enterprise has been entirely abandoned.

AGRICULTURE.

Thirty years ago the broad prairies of the "black waxy" lands in the middle part of the State were thought to be too much subject to drouth to be suitable for cultivation, except for wheat. Now they are the finest in the State. Ten years ago, when the Texas and Pacific crossed the Brazos on its westward march to the Rio Grande, it entered a country almost entirely devoted to stockraising, with only here and there a small farm, and the general expression and belief was that it would always be so. Before the Colorado was reached even the stockman was not found, and the Staked Plains were thought to be a barren sandy desert over which even the wild game did not roam. Ten years ago all the Panhandle was unoccupied except by stockmen. Now prosperous towns have sprung up along the lines of the railroads, and farms are being opened up at a rapid rate. On the Staked Plains, where there was thought to be no water, and where whole parties of emigrants on their way to California and thousands of cattle being driven across the Plains perished for lack of water, it has been demonstrated that everywhere at a depth of from thirty to one hundred and fifty feet abundance of water can be obtained by digging. These lands, instead of being, as the geographers taught, a desert, are covered with a luxuriant growth of nutritious grasses, and the soils are as good as any to be found in the State.

Steadily the settlement of the country has gone on, and the large cattle ranches that once occupied the entire country are giving place to the agriculturist.

Thirty years ago the half of Nebraska was thought to be only fit for grazing purposes, but now it is the center of one of the most fertile corn producing countries in the world. Colorado was once thought to be the same; so was California; yet the value of their farm products is more than the output of their mines in a single year.

These results have been obtained by utilizing the rainfall by deep plowing and subsoiling, and thereby forming a reservoir for the surplus water which formerly ran off and was wasted.

Last winter, at the foot of the Plains in Dickens County, we purchased oats at a ranch at the same figures we had to pay for them in Wichita County. They had been raised on a farm of three hundred and twenty acres sown entirely in oats and barley. The oats had averaged over forty bushels to the acre.

In Baylor County it has been demonstrated that good crops of cotton can be made that will class with that raised on the "black waxy" lands of Dallas and Collin counties.

Wichita County is claimed to be the banner county of the State for small grain; and these counties are but samples of what may be done in any of the counties of the northwest. Practical tests have proven that the Panhandle of Texas is destined to become a fine agricultural district.

In determining the agricultural possibilities of a country there are two things of importance to be considered; first, the quality of the soil; second, the rainfall or the possibility of irrigation.

In discussing the question of rainfall, the time at which the greatest precipitation comes and the mean temperature of the country will be taken into consideration. If these be favorable, it is then for the farmer to adapt his crops and manner of cultivation to the peculiarity of these things, that he may secure the best results.

In studying the capacity of the soils in the Northwest for agricultural purposes, I have thought best to give a brief statement of the chemical ingredients necessary to the composition of fertile soils, and then to see how nearly the soils of the Northwest will be found to correspond with this ideal soil.

The soils get their chemical qualities from the rocks from which they have their origin. The first thing, therefore, to be considered is the origin of these soils.

SOILS.

The origin of all soils is from the decomposition of the rocks, clays, shales, and other material going to make up the crust of the earth. When any part of the earth's crust is exposed to the influence of the rain and dew, the cold of winter and the heat of summer, no matter how compact that material may be, it gradually decomposes and the particles wash down and make the soils of the valley below.

Then again the lichens, although in many instances they are of microscopic size, fasten themselves upon the rocks and there secrete an acid which gradually decomposes the rocks, and the particles go to make up the soils. The clays and other soft materials are more easily broken up and washed down by the rains, and they too enter into the composition of the soils. Again, growing upon this newly made soil will be plants which in turn will die, and the material of which they are composed will combine with the rock material and form a soil somewhat different from that of purely mineral origin. The difference in the soil is often observed in the color of the two; the last, or that on top, is usually darker than that below, caused by the large amount of vegetable matter contained therein.

The material from which most soils are derived has been subjected to this disintegration several times since it was first deposited as rock material. The sandy soils are mostly made up from the sandstones of the different formations, which were in turn derived from the granites and other igneous rocks and deposited along the shores of the former oceans. The calcareous soils have their origin from the limestones, and the limestones were deposited in the bed of the old ocean, the material coming from the worn-out shells of the bygone times. A perpetual round of disintegration, mixing, and redeposition has been going on since the beginning, our soils being the work of all the ages. In the classification of the soils some writers have distinguished them as sedimentary soils, being those which are in the immediate vicinity of the rocks from which they were formed, and the transported soils, being those which have been brought from a distance. This classification will be well enough if the fact be kept in mind that nearly all the stratified rock material has itself been brought from another locality by the very same forces that are now transporting and depositing the other class of soils. There is no rock that has not at one time been soil.

There are fifteen principal chemical properties composing all soils, aside from many other elements that occur only in small quantities or not at all. These are: 1, hydrogen; 2, carbon; 3, oxygen; 4, nitrogen; 5, silicon; 6, chlorine; 7, phosphorus; 8, sulphur; 9, aluminum; 10, manganese; 11, potassium; 12, calcium; 13, sodium; 14, magnesium; 15, iron. Besides these elements soils often contain other ingredients which are, when in excess, quite deleterious to plant life.

These elements are contained in the primitive or granitic and metamorphic rocks, with little or no admixture of the elements or combinations caused by the admixture of the acids with the basic elements. As there are no primitive or metamorphic rocks in that part of the State to which this Report relates it will be unnecessary to discuss the question of the mode of occurrence and the combination of these elements in the primitive rocks. The soils of this part of the State are derived from the sandstones, limestones, and clay and shale beds found in the district.

These stones and beds were originally formed by the disintegration of the material of the primitive rocks. The materials of the limestone were brought down by the rivers into the sea, and were finally deposited with the comminuted shells of the ocean in the deep, quiet ocean in beds as they are now formed. These limestones are composed principally of calcium, carbon, and magnesium, with iron, silica, clay, bitumen, and other substances as impurities.

The sandstones were deposited along the sea beach, and are composed principally of silica, being nothing more than fragments of quartz. This material is bound together by clay or lime, and sometimes by iron.

The clay beds were formed in the shallow seas and along the estuaries and mouths of rivers, and are principally aluminum silicate and carbonate of lime.

Soils are largely indebted to vegetable life for their fertility and for their ability to receive heat and moisture and to transmit it to the growing crops. This vegetable material after it has reached a certain state of decay is called humus. This material has no fixed chemical constituents, owing to the effect produced and the combination formed with other substances in the process of decay. Many soils owe their dark color to this material. It renders a soil more susceptible to heat and moisture. It also causes the undissolved particles of rock material remaining in the soil to disintegrate and give up their unused material to form a part of the soil.

All soils of whatever kind and for whatever agricultural purposes they are used must be placed in proper condition to sustain the intended plant The plant is dependent upon the soil for a place in which to grow and mature. It must have food, air, heat, and moisture; and if either of these are lacking the plant withers away before maturity, even if it germinates or begins to grow.

The first important thing in regard to the soil is that it shall be of sufficient depth to support the plant in its upright position while growing. If there be no depth of earth the roots can not penetrate deep enough to hold the plant in position. The roots of a plant are not only for taking up nourishment from the soil, but also for the purpose of bracing and supporting the plant in its proper position while growing. If a soil be so shallow or so hard that the roots can not penetrate to a sufficient depth, the plant would be uprooted by the first winds that spring up. Or if the soil is so loose that the roots are easily drawn out, the same results will follow. Soils may be improved in these particulars by cultivation, which will be noticed more fully in another place.

The next important quality of soil to be noticed is its capacity to absorb and retain moisture. This is probably of more importance in Northwestern Texas agriculture than any other quality, and one that ought to have more than ordinary consideration.

In the growing plant water constitutes a large part of its substance. The organic material on which the plant feeds is held in solution in the water, and is taken up and conveyed by absorption to the various parts of the plant and there assimilated. There are also materials not necessary to the plant life held in solution, which if retained in the plant would prove deleterious to its growth. A certain amount of water is thrown off by the plant, and with that water is excreted the unnecessary organic matter. A great deal more water is exhaled by the growing plant than is returned to the soil by rains and dew during the period of growth. The plant will therefore be dependent upon the water stored up from previous rains for its supply of moisture. That soil which absorbs the greatest amount of water will not, however, always be most productive, for there are several other things to be taken into consideration. Some soils absorb moisture very readily in large amounts, but are not productive because from their physical properties they permit the water to pass beyond the reach of the roots of the plants or they steadily give off their moisture in the form of vapor. The ability of a soil to retain moisture against these influences is determined by the size of the material going to make up the soil.

The power to absorb moisture by the various ingredients making up the soil are as follows: Siliceous sand, 0; sandy clay, 28; carbonate of magnesia, 90; gypsum, 1; loamy clay, 34; humus, 110; calcareous sand, 3; pure clay, 48; slaty marl, 35; common soil, 23; carbonate of lime, 35.

The addition of vegetable material will always increase the capacity of a soil to receive moisture. The power to receive and retain moisture by a soil is almost in the same ratio.

Another important factor of good soil is its power to receive and transmit heat. The color and texture of a soil have much to do with its power to absorb heat. The dark lands absorb heat much more rapidly than those of a lighter color. Sandy soils absorb much more heat than clayey soils. Yet clayey soils give off their heat much more rapidly than sandy soils. A proper analysis of the soils of the State will enable those who desire such information and will act upon it to adapt their crops to the soil and plant only such crops as can get most readily their food supply from it.

By repeated chemical analyses of plants it has been found that the following elements are essential to plant life, and if a soil be lacking in any one of them, or the plant so situated that it can not absorb the missing ingredient from the atmosphere, it is impossible for plant life to exist. These elements are: 1, carbon; 2, hydrogen; 3, oxygen; 4, nitrogen; 5, phosphorus; 6, sulphur; 7, chlorine; 8, iron; 9, magnesium; 10, calcium; 11, potassium.

The sources of these elements as appropriated by the vegetables are as follows:

Carbon.—At least one-half in weight of dried plants is composed of carbon. The plant gets this material from the atmosphere. The plant is capable of absorbing some carbon from the soil from its roots, but not enough to sustain itself. The open leaves take up the carbonic acid from the atmosphere, and if exposed to the light assimilates the carbon, while the oxygen goes back to the air.

Hydrogen.—This material exists abundantly in nature. About one-tenth of dried vegetable matter consists of this element. The plant receives this material in the form of water. The water is taken up by both the roots and leaves, but principally by the roots. This element all comes from the atmosphere, but large amounts of it fall upon the earth in the form of rain and is absorbed by the soil and stored up for the future use of the plant.

Oxygen.—As has already been noticed, this element is in combination with carbonic acid and water, and the plant receives it in combination with them through both roots and leaves.

Nitrogen.—This material exists abundantly in the atmosphere, the atmosphere being composed of oxygen 23.04 parts and nitrogen 76.96 parts, omitting carbonic acid and water. But it is doubtful if a plant has the power of assimilating nitrogen from the atmosphere unless in combination with other elements. Large amounts of nitrogen are evolved by decaying vegetable and animal substances, which is taken up by the atmosphere and returned to the earth in rains.

Phosphorus.—This element is entirely taken from the soils, where it occurs as phosphate of lime, or alkalies. It comes from the decomposition of phosphatic rocks, and is taken up by the roots of the plants.

Sulphur.—This element is taken up by the plants in combination with sulphuric acid and lime, potash, soda, and other sulphates. Nearly all the soils of Northwestern Texas are supplied with this material in the form of sulphate of lime or gypsum.

Chlorine.—This element is also taken from the soils, where it occurs in the form of chloride of sodium, or common salt. This material is abundantly supplied to the soil by the decomposition of the red clays of the Permian in Northwestern Texas.

Iron.—This element exists in the soils and is taken up by the roots in small quantities in combination with various kinds of acids.

Lime.—This element exists in the soils and is in combination with some one of the acids. It generally occurs as carbonate or sulphate of lime—that is, as the material derived from the decomposition of common limestone—or as gypsum.

Potassium.—This element exists in nearly all the soils in combination with other salts and acids—more often with common salt or Glauber salt. When there is a superabundance of this material in a soil it is known as "alkali land."

Magnesium.—This element is found in the soils, and is derived from the decomposition of magnesian limestone, where it exists as carbonate of magnesia. It also occurs as a sulphate of magnesia or Epsom salts.

These organic elements are largely contained in the soil and held in solution in the moisture, ready to be taken up by the plant when demanded. If the soils are loose and deep a large amount of this plant food may be stored up for future use; or if the water flows through the soil too readily the salts of various kinds held in solution may be carried off or beyond the reach of the roots of the plant, which can only extend a few feet at most; hence the best soils will be found to be those of moderate depth with a clay subsoil tha is almost or quite impervious to water.

ANALYSES OF SOILS.

By an analysis of a soil its chemical properties can be determined and its adaptation to certain crops be ascertained with a tolerable degree of certainty.

To analyze the soil of every tract of land in the State would be an endless undertaking, and one that is altogether unnecessary. Large districts of country derive their soils from the same source, and a chemical analysis of soils from different tracts of land in the same district will be sufficient.

There are but few classes of lands in this part of the State, each one of which will have its peculiar characteristics and chemical properties.

An ideal soil would contain all the ingredients that are necessary to the life of a plant, some plants requiring more than others of the different materials. The fertilizing of soils by the use of various manures is simply giving to the soils that of which they are found to be lacking in chemical analysis. An ideal soil would contain the following ingredients:*

* Hillgard.

1.	Potassium oxide	0.20
2.	Sodium oxide	0.40
3.	Calcium oxide, or lime	5.90
4.	Magnesium oxide, or magnesia	0.85
5.	Iron oxide	6.10
6.	Aluminum oxide	5.70
7.	Manganese oxide	0.10
8.	Silicon oxide (sand)	64.80
9.	Sulphuric acid (anhydride)	0.20
10.	Phosphoric acid	0.45
11.	Carbonic acid	4.00
12.	Chlorine	0.20
13.	Organic matter	1.40
		100.00

SOILS OF THE PERMIAN.

To apply the principles to the soils of the district embraced in the Permian territory a brief description of the different classes of soils found therein will be necessary.

"There are three principal kinds of soils in this district, classed by their derivation rather than by their chemical properties. The first are those derived from the immediate underlying strata, and have only such foreign ingredients as have come from the decomposition of the vegetation growing upon them from year to year.

Soils of the first class are purely local and do not extend over very wide areas in any one locality. They vary in composition and color according to locality. Where they are derived from the massive friable sandstones and clays they are quite sandy and have a deep red color. In such localities the color and composition have been very little changed by vegetable deposits. In the limestone belts, where the origin of the soil is due to the decomposition of the limestones and the accompanying bluish clay beds, the soils are dark, and in places are quite black. They have a good deal of vegetable material in their composition, and owe their dark color largely to this fact. All of this class of soils are more or less sandy. These I will call residual. They are found along the north side of the Concho River, below San Angelo; in Taylor County, near Abilene; in parts of Baylor and Wichita counties, as well as all the counties in the Permian district.

This class of soils is as good as any to be had in the district. All of them can be improved by deep plowing, the deep plowing enabling the soils to receive and retain the rain that may fall and store it up for future use of the plants. These soils have been given practical tests, and have in every instance given satisfaction where the tests have been fairly made. No more prosperous farmers can be found in the State than those who are cultivating this kind of land, and if the lands do not stand the drought as well as some other lands in the district, it is because they have not been broken deep enough at the beginning. In that case the remedy will be subsoiling in the fall.

The second class are those having in their composition such material as has been brought from other localities; they were deposited during the time of the great erosion, and have derived very little if any of their material from the strata upon which they rest.

These soils I will call soils of transportation.

The second class of soils are by far the most abundant in the region under consideration. They are very homogeneous in composition and color, yet in places they have been changed in both respects by their immediate contact with the underlying strata.

In considering the composition of this class of soils it will be necessary to remember that several hundred feet of material has been eroded and carried away or redeposited. During this period of erosion the water probably spread out in broad sheets. These waters were heavily laden with the materials gathered up on their way, the material being precipitated to the bottom on any decrease in the rapidity of the flow of the waters.

Afterwards the rivers and creeks cut through these deposits in various directions into their present drainage basins and left the deposits as they now are, in broad, level, high plateaus. The overlying strata destroyed by this great erosion were several hundred feet of the Lower Cretaceous formation, composed of sand beds and limestones, and several hundred feet of the Permian strata, composed of sandstones, limestones, clay beds, and gypsum. Still further northward the beds that have been called Blanco Canyon Beds, composed of sands and white clays, were involved in the erosion. The material derived from all these beds was mixed into a homogeneous mass and deposited, making the broad, level plateaus. The soils of these plateaus will therefore be composed of the white clays and sands of the Blanco Canyon Beds, the clays, sands, and limestones of the Cretaceous, and the sands, clays, and gypsum of the Permian.

It will be seen from a glance at the composition of these soils that they are derived from such a variety of sources that they are likely to contain the materials necessary to the composition of first-class soils. Experimental tests, which after all are the best sources of information, have proven that they will produce abundant crops of wheat, oats, and corn. In Baylor and Wichita counties, where this soil largely prevails, the average crop of wheat was over twenty-nine bushels per acre. I mention these two counties because they are the only localities where I have personally examined the matter of crops, and they are the fair representatives of that part of the State in the way of soils.

The thickness of this class of soils ranges from a few inches to many feet, owing to the undulating and uneven surface of the underlying strata at the time of their deposition. The surface is often so level that the difference in height will not vary over five feet in a mile. It might be supposed from this statement that the soils would be unfit for cultivation for want of drainage, but such is not the case. There is so much sand in the soil that the water is soon taken up and none left on the surface, and therefore no surface drainage is necessary. Water is always found in wells at the base of these soils, and by capillary attraction they are always kept moist.

This class of soil makes the Lipan Flat, in Tom Green County; the broad plateau between Sweetwater and Colorado City; the Big Flat, between Haskell and the Brazos River; the broad level prairie west of Seymour; the country in the vicinity of Vernon, and all soils of a similar character. In composition they are as near the ideal standard as any in the State.

"The third class of soils might very well be classed as a variety of the second class, as the most of their material has been brought from a different locality from that where they are found. They were, however, deposited by different agencies, and are somewhat different in composition. They are found along the present courses of the rivers and creeks, and might with propriety be called bottom lands.

"There is ordinarily more timber on them than on either of the others. Where these lands have been put into cultivation their fertility has proven equal to any in the district. They do not usually lie in as large bodies as do the second class of lands mentioned in this Report."

Where the farmer desires to make a selection of land for the purposes of agriculture, and has not the time to have the soil analyzed and can not identify it with either of the soils mentioned herein, if he will observe the character of growth upon the land it will very readily indicate to him the fertility thereof. On broad plateaus, mentioned as the second class of soils, it will very often be the case that very little is to be seen except grass, and that the short, curly mesquite that would to him probably not indicate a soil of much fertilty. In that case let him look for a place in that region where the turf has been destroyed—the side of a road or a gulley, or some other place—and examine the weeds that have sprung up there, and they will very readily indicate the kind of stalks that will be produced in the cultivated plants. A soil that will grow big weeds will make good grain or cotton if the weeds are kept down.

The amount of ammonia contained in a soil is readily indicated by the growth of a plant. If a plant is inclined to go to stalk there is sure to be enough ammonia in the soil for all practical purposes. Clay and humus are the great absorbants of ammonia, and in none of the soils of the North and West is there any likelihood of there being a deficiency of that material.

RAINFALL.

In considering the agricultural possibilities of Northwestern Texas it is highly important to give particular attention to the question of rainfall. The soil may be all that could be desired in a country and the rainfall be so small that it would be utterly impossible to raise any of the ordinary crops. I have therefore availed myself of all possible resources to get information on this subject.

A few years ago the United States government collected all the data possible upon this subject and published the results.

It is thought that twenty inches of rainfall per year is necessary to the production of ordinary crops. That crops could be raised with less than twenty inches of water if the rain comes at the times most needed and within the time of the growing crops.

The western boundary of the twenty-inch rainfall in Texas was placed by the United States Government Report at about the one hundred and first meridian, or a line commencing at the mouth of Devil's River and crossing the Texas and Pacific Railway at Big Springs, and thence along the foot of the Staked Plains, and crossing the State line at the mouth of Paladora Creek, in Hansford County. This line would only be approximately correct, and I am sure it is in no place far enough west. As this Report is not intended to cover any part of the district west of that line, I have only collated such facts as relate to that portion of the State covered by the Carboniferous and Permian formations as is given in another part of this Report.

The following tables have been prepared from the data collected from various sources. Table II shows the mean amount of rainfall for the time given, the small figures in the upper part of the spaces showing the time for which the observations were made. It will be observed that at only two stations does the mean precipitation of rainfall go below twenty inches per annum, the amount thought necessary for successful agricultural purposes; and these stations are only for two years, a length of time too short to get a correct average.

TABLE II.

(Taken from Spaight's map, December 1, 1882.)

Stations.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Period of Registration.	Mean Annual Rainfall.
Coleman City..	5 1 22	5 1.48	5 1.34	5 1.88	5 3.26	5 3.36	5 4.48	5 2.35	4 4.94	4 2.18	5 1.14	5 2.67	July 1, 1877 to Sept. 1, 1882	3 27.71
Concho	5 1.27	5 0.60	5 0.79	6 1.67	6 2.87	6 2.65	6 3.92	6 4.30	5 4.65	5 1.53	5 1.09	5 1.29	April 1, 1877 to Sept. 1, 1882	4 25.07
Fort Elliott...	3 0.27	3 0.32	3 0.31	3 0.69	3 5.74	3 2.05	3 3.68	3 1.25	2 1.86	2 1.55	2 0.26	2 0.24	Feb. 1, 1880 to Sept. 1, 1882	2 16.47
Fort Griffin...	5 1.25	5 1.10	5 0.53	5 2.08	4 3.18	5 4.38	5 3.03	5 1.25	5 2.73	5 2.85	5 2.26	5 1.82	June 1, 1877 to May 1, 1882	4 24.57
Fort McKavett.	5 1.13	5 1.30	5 0.60	5 1.33	5 2.77	5 1.84	6 3.18	6 3.15	5 2.95	5 3.07	5 1.41	5 1.17	July 1, 1877 to Sept. 1, 1882	4 22.71
Graham	3 1.29	3 2.53	3 1.17	3 2.28	3 2.85	3 2.03	3 5.24	3 5.16	2 2.94	2 2.40	2 1.21	2 2.31	Jan. 1, 1880 to Oct. 1, 1882	1 25.11
Henrietta.....	3 1.63	3 1.14	3 1.81	4 2.86	4 2.63	4 3.26	3 2.24	3 3.98	2 1.51	2 1.38	3 1.22	3 0.87	April 1, 1879 to Sept. 1, 1882	1 22.73
Jacksboro ...	5 0.86	5 1.86	5 1.03	5 1.77	5 3.50	5 4.10	4 4.88	5 2.24	4 2.73	4 2.61	4 1.83	4 1.25	May 1, 1872 to Sept. 1, 1882	3 26.20

TABLE III.

Rainfall at Baird, Texas.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1882 ..	2.26	3.38	.59	.39	5 33	2.54	6.38	8.03	.73	1.93	2.67	.69	34.92
1883 ..	....	2.26	1.99	.61	2.71	3.96	1.94	.21	1.63	3.72	2.04	1.50	22.37
1884 ..	.78	1.44	.50	.63	7.02	4.95	1.24	.24	3.25	2.96	2.40	3.28	29.69
1885 ..	2.31	.60	.77	2.52	7.00	.50	1.51	1.13	.87	.45	.....	1.33	18.89
1886 ..	.05	.63	1.22	1.05	.40	.....	.61	1 97	2.10	.16	1.45	.....	9.64
1887 ..	.48	.54	....	2.83	2.98	3.16	2.09	.65	2.54	4.28	1.00	.74	21.29
1888 ..	52	2.82	1.22	4.12	3.70	1.68	...	3.13	1.00	1.30	4.25	2.79	26.53
1889 ..	2.93	2.15	1.04	2.35	2.84	8.76	1.61	.....	6.21	1.35	2.46	.....	31.80
1890 ..	.25	.75	...	10.84	2.02	.50	.77	4.49	3.71	3.36	3.07	.....	28.72

TABLE IV.

United States Signal Station at Abilene.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1886.........	.11	.61	2.47	1.67	.33	3.38	1.48	2.03	4.17	2.24	.65	.98
1887.........	.06	1.21	.03	2.45	3.95	3.26	2.71	1.10	2.64	4.77	.87	.....
1888.........	.76	2.40	1.16	5.16	3.63	2.77	.46	4.08	.05	2.00	4.80	1.58
1889.........	2.74	2.62	1.07	.71	2.93	6.36	1.80	.21	3.03	1.22	.54	.29
1890.........	.33	1.81	.14	9.80	2.69	.65	2.10	2.11	5.19	.97	.....	.....

TABLE V.

United States Signal Station, Silver Falls, Blanco Canyon, Crosby County.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1886	.....	.....	.....	.....	.....	....	3.03	3.31	5.58	3.44	.03	.....
1887	.....	1.07	.....	1.89	4.25	.98	1.89	2.37	1.19	2.10	.31	.30
1888	.05	1.59	.93	4.45	1.21	.....	.....	4.29	.27	1.88	4.68	[a].81
1889	[b]1.25	.12	.....	1.26	.82	3.57	1.39	.....	1.57	2.98	1.11	.....
1890	.79	[c]	.40	4.34	2.75	3.84	.05	1.07	.34	.....	.....	.....

a One-half inch of snow. *b* Five and one-half inches of snow. *c* Five inches of snow.

TABLE VI.

Rainfall at Marienfeld.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1883	.....	.....	.....	.....	1.71	.70	4.89	.85	1.61	8.22	1.50	1.50
1884	.60	1.20	.20	.71	3.46	5.20	.55	.63	2.23	1.95	1.38	2.25
1885	.75	.50	.60	1.08	1.53	10.65	3.10	3.55	.65	.....	.....	.....

TABLE VII.

Rainfall at Fort Elliot, Wheeler County.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1880.........	.....	0.05	0.41	0.16	4.48	4.50	2.11	1.70	0.54	2.40	0.10	0.35	16.79
1881.........	0.47	0.76	.....	1.26	5.27	0.10	3.28	0.49	3.18	0.60	0.42	0.26	16.16
1882.........	0.33	0.16	0.53	0.66	7.48	1.54	5.65	1.55	3.18	2.32	0.96	0.40	24.76
1883.	.....	0.33	0.04	0.82	4.56	1.66	2.87	6.56	4.97	5.32	0.04	0.84	33.91
1884.	0.61	0.27	0.32	1.08	6.29	6.82	1.29	5.60	0.84	5.54	2.14	3.05	33.91
1885.........	0.65	0.87	1.86	4.67	7.23	9.82	3.62	4.94	0.65	0.60	0.25	2.11	37.07
1886.........	0.62	1.44	1.49	2.44	0.23	3.45	1.50	4.57	0.60	5.04	0.18	0.09	21.67
1887.	0.01	0.06	0.10	6.06	7.01	2.39	0.92	.....	.....	.....	.....	.....	......

INCREASE OF WATER SUPPLY.

The question is often asked, and is generally supposed to be true: "Does not the settlement of a country and the building of railroads and telegraph lines produce an increase in the rainfall?" The general impression from observation is that there is a perceptible increase in the rainfall in the western part of the State since the settlements began, but the records kept at the various stations by the United States Signal Service proves the contrary. Table No. VIII shows the annual rainfall at Fort Concho for twenty-one years, and no perceptible change in the annual rainfall is observable:

TABLE NO. VIII.

Fort Concho, Texas.

Year.	Rainfall.	Year.	Rainfall.	Year.	Rainfall.
1868	28.12	1876	11.66	1883	20.01
1869	20.35	1877	16.58	1884	35.24
1870	37.26	1878	16.29	1885	21.06
1871	16.37	1879	13.20	1886	10.55
1872	17.05	1880	33.79	1887	15.08
1873	17.20	1881	13.76	1888	22.08
1874	24.80	1882	26.80	1889	*9.97
1875	14.70				

*Through May.

The time of year at which there is the greatest amount of precipitation has an important bearing on the question of agriculture.

If there are rainy seasons in which the rains come and the balance of the year is dry, if this rainy season is at the time of year when the crops can be planted and matured, a much smaller amount of rainfall will be sufficient.

In parts of California sixty per cent of the rainfall comes in the winter months, while in Texas nineteen per cent comes in spring and thirty-six per comes in summer, as will be seen by reference to Table No. II.

In California the rainfall does not benefit agriculture to any great extent, while in Texas excellent crops are raised upon proper cultivation.

CULTIVATION.

It is not my purpose to write at length upon the subject of the cultivation of crops, but simply to call attention to things that if heeded will assist in making farming in the northwest what every one desires it to be—a success.

One of the most important things is the subject of tillage and the time when the land should be broken up for the following crop. Universal experience has been that the farmer who breaks his land in the fall is the most successful in raising a crop every year. The reason for that is that he does not have to wait in the spring, if there happens to be a drought just about the time that he wants to plant his crop, for a rain to soften the ground so that he can plow it, but he is ready to plant it when the time comes, rain or no rain, and thus secures an early crop before the dry, hot months come. Another reason in favor of fall plowing is that it returns to the earth vegetable material which is so important to good plant growth, and a material in which some of our soils are very much in need.

I know of no reason against fall plowing except the lack of time by the farmer to do that kind of work.

The most important question in relation to tillage is that of depth.

In some countries a question of subsoiling very often arises that need not be considered here, and that is whether or not the subsoil shall be brought to the top. This question could only arise where the subsoil was a tenacious clay and was not rich in plant food. Anywhere in the northwest that question need not be considered, for any of the soils would be benefited by the admixture with them of the underlying subsoil.

There are several reasons that can be given in favor of deep tillage:

1. It furnishes an additional amount of soil from which the roots of the plant may derive the nourishment necessary. Below the depth of a few inches that has been broken up by the ordinary cultivation and which constitutes the soil, the subsoil is very often so compact that the rootlets can not penetrate it, and only the amount of plant food in the soil is available, but if more plant food is brought within the reach of the roots by subsoiling great advantage will necessarily result.

2. It permits the water to percolate through the soil to a greater depth and deposit the gases obtained from the atmosphere by it so essential to plant life. Carbonic acid as well as some others are taken from the atmosphere by rains, and are carried by water into the soil and there deposited or held for future use.

3. It loosens the subsoils so that the heat and air may permeate through it and elaborate the elements needed by the plants. Where the subsoil is so hard and compact that the air and heat can not pass through it the elements that would otherwise be available for the growing plant had just as well not exist. The material when reached by the atmosphere is put in such condition either by combination or disintegration that it becomes possible for the plant to assimilate these elements.

4. The excess of water that falls upon the ground runs off and carries with it many of the fertile qualities of the soil. If there is a deeper amount of loose earth made by deep plowing, that surplus water goes into the ground and deposits the fertile qualities into the soil. In a word, deep plowing makes a storehouse where the elements needed for plant life may be kept for future use, instead of being carried off by excessive rainfall.

5. By deep plowing the excess of moisture is taken up and the surface dries much quicker in spring time, and plowing can be done much earlier in the season. Deep plowing provides a storage for the rains that fall, so that there may be moisture in the ground within reach of the roots of the plant during drouths. In all the northwest the average rainfall is sufficient to make good crops if the largest part of the water did not run off into the creeks and rivers. All soils will take up and hold a large amount of water that can be utilized by the roots of the plants if the soil is only deep enough. And then deep plowing will so loosen up the soil that the water may be raised by capillary attraction to within the reach of the rootlets of the plant. This is

by far the most important reason why deep plowing should be practiced in the northwest. The soils are good and the seasons are all that could be desired in temperature, if there was only sufficient moisture. So anything that will go to improve that matter will materially add to the agricultural development of the country.

The question may be asked, how deep should the soil be broken? In most of the lands I would answer, the deeper the better. If it is possible, let two furrows be run in the same place. A furrow should be made with the common plow eight or ten inches deep, and that followed by the subsoil plow to a depth of twelve or fourteen inches. Whether the subsoil should be thrown up to the surface depends upon the character of the soil and the subsoil and the crops to be cultivated upon it. For the purpose of furnishing a storage for the surplus water, which is the most important for this country, either way would prove equally beneficial.

A few experiments of this kind would satisfy the farmers that it would be better to have a small farm well tilled than a large one that has to depend upon the shallow tillage for moisture during a short drouth.

FRUITS.

The wild fruits of the northwestern part of the State are restricted to a few kinds only. The plum, currant, wild haw, grapes, dewberries, blackberries, and algireta are the principal kinds.

Plums.—There are several kinds of wild plums found in the northwest, some of them in the greatest abundance. Along the rivers, especially the Brazos, Big Wichita, Pease, and Red River the wild Chickasaw is very abundant; along the sand beaches and sand dunes the thickets grow in the greatest profusion. These plums are of a very fine quality, and large amounts are gathered every year by the citizens and preserved in various ways. They seem to be of two kinds, differing apparently only in color, and both varieties often growing in the same thicket.

Currants.—Currants grow along the upper branches of the rivers and along the foot of the Staked Plains. They are quite abundant in places and are of excellent flavor.

Wild Haw.—There are several kinds of red haw growing along the creeks and rivers in the northwest. Although the berries are small, yet in the absence of other kinds of fruit they are very palatable, and a great many of them are gathered and used. Black haws are abundant, and are relished by everybody who takes the time to gather them.

Grapes.—Wild grapes grow abundantly in places. A kind known as the sand beach grows along the rivers and creeks in the northwest very abundantly. The vines are short and very seldom need any support other than their own stems. I do not know that any attempt has been made to cultivate them, but they are certainly worth the trial. They are of good size and excellent flavor, and if they could be cultivated and protected from the stock it seems to me that in that way a profitable industry could be developed. The land on which the vines now grow is generally a deep sandy soil that could easily be cultivated, and if necessary to protect the vine from frost in the winter, as is necessary with the Mission grape at El Paso, the soil could easily be used for that purpose.

There is also in places a small grape with a climbing vine. It is known as the "fox grape," and is very similar to the little "winter grape" of some of the Northern States.

The mustang grape grows abundantly in places, though not so prolific as in the middle part of the State.

Berries.—Dewberries are found growing wild everywhere, and are very abundant in places. In some localities the wild blackberries grow, but they are confined entirely to the sandy country of the Carboniferous.

The most abundant berry is the algireta, which grows along the edge of the Cretaceous and over the southern part of the Carboniferous. The berry resembles the cranberry of the North, in color, but is entirely different. The berries grow upon a low scrubby bush with leaves sharply pointed with thorns, very much like the wild peach leaves. The berries are gathered by spreading a sheet or some such thing under the bush and then beating them off with a stick. The berries are then dried in the sun and kept for winter use. It is only occasionally that that there is an abundant crop of these berries, as they bloom in winter and early spring and the late frosts kill the young fruit.

As far as fruit raising has been attempted in Northwestern Texas, it has proven in every way satisfactory. Like all other countries, a great many fruit trees have died from neglect or want of proper care after planting. Sometimes the tree has been planted in a soil that was so close that the roots could not penetrate it, and the hole in which the tree was planted was so small that only a small amount of moisture could be stored up, and so when the dry time has come the tree died from lack of moisture. Where proper care has been exercised in planting and cultivating, no trouble has been experienced in getting the trees to grow. All trees planted have a vigorous growth and make plenty of wood, sometimes too much for good fruit producing.

The principal kinds of fruit raised are apples, peaches, pears, plums, apricots, and grapes.

It is generally thought that the summers are too long and dry for good apples, yet some early varieties have done very well. The trees grow well enough, but very often the fruit when matured is of an inferior quality, being dry and hard; yet if attention is given to selecting the proper varieties, a good fruit can be raised.

Peaches.— There is no country that can produce a better variety of peaches than the northwestern part of the State. The varieties that thrive best are those that mature early, or at least before the dry summer comes on. The cultivation should be thorough and the trees should be trimmed very low, so that the winds will not injure them. If possible the orchard should be in such a locality that they will be somewhat protected from the winds. Yet I have seen very fine orchards where there was not the slightest protection.

The fruit that matures early finds a good market in the North, and at good prices. Canning establishments have been put up in various localities that purchase all the fruit brought to them.

Plums.— The several varieties that are planted all prosper. They are in their native country, and fruit well. The fruit is liable to be injured by the curculio, unless care is taken to prevent them, and when once they get possession of an orchard it takes years of constant watchfulness to get clear of them.

Pears.— Pears have been raised very successfully, but the trees are subject to blight, and the fruit raisers have not given much attention to this kind of product.

Grapes.— Those who have tried raising grapes in this part of the State have been very successful, and there is no reason why it should not always be the case if the proper location is selected. The greatest trouble has been that the vine has produced too much wood, and the result has been that the fruit rotted before its maturity from being shaded too much. This trouble can no doubt be remedied by the proper attention and cultivation.

I have not given the subject enough attention to make any practical suggestions.

FISH.

All our streams and lakes have fish in them to a greater or less extent. Nearly all of them are excellent for food. No particular study of the fishes of the State has ever been made, and what is known is the result of accident more than anything else. In making our expeditions over the State collecting data for our Geological Report it has been our custom to take along fishing tackle in the way of hooks and lines, seine and trammel net, for the purpose of supplying ourselves with an occasional mess of fish. When reaching a stream at noon it was the habit of some of the party to take hook and rod and, with a grasshopper for bait, proceed to catch a mess for the party, if the fish would bite; or if we remained for a day or two in a place, some of the men would take a turn at seining, catching only enough to supply the camp for a mess or two. Sometimes at night the "gill net" would be stretched across a stream and left there until morning, when it would be taken up, and most generally a lot of several kinds of fish would be found entangled in it.

The kinds of fish usually taken with the hook were perch, catfish, and bass. Those taken with a seine were suckers, buffalo, and gaspergoo. The gill net caught them all alike.

Of perch there were several kinds, and they were found in all the streams. The goggle-eye, yellow perch, black bass, wide-mouth, barred, short-ears, long-ears, and red-eye are some of the species I have seen.

There are two kinds of suckers and two kinds of buffalo.

Of the catfish there are four kinds, channel cats, yellow cats, mud cats, and shovel-billed cats.

There are in the rivers a few eels, but they are rare.

There are several kinds of gar fishes. They are seldom used for food except when they are very small.

We found excellent fishing for cats in the Colorado River, some of the fish in that stream reaching the weight of eighty pounds. The best size for use are those weighing from three to six pounds.

The San Saba River and its tributaries are full of bass, catfish, perch, and suckers. The Brady was the finest stream found on our trip for perch. We also took there a great many channel cats and some striped bass.

The Concho rivers are clear streams and have abundance of yellow cats, perch, suckers, and bass.

The Salt Fork of the Brazos River is not so good for fish, yet we found some catfish there. The streams that run into the Salt Fork of the Brazos River are generally clear and have a great many fish. The Clear Fork of the Brazos is a good stream for fish. Pecan Bayou, from head to mouth, is a good stream for perch, black bass, suckers, and catfish.

We have always been enabled to supply ourselves with plenty of fish when we had the time and the inclination to catch them.

FISH CULTURE.

This industry has never received the attention in the northern part of the State that its merits demand. It has always been thought that there was not water enough in that part of the State to warrant the experiment. Another reason is the want of a market convenient. Another excuse pleaded by the people for their neglect of the matter is a want of knowledge on the subject of fish culture.

It has been asserted on good authority that more pounds of good food could be produced in a given time from one acre of a well stocked pond than can be made in beef and pork from ten acres, and with much less labor. The first thing to be determined is the kind of fish to raise.

Several of our native fishes will bear domestication well. None of our fishes are migratory, and would stay in artificial ponds very well unless they are flooded, at which time the fish would run off and could probably not get back.

In the clear pools that are made from springs several of our native fishes would do excellently, and it is not advisable to try to raise more than one kind of fish in the same pond. The suckers are a fish that bear domestication well and are easily kept, and the flesh is of good quality, but they are not desirable on account of the great number of small bones they have.

The catfish do well and only need a small amount of running water; or where the pool is fed by a running stream, the striped bass would do finely. They are the best of all our native fishes, but they multiply very slowly. Although a bass at a single spawning will produce one thousand young, and will guard her nest with the utmost care for a period of six weeks, yet after that time she has no regard for her own young and will devour a great many of them.

It is probably better after all to raise the German carp, as they are vegetareous and will live and prosper in almost any kind of water. They can live in a small quantity of water. They have been known to live and do well in a pond so low that their dorsal fins remained out of the water; but this ought not to be allowed by those attempting to make a success of fish culture.

This fish prefers a warm temperature and a muddy bottom. They are vegetareous, and the ponds should be supplied with aquatic plants. They will also eat the refuse from the kitchen. I asked a gentleman what a carp would eat, and his reply was, "Anything that a pig will eat." They grow to the size of eight or ten inches in length in a year if well fed, and they continue their growth until three or four years old and attain a weight of eight or ten pounds.

The pond for carp may be supplied from surface drainage. The pond will be better if it has broad, shallow margins where water grasses and weeds grow.

There are a great many tanks built for supplying stock water that would make good pools for carp raising. Care should be taken that the water does not all dry out and the fish be destroyed. This could be remedied by having a deep hole sunk in the middle of the tank that would be inaccessible to the stock and into which the fish could retreat when all other parts of the pond are dry. It is better if one can have a windmill to supply water from a well where there is danger of the water being exhausted during drouths.

The carp become very gentle and can be taught to come near the margin of the pool to get their food at the ringing of a bell. They should be fed regularly. The best time is just at the rising of the sun, but any other time will answer, but it should be done about the same time every day.

Mr. D. Richardson, of Baird, has a small tank built expressly for carp raising, and speaks in the very highest terms of his success. He has been supplying his neighbors with young carp, and wherever they have taken care of them they have been successful. One of the principal objections brought against the carp is that it has an earthy flavor; it tastes like the mud. This is largely due to the want of care in dressing. The following instructions should be followed in cleaning a fish: "Take off the scales by scraping and scrape the skin thoroughly so as to remove the mucus matter. After removing the entrails the cavity should be thoroughly cleaned of all fatty matter, and the white, bladder-colored skin with which it is more or less coated taken out. When thus cleaned place the fish in a moderately strong brine for six to twelve hours. When taken from the salt water if it be intended to fry the fish it should be cut into suitable sized pieces, wiped dry, salted, and rolled in corn meal, and then placed in a pan of hot boiling lard and cooked until thoroughly done."

The State has done very little towards protecting the fish in her territory, and the laws passed have been "dead letters" on the statute books. The practice of killing fish in the streams with dynamite is reprehensible in the highest degree, for it not only kills those of suitable size for food, but destroys the smallest minnow that may be in reach of the explosive.

ARCHÆOLOGY.

Very little time has been given by me to this subject, either in the way of making observations or collecting specimens, and the work done and the specimens collected were more a matter of accident than otherwise. That the field will be very interesting and will be rich in specimens there is every reason to suppose. It is thought by those who have given this matter some attention that the mound builders of the East probably had a line of travel between their settlements along the Mississippi and other eastern rivers, to South America, passing somewhere through Texas, and that probably they had numerous settlements along the way. Before anything like definite conclusions can be reached and expressed on the archæology of the State some systematic work will have to be done.

The country everywhere gives evidence of its once being the home of the more recent tribes. Flint instruments are found scattered about the country everywhere. Along the rivers and creeks and near the permanent water holes and springs the ruins of ancient villages are found. These villages often cover as much as one-half mile square. About such villages these flint instruments are abundant, such as arrow and spear points, knives, awls, axes, etc. There are also vessels made of sandstone or other kinds of hard stones found at these villages. At places the ruins of these old villages are covered up entirely by soil to a considerable depth and can only be seen in the gulleys that have been washed through them of recent date.

Scattered over the country, always near the water, are single mounds which seem to have been circular buildings. These mounds are from ten to thirty feet in diameter, and seem to have been built of small stones and mud—at least the stones are all small now, and all have the appearance of having been burnt. Some of these mounds are three or four feet high, and where they have been pretty well preserved have a circular depression at the top. Whether this depression shows the entrance to the building to have been at the top, or whether it is the natural position the material of a falling wall would assume, is yet to be determined. The uses to which the houses, if houses they were, were put can only be a matter of conjecture, and why the stones composing them should all appear as if they had been burnt. The stones used in their construction were from the immediate vicinity in which they are located. Sometimes they are limestones and sometimes they are sandstones, and at other times they are of both. The siliceous pebbles which are often abundant in the vicinity of these mounds do not seem ever to have been used in their construction. The mounds seem to have been constructed on the surface of the ground without any excavation. Nor is there any evidence of walls, but the material presents the same general appearance throughout. In places I have seen these mounds where creeks had washed away part of them leaving a good section exposed. No evidences have been found in them that they were used for other purposes than that to which an ordinary wigwam would be put. At the villages there is always to be found one or more of these large mounds and a number of smaller ones.

The material from which the flint implements are made is found in the nodules of flint which occur in the Cretaceous and Carboniferous rocks of this part of the State. At only one place did I find any metal instrument, and that a single copper arrow point. In the northern part of the State I have found no pottery of any kind, and no carving on stone, or pipes of any kind.

In several places I have found caches of flints. The holes were circular and about eighteen inches deep, and the flints packed into them as closely as possible. The flints were all in partially completed condition, some more and some less, but none complete. They were probably put into those places to be taken up at some future time, but from some cause that time never came.

I do not remember to have seen anywhere east of the Pecos River any water or corn holes cut in the rocks, but in the western part of the State they are very numerous. These holes are of various sizes and depths; some of them are fifteen inches deep and not more than eight inches across the top. They are cut in rocks of all kinds, from soft sandstone to hard porphyry. They are almost always in pairs. They are generally near some watering place, yet I have seen them where there was no water in miles and miles of them. I have found them covered with a flat rock, as if to keep the animals out of them, and such holes were in a place where they would catch the water that might fall upon the rocks. These were evidently intended to furnish a small amount of water, probably to their runners that were sent from one town or settlement to another.

West of the Pecos there is a great deal of pottery to be found in broken fragments. It is probable that the Pueblo Indians had once a large city in the vicinity of the Hueco Mountains, twenty-five miles northeast of El Paso. In the caves made by the falling down of large pieces of granitic rocks I have seen many pictographs. They are the representations of animals of various kinds, and men in various positions. One is the representation of a huge serpent at least thirty feet long. The only place I have seen obsidian arrow points is along the Pecos River. There are none found east of the Staked Plains. It is probable that there was no communication between the tribes who inhabited the different sections. The absence of pottery of any kind would indicate that the Pueblo Indians never inhabited or visited the country east of the Plains.

The contributions that Texas could make to the study of ethnology would no doubt be interesting, if not important; but the collections will have to be made in a systematic manner before they will be of much importance or value to the science.

PART III.

DESCRIPTION OF COUNTIES.

YOUNG COUNTY.

Young County has long been known as a place where the best coal could be found in the northern part of the State. The Belknap Beds were worked by the United States soldiers as early as 1852, when the troops were stationed at old Fort Belknap.

Dr. George G. Shumard, geologist with Capt. R. B. Marcy, in his report, "Exploration of the Red River of Louisiana, 1852," says: "Recently a number of seams of bituminous coal, varying in thickness from two to four feet, as well as the characteristic fossil forms of the Carboniferous era, have been discovered."

Since that time every geological expedition which has passed through this county has had something to say of these beds.

The seam found in the vicinity of Fort Belknap is Seam No. 7 of the general section. I have made a personal inspection of every outcrop of which I could hear and every one that I could find by tracing the seam through the county, and give below a description of the various localities as I have observed them.

Coal Seam No. 7 crosses the east line of the county just east of Flat Top Mountain, passes along by Coal Bank Branch, the mouth of Coal Creek, Belknap, and goes out of the county on the south line near Fish Creek. Coal has been mined in a small way to supply the local demand for several years at several of these localities, but not enough has been done at any one place to fully develop and show what the quality of the coal really is.

The following section was made at Flat Top Mountain, in the northeastern part of the county, about eight miles northeast of the town of Graham. Beginning at the bottom:

1.	Fire clay	4 feet.	
2.	Coal		8 inches.
3.	Carbonaceous shale	3 feet.	
4.	Slate		2 inches.
5.	Coal	1 foot	8 inches.
6.	Slate	3 feet.	
7.	Sandy clay	40 feet.	
8.	Sandstone	4 feet.	
9.	Conglomerate with *calamites*	3 feet.	
	Total	59 feet	6 inches.

About one-half mile southeast of Flat Top a shaft has been put down to the coal, which has been reported to be forty-eight inches thick. The shaft was filled with water at the time of my visit so that I could not make a personal examination as to the thickness of the seam, but I suspect that in estimating the thickness of the seam they put in the Carbonaceous shale that is over the eight-inch seam at the Flat Top section.

About five miles west of Flat Top Mountain, on Coal Bank Branch and on Colony Survey No. 604, there is another outcrop of the coal. It outcrops along the north side of the hill for at least one-half mile. At this place coal has been mined at times for several years to supply local demands. Shallow pits are dug down to the coal by each man who goes after a few loads of coal, and what he wants for his present purposes is taken out, and the same thing is repeated when he, or some one else, at some other time desires another supply. Where they sink the pits it is not more than four or five feet down to the coal, and with such thin covering the coal is not as free from atmospheric influences as it is desirable to have in order to be of good quality.

The following section was made at that place. Beginning at the top:

1.	Shaly yellowish limestone	10 feet.	
2.	Clay	1 foot.	
3.	Coal		8 inches.
4.	Slate		4 inches.
5.	Coal		8 inches.
6.	Slate	2 feet.	
7.	Coal	2 feet.	
8.	Slate		6 inches.
9.	Coal		8 inches.
10.	Fire clay	2 feet.	
	Total	19 feet	10 inches.

There has been a shaft sunk down to the coal about three thousand feet north of this place, which shows about the same conditions and surroundings.

Again, about one mile west of the above section, on the west bank of Salt Creek, near the foot of a high hill, there is another outcrop of the coal. At this place it is in the bed of the stream. This would be an excellent place to open a mine when there can be secured a means of transportation for the coal. The dip of the coal seam at this place is north 80° west, forty-seven feet to the mile.

COAL CREEK.

About three miles southwest of the mine on Coal Bank Branch is the mouth of Coal Creek. In this vicinity there are several outcrops of the coal seam. On Colony survey No. 426, on a branch running into Coal Creek from the south side, there is an outcrop of the seam at which I made the following section. Beginning at the top:

1.	Heavy shales	3 feet.	
2.	Coal		10 inches.
3.	Slate		1 inch.
4.	Coal	2 feet.	
5.	Fire clay (base not seen)		8 inches.
	Total	6 feet	7 inches.

A shaft was put down just before my visit to the place about two hundred yards southeast of this outcrop, but which was partly filled with water. The following section of the shaft was given me by Col. E. H. Graham:

1.	Surface soil	2 feet	6 inches.
2.	Reddish sandstone	8 feet.	
3.	White sandstone	25 feet.	
4.	Soapstone	4 feet.	
5.	Sandstone		9 inches.
6.	Blue slate	7 feet.	
7.	Coal		7 inches.
8.	Slate		1½ inches.
9.	Coal	2 feet	11 inches.
10.	Soapstone	11 feet.	
11.	Sandstone	1 foot.	
12.	Slate	2 feet.	
13.	Coal		2 inches.
14.	Slate	3 feet.	
15.	Coal		3 inches.
16.	Soapstone	6 feet.	
17.	Sandstone	5 feet.	
18.	Soapstone	5 feet.	
19.	Limestone (magnesian)	5 feet	6 inches.
20.	Soapstone	1 foot	1 inch.
21.	Hard blue limestone		8 inches.
22.	Soapstone	1 foot.	
	Total	92 feet	6½ inches.

About one mile north of this last place and on Colony survey No. 616 is the Lewis Coal Mine. At this place coal has been mined at various times for several years by stripping the dirt off the seam. Below the seam is a bed of blue clay with selenite crystals. Above the coal is a bed of blue clay with nodules of sandstone covered with gypsum crystals. These surroundings are a very marked feature of this seam wherever there is sufficient exposure to show them. The method of mining that has been adopted at this place does not give the best results, as the coal is too near the surface and has been injured by being exposed to the weather.

About three miles south of the mouth of Coal Creek, on the Bradwell survey, near the Taylor farm, I found an outcrop of coal that is a different seam from No. 7, the one I have mentioned at the other localities. It is below a bed of limestone. I made the following section at that locality. Beginning at the bottom:

1.	Blue clay (bottom not seen)	4 feet.	
2.	Coal		4 inches.
3.	Clay		6 inches.
4.	Limestone	2 feet.	
5.	Blue clay	3 feet.	
6.	Limestone, thin-bedded	3 feet.	
	Total	12 feet	10 inches.

This seam was reported to have been found in several places in the vicinity, but I did not see it anywhere else, as the reported find was generally in a well or the bed of a creek or river, or some other inaccessible place.

At the mouth of Whisky Creek, two miles north of Belknap, Coal Seam No. 7 outcrops in several places. At this place coal was mined to supply the United States post at Fort Belknap many years ago. Since the abandonment of the post the mine has not been used, and all the old works have fallen in.

At the mouth of the creek I made the following section. Beginning at the top:

1.	Soil	2 feet.	
2.	Conglomerate	40 feet.	
3.	Coal	1 foot.	
4.	Sandstone and shale	8 feet.	
5.	Coal	1 foot	8 inches.
6.	Sandstone	25 feet.	
7.	Limestone	2 feet.	
8.	Coal	1 foot	2 inches.
9.	Shale	3 feet.	
	Total	83 feet	10 inches.

Two hundred yards above the mouth of Whisky Creek the following section occurs. Beginning at the top:

1.	Shaly sandstone, ripple-marked	3 feet.	
2.	Fine grained sandstone and clay, even-bedded	1 foot	6 inches.
3.	Shaly sandstone and clay	3 feet.	
4.	Shale, with sandstone nodules	1 foot	6 inches.
5.	Coal	1 foot.	
6.	Bluish clay, with selenite	6 feet.	
	Total	16 feet.	

I traced the seam of coal by its outcrops from hill to hill up Whisky Creek for one mile, to the new road crossing. The bottom bed of coal passes out of sight beneath the overlying strata near the old road crossing, and the bed of sandstone above that bed becomes the bed of the creek for some distance and finally passes out of sight at the new crossing. The dip of the strata here is forty feet to the mile, north 60° west.

At the new road crossing on Whisky Creek the following section was made. Beginning at the bottom:

1.	Sandstone	8 inches.
2.	Blue clay	6 feet.
3.	Coal	1 foot 6 inches.
4.	Yellow shaly sandstone	4 feet.
5.	Sandstone, thin-bedded	2 feet.
6.	Yellow clay, with clay ironstone	8 feet.
	Total	22 feet 2 inches.

The following fossils were found in the strata at the mouth of Whisky Creek: *Productus punctatus*, *P. nebrascensis*, *Spirifer cameratus*, *Myalina subquadrata*, *Nuculana sp.*, *Fenestella*, *Aviculopecten occidentalis*, *Nuculana bellistriata*, *Synocladia*, *Zaphrentis*, and a *Bryozoan*.

One-half mile below the mouth of Whisky Creek, and on the same side of the Brazos River, I made the following section. Beginning at the bottom:

1.	Blue clay, with selenite	6 feet.
2.	Coal	1 foot 8 inches.
3.	Limestone	2 feet.
4.	Shaly sandstone and clay	6 feet.
5.	Sandstone, ripple-marked	2 feet.
	Total	17 feet 8 inches.

In all the wells at Belknap they reach the coal seam at a depth of about forty feet. Just south of the town the coal outcrops in the side of the hill or river bluff. It is at this place just below a massive limestone, but is evidently the lower bed seen at the mouth of Whisky Creek. The other beds have been destroyed at that place by erosion.

On the south side of the Brazos River, near the Eliasville road and about two miles from Belknap, the coal outcrops near the top of the hill. At this place both the upper and lower beds are seen. These seams are very easily traced up the river on the south side for a mile or more.

From the mouth of Whisky Creek westward I traced the coal seam up the river for about three miles. At about that distance from the mouth of Whisky Creek the upper bed passes under the bed of the river. At that place I made the following section. Beginning at the bottom:

1.	Blue shale	4 feet.
2.	Shaly coal	2 feet.
3.	Yellowish sandstone, shaly	3 feet.
4.	Blue and yellow clay	15 feet.
5.	Coal	4 inches.
6.	Blue clay	10 feet.
7.	Carbonaceous shale	3 feet.
8.	Sandstone	4 feet.
	Total	41 feet 4 inches.

The following prospecting shafts and outcrops are near the south line of Young County, between Fish Creek and the Clear Fork of the Brazos. Plate VI shows the relative position of the several places mentioned in the Report in this vicinity:

RUSSELL SHAFT.

At the southwest corner of a survey made in the name of J. P. Williams is the Russell shaft. It is twenty-six feet deep, and shows the following section:

1.	Soil, small sandstone boulders, and clay	2 feet.	
2.	Soft sandstone in irregular thin layers, with occasional streaks and pockets of clay	8 feet.	
3.	Alternating layers of soft sandstone and bluish clays, the sandstone being in excess, and both in one-fourth to five-inch layers	10 feet	6 inches.
4.	Coal		7½ inches.
5.	Shale, rather soft		10½ inches.
6.	Coal		8 inches.
7.	Clay		3½ inches.
8.	Coal (parting of clay in centre one-fourth inch)	2 feet.	
9.	Shale		8 inches.
10.	Coal		3 inches.
11.	Blue clay		10 inches.
	Total	26 feet	8½ inches.

The sandstone at this place will make good roofing for a mine. The shaft is entirely free from water and has been ever since it was put down.

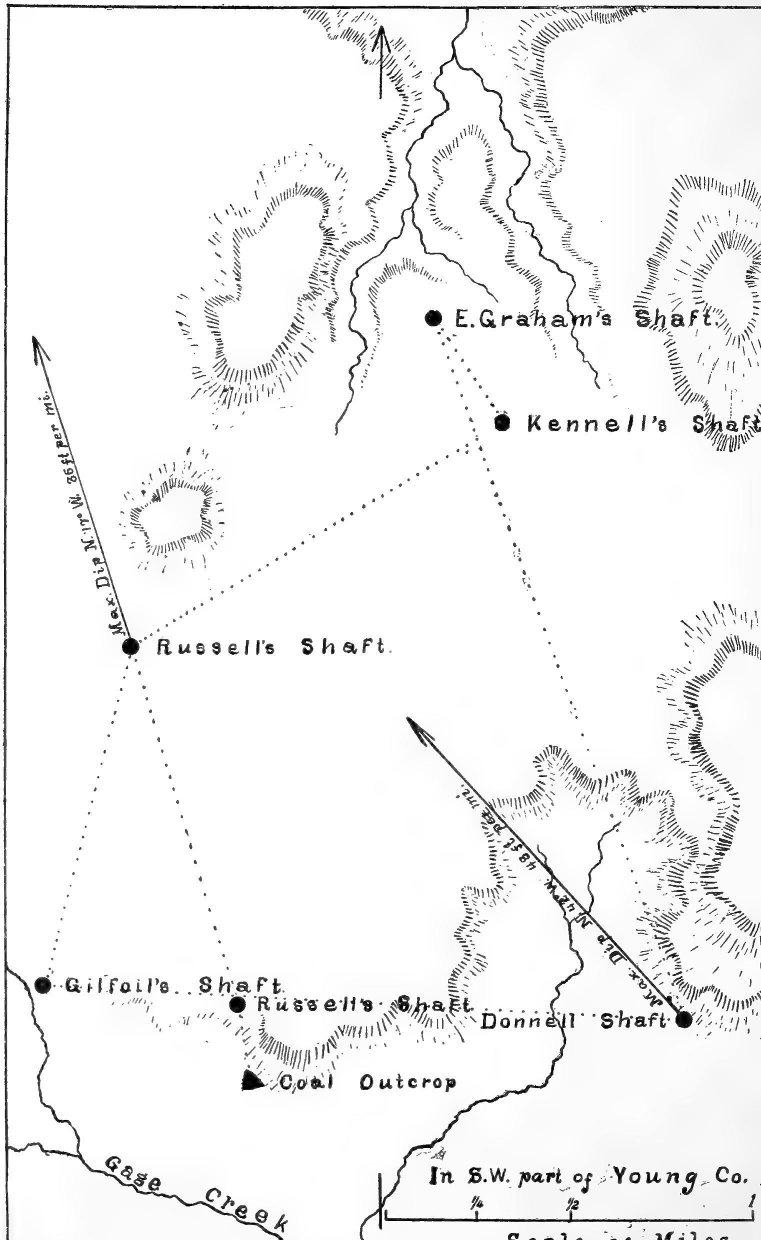
The quality of the coal is the same as that at the Gilfoil shaft, described at another place in this Report.

GRAHAM SHAFT.

This shaft is situated on survey No. 19,556, made in the name of Beaty, Seale & Forwood, for six hundred and forty acres. It is thirty-three feet deep.

The following is the formation passed through in sinking this shaft, beginning at the top:

PLATE VI.



SOUTHWESTERN PART OF YOUNG COUNTY.

1.	Alternating layers of thin, soft sandstone and bluish clay	10 feet.	
2.	Thin layers of sandstone, with greater thickness of clay layers	4 feet.	
3.	Hard blue clay, slightly shaly at the bottom	8 feet.	
4.	Hard black shale, hardest at the bottom	6 feet.	
5.	Coal		10 inches.
6.	Hard black shale		3 inches.
7.	Coal		$8\frac{1}{2}$ inches.
8.	Fire clay		6 inches.
9.	Coal, with parting of clay one-fourth inch	2 feet	3 inches.
10.	Clay and shale		4 inches.
11.	Coal		3 inches.
12.	Clay		
	Total	33 feet	$3\frac{1}{2}$ inches.

This shaft was put down the past summer, and is entirely free from water. It is situated east of a range of hills, in a broad plateau covered with small timber. The covering of coal is good. This location would be a good place to mine the coal.

KENDALL SHAFT.

This shaft is situated on school section No. 2 (6460), made in name of Beaty, Seale & Forwood. This shaft is about seventeen hundred and seventy feet south 31° east of the Graham shaft, and was the first one put down in this vicinity. The section of the strata is the same as that made at the Graham shaft. The depth of the shaft is about the same.

DONNELL BROTHERS' TUNNEL.

This opening was made by cutting an open tunnel into the side of the hill. It is situated on the Texas and Pacific Railroad survey No. 2 (file No. 6460).

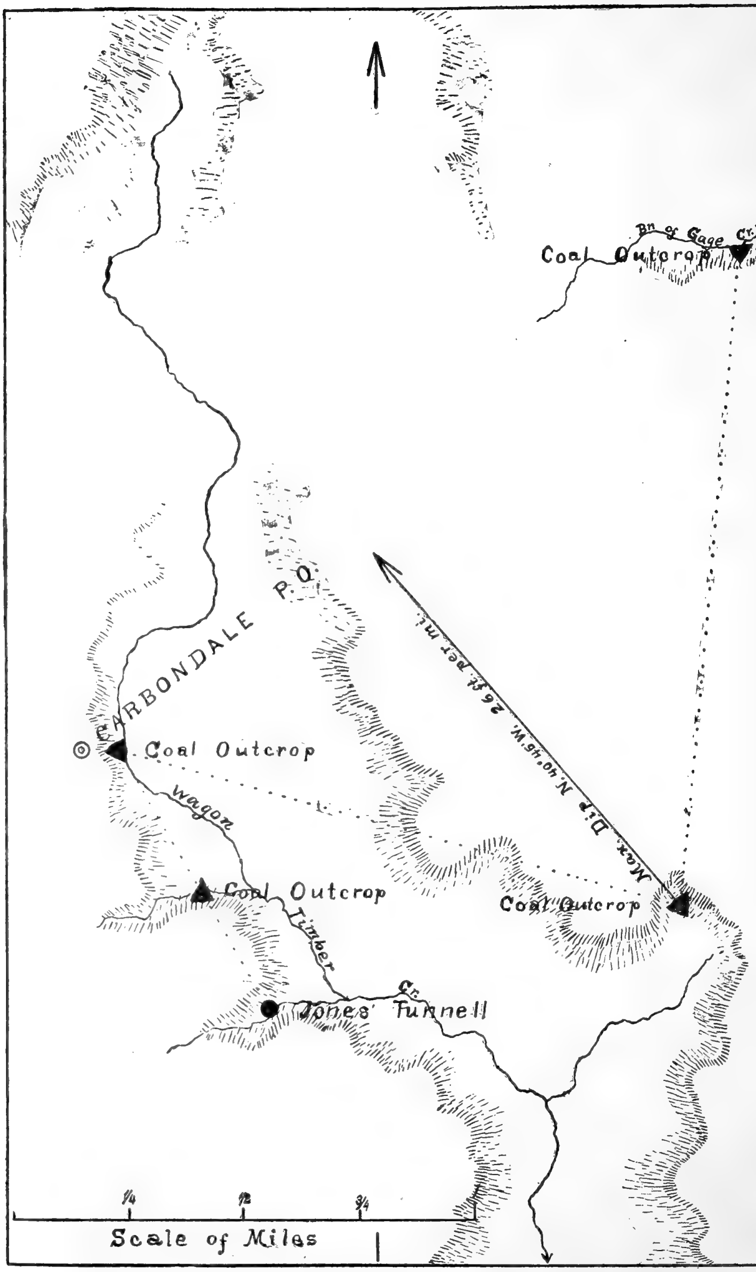
This opening shows the same covering as at the Graham shaft. The coal is the same as in the other shafts in the vicinity. The opening is made on the west side of the hill. This place is the farthest east of any outcrop in this vicinity. This property belongs to the Donnell Brothers, at Eliasville, Texas. I do not think this would be a desirable place to open a mine, as the area containing coal is too small. The seam will evidently outcrop on the eastern side of the hill, which is only a few hundred feet through. The dip of the strata is to the northwest.

GILFOIL SHAFT.

This shaft is situated near the southwest corner of Gilfoil survey of one hundred and sixty acres.

It was partly filled with water at the time of our visit, so that no detailed section could be made of it. The water came in from the surface. The

PLATE VII.



NORTHERN PART OF STEPHENS COUNTY.

same sandstone was found in this at the top as was seen in the Russell shaft. The coal, of which we took samples from a heap at the mouth of the mine, presented the same general appearance as that of the coal from the other openings in the vicinity. An analysis of the coal is given in another part of this Report.

Plate VII shows the various localities mentioned in the vicinity of Carbondale.

JONES MINE.

About one-half mile southeast of Carbondale, on the J. C. Jones survey, is the Jones mine. An opening has been made on the coal seam for more than one hundred feet. The tunnel was partly filled with water from surface drainage at the time of my visit so that I could not enter it.

The top part of the coal is eighteen inches thick, then four inches of slate, and then two feet of coal. The roof is a heavy bedded yellowish sandstone with uneven structure. The coal is thicker here than at any place I have seen in the vicinity, and it is the only place where the heavy-bedded sandstone lies directly upon the coal. From some cause the clay and shaly sandstone that is ordinarily above this coal seam and the massive sandstone have been destroyed and the sandstone has formed upon the coal bed.

This state of things continues for some distance, for on Huffstuttle Creek, about two miles west of Carbondale, the coal outcrops again, and it is there again overlaid by the massive sandstone.

About one-half mile east of Carbondale and about the same distance north of the Jones mine coal has been taken out of a shallow pit in the bed of a branch. The pit was filled up at the time of my visit so that I could not see the coal nor any of the surrounding strata, and can not therefore say whether it is the same or a different seam from that at the Jones mine, but take it to be the same.

About two miles and a half south of Carbondale there is an outcrop of the coal in a branch. The seam is divided by one foot of impure limestone. The bottom part of the seam is twenty-two inches thick and the upper part twelve inches thick. From some cause the parting in the seam, which at all other places where I have seen it is slate, has here changed into an impure limestone. Above the coal is a shaly sandstone and on top of that is a conglomerate. The same seam is seen just a small distance east of this place, and there the parting between the beds is slate. About three feet of coal is shown at the last place mentioned. About a mile northeastward from the last mentioned place, on the eastern side of a hill, the coal outcrops below a bed of limestone, very much the same as at the mouth of Whisky Creek on the Brazos above Belknap. Between the bed of limestone and the coal seam is a thick bed of shales with hard sandstone concretions covered with crystals of selenite. This is evidently the same seam and bed of coal traced from the mouth of Sandy Creek, Stephens County, to Flat Top Mountain in the eastern edge of Young County. In the limestones and shales are a great many *Myalina subquadrata.*

To the eastward of this place the coal outcrops near the top of the hills in several places. Two miles northeast of Carbondale and about one mile south of the Gilfoil shaft the coal outcrops in the banks of a branch, showing the same shaly sandstone usually found above the seam of coal in this vicinity.

TOPOGRAPHY AND DRAINAGE.

The dip of the formation being to the northwest gives several lines of escarpment in the county running from northeast to southwest. These escarpments are of various heights, according to the thickness of the soft material underlying the several beds of harder material. In places these escarpments have been cut across by the rivers and creeks, and the result has been isolated hills of various sizes and shapes, some of them rising to the height of two hundred to five hundred feet above the surrounding country. The highest points in the county are the Belknap Mountains, situated east of Fort Belknap on the Graham road. Flat Top Mountain is near the northeast corner of the county, and being in the prairie can be seen for many miles from every direction. The valleys and much of the uplands are level and are well adapted to agricultural purposes. Some of these lands are remarkably fertile.

GEOLOGY.

This county is situated entirely within the Coal Measures. Mr. Chas. A. Ashburner reported that the Sub-Carboniferous formation was found in this county, but after a very careful examination of the county I am sure that the only formation found here is that of the Upper Coal Measures. Certainly there is no Sub-Carboniferous. It may be that the northwestern part of the county will be found to be Permian upon a more detailed examination than I had time to make.

The strata comprise sandstones, limestones, clay beds, and conglomerates, in beds of various thickness. The conglomerates are composed of rounded water-worn siliceous pebbles, and often pass into coarse grained sandstones. The limestones have various colors and degrees of hardness. The clay beds are often very thick and are red, blue, yellow, and variegated.

SOILS.

The soils of the county are of three distinct varieties, according to their sources. The river valleys are a red sandy loam, and are formed from the different strata along their course. They are very fertile and have been enriched by passing through the great gypsum beds along the upper Brazos. These valleys are probably the best lands in the county.

Another class is the black sandy soils found along the creeks. They are derived from the strata found along the several courses of the streams. The limestones, the sandstones, the clay beds have all contributed to their composition. These soils produce abundant crops of grain and cotton.

Another class of soils owe their origin to the immediate underlying strata of the several localities. In some places where the soil is derived from the disintegration of the limestones and the blue shales it is inclined to be black in color, and is in larger bodies than any of the other kinds. Again, the land is principally derived from the sandstone or conglomerate, and is more or less sandy.

This kind of land is generally overgrown with timber and brush. It is none the less productive, and will probably produce more kinds of grain than the prairie lands, taken one year with another.

TIMBER.

This county may properly be called a timbered county. It is at the western boundary of the "Upper Cross Timbers." There are, however, some large prairies in the northern part of the county, but all are within easy reach of the timber. The timber is mostly post oak and blackjack on the uplands, with elm, hackberry, cottonwood. burr oak, and water oak along the creeks and rivers, while mesquit is abundant along the margins of the large prairies, and sometimes covering whole districts of country.

WATER.

Water for domestic purposes is found abundantly almost everywhere in shallow wells. There are places, however, where the clay beds are very thick, and where it is almost impossible to get water at any depth. The clay beds make excellent places for open tanks, and with a little work in making them there can always be an abundance of water stored for all purposes. There are not many springs in the county, and there is not much probability that artesian water of good quality can be found by deep boring. If water should be found that would flow from a deep well, it is more than probable that it would be highly impregnated with salts of various kinds.

BUILDING MATERIAL.

SANDSTONE.—The beds of sandstone found in various localities will make an excellent building material. It is uniform in color throughout the various beds, and is easily quarried and dressed and hardens on exposure. It is principally a light brown, and changes very little in color on exposure to atmospheric influences. Wherever this stone has been used it has always given satisfaction.

LIMESTONE.—There are some places where the limestone would make good building material, but the stone would have to be selected with care. A great deal of the limestone in this county is shaly and unfit for building material.

There is a fine bed of limestone near the crossing of the Jim Anderson Creek, on the road between Fort Belknap and Graham, and at other places in the county. There is one place, two miles above the town of Graham, where the limestone is as compact as marble and takes a fine polish. This place is on the lands of Col. Gus. Graham.

CLAY.—Clay for bricks is abundant in any part of the county. Almost any of the clays in the county would make excellent bricks if mixed with a due proportion of sand, which is found abundantly everywhere. Material for making a most excellent quality of pressed brick can be found in some of these clay beds, and that will color a nice red on burning.

LIME.—Lime can be burned from many of the limestones in this county; and while some of the lime would not be white, owing to the presence of iron and clay in the limestone, yet it would all be of excellent quality. Some care will have to be taken in selecting the limestone from which to burn the lime.

IRON ORE.

There are places in the county where iron ore is quite abundant. It occurs in various forms, but whether in sufficient quantity to be of any commercial value remains to be determined.

About seven miles east of the town of Graham, on the Weatherford road, I found a bed of ore which is the largest deposit I have seen in the county, yet it is probable that there are many more equally as good. A sample taken from this place gave the following result by analysis:

Silica	44.50.
Oxide of iron	46.66.
Alumina	4 44.
Lime	.80.
Manganese	Trace.

It will be seen by this analysis that there is too much silica to render this a good iron producing ore.

PAINT.

Materials for making mineral paint of various colors are abundant in the county.

SALT.

At the town of Graham several years ago salt was manufactured in considerable quantities. Salt Creek gets its name from the fact that during dry periods the salt is found along the creek near the town encrusted upon the rocks and gravel in the bed of the stream. The salt was made principally by evaporating the water obtained from shallow wells.

At a later period a deeper well was put down and an inexhaustible supply of water found giving about twenty-two to twenty-five per cent of salt. The following is a section of the well. Beginning at the top:

1.	Sandy loam	16 feet.
2.	Blue sandy clay	3 feet.
3.	Gravel and sand	8 feet.
4.	Conglomerate	16 feet.
5.	Cream colored clay	8 feet.
6.	Yellow and bluish sandstone	10 feet.
7.	Hard yellow sandstone	5 feet.
8.	Coal	1 foot.
9.	Coarse yellow soft sandstone	4 feet.
10.	Hard quarzose conglomerate	13 feet.
11.	Fire clay, bluish	42 feet.
12.	Hard brown clay	5 feet.
13.	Brown sandstone, porous, producing gas	5 feet.
14.	Clay and slate	9 feet.
15.	Brown clay, very hard	8 feet.
16.	Variegated clay	148 feet.
17.	Fire clay, with thin stratum of shale	70 feet.
18.	Black slate, hard, abounding in gas	8 feet 6 inches.
19.	Red shale	10 feet.
20.	Sandstone	1 foot 6 inches.
	Total	391 feet.

The main Brazos River runs diagonally through the county from northwest to southeast. The Clear Fork of the Brazos comes in from the southwest and forms a junction with the main fork a few miles south of the town of Graham.

These rivers, with their numerous lateral streams, give abundant supplies of water.

MONTAGUE COUNTY.

TOPOGRAPHY AND DRAINAGE.

This county is comparatively level, yet there are some rough lands. Along the western line of the county there are isolated hills or buttes, left there by the erosion that left bare the Carboniferous and Permian formations to the westward. Queen's Peak and Brushy Knob are noted examples. The drainage is into the West Fork of the Trinity River on the south, and into Red River on the west and north. Denton Creek runs through the center of the county from west to east and finally empties into the Elm Fork of the Trinity River.

The high Cretaceous escarpment, facing to the westward, extends along the entire east line of the county. Along Red River the hills are generally precipitous, having cut broad, deep channels having been cut through the Cretaceous and Carboniferous strata.

GEOLOGY.

The western part only of Montague County belongs to the Carboniferous formation. It is the Cisco division of the Coal Measures, and is overlaid on the west by the Wichita Beds of the Permian, and by the Trinity Sands of the Cretaceous on the east.

A large part of the county is covered, to a small depth, by the disintegrated material of the Trinity Sands, so that this county may justly be called a sandy county. Very few fossils have been found in the Carboniferous Measures in the county, and the determination of the strata has been made principally on lithological and stratigraphic grounds. A small collection of the fossil flora was made at the Stephens coal mine, a few miles west of Bowie, in the southwestern part of the county, but have not yet been determined.

The Carboniferous strata have been exposed along the valley of Red River by the deep erosion of its channel, to near the northeastern corner of the county.

SOIL.

The soil of Montague County is derived principally from the underlying strata. Along the Red River the soil is made from the material through which that stream passes in the country above. There are no better lands than these valleys in the State, as is shown by the abundant crops of grain and cotton that are raised on them every year.

The greater part of the county, however, derives its soil from the disintegration of the Trinity Sands of the Cretaceous, and that of the sandstones and clay beds of the Cisco division of the Coal Measures.

These soils are generally light sandy, yet in places there is more or less clay subsoil, and while these produce fine crops of corn and cotton, they are preeminently suitable for fruit raising. This part of the Upper Cross Timbers is destined to become one of the greatest fruit raising districts in the State, and being in direct communication with Colorado over the Fort Worth and Denver Railway, ready market can be found for all the early fruit that can be raised. There is no place in the State where peaches grow to better advantage or to greater perfection, and they can be put on the market in the North months before the earliest fruits mature there.

TIMBER.

This county is almost entirely within the Upper Cross Timbers. It is entirely so except along its western border. The timber is post oak and blackjack, with elm and hickory along the streams and cottonwood on Red River. Although this timber is rather scrubby and seldom grows very high or large, yet it supplies all necessary demands for domestic purposes and makes good ties for railroad building. It also makes good fence posts and is used extensively for such purposes on the adjoining prairies.

WATER.

The water supply in this county is mostly confined to shallow wells, which can be had at any locality at from ten to thirty feet in depth. There is always an abundance of water in the Trinity Sands and in the sandstones of the Carboniferous. No attempt, so far as I am informed, has been made to sink deep wells, as no occasion has been found for a greater supply of water than is found in the shallow wells.

Some of the streams in the county supply water for stock purposes part of the year, and some of them all of the time. Many large open tanks have been built, and there need be no scarcity of water for any purpose by taking the necessary trouble to secure it. There are men in all countries who will haul water from a neighbor's well or tank, or creek or river, for years, when three or four days work would give them a good well or tank of their own, and so it is in this county.

The water is generally found in sand or sandstone, and is comparatively free from impurities.

BUILDING MATERIAL.

The sandstone along the western part of this county makes an excellent building stone. It is easily quarried and dressed and hardens on exposure. It is a light brown in color and makes a very neat structure. The court house in the town of Montague is built of this stone, from a quarry a few miles west of the town. There are also some houses in the town of Bowie that are built of this stone, but from a different locality.

The sandstones of the Trinity Sands are never, so far as I know, sufficiently compact to make good building material. The sands are generally in the form of "packsand." While they are considerably indurated in places, they are never regularly bedded in hardness, and disintegrate rapidly on exposure to the weather.

Clay for making a good article of brick can be had in many places, and such material has been used in the towns for building purposes.

Lime for making mortar can be made from the Cretaceous limestone along the eastern border of the county, and sand is abundant everywhere. There are no limestones for making lime in the western part of the county in the Carboniferous strata.

COAL.

STEPHENS' COAL MINE.

The only place in this county where any attempt has been made to develop the coal is the Stephens mine, four miles southwest of the town of Bowie, on the Josepha Diaz survey and vicinity. A tunnel four hundred feet long was driven into the side of a hill on the coal seam. Four shafts have been put down to the coal to the north of the tunnel, the farthest about one and a half miles from the tunnel. The dip of the coal seam is to the northwest. The seam of coal was reached in the last shaft at a depth of one hundred and fifty feet. Water was encountered in all the shafts above the coal, but none was found in the tunnel. It is found in the sandstone overlying the clay above the coal. No difference was observed in the thickness of the coal seam in any of the shafts, but the quality of the coal was much better in the last shaft, which has recently been put down, than in the others, and it is the farthest north.

The following is a section made at the mouth of the tunnel. Beginning at the top:

1.	Sandstone	6 feet.	
2.	Clay	20 feet.	
3.	Sandstone	15 feet.	
4.	Slate	3 feet.	
5.	Coal	2 feet.	
6.	Slate		6 inches.
7.	Coal	1 foot	4 inches.
8.	Fire clay		10 inches.
	Total	48 feet	2 inches.

The property has recently changed hands and the present owners intend to fully develop their property. This is Coal Seam No. 7 of the general section.

COPPER.

A small deposit of copper has been found in the northern part of the county, but no attempt has been made to develop it. It is probably a part of the Permian copper that is found in the Wichita Beds at other localities.

GALENA.

I have seen small pieces of galena that were taken from the wells in the western portion of the county, but it has not been found in sufficient quantity to be of economic value.

This county is not free from the usual tradition of rich Spanish mines. There is an old fort in "Spanish Fort Bend" on Red River that, tradition says, was built for the purpose of protecting the miners while at their work, but, like all such traditions, no mines have ever been found.

JACK COUNTY.

DRAINAGE AND TOPOGRAPHY.

This county is quite rough along the West Fork of the Trinity River, which runs through the northern part of the county from west to east. In fact, the county is hilly throughout its entire extent, with broad, open, level plateaus between the hills and ridges. The drainage is all into the Trinity River except at the southwest corner, where Keechi Creek, a tributary of the Brazos River, has its source. These creeks and rivers have cut down into the strata, making deep and wide valleys, and the hills are protected on top by thick beds of sandstones, conglomerates, and limestones, which give to the country a much more rough and broken appearance than it really has. Between these hills are many broad valleys or plateaus, some of them even miles in extent, that furnish fine locations for extensive farms.

GEOLOGY.

Jack County belongs entirely to the Coal Measures. The strata are composed of sandstones, limestones, clays, conglomerates, and fire clay, as well as two coal seams.

Coal Seam No. 7 runs through the northern part of this county from northeast to southwest, passing near the town of Gertrude, and is the only seam that is of any commercial value. No part of the Albany Beds extends into this county. The entire strata above the coal seam in this county are sandstones and clays, and are overlaid along the north line of the county by the Wichita Beds of the Permian.

SOIL.

The soil of Jack County is made up entirely from the underlying strata, and varies in character according to the various localities. It is all more or less sandy, but in places it is quite black and sticky, like the black waxy lands of Northern Texas. At other places the land is black sandy with a clay subsoil, while at others the soil is light sandy with clay subsoil. All of these soils are fertile, and with proper cultivation produce excellent crops of grain and cotton. There is no county where small farmer could come nearer getting just the size piece of land and character of soil he might desire, and still be separated from other farms, than in this county.

The broad valleys along the West Fork of the Trinity River are fertile, but are subject to overflow. The uplands are considered more desirable.

TIMBER.

This is another county that is within the "Upper Cross Timbers," and has an abundance of timber for all purposes—post oak and blackjack on the hills, with pecan, elm, hackberry, and wild china in the bottoms, and ash and overcup oak along the river.

There are no very large prairies in the county, and all are within easy reach of the timber.

Persons coming from Eastern Texas or the other States to this county and seeing this timber would think it could not be used for any purpose except fuel, but it can be split into posts or rails almost as easily as cedar. The post oak timber is very durable for posts or railroad ties, for which purposes it is used very extensively.

WATER.

Water is sufficient along the river and creeks, and in most places can be had in wells of shallow depth. There are some fine springs in the county, where the massive limestone prevails. At other places they have had to resort to building open tanks for stock water and cisterns for domestic purposes. No deep wells have been put down to test the possibility of obtaining artesian water, and it is not probable that a supply of good water could be obtained in that way. If wells should be put down and flowing water secured, it is more than probable that it would be highly impregnated with salts, as nearly all the deep water is in the Carboniferous formation in Texas.

BUILDING MATERIAL.

There are many places in this county where the sandstone will make good building material when there shall be a good demand for it. At only a few places has any attempt been made to use the sandstone, and that only for building chimneys. This stone is similar to that found in other counties in the Carboniferous formation.

There are also fine beds of blue limestone in this county which makes excellent building material. There is a quarry of this stone near the town of Jacksboro which is exceptionally fine. The court house in the town of Jacksboro is built of this material, and there is not a nicer building of its size in the State. The beds are very even and are in layers that are very suitable for building purposes, so that an entire house might be put up out of a uniform thickness of rock without having to cut them down. They are so even bedded that no dressing is required on the top or bottom, and they break very evenly, so that very little dressing is required on the sides.

Clay for brick making is very easily obtained at many places, and no inferior material for this purpose need be used for want of better at any place.

The limestones make good quick lime, and are generally burned for that purpose in open furnaces. Sand for making mortar can be found in almost any locality.

COAL.

Coal Seam No. 7 extends across the northwestern corner of the county and has many outcrops along the West Fork of the Trinity River. Prospecting has been done at several places, and when there shall be facilities for transportation there will be good coal mines opened in this county.

The following is a description of some of the localities where I have seen the seam outcropping in this county:

One mile north of the mouth of Lodge Creek there is an outcrop of coal in the side of a hill on the east side of a creek on a survey in the name of McDonald. At that place I made the following section. Beginning at the top:

1.	Conglomerate	20 feet.	
2.	Sandstone	4 feet.	
3.	White and reddish clay	50 feet.	
4.	Coal		6 inches.
5.	Shale, with many *calamites*	2 feet.	
6.	Coal	1 foot.	
7.	Blue clay	2 feet.	
	Total	79 feet	6 inches.

The farthest point east in Jack County at which I saw the coal outcrop was near the residence of Mr. W. N. Cooper, on the northeast quarter of section No. 2, made for the Texas and Pacific Railway, file 2379. The following section was made at that place. Beginning at the bottom:

1.	Blue clay	10 feet.
2.	Coal and shale	2 feet.
3.	White fine clay	8 feet.
4.	Blue clay	7 feet.
5.	Rough sandstone	6 feet.
	Total	33 feet.

About one-half mile west of Cooper's house, in a ravine near the road, there is another outcrop of this seam of coal. At this place a tunnel has been driven into the side of the hill about twenty feet. The coal at this place is too thin to be of any economic value.

About three-fourths of a mile west of Cooper's, at a point on the hill near the Henrietta and Jacksboro road, this same seam of coal is found outcropping again. About one-half mile southwest of the last named place there is another outcrop of this same seam. At all of these places the coal is too thin to be of any value. It is perfectly useless to expect to get better coal or a better seam by following the seam under the hill. A better place would be one-half mile northwest of there, where the seam passes under a ridge of high hills.

Another outcrop is near the west line of the R. O. W. McManus survey, just north of the residence of Mr. F. M. Sloan. At this place the coal may be traced by its outcrop for some distance in a northwestern direction. It is too thin to be of any economic value.

About one mile west of Sloan's house is another outcrop of the same seam. This seam may be traced by its outcrop for a mile northwestward from this last named place. The dip of the seam at all these places is to the northwestward and towards a range of high hills. If it shall be found that the coal becomes thicker as the seam is traced away from the outcrop in the direction of the dip, then there will be sufficient covering to prevent atmospheric influences from injuring the coal before it is taken out; and it is possible that the coal may thicken up in that direction, yet I have seen nothing that would lead me to definitely determine that it would. A shaft or two would determine this matter very certainly. A diamond drill that would bring up a core would give a very good idea of the matter if it was run by reliable parties, or by parties who were competent to determine what coal was when they saw it, and were reliable enough to make a report of the facts as they were found.

BRANNON MINE

Is situated about two miles southeast of the mouth of Lodge Creek and on the south side of the West Fork of the Trinity River. A tunnel had been driven into the hill on the coal seam at this place, but it had fallen in so badly at the time of my visit that I did not venture into it.

The tunnel is driven into the hill from the north side. The seam was thicker here than at any place I have seen it in this vicinity. The seam could be worked to advantage at this place when means of transportation can be secured. The hills rise to at least two hundred feet above the seam and extend back for more than a mile, giving a considerable area of coal before the outcrop would be reached on the east.

At another place, about one-half mile northwest of the Brannon mine, the coal again outcrops in the side of a hill. This place has never been prospected for coal, but it is probable that it would be as good a locality for a mine as at the other place. The outcrop is on the southeast side of the hill, and the dip being to the northwest it would soon have sufficient cover to protect the seam from atmospheric influences. The hills rise to the height of one hundred and fifty feet.

On the south side of the West Fork of the Trinity River, about one mile from the Brannon mine, on the south side of a hill, in a gulch, the coal seam is again exposed. At this place it is only about one foot thick, but will evidently increase to more than this farther under the hill, away from where it has been exposed to the weather. This place is near the Jacksboro and Henrietta road that crosses the West Fork of the Trinity River at the mouth of Lodge Creek.

The seam of coal could be found on the sides of any of the hills along here by digging through the debris that has washed down from the hill above and now hides the outcrop. On the Jacksboro and Antelope road, about two miles southwest from the last described place, there is a seam of coal outcropping in the south side of a hill and on the north side of the road. No prospecting has been done at this place, yet it is probable that it would be as good a locality for coal as any in the vicinity. There is sufficient covering above the seam to protect it from the influence of the weather, and the hills are on the north side of the outcrop. One-half mile southwest from this last locality, at the base of a hill, a seam of coal outcrops that appears to be a different seam from that at the place just described. It is about one foot thick at the outcrop. At the place of outcrop it has been greatly exposed to the influence of the weather, and no prospecting having been done on it, it was impossible to know just what it was. The surroundings would indicate that it was the same seam as that at the Brannon mine.

JACKSON MINE.

At this place a tunnel has been driven into the hill from the east side for about seventy five feet. The coal seam is about twenty-five to twenty-seven inches thick, and appears to be of an excellent quality. Above the coal the hill rises to the height of one hundred feet. Near the top of the hill is a thin seam of coal, only three inches thick. The Jackson mine will no doubt be worked when there shall be transportation for the coal. The roofing is good, and the hills are high in the direction of the dip. The following section was made at this place. Beginning at the top:

1.	Conglomerate	20 feet.
2.	Sandstone, irregular bedded	10 feet.
3.	Sandstone and clays	50 feet.
4.	Shaly sandstone, in layers of one to two inches	5 feet.
5.	Blue clay and slate	57 feet.
6.	Coal	2 feet 3 inches.
7.	Fire clay	1 foot.
	Total	145 feet 3 inches.

ANTELOPE.

In and about Antelope, in the northwest corner of Jack County, coal is found in all the wells at a depth of from fifty to sixty feet. The coal is reported to be from eight to eighteen inches thick.

About three miles southwest of Antelope, on the south side of the West Fork of Trinity River, I made the following section. Beginning at the bottom:

1.	White sandstone	4 feet.
2.	Fire clay	1 foot 6 inches.
3.	Bituminous shale, with thin seams of coal	1 foot 2 inches.
4.	Bluish clay, with clay ironstone	8 feet.
5.	Brown sandstone	3 feet.
6.	Reddish clay	10 feet.
7.	Sandstone	2 feet.
	Total	29 feet 8 inches.

At this place in the clay ironstone we found a great many impressions of coal plants.

At Antelope is the farthest place in the northwest where coal has been found in digging wells. It is only a few miles in that direction to the line of contact between the Coal Measures and the Permian.

GERTRUDE

Near the town of Gertrude, at the forks of Cameron Creek, there are several outcrops of the coal seam, all of them showing about the same thickness of coal as at the former places described. In fact it is possible to trace the seam by its outcrop from hill to hill for several miles. The dip of the seam is about northwest, and the range of hills runs with the strike of the strata, thereby exposing the coal all along their southeastern sides. Just below the coal seam a bed of limestone occurs at this place. In the limestone I found the following fossils: *Spirifer cameratus*, *Productus punctatus*, *Athyris subtilita*, *Fusulina cylindrica*, *Terebratula*, *Fennestella*, and stems of *Encrinites*.

About four miles from Gertrude, on the Graham road, near the corner of Loving's pasture, I made the following section. Beginning at the bottom:

1.	Clay	4 feet.	
2.	Coal	1 foot.	
3.	Clay	55 feet.	
4.	Coal and bituminous shale	10 feet.	
5.	Clay	12 feet.	
6.	Sandstone	4 feet.	
7.	Clay	8 feet.	
8.	Coal		4 inches.
9.	Sandstone	4 feet.	
10.	Clay	20 feet.	
11.	Sandstone	6 feet.	
	Total	124 feet	4 inches.

Along the line of outcrop as I have described, it is possible to find the same seam of coal at almost any place at the same geological height. The seam will be higher on the hills east of any of the outcrops I have mentioned, and lower on the hills west of the outcrops, as the dip of the stratum is to the northwest. If coal should be found outcropping other than I have indicated it would not be Seam No. 7, and as I think this to be the only seam that is thick enough to be of any economic value in this county, it would be useless to spend much money or time in prospecting on any other seam. If another seam should be found that would give some promise of being thick enough to work, a few feet of work would determine the matter. It is useless to follow a thin seam under a hill supposing it will thicken. Just as soon as a tunnel is driven on a seam far enough to get away from the atmospheric influences all the facts about the seam in that vicinity can be seen. At some time when there shall be means of transportation there will be opened and developed in this part of the county good and paying coal mines. For the present nothing can be done for want of transportation.

WISE COUNTY.

TOPOGRAPHY AND DRAINAGE.

Only the western part of the county is included in this description, that being the only part belonging to the Carboniferous formation.

This part of the county is somewhat broken, especially along the creeks and rivers. A line of high hills extends along the entire Trinity River on both sides and is cut through by the lateral streams, often making isolated buttes of considerable size and height. The plateaus on the tops of the hills and back from the rivers are level and many fine farms are on these plateaus. The valleys along the river and creeks are broad and generally above overflow.

The West Fork of the Trinity River runs through the county from northeast to southwest in a very tortuous channel. Several lateral steams of considerable size run into the river from both sides, notably that of Sandy Fork on the north, which has its source in Montague County and runs almost south to its confluence with the West Fork, a few miles east of Bridgeport. The drainage of this part of the county is all into the West Fork of the Trinity River.

GEOLOGY.

Only the western part of this county is in the Carboniferous formation. The eastern half belongs to the Cretaceous. Leaving Decatur going west one descends at once the steep hills of the Cretaceous limestones and for a few miles travels over the beds of the Trinity Sands. The first section that could be referred to the Carboniferous was at Dry Creek, eight miles west of the town of Decatur.

Coal Seam No. 1 passes below the Cretaceous in this county. The geology is about the same as that in the vicinity of Millsap, yet some of the beds of clay have become much thinner. The limestones just west of Bridgeport are the same that are found west of the Coal Seam No. 1 at Strawn.

SOIL.

The soil of this county is derived principally from the underlying strata. The valleys along the rivers are generally broad and may be classed as black sandy, in places having only a small percentage of sand. These soils are very fertile and are fine cotton and corn lands. Some of the lands in the limestone belt are black clayey soil and make good crops of grain and cotton. The largest percentage of soil in the western part of this county are the sandy lands with clayey subsoils, which have been derived from the strata immediately below them. Some of the soils of this kind are very light, deep sandy, while others are a dark chocolate, with the subsoil only a short distance from the surface. These sandy lands are partly made from the detritus from the Trinity Sands, which are found along the entire eastern part of the county.

TIMBER.

The western part of this county is in the "Upper Cross Timbers." The timber is about the same as found in all the counties belonging to this strip of country. Along the Trinity River and some of the lateral streams some of the timbers, such as pecan, overcup and water oak, grow to a large size. The timber on the uplands is short and scrubby, but in sufficient quantity to supply the demand for domestic purposes. There is only one thing about this timber that is a matter of surprise to persons acquainted only with scrubby timber in other States, that is the ease with which it can be split. There it is invariably tough and hard to split, but here the most knotty, snarly tree to be found can be split almost like cedar.

The timber is large enough to make props for coal mining purposes, and for railroad ties, as well as fence posts.

WATER.

Water can be found everywhere in shallow wells. Stock water is furnished by the river and creeks. Only at a few places in the county has it been found necessary to build tanks for watering stock.

No deep wells have been put down to test the possibility of flowing water, as the surface water has always proven sufficient for all purposes. It is doubtful if flowing water could be obtained here, as the eastern part of the county (the Trinity Sands) is the source or bed in which the artesian water is obtained at localities eastward from this county.

A few good springs have been found in different parts of the county. The general reliance for water is on shallow wells, in which abundance of water has always been found.

BUILDING MATERIAL.

The Carboniferous sandstones to be found along the western part of the county are of the same character as the Carboniferous sandstones found in other parts of the State. Good quarries could be opened in the vicinity of Bridgeport, but there has been no demand for such material outside of a few persons in the neighborhood for building chimneys—and for that purpose the outside stones that had been weathered out were used—and no quarry has been opened.

There are in the western edge of the county heavy beds of limestone that could be used for building purposes, but so far no use has been made of them. The limestone from which the court house and other buildings in Decatur are erected is the Cretaceous limestone found in that immediate vicinity in great abundance.

Clays for brick making are abundant, and are often found properly mixed for making a good quality of bricks.

COAL.

Coal Seam No. 1 is found in the vicinity of Bridgeport on both sides of the river. This is the farthest place northward of the outcrop of this seam. It here passes beneath the Trinity Sands of the Cretaceous. Considerable prospecting has been done at this place, and an opening has been made on the coal at one place for several hundred feet. Numerous shafts have been put down to the coal in the vicinity, and many holes have been put down by a diamond drill. All these methods have proven the existence of a large body of coal. The coal seam in the opening, where a good deal of coal has been taken out, is twenty-four inches thick. The coal taken out of the mine has been hauled in wagons to Decatur and sold to supply the local demand.

It is reported that the coal seam thickens to the northwest. I could not make any personal examination as to the correctness of the report, as the shafts had either fallen or were partly filled with water at the time of my visit.

The coal is as good in quality as any found in the State, as the analysis given in another place will show.

Recently arrangements have been made to build a railroad from Decatur to the mines, and when that is done this will be a good property. The roofing is good, and the mining can be as easily done as at any other thin seam of coal. The mine is entirely free from water and gas.

There is plenty of timber in the vicinity for all the props needed, and all that is needed to make this as good a locality for coal mining as any in the State, is transportation facilities to get the coal to market.

Just north of the mine, and about twenty-five feet above the coal, the following fossils occur:

Aviculopecten occidentalis, *Pleurotomaria sphærulata*, *P. tabulata*, *P. turbiniformis*, *Productus semireticulatus*, *Chonetes mesoloba*, *Conularia crustula*, *Campophyllum torquium*, *Michelina placenta?*, and others that are undetermined.

About one-half mile southwest of the bridge across the river at Bridgeport the coal outcrops in the head of a ravine. The seam at the outcrop is thirteen inches thick. The dip of the strata is to the northwest. This is evidently the same seam as that on the north side as the river east of Bridgeport. Again, about one-half mile west of this last described place is another outcrop of the same seam.

Five or six miles southwest of Bridgeport, and on the west side of Boon's Creek, the coal outcrops at the foot of the hill, and is overlaid by the Trinity Sands of the Cretaceous.

OTHER MINERALS.

Gold, silver, copper, and platinum have been reported from the vicinity of Decatur, but the most delicate tests of the laboratory have failed to detect anything except a trace of copper and a small amount of nickel. There are small pieces of meteoric iron found in the Trinity Sands at this locality, and in that is found a small percentage of copper, but no gold, silver, platinum, or other rare and precious metals have been discovered by the members of the Survey, nor have they been found in the material sent for examination to the laboratory by others.

PARKER COUNTY.

COAL.

Only a narrow strip of the western edge of Parker County belongs to the Carboniferous formation. The hills three or four miles east of Millsap are Cretaceous, and only that part of the county west of those hills is Carboniferous.

Coal Seam No. 1 outcrops in a number of places on Rock Creek, three miles and more from Millsap northwestward.

The following is a description of some of the outcrops and shafts seen in this vicinity. Plate VIII shows the various localities mentioned:

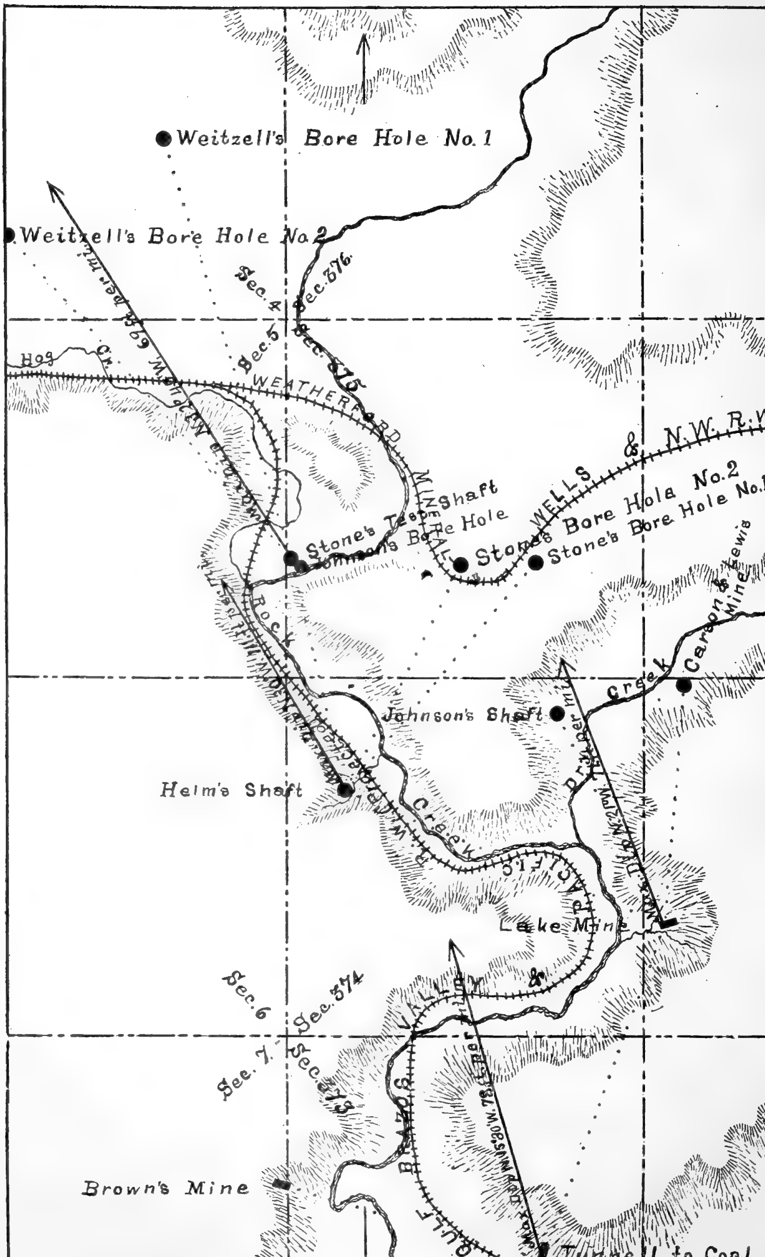
CARSON & LEWIS MINE.

This mine is situated on the northwest quarter of section 359, made for the Texas and Pacific Railway, and on the east side of Dry Creek. The shaft is partly filled with water and the timbers are rotting and falling in so as to make it dangerous, if not impossible, to enter the mine. The mine was worked by sinking an inclined shaft to the coal.

The seam in the mine is from eighteen to twenty-six inches thick, is of fair quality, having but a small percentage of sulphur. The coal mined here was hauled in wagons to Weatherford and used in the Carson & Lewis Steam Flouring Mills for driving their engine, and for domestic purposes in that town.

About two hundred yards west of the mine, in the bank of Dry Creek, is a bluff showing ten feet of soil, with a bed of sandstone, and below the sandstone a bed of shaly sandstone and bluish clay ten feet thick. This is entirely above the Coal Seam, and I did not get a section in the vicinity showing the Coal Seam.

PLATE VIII.



BETWEEN WEATHERFORD AND MILLSAP.

In a bed of clay above the mouth of the shaft the following fossils occur: *Nuculana bellistriata*, Stevens; *Pleurotomaria sphærulata*, Conrad; *Spirifer planoconvexus*, Shumard; *Chonetes mesoloba*, Norwood and Pratten; *Myalina subquadrata*, Shumard; *Spirifer lineatus*, Martin; *Productus prattenanus*, Norwood.

LAKE MINE.

This mine is situated on the southwest quarter of the same section as that of the Carson & Lewis mine. At this place the openings were made on the seam in two directions. The outcrop is in a hollow and the openings were made in the hills on both sides of this hollow. The Coal Seam is from eighteen to twenty-six inches thick. The coal taken out was hauled in wagons to Millsap and sold to the Texas and Pacific Railway Company for use in their locomotives. The work has been abandoned for the reason that it would not pay to transport coal four miles by wagons, and this was the only means of transportation and the railway company the only buyers.

The following fossils were found in the clay above the coal: *Bellerophon crassus*, Meek and Worthen; *B. carbonarius*, Cox; *Productus costatus*, Sowerby; *Discina convexa*, Shumard; *Spirifer cameratus*, Morton.

About one mile southwest of the Lake mine a shaft has been driven into the hill on the coal a distance of three hundred feet, but it was found that the seam had been too much exposed to atmospheric influences to pay to develop, so the work was abandoned.

In another place, about one-half mile west of the last place mentioned, is what is known as the Brown mine. At this place a shaft and tunnel were put down to the coal and some coal taken out, but the work there has also been abandoned.

About one mile northwest of the Lake mine a Mr. Helms put down a shaft to the coal, which he found at a depth of forty feet. Quite a number of holes have been put down to the coal in this vicinity with satisfactory results. Plate No. VIII will show the relative positions of these several shafts and their relation to the railway that has recently been built from Weatherford to Mineral Wells.

PALO PINTO COUNTY.

TOPOGRAPHY AND DRAINAGE.

This county is traversed from northwest to southeast by the Brazos River. There are several lateral streams of large size running into the county from both sides, notably Palo Pinto Creek on the south and Keechi Creek on the north, as well as many others of smaller size. The Brazos River is very crooked and the hills on either side very precipitous. This county is the roughest in the northern part of the State. The thick beds of limestone and underlying clays dipping to the northwest cause high escarpments facing to the southeast.

In places in the county there are broad, level plateaus, called in this part of the State "valleys," that furnish good localities for large and fertile farms. The valleys along the rivers and lateral streams are broad, and are generally covered with timber, and upon them are some of the largest and best farms of the county.

GEOLOGY.

This county is entirely within the Coal Measures series. It has been stated that this county belonged to the Chester group of the Sub-Carboniferous. The reasons given for so stating were based upon stratigraphic reasons alone. It was supposed that the conglomerate beds found on the tops of some of the highest hills along the Brazos River and elsewhere were the equivalent of the Millstone Grit of the Pennsylvania Coal Measures, and which is the bottom of the Coal Measures in that State; and then finding heavy beds of limestone lying below the conglomerate, the conclusion was reached that these limestones were Sub-Carboniferous. After a pretty thorough examination of these conglomerates I am satisfied that they are not the equivalent of the Millstone Grit, and that the limestones are not Sub-Carboniferous. The following fossils were found in the vicinity of Mineral Wells, in the northeastern part of this county, which show conclusively that the formation belongs to the Coal Measures:

Anthyris subtilita, Hall; *Bellerophon carbonarius*, Cox; *B. nodocarinatus*, Hall; *B. crassus*, Meek and Worthen; *Chonetes granulifera*, Owen; *Chonetes mesoloba*, Norwood and Pratten; *Conularia crustula*, White; *Discina nitida*, Phillips; *Euomphalus rugosus*, Hall; *Lingula umbonata*, Cox; *Loxonema rugosa*, Worthen; *Lophophyllum proliferum*, McChesney; *Michelina placenta?*, White; *Machrocheilus ventricosa*, Meek and Worthen; *Myalina subquadrata*, Swallow; *Nuculana obesa*, White; *Nuculana bellistriata*, Stevens; *Nucula ventricosa*, Hall; *Orthoceras rushensis*, McChesney; *Productus cora*, D'Orbigny; *P. costatus*, Sowerby; *P. longispinus*, Sowerby; *P. semireticulatus*, Martin; *Pleurotomaria sphærulata*, Conrad; *P. tabulata*, Hall; *P. broadheadi*, White; *P. brazosensis*, Shumard; *P. turbiniformis*, Meek and Worthen; *Retzia mormoni*, Marcou; *Rhynconella uta*, Marcou; *Spirifer cameratus*, Morton; *S. planoconvexus*, Shumard; *Spirifer lineatus*, Martin; *S. rockymontanus*, Marcou; *Spiriferina kentuckensis*, Shumard; *Synocladia biseralis*, Swallow; *Terebratula bovidens*, Morten; and others not yet determined.

I traced the formation beyond the eastern boundary of the county, and to where the Carboniferous strata was overlaid by the Cretaceous, and at the very base of the Carboniferous found a limestone that was almost entirely made up of *Fusulina cylindrica*, which has never been reported in the Sub-Carboniferous formation in North America.

SOIL.

The soils of Palo Pinto County are derived principally from the immediate underlying and surrounding strata. The only exceptions to this are the broad valleys along the Brazos River. The Brazos River soils are derived from the country through which this river passes, from the foot of the Staked Plains to their present locality. They are a red sandy loam, and are very fertile. They generally lie above overflow. Some of the best crops in the country are made on these lands. They are better for corn and cotton than for the small grains. Another class of soil is the black sandy land found along the creek bottoms. This soil is derived from the strata passed through by the several creeks on their way to the river. They are generally overgrown with timber and brushwood. The other kind of soil is that derived from the strata immediately underlying the localities. These soils vary in color and composition, according to the material from which they are derived. Some of them are black, some reddish, some light sandy. Some of them have a large per cent of lime, while others are made principally of clay. These soils are in bodies varying from a few acres to several hundreds of acres in extent. The county will never be as completely enclosed with farms as some of the counties to the westward, but there is enough good land in all parts of the county to form good settlements. Some of the lands are too broken to be good for agricultural purposes, but all the lands are covered with a fine growth of nutritious grasses. Stock raising is carried on quite extensively in the county. The grass is mostly mesquite. The protection for stock in winter is all that could be desired.

TIMBER.

This county is almost in the center of the "Upper Cross Timbers." There are no large prairies in the county. Everywhere timber is abundant. The principal kinds are post oak, blackjack, elm, hackberry, pecan, red oak, and cottonwood. Mesquite is also abundant. There are large cedar brakes along the Brazos River, where large amounts of timber have been obtained for railroad construction and fencing. More timber has been taken out of this county for fencing purposes on the great prairies of the west than from any other county in the State, and still there are thousands of acres of the very finest timber for this purpose awaiting a demand for its use. At the present there is but one railroad that reaches this timber, and that at its southern extremity. The posts are loaded on the cars at about twelve cents apiece, by the carload. This is about the rate paid for the best quality of posts.

WATER.

This is the best watered county in this part of the State. The river and larger creeks always have an abundance of water in them for stock purposes. There are also many fine springs in the county. These springs come from the massive limestone. Several of these springs are in the vicinity of the town of Palo Pinto. Water can be found in shallow wells at almost any place. The water is very cold and quite free from salts. Where running water can not be had and where the clay is so thick that water can not be easily obtained by sinking shallow wells, open tanks can be made that will supply all demands.

Artesian water has been found at several places in the county, but it is always highly impregnated with common salt. Two of these wells are in the vicinity of Gordon, in the southern part of the county. It is probable that flowing water could be obtained at many places in the county, but it would all be more or less impregnated with salts of various kinds.

Mineral water has been found at several places in the county. Mineral Wells has become quite a health resort, and the waters are very beneficial to all who use them for such diseases as result from derangement of the digestive organs. Want of comfortable hotels has heretofore prevented this place from becoming one of the finest health resorts in the State, but now that a railway has reached the town it is probable that some one will make the necessary arrangements to accommodate all who may desire to visit the town.

The following is an analysis of the water from Mineral Wells:

ANALYSIS OF WATER FROM MINERAL WELLS.

Analysis by State Geological Survey.

	Grains per Gal. 231 cubic in.	Parts per 100,000
Chloride of sodium	20.084	34.44
Sulphate of soda	256.599	440.00
Carbonate of soda	29.064	49.84
Carbonate of lime	15.657	26.85
Carbonate of magnesia	6.186	10.61
Alumina and iron	.874	1.50
Silica	1.195	2.05
Total solid contents per gallon	329.659	565.29
Total residue by evaporation	328.965	564.09

Gas cubic inches per gallon: Carbonic Acid Gas 4.625

BUILDING MATERIAL.

The sandstones of the Carboniferous are excellent for building. This stone is found abundantly in a great many places in the county. Only a few quarries have been opened, but in almost every neighborhood good quarries might be opened if there was any demand for the stone.

On the line of the Texas and Pacific Railway at the crossing of the Brazos River one or two quarries have been opened and the stone shipped to Dallas and Fort Worth and used for buildings. The Grand Windsor Hotel in Dallas is built of stone from this quarry.

On Grindstone Creek, near the southeastern line of this county, the stone has been quarried and manufactured into grindstones of excellent quality. The railway from Weatherford to Mineral Wells crosses some excellent beds of this stone and will no doubt be the means of opening new quarries.

A quarry of sandstone has been opened one mile southeast of the Texas and Pacific mine that promises good results. The bed of sandstone is eight feet thick, of even texture and color, and is in unlimited quantities. It will take about one-fourth of a mile additional railroad to be built to reach the quarry. The only question as to the practicability of this stone is the question of transportation at such rates as will warrant proper investment.

The old switch that was formerly used by the Gordon mine is now being used for the transportation of sandstone quarried in the hills between the old mine and the main line of the Texas and Pacific Railway.

The limestones make good building material, but are not so easily dressed as the sandstone. Some of them are very compact, and would retain their color for a long while.

The hard blue limestone in the southern part of the county, in the vicinity of Santo, has been quite extensively used in Dallas for paving. This stone wears out very slowly, and makes an excellent hard pavement.

Good clay for making brick can be had at many places. Recently a large establishment has been put up near the mouth of Rock Creek, a few miles west of the town of Millsap, for the purpose of making pressed brick from the beds of clay found so abundantly in that locality.

Lime can be made from many of the limestones, and sand is everywhere abundant for making mortar.

NATURAL GAS.

In several places in this county natural gas has been found in sinking deep wells for water or prospecting for coal, but no effort has been made to test the quantity of gas at any given locality nor the extent of territory in which it can be found. In sinking a deep well at the town of Gordon, at the depth of three hundred and seventy-one feet a flow of salt water was found, and with it a small but continuous flow of gas. A beer keg turned over the well with a gas pipe and burner inserted in it collects enough gas to keep a constant light burning. Beyond that there has been no attempt to utilize the gas in any way.

One-half mile east of Gordon another well was put down, and at the depth of three hundred and sixty feet a flow of salt water was found, and with it a flow of gas, but no effort has been made to utilize the gas in any way.

At Thurber a deep well was put down, and at the depth of four hundred and eighty feet a flow of salt water was reached, and with it gas, but in what quantities has not been tested.

About five miles southwest of Strawn a deep hole was put down with a diamond drill, and a flow of water and gas was reached.

Five miles north of the town of Palo Pinto, at Dalton's, a very remarkable flow of gas was found at a depth of three hundred and eighty-four feet from the surface. The gas rushed from the well with a noise like a locomotive blowing off steam and that could be heard for miles around. The gas was accidentally lighted, when there was an explosion like thunder, and the flame shot up to the height of forty feet or more. After five or six hours of constant working to shut off the gas, the flame, which had endangered the family residence, was extinguished and the hole filled up with cement and gravel. Since that time nothing has been done to develop the gas or examine the extent of the supply. The owner of the well, to whom I talked, said he was "hunting for water and not fire."

The principal reason for the delay in the utilization of these gas fields is the fact that there is at present no demand for that kind of fuel nearer than Fort Worth or Dallas, at least eighty miles away, and it has been thought too far to pipe the gas to these cities with their present demand for such material.

COAL.

Coal Seam No. 1 outcrops in this county for a considerable distance, beginning about five miles east of Mineral Wells and running southwestwardly, passing out of the county near the town of Thurber.

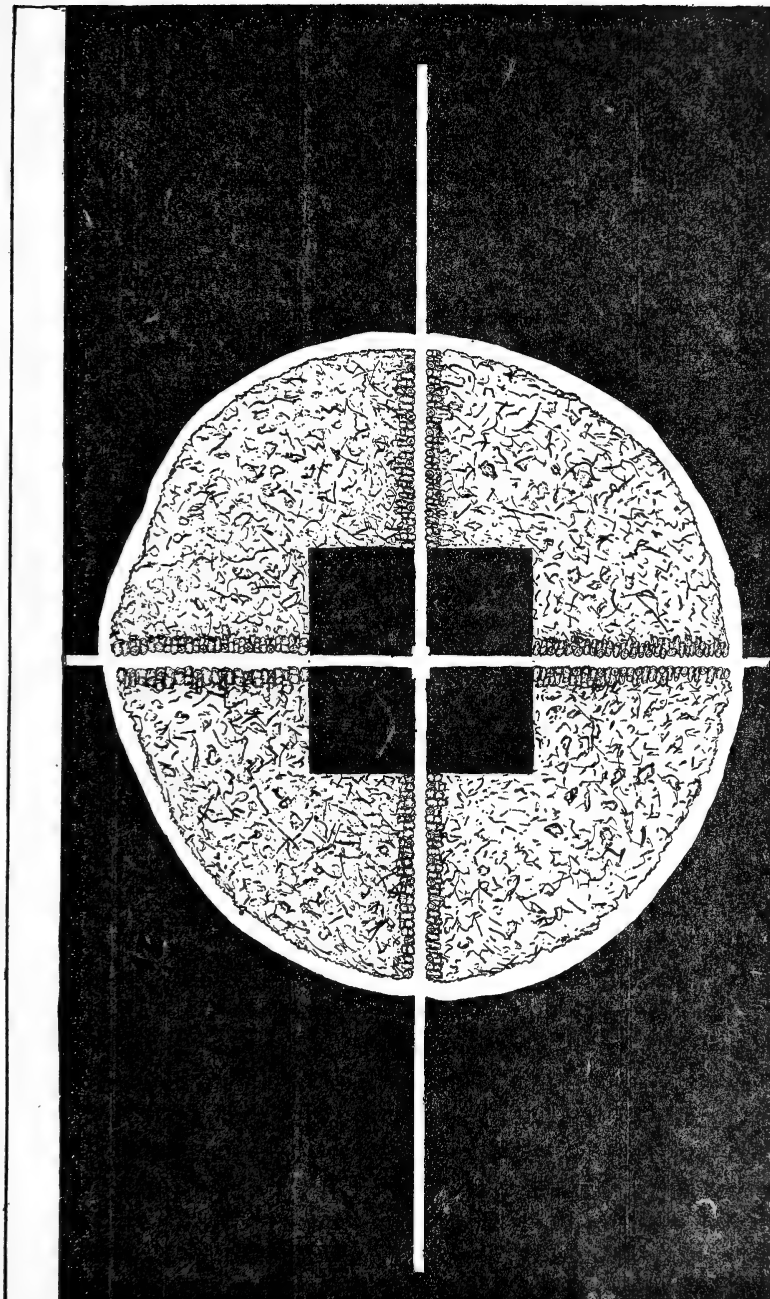
The following is a description of the various places where I have seen the coal seam on the line of outcrop in this county, and the few places along the borders of other counties that are not described in this Report:

TEXAS AND PACIFIC MINE.

This mine is the same as was reported on in the Preliminary Report under the name of Johnson mine. See Report of Progress, page 48. Since that time the property has changed hands and has been given another name as above. It is situated near the north line of Erath County, at the town of Thurber, about four miles southwest from the town of Gordon. The mine is on the Pedro Herrara survey of 2253 acres. The company own several thousand acres adjacent to this property.

The seam of coal worked at this place is No. 1, has a thickness of twenty-

PLATE IX.



GROUND PLAN OF A LONG-WALL WORKING.

eight to thirty inches, and is very uniform in thickness throughout the entire property. This seam of coal has a thin parting of slate in the centre of about one-fourth of an inch.

The method of working the mine is what is known as the "long-wall advancing" system. By this system all the coal is taken out in a circle around the shaft, after having left one hundred feet square of solid coal around the shaft on which the hoisting machinery is placed, and through which also the main entries are driven after all the coal is taken out, and "gob," the dirt taken out from under the coal, is put back in the vacancy left by taking out the coal, and the roof is allowed to settle down all around. To prevent the roof from settling down against the face of the coal, it is supported by temporary props, which are afterwards taken out or left, as may be convenient. Plate No. IX will give an idea of the workings of the long-wall system. This plate shows the one hundred feet of solid coal left around the main shaft, with the main entrances running in four directions, with the broken-down walls behind the miners; the open space between the "gob" and working face of the coal. Plate No. X shows a vertical section of the same.

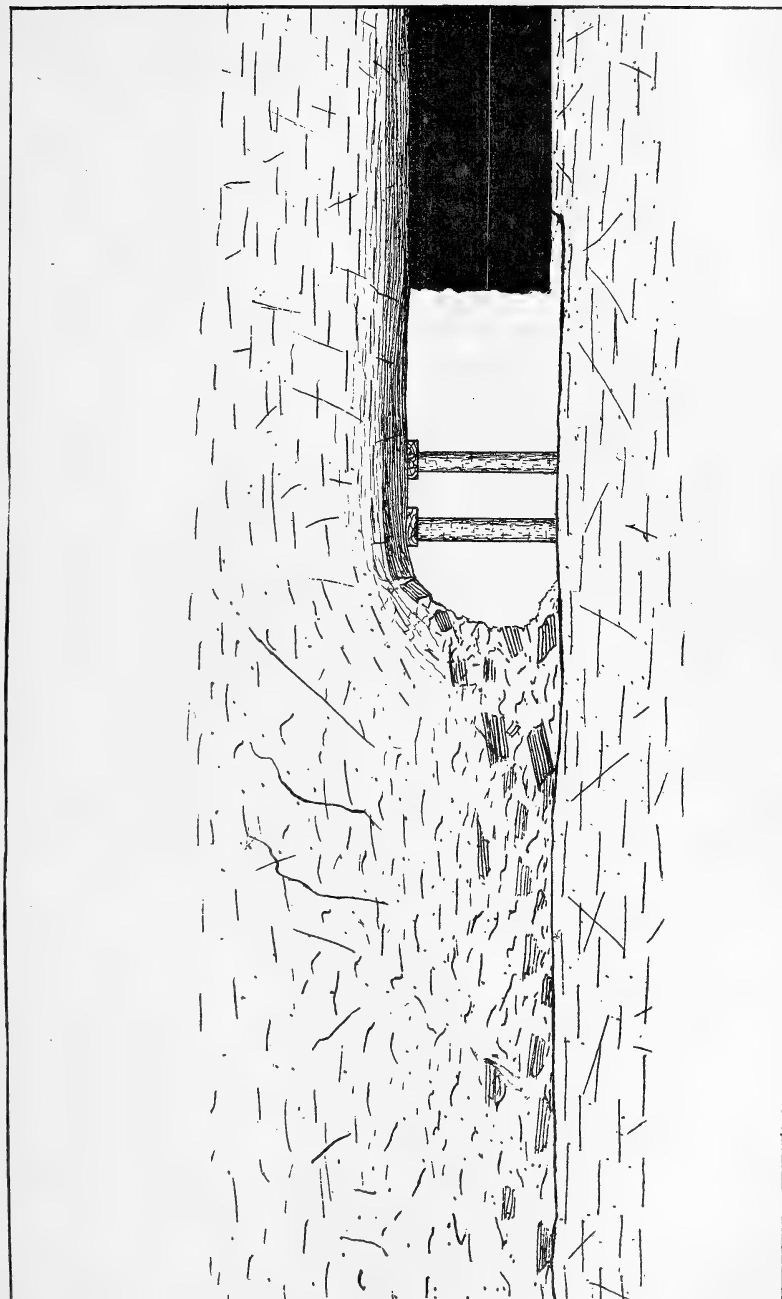
The props used in this mine are made of wood, and are about thirty inches long. On the top of the props is placed a cap a foot wide and eighteen inches long, to prevent the props from sinking too rapidly into the descending roof. The timber for these props and caps is gotten from the timber in the immediate vicinity of the mine.

There are three openings on the property, known as shafts No. 1, No. 2, and No. 3. No. 1 was the first one put down, and is fifty feet deep, and is the farthest one to the east. No. 2 is thirty-nine hundred and sixty feet north 41° west from No. 1, and No. 3 is forty-two hundred and thirty-nine feet southwest from No. 2. Plate No. XI shows the various places mentioned.

The coal is brought to the bottom of the shaft from the face of the coal in mine cars drawn by mules. The mules are fed and watered and stabled in the mine. The coal is hoisted out of the mine in cars and dumped directly into the railroad cars for transportation, passing over a screen at the tipple. Men are placed on each car as it is loaded to throw out any slate or other matter not desired that may have been negligently left mixed with the coal by the miner, and in this way the grade of coal put on the market is kept comparatively clean. No attempt has been made to utilize the waste from the mine, except an occasional sale of a single carload to be used by some stationary engine.

The average output of this mine is about seven hundred tons per day. The entire output is taken by the Texas and Pacific Railway Company and used on the western division of their road. The reports of its use by the locomotives shows it to be satisfactory.

PLATE X.



SECTION ACROSS THE FACE OF A LONG-WALL WORKING.

The working of the mines is as easily performed as in any thin seam of coal. The roofing is good, and only a few accidents have occurred, and these generally resulted from the negligence of the miners themselves or from the ignorance of some green hand who would not listen to the caution of the more experienced.

The mine is dry throughout, and no gas has been found, and there is not much probability that any will be encountered. The mine is ventilated by fans run by machinery at the top of the shaft, and the miners say they have good air. The seam of coal has a very uniform thickness. It has been found to pinch out in places and leave the coal resting immediately upon a bed of indurated sand, making the mining somewhat difficult, but this has only been found in a limited area in mine No. 1, and that on the eastern side next to the outcrop.

The miners take out from two to two and a half tons per day, for which they are paid one dollar and twenty-five cents per ton. The method adopted of paying the miners for the coal is to pay once every month the whole amount due them either for driving the entries or other contract work for the amount of coal taken out.

The mine owners have adopted the plan of advancing on the month's work before pay day by giving to the miners a book of tickets worth five dollars, good at the company's store for anything the miner may need in the way of supplies. The tickets are not good if detached from the book by the miner, and thus preventing him from using the tickets except for the purpose of buying necessary supplies. The miner is not required to purchase from the company his supplies further than to the amount for which he has taken tickets.

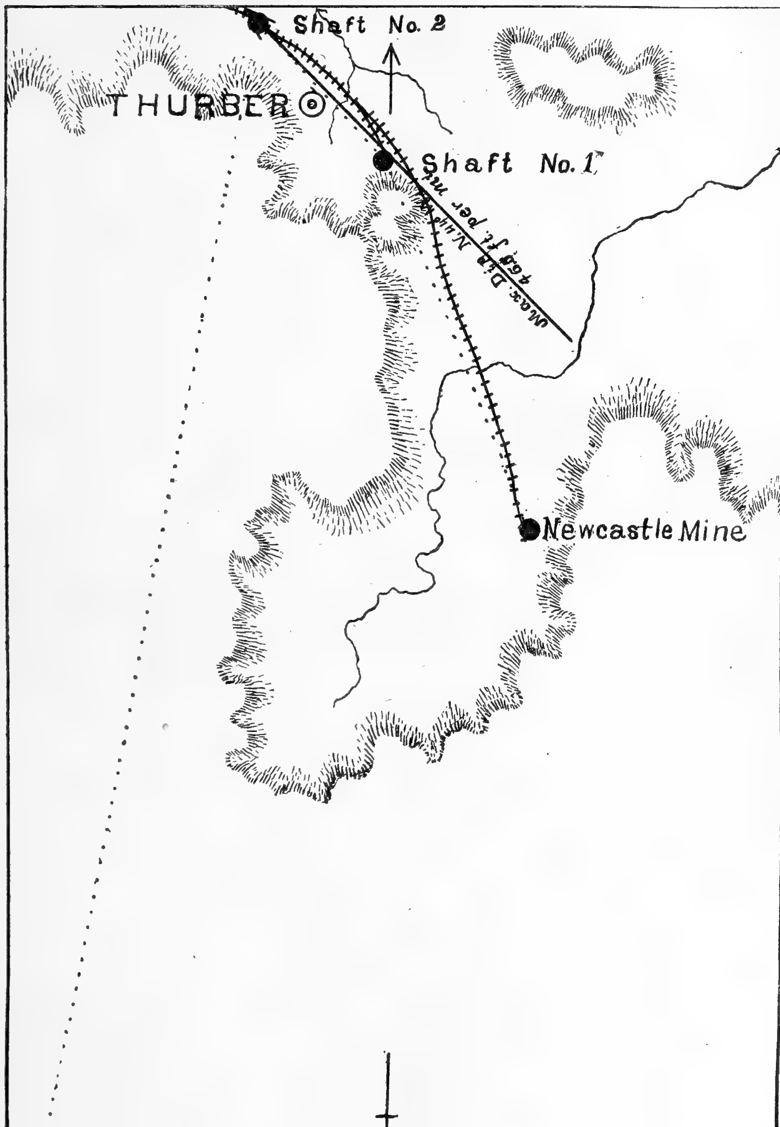
The houses are owned by the company, and are rented to the miners at reasonable figures.

An attempt was made to get water for the mines by sinking a deep well, but after going to the depth of eleven hundred feet only salt water has been reached, which flows in a nice stream from the top of the well. Water for the use of the mines is brought in on the railroad from near Strawn in water cars, and from thence is delivered to the miners by water wagons.

It is intended by the proprietors to increase the output of the mine to at least double its present production, which can be very easily done.

There has been a spur built out to this mine from the main line of the Texas and Pacific Railway, beginning at a point about midway between Gordon and Strawn, and is about one and a half miles long.

PLATE XI.



THURBER, IN ERATH COUNTY.

FINCASTLE MINE.

This mine is situated about one and a half miles southeast of the Texas and Pacific mine and is on the same seam of coal.

They have several thousand acres of land surrounding the mine under which the coal seam extends. For some reason the mine was not running at the time of my last visit, but the suspension was only temporary; yet it prevented me from getting the facts as fully as I wished in regard to their operations.

The railway switch that was built out to the Texas and Pacific mine has been extended to this place, so that their means of transportation is as good as from the other mine.

The general surroundings of this mine are about the same as those of the Texas and Pacific. Their shaft, of which they have but one, was put down nearer the eastern edge of outcrop, and the coal has been colored a little by the oxidation of the iron, but is of as good quality as the other mine. A shaft put down far enough to the westward from their present working will furnish coal free from the stain of the iron above mentioned. The property has recently changed hands, and the present owners propose to develop their property to its fullest capacity.

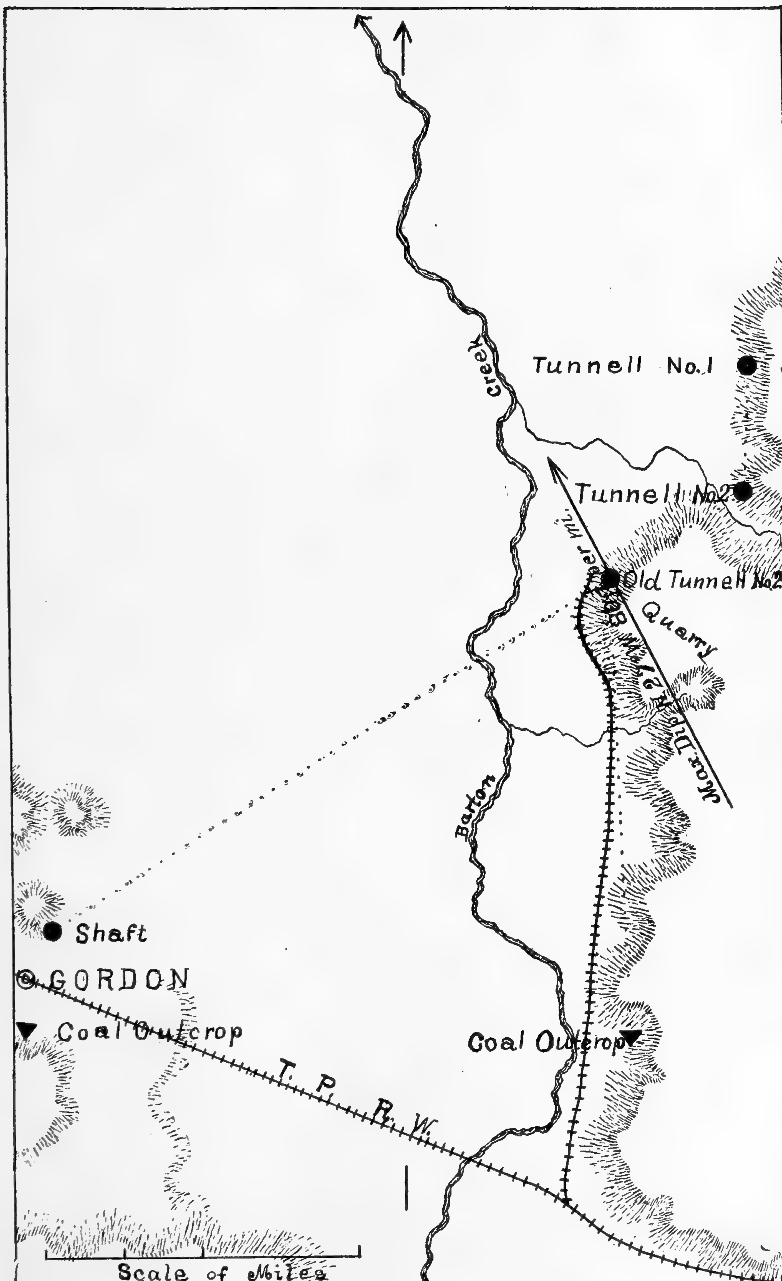
GORDON MINE.

About three miles northeast of the town of Gordon is the locality of the old Gordon mine, where a few years ago was a thriving town and hundreds of miners, with an output of coal of more than six hundred tons per day; but the mine has been abandoned and the houses all or nearly all moved away. Various causes contributed to this result. The principal reason was for want of proper management on the part of the owners of the property.

The mine was developed by driving three different openings into the hill on the coal seam, one of which passed entirely through the hill, coming out on the eastern side. The other two tunnels were in another hill across the hollow from the one first mentioned. The coal is found outcropping for several miles to the northeastward along the sides of the hills. It is very evident that the place where the old mines were located was not well selected. The coal was too near the outcrop, and had all been injured by atmospheric influences to a greater or less degree.

This is the same seam of coal as is being now so successfully mined at Thurber. The seam of coal can be traced along the hills southward for a mile and a half to the line of the Texas and Pacific Railway, and from thence eastward along the hills on the north side of the railroad for two or three miles, where it finally lies at the very tops of the hills.

PLATE XII.



GORDON, PALO PINTO COUNTY.

About one mile west of the Gordon mine, on the west side of Palo Pinto Creek, a shaft was put down, reaching the coal at forty feet. At this place the coal has good roofing, and is free from atmospheric influences, and would be an excellent place to open a mine. This is known as the Swank mine. At several other places in the vicinity of Swank's the coal seam has been reached in sinking wells for water at various depths.

One mile north of Gordon coal was found in a well at a depth of sixty-nine feet. I traced the outcrop of the coal from hill to hill for several miles to the southwestward from the old Gordon mine. The seam is just above the town of Gordon, at the south edge of the tank; it can be traced from there around the hills to the eastward, and up Barton Creek on the west side, and passing through a gap in the hills to Brooks Hollow, and thence up that hollow to its head at a point one mile east of the Fincastle mine. Then it may be seen on the southeastern side of the hills about one and a half miles from there, and traced from hill to hill by the outcrop to the Bridge Farmer place on Rush Creek, eight or nine miles south of Strawn, where it is in the bed of the creek, and soon passes under the higher beds of the formation, which are in turn overlaid by the Cretaceous.

A railroad has been surveyed from the Texas and Pacific mine to a point on the Houston and Texas Central Railway in the vicinity of Dublin. A road built along that line would pass over available coal land for a distance of ten miles.

STEPHENS COUNTY.

TOPOGRAPHY AND DRAINAGE.

This county is hilly, with broad valleys along the river and creeks. Broad, level plateaus are often found on the top and between the hills. There are many small areas of level land scattered among the hills that will make good homes for small farmers. The Clear Fork of the Brazos River runs through the county from west to east, and several large streams run into the river from the south side. Hubbard Creek is the largest which flows from the southwest, and Gonzales comes in from the south. Sandy Creek runs into Hubbard from the south a few miles from its mouth. This county can be said to be well watered by creeks and river, as these creeks always have an abundance of water in them for stock purposes.

GEOLOGY.

The formation in this county belongs entirely to the Coal Measures. Several years ago Mr. Charles Ashburner visited the county for the purpose of examining the coal beds, and in a paper read before the American Institute of Mining Engineers placed the coal seams at the bottom of the Coal Measures just above the Millstone Grit, and the limestone beds below that he placed in the Chester Group of the Sub-Carboniferous. He based his conclusions upon the supposition that the conglomerate found here was the Millstone Grit, and therefore any limestone found below it would necessarily belong to the Sub-Carboniferous. He found what he supposed to be the same conglomerate in the eastern edge of Palo Pinto County and called it Millstone Grit, when in fact there is more than fifteen hundred feet of strata between the two beds of conglomerate, and neither one of them is the equivalent of the Millstone Grit. He gives a bed of limestone—which he calls the Chester—as being two hundred and fifty feet thick, when in fact there is no such bed to be found anywhere in this part of the State. All the limestone beds in the county put together would not make one hundred feet. The Coal Measure fossils are abundant and well preserved, and I see no reason to think that these limestones belong to the Sub-Carboniferous, but instead I find them to be in the Upper Coal Measures.

The following fossils were taken from a section just above Coal Seam No. 7, five miles southwest of Crystal Falls:

Chonetes granulifera, Owen; *Fenestella*, ———; *Hemipronites crassus*, Meek and Hayden; *Productus longispinus*, Sowerby; *P. semireticulatus*, Martin; *P. prattenanus*, Norwood; *P. punctatus?*, Martin; *Spirifer cameratus*, Morton; *Pinna peracuta?*, Shumard; *Fusulina cylindrica*, Fischer; *Zaphrentis spinulifera*, White.

The fossils taken at Graham, a list of which is given elsewhere in this Report, were all taken from strata below the limestone which was placed by Mr. Ashburner in the Sub-Carboniferous. That list, as well as the list taken from Mineral Wells, which is still below the horizon at Graham, shows the strata to be true Coal Measures, and high up in the measures at that.

SOIL.

What has been said of the soils of Young County may be repeated of the soils here. The soils along the river are somewhat different from those along the main Brazos River in Young County, but with that exception they are about the same. The soil along the Clear Fork of the Brazos in this county is generally black sandy, with places of red sandy loam. These lands are in broad, level valleys, often a mile or more wide. They are the very best lands for farming. The same may be said of the valleys along the larger creeks.

The soils on the uplands being made from the underlying strata vary according to location. Some of them are light sandy, while others are sandy loam. Some of them have too large a percentage of clay to be very good for agricultural purposes, but all are good grass lands. The grass is generally what is known as "curly mesquite." While it is a short grass there is none more nutritious, and is a grass that keeps well through the winter months. It does not stay green during the winter, but retains its nutritive qualities even after being killed by the frost. Unless there is a good deal of rain during the winter to rot it, the grass will be almost as good in the latter part of the winter as at the beginning, and stock cattle do well on it without any other feed.

TIMBER.

This county is entirely within the "Upper Cross Timbers," and has the same kinds of timber as are generally found within that belt. Along the river and the larger creeks there are many fine groves of pecan trees of large size. The overcup trees are large, and in the creeks and river bottoms are ash, hackberry, and wild china. The county may be said to be well timbered for this part of the State. There are large prairies in different parts of the county, but all within easy reach of the timber. The mesquite timber is fast encroaching upon these prairies, and in a few years, if the fires are kept out, there will be an abundance of this timber everywhere.

WATER.

Outside of the river and creeks there is a scarcity of water in the county. The clays of the Coal Measures are thick and are impervious, and no water can be found in them. The sandstone beds do not seem to be water bearing. It is only occasionally that water can be had by digging. No deep wells have been put down, and if there had been it is not probable that good water could have been obtained. Resort has been had to open tanks for water supply on the farms. Very often after a tank has been built a well would be put down below the dam, and the water from the tank would filter through the dam and underlying beds, and by this means a very good supply of very good water would be obtained. Generally these tanks are too small, for when the long dry seasons come, which is almost every year, the water gets very low in the tanks and is not good, or dries up altogether and forces the farmer to drive his stock to water and haul supplies for domestic purposes, sometimes a distance of several miles; and then perhaps have to get his water from a tank or creek that is used by large herds of cattle and is anything else but healthy, to say nothing of its uncleanliness.

By proper efforts water in abundance can be had by some of these methods in every part of the county, and at small cost.

BUILDING MATERIAL.

Sandstones are everywhere abundant in this county, and many of them would make good building material. No quarries have been opened except in a small way. The court house and other buildings in the town of Breckenridge have been built of this material. The stone is similar to the best sandstone in the Carboniferous formation in the State.

The limestones in places are very compact and hard, and would make excellent buildings or piers for bridges. In the vicinity of Crystal Falls it lies in beds of from six to eighteen inches thick, and has been used to build the piers of a bridge across Hubbard Creek near that town. There are many places in the county where this kind of material is abundant.

Clays for making brick can be had abundantly almost anywhere that such material is desired for use. There is plenty of fire clay in the vicinity of the coal beds.

Some of the limestones will make good quicklime, and sand can be had without much trouble.

Sand for making mortar or cement can be had at little cost of time or trouble.

COAL.

Coal has been known to exist in this county for a long while, but it has been so far from lines of transportation that it has only been developed and used in a small way. When the United States soldiers were stationed at Fort Griffin they used to come down to this locality and get the coal for use at the fort, but since their removal and the fort's abandonment there has been but a small demand for the coal.

The following descriptions are of the various outcrops in the county as I have seen them. They are all in Seam No. 7, and are of the same character of coal as that found in the vicinity of Belknap and other places in Young County.

The coal seam passes through the northwestern part of the county, entering it at or near Crystal Falls, and thence extending southwestward, leaving the county on its south line, near Sandy Creek. Excellent localities for coal mining can be selected at a number of places in the county.

Plate XIII will show the several places mentioned.

JAKE WIZEART MINE.

About three-fourths of a mile southwest of the town of Crystal Falls is the Jake Wizeart mine. More work has been done at this place than at any other opening in this county.

A tunnel has been driven into the hill for a distance of four hundred feet on the seam, and a cross-tunnel one hundred feet long has been made at right angles with the first. At the distance of three hundred feet from the mouth of the tunnel an air shaft has been put down.

The following section was made at this locality. Beginning at the top:

1. Shaly sandstone	10 feet.	
2. Slate	4 feet.	
3. Coal		6 inches.
4. Shale		4 inches.
5. Coal	2 feet.	
6. Fire clay		10 inches.
Total	17 feet	8 inches.

In this mine the four inches of slate between the two seams of coal will have to be taken out of the mine, for the reason that it is highly impregnated with sulphuret of iron, and on being broken down and exposed to the atmosphere will cause spontaneous combustion and set the mine on fire. This mine was once on fire for several months, caused by a miner carelessly leaving the material broken down for a couple of days in the mine. The necessity for removing this material from the mine will materially increase the cost of mining.

Coal has been taken from this mine for several years to supply a local demand in the surrounding towns.

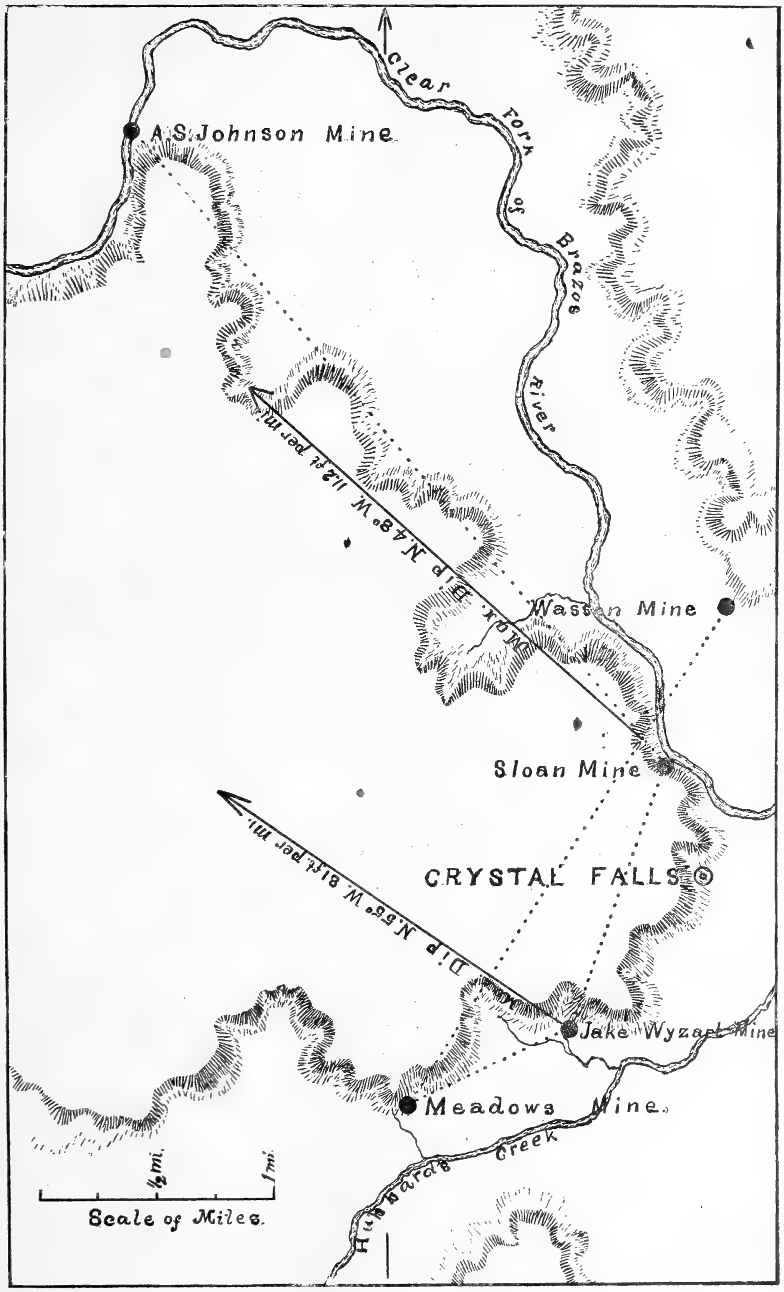
BERRY MEADOWS MINE.

About one-half mile west of the Wizeart mine, on the land of Berry Meadows, an open tunnel or cross-cut has been made in the side of the hill for about fifty feet on the seam of the coal, and coal taken out to some extent to supply the demand at Breckenridge. The seam at this place presents much the same general appearance. It has the same band of pyritiferous shale that was seen at the other locality. The roof is good, and the hill above the seam rises to a sufficient height to give good covering. There has been very little work done here for several years.

At another locality, about half a mile still further southwestward from the Berry Meadows mine, another opening was made in the head of a ravine, that shows about the same conditions as at the other two localities. Where the clay below the seam of coal can be seen it has the nodules of hard sandstone embedded in it which is characteristic of this bed of clay wherever exposed.

In the sides of the hills facing to the south along Hubbard's Creek in this vicinity, the seam of coal shows in many places.

PLATE XIII.



VICINITY OF CRYSTAL FALLS, STEPHENS COUNTY.

On the south side of Hubbard's Creek, about one mile from the Berry Meadows mine, there is another outcrop of the same seam of coal.

SLOAN SHAFT.

One mile north of the Jake Wizeart mine, on the north side of the hill fronting on the Clear Fork of the Brazos River, an opening has been made on the coal seam that shows the seam to be about the same as at the other places mentioned in the vicinity.

On the north side of the Clear Fork of the Brazos, and about one and a half miles north of Crystal Falls, is the Wasson mine. The coal outcrops in the head of the hollow, and is about at the same level as the Sloan mine. There is over this seam the same shaly limestone as seen at the outcrops and shafts on the south side of the river, and it is evidently the same seam. A tunnel has been driven into the hill at this place directly north one hundred feet, following the coal. The coal at this place is thirty-six inches thick, with the same seam of shale as seen at the other places. Here it is six inches thick. The bottom layer of coal is twenty inches thick and the upper layer sixteen inches thick.

ALBERT SIDNEY JOHNSTON MINE.

About six miles west of the town of Crystal Falls, on the Albert Sidney Johnston survey, the coal seam is in the bed of the Clear Fork of the Brazos and is always covered with water.

It was at this place that the United States soldiers when stationed at Fort Griffin used to get their coal. They would wade into the river and with levers prize up the blocks of coal and float them to the shore and load them on their wagons. This is the same seam (No. 7) as was seen at Crystal Falls. A few years ago Charles A. Ashburner, of the Pennsylvania Survey, visited this place, and his report of the locality put the bed of coal at this place forty-five feet below the seam at Crystal Falls; but this could not be for the reason that the strata dip to the northwest, and this locality being west of Crystal Falls it would necessarily be at a lower height than at Crystal Falls. I ran in a line of levels between the two places and traced the outcrop from hill to hill as well, and know that it is the same seam.

The seam could not be examined with any degree of satisfaction at this place, as it was at least two feet under water. Its thickness has been reported as at least four feet, but I do not consider the report as any way reliable. The seam will have to be worked at this place on the west or north side of the river. There is, however, a high hill on the east side that will furnish very good cover, but the probabilities are that the covering is poor in the valley on the east side of the river in the Johnson Bend.

The available coal area in this vicinity is at least eight miles wide. Five miles southwest of Crystal Falls there is another outcrop of the seam, and again about eight miles southwest, at a place called Coal Mountain, the coal crops out on all sides of the hill. On the eastern side of the mountain the coal is twenty inches thick, with a band of slate four inches above, and then a seam of coal nine inches thick. Considerable prospecting has been done here at one time, and the coal mined was taken to Fort Griffin, but since the removal of the troops from that place the work has been abandoned.

Above this seam at the height of ten feet at this place another seam comes in that is ten inches thick, and again about ten feet above that is another seam one foot thick That the lower seam mentioned at that place is No. 7 and the same as seen at Crystal Falls there is no doubt. The very characteristics of the coal and the inter bedded band of slate, as well as the shale containing the hard sandstone concretions and pieces of selenite, would prove it the same, but the seams above are local and have not been seen elsewhere.

At a hill about one-fourth of a mile southwest of Coal Mountain there is another outcrop of Seam No. 7, showing the same parting of clay and the same clay containing the hard sandstone concretions.

Again, at the mouth of Sandy Creek, in the channel of that creek, the seam again outcrops. At this place all the strata above the coal have been destroyed and the sand and gravel deposited on the top of the coal seam. Again the hard concretions of sandstone are seen in the clay below the coal seam as at the other places.

On Sandy Creek, about fourteen miles southwest from Breckenridge and one mile and a half above the old road from Belle Plain to Breckenridge, the coal outcrops in the bed of the creek. The upper stratum above the coal has been destroyed and the gravel has been redeposited on the top of the coal. If it shall be found desirable at any time to open the seam at this place sufficient cover will be found by going a short distance westward to where the hills rise to the height of one hundred feet or more above the valley of the creek.

BROWN COUNTY.

TOPOGRAPHY AND DRAINAGE.

This county is traversed from the northwest to the southeast nearly through the centre of the county by Pecan Bayou, a stream of considerable size and having its source near the western line of Callahan County.

Jim Ned Creek, a large affluent of Pecan Bayou, comes in from the west side, running into the bayou twelve miles north of the town of Brownwood.

Several other streams flow through the county in various directions. The county is bounded on the south by the Colorado River. The entire drainage is from the northwest to the southeast.

The topography of the county is varied. The hills along the larger streams are high and often precipitous. There has been great erosion in this part of the State, which has left in places high hills and bold escarpments. In places the plateaus are broad and level and the creeks and river valleys are broad.

The high escarpment of the Cretaceous on the eastern side of the county stands out in bold relief. Here and there in the county are isolated buttes of Cretaceous strata.

GEOLOGY.

Brown County belongs partly to the Carboniferous and partly to the Cretaceous formations, the greater part to the Carboniferous.

The high hills along the eastern border of the county are Cretaceous, and there is a belt of the Cretaceous between Pecan Bayou and the Colorado River southeast of Brownwood and extending as far west as the upper road from Brownwood to San Saba. The Carboniferous of the county is about the middle portion of the formation in Texas. The limestone at the mouth of Jim Ned Creek is the same bed that occurs at Rock Creek, in Jack County, and the bed south of Brownwood is the same as that found at the mouth of Keechi, in Jack County. Both of these beds of limestone are much thinner in the southern counties than in the counties farther north. The sea was deeper on the north during the Carboniferous times than along the south, and this was to have been suspected from the fact that the sea shore in that time was only a short distance farther to the south in Llano County.

The sandstones in the southern part of the county are the same as found above the coal at the Texas and Pacific mine, in Palo Pinto County.

SOIL.

The soils of Brown County are principally of three kinds, whose character is determined by the strata from which they were derived. The Trinity Sands of the Cretaceous has contributed largely in places to the soil making, and where that is the case they are quite sandy. Yet there are no more fertile soils in the county than these. The limestones and clay beds of the Carboniferous have made other soils, which are black and in places more or less sandy, the sand coming from the disintegration of the Carboniferous sandstones. Another class of soils are those made from material beyond the limit of the county, that have been brought there during the period of erosion or by the floods during overflows in the rivers and larger creeks.

The native growths of plants and grasses show that the soil is fertile. The crops of grain and cotton which have been raised there from year to year show that the soils are productive.

Pecan Bayou has many broad valleys that are of superior quality for agricultural purposes.

TIMBER.

Brown County is partly within the belt of the "Upper Cross Timbers," yet there are wide stretches where there is not much timber of the class found farther north. There are fine groves of pecan timber along the creeks and rivers. Evidently Pecan Bayou took its name from the prevalence of that kind of timber along its entire course. Its groves of pecan timber can not be excelled in the State.

There is plenty of timber everywhere for domestic purposes. The pecan nuts gathered in this county almost every year amount in value to many thousands of dollars. A few years ago it was the custom of those wanting nuts to go into the forest and gather what was wanted, either for home use or for market, without regard to the ownership of the land; but now all that has been changed, and the owners of the groves either lease the groves for so much per year or have the nuts gathered at so much per bushel. There are trees along the valley of Pecan Bayou that will yield as much as ten bushels of nuts per year. The price of the nuts ranges from two to three dollars per bushel.

WATER.

Water for stock purposes is generally abundant in the creeks and rivers, yet it has been necessary in places to construct artificial ponds or tanks for this purpose. Wells can usually be found with little trouble. There are places, however, where the clay beds are very thick, and it is almost impossible to get water at a reasonable depth.

Deep wells in the vicinity of Brownwood have proven that water can be obtained at a depth of one thousand feet or more that will probably flow at the surface on proper casing.

BUILDING MATERIAL.

The sandstones of the Carboniferous in this county make excellent building material. In almost every neighborhood in the county a good quarry of this kind of stone may be found. Only a few such quarries have been opened in the county. Some of the buildings in the town of Brownwood are constructed of this material.

The limestones in places are good building material. They are easily quarried and are of an excellent color. They are not so easily worked as the sandstones, and have not been utilized to any very great extent. The limestones make a good article of quicklime when properly burned.

BRICKS.—Good clay for brick making can be had at many localities. The quality of brick made is good. For ordinary purposes they are as good as any in the State. The clays are abundant in the county for making the very best quality of bricks, but are not always mixed with the proper amount of sand; but this defect can be easily remedied, as there is sand in abundance in easy reach of any given locality. Again, other clays are too sandy and make brick that are not sufficiently compact to stand heavy pressure. But mixing a portion of the clay found everywhere in the Carboniferous strata will very readily remedy this defect.

OIL.

In a well at Brownwood oil has been found that rises on the top of the water and is brought up in the buckets. The amount is small, probably only a few gallons per day.

Recently a company has been organized to prospect for oil in this vicinity and determine the extent of the oil bearing field and the quantity to be obtained.

COAL.

Very little coal has been found in this county, and there is not much prospect that workable beds will be found.

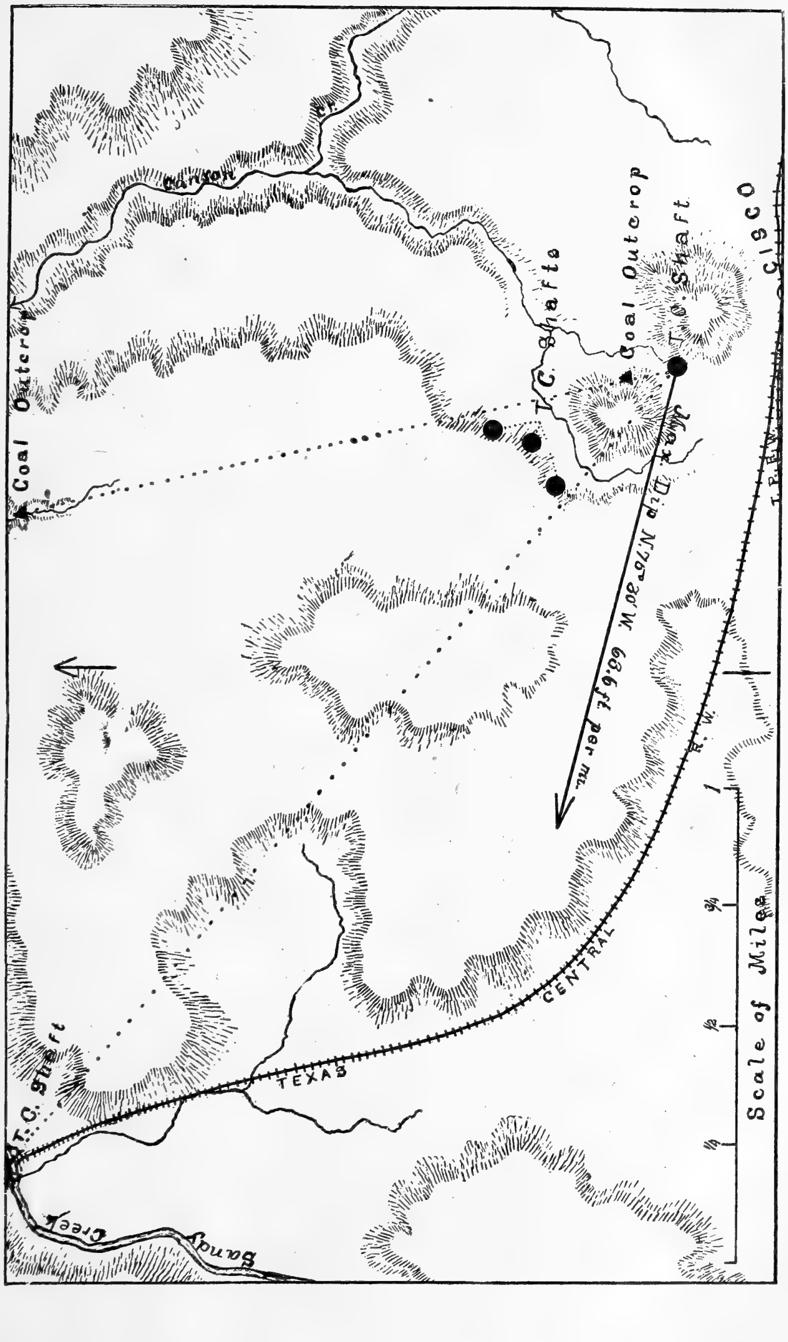
Coal Seam No. 7 crosses the northwest corner of the county. It crosses Pecan Bayou in the vicinity of Bird's old store and runs southwestward from there in the direction of Waldrip, in Coleman County.

EASTLAND COUNTY.

I have only examined that part of Eastland County which lies north of the line of the Texas and Pacific Railway, and will not attempt a description of any of its natural resources in the present Report except that of the coal in the northern part of the county. The only place where any prospecting has been done in this part of the county is near Cisco.

The mines at Cisco are on seam No. 7. At one time and another there has been considerable work done on this seam in the vicinity of Cisco. The outcrops are numerous. The seam is twenty inches thick, with a band of slate above it, followed by a seam of coal four inches thick. The band of slate is from four to ten inches thick between the coal seams. At another place where I examined this seam there are nine inches of coal and twenty inches of bituminous shale.

PLATE XIV.



VICINITY OF CISCO, EASTLAND COUNTY.

This shale will burn when put on the fire, but loses none of its bulk in burning, and is absolutely worthless as a fuel. There is no probability that this seam can be worked in this particular locality, owing to the thinness of the seam and the further fact that the stratum of bituminous shale will have to be taken out of the mine, for it is so highly impregnated with sulphuret of iron that when the material is exposed to the atmosphere and it begins to slack, the sulphuric acid escaping will set the whole mass on fire. The seam may be thicker at some distant locality, but there is no hope that it will change for the better anywhere near Cisco. Four miles from Cisco, to the northwest, on the line of the Houston and Texas Central Railway, this same seam of coal was found about the level of Sandy Creek. A good deal of work was done at this place several years ago, but the mine has been abandoned on account of the fact that the seam was too thin for successful mining. Attempts have been made to develop this seam in several other places, with like results."

Plate No. XIV will give the relative position of the various localities in this vicinity where the coal has been mined.

It has been reported that coal is found in the vicinity of Carbon, in the southern part of the county. If it is there it will probably be seam No. 1, the same as at Thurber, and might be of commercial importance I was unable to visit that locality when in the county.

COLEMAN COUNTY.

TOPOGRAPHY AND DRAINAGE.

This county is comparatively level, except where it has been crossed by the larger creeks. The hills on the south side of the county are bold escarpments, caused by erosion and the fact that the strata dip to the northwest. In the northern part of the county the high hills are mostly confined to the narrow strips along the creeks.

The drainage on the south is into the Colorado River, and on the north into Pecan Bayou.

The Colorado extends along the entire southern border of the county, making the division line between this county and the counties on the south. Bull Creek, Camp Creek, Home Creek, and Mukewater are large creeks flowing into the Colorado River. Jim Ned runs along the northern side of the county.

GEOLOGY.

Coleman County belongs entirely to the Carboniferous formation, except the high hills known as Santa Anna Mountains, which are two isolated Cretaceous buttes that have been left at the time of erosion which uncovered the Carboniferous strata in this part of the State.

The upper part of the Texas Coal Measures is the only part found in the county. As compared with the northern part of the State, there are no strata below Coal Seam No. 7, except a small area in the southwestern part of the county.

There are many fossils found in different parts of the county. The following specimens were found just above the coal on Home Creek: *Spirifer cameratus*, Morton; *Productus nebrascensis*, Owen; *Fusulina clyindrica*, Fischer; *Hemiphronites crassus*, Meek and Hayden; *Myalina perattenuata*, Meek and Hayden.

SOIL.

The soils of this county have mostly been made from the underlying strata and are varied in character according to the different strata below.

There are broad, level plateaus in places that are the detritus left at the time of the erosion that carried away the Cretaceous. These soils constitute some of the best lands for agricultural purposes in the county. The clay and beds of shale are in places very thick, and this has formed broad plains extending back from an escarpment to where another stratum comes in, making the next line of escarpments.

The creek valleys are very fertile, being generally a black sandy loam, while in other places they are more inclined to be a red sandy loam. All are fertile and about equally productive.

TIMBER.

Only part of this county can be said to be well timbered. The timber is generally confined to the creeks and rivers, except that of the mesquite, which is abundant everywhere.

Post oak timber is plentiful in the southeastern part of the county, and the creeks and branches have enough timber in the prairie part of the county to supply domestic purposes. There is also some post oak timber in the northeastern part of the county.

WATER.

There is an abundance of water in every part of the county. The creeks are numerous and most of them have water in them the entire year. This county is famous for its fine stock ranches, and they are so because of the great abundance of water in them.

It is true that the grass in this county is of the very best quality—that of the curly mesquite—and is famous for that fact, but it is more so on account of its great abundance of water for stock purposes. Water can be had in shallow wells in every locality, and there are numerous springs in different parts of the county. No deep wells have been put down in the county except at Trickham, where some prospecting for oil has been done, and in the wells there only salt water has been found, which flows from the top of these wells.

BUILDING MATERIAL.

The Carboniferous sandstones are abundant in parts of the county, and wherever found make good building material.

The Carboniferous limestones are found in places, and are good. They are of uniform color, and are of such thickness of beds that they need no dressing except on the edges which are to be exposed in the building.

The Cretaceous limestone on the top of Santa Anna Mountain has been used extensively in this county. It is easily quarried and takes an excellent finish and is easily dressed by the masons. The supply of this place is practically inexhaustible.

This limestone makes good quicklime, as do also many of the Carboniferous limestones in different parts of the county. Clays for bricks are abundant in almost every locality, and where it is not already of the proper composition the necessary materials are near at hand and the manufacturer may mix the ingredients to his own liking so as to get the best practical results.

OIL.

At Trickham, in the yard of Hon. L. L. Shields, a well was put down for water. At a depth of one hundred feet a flow of salt water was reached and with it a small quantity of oil, which collects on the top of the water. No analysis of the oil has been made, and it seems to be about the same quality as that found at Brownwood. The geological horizon is probably about the same.

The extent of the oil bearing rocks in this locality has never been tested, nor the quantity of oil that might be obtained if desired.

NATURAL GAS.

In the well (already mentioned) of Hon. L. L. Shields, at Trickham, there is a flow of gas that would probably be abundant if the water was shut off. When the water is drawn out of the well rapidly a great volume of gas rushes out with a roaring sound.

About one mile west of this place another well was put down by Mr. Shields, on his place, and at a depth of two hundred and eighty feet a flow of salt water was found, and with it a flow of gas that will burn any time by lighting it with a match. When the water is taken out of the well there is such a rush of gas that if it is then lighted the flame will extend twenty-five or thirty feet high, and continue so until the water rises in the well and cuts off the gas supply. There is evidently a good deal of gas in this vicinity, and if there was any demand for such material within reach it would be developed very soon.

COAL.

The coal in Coleman County is found along a line of outcrop running from northeast to southwest. It enters the county near the northeast corner and extends to Waldrip, on the Colorado River.

The seam is No. 7, of general section. About six miles west of the town of Trickham, on the Scurlock survey, near Home Creek, some prospecting has been done for coal, but it was not done in a very satisfactory manner, and the result was not encouraging. I am of the opinion that upon proper investigation a good bed will be found at that place. The coal outcrops in several places in that vicinity, along Home Creek and the lateral branches. No good coal can be expected east of Home Creek in that vicinity, and for some distance west of the creek the coal would be too near the surface to be free from atmospheric influences. The following section was made at that place. Beginning at the bottom:

1.	Sandstone	4 feet.	
2.	Yellowish clay	10 feet.	
3.	Bluish clay	8 feet.	
4.	Limestone, massive	4 feet.	
5.	Clay	8 feet.	
6.	Fire clay	2 feet.	
7.	Coal	2 feet	4 inches.
8.	Fire clay		10 inches.
9.	Bluish clay	20 feet.	
10.	Massive sandstone	8 feet.	
	Total	67 feet	2 inches.

Again, an outcrop is seen a few miles north of the town of Waldrip, on Bull Creek. At this place several shafts have been put down, and the seam outcrops at several places along the creek. The seam in places is almost entirely cut through by "horsebacks" from below. The seam is not persistent in thickness, but thins and thickens in short distances. I doubt if any place can be selected here that will be capable of very large development.

Mr. J. W. Gibson has done quite an amount of prospecting in this vicinity and in the valley of Little Bull Creek. The only shaft open at present is the one about one mile east of the road crossing on Bull Creek, and is west of the principal place of outcrop. The shaft is forty-eight feet deep. The coal is twenty-four inches thick at the bottom, then a parting of slate two inches thick, and then ten inches of coal.

In the bank of the creek four hundred feet east of the shaft the coal outcrops eight feet above the bed of the stream. There the lower stratum of coal is twenty inches thick and the upper stratum eight inches thick, with two inches of slate between them. Again, about three-fourths of a mile up the creek, about northeast, the coal outcrops on the west side of the hill, showing about the same condition. There are several outcrops on the eastern side of the creek, and some prospecting has been done on the seam, but none of the shafts could be entered at the time of my visit. In the vicinity of Gibson shaft, near the mouth of Bull Creek and three miles northeast of the town of Waldrip, I made the following section. Beginning at the top:

1.	Limestone	3 feet.	
2.	Sandstone	10 feet.	
3.	Clay	40 feet.	
4.	Sandstone	3 feet.	
5.	Shaly limestone	2 feet.	
6.	Clay	6 feet.	
7.	Coal		10 inches.
8.	Slate		2 inches.
9.	Coal	2 feet.	
10.	Fire clay	2 feet.	
11.	Sandstone	3 feet.	
	Total	72 feet.	

There has been some prospecting for coal done on the south side of the river near the town of Waldrip, mention of which will be given in this connection, as it is not intended to give a detailed description of McCulloch County in this Report. About one-half mile west of Waldrip is the Fink mine. The shaft is eighty-four feet deep. The coal is twenty-eight inches thick, with two partings of slate. The owners of the mine took the trouble at the time of my visit to clean out the shaft, as the work had been abandoned for some time, so that I could make a personal inspection of the workings. An entry has been driven into the seam in an easterly direction for a distance of fifty feet and the coal taken out for several feet on each side of the entry. The coal is cf fair quality, but other prospecting will have to be done before the question of the quantity of coal in the vicinity can be determined. The trouble about the seam in this part of the State is that it is not persistent in thickness. It sometimes changes very rapidly in short distances. The Williamson shaft is about one mile northeast of Waldrip. A few years ago a company at heavy expense put down this shaft, eight by eight feet, and timbered it from top to bottom with pine lumber two inches thich, hauled a long distance, and when they finally reached the coal, at a depth of one hundred and sixty feet, it was only one foot thick, and the work was abandoned at once. No one should go to such heavy expense in the way of development until sufficient prospecting has been done to definitely determine the thickness and extent of a coal seam in any given locality. Where a seam has a tendency to thin out rapidly in a locality—and this fact can generally be determined by an examination of the outcrop—there should be a great number of the cheapest kind of prospect holes put down with the sole object in view of testing the thickness of the seam in that particular locality.

The Chaffin mine is about two miles southeast of this shaft. At this place the seam outcrops in a small creek, immediately below a shaly limestone, and is twenty inches thick. At various times in the past coal has been taken out of this place for various purposes. The mining was done by following the seam from the surface a few feet. No prospecting has been done to determine the extent of this thickness in the immediate vicinity.

On John Kellett's farm, about three miles southwest of Waldrip, a drill hole has been put down three hundred and twenty-four feet, near the bank of the river. Out of this hole flows a stream of salt water which by analysis gave thirty pounds of common salt to one hundred gallons, with a trace of iron. With the water comes up a flow of gas sufficient to keep a constant flame burning several feet high. No effort has been made to test the quantity of gas in this locality.

ANALYSES OF TEXAS COALS.

Locality.	Water.	Volatile matter.	Fixed carbon.	Ash.	Sulph'r.
1. Bridgeport, Wise County	2.00	31.47	56.32	8.15	2.06
2. Sheuber shaft, near Bowie, Montague Co.	2.30	34.48	61.28	0.60	1.14
3. Gilfoil shaft, Young County	1.10	35.50	43.00	15.60	4.60
4. Thurber, shaft No. 1	0.85	31.23	56.98	9.30	1.64
5. Thurber, shaft No. 2	0.90	30.96	60.01	6.85	1.28
6. Thurber, shaft No. 3	0.90	33.51	53.46	10.65	1.48
7. Waldrip, McCulloch County	4.55	38.50	44.80	12.14	7.96
8. Bull Creek, Coleman County	10.40	35.94	49.46	4.19	1.53

NOTE.—The coal of Nos. 3 and 7 in this table of analyses were samples taken from the dump, and were not fair specimens of the coal at these localities.

APPENDIX.

HADROPHYLLUM, E. & H.

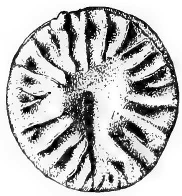


Fig. 60.

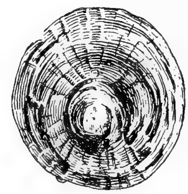


Fig. 60a.

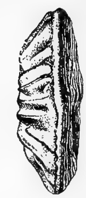


Fig. 60b.

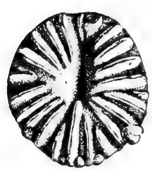


Fig. 61.

Fig. 61a.

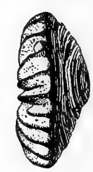


Fig. 61b.

EXPLANATION OF PLATE.

Fig. 60. Calycular view, natural size.
Fig. 60*a*. Under side of same example.
Fig. 60*b*. Side view of same example.
Fig. 61. Calcyular view, natural size of a smaller example.
Fig. 61*a*. Under side of same example.
Fig. 61*b*. Side view of same example.

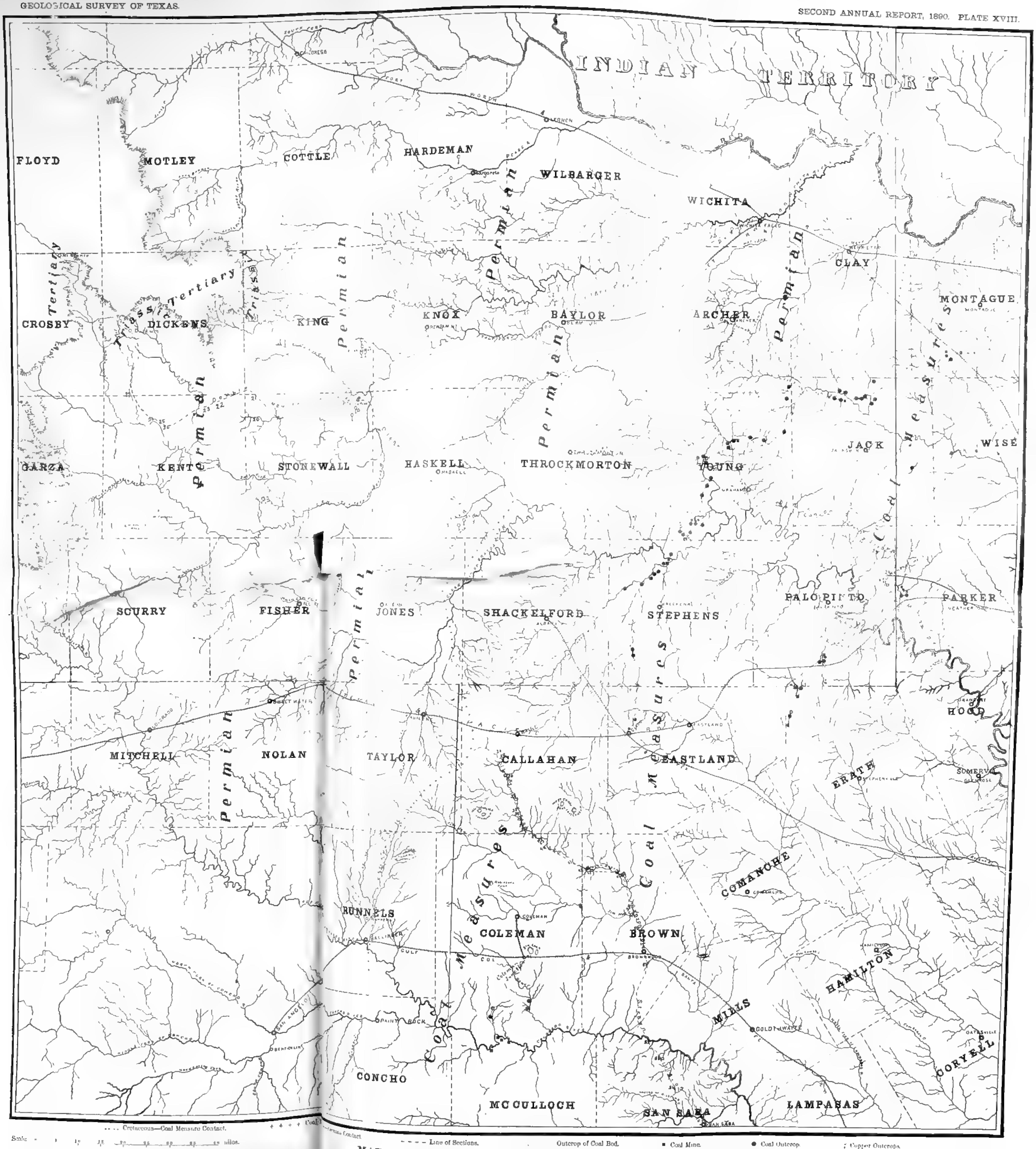
H. APLATUS, sp. nov., Cummins.

Corallum flattened, discoidal; periphery attenuated; under side nearly flat and marked by concentric wrinkles; upper side convex; fossette deep, reaching from the centre to the periphery; septa prominent, extending from the fossette to the margin, single, numbering from twenty-one to twenty-five. Transverse diameter twenty-six mm. Thickness seven mm. in full grown individuals.

The bilobed bodies which appear near the edge of the specimens, and which are shown in the drawings, are perhaps parasites.

This species differs from *H. glans*, White, in the number of the rays and the length of the corrallum.

Locality. Bend Division of the Carboniferous, which is at the base of the Coal Measures series in Texas.



MAP OF COAL MEASURES AND PERMIAN.

REPORT

ON THE

GEOLOGY AND MINERAL RESOURCES

OF THE

CENTRAL MINERAL REGION OF TEXAS

CHIEFLY SOUTH OF THE SAN SABA RIVER AND NORTH OF THE PEDERNALES RIVER, WEST OF BURNET AND EAST OF MENARDVILLE AND JUNCTION CITY.

BY

THEO. B. COMSTOCK, F. G. S. A.

REPORT

ON THE

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BY THEO. B. COMSTOCK, F. G. S. A.

SKELETON.

PART I.—GENERAL REVIEW OF GEOLOGIC STRUCTURE.

Outline of the geologic groups, for use of persons engaged in prospecting and development. Statement of the classification adopted, with chart showing the various terranes in chronologic order. General statement of the economic products of each main geologic horizon.

PART II.—ECONOMIC GEOLOGY.

How to use the Report for practical purposes. Plan of this part.

METALLIFEROUS DEPOSITS.

PRECIOUS METALS. *Gold.*—Possible sources stated, with results of assays, etc. *Silver.*—Sources of supply. Districts limited and ores discussed.

BASE METALS. *Copper.*—Belts defined, with descriptions of localities and cuts showing structure. *Lead.*—Districts outlined; outcrops illustrated and described. Review of the situation. Guide to prospectors. Table of assays for gold, silver, copper, and lead. *Tin.*—Full discussion of the present situation, with cuts showing the geologic conditions where tin ore has been found; character of ore and mode of occurrence Uncertainty of discovering the mineral in commercially important quantities. *Zinc.*—Absence from this district. Unsupported claims of discovery of zinc blend in 1890. *Manganese.*—Areas in which ores outcrop. Belts defined. Discussion of ores and modes of occurrence. Table II of analyses. *Iron.*—Extent and importance of the ores of the district. Hints regarding the development of the iron fields. Separation of the ores into five classes, individually discussed in detail, with location, description, and full treatment of the six great belts, or axes, including important hints concerning the mining of the ores. Table III, analyses of iron ores. Metallurgic review of iron fields. Probable future of the iron industry.

BUILDING STONES. *Granites.*—Seven classes, distribution and economic value. *Marbles.*—Three classes, their distribution and uses. *Limestones* and *Dolomites.*—Localities and character of material. *Sandstones*, *Slates*, *Schists*, *Clays*, and materials for *Cements*, *Lime*, *Mortars*, etc.

REFRACTORY MATERIALS. FICTILE MATERIALS. MATERIALS FOR PAINTS.

PART III.—SUPPLEMENT.

Additional notes on stratigraphic geology.

PART I.

GENERAL REVIEW OF THE GEOLOGIC STRUCTURE.

The area of Pre-Carboniferous rocks comprising the Central Mineral Region, as defined in the Report of this Survey for 1889,* was estimated at less than four thousand square miles. The more complete survey of 1890 has materially extended the boundaries of the tract by the discovery of uncovered Silurian and Cambrian strata in extensive fields hitherto supposed to be capped by the Cretaceous. The maps accompanying the present Report include only enough of the territory outlying to give a fair idea of the relations of the Pre-Carboniferous terranes to those of more recent origin. These sheets represent an area of six thousand square miles, of which considerably more than five thousand square miles contain exposures of an earlier date than the Carboniferous.

The preliminary classification of the strata of the Central Mineral Region, as announced in the Report of 1889, requires no important modifications after another season's field study. At least it may be stated that all the positive assertions there made have been confirmed by more extended observations, and none of the provisional announcements have been found erroneous.

At the same time, more office work is needed upon the collections before the paleontological evidence of the tripartite character of the Cambrian can be said to be clear, and there are still many problems which can only be solved by work of a much more detailed character than has been possible under existing circumstances. In the present Report the economic results must be given special prominence, for which reason the outline of the stratigraphy here introduced is prepared with the primary object of affording a kind of key to those whose practical needs preclude the task of selecting from the mass of technical description the particular details which apply to individual cases. Those who desire a more complete account should consult the First Annual Report of this Survey, pp. 339–391.

There are representatives of the Archean, Eparchean, and Paleozoic groups in the Central Mineral Region, which, as we now understand them, are regarded as the geologic equivalents of the Laurentian, Ontarian, Algonkian, Cambrian, Silurian, and Devonian systems of other parts of the United States. To avoid difficulties which might arise should our provisional correlations

*A Preliminary Report on the Geology of the Central Mineral Region of Texas. By Theo. B. Comstock, F. G. S. A. First Annual Report of Geological Survey of Texas. E. T. Dumble, State Geologist, Austin, 1890, p. 239.

hereafter prove inapplicable, and also because it is as yet impossible to make wholly satisfactory comparisons with the strata of remote areas, local names have been chosen to designate systems, series, and divisions. In a general way these terms also serve to indicate the strata which are abundant in particular localities; but it must not be inferred that these titles are ordinarily comprehensive enough to include the whole range of any terrane, although it may be so in individual cases. Thus the Fernandian system is named from excellent exposures of the rocks in a portion of the drainage area of San Fernando Creek, in Llano county, but this region by no means monopolizes the outcrops of that system, nor do the names Lone Grove, Iron Mountain, Llano, Katemcy, etc., respectively indicate the only localities in which the rocks designated by these cognomens are visible. The same remarks apply with equal force to all the nomenclature adopted for the various rock stages in our region.

The Taxonomic Chart* gives a condensed view of the geologic divisions as they have been worked out by the writer, corrected to January 1, 1891. This varies but little from the arrangement given in the First Annual Report, Plate III, but it may perhaps be found more convenient for reference, and its introduction into this volume will also facilitate the use of the geologic map of our region.†

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*The original names Burnetan, Fernandan, Texan, Niagaran have been changed to terminate in *ian*, to conform to the requirements of the International terminology.

† At the last moment it was found necessary to omit the coloring of the topographic map (Plate XXIII) which was prepared to illustrate the geology of this district.

STRATIGRAPHIC CHART SHOWING THE TAXONOMY OF THE ROCK GROUPS OF THE CENTRAL MINERAL REGION.

Arranged and Corrected to January 1, 1891.

Group (Era).	System (Period).	Series (Epoch).	Division (Age).	Beds.
	DEVONIAN.			Dark limestone, weathering yellow and porous. Possibly other beds. As yet uncertain.
	NIAGARIAN.			*Absent, unless part or whole of Deep Creek Division belongs here.*
				"Spongy" chert and "spongy" quartz.
				Dolomitic siliceous rocks.
			Deep Creek.	Massive chert.
				Thinly laminated tough cherty dolomites.
				Fine-grained siliceous dolomite.
		SAN SABA.		Slabby sponge bed.
			Hinton. — *Sponge.*	Sandy calcareous shale.
				"Hat" sponge beds.
				Calcareous shales.
PALEOZOIC.				Crystalline dolomite.
			Hinton. — *Birdseye.*	Mottled, or birdseye, limestone.
				Siliceous limestone, or semi-conglomerate.
	SILURIAN.			Fine-grained gritty crystalline limestones.
			Hoover.	Thin slabby fossiliferous limestone—Burnet Marble.
				Dark fucoidal limestone.
		LEON.	*Wyo.*	Brown weathering dolomites and brown shaly magnesian limestones.
			Beaver. — *Bluff.*	Siliceous magnesian limestones.
			Beaver. — *Cavern.*	Sandy shaly dolomites.
			Potsdam Limestone.	Limestone, calcareous.
		KATEMCY.		Conglomerate.
			Potsdam Flags.	Shales.
	CAMBRIAN.		*Potsdam Sandstone.*	White and red sandstone.
				Chocolate limestones, calcareous.
		RILEY.		Sandstones, sandy shales.
		HICKORY.		Massive sandstones, coarse conglomerate.
	TEXIAN,	PACKSADDLE.		Marbles and shaly beds.
EPARCHEAN.	OR	LLANO.		Quartzites and sandstones with eruptives.
	ALGONKIAN.	MASON.		Sandy shales and schists.
		CLICK.		Calcareous rock.
				Chloritic slates and shales.
	FERNANDIAN,			Carbonaceous schists.
	OR	IRON MOUNTAIN.		Ferruginous rocks.
	ONTARIAN.			Quartzites.
				Acidic schists.
ARCHEAN.		VALLEY SPRING.		Basic schists.
	BURNETIAN,	BODEVILLE.		Mica and chloritic schists (chiefly *Acidic*).
	OR	LONG MOUNTAIN.		Hornblende and pyroxene rocks (*Basic*).
	LAURENTIAN.	LONE GROVE.		Gneiss, granites, etc.

I. ARCHEAN GROUP.

The Archean rocks in this portion of Texas are those which make up the greater part of Llano County and the eastern half of Mason County, extending also into western Burnet County and the adjoining portions of Blanco and Gillespie counties on their north line. The rocks are essentially crystalline, and within the belts which they occupy are to be sought most of the rare minerals and valuable metallic ores of the district. There are two well marked systems which have such pronounced features as seem to entitle them to be placed as the probable equivalents of the Laurentian and Ontarian systems, respectively, of British America and the Northwestern United States. Our strata are apparently more nearly related to those exposed in the region of Lake Superior and the Lake of the Woods.

1. BURNETIAN (LAURENTIAN) SYSTEM.

The oldest rocks are gneisses, gneissic granites, and schists, which, in most exposures, trend north 75° west, or within 6° of an east-west line by compass bearings. They usually dip at high angles and can often be traced readily for long distances be repetitions of their peculiar exposures. In places where later trends have partially cut them out they may sometimes be turned into different courses, but this complication is only occasional, granitic and feldspathic dikes of later date having confused the structure in some places, however. Mounds of white quartz, often carrying black and greenish micas in large plates, are especially characteristic, and in these the rare minerals are apt to be found. Belts of garnet deposits are another feature, and the tin ore recently discovered by the writer occurs in this system. Masses of feldspar and graphic granite and a great variety of interesting minerals abound over the areas in which these rocks are uncovered. A separation into series has been attempted, although it may be doubted if we have knowledge enough to make distinctions which will stand the test of the most thorough study.

1. LONE GROVE SERIES.

The basal gneisses and gneissic granites, or granitoid gneisses, with the graphic granites and some felsite porphyry carrying the belts of rare minerals, are now regarded as a separate series, which is fairly exemplified in the vicinity of Lone Grove. This terrane crosses the Central Mineral Region probably in three or more axes, and it is especially prominent in the eastern half of Llano County and over a limited area in western Burnet County, although it extends well into Mason County. The search for tin ore should be conducted along these lines.

2. LONG MOUNTAIN SERIES.

Such rocks as belong to the Burnetian trend, which carry garnet, serpentine, and the heavier green and dark colored iron bearing minerals, are for the present classed in a separate series. They occupy belts parallel with the axes of the Lone Grove Series and lying between them. Exposures occur on Clear Creek and Spring Creek, in Burnet County, and in the country adjacent to Long Mountain, in Llano County, as well as in the heart of the King Mountains farther west. The soapstone of Llano County is largely, if not wholly, in this terrane, and serpentinous rocks mark its course in Gillespie County. Mason County has also some good exposures.

3. BODEVILLE SERIES.

A marked aggregation of micaceous schists extends in belts alternating with the Lone Grove and Long Mountain series in the same Burnetian trend. It is not known that any of these rocks carry accessory minerals of particular value, but some of them possess qualities which make them useful as they are for special purposes.

2. FERNANDIAN (ONTARIAN) SYSTEM.

One of the most important systems, considered economically, is the Fernandian, which has a trend almost exactly northwest by the compass. Its true course is north 36° west, but in practice it will be more convenient to follow the ordinary compass bearing. Care must be taken, however, to make numerous observations in order to avoid errors which may arise from local attraction by the large deposits of iron ore which occur in these strata. The rocks here included commonly dip at angles above 35°, and from that pitch to vertical or nearly so. They may be found involved in later uplifts, as in a narrow belt west of Packsaddle Mountain, in Llano County, but it is not usually difficult to recognize them in good exposures, comparatively few of which fail to show some evidences of the original course. The vast beds of the richer iron ores and other accumulations of economic importance will cause this system to become better known than any other in the region, so that the only precaution necessary in most cases is to avoid confounding the Fernandian rocks with some similar deposits of the later Texian System, the different trend of which is rarely inappreciable. The Fernandian strata have been much folded and subsequently denuded, resulting in numerous bands or belts traversing the country in which they are predominant. Besides the iron ores, important manganese ores, graphite, marble, etc., are very abundant, and the outcrops of these often aid materially in tracing the former. In all the complete sections yet examined there are practically seven distinct beds, which admit of a fairly satisfactory grouping into three geologic series, as below:

VALLEY SPRING SERIES.

Certain schists in the northwest trend, having for the most part a granular or friable texture, form the base of the Fernandian System. These are of two varieties, one being green or black or dark gray in color and carrying hornblende, the other resembling more nearly the earlier micaceous schists. Some of the members of this series are slaty, but there are also thick beds of more massive character. One of the best regions for studying the former is near the head of the Little Llano, east of Babyhead Postoffice. The latter set is well developed on Phillips and Johnson creeks, not far from Valley Spring.

IRON MOUNTAIN SERIES.

The extensive outcrops of magnetite and hematite in Llano and Gillespie counties in their original situations belong to the middle of the Fernandian System. The ores are usually underlaid by fine-grained yellowish quartzites, which shade off below into the earlier mica schists, and above into the magnetites. Overlying the iron ores there is a set of carbonaceous rocks comprising graphite schists and graphitic clay slate, and above these may sometimes be recognized a slaty chloritic schist. Special consideration of the iron Mountain series will necessarily be given in the discussion of the economic values and relations of the ore deposits. It is possible that graphite deposits of some value may be found in this series.

CLICK SERIES.

The marbles of the Fernandian System must not be confounded with those of the succeeding Texian period. The Click marbles are usually blue, weathering almost black. They are prominent in the area of the iron ores, but are less characteristic of the best mining tracts than of special districts where those are largely unexposed. Near the town of Llano, east of Valley Spring and between Packsaddle Mountain and Honey Creek Cave, there are outcrops of several parallel bands in which the marbles are thoroughly crystalized.

II. EPARCHEAN GROUP.

A group of strata of later origin than the Archean and unconformable thereto, upon which the Cambrian terranes are not conformably placed, is regarded as Eparchean, because of its relation in general to the rocks which have been so designated by members of the United States Geological Survey. Only one system is recognized in Central Texas.

3. TEXIAN (ALGONKIAN) SYSTEM.

Walcott's Algonkian System, composed of Powell's Vishnu, Grand Canyon, and Chuar Series, is in many respects parachronous with our Texian System, which includes three very similar series of strata. In Central Texas the primary trend of the series is within less than 1° of a true north-south course, or about north 10° west by the uncorrected compass bearing. As with the earlier systems, this has a particular region for its best expression, and in districts not too much disturbed by more recent upheavals it is easy to distinguish the characteristic strata. They are sometimes tilted at high angles, but frequently less than 65°, down to 30° or less. Many of the rocks have a general resemblance to some of the Fernandian members, but it is usually possible to detect signs of wear in the particles, implying an origin in part from the degradation of the earlier formed terranes. Shales, sandstones, or quartzites, and clear white crystalline marbles are characteristic The areas of best exposure are in the eastern half of Mason County and in the southeastern corner of Llano County. The most important economic feature is the occurrence of a very interesting class of minerals carrying rare metals.

MASON SERIES.

The sandy shales and schistose rocks which characterize the Mason series are such as might readily be formed from the erosion of the gneisses and schists of the Burnetian System, which were well exposed where these were deposited. They are especially prominent in the upper valley of Comanche Creek and in much of the region about Mason, more especially northward from that town.

LLANO SERIES.

This was the series first reported by Mr. Walcott as seen by him in subcontact with the Cambrian sandstone of Packsaddle Mountain. But there it is not in the axis of a Texian uplift, owing to important subsequent upheavals which have obscured the earlier history. Good exposures in the characteristic north-south trend occur farther southwest at the eastern base of the Riley Mountains and at the northern edge of the same irregular range, a few miles west of Sharp Mountain. The rocks are granular quartzites, or sandstones, and platy quartzite rocks of more dense texture, with green schists alternating with them in some sections. The intersecting belts of glistening iron ores near Fly Gap, Mason County, at the source of Herman and Willow creeks, are probably in this terrane, although their occurrence is due to special and local influences.

PACKSADDLE SERIES.

The best normal outcrops of the highest Texian series are in Llano County, south of Packsaddle Mountain, and in a small area in Mason County, coincident with the earlier series. In other places, as west of Packsaddle Mountain, in Llano County, and near Niggerhead Peak, in Burnet County, they are not always lying in the position into which they were thrown by the uplift next succeeding their deposition. The marbles and graphitic shales of this set may be mistaken for the Fernandian strata of similar appearance, but close inspection will enable one to distinguish each from the other. The Packsaddle marbles are clear white, usually weathering yellow, unlike the dark weathering blue marbles of Fernandian (Click) time. The graphitic shales of the Packsaddle series are plainly detrital, as far as we have observed them, while the Fernandian (Iron Mountain) graphitic schists are crystalline and more evidently foliated. In the majority of exposures the trend of the beds is sufficient to determine the system without much further examination.

None of the graphite of this series is liable to possess any important commercial value, in my judgment, after the tests which have been made by myself and the chemists of the Survey.

III. PALEOZOIC GROUP.

The Paleozoic rocks of Central Texas are made up of sandstones and limestones, and their exposures occupy all the territory outside of the crystalline rocks which is not covered by the so-called "mountain limestone," or Cretaceous. Excepting a few small patches of Carboniferous rocks on the borders, and limiting the area to what is known as the Central Mineral Region, this statement is explicit enough as a general description of the strata included in the present review. For the certain detection of minor terranes a knowledge of the fossils is necessary, but the descriptions here given will aid in their determination roughly. They lie chiefly as irregular fringes around the borders of the earlier rocks and adjacent to the Cretaceous escarpment, except upon the north, where the contact with the Carboniferous forms much of the boundary line. We have representatives of the Cambrian and Silurian systems in profusion, and there is also a rather persistent but moderate development of the Devonian, as the writer now regards it. The Niagarian (Upper Silurian) Period has no representatives which can certainly be recognized as such at the present writing, although it is possible that the upper part of our provisional Silurian may really belong to that system.

4. CAMBRIAN SYSTEM.

The Cambrian rocks include sandstones, shales, and limestones, usually not very thick-bedded except in the case of some of the tough conglomerates near the base of the system. Red, white, and green colors are largely characteristic and false bedding is very common. There are few compact layers and many of them are friable. They are well represented in the western part of Burnet County, and in parts of Llano County, but more extensively in Mason County, the areas of exposure extending also into Blanco, Gillespie, Kimble, McCulloch, and San Saba counties. Valuable sands and important deposits of iron ore (hematite) occur in special localities described elsewhere in this Report. Three series have been provisionally announced by the writer, but it is not an easy matter for one unacquainted with geology to distinguish the strata of the different sets.

HICKORY SERIES (LOWER CAMBRIAN).

The lowest Cambrian series is not present in all sections, but in places in Burnet, Llano, and Mason counties there occurs a peculiarly dense yellow to white sandstone of non-homogeneous texture, containing grains and small rounded pebbles of white quartz with similar inclusions of darker hue. This occurs in beds of great thickness, and sometimes mounds of it are left with a glassy exterior. Such are the Castle and similar monumental elevations in Mason County, on Little Bluff Creek, also near a branch of Katemcy Creek, and at other points. This sandstone forms the base of the sandstone capping of Packsaddle Mountain, and it is well displayed on House Mountain, Smoothing Iron Mountain, and elsewhere. In some sections it is underlaid by a coarse conglomerate carrying larger quartz fragments.

RILEY SERIES (MIDDLE CAMBRIAN).

This is a geologic division not yet securely established, although the writer believes it is founded upon good stratigraphic evidence. The rocks included are sandy shales, calcareous sandstones, and chocolate sandy limestones, such as abound in portions of the Riley Mountains, in Llano County, and farther west in the southern part of Mason County.

KATEMCY (POTSDAM) SERIES (UPPER CAMBRIAN).

There are three well marked divisions in the highest set of Cambrian Rocks, as below:

1. THE POTSDAM SANDSTONE.—Red and white and green fine-grained sandstones, with some coarser layers, especially well developed, as an inner fringe along the northern border of the Central Mineral Region, but not restricted to that area.

2. The Potsdam Flags.—Shales and thin-bedded limestones exposed in good sections along Beaver Creek, Burnet County, and near Camp San Saba, McCulloch County, but also visible in many other Potsdam sections. (See photo-engraving, this Report.)

3. The Potsdam Limestone.—A peculiar shingly limestone conglomerate, overlaid by limestone (fossiliferous) of a greenish color in large measure, characteristic of the Cambrian sections in the northwest, but appearing in other places.

5. SILURIAN SYSTEM.

As a whole the Silurian* of Central Texas is a system of siliceous dolomites and chert. There is some variety in the beds, but they embrace the so-called "marbles" and their associates, as distinguished from the "mountain limestone" of the local vernacular. The topography of the Silurian region is uneven, the creeks running much in canyons, and agriculture is chiefly confined to the bottom lands along the streams. The soil is usually thin and strewn with rocks, making wagon travel across the country very difficult. Almost the whole of the region where these strata outcrop is used for grazing, and there are no important minerals besides the veins of calcite and hydrated iron ores of limited extent. The Silurian beds lie upon the outer borders of the Central Mineral Region, being well developed in parts of Burnet, San Saba, McCulloch, Mason, Blanco, and Gillespie counties, and to a slight extent in Kimble County.

The best stratigraphic classification which we have yet been able to adopt is that announced in the First Annual Report of the Survey,† making two series, as below:

LEON SERIES.

The lower members of the Silurian System are shaly at base, becoming gradually less impure and even crystalline at the summit of the Leon series. They are best exposed in Burnet, McCulloch, and Mason counties. Three divisions have been established, which are not, however, of sufficient importance economically to be separated in practical explorations, although the "Burnet marble" is the chief constituent of one of them.

1. The Beaver Division.—The lowest members of the Leon series are magnesian limestones, of yellow and bluish hues, having characteristics sufficiently distinct to entitle them to be classed separate subdivisions.

*Following Dr. J. D. Dana, this term is used for the Lower Silurian, as formerly understood. For the old term Upper Silurian the name Niagarian is substituted here, as in my report for 1889. T. B. C.

†Page 306.

a. *The Cavern Subdivision.*—A cavernous weathering, soft yellow dolomite, sometimes including beds enough to make a section of fifty to one hundred feet. This occurs at the Silurian base north of the Colorado River, in Burnet County, and to some extent farther west, as well as along the southern border area in Mason County.

b. *The Bluff Subdivision.*—A bluish, tough, thick-bedded, siliceous dolomite, overlying the cavern beds, usually forming vertical bluffs along the streams and in the escarpments where it occurs. Well exposed along the inner northern border of the Silurian eastward, and on Cold Creek, and in parts of the Llano canyons in the southwest.

2. THE WYO DIVISION.—In some parts of the Silurian area there are craggy cliffs made up of thin shaly beds which overlie the bluff beds, and are themselves overlaid by beds of transition to more pure limestones like the "Burnet marble." There are good exposures of this kind in the country west of James River, in Mason County; also in the region west of Ten Mile Creek, in Mason County, and near the west bank of Little Llano Creek, in Llano County.

3. THE HOOVER DIVISION.—In Hoover Valley and eastward and southeastward in Burnet County, also in a broad belt partly encircling the Central Mineral Region, the Hoover beds are very prominent. They include the largest part of the so-called "lithographic stone" and "Burnet marbles," besides a set of fucoidal beds at the base which partake of some of the characters of the preceding division. Near the summit of the Hoover division the strata are rather crystalline, like true marbles, while the inferior members and alternating layers are compact limestones, of a texture resembling the lithographer's material. Fossils are rather abundant in some portions of this terrane.

SAN SABA SERIES.

A series of strata allied by the fossils to the Silurian System, but possessing some features which make it possible that it belongs in part to the Niagarian Period, are provisionally put together in a series intended to rank with the Trenton in other States. The rocks are all more or less cherty or siliceous, but there is sufficient diversity to separate the members into two divisions. They are confined to the eastern and northern portions of the regions under review, being especially prominent in San Saba County south of the San Saba River.

1. THE HINTON DIVISION.—The lower portion of the San Saba series has best expression in sections along the course of Hinton Creek and eastward, in San Saba County; in the mid-course of Cold Creek (east bank), in Llano County; and in parts of the San Saba River bottom west of Camp San Saba,

in McCulloch County. This division is but imperfectly represented along the southern border of the Central Mineral Region. Its rocks are crystalline and shaly limestones or dolomites, somewhat fossiliferous in parts, with two prominent beds made up largely of sponges and other similar remains. It is convenient to make two subdivisions, but we have not been able to give them the attentive study which they must receive before they can be safely correlated with the strata of other States. Excepting as building stones and road metal (and possibly as a source of quicklime in some cases) the economic value of the Hinton beds is not very great.

a. *The Birdseye Subdivision.*—The base of the Hinton is sometimes marked by one transitional bed, or more, of siliceous limestone, with a layer of mottled limestone simulating a calcareous conglomerate. Overlying this is a pink, white, or variegated limestone with crystalline dots or facets. This is very similar to what is known as the "Birdseye" limestone in New York State, and its stratigraphic position is certainly closely related to that stratum in the Eastern United States. On Cold Creek, Llano County, this layer is well exposed in the canyon above Bauman's, especially near the top of the ridge lying west of the creek. Overlying the birdseye rock, in complete sections, there are peculiar crystalline gritty dolomites, sometimes fossiliferous. For practical uses these may be temporarily regarded as belonging to the same subdivision, although very close study may eventually make a different arrangement desirable.

b. *The Sponge Subdivision.*— The upper portion of the Hinton division may readily be distinguished from all other terranes by the immense masses of fossil sponges of which the principal beds are composed. The lower stratum contains globose forms, often of very large size, which Mr. Nagle has aptly termed "hat sponges," from their peculiar appearance when the rock has become water worn, as in the bed of Cold Creek, Llano County, at Baldwin's ranch; also in the lower course of Bluff Creek, Mason County, in several places; and in the bed of Deer Creek, above the mouth of Hinton Creek, in San Saba County.

2. The Deep Creek Division. — This may be termed the chert division of the Silurian. There are other cherty horizons in the Carboniferous and Cretaceous, but one who becomes familiar with the thick and peculiar beds of the Silurian will not often mistake the other coutcrops for them. There is a black chert in the Carboniferous which is sometimes regarded as coal by ignorant people, but the Silurian chert is usually massive, of light blue or grayish tint, and ordinarily not nodular, as is much of that in the Cretaceous rocks. Some of the beds are very thick. The set comprises a variety of rocks, all highly siliceous, some weathering roughly, others honeycombed and more or less crystalline. The upper layers are spongiform, with drusy crystals

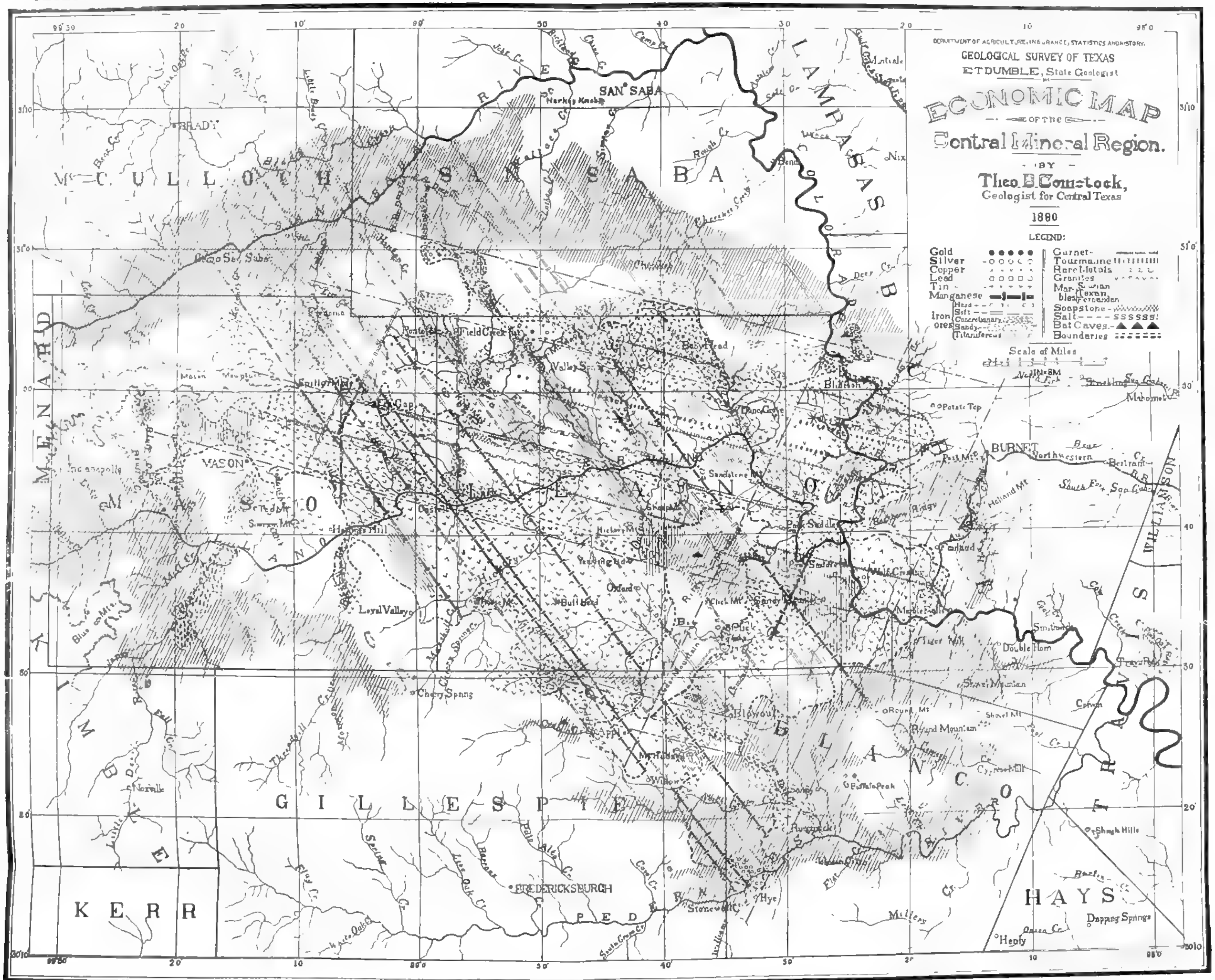
lining the cavities, and among these are several typical kinds. Fossils are preserved in the last mentioned in many cases, but usually this material occurs as fragmentary "float." Although very interesting geologically, no present commercial use is known for the rocks of the Deep Creek division. They are especially prominent along the lower reaches of Deep Creek, and southward over a considerable portion of San Saba County; also forming the hills east of Cold Creek, Llano County, north of the Burnet and Brady road.

6. DEVONIAN SYSTEM.

An inner fringe of rocks, mostly black or dark dolomites, some of which weather yellow to red brown, with minutely honey combed texture, have been provisionally referred by the writer to the Devonian, but this designation may not hold after the fossils have been examined by the specialist who now has them in hand. If not Devonian, they are probably Carboniferous. The areas in which they are exposed are not extensive, and they possess no economic value so far as known.

7. CARBONIFEROUS SYSTEM.

Some patches of Carboniferous rocks occur along the outer edge of our district, and a vast area skirts it upon the north. An isolated patch forms a part of Honey Creek Cove, in the Riley Mountains, Llano County. Aside from the very thin and unimportant seam of coal which is occasionally visible in sections south of the Colorado River, there is nothing of special economic value except some fair building stones for local service.


GEOLOGICAL SURVEY OF TEXAS
E T DUMBLE, State Geologist
ECONOMIC MAP
OF THE
Central Mineral Region.
BY
Theo. B. Comstock,
Geologist for Central Texas
1890
LEGEND:
Gold
Silver
Copper
Lead
Tin
Manganese
Iron ores
Soapstone
Salt
Bat Caves
Boundaries
Granites
Scale of Miles
MCULLOCH
SAN SABA
LAMPASAS
MENARD
MASON
LLANO
BURNET
WILLIAMSON
KIMBLE
GILLESPIE
BLANCO
TRAVIS
HAYS
KERR
SAN SABA
BRADY
BURNET
FREDERICKSBURGH
Loyal Valley
Field Creek
Baby Head
Valley Spring
Cherry Spring
Round Mountain
Cypress Mill
Double Horn
Marble Falls
Smithwick
Hye
Stonewall
Henly
Dripping Springs
Nix
Bertram
Mahomet
Northwestern
Round Mt
Buffalo Peak
Willow
Blowout
Oxford
Buff Bed
Click Mt
Sandstone Mt
Pack Saddle
Hickory
Shovel Mountain
Shovel Mt
Cedar Mt
Holland Mt
Potato Top
Mason Mountain
Harkey Knob
Cherokee
Bluffton
Norvelle
Spring Cr
Coal Cr
Cedar Cr
Bear Cr
Miller Cr

[illegible]

PART II.

ECONOMIC GEOLOGY.

HOW TO USE THE REPORT.

The prospector, capitalist, or property holder who desires to make the most of this Report as a guide to the probable outlook for the discovery of commercially valuable products upon any given tract of land, may save much needless labor and expense by proceeding as herein directed:

I. *Examine carefully the Topographic Map of the Central Mineral Region* (Plate XXIII) *and determine the situation of the land with respect to prominent points not far distant. Make a list of these, and use the index at the close of the volume to ascertain the pages upon which such localities are specially mentioned.*

II. *Turn to the different pages selected under* I *and read the references to your neighboring localities*, with the object of determining as nearly as may be the geologic conditions of your immediate district.

III. *Observe the color or colors which the particular area holds upon the geologic map* (Plate XXIII.*) From this inspection determine the range of the geologic systems in your vicinity.

IV. *Turn at once to Part I of this Report and read what is said of the rock divisions under each system exposed near your property*, from which you can usually make out the general character of the rocks, and often by comparison with what you actually find, you will thus be enabled to ascertain even the minor division or subdivision to which they belong.

V. *In many cases the foregoing method faithfully pursued will afford direct hints as to the character of the mineral resources which can justly be anticipated. In such event a perusal of what is given under the appropriate headings in this part of the Report will rarely fail to afford a decisive answer as to the probabilities.*

VI. *Where the results of an inquiry made by this logical method are favorable*—that is to say, when you are reasonably certain that one or other of the deposits of commercial worth is liable to exist upon your property—there are open to selection two radically different methods of procedure.

First, you may develop the claim under the advice of a thoroughly trained mining engineer, whose knowledge and services are as important in this case as are those of a lawyer or a doctor in his respective field of operation; or,

Secondly, you may adopt the more expensive and far less effective plan of exploring the territory by such haphazard excavations as inexperience is sure to dictate.

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* See foot note concerning this map on p. 557 of this volume.

Hundreds of thousands of dollars have been expended in Texas according to the latter idea, as against comparatively small sums devoted to the former mode of procedure, and the difference in the results is most strikingly apparent in favor of the systematic method first mentioned.

VII. *If the preliminary investigation here advised does not show some evident possibility of the existence of valuable materials*, it will not be wise to undertake any costly experiments; for the writer has neglected no opportunity for examining all parts of the region, and it is certain the chances for discovery are stated here in as favorable a light as possible for every geologic terrane which occurs in the district.

PLAN OF PART II.

For convenience of reference the substances which can be made available in the arts and trades are classified according to their commercial uses in the first place, with subdivisions based upon their mutual relations. The metalliferous are first treated somewhat in the order of their intrinsic values, after which the more important substances follow in an arrangement not wholly arbitrary, but less with reference to a scientific classification than to meet the wants of practical men engaged in commercial pursuits.*

I. METALLIFEROUS DEPOSITS.

The field work of this division of the Survey in 1890 has given us a view of such parts of the region as were not covered by the explorations of the previous year. Although much attention has been given by prospectors and capitalists to the testing of deposits heretofore known, and the determination of their geographic distribution, there has really been but little gain in actual development of the metallic resources of the Central Mineral Tract. As clearly explained in the report of 1889, the complexity of structure and the greatly broken character of the strata make mining very disastrous pecuniarily, unless undertaken by thoroughly trained engineers who can properly interpret the meaning of these numerous irregularities. The work done thus far for the most part has not been of this systematic character, for which reason it is still very difficult to arrive at just conclusions regarding the out-

*A full discussion of the field from a scientific standpoint, illustrated by detail maps and sections, was nearly completed for publication as Part III of this Report, but it has been found necessary for the present to condense this matter into the few pages, which appear as the Supplement, and to omit the illustrations. The value of the Report, even to those who care only for the business aspects of our resources, is materially affected thereby, because very much of the cost of working and of prospecting may be saved by the knowledge of the geologic structure which has been acquired by this Survey, and which only awaits publication to become generally available.

come of the district. There is a prospect that some better knowledge may be obtained through test borings which are now in progress with the diamond drill.

There is apparently a somewhat prevalent idea, among speculators in metalliferous mining property, that the real market value of a "prospect" is a variable quantity, subject to the same fluctuations as ordinary real estate, and dependent largely upon artificial conditions. This fallacious notion has been the one great cause of disaster in investments based upon the sanguine expectations of those who are ignorant of the mining industry and its requirements. Nothing is more certainly ascertainable than the actual cash value of a properly developed mine, and the element of chance can be wholly eliminated in such cases if the purchaser will obtain a report from a reputable engineer. But no one can safely guess at values that are indeterminate, and the most incompetent to do so are the very persons who are ordinarily the most free to express opinions. This is not always from dishonest motives, to be sure, but the effect is exactly the same when ignorance makes bold as when one is duped by the effrontery of fraud. There will be comparatively little money lost in mining enterprises when investors realize that the real security for their advances lies in knowing what is "in sight," in the true technical usage of this term. And it may as well be understood at once that nothing but the experience and training of a mining engineer of tried ability can be trusted in such estimates. The services of such an expert are fully as necessary as the offices of a civil engineer in railroad building, or of a lawyer in a knotty problem at law.

It seems important to make this introduction for the reason that many well meaning people have somehow gained the impression that the proper office of the Geological Survey, in its economic reports, is to deal in glittering generalities, and to present facts in such glowing colors as to make the market for mining property active, so that sales may be made at enhanced prices. The present writer is strongly imbued with the notion that this is not his province, but that honor and the public weal alike dictate such a presentation of facts as shall as far as possible enlist capital in legitimate business enterprises which shall be profitable to those who engage in them. In default of such knowledge as can often only be obtained by risking considerable sums in exploration, it may be necessary to discount chances in the early stages of development, but unless landholders are willing to share with capital in such ventures by offsetting money with real estate, they can not justly expect enormous prices for their land.

On the other hand, wherever well advised investors are willing to offer excessive rates for land, it may be regarded as proof that they know facts that are not understood by the property owners. It therefore behooves the latter to inform themselves and look sharply to their own interests. But at the same time it is not true, as many believe, that mineral land is worth as much to the impecunious holder as to one who is able to properly work it. While it is to the interest of the people of Texas, at whose expense this Report has been prepared, to have their mineral resources fully developed, they cannot afford to induce outside capital to enter the State under false pretenses, or even to permit those who invest liberally to be deceived by their own false hopes. The success of future mining enterprises is essential to the material progress of the Central Mineral Region, and every dollar expended in actual exploitation will be worth hundreds devoted to buying mineral rights. When, by a liberal policy on the part of the land owners and the investment of moderate capital in actual work, the intrinsic value of the mines has been proven, there will be a real basis of calculation, a diminution of risks, which will give to certain undeveloped tracts a market valuation not now attainable. It is, therefore, the part of wisdom to encourage development early by liberal concessions, at the same time holding on to the greater portion of the property for future enhancement.

With these hints, by way of introduction, we may proceed to the discussion of the metallic resources in their practical business aspects, as they have been studied in the office and laboratory after careful collecting in the field.

A. THE PRECIOUS METALS.

The situation as regards gold and silver in the Central Mineral Region remains practically as reported by the writer in the First Annual Report, 1889. Some of the enterprises which were then regarded as very uncertain have been wholly abandoned, one or two have advanced further in development without added encouragement, and very few new excavations have been made with the primary object of searching for the precious metals. Still it can not be said that the prospects are less flattering than they have been. There is sufficient inducement in the surface indications, as remarked last year, to warrant a considerable extension of economical explorations systematically conducted under competent direction. The prospecting which is ordinarily done is chiefly but wasted energy, as it is guided by no intelligent method, and its results are in the main of little positive value, although in many instances they may be of great detriment to the growth of the district, by reason of their unprofitable termination, without really yielding any adverse evidence. Notwithstanding the knowledge acquired by the Survey of the conditions under which the veins have been formed, and of the structure resulting from the many disturbances, it has not been possible as yet to decide whether any workable ore bodies occur in the tracts where the minerals bearing gold and silver are known to exist. This is because the developments to date have not thoroughly tested any of the deposits. The quantity already mined has been insignificant, and the indications do not augur well for future discovery, but the possibility of procuring these as extras in the mining of baser ores gives at least a little inducement to persevere in the work of exploration. Such expensive methods as trial shafts and drifts are unnecessary, and their proper location is a very puzzling problem in numerous localities; but judicious prospecting with the diamond drill may lead to information of very great importance. The main difficulty in this work is to select points for boring which shall yield the most conclusive evidence, and this choice of site must be entrusted to experienced persons familiar with the geology of the region as well as with the mechanical details involved in the boring process. It is not enough that the one in charge be capable of excavating adroitly, for if he be not also alive to the meaning of each change in the rock, and practically acquainted with the geologic structure of the region, his results, if at all valuable, will prove very costly, as has already happened in Texas more than once.

The relations of gold and silver in nature are such that they frequently appear in identical situations, although there are enough differences in the modes of occurrence to make one abound sometimes in places where the other is not present in commercially important quantities. For this reason each metal is here treated by itself.

1. GOLD.

As remarked in the writer's report for 1889, there are three principal situations in which we may expect to detect its presence by tests of suitable material if gold exist in the district in notable proportions. The examination of these possible sources of supply has been materially extended in 1890, so that the conclusions here announced may fairly be regarded as final concerning the likelihood of obtaining this metal in workable quantities, unless deeper working should disclose more solid ore bodies. The probabilities are not in favor of such results.

The outcrops to which especial attention has been given are:

(a) The multitudinous dikes, veins, and bosses of quartz which traverse a considerable variety of the rocks of different ages, more particularly those of ancient origin.

(b) Quartz and other vein fillings occurring in fault fissures and joint crevices.

(c) Bands, pockets, and segregations of pyrite and special minerals.

a. LARGE QUARTZ MASSES.

There does not seem to be any good reason for separating the large quartz exposures from those of the succeeding classes, except that the latter are more apt to resemble in appearance the gold bearing veins of other regions. But if the conditions for the deposition of gold were prevalent at the epochs of quartz formation in the one case they were probably no less prominent in the other. Judged from appearances only and from such criteria as miners unskilled in geologic study are prone to apply, there is no great difference between many of our Central Region outcrops and such auriferous masses as occur in the Black Hills of Dakota and in parts of Colorado, where they are profitably worked. But there is a wide divergence in the geologic conditions, and this renders very doubtful the probability of developing any paying gold mines in our area in these quartz deposits.

Samples have been taken with care from many outcrops, and a number of the assays reported in Table I are of this class of quartz. The principal masses lie in the trend of the Burnetian System. They are most commonly opaque, milk-white, and homogeneous. As shown by the assays none of them are gold bearing.

b. QUARTZ (AND OTHER) VEINS.

There is a great variety of vein shafts in the Central Mineral Region, but none of them have as yet yielded any traces of gold, excepting those which traverse the copper bearing districts. The Pecan Creek and Babyhead silver tract in Llano County offers a prospect of gold returns possibly sufficient to offset the cost of mining in some instances, leaving what other metals may be obtained to meet expenses of treatment and return the profits. There is not enough gold in the veins to yield any profit by itself, so far as can be judged from the developments heretofore made.

The quartz of the veins is sometimes white, like that of the masses alluded to in the preceding section, but more often rusty, cloudy, or even transparent. Assays of these varieties have been made in such numbers as to leave no doubt of the sparcity of gold in the region.

Some veins of irregular development and streaks of similar character in different localities have been worked in the belief that gold could be obtained from them, because "the veins have splendid walls." In most cases the "walls" are simply planes of stratification or of jointage in much disturbed schists, and the deposits have invariably failed to yield gold by assay. I have collected freely and with great care from very many such pockets and stringers of quartz, pyrite, limonite, and other minerals, not only in every excavation that could be found, but in natural exposures all over the region, but none of the samples have returned any gold except as indicated in Table No. I.

Probably there will be some hereafter who will be innocently inclined to report gold discoveries in the district, others perhaps not with honest intent, because of the finding of old shafts or the tracing of veins not before suspected by the inhabitants of the country. For the benefit of all, I desire to state that I have faithfully and diligently prospected the region, collecting everywhere, and taking samples from even those places which no geologist or mining engineer would admit to be gold bearing by any possibility. All these collections, as well as those of several assistants, aggregating many thousand specimens, have been tested in the laboratory by myself or the Survey chemists, or both by them and myself, and if any gold existed in paying quantities anywhere in the district it could not have escaped notice. Table I shows all that has been detected by this rigid scrutiny.

c. SPECIAL AURIFEROUS (?) DEPOSITS.

Diligent search has been made by the writer, in the field, for indications of gold in special situations where processes of infiltration and segregation have presented favorable conditions for deposition, provided that the gold has ever been present within the reach of their action. No results of value have come from this investigation, as will be seen by reference to the tables of analyses appended hereto. The frequent excavations which have been made in search of this metal in iron ore deposits, sandstones, limestones, and granites, and in other unfavorable situations, have been possible only because of the blighting popular delusion that a knowledge of minerals and mining is unnecessary on the part of those who are employed to direct such work.

Table I gives the results of assays made in the Survey Laboratory, including the list published in the First Annual Report. Besides these a large number of unreported qualitative tests, resulting negatively, have been made by the writer of quartz and other material taken from every part of the region. The investigation has been most thorough, and the conclusions given here may therefore be relied upon as a faithful representation of the real situation. The Central Mineral Region, however, abounds in resources which will give it far more prestige and profit than could ever come from gold mining alone.

2. SILVER.

The economic condition of the silver areas has not materially changed since the publication of the First Annual Report (1889), but it may be stated with somewhat more of certainty, perhaps, that the chances are fair for the discovery of this metal in moderate quantities in some of the ores. There is no locality in the Central Mineral Region in which an extensive silver mining industry can be established by itself, although there is now a prospect that this metal may eventually be obtained in sufficient amount to give it some importance as an adjunct in the output of both copper and lead ores, should those hereafter be profitably worked. In the Babyhead district the ores are of excellent quality, being largely of the class popularly known as "gray copper," some of which is here very rich in silver. But the sparse dissemination of the mineral in the quartz in most cases gives uncertain hopes of profit in the mining, although it can not be said that any very comprehensive tests of the ore bodies have heretofore been made.

The copper ores of both the Babyhead and Pecan Creek districts, perhaps also those of Mason County, sometimes yield silver in notable and paying proportions. Probably this occurs as tetrahedrite, freibergite, or some similar mineral of the "gray copper" class, but it is usually so completely mingled with malachite, azurite, bornite, chalcopyrite, etc., that it is impossible to determine its separate mineral composition. This mode of occurrence is the most promising in the region from the developments already made, for there is evidence in such copper deposits as are now considered that richer and more abundant supplies exist at greater depths. There has been no observation of any proportional agreement in the silver contents of the copper-bearing veins. That is to say, increase in percentage of one metal does not imply either increase or decrease of the other. At the same time it is true, as a very general statement, that the silver ores are usually associated with copper ores in these districts. Just why some of the rich copper-carrying minerals are almost barren of silver in some localities, while others of the same character in different situations are occasionally highly argentiferous, is an unsettled question as to details. But the structural features as observed in the field make it evident that the trend of the Burnetian rocks has had much to do with these results. Other later trends have modified the structure in other parts of the copper field, but in the limited area in which the silver ores have been discovered the Burnetian expression is most apparent. This district comprises a narrow tract extending from the valley of the Little Llano Creek in the course north 75° west, via the head of Yoakum Hollow, the "Mexican Diggings" on Babyhead Creek, and the principal former workings on Pecan Creek, to near the head of Magill Creek, all in Llano County. Eastward and westward from the ends of this belt the later rocks cover the Burnetian strata more deeply than is consistent with the economical working of any possible buried deposits of the kind, and the complications induced by subsequent disturbances have added so much uncertainty that no hope can be held out for deep shaft prospecting in those areas. There is, however, a continuation of the same trend in exposures north of the Baldwin Canyon, on Cold Creek, and westward nearly to Field Creek, as well as in the country intervening between Magill Creek and Cold Creek. These last named outcrops are south of the great Silurian escarpment which forms the bluffs extending near from Magill Creek to Sponge Mountain. Some smaller isolated areas, uncovered by erosion, occur in San Saba County, at the sources of Deep Creek and Deer Creek. These are all in line with the Babyhead-Pecan-Cold-Field Creek belt. The selected specimens reported as Nos. 79, 80, in Table I, are from Borough's Prong of the East Branch of Deep Creek, where the northwestern corner of the main exposed silver belt was tapped by excavations made late in 1890.

B. BASE METALS.

Copper, lead, and tin are the only metals of this class occurring in ores of economic importance at any point in the Central Mineral Region (if we exclude iron and manganese which fall to be treated by themselves). Zinc, as explained in my former report (1889), is almost wholly absent from this district, but indications of the presence of tin, possibly in proportions of some importance commercially, have been detected by tests of material collected by this Survey. These last results were not anticipated when that Report was issued.

1. COPPER.

Although the outcrops of the cupriferous ores have been a little more explored by prospectors than in 1889, no new facts have been developed. The last report by the writer contains practically all the information to date upon the subject, and recent discoveries, with trifling exceptions, have been made within the bounds set by that announcement. Nothing like systematic mining has been yet attempted. Even the exploratory work has been desultory, and with little or no regard to preconceived plans of operation. Whenever organizations supported by adequate capital shall enter this field, with thoroughly competent engineering skill in the management, the results will be such that at least one may be able to form a sound judgment as to what the business chances are. The mere opening of "prospect holes" which enables small specimens of rich ore to be exhibited can never afford a basis for judicious investment, however valuable a property may actually be. It is this lack of method in development more than anything else which has held back the region. Those who purchase grazing lands must be content to hold or sell them as such, and not as mineral lands, unless they are willing to share the risks which they expect capitalists to take in proving the validity of their hopes. A very good method, fair to both owner and investor, is to offset capital by land to a limited extent; the investor agreeing to expend a given sum in mining work, according to a stipulated plan, and receiving therefor a definite interest in a small part of the property, with a fair option to acquire an interest in adjoining territory, conditioned upon actual expenditure of reasonable sums in development. In this way both sides assume some risk, but both are equally protected against heavy losses of money or land. While such a method is desirable in all mining operations in a new country, it is particularly applicable to a region like this, in which there have been no paying mines; and more than all is it necessary for the mining of copper ores, which must be obtained in fairly uniform grade and quantity in order to be profitably worked.

The hydrous copper carbonates (*azurite* and *malachite*) are the results of alteration of copper sulphides by the action of air and water, and these are therefore not to be expected at very great depth in the workings. The sulphide ores are often less conspicuous to those unacquainted with their characters, but they are liable to become the chief source of copper in this region eventually. Although they may be regarded as more rebellious, there may be an advantage in the fact that they can sometimes be concentrated by washing before reduction, that mode of treatment being practically impossible with the carbonates.

The copper fields of the Central Mineral Region are all within the areas exposing rocks of the Burnetian System. Presumably anywhere that these strata can be reached along two or more axes trending north 75° west across the area there will be found evidences of the existence of copper ores. As yet the explorations have commonly revealed only the oxidized and sulphureted minerals, but it is not beyond possibility that some deeper source of supply is a deposit of native copper. The chief reason for the suggestion of such a possibility is, however, the analogy in point of age of the Burnetian rocks to those which carry the copper in the Lake Superior Region. While this may not be regarded as convincing evidence, it is strengthened by a very significant structural feature, which was pointed out in my former report on this region in the following words:*

"The element of distribution is the north-south trend, and apparently a basic eruptive of Post-Texian age is the exciting cause. * * * But it is not probable that the richest ores lie in this trend at the surface; on the contrary the assays made for this Report give the best record to the most ancient course, north 75° west, the one in which the silver ores chiefly occur."

The carbonates—azurite and malachite—occur in all parts of the copper region, but the sulphides—bornite, chalcopyrite, etc.—are usually associated with the silver ores. It is very significant that the copper districts are almost invariably tracts in which both the Burnetian and the Texian uplifts have marked expression. Exceptions to this rule are in line with pronounced axes of both trends, although the two disturbances may not be readily traceable at the surface. The Fernandian trend is also commonly manifest in the same

*First Annual Report Geological Survey of Texas, 1889, pp. 334, 335.

regions. Knowledge of these structural features enabled the writer to predict with some confidence, in speaking of the future of a mining shaft in Gillespie County, that "there is a possibility that deeper working may strike similar schists to those in the earlier trends in the Babyhead district," etc.* This has been verified by the discovery in this shaft, early in the year 1890, of copper-stained schists identical with those farther north. Test borings with the diamond drill now in progress under the direction of Mr. G. Ç. Gage on Pecan Creek, Llano County, show similar complications in the structure.

THE NORTHERN OR LLANO-SAN SABA BELT.

The cut (Fig. 62) illustrates the general character of the surface conditions as shown in an actual section instrumentally taken from the boundary line between Llano and San Saba counties, southward down the valley of Pecan Creek nearly to Cottonwood Creek. In this section the Burnetian schists are cut directly on the dip, but the other systems cross the line of section obliquely and can not be drawn so as to represent the real dip.

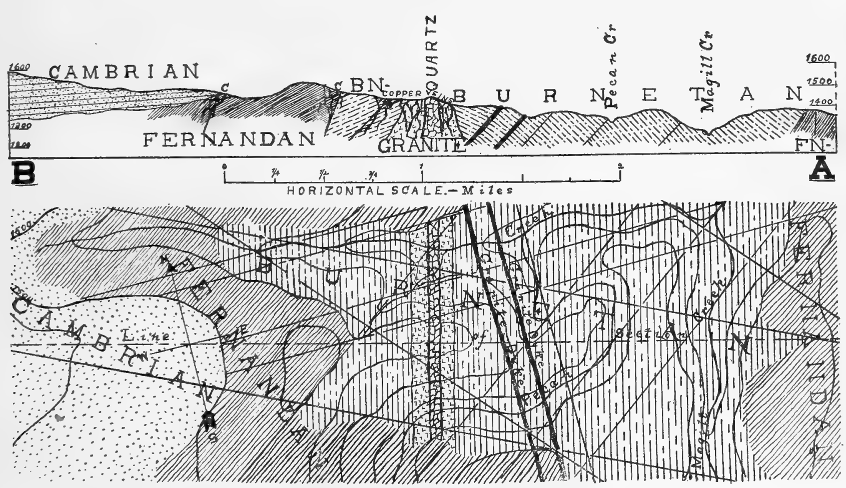

Fig. 62.

Section through the Northern Copper Field, along the upper valley of Pecan Creek, Llano County. Taken along line A–B, on map (Plate XXI).

The copper ores occur in regular veins filling small crevices in the gneissic rocks and their associates, and these are best developed as mineral bearers in the axis of a main uplift, or at points where later trends cross the belt. Much of the gneissic material is so highly impregnated with malachite (green copper carbonate) as to give it a rich green color which masks the real character of

*Loc. cit., p. 331.

the rock. Dykes or bosses of white quartz mark the axial line of this belt, as well as others in the Burnetian area, but there have been no reports of any occurrence of rare metals in such masses in the copper fields. Much of the quartz is barren, but in some places it forms the matrix for the silver bearing gray copper ores, which are sometimes associated more or less with the copper sulphides—chalcopyrite, chalcocite, and occasionally bornite. This is the condition in the "Mexican Diggings," near Babyhead Mountain, and in the westward continuation of the belt on Babyhead, Wolf, and Pecan creeks, and in the patches exposed in the upper valley of Cold Creek, all in Llano County.

Another small outcrop directly in the course of the same axis has recently been worked with encouraging results by J. M. Boroughs, of Austin, near the head of a branch of Deep Creek, in San Saba County. The rock taken from this locality is thus far gneissic, highly impregnated with malachite and carrying thin seams of gray copper (tetahedrite). This class of ore and its mode of occurrence here described are especially characteristic of the northern edge of the uncovered Burnetian area. The belt is less than six miles in width. It includes the whole of the Babyhead district and the Wolf-Pecan Creek district. Eastward and westward from that region it is mostly obscured by Cambrian or Silurian deposits. The Boroughs diggings are in the most northern locality known to be exposed. A line drawn through this spot, however, in the direction of the Burnetian axis, passes through several points where gneissic rocks outcrop, and where there are structural evidences of unconformity of deposition in the sedimentary beds. This line crosses Hinton Creek and Deer Creek at places which exhibit peculiar contacts, implying that some ancient terrane exerted an influence upon deposition, even as late as Silurian time. The eastward prolongation of the line traverses an area wholly covered by Cambrian and Silurian strata until it reaches the head of Little Llano Creek. Thence it passes along the edge of the Babyhead copper-silver tract, and then crosses another area covered by Cambrian and Silurian rocks. Farther eastward come in the granitic rocks of the Colorado River, near the mouth of Beaver Creek, and those exposed on Beaver Creek and Silver Mine Hollow. These seem to be more intimately connected with later uplifts, but it is at least possible that they may have derived their present position in part from some weakness along the old Burnetian axis.

The copper deposits of other parts of the Central Mineral Region do not belong to the Northern Belt, although they lie in parallel folds.

THE MIDDLE OR MASON BELT.

South of the Llano-San Saba tract there is an area in which the gneisses and schists of the Burnetian System are well exposed in the eastern half of Mason County, where they are copper bearing in places. As in the northern belt, it is at points more or less broken by the north-south Texian cross-trend that the ores are mainly apparent. The section (Fig. 63) gives a fair idea of the general situation, although it is impossible to indicate all the complications of structure which are similar to those outlined in the figure, but with less of localization of special features.

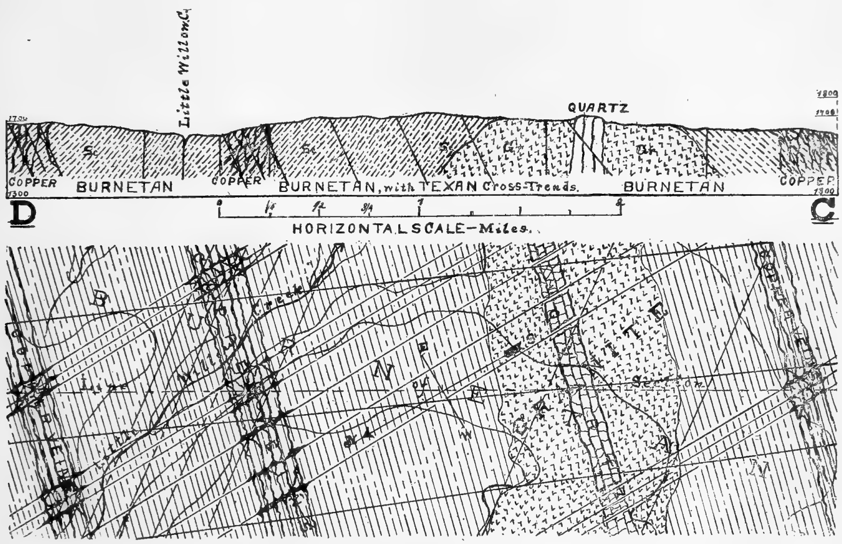

Fig. 63.

Section from C to D on map (Plate XXI), crossing the Mason Copper Field transversely to the Burnetian Axis.

In this belt there are three lines along which the indications of copper are sufficient to justify further exploration. The carbonate ores show at surface chiefly where the north-south Texian uplift is evident, and this restricts the developments largely to the eastern half of Mason County, because in the other areas the earlier or later strata exert the greater influence. In Llano County the Fernandian and Burnetian systems cover the greater portion of the middle belt, with comparatively few evidences of serious disturbance or igneous irruption which can be assigned to the Texian Period. West of the valley of Comanche Creek, in Mason County, this belt is covered deeply by the Paleozoic rocks for the most part, and this feature even more effectually obscures the Texian effects which may presumably have once been evident in that region. Thus erosion, or possibly lack of deposition, in the east, and subsequent sedimentation without adequate erosion in the west, have left a more restricted area in which copper can be reasonably sought in the Mason belt than in the case of the Llano-San Saba belt.

The Northern Outcrops.—The exposures in the Mason belt lying in the most northern line have received the greatest amount of practical attention. The Haynie mine, near Fly Gap, and some prospect holes west and southwest of that locality, are included in this tract. Some of the openings show more epidote than copper bearing mineral, and some have only the epidote to show for the work done. This is a greenish yellow alumina-iron-lime silicate, which is very abundant all through the areas of Burnetian and Fernandian exposures, and it is frequently mistaken for a copper ore by persons not familiar with minerals. When once the distinction is learned, however, this error need not be made.

THE MIDDLE BAND.—At the junction of Dog and Little Willow creeks an old shaft has exposed a peculiar gray schist, highly quartzose, which is streaked and coated with malachite. This rock dips about north 15° east, in consonance with the Burnetian trend, and there is some indication of a cross-trend in the characteristic Texian course. Not far south of this place, on survey No. 141, August Abel has some outcrops of copper ore which seem to pursue a different course. The rock there is charged with malachite, bornite, and chalcopyrite, and the vein is pronounced and persistent. This tract merits thorough development. It is particularly interesting as an example of an important deposit intimately associated with the northwest (Fernandian) trend, although its relations to the Texian and Burnetian axes are apparently as real as in other exposures. This band is the one which outcrops south of Llano City and at points further east.

THE SOUTHERN BAND.—There have been enough tests of the third line of outcrops to prove its continuity across much of Mason and Llano counties, although the band is broken by wide stretches in which no surface indications have yet been detected.

BAUER AND DURST DIGGINGS.—Messrs. M. Bauer and George Durst have struck this band in a slope which they have excavated near the west side of survey 744, Mason County, east of Herman Creek, less than one mile from its mouth at the Llano River. The rocks in which the copper stain occurs are Burnetian in the normal trend, dipping here about 45° south 15° west. The outcrops can readily be traced eastward into survey 746, where they become confused by the crossing of several of the later trends.

THE SOUTHERN OR BLANCO–GILLESPIE BELT.

An axis of the Burnetian rocks crosses a portion of Blanco and Gillespie counties, and it is probably continuous for many miles eastward and westward beneath the later strata which now cover the region. Occasional exposures at the surface or in the deeper workings of shafts enable us to construct a section, as shown in Figure 64.

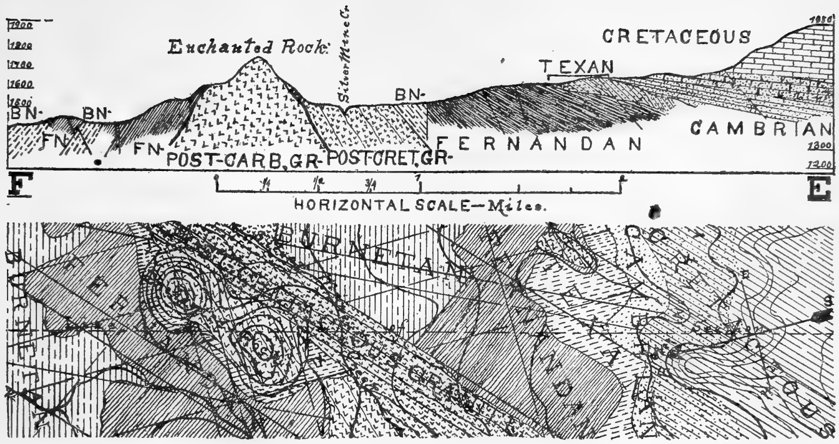

Fig. 64.

Section and plan along line E–F on map (Plate XXI), crossing the most southern of the Burnetian Folds exposed in the Central Mineral Region.

The area in which there may be some little chance of the discovery of copper ores in this belt may be roughly defined as extending from west of Round Mountain, in Blanco County, to a line east of Loyal Valley and Cherry Spring; but there is very little of the tract in which the copper bearing strata are near enough to the surface to make mining profitable in any event. In fact, the existence of the belt as such is chiefly predicated upon the discovery of traces of malachite in the deeper workings of the Nonly mines, near Enchanted Rock. At that point the structure is very complicated, and the inducements offered by the returns have not been such as to justify extensive exploration. It may be confidently predicted that if any copper deposits of economic value be hereafter found in this region they will be such as conform in all essential particulars to the conditions here announced.

2. LEAD.

The distribution of lead ores in the Central Mineral Region has received much attention at our hands the past season, the conclusions reached in 1889 and published in the Report of that year being well substantiated by the additional facts ascertained.

The percentage of lead in the districts referred to under the title "Silver" (this Report) is comparatively small. The galena which may eventually be mined from these areas will be of more importance as a smelting factor for the associated ore than for any figure it may cut in the lead mining industry. But there are other deposits of this mineral which carry but little silver ordinarily, and which may perhaps be of sufficient value to work as simple lead ores. In writing of these accumulations in the last Report I remarked:*

Of these trends only one has shown good warrant for the hopes of its advocates, although it would seem that this can not monopolize the essential conditions, for there are other very similar exposures. * * * It is very probable that systematic exploration in this region may result in the discovery of large and valuable deposits of galena, for the rocks, the mode of occurrence, and the geologic age of the ore beds correspond generally with the conditions existing in Missouri, Illinois, and Wisconsin where lead has been extensively produced. * * * It may be many years before the usual process of discovery will determine the value or lack of value of the district, but comparatively little well directed effort under competent guidance would soon settle the question whether lead bonanzas exist in cavities in the limestone. As preliminary this Survey will undertake to determine the coming season, if possible, the geologic relations of the strata in which the lead has already been found.

The field work of this division in 1890 has enabled me to speak with more definiteness concerning the conditions which prevail in the localities previously announced, and to report some new discoveries which agree in all essential points of structure. The possibility is that only a small part of the deposits of galena has yet been brought to light, for the conditions which prevail in the known localities are not unique There are many places where explorations might be conducted with at least a moderately fair chance of discovery, but it is necessary to pursue such investigations with a clear understanding of the situation in the productive areas. This may be better gained from the following descriptions and illustrations.

In a region so imperfectly worked as this there is an impropriety in attempting to lay out geographic or geologic areas which may even approximately represent the lead bearing belts. Such allotment is particularly inapplicable here on account of the broad extent of the rocks which may possibly be charged with the ore. The classification of localities adopted is therefore to be taken only as one of convenience for present purposes.

THE BURNET COUNTY TRACT.

The exact conditions of the substructure in the lead bearing area on Beaver and Silver Mine creeks, in Burnet County, can not be made out in sufficient detail to serve as a working guide until more mining has been done, or at least until more time can be given to the study of the problems involved in the situation. The cut (Fig. 65) exhibits, however, a geologic plan and section which does not exaggerate the complexity, although it may not represent all the details as they will eventually be worked out in the development of the tract.

*Op. cit., p. 340.

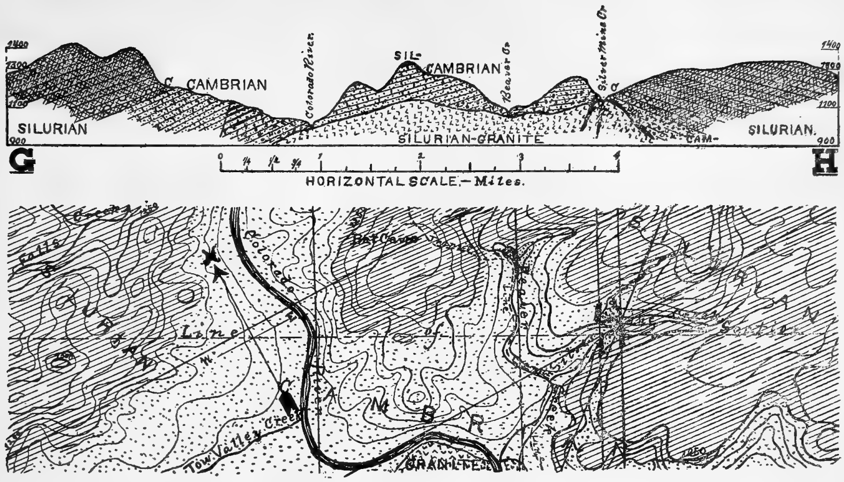

Fig. 65.

Plan and section illustrating the geologic structure in the Lead Region of Northwest Burnet County.

The faults are certainly more numerous, following for the most part the courses of the streams, which run in canyons evidently originated by these structural lines.* Without further remark it is sufficient to say that the topography as indicated will give to an experienced person an idea of the positions of the breaks. The points of greatest interest are the deeper seated effects of the later upheavals and the unknown section below the base of the Cambrian.

There is a possibility that a small portion of the unexposed granite here referred to the Post-Silurian geanticline is really a portion of the much earlier Burnetian axes. A gneissic rock, much altered, which was encountered in one of the workings at Mr. Gage's camp, in Silver Mine Hollow, lends color to the supposition, and it is strengthened somewhat by the facts stated elsewhere with reference to the extension of the northern edge of the Burnetian folds through this area. The absence of schistose rocks also, and the manifest thinning of the beds of both the Cambrian and Silurian systems, might be taken as further evidences that the granite is of Pre-Cambrian age.

But the reference of the main portion of this rock to the Post-Silurian, Pre-Devonian uplift is based upon grounds which appear much more tenable. In the first place, the area in question lies directly in the track of this latter upheaval, as clearly defined southward across Llano County and beyond in a

*The positions of a number of the extra faults and fractures might be readily plotted, but although this would give a much more accurate idea of the local surface geology the scale of our plan and section is too small to admit of this without unduly confusing the facts relating to the lead deposits.

considerable portion of Gillespie County. Moreover the geology of the Beaver Creek district is very similar to that of the country westward as far as Little Llano Creek, where the effect of this same Silurian geanticline is well marked, and where a prominent fault has left the Burnetian axis upon the eastern side far beneath the present surface. Again, the granite here, as in other places where the undoubted Post-Silurian uplift is manifest, contains in places the characteristic schist inclusions. Another confirmation of the same reference is the very similar geologic situation in the Pedernales River galena district, which lies very nearly in the course of the Silurian axis prolonged southward from Beaver Creek.

Workings.—Since 1889 Mr. G. C. Gage has been more or less constantly engaged in testing the outcrops in Silver Mine Hollow and in Beaver Creek Canyon above the mouth of Lacy Branch. Former excavations made in the path of the dyke and along the granite-Silurian contact have afforded considerable information regarding the positions most favorable for development, but with all the explorations heretofore made no profitable accumulations have been discovered. We may better discuss the causes for this after the situation in other cognate districts has been described.

THE PEDERNALES TRACT, BLANCO COUNTY.

North of Hye Postoffice, in Blanco County, in the neighborhood of the now abandoned Westbrook Postoffice, there is a small area in which the segregations of lead ore are of sufficient moment to attract special attention. The geologic situation so far as the galena deposits are concerned is very similar to what has been described under the preceding head in Burnet County. Figure 66 shows this more clearly than it can be stated in words.

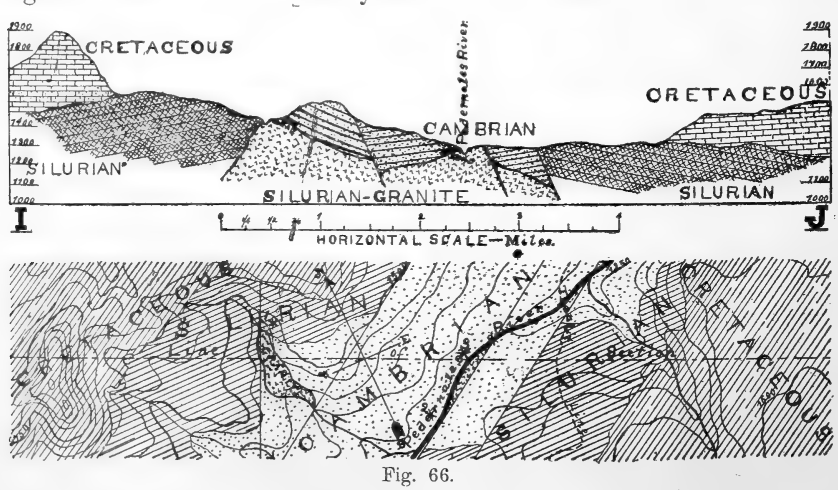

Fig. 66.

Plan and section along line I–J of map (Plate XXI), illustrating the geology of the Lead District north of Hye Postoffice, in Blanco County.

A comparison of the sections in Figures 65 and 66 will show the close structural relations of the two districts and the identical features in the mode of accumulation of lead deposits.

The workings in this field have not been extensive, but there are two or three localities, not widely separated, from each of which a small amount of galena has been taken. These spots are marked upon the plan (Fig. 66) by asterisks. Mr. McMillan has dug some small shallow shafts at the contact of the granite with the Cambro-Silurian limestones, and a very similar set of conditions is evident in the tract further south at the Pedernales River, and on the land of Mr. Holden, nearly east from McMillan's, at old Westbrook Postoffice. These are all parts of the same ore field, and the prevailing conditions are alike in all, none of the features being essentially different from what has been observed in the Burnet County tract previously described.

THE MASON COUNTY TRACT, OR CAYLOR DISTRICT.

This area was noted in the last Report.* While the conditions affecting the occurrence of lead at this point are much the same as those already noticed under the two preceding heads, the complications in the structure are far more confusing. The details shown in Fig. 67 give some idea of the disturbances which have mangled the remnants of the lead bearing rocks, but it is almost impossible to depict the contortions, displacements, and entanglements which have ensued.

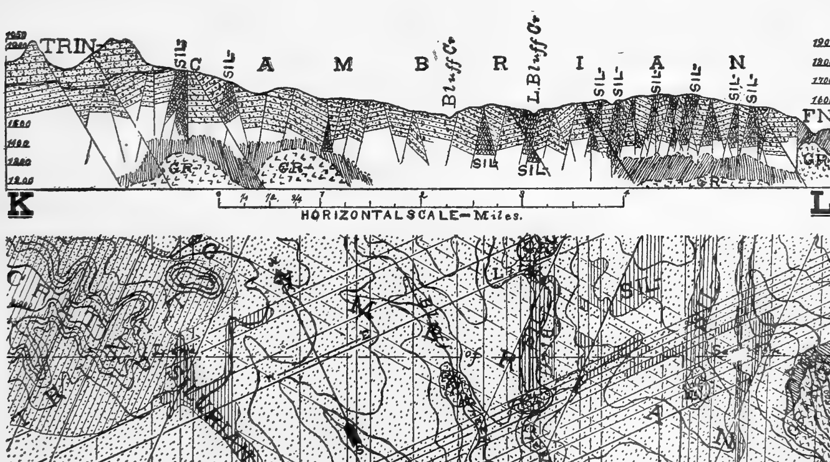

Fig. 67.

Section on line K–L of map (Plate XXI), crossing the Caylor tract on divide between Honey and Little Bluff creeks, Mason County.

* Pages 341 and 342.

The rocks have been plicated, crumpled, twisted, and metamorphosed until all semblance of order has been obliterated, excepting that the successive trends characteristic of the various uplifts are all discernable in their normal chronologic sequence. But the system worked out and portrayed in the plan and section is by no means as apparent to the eye of a casual observer. In such a field systematic mining is not among the possibilities. The confusion is of course due to the crossing of the several axes at this point, and it may be that somewhere in the neighborhood, in a less jumbled area, the lead ore may be more accessible, in comparatively better masses. As yet the results of explorations have not been wholly encouraging. The faults shown in Figure 67 are very apparent also in the surrounding country, into which they radiate from this centre, and it is probable that the latest of these have had a very important influence in dislocating any possible segregations of commercial value. For the present, therefore, it will be most advantageous to prospect only in the least disturbed localities, or at least in those in which the old Silurian axis (north 25° east) has not been much obscured by the later lines of uplift.

REVIEW OF THE LEAD BEARING ROCKS.

After close attention to the whole subject of the nature and mode of occurrence of the lead ores in this region, the conclusions here announced are the best that can be given at this writing.

CHARACTER OF THE ORE.—The lead ore is almost wholly galena, in cubical crystals of comparatively small size. In some cases a meagre incrustation of lead carbonate of oxide is apparent in the limestones, but no important deposits of this nature have been discovered. There are usually no other minerals associated with the galena, which is scattered through the containing rock without regularity, and commonly not in any considerable abundance.

MODE OF OCCURRENCE, ETC.—Until now there has been no clear understanding of the origin of the lead deposits. In my Report last year* the information then gathered was summarized as follows:

> We know that the galena occurs in beds that lie somewhere between the base of the Potsdam limestone and the Deep Creek division of the San Saba series, and it is more than probable that the horizon is very close to that of the Galena limestone of other States.

One of the difficulties connected with the determination of the geologic horizon of the lead bearing limestones is the fact that the sedimentary beds are mainly shallow water deposits, and consequently their irregularity is a prominent characteristic. Again, as in every case yet observed there is a close connection of the lead accumulations with disturbances of the strata and with irruptions of granite, it is not easy to make out whether the original

*Page 341.

EXPOSURE OF UPPER CAMBRIAN SHALES (POTSDAM FLAGS) SILVER MINE CREEK, BURNET COUNTY.

locus of the galena was the limestone itself or the substratum through which the granite was protruded. Still another difficulty arises from the absence of fossils in the containing rocks. We have therefore only the knowledge which comes from a certain familiarity with the Cambro-Silurian section, its practical identity in the separated lead bearing areas, and a not very narrow range of strata lying between the known Cambrian and known Silurian, as adjudged by fossil evidence.

In every instance thus far discovered the galena occurs in rocks not older than the Potsdam greensand and at least as old as the upper part of the Leon series of the Silurian. A certain greensand, probably Potsdam, but possibly Silurian, is a constant accompaniment, and as before stated an intrusive granite of Silurian or Post-Silurian age invariably appears in contact with the Cambrian beds, or with beds low in the Silurian system. But there are usually faults in the vicinity which bring the Silurian and Cambrian beds into such close proximity that new doubt is introduced as to the local origin of the galena deposits. In the Beaver Creek district (Fig. 65) and the Pedernales Valley tract (Fig. 66) the relations of the Post-Silurian faults to the mineral accumulations are very evident, and the same is true of the Mason County area (Fig. 67), except that there the structure is so chaotic as to preclude any attempt at correlation in detail with other districts.

We may, perhaps, get a further clew to the history of ore deposition from this last named region; for while the Silurian trend is prominent here as in the other fields, the later uplifts have apparently disjointed and separated the lead deposits instead of forming new channels for their accumulation. This fact may perhaps imply deposition earlier than the Devonian Period.

The Cavern limestone of the Silurian Period and the galena bearing greensand lie in juxtaposition in the fault fissures on the south side of Silver Mine Hollow, Burnet County; a similar slip in the Blanco County tract has brought the same greensand to the level of the Hoover strata along a parallel fault; but at Caylor's there is hardly a possibility of determining accurately what conditions prevailed immediately after the Post-Silurian disturbance. Moreover, we have no evidence that the Devonian or Carboniferous strata ever formed a cap in these regions. The presumptions based upon known facts are against such a belief. The chances are that the processes of vein formation of the ordinary kind have never since been as favorably conditioned in these areas as when the initial effects of the Silurian upheaval were active.

From thoughtful consideration of all the known facts I can not reach any other conclusion than that the galena is a product of about the same age and character as the lead masses of Missouri, formed originally under very similar circumstances; but that our ore deposits are less extensive, and have been much more affected by disturbances of the strata occurring since the epoch of accumulation. This deduction, if it be not modified by future discovery, makes the prospect for lead mining in the Central Mineral Region less hopeful than could be desired, but it need not prevent the judicious exploration of certain possibly pregnant fields.

Guides to Prospectors. — 1. In searching for galena deposits in the counties of San Saba, McCulloch, Mason, Llano, Blanco, and Gillespie, and in the western portion of Burnet County, there is no need of examining any locality which is not more or less covered by Cambrian or Silurian strata, i. e., by sandstones or limestones.

2. The occurrence in such areas of a greensand, or a brown weathering limestone, or of both, along a line of faulting, especially near where a dense but somewhat coarse-grained granite outcrops, is the best situation for exploring. The granite usually has inclusions of black schist fragments.

3. The prominent break, joint, or fault in the strata should trend east of north from ten to twenty degrees by the compass needle.*

4. The galena will be found in the brown limestone or greensand, or occasionally in dykes or in zones of distribution in other layers.

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*Corrected bearing, nearly north 25° east.

TABLE I.

ASSAYS FOR GOLD, SILVER, COPPER, AND LEAD.

The collections were all carefully made by Theo. B. Comstock or under his personal supervision, excepting those numbers followed by (J), which were collected by Mr. G. Jermy, while acting as Assistant Geologist, in 1889. Analyses marked * by J. H. Herndon, † L. E. Magnenat.

No.	Locality.	Material.	Gold, oz. per ton.	Silver, oz. per ton.	Copper, per cent.	Lead, per ct.
	BURNET COUNTY.					
1*	East Branch Spring Creek	Ferruginous quartz [a]	......	......	......	......
2*	Davis Branch Spring Creek	Quartz, slightly ferruginous	......	......	......	......
3†	Near Lion Mountain	White quartz	......	......	......	......
4†	Near Lion Mountain	White quartz	......	......	......	......
5*	Slaughter Mountain	Quartz [b]	......	......	......	......
6*	J. M. Sparks survey	Hematite in quartz [c]	......	......	......	......
7*	Moore and Encke's mine, Hoover Valley	Ferruginous quartz [d]	......	......	......	......
8*	Moore and Encke's mine, Hoover Valley	Pyrite seams in quartz	......	......	......	......
9*	East of Niggerhead (Devil's Half Acre)	Quartz with lithomarge (*carnat*)	......	......	......	......
10*	Branch Peters Creek	Reddened quartz [e]	......	......	......	......
11*	Beaver Creek	*Galena* in limestone [f]	......	Trace.	......	45.30
	LLANO COUNTY.					
12†	Ash Spring Creek	White quartz	......	Trace.	......	......
13†	Ash Spring Creek	Ferruginous quartz	......	......	......	......
14*	Barringer Hill	White quartz	......	......	......	......
15*	McCoy's, Little Llano Creek	Quartz with adhering schist [g]	......	......	......	......
16†	Copper Hill, near head of Little Llano Creek	Red quartz	......	......	......	......
17†	Copper Hill, near head of Little Llano Creek	Quartz (Thetis hair-stone)	......	......	......	......
18†	McGehee mine, McGehee Mountain	Copper ores, *malachite*, *azurite*, *bornite*, *chalcopyrite*. [h]	......	......	1.50	......
19*†	H. & T. C. R. R. land, mouth of Yoakum Creek	Amphibolyte with *malachite* [i]	......	......	2.30	......
20*†	H. & T. C. R. R. land, Yoakum Creek	Altered granite charged with *malachite* [j]	......	......	3.50	......
21†	Yoakum Creek, near head (McGehee shaft)	*Tetrahedrite* and *malachite*	0.20	12.20	45.60	......
22*	Head Little Llano Creek	Garnet rock with *bornite*(?) [k]	......	......	1.30	......
23*	McGehee diggings, Little Llano Creek	Garnet rock with *bornite* [l]	......	Trace.	0.60	......

a Vein in mica schist.
b From west side of mountain.
c Erroneously supposed to be "gray copper."
d Tough quartz, with band of hard *limonite* and yellow incrustation of *limonite*.
e From schist contact.
f Hand assorted.
g Supposed valuable ore. Schist contains minute pyrite crystals.
h Average lot.
i Not assorted. Average lot, with *magnetite*, etc.
j One-fourth mile west of No. 19.
k Stained also with *azurite* and *malachite*.
l Same locality as No. 22.

TABLE I.

ASSAYS FOR GOLD, SILVER, COPPER, AND LEAD—*continued.*

No.	Locality.	Material.	Gold, oz. per ton.	Silver, oz. per ton.	Copper, per cent.	Lead, per ct.
24*	Yoakum Creek	Ferruginous quartz [a]				
25*	Northeast base of Packsaddle Mountain	Texan quartzite				
26†	Packsaddle Mountain	Quartz		Trace.		
27*†	Near Packsaddle Mountain	White quartz [b]		Trace.		
28*†	Chaney diggings, southwest of Packsaddle Mountain	Pyritous marble				
29†	Lockhart Mountain	Quartz				
30†	Lockhart Mountain	White quartz				
31*	Mexican diggings, near Babyhead Mountain	*Vesuvianite* in quartz [c]				
32†	Babyhead Mountain	Copper ores [d]		5.60	2.80	
33†	Babyhead Mountain	Quartz				
34†	Babyhead region	Quartz				
35*†	Babyhead Mountain	Assorted ore, chiefly *tetrahedrite* in quartz [e]	0.20	107.80	6.40	Trace.
36*	Mexican house, Babyhead Mountain	Lead matte [f]		3.00		44.83
37*	Mexican diggings, Babyhead Creek	Quartz [g]				
38*	Mexican house, Babyhead Creek	Galena and slag [h]	Trace.	93.50		43.34
39†	Streeruwitz's camp, Pecan Creek Branch	Copper ore in granitic rock [i]		Trace.	7.60	
40†	Streeruwitz's camp, Pecan Creek Branch	Quartz [j]				
41†	Branch of Pecan Creek	Epidotic veinstone			Trace.	
42†	Pecan Creek	Pipe iron ore conglomerate				
43*	Pecan Creek, Miller mine	*Malachite* spots in granite			1.00	
44*†	Pecan Creek, O. W. Miller diggings	*Azurite* and *malachite*		25.00	25.60	
45*†	Pecan Creek, Miller mine	Granite with *malachite* [k]	Trace.	3.50	10.80	Trace.
46*†	Miller mine, Pecan Creek	*Malachite* [l]			40.40	
47*	Ten miles east of Llano town	Quartz				
48*	Burnet and Gainesville road, 9½ miles east of Llano	Quartz				
49*	South end of Sharp Mountain	Quartz				
50*	Three miles southeast of Llano	Quartz				
51*	Bill Parker tract, Parker survey	Quartz [m]				
52*	Two and one-half miles north of east from Valley Springs	Bluish mottled quartz				

a Contains *wocheinite* or altered *turgite*.
b Contains specular *hematite*, sometimes mistaken for "gray copper."
c Altered largely to a yellow amorphous mineral.
d Selected to show general run of ore.
e General character of ore, but closely assorted.
f Produced by Mexicans in reverberatory furnace.
g Rock similar to No. 9, but slightly stained with *azurite*.
h From ore in store house; not collected "in place," but much like ores of the region.
i Gneiss surcharged with copper.
j Not "in place."
k Similar to No. 39.
l Traces of zinc.
m Five miles northeast of town of Llano.

TABLE I.

ASSAYS FOR GOLD, SILVER, COPPER, AND LEAD—*continued.*

No.	Locality.	Material.	Gold, oz. per ton.	Silver, oz. per ton.	Copper, per cent.	Lead, per ct.
53*	Cat Mountains	Quartz	......	......	......	......
54*	Cold Creek	Rusty quartz [a]	......	......	......	......
55*	One mile east of Field Creek postoffice	Rusty quartz	......	......	......	......
56†	Two miles south of Field Creek postoffice	Quartz	......	......	......	......
57†	Davis Gap, King Mountains	Reddish quartz	......	......	......	......
58*	Chr. Snyder's pasture, Elm Creek	Rusty quartz [b]	......	......	......	......
59†	Branch west of Deer Creek	Cloudy quartz	......	......	......	......
	MASON COUNTY.					
60*	Pontotoc	Washings [c]	......	......	......	......
61*	Pontotoc	Quartz [d]	......	......	......	......
62*	New Pontotoc and Castell road	Mixed quartz	......	......	......	......
63*	Pontotoc road, north of Fly Gap	Quartz with *hematite*	......	......	......	......
64*	Near Fly Gap	Quartz	......	......	......	......
65*	One-half mile northeast of Fleming postoffice	Quartz with *hematite* crystals [e]	......	......	......	......
66*	Kothman's water gap	Quartz	......	......	......	......
67*	Survey 141, west of Shaft Mountain	Copper ores, *malachite* and *chalcopyrite*	......	......	0.06	......
68†	Six miles north of Mason, east of Mason and Camp San Saba road	Quartz	......	......	......	......
69†	East of Mason and Camp San Saba road	White quartz [f]	......	......	......	......
70†	Comanche Creek, north of Koochville	Quartz	......	......	......	......
71*	German Emigration Survey No. 750, one mile northwest of Koochville.	*Malachite* stains in hornblendic rock [g]	......	......	1.80	......
72†	Divide between Honey Creek and Little Bluff Creek	Siliceous dolomitic marble	......	Trace.	......	......
73†	One-fourth mile east of Caylor's diggings	Dolomite	......	Trace.	......	......
74†	Near Caylor's diggings	Segregated *hematite* and *limonite* in limestone [h]	......	Trace.	......	......
75†	Caylor's diggings	Blue quartz	......	......	......	......
76*	Caylor's diggings	*Calcite* [i]	......	......	......	Trace.
	SAN SABA COUNTY.					
77†	Deep Creek	Veinstone	......	......	......	......
78†	Kuykendahl's, Deep Creek	Blue quartz	......	......	......	......

a North of Smoothing Iron Mountain.
b Near Castell.
c From gravel in creek.
d Carries a bright micaceous mineral, often mistaken for gold, which it closely resembles.
e Specular *hematite*, erroneously supposed to be "gray copper."
f Near locality of No. 68.
g Very similar ore to No. 19.
h Cambro-Silurian exposure, contorted and much broken.
i Traces of zinc.

TABLE I.

ASSAYS FOR GOLD, SILVER, COPPER, AND LEAD—*continued.*

No.	Locality.	Material.	Gold, oz. per ton.	Silver, oz. per ton.	Copper, per cent.	Lead, per ct.
79	Boroughs' Prong, Deep Creek	*Tetrahedrite*, etc.	......	2.00	......	......
80	Boroughs' Prong, Deep Creek	*Tetrahedrite*, *malachite*, and *azurite*	Trace.	5.00	12.10	Trace.
	GILLESPIE COUNTY.					
81*	Crab Apple Creek	Green quartz	......	......	......	......
82*	One-half mile north of Nonly's mine	Rose quartz	......	......	......	......
83*†	Nonly's mine	Mica schist, altered [a]	......	Trace.	......	......
84*†	Nonly's mine	Talcose and graphitic schist with *pyrite* [b]	......	Trace.	......	......
85*	Nonly's mine	*Pyrite*, etc	......	......	......	......
86†	Nonly's mine	*Pyrite* in *turgite*	......	......	......	......
87*	Near Enchanted Rock	Quartz	......	......	......	......
88*	Near Enchanted Rock	*Epidote* in quartz	......	......	......	......
89*	Head of Crab Apple Creek, southeast of Enchanted Rock	Brassy *pyrite* in schist [c]	......	......	......	......
90*	Bell Mountain	Quartz	......	......	......	......
91*†	Kino Creek (J)	Altered *pyrite* [d]	......	......	......	......
92*†	Pedernales River (J)	*Galenite* [d]	......	Trace.	......	Trace.
93*†	Pedernales River (J)	*Galenite* [d]	......	Trace.	......	Trace.
	BLANCO COUNTY.					
94*†	Sandy shaft (J)	*Graphite* and *pyrite* [e]	......	......	......	......
95*†	Sandy shaft (J)	*Graphite* and *pyrite* [e]	......	......	......	......
96*†	Sandy shaft (J)	*Graphite* and *pyrite* [e]	......	Trace.	......	......
97*†	Sandy shaft (J)	Altered *pyrite* [e]	......	......	......	......
98*†	Sandy shaft (J)	*Graphite* and *pyrite* [e]	......	......	......	......
99*†	Sandy shaft (J)	*Graphite* and *pyrite* [e]	......	......	......	......
100*†	Sandy shaft (J)	Altered *pyrite* [e]	......	......	......	......
101*†	Near Iron Creek (J)	*Galena* [e]	......	Trace.	......	Trace.
102*†	Near Iron Creek (J)	*Galena* [e]	......	Trace.	......	Trace.
103*†	Hickory Creek (J)	*Pyrites* [c]	......	Trace.	......	......

a Somewhat pyritiferous.
b So-called ore streak.
c Copper test by T. B. C.

d The character of the material is given in these cases from Mr. Jermy's labels, but the minerals named are present only *in traces.*

e The material is named from Mr. Jermy's labels, but, as is clearly shown by the assays, the bulk of the mass in each case is mere waste rock, the ores forming barely enough of the whole to be recognized with very careful scrutiny.

3. TIN.

Since my last report the question concerning the occurrence of tin in this region has been given much study in the field and office. I quote from the First Annual Report (page 345) all that was known at that time by myself:

> The same might be said of tin as of zinc, were it not for claims which have been made of the discovery of the former in two or three separate localities. On this account, and because of the receipt of a very fine crystal of *cassiterite* (tin oxide) from a gentleman who did not seem to know its nature, and who stated that it came from the stream "wash" near the point where he gave it to me, I have taken much pains to search for tin ore. Failing to get reactions for this metal in any of the minerals of my own or my assistants' collections, Mr. Huppertz was specially charged with the examination of the locality referred to above and of the adjoining region, in the hope that more of the same material might be found. But the quest has been fruitless. The area is an extension of the Barringer tract, and one not unlikely to yield tin minerals, if they exist at all in the Central Mineral Region.
>
> Great care has also been exercised to detect tin in the rare minerals of the immediate Barringer district. To this date (May 1, 1890) no evidences of the presence of the metal in any combination have been seen by me anywhere, although I have examined critically more than eight thousand specimens collected from various parts of my district. There are areas in Blanco and Gillespie counties which I have not worked over except in the most cursory manner. Of these it is impossible to speak authoritatively at present, but such collections of the Survey as have come under my inspection certainly contain no tin.

On the map of Llano County, published in 1875 by A. R. Roessler, cassiterite is indicated as occurring near the southeastern corner. This is the only record known to me of the discovery of tin ore in the Central Mineral Region prior to my announcement in the foregoing words in 1889. Dr. Edgar Everhardt, of the University of Texas, and Prof. von Streeruwitz, of this Survey, have heretofore reported mere traces of tin in other ores. Our investigations in spots marked by Mr. Roessler have not confirmed his report as yet, and the geologic conditions there are not exactly similar to those in which the tin ore occurs elsewhere. The nearest point to Roessler's reported locality at which I have observed the cassiterite is some twenty miles northward, in a different belt.

Since the publication of the First Annual Report I have discovered this mineral in the Survey collections from the Central Mineral Region in other localities than the one therein doubtfully reported. A study of the areas from which specimens have been taken shows that the conditions are not exactly like those which have favored the production of silver and copper ores in our district, and yet there are certain points of similarity which bring these different deposits into somewhat closer relationship. The mineral referred to in the quotation above is undoubtedly tin oxide, but up to a recent date it was the only piece of the mineral which had come under the writer's eye, notwithstanding the fact that he had then studied above fifteen thousand specimens in the Survey collections from the Central Mineral Region. Almost by accident, in looking over earlier collections from the district, a brilliant, brittle, black mineral in quartz attracted my attention, and its high specific gravity was at once noticeable. A very little further examination proved it to be cassiterite, yielding copious metallic scales upon reduction on charcoal, with soda and potassium cyanide. The locality was given upon the label as Herman Creek simply.* This stream is comparatively short, heading up near Fly Gap, in Mason County, and flowing nearly south to the Llano River, which it joins about seven miles above Castell.

In the hope of determining the exact *locus* of the outcrop, I visited the region, with Mr. F. S. Ellsworth as assistant, and collected freely over a considerable area which had previously been neglected in part, owing to lack of time. The results of the trip, although very interesting, and conclusive as to the occurrence of tin, are not yet wholly satisfactory in a commercial way. But the evidence obtained, taken together with our studies of the stratigraphy of the region, is sufficient to warrant the belief that the known occurrences of tin ores are but the indicators of more extended and uniform deposits which may be brought to light by means of the guides which our present information can furnish. No workable deposits have yet been found, and the reports to that effect in the newspapers did not emanate from this Survey

The history of the reported discovery of tin in Central Texas is made up of a long series of blunders in determination of minerals which were regarded as cassiterite by ill-informed prospectors who had seen the real article, but who were prone to mistake for it such species as almandite, tourmaline, and special forms of the purer iron ores. The greater portion of the tourmaline of this district is indistinguishable from the cassiterite, as we now obtain it, except by such tests as the mineralogist applies. And moreover, it is unfortunate that the very trend, viz., the oldest Archean or the Burnetian axis, in which the cassiterite occurs, is the one which abounds in black tourmaline.

There are several tracts in which the chances for the discovery of tin ore are at least hopeful. In a general way it may be stated that the tin oxide (cassiterite) occurs chiefly in more or less specialized cloudy or banded quartz in a belt extending over a small area in western Burnet County, across Llano County, and well into Mason County, a distance east and west of some fifty miles. The breadth of the belt from north to south is irregular, but may be said to average ten miles or more, although this method of description is very unsatisfactory for a tract so much affected as this has been by subsequent orographic disturbances. Starting with Barringer Hill, upon the west bank of the Colorado River, from the vicinity of which another sample of tin ore has been obtained, and tracing the Burnetian axis by interrupted outcrops

*Collected by Chas. Huppertz, 1888.

along a line bearing thence north 75° west to the valley of Herman Creek and beyond, there are many places where all the conditions which exist at the two extremes of the line are present and geologically identical with them. We have not yet discovered cassiterite in all the intervening areas, nor can it yet be determined what influence, if any, may have come from the later upheavals, which have complicated the structure more there than elsewhere. But there is a very apparent similitude in the occurrence of rare metals in all the Burnetian outcrops wherever found. Besides this it is significant that in the later cross-trends, which in wide bands have as it were cut out parts of the Burnetian nucleus, there sometimes are traces of tin in the special minerals which characterize the successive uplifts. The direct relations of this peculiarity to the oldest Archean (Burnetian) axis is most pronounced, for it is only where that backbone is prominent that the cross-folds are tin bearing. To illustrate the point more clearly the following observations are adduced:

a. The uplift next succeeding the Burnetian is the Fernandian, with a northwest (north 35° west) trend. This cuts out the Burnetian axis in much of Llano County, where the remarkably abundant and pure magnetites and hematites are well displayed. The easternmost folds of the latter system, adjoining good exposures of the earliest trend, carry magnetic iron ores of a peculiar, tough, coarsely crystalline character, of high specific gravity and brilliant surfaces of fracture, which yield occasional traces of tin and the rarer metals. Wolframite and minerals with smaller proportions of tungsten are associated.

b. The Post-Texian uplift, succeeding the Post-Fernandian, has strong expression in a part of Mason County. West of Fly Gap and Herman Creek it is especially prominent. Here there is a development of a remarkable iron ore upon a large scale. This stratum, lying in the normal north-south trend of the Texian System, is a most extraordinary aggregation of Burnetian, Fernandian, and Texian mineral components, commingling as it does the rare elements of the first named, the magnetite of the Fernandian, and the peculiar quartz rock of the last named period. Narrow bands of the Texian quartzite alternate in the same mass with smooth, glistening layers of the iron ore, which carries considerable titanium and rare elements such as tungsten and niobium. With these are also ribands of a scaly specular hematite sandstone.

c. The great Silurian geanticline, which further modifies the structure and complicates the mineral relations in some areas, was chiefly manifested in the Archean and Algonkian tracts by vein fissures, now filled by quartz which often carries alternate varieties of iron (and perhaps manganese) ores similar in composition to that mentioned under *b*, but usually without the rarer ingredients.

There is an interesting parallelism or symmetry in the arrangement of the mineral belts within the Burnetian tract, which goes far to prove the original continuity of the broken axis across the whole tract. So far as my observations go* the cassiterite and the minerals which carry tin in minute quantities are confined to the northern half of the tract, the cassiterite itself being apparently within the southern half of this portion. Garnet seems to occur in two belts lying respectively north and south of the distinctive tin field, but there is also a medium garnet tract which corresponds more or less closely with the central belt, or the tin and gadolinite area. Tourmaline is chiefly characteristic of the southern half of the whole tract, and keilhauite appears to cling to its vicinity in a measure.

Epidote is an abundant northern representative; labradorite is scarce and confined to the southern half; voigtite, hitherto unreported, is of the medium belt, in which cassiterite, gadolinite, fergusonite, cyrtolite, allanite, and other rare minerals occur, and idocrase is also thus distributed. In this central band albite, fibrolite, opaque white quartz, and what may be called "graphic orthoclase" are striking features. Quartz mounds, some known to contain similar minerals to those at Barringer Hill, are also characteristic of the middle portion.

A feature of the northern third of the region is the occurrence of the ores of copper and of silver (sparingly), which are much less characteristic of the southern tract and of rather local distribution in the median belt.

Much of the area in which cassiterite may reasonably be sought is now deeply covered by detritus and no prospecting or exploration has been done as yet. The Burnetian rocks are likewise exposed southward in portions of Blanco and Gillespie counties, where equivalent features are apparent, but the complexity there is such that generalizations as to distribution are much less satisfactory.

The percentage of tin in such minerals as contain but traces in the northern tract is sufficient to give the red borax bead with copper oxide in the lower reducing flame, and with greater saturation a copious reduction of the sub-oxide. In the solution nitric acid sometimes gives a rather heavy white precipitate, but with soda and cyanide and considerable borax no appreciable reduction of metallic tin is usually possible, excepting in the cassiterite.

More than thirty years ago Mr. J. Geo. Durst discovered the remains of two old furnaces about three miles apart, each of considerable size. From one of these, near the head of Willow Creek, in Mason County, a large amount of matte and slag has been taken (so Mr. Durst says) in the belief that silver bearing ores had been smelted there by the Spaniards in early

*I have traversed and mapped the whole region in such manner that no important outcrop can have been overlooked.

times. Possibly these furnaces may have given rise to the traditions rife among the people and referred to by Dr. Roemer, to the effect "that on the San Saba River silver mines have been worked formerly by the Spaniards," etc.*

At the time of my visit (November 2, 1890) nearly all traces of the furnace itself had been removed, but there are still evidences of its former existence in the shape of roughly hewn stones, fragments of ore, slag, and cinders. Such pieces of ore as could be reasonably regarded as of the raw material used in the furnace are chiefly identical with the glistening iron ore which abounds in Shaft Mountain, south of the locality, where Mr. Durst also showed me an old shaft. This excavation was made in a ledge of feldspar carrying the bright iron ore in plates irregularly distributed. Adjoining it are the quartz and sandy hematite layers already referred to. The slag and matte are extremely interesting. The general color of well fused portions is reddish-brown exteriorly, with glassy portions brown to black, the vesicular portions being gray to greenish, and surfaces of fracture greenish-black to jet black and nearly adamantine in lustre. The specific gravity varies from 3.37 to 5.24, the latter probably a matte or partially fused ore. Some pieces have small globules of metallic tin adhering or imbedded, and nearly all contain a very noticeable amount of this metal, which has usually been reported as silver by those who have found it heretofore. The following are the results of a qualitative analysis by the writer:

Small fragments were broken from different pieces of the lighter slags to make a rough average, carefully rejecting all lumps which showed metallic globules to the unaided eye. None of the heavier, less fused pieces were taken. The powder of the whole was dark greenish gray. With borax and cupric oxide in the lower reducing flame a decided reaction for tin was observed. With boiling dilute hydrochloric acid a partial solution was obtained of a dark brownish yellow color, with the separation of a copious slime of silica and a slight evolution of chlorine, thus showing traces of manganese. Dilute nitric acid gave a partial greenish yellow solution, with barely perceptible precipitation of a white powder, indicating the presence of tin. Strong aqua regia, after long boiling, with successive additions, left a black residue, with much silica. Further reactions were obtained in the systematic analysis, as below:

Tin, present in very evident traces.

Iron, abundant.

Manganese, traces.

*American Journal of Science (2d Ser.), Vol. II, 1846, p. 364. (Willow Creek flows southward into the Llano River, but the locality in point is near the divide between the waters of the Llano and the San Saba rivers. T. B. C.)

Silica, abundant.

Potassium, small amount.

Sodium, trace.

Tungsten, trace.

Titanium, and probably tantalum and niobium, present together in large amounts.

In the precipitate containing sulphides and hydroxides of the metals of the third and fourth groups of Fresenius (thrown down after the application of ammonium chloride, ammonia, and ammonium sulphide), the part insoluble in cold dilute hydrochloric acid was in large proportion. This when dried was a white powder, giving the reaction for titanium in the bead of phosphorus salt. The colors and changes were very pronounced, but the blood-red color produced by the addition of ferrous sulphate, although evident, was much less intense than the reactions which might be confounded with those of the metals mentioned after titanium above. The insoluble residue, after fusion with alkali, gave a strong reaction for niobium.

Some of the partially fused fragments have minute adhering scales of a rusty mica, usually with grains of quartz associated, a result which was very possibly due to the use of schistose rocks from the vicinity as linings to the furnace, although the glistening iron ore is itself occasionally slightly micaceous. The fuel was probably charcoal, as old pits containing relics of this material are still traceable in the neighborhood. The high specific gravity and the imperfectly fused condition of the greater part of the slag, as well as the remaining globules of tin in much of it, would lead to the inference that the smelters had access to some deposit of cassiterite in the region. This may perhaps eventually be discovered, now that the geological conditions for its occurrence have been shown by the writer to exist in a belt crossing near this locality. The prominence of the metals of the shiny titanium ores in the slaggy relics, and the evidences of early mining in the area of their occurrence in Shaft Mountain, render it almost certain that the furnace was used for the reduction of those minerals in part. The other ingredients suggest the admixture of feldspathic minerals as an inferior flux, for it is certain that no limestone nor ordinary fluxing ingredient (except perhaps ferric oxide) could have been used in this instance. The shaft referred to was sunk in orthoclase, carrying the ore described under *b*, page 597.

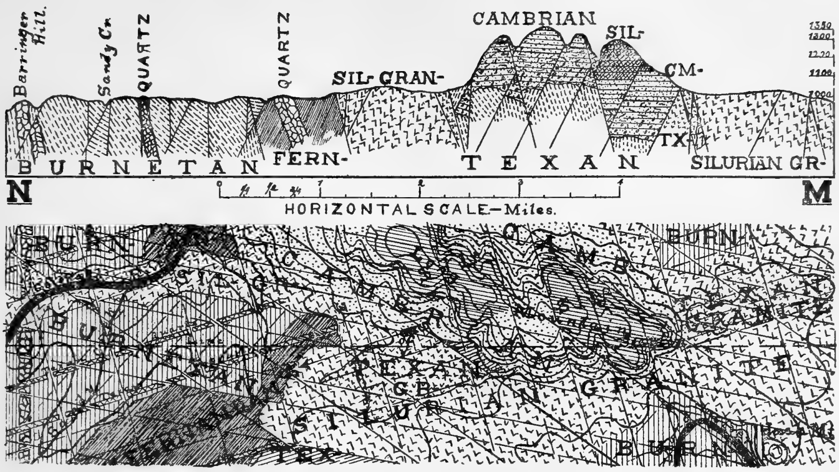

Fig. 68.

Plan and section along line M–N of map (Plate XXI), showing some of the complications in the structure of the eastern end of the Tin Belt.

Figure 68 illustrates some of the complexities of the region south and southwest of Barringer Hill, Llano County, and Figure 69 exhibits the structure in the region around Shaft Mountain, Mason County. The courses of the breaks and faults are correctly drawn and their relative ages properly indicated, but the exact details of the underground features can not be vouched for wholly, as the hade of the joints has not been closely studied in many cases. The general aspect of the country and its geology, however, are correctly portrayed in these cuts.

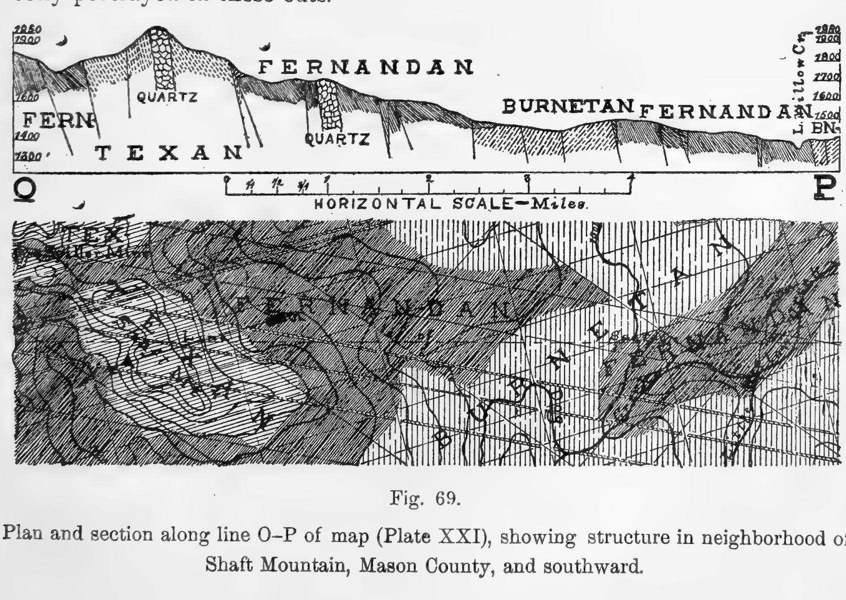

Fig. 69.

Plan and section along line O–P of map (Plate XXI), showing structure in neighborhood of Shaft Mountain, Mason County, and southward.

The prolongation westward of the Burnetian axis, from Barringer Hill, passes considerably north of the left hand end of the section in Figure 68. As the discoveries of cassiterite seem thus far to belong to one narrow belt trending north 75° west from Barringer Hill, it is probable that the region in which tin ore will eventually be mined, if ever commercially important, will be limited to a belt somewhat narrower than that indicated upon the map (Plate XXII); and as the outcrops are restricted and more or less confused by later deposition and disturbances, it is reasonable to expect that certain situations will yield better than others along the line. At present the indications are best in eastern Llano County and northwestern Mason County, but I have traced the peculiar glistening titaniferous iron ores through disconnected outcrops across much of the intervening territory, and there is a fair prospect that diligent search will bring to light new deposits. The axis of the belt passes near Field Creek, Pontotoc, and Fredonia. The best exposures of the peculiar ores are closely related to outcrops of Texian rocks, at least geographically, and I think also geologically. A special examination of the whole area of the tin belt in an economic way is essential to a thoroughly accurate estimation of the resources available. This has not been possible as yet with the means at the disposal of the Survey and the necessity of covering unprecedentedly large areas in each field season. It is to be hoped that a thorough investigation of this important subject may be undertaken at an early day.

4. ZINC.

The absence of zinc continues to confront us, as was stated in the First Annual Report (p. 344). The only claim made as yet concerning its occurrence anywhere within the limits of the maps accompanying this present Report has been the sending in of a small crystalline fragment of "ruby" zinc blend (sphalerite) by one who obtained it from another who said it came from near Fredonia. The claim lacks verification, and everything militates against the correctness of it. I have no doubt that it is a mistake. The mineral is very similar to some of the Joplin, Missouri, ores, and nothing like it has been observed by any of our staff in my district at any point, although we have worked extensively over the region from which this is said to come.

5. MANGANESE.

The remarks made under this head in Report for 1889 (pp. 345 to 347) need little modification, except to extend them by calling attention to the wide areas over which the deposits there indicated may be sought with confidence. The belts are well portrayed on the map of mineral districts (Plate

XXII), and the geologic structure, so far as it can be predicted from present knowledge, is sufficiently illustrated in the hachured map and sections given in Figure 70.

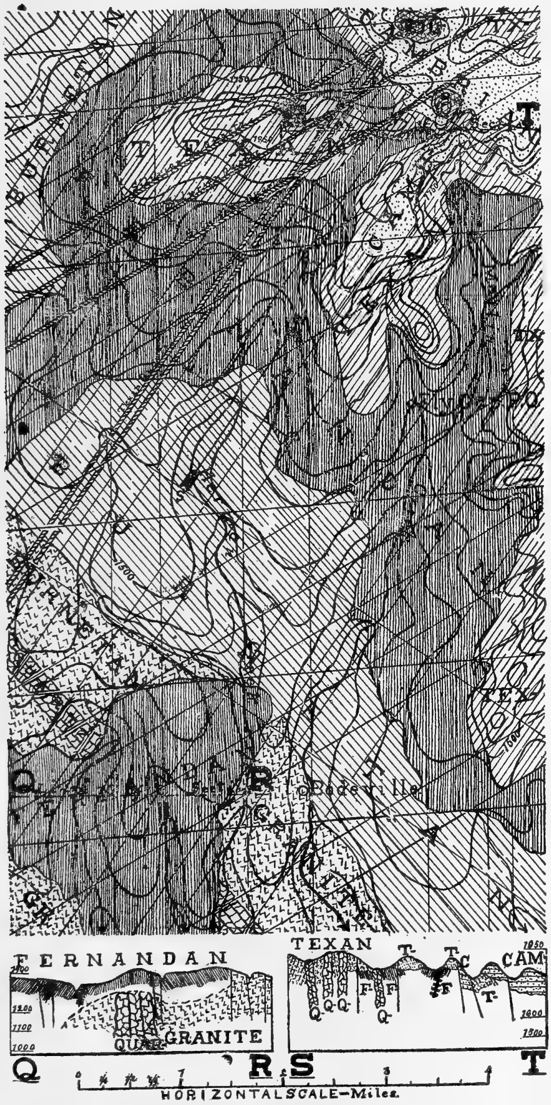

Fig. 70.

Plan and sections along lines Q–R and S–T of map (Plate XXI), illustrating Geology of region about Spiller Mine and Diggings, on survey 764 (Pluennecke), Mason County.

The manganese belts, omitting for the present the manganiferous iron ores, are somewhat definite geological areas whose relations in structure appear to be very close to the iron ores. But a careful study reveals peculiarities which are so persistent and so distinct from the strictly Fernandian aspect of the principal iron fields that a different mode of origin is plainly indicated.

In my Report for 1889, page 307, allusion was made to a series of structural breaks in Silurian strata corresponding in trend to the buried Fernandian axes. This is not the place to discuss such topics in detail, but it may be remarked that more extended observations have made it appear very probable that the manganese deposits are really secondary aqueous vein formations of Post-Silurian date. They follow the northwest trend frequently, but other accumulations lie in the trend (north 25° east) of the uplift at the close of the Silurian Period. These two vein courses occur together in the same fields, and almost invariably there is evidence of a later origin than the adjacent rocks whenever the manganese ores are exposed.

It should be understood that the bands drawn across the Economic Map are intended to indicate the courses of the outcrops, and not to imply the occurrence of manganese ores continuously. There will be no use prospecting over the areas in which the Burnetian rocks are at the surface.

THE SPILLER BELT.

The Spiller mine has been left practically in the same condition reported last year. Such prospecting as has been done in adjacent areas has vindicated the statement in my former Report (page 346) to the effect that "prospecting in the locality would be justifiable from the surface indications."

The chief element of uncertainty is the vein-like character of the ore bodies, which are liable to prove irregular and pockety as well as uneven in quality. The showing of the Spiller mine is, however, very encouraging, and there is good reason to look for a continuance of that deposit in a southeastward course. Little can be predicted as yet of the companion course (north 25° east), although what evidence we have is less favorable for continuous veins. In a northwestward direction the chances for outcrops of the ore are not as good, but there are some localities where it would not be surprising to discover similar deposits. These are indicated in a general way upon the accompanying Economic Map (Plate XXII).

The mineral is principally psilomelane or a near ally, but there is much variety in composition in different parts of the belts. Some samples approach more closely to pyrolusite, and some even to braunite, while much of it is so irregular a mixture as to be more properly regarded as "wad." Silica in excess is characteristic of a considerable portion of the product from the northern portion of the belt near the Spiller mine; farther west (Pluennecke survey, No. 764, Mason County) the material can only by courtesy be regarded as a manganese ore. This last is really a manganiferous iron ore carrying only from two to ten per cent of manganese in the Survey samples. Table II gives analyses from these localities.

Within the last few months the southeastward prolongation of the Spiller Belt has been prospected, and some promising manganese deposits have been brought to light. It is probable that many more outcrops or easily exposable occurrences of similar material will be discovered by careful scrutiny over intervening areas. At present the best known exposures are near the boundary line between Blanco and Gillespie counties, along the drainage basin of North Grape Creek. Excellent surface croppings, apparently of transported material, have been found on the eastern half of survey No. 251 (William Starrock league), Blanco County. In much of the area, however, the later rocks now cover the natural position of the veins too deeply to give any hope of profitable returns from working them, while another large portion of the the tract has been denuded of the whole set of rocks in which the manganese ores were originally entombed. Parallel belts cross the Rutersville College survey, No. 217, Gillespie County, and these have been exposed at various points along the vein courses as indicated upon the map.

THE PACKSADDLE BELT.

The region referred to in the Report for 1889 (page 346) lying "between Packsaddle Mountain and the Riley Mountains," including "that portion of the district in which the northwest strike is at the surface," has been examined more thoroughly since then, and the conditions affecting the occurrence of manganese and its distribution have been more clearly made out. The prolongation of the belt northwestward in Llano County, through the region of Horse Mountain and its extension southeastward into Blanco County, are well known. In both directions some prospecting work has been done. The results do not materially change the conclusions drawn by the writer last year. The products are not strictly speaking manganese ores, but more properly manganiferous iron ores. Some of them may have a decided commercial value eventually in the manufacture of ferro-manganese, or in the production of manganese steel. From a geologic standpoint—i. e., regarding their mode of origin—they are allied to the true manganese ores more closely than to the original iron ores. In other words, they are secondary products and associated with the limonites. They have the same structural relations and occur under the same conditions as the manganese and manganiferous ores of the Spiller Belt. Peculiar features of both districts are the high silica contents and the low percentages of water, etc. ("loss on ignition"), although the association with the limestones is intimate, and calcite is not infrequent as an accompanying product. This may, perhaps, be explained by reference to the siliceous nature of the Silurian dolomites which are traversed by the veins, and it is also noticeable that lime and magnesia are much more abundant than in the ores of the iron belts. Barium, which is a component of most manganese ores, is so far as our analyses go wholly absent from those of the Central Mineral Region.

The great difficulty is to decide from what source of supply the manganese minerals have been derived; for it would seem that any process of solution which might have drawn this material from the older iron ores would certainly have brought up the iron as readily, making the secondary product as highly ferruginous as the original deposits. To some extent in certain situations this has been the case, and perhaps we may reasonably conclude that the least ferruginous manganese ores have been formed under special modifications of similar conditions. Somewhat equivalent conditions in segregations may be observed in what appear to be more or less well defined belts of the Cambrian hematites. That is to say, in some of the tracts in which the iron segregations have been excessive the resulting ores have been highly manganiferous, and this usually where there is a manifest distribution along the northwest-southeast course in structural breaks. This feature is especially noticeable near the north end of Smoothing Iron Mountain, and on the James River near the mouth of Salt Creek, as well as in extensions of both these belts, the former across Llano County into San Saba and Blanco counties, the latter into Gillespie County, and to some extent in both directions in Mason County.

TABLE II.

MANGANESE ORES.

Number.	Locality.	Water.	Silica.	Ferric oxide.	Alumina.	Lime.	Magnesia.	Phosphoric acid.	Sulphuric acid.	Manganese protoxide.	Manganese sesquioxide.	Manganese dioxide.	Remarks.
1†	Spiller mine, Mason County	....	11.47	.....	....	3.05	1.31	Trace.	Trace.	.....	56.63	......	Ferric oxide with alumina, 9.00.
2†	Spiller mine, Mason County	....	46.15	.. ..	....	8.90	Trace.	Trace.	......	.....	36.12	1.48	Ferric oxide with alumina, 7.50.
3†	Spiller mine, Mason County	....	43.10	....	....	9.74	Trace.	Trace.	......	29.04	.....	Trace.	Ferric oxide with alumina, 18.35.
4†	Spiller mine, Mason County	3.00	19.13	.....	...	0.73	Trace.	......	......	.....	66.64	3.06	Ferric oxide with alumina, 7.63.
5†	Near Harper's, Fall Creek, seven miles west of Castell.	....	47.50	25.88	....	......	......	Trace.	0.17	.....	8.27	......	Metallic iron, 18.12.
6†	Near Harper's, Fall Creek, seven miles west of Castell.	....	19.90	74.75	....	......	......	Trace.	Trace.	... .	2.13	......	Metallic iron, 52.33.
7†	Chaney diggings, Llano County	4.45	21.65	57.65	3.09	3.20	2.34	......	......	.....	.....	11.12	Metallic iron, 40.36.
8*	Gillespie County (J)	....	27.00	53.85	4.15	8.80	0.75	Trace.	Trace.	.....	....	5.20	Metallic iron, 37.70.
9*	Gillespie County (J)	....	54.80	34.88	5.32	Trace.	0.41	Trace.	0.12	....	.....	4.78	Metallic iron, 24.42.
10*	Gillespie County (J)	...	36.20	41.31	9.09	3 45	1.51	0.24	0.03	....	.....	8.54	Metallic iron, 28.92.

Analysis by *J. H. Herndon, †L. E. Magnenat.

D. IRON.

From the vast extent of the workable fields, the enormous quantity exposed in the outcrops, the unsurpassed quality of the product, and the remarkably favorable conditions for economical mining, there is nothing equal in importance to the iron ores of our district. Whenever they receive the attention from ironmongers to which their manifest superiority entitles them the industrial development of Central Texas will make strides far in advance of the dreams of her present inhabitants. It seems marvelous that such extensive accumulations of the highest type of raw material, so readily accessible, have hitherto lain unapplied, if not really unrecognized, while material of inferior quality occurring less abundantly has already become an important factor in the commercial development of Texas. There are three reasons for this state of affairs, which it behooves us to remember in all discussions bearing upon the industrial progress of the Central Mineral Region.

First of all, railroads have not yet penetrated this field. In this respect Eastern Texas has long held an important advantage. But railroads can always be had where capitalists can be made to realize their justification in dollars and cents. We must therefore seek further for an explanation of the past neglect of these undoubted resources. A full exposition of the facts can do no harm to legitimate interests in the region. We thus discover that,

Secondly, there is an insufficient present supply of fuel for the economical reduction of these ores within the area in which they occur. I am aware that contrary opinions have been held by residents of the district and by several persons who have reported upon individual properties, but my assertion is based upon careful personal observations in every portion of the area, extending over a period of many months of actual field study. The results of such an investigation may, I think, be fairly regarded as more liable to be correct than either the estimates of inexperienced residents or the judgment of outsiders hastily skimming a part of the tract. In all questions relating to metallurgic practice the value of opinions is mainly dependent upon the technical knowledge of the field and of the subject which is possessed by the person reporting. This question is a vital one, and it will receive special attention presently.

Thirdly, the citizens of different parts of Texas have not yet come to an understanding with regard to the right relations of their respective areas as commercial nuclei. This is a topic which few can discuss without local bias, excepting those who view it as a simple economic problem; nor is it really advisable that it should be otherwise, looking merely from the standpoint of an interested individual or a trade centre. Artificial aids, often the result of wholly unforeseen causes, may remove natural obstacles or enable handicapped localities to outstrip those which are possessed of great natural advantages. It would therefore be but folly to attempt here any portrayal of the future of the iron districts except in the most general way. In some of the cities which have cause to anticipate the most good from the development of these fields there has been shown the least tendency to reap the benefits of close trade relations, and the struggling denizens of the mineral region have often had the most encouragement from the enterprise of those most remote and least favorably situated for building up the iron and steel industry. While much of this condition may be due to greater enterprise in certain places, it can not be doubted that it is in a large measure the result of misinformation in other quarters concerning the true situation.

Without taking a hand in the contest for commercial supremacy which is sure to ensue, or in any way attempting to define the relative situations of rival communities, one charged with the investigation of the resources may properly present in outline the case as he finds it, hoping thereby to contribute his mite in the laudable endeavor to prevent waste of energy where it can not avail, and to stimulate enterprise in directions marked out by nature for easy conquest. In this spirit I desire to state some facts which are well worthy of consideration by all who may contemplate engaging in any business connected with the mining and smelting of the iron ores of this region.

1. The existence of the ore in such large and easily mined deposits must sooner or later attract the attention of capitalists and lead to the building of railroads. This will enable mine owners to ship ores to points where it can be smelted. Some assert that it will build up a local smelting industry by bringing the fuel supply within reach. But there are many considerations besides these which affect the economy of treatment, and the relations of the smelting centre to the markets which must absorb the product are of prime importance.

2. Comparatively little of the iron and almost none of the steel produced in the United States is made at points far removed from the great trade centres. The chief reason for this is the necessity for locating at a focus of the trunk arteries of commerce, in order to promptly and economically distribute the products of the mills, which now are usually connected with the furnaces or not far distant from them. It must be borne in mind that we are dealing with business questions of the day, and not of former methods which have been superseded by the multiplication of furnaces and iron working plants.

3. It is not reasonable to suppose that the national trunk lines will neglect the large trade nuclei already established in Texas in order to enter this new field. All the railroad lines now projected have in view the connecting of this region with other Texas cities rather than the establishment of a rival

distributing point. What effect the settlement of the surrounding country may have upon these existing circumstances can not now be foreseen, but the manifest interest of transportation lines is not in the direction of in-hauling fuel so much as out-hauling ore.

4. Assuming that Llano or some other point in the iron bearing tract be chosen as the site of smelting furnaces, it would be necessary to find a market for the product. This must lie within the State of Texas, or in a limited area adjacent thereto.

The present iron ores cover a very large area, but their outcrops are restricted to very narrow bands persistently crossing the belt in parallel lines. There is an important structural difference between them and the manganese ores, although many observers would overlook this important feature even in working the deposits superficially. The iron ores which are not segregations or secondary erosion products follow practically the same course as some of the manganese veins. But the former are component parts of the Fernandian system, folded and denuded in unison with the same; whereas the manganese ores probably fill vein fissures of Post-Silurian date. From the strict parallelism of the bands of the two areas, and from observations of the manganese veins where they have been sufficiently eroded, it seems reasonable to infer that they may become more ferruginous at greater depths, and exhibit there the original facies of the true iron ores farther east.

We have been unable as yet to give such topics their merited attention, and it is doubtful if circumstances will permit of the necessary investigation of them in the near future. The Economic Map accompanying this Report (Plate XXII) shows the distribution of the ores in detail. A close examination and comparison with known outcrops will make it apparent that the positions of the ore belts are there indicated with precision.* The bands of iron ore cross the roads and creeks and individual surveys exactly as laid down upon the map, and the information given in the Report should be all that is needed for the guidance of prospectors for many years to come.

CLASSIFICATION OF IRON ORES.

There are several varieties of iron ore in the Central Mineral Region, and these may be classified in various ways, according to their composition, mode

*This map is the result of the plottings of very numerous outcrops, and of observations of dips and strikes, first upon the scale of one thousand and forty feet to one inch on convenient sheets, accurately reduced to about one mile to the inch and this again to one-half that scale, then to one-fourth, and finally by photography to the published scale. As evidence of the thoroughness with which the field and office work has been done, I may point with some pride to the fact that of the large number of prospects of all kinds opened since the notes were taken not one has been authoritatively reported which did not lie directly in that one of the mineral belts defined upon this map to which the ore corresponds.

of occurrence, origin, and metallurgic uses. It will be convenient here to adopt a scheme based upon commercial relations and modes of occurrence, with reference also to the composition, which has much to do with their economic utilization. Thus we may separately discuss them under the following heads, viz.:

1. The Hard (anhydrous) or Belt Ores.
2. The Sandy or Comminuted Ores.
3. The Concretionary or Segregated Ores.
4. The Soft (hydrous) or Vein Ores.
5. The Titaniferous Ores.

This grouping has the slight disadvantage of failing to afford a strictly scientific arrangement, and yet the geologic affinities are more close to the economic relations than might be at first sight supposed. There is also a certain fitness in making two broader divisions; the first to include 1, 4, and a part of 5, or those low in silica (below six per cent); the second comprising 2, 3, and the remainder of 5, or the siliceous ores. Analyses of all grades are given in Table III.

1. HARD OR BELT ORES (ANHYDROUS).

The lines running about northwest by southeast through the space marked "Iron Ore Belt" upon the Economic Map (Plate XXII) represent the courses of what are probably the axes of folds in the Fernandian rocks. At any rate along each of the lines, wherever these rocks outcrop, there are evidences of the existence of more or less valuable, usually workable, deposits of the hard ores, magnetite and hematite. There has been so much disturbance of the strata, and such an amount of igneous action in places, that absolute uniformity of exposure or of quality can not be expected. There is, on the contrary, enough variety in the product to make the proper location of mines a matter of some importance. Nevertheless there is far less difference in the character of the ore in each individual line than among the different lines. The magnetites and hematites are occasionally distinctly separated, but in many exposures the two run together, either in separate bands in the same bed or commingled in varying proportions. The general situation, with much detailed description, was clearly depicted in my Report for 1889. Some of that material, with important additions, is incorporated in what is given below.

A. THE MAGNETITES.

The original magnetites lie in the northwest Archean or Fernandian trend.* They do not appear in their greatest development in all exposures of these

*North 36° west by south 36° east nearly.

rocks, and it might be doubted whether there is actually a continuous bed, or set of beds, forming a definite horizon in the Fernandian System. At first sight some of the outcrops comport nearly as well with the idea that they are "lenses" or "bosses" of ore brought into their present positions by local causes. But it has been found that while the large masses may be apparently discontinuous across the region, there is almost always an indicator of continuity in the shape of a line of ferruginous soil or other landmark; and when the undecomposed hard ore again presents a topographic outline of its own it invariably possesses the same character as its representatives in the same band. This statement may be verified by any one who will take the trouble to note the positions of the bright red soil belts which are successively crossed in traveling between Lone Grove and Camp San Saba, on the Burnet and Brady road, or in traversing an equivalent stretch of country by almost any other route. It is also a very interesting fact that the derived, or secondary, iron deposits of later date in the basal Cambrian strata at least follow roughly the same trend, though in a much less pronounced manner. These facts come out very strongly upon the accompanying Economic Map.

The area in which the Fernandian beds prevail as surface rocks may be limited for the present practical purposes by northwest-southeast lines drawn through Lone Grove, Llano County, upon the east, and through Katemcy, Mason County, upon the west. This blocks out a district thirty miles wide and extending perhaps thirty miles in the direction of the strike. Within this field, however, various structural features have prevented in many places the outcropping of the iron bearing system, so that a part of the area is not in a condition to yield ore without removing thick deposits of later origin. Besides it must be understood that only a small fraction of the thickness of these strata is iron ore. Keeping in mind also the folded condition of the rocks, it is evident that the chances for mining will be dependent largely upon the character of the erosion, it being premised that the iron stratum is not very near the top of the system to which it belongs.

The Iron Mountain Series, which includes magnetites, was described in some detail at page 271, *et seq.*, in the Report for 1889. The horizon of the magnetic ores is near the middle of the Fernandian System and below the middle of the Iron Mountain Series.

The iron deposits lie between carbonaceous and calcareous beds which overlie them and quartzose beds beneath. Knowledge of these facts will assist greatly in the search for the ore; for wherever the graphitic schists and marbles appear at surface, as is the case for instance just west of Llano Town, the iron stratum is buried, and wherever the quartzose beds outcrop the hard iron ores must be sought in positions above them. A warning is necessary, however, against confounding the more granular and less metamorphosed Texian marbles and graphitic rocks with the similar Fernandian types. A little observation will teach the differences, which can often be determined by the discordant trends, although this is not a safe guide over extended areas. The difficulty may be almost wholly avoided by keeping in mind the fact that the Fernandian graphite is schistose rather than slaty, and that the Fernandian marbles are usually blue, while the Texian System includes those which are white and yellow. The marbles of both systems are crystalline dolomites, not amorphous beds like the "Burnet marbles" or "lithographic stone" of later origin.

The magnetites, strictly speaking, are confined to the Fernandian System. Upon the Economic Map the courses and positions of the bands are accurately placed, and in a general way the locations are shown where there is any reasonable prospect of discovering workable deposits. It will be noticed that the belts are interrupted in places. This is due to the absence in those spots of the iron bearing series or to its being buried beneath later strata. The former condition prevails in those areas in which other characters are depicted upon the map, and the covered areas are left blank or are traversed by bands of the vein ores which have been derived from the buried extensions of the hard ore bands. Whenever the Fernandian strata are the surface terrane the chances for the discovery of good bodies of Bessemer ore are very favorable, provided that search is made in the course of the hard ore bands, as shown on the Economic Map herewith. I have plotted these bands in some cases where they may not exist, in order to show their courses through the interior area, and because there are certain places where it is possible that local patches of Fernandian rocks may have escaped notice in my survey of the region.

The analyses made by the chemists of the Survey of my samples, as reported in Table III, give a very clear notion of the general run of these ores. Below are given some of the distinguishing features of the separate bands, although there is a close resemblance among them all, as might be inferred from the structure. It should also be premised that the nearly vertical position of the beds in the Iron Mountain and other bands is not a necessary concomitant; and it may well happen that in some areas the low inclination of the iron stratum may make it profitable to work it over somewhat wider tracts than in those particular fields. An accurate section across the area in any one line must fail to express the situation so that it may be readily understood, and the complication is so great that it is not safe to make stratigraphic generalizations to be used as guides in practical work.

For the benefit of prospectors and those engaged in mining exploration, the following hints are reproduced from the writer's 1889 Report:

The main facts and the conditions in which the magnetic ores are placed are these:

1. Whenever a set of rocks appear such as are described in Part I of this Report under the head of Iron Mountain Series,* there is liable to be a valuable deposit of *magnetite. In prospecting be sure that you have a set of rocks whose general strike is very nearly northwest (magnetic).*

2. If, in the same connection, a large amount of red soil occurs in comparatively narrow strips, there may be a good ore body at no great depth beneath the decomposed portions. Wide belts, especially along valleys of stream, are usually not of this class. *To test the matter, dig down to bed rock only, and do not waste labor in excavating rocks which you do not know. Pay out money for competent advice and act upon it. If you or your friends or "practical miners" "have never seen such rocks before," experienced engineers can tell you their values accurately by their tests.*

3. A body of *magnetite* ore having been found, it may be followed by the dipping needle or by prospecting in a northwest or southeast direction. *But when you strike the red sandstone or other rock overlying, the beds with the northwest strike will disappear beneath the others.*

4. Beds trending nearly north-south resemble these somewhat, but they are of later date and the magnetic ores occur beneath them. *You can rarely find the ore bodies by digging in such places unless you have an intimate knowledge of the geology of the country.*

5. There are six parallel belts in which it is possible that valuable deposits of *magnetite* may be discovered.†

THE BABYHEAD BAND.

The easternmost outcrops of the hard ores follow a course represented by a line bearing southeastward, passing near Babyhead and Lone Grove post-offices, and coming out southward very near the Wolf Crossing of the Colorado River. This belt is well exposed in the Babyhead Mountains, but is buried beneath the Cambrian strata just beyond the north line of Llano County, which is thus practically the northern limit. As exhibited on the Economic Map, other buried bands are indicated by the outcrops of derived vein ores further east, but so far as yet determined there are no important exposures of the hard ores anywhere in the courses of these bands, although certain of the hematite pockets in quartz veins afford examples of this class, having closer affinities to the soft vein ores in their mode of occurrence. (See remarks beyond under the head of "The Eastern Burnet County Band of Soft Ores.")

The typical strike of the Fernandian System can be traced southeastward nearly to the Colorado River, with some breaks where erosion, more recent uplifts, or alluvial deposits have cut out or obscured its path, but no workable outcrops of the hard ores have attracted attention except those in the vicinity of Babyhead Town. There is every reason to expect good results from prospecting in the tract here outlined, especially in the north half, down

*See page 271 of First Annual Report.

†Three was given as the number recognized in 1889, but I have since been able to work the region more thoroughly.

to the crossing of Miller Creek. Northward between Lone Grove and Lockhart Mountain, and southward from Lone Grove as far as Miller Creek, the carbonaceous and calcareous strata have not been eroded from above the ore beds, and still farther southward the later granitic masses have largely obliterated the original structure. These geologic features are not as favorable to economic mining as the conditions prevalent north of Lockhart Mountain, because the ore can not always be found at the surface in the former areas. But the exposures in the Babyhead Mountains are partly due to faults, and it is not improbable that limited districts elsewhere in the belt may also present conditions suitable for working.

However, it must be remembered that this field is one in which the Burnetian system is prominent, and a portion of it is covered by Texian strata. This means that denudation or lack of deposition over much of the belt has left no chance for discovery of any of the Fernandian rocks, or of their thin edges only. The magnetite beds themselves are not here so thick nor so prominent as in some other districts. There is some evidence that this is due to subsequent denudation and not to discrepancy in original deposition, for it is a fact that the comminuted ores of later date are more abundant along the path of this and adjoining magnetite bands. Analysis No. 1 reported in Table III is of a sample of the Babyhead ore, perhaps somewhat below the average product. Specimens of lodestone have been taken from this band near Babyhead by Mr. E. T. Dumble, State Geologist. The line of outcrop appears upon the Hensley league, survey No. 410, Llano County, but it is there somewhat obscured by the overlying marbles, and it is also in part converted into a hydrated ore (No. 47, Table III).

THE TWO LLANO BANDS.

There is an area about five miles in width between Packsaddle Mountain and the Riley Mountains in which the Fernandian rocks are well exposed wherever they are not cut out by later uplifts. This belt extends northwestward to the Cambro-Silurian escarpment a little north of the south line of San Saba County. The rocks are folded here as in the areas upon both sides, and several times the succession of the strata is repeated. In all the exposures the typical Fernandian section is exhibited, and there is usually some indication of the presence of iron ores in situations which correspond to the horizon of the Iron Mountain Series. The marbles and graphitic schists cross the Brady road between Pecan Creek and Valley Spring in two places, and ores of value have been detected in a number of places among these outcrops.

Near the mouth of Public Pen Creek, northeast of the Cat Mountains,* between the two roads from Lone Grove leading to Valley Spring and Llano respectively, I have seen good altered surface indications of the magnetite, and such also appear in Public Pen Creek not far northwestward, and again in the upper valley of Willow Creek. In the same course, southwestward, this band crosses the Llano River near the lower ford at Llano, where it exhibits similar features,† and similar outcrops are repeated near the upper ford one mile above Llano, but in both these cases the marbles prevail, indicating that the hard ores lie beneath.

In all the outcrops of these two Llano bands, which are broken at intervals by faults and granitic irruptions, the magnetite seems to lie at a considerable depth below the surface, and its altered products often appear now as hematite or limonite. Neither of the bands has been prospected extensively, because the hard ores are not plainly visible at the surface, but there is every reason to believe that they exist beneath at the proper horizon, and that they may be eventually mined with profit. Numerous observations have been made which confirm my judgment that the magnetite horizon is a persistent one in the Fernandian System.

THE IRON MOUNTAIN BAND.

There are several localities in this course at which the development of the magnetite deposits has been undertaken with some degree of enterprise, and in which very large and valuable masses of this mineral have been exposed. This belt is most persistent and can be traced for many miles. It has been worked in Llano County at Iron Mountain and at points southwest of Llano, while fragments of ore have been collected from the tracts at the southeastern base of the Riley Mountains, where the quantity of derived segregations on the surface is also enormous. In all good exposures, or wherever the ore body has been tapped along the course as indicated upon the Economic Map, between the Cambrian escarpment at the northwest and the similar cap at the western edge of the Riley Mountains, the magnetite is invariably found to be abundant and of the very best quality. And the same is true of the exposed

*Name given on our maps to the hills locally known as Wolf Mountains, because there is a Wolf Mountain on another Wolf Creek, also tributary to Pecan Creek, which is liable to be confounded with them. For the same reason I have changed the name of the creek here known as Wolf Creek to Cat Creek on my maps.

†Slight changes in the geographic outlining of the more eastern Llano band are rendered necessary by the plotting of our Survey. In last year's Report I referred a part of this band incorrectly to another one which lies farther east. The Chaney diggings near Packsaddle Mountain do not belong to either of the two Llano bands. That band has been described under the head of Manganese Ores, on page 605 of this Report.

extension of the band across the areas southeast of the Riley Mountains, as far as the scarp of later rocks which obscures it near Blowout, in Blanco County.

The Cold Creek Area.—By reference to the Economic Map, it will be seen that the upper valley of Cold Creek is traversed in part by the northwestern outcrop of the Iron Mountain band. Some very choice ore has been taken from this district in Simpson's pasture and at other points in the course of the band between Sponge Mountain, in Llano County, and the Cambrian escarpment near the Fredonia and Cherokee road, in San Saba County. In all respects the features are very minutely identical with those in the other tracts to be described in this same band. Development has not gone far enough to determine the quantities available, but the only doubt upon that point arises from the apparently greater plutonic or igneous action in this district, although that may really be more favorable than otherwise. In this particular there are certain resemblances to the conditions surrounding the Lake Superior ores. The time may come when the State of Texas shall be able to appropriate funds sufficient to enable all these details to be studied carefully. A vast amount of material has been collected bearing upon questions connected with the origin and history of the ores, but the Survey has not yet the facilities for elucidating the subject.

The "Iron Mountain" Outcrop.—About one mile and a half northwest from Valley Spring Postoffice, upon the right bank of Johnson Creek, the ground slopes somewhat steeply beyond the old flood plain of the stream, and at the culmination of the hill a small ridge or mound formerly stood out in relief. This was the condition at the date of the writer's first visit, in June, 1889, but by the time it was again examined, in the following August, the excavations made in the so-called Iron Mountain had changed its appearance, so that now it would be difficult to understand this nomenclature. The course of the iron ore and its probable persistency in the northwest trend was clearly made out when I first examined the locality, and the excavation of numerous pits all over the adjoining space was unnecessary, as has been proved by the results, which fully confirm my original views regarding the strike and character of the mass. The section of the rocks at this point is given under the head of Fernandian System, in Part I of this Report. The quantity of magnetite and hematite at this outcrop is very great, and the explorations made have increased the knowledge of its extent.*

The occurrence of a very high phosphorus hematite layer upon one side of this outcrop is peculiar, as almost no phosphorus exists in the average of the ore. A reference to the section given under the head of the Iron Mountain Series in the last Report† will explain the probable cause of this streak. A band of altered binary granite is there associated with the magnetite, and in this is a green phosphatic mineral. The adjoining thin layer of the iron ore is thus contaminated with phosphorus. As in some samples from this streak

*First Annual Report, p. 351.

†Page 271.

the percentage is very high, it will be important to separate it in the mining, a matter of very little difficulty in any of the openings which I have examined.

Analyses Nos. 2, 3, 4, 5, 6 of Table III show the quality of ore which can be mined in great quantity at very moderate cost in the Iron Mountain tract.

The Wakefield Tract.—Quoting from the last Report (p. 351):

In the course of the Iron Mountain belt prolonged southeastward there are other exposures of the magnetite, but erosion has apparently not extended far enough in parts of the line to uncover the ore, while in other places the detrital deposits have obscured the continuation, if it exists, as the writer believes. About three miles south of Llano City considerable prospecting has been done in this and parallel belts. For want of a better name this will be referred to as the Wakefield tract, although the work done by Mr. Wakefield in the region is by no means limited to this area. Here the magnetites and associated rocks and ores of the Fernandian type have been again brought to view in a position adapted to mining, and the situation is very similar to what has been noted concerning the Iron Mountain outcrop. The ore, especially from Shaft No. 1, is almost identical with the Iron Mountain product, and there is little to be said of one locality in this Preliminary Report which will not apply with equal force to the other, excepting that the topography of the two areas is not the same in detail.

There has been no important change in developments within the past year in this locality. The continuation of the band across intervening country between Iron Mountain and the Riley Mountains has been confirmed by abundant observations. The great thickness of the deposit, its convenient exposure for working, and the high quality of the ore all alike give it a prestige which has not been attained as yet by any other openings, except those in the same band. This and its continuations, with the neighboring bands, may be said to constitute the foundation of the iron industry which must ere long be based upon the output of this region.

The Click Ore Field.—The extensive sedimentary deposits of the Riley Mountains have deeply buried the extension of the Iron Mountain band southeastward, but it becomes again apparent in the denuded area adjacent to Click Postoffice. Some very good ore has been taken from the surface in this region, and there is hardly a doubt that important supplies of the kind exist at reasonable depths, for the geological conditions are in all respects identical with those which hold in other parts of the Iron Mountain band. The segregated ores are also very abundant and rich in the Cambrian sandstones where this ore band disappears beneath the Riley Mountains.

THE OXFORD BAND.

Under the head of the Western Belt I remarked in the last Report:

West of the Riley Mountains, between that range and the Enchanted Rock, and perhaps over a greater breadth in the northwest, the Fernandian Beds appear occasionally, and in wide exposures in some areas. The outcrops of the magnetite are less understood in this belt, because the country is fenced in and not easy to investigate. It is also a tract which has many complications, and one which had to be neglected in part last season (1889) for lack of time to work it properly. Still the belt was crossed by us with section lines in four places, and several special reconnoissances were made in other parts, so that a generally correct idea has been obtained of the economic situation. The indications are good for the discovery of important masses of iron ore in the district, but at present I am unable to clearly define the position of the magnetite except by analogy with the outcrops of other belts. Much of this tract is covered by thick deposits of the later sediments (Cambrian, etc.), and granitic irruptions and other complications have made rather a puzzling structure. But there are two or three parallel lines trending northwest across the area in which the hematites are well developed, from which I judge that the magnetites are not very far to seek in certain outcrops.

Having had better opportunities to study this region in 1890, I am now prepared to define with some degree of certainty the positions of two distinct bands which are indicated upon the accompanying Economic Map. Of these the more eastern line of outcrop passes not far from Oxford Postoffice and a short distance south and west of Field Creek. The actual exposures are probably not as prominent as might be inferred from the map, but the course of the band is correctly indicated thereon. Its relations to the parallel belt farther west are somewhat close, and it may be that the intervening territory may not be found to be barren in all parts; but the general relations of the two bands are shown with moderate precision as they have been drawn upon my map. The iron ores, however, have been cut out along a considerable portion of the line, and this band therefore can not be considered as promising a field for iron mining along its whole course, as is the case with a number of others in the region. The complications of structure in western Llano County are not easily defined in general terms, although they are not difficult to understand when one has the key supplied by a knowledge of the different geologic systems. The best manner of searching for the hard ores in this band is to employ a dipping needle, and to obtain a fair acquaintance with the Fernandian rocks in their typical exposures. Slips, faults, contortions, and other results of numerous disturbances of the strata, besides the effect of irregular erosion, have made it very difficult for any but a skilled engineer with unstinted time at his disposal to successfully follow the courses of the iron ores in this region. They often crop out well developed in unforeseen situations, and again they disappear as suddenly where the complications of structure seem least evident at the surface. The Barder tract, on surveys 330 and 331, Llano County, affords a good illustration of this confusion, although it also yields some of the best ores of the Oxford band in great abundance. Nos. 7 and 8, Table III, are average samples.

The Oxford band is also exposed to some extent in the region around Blowout, Blanco County.

THE PONTOTOC BAND.

The hard ore band drawn upon the Economic Map as passing very near Pontotoc is not as well exposed as the parallel band upon the east, and it is not as certain that it represents a distinct structural line. Magnetite is not well displayed along its course, and the surface ores are largely segregations in the later rocks. But the existence of a band of high grade ore in this path is a fact, and all the evidence points to the occurrence of a source of supply beneath it which is of the same character as that of the other magnetite bands discussed in these pages. Probably the same is also true of the bands of manganiferous iron ores and manganese ores which lie in the equivalent trend farther west. This view is based upon the close relations in distribution which invariably exist between all classes of the iron ores in our districts, as will be shown in treating of the derived and associated ores beyond.

THE MANGANESE AND MANGANIFEROUS IRON BANDS.

The manganese tract defined upon the map, and already described as variable in its outcrops, has isolated exposures of ores in the Fernandian areas which may occasionally be classed more appropriately among the hard iron ores. The magnetites are, however, rarely represented in the region, as far as my observations go. The band farther west appears to be the most ferruginous.

B. THE HEMATITES.

In the Report for 1889, the ores being classified in a somewhat different manner, all the hematites were grouped together, minor divisions being based upon modes of occurrence. In this place, by the present method, we have to consider only those which belong to the class of belt ores. There are none of much importance, however, which pursue independent courses, their distribution being mostly coincident with the magnetites. In many portions of the magnetite bands already described these hematites lie in associated layers, but often the latter are wanting or nearly so. I do not know of any instance in which any considerable layer of hematite occurs without its accompanying magnetite, except in situations entirely different from the belt type of ore bodies. The analyses of hematites (Nos. 10 to 24, Table III), show well their relationship to the magnetites. It will be noticed that ten of them have enough of the latter mineral to give considerable percentages of ferrous oxide.

There is, it is true, a special manifestation or mode of occurrence of specular hematite ore in quartz. This seems to be connected with the titaniferous iron ores in origin, and it is especially characteristic of areas in which several axes of uplift cross. The occurrences are of much scientific interest, and they afford important evidence concerning the geologic history of the region. No deposits of this kind have yet been found of sufficient richness to pay for working. Although the ore itself is excellent, it is rather sparsely scattered through the white quartz in veins of no great width, usually. A similar situation for this material is in the quartz masses which lie in the trend of the Burnetian rocks, as at Barringer Hill and elsewhere, but the best deposits are of more recent date. Near Fleming's (Fly Gap Postoffice), in Mason County, the quartz is largely of the north-south Texian trend, but the garnets and other members of the Burnetian System are exposed in a decided outcrop crossing the tract. There is another similar area of some importance in the granitic region about the headwaters of Spring Creek, Burnet County, in the neighborhood of Capitol Rock. Good outcrops occur on the J. M. Sparks survey and on the D. L. Cross survey, and in other localities in that vicinity. (See further under the head of Eastern Burnet County Band.)

The hematites which fall to be treated elsewhere are without exception alterations of pre-existing ore bodies, and their distribution, irregular as it may seem, is very closely dependent upon the situation of the underlying and often inaccessible magnetite bands heretofore described.

Table III sufficiently indicates the variety in composition and the general distribution of the hematites of the belt region. The affinities to the magnetites are there shown by the gradations in the percentages of ferrous oxide. Analyses Nos. 10, 11, 12, 13 are of ores from the Babyhead band; Nos. 14 and 15 come from the Packsaddle manganese band, or near it; Nos. 16, 17, 18, 19, represent the Iron Mountain band; No. 20 came from the Oxford band; Nos. 21 and 22 are Pontotoc band samples; No. 23 was taken in the easternmost manganese band; Nos. 24 and 25 show fairly the character of the westernmost band.

2. COMMINUTED SANDY ORES.

The interior region of the hard belt ores is bordered largely by outcrops of the sedimentary beds of Cambrian time, dipping at low angles. The study of the section of these later beds is rendered difficult by the very irregular lithologic character of the basal strata which are in contact with the earlier rocks. But this irregularity really facilitates the discovery of suitable positions in which to work the iron ore deposits, and it also affords valuable clues to the nature of local outcrops.

Where these basal Cambrian strata rest directly upon the Burnetian rocks or upon Texian rocks (as a rule), or where they directly overlie barren portions of the Fernandian System, they are apt to be lighter in color, less heavy, and more highly siliceous than in places where the hard ore bands pass beneath them. This principle can not be carried to an extreme in a practical way because there is only a gradual diminution in the ferruginous contents of the sandstones as one passes upward through the Cambrian beds; and the Lower Cambrian strata as a whole are more heavily charged with iron than are the Middle and Upper Cambrian series. But to one who has acquired a certain familiarity with these beds there are special criteria by which the commercial values may be roughly determined.

Prior to the deposition of the Cambrian strata the Central Mineral Region had been eroded extensively, so that the conglomerates and sandstones which formed along the early Cambrian seashore in this area were deposited upon an uneven surface, exposing patches of each of the three preceding systems. In some places, no doubt, the magnetites of the Iron Mountain series were thus left uncovered, so that they became a prey to the waves, were comminuted by them, and the sandy product was afterwards redeposited alone or with the material from the degradation of the associated rocks. In this way somewhat indeterminate accumulations of magnetic and hematitic sandstones may be explained. These lie at different points along the tortuous border of the Cambrian outcrops, and no definite shape or extent to any exposure can be asserted without detailed examination. Some of the general areas in which this class of ore is prevalent are roughly plotted upon the map accompanying this Report, but it would be impossible to show them in detail without devoting a whole season to the special study of their distribution. A few general specifications will be all that is needed to indicate their nature and the mode of determining their value in individual cases.

1. *The sandy ores do not occur in narrow bands or belts,* but in disconnected patches, representing the remnants of an old shore line which has been obliterated in many places by denudation, and which is buried at other points beneath a varying thickness of the later sediments. Besides this, the uneven character of the supply rendered the assorting process so irregular that the existing relics can hardly be said to exhibit any readily discernible relation to the positions of the hard ore bands from which they have been derived.

2. *These ores are liable to be more abundant where the hard ore bands have been worn away,* provided that the erosion has not taken place since the deposition of the former.

3. *The sandy ores must be worked in local patches, according to individual merit,* for the amount and quality are dependent upon so many purely local contingencies that only the most general description can apply to all. They vary so greatly in the percentages of quartz, magnetite, hematite, and even limonite (by alteration), that nothing but the most careful inspection and chemical tests can determine the relative values of different parts of the same

outcrop, even if samples be taken at frequent intervals. The analyses given in Table III of this class are very inferior types, but some of them might readily be benefited by jigging or washing, although these are not really average lots.

3. SEGREGATED CONCRETIONARY ORES.

Given a porous sandy rock, in many places made up in large part of the sandy iron ores just described, in other portions having a very direct connection with subjacent bands of the hard belt ores, and it is reasonable to expect a noticeable amount of infiltration from below. This is the case in marked degree in the tracts defined upon the Economic Map, and perhaps in other similar exposures which have not been plotted there. The richness of the resulting ores is probably very closely related to the nearness of the deposit to a buried band of magnetite, other things equal; but there are other conditions which may unfavorably affect the quality of the product to such an extent as to possibly overcome the advantage of proximity to the original source of supply. On the other hand, conditions especially favorable to segregation may have induced excessive deposition at points remote from the advantageous contact in particular cases. Besides, the segregated ores will have their best expression in districts where the Fernandian rocks are not exposed by the removal of the Cambrian strata in which these supplies occur. For these reasons the richest accumulations must serve rather as indicators of the presence of buried magnetites, instead of being themselves discovered by means of the magnetite bands. At the same time the knowledge that a given magnetite band passes beneath the Cambrian sandstones at any point may be taken as presumptive evidence of the good quality of the local segregations until the contrary has been proven.

Appearances, or even crude estimates of weight, made by holding specimens in the hand, are commonly deceptive, and only complete chemical analyses of average pulp from large samples can be safely relied upon in forming judgment of commercial values. The patches which are noted upon the Economic Map are not accurately outlined, but they show many of the prominent areas in which this class of ore is abundant. A number of analyses are given in Table III from different tracts, to exhibit the great variations in quality. Some of the material which runs very low in iron can not be distinguished without much experience from the samples which are rich in that metal. The rock does not always appear like an iron ore, and in some regions it is covered with a glossy black coating of manganese oxide. It differs from the sandy ores in being non-granular, usually very tough and compact, and often having delicate impressions of shells of *Lingula* and allied forms of Cambrian fossils.

The great bulk of the material is hematite, as shown by the blood red streak and powder, but analyses ordinarily yield small percentages of water. It does not necessarily occur in concretions with concentric layers, although such are abundant at times, but there is very commonly a nodular weathering. Occasionally, however, the ore forms encrusting shells or plates interlacing or ramifying through the substance of the sandstones. There are also instances of the enlargement of the streaks until they reach a very considerable thickness and weather out from the containing rock in masses which closely simulate fragments from the original band ores. This last mode of occurrence is particularly evident in some of the deposits on and near Elm Creek, north of east from Castell.

The concretionary ores may perhaps have been themselves subjected to a process of solution and resegregation in some instances, and in other places they have no doubt contributed their quota to the degrading action which has produced the later and less valuable ores of the sandy type. Many of the Cambrian sandstones, especially of the Middle Series, are merely cemented or even only colored by these mild impregnations, and these effects are usually restricted in distribution.

4. SOFT (VEIN) ORES.

The hydrated ores, commonly known as limonites, are more abundant than was at first supposed in examining the resources of the Central Mineral Region. As remarked in the Report for 1889, page 359:

> Aside from the insignificant quantity which comes in as contaminations through alterations of the anhydrous ores, these hydrous oxides appear almost exclusively in veins, for the most part in the older rocks. The most important fact connected with their distribution is their occurrence largely in places where there is every reason to believe they are connected with the buried magnetic ores. They often pursue courses more closely related to the Fernandian trend than to the principal fault lines at surface in the areas where they outcrop, and where they do not follow this law there is usually an irregular development of the veins which roughly corresponds with the distribution of the magnetites in belts beneath them.

The Economic Map presented with this Report clearly illustrates this feature, which is in a large measure caused by the northwest-southeast fractures in the Silurian and Cambrian strata, these following almost exactly the courses of the buried hard ore bands. There is also the more characteristic Silurian course of fractures (north 25° east) which has its veins of limonitic material. Owing to the variety of the rocks traversed by the veins in depth, and the influence of the sedimentary wall rocks, there is no recognizable standard of vein deposition in this class of ores. It may be predicted that those richest in iron will be most likely to be found where the magnetite bands marked upon the map pass beneath the Cambro-Silurian section; that they will ordinarily, but perhaps not always, be better in the northwest trend than in the northeastern course, and that the regularity of the veins is apt to be less disturbed in their path through the compact Silurian limestones than along the line of their passage through the porous Cambrian sandstones.

In the analyses of typical samples reported in Table III the "loss by ignition" does not, of course, represent the exact proportion of water in all cases, but the general relations of the ores may be understood by reference to that column. *Turgite*, *goethite*, and *limonite* are the prevailing types, some very fine radiated examples of *turgite* occurring near the divide between Hinton Creek and Deep Creek on the Fredonia and San Saba road. In fact it is necessary to draw arbitrary lines, owing to mixtures of the principal minerals in the ores. Some of these veins have been worked by persons who have believed them to be rich silver ores. No. 61, Table III, is an example from one of these prospects. As will be seen by the analysis, it is a very good limonitic iron ore, but with rather a high percentage of phosphorus, due no doubt to its proximity to the greensand beds of the Potsdam Series.

The limonites may become important sources of revenue in addition to the other iron ores, although they are not always abundant enough to sustain any metallurgic industry by themselves. In some cases, however, as at the Chaney diggings, southeast of Packsaddle Mountain, the quantity is sufficient for profitable working, and the prospect for better ore (manganese or iron) below is very good when the structure is considered. The same remarks apply to veins near Camp San Saba, on Long Mountain, Llano County, in southwestern Burnet County, and elsewhere. There are many localities in the Silurian and Cambrian rocks where veins of this kind outcrop, especially in the San Saba River valley.

The lines indicated upon the Economic Map are mostly the actual courses of veins ascertained by a multitude of observations in the field. While they have in no sense been drawn to fit the theory of intimate connection in distribution with the basal magnetites, it will be seen that they confirm that idea in a most remarkable manner.

I have mapped the veins as far as practicable to the outer edges of my district, where they appear to pass beneath the post-Silurian strata. Where the Devonian, Carboniferous, or Cretaceous strata overlie the prolongations, the lodes are buried beneath them, I presume, although this inference is of course not based upon extensive examinations of those terranes, which have been assigned for study to other members of the Survey. Mr. Cummins confirms my opinion by informing me that such veins do not appear in the Carboniferous rocks of his district, and they have not been reported, to my knowledge, in the Cretaceous System. I have not observed them in any outcrops of either system which have been passed over by my field parties.

In using the map for practical purposes it must be borne in mind that local complications may sometimes affect the situation in any given area, but those who have not tested it will be surprised to learn how few and unimportant the variations will be from the charts outlined by our work in the field.

The prominent vein courses possess more or less of individual interest, and each band may be advantageously reviewed by itself.

THE EASTERN BURNET COUNTY BAND.

It is hardly possible to characterize or to define the limits of the band which passes northwestward across a portion of the valley of Hamilton Creek, near the western bases of Holland Mountain and Lion Mountain, thence across the valleys of Morgan and Beaver creeks, and on through the Silurian limestones into the southeastern corner of San Saba County. It is inconstant, both in continuity and composition, owing to the numerous and extensive changes which have taken place in the arrangement of the containing strata before and after the vein deposition. The line drawn upon my map indicates in this instance a generalized course of outcrop rather than a definite projection of a continuous vein system. While I believe that it represents very nearly the former course of a dominant soft ore vein, there is now much vacant territory where the surface rocks are older than the original hard ore matrix, and others in which more recent disturbances have possibly obliterated portions of the veins which might have existed previously. Again, in the same line, or not far from it, on Spring Creek headwaters especially, there are some very good exposures of the hard specular ore in quartz, which in part at least lie in the Burnetian trend.* Other limonitic and manganiferous iron ores follow the companion course (north 25° east) to the Silurian veins of the northwest trend. These transecting bands come together in the eroded area west of Niggerhead Peak, between Clear Creek and Spring Creek, in western Burnet County.

Nos. 45 and 46, Table III, are examples of the composition of the limonites from two localities in this band.

THE DISCONNECTED BURNET COUNTY OUTCROPS.

It is possible that vein ores cross the area upon the west of the band just described somewhere between the two courses laid down upon the map, in southwestern Burnet County. There are outcrops of ferruginous materials within that space, but diligent study has not thus far afforded satisfactory proof of the existence of any definite band of workable ore. The occurrence of Fernandian marbles near Niggerhead are a good indication of the presence

* See reference to this ore field in the review of the hematites on page 621 of this Report.

of magnetite, and the iron segregations in the Cambrian sandstones at High Point may be connected with such a buried deposit. The southeastward prolongation of this line passes near other concretionary accumulations, but my observations tend to the conclusion that these and many other isolated or irregularly disposed patches are rather the remnants or partial exposures of an extensive Cambrian bed which covered much of the region formerly. This is rendered more probable from the leanness of the ore and its altered character. The outcrops of the blue marbles may serve, however, as indicators of the positions of buried iron ores which it may be possible to reach by prospect shafts.

THE MARBLE FALLS BAND.

A vein course of much importance carrying in parts of its outcrop some excellent ore is approximately plotted as passing a little east of Marble Falls; thence northwestward through the Logan Vandivier survey, No. 206, Burnet County; thence in the same course, crossing the Shinbone near where that ridge is intersected by the Austin and Northwestern Railway; and so on through Backbone Ridge and across the northern end of Long Mountain (Llano County). There are indications of the same band at different points in both directions beyond the limits here named, and wherever the ore has been tested in the outcrops it has been found rather abundant and of good quality. Analyses Nos. 43 and 44 are fair samples of the ordinary yield.

THE CHEROKEE–TIGER MILL BAND.

The vein course which approximately extends the Babyhead magnetite band through the border areas of sedimentary rocks is not as well defined as some others, partly because it is cut out by denudation in many places, even to the exclusion of the Fernandian supplying rocks, and partly from the lack of opportunity for the exposure—perhaps also for the formation—of veins upon the large scale.* There is a suspicion, which has not yet been fully confirmed, that the limonitic veins do not penetrate the San Saba Series, at least in the upper (Deep Creek) division.† As much of the area northwestward in San Saba County is covered by the San Saba Series, the lack of vein exposures in this path may possibly thus be explained. But, as the decom-

*I should be glad to speak authoritatively concerning one feature of structure which is still unsolved in the Silurian area. The plans of my Division of the Survey for 1891 contemplate the settlement of the question, if it be possible, by wider observations. The problem is to determine the true relations of the San Saba and the Leon series, and the distribution of the veins may afford the clue which is now lacking.

† This would seem to imply that the Deep Creek division, and perhaps also the Hinton division, should really be included in the Niagarian (Upper Silurian) System.

posed chert or chert gravel of this age obscures everything, there is a chance that the veins do approach nearer the surface than is supposed. My observations do not, however, lend probability to this last hypothesis. The outcrop of this band may be regarded as rather overdrawn upon the map, but its course is properly indicated, giving hints as to the best places for prospecting. No important discoveries of the limonites have yet been made in this line.

THE MAGILL PEAK BAND.

Practically speaking the vein course which passes northwestward via Magill Peak is but an extension of the manganiferous iron ore field of the Packsaddle Mountain band. But its contents vary somewhat in different parts of the outcrop line. Wherever the Silurian beds occur in its path the ore is usually of good quality. As to exposures in the area of the San Saba Series, the same must be said as was remarked under the previous head. The whole belt is an important one, but individual outcrops must be adjudged wholly by the results of special tests.

THE RILEY MOUNTAIN BANDS.

The extensions southeastward of the Llano bands of magnetite strike through the middle portion of the Riley Mountains. The veins are very large and the ores of superior quality. One of the most characteristic outcrops has been worked by Chas. Roberts, upon the eastern flank of the Riley Mountains, a little south of the entrance to Honey Creek Cove, Llano County. Good exposures of the same band also occur northwest of the magnetite area, in the San Saba River valley. Southeastward, in Blanco County, other promising indications appear in the lines shown upon the Economic Map herewith.

THE CLICK MOUNTAIN BAND.

The vein which follows the course of the Click band of hard ore is usually well defined and valuable wherever its outcrops can be traced through the Silurian limestones in the course indicated upon the map. It is not possible to be more explicit, because complicated faults have broken up the veins in some cases, more especially, perhaps, in the southeast. In San Saba County this band is usually less disturbed, but in some places it is covered by the later rocks. Wherever the plotting on the Economic Map is deficient, it will ordinarily be found that a reference to the Geologic Map will explain any apparent discrepancy, although it has been impossible to record every detail of structure upon maps drawn to such small scales as we have been compelled to adopt in this Report.

The Click Mountain band should be one of the best in the region as a soft ore producer, provided that the process of the vein accretion has had free scope, for it has drawn its supply from the Iron Mountain band of hard ore. Its richness, however, in any given portion must depend upon such a variety of local conditions that generalizations of value are not permissible. The samples reported in Table III from this line are particularly choice, being remarkable for their contents of carbonic acid, an unusual ingredient in most of the Central Texas limonites, even in the limestone region. (See analyses Nos. 57, 58, etc.)

CEDAR MOUNTAIN BANDS.

A prominent vein can be traced beyond the interior area northwestward through the Silurian limestones as far as the mouth of Little Brady Creek, in McCulloch County, and another parallel vein courses through the same region westward, both marking the lines of well developed faults. These veins also appear on Cedar Mountain, in Llano County, and in the Silurian areas southeastward. They are the offspring, as it were, of the Oxford and Pontotoc magnetite bands, respectively. Their characteristics are not very unlike what has been stated of the other vein masses. The more eastern outcrops in southwestern San Saba County have, however, some interesting features, including concretionary crystallizations of the ore (*turgite*) and of *calcite*, *aragonite*, etc. As will be seen from analysis No. 60, Table III, this locality has yielded richer ore than any of the soft ore deposits yet tested from the Central Mineral Region. It is well exposed in the line of the fault, near the the San Saba and Fredonia road, almost at the divide on the east side of Hinton Creek. I am not as confident of the direct continuity of these iron ores, although they have been detected in many places along the plotted line. The calcite seems to be a very constant material in the vein.

The more western vein has very much the same character, and on this account calls for no special mention.

Still another vein crosses Cedar Mountain farther south, and is recognized at various points as the prolongation of the course laid down on the map as a manganese band. This has already been noticed under the head of Manganese Ores, on page 602. Although its product is sometimes more nearly like our ordinary soft iron ores, it is not necessary to give it further description here nor to designate it by number and name in this connection.

THE LOST LOAFER CREEK BAND.

Again, in a fault line marked by outcrops apparently related in a similar manner to a buried hard ore band a vein runs through the border districts upon both ends of the interior area. It shows east of Fredonia, on Lost Creek and at points northwest, as on the Voca and San Saba road about one mile and a half east of Voca, and what is probably the same vein appears on the Pedernales River near old Westbrook Postoffice (Holden's).

THE CAMP SAN SABA BAND.

A large and valuable vein is visible at surface over much of the country northwest and southeast of Camp San Saba, and it is especially prominent near the mouth of Katemcy Creek. The ore there has rather a large percentage of phosphorus, which may be explained by the nearness of the Potsdam greensand to this particular outcrop. That this is not a type of the whole vein is evident, for in its course near Herman Creek, in Mason County, it is highly manganiferous; in other places so much so as to be properly regarded as a manganese ore.

5. TITANIFEROUS ORES.

Because of their secondary importance the titaniferous ores are placed last in our description, although their geologic position entitles them to consideration directly after the Fernandian iron deposits. Thus far my observations have not given any hint of the existence of this class of iron ores in more than two trends, and there is always a pointer to the original occurrence in only one course, that of the normal Texian uplift. The titanium contained in these veins, for such the accumulations almost invariably are, is evidently derived from the Burnetian rocks; for the associated elements are in many cases those rare metals which occur elsewhere only in Burnetian matrices. The iron contents of the minerals of these veins may largely have come from Fernandian material, but some of the lightly charged quartz veins of the Silurian trend (north 25° east) may very well have been supplied by the Burnetian alone, or their deposits may be due in part to alteration of the Texian ores. The bands indicated upon the Economic Map are pointers which may serve to indicate the localities of outcrops. Others may be found, but I have not met them heretofore. The principal exposures are in Mason County east and west of Fly Gap Postoffice, in the Kothman Hills, and on Shaft Mountain. The ore in the north 25° east trend occurs in patches or flakes in white quartz, and is usually a titaniferous magnetite or hematite. That which lies in the north-south (Texian) trend is more frequently contaminated with traces or notable proportions of the rare metals of Burnetian ilk. Ordinarily this class of ore may be readily distinguished from the hematite by the glistening surfaces and the brittleness of the material, as well as by the black streak and powder. As a rule, only a small portion of the whole is attractable by an ordinary hand magnet.

METALLURGIC REVIEW OF IRON FIELDS.

As previously remarked, it is not feasible to predict what lines of development will be followed in the commercial utilization of the immense stores of iron ores awaiting movement in the Central Mineral Region.

The magnetites and hematites are so abundant, and they, with the manganese ores, have been so clearly mapped by the Geological Survey, that in the event of the establishment of steel works to handle this material in or out of the district, there will be no question of the supply being adequate. There is enough of the very best Bessemer ore to build up an industry far in excess of the requirements of the southwest for long years to come, even with a growth far beyond the calculations of the most sanguine advocates. There will undoubtedly be a demand from without for these hard ores, and the smelters of Eastern Texas are beginning to realize the advantages of mixing them with their own abundant soft ores. Already a movement is well under way to make such railroad connections as are necessary to ship to the Alabama furnaces, which now draw their supply of hard ores from Lake Superior, a distance more than 1000 miles in excess of the direct route from Llano to Birmingham. There can be no doubt, therefore, of the future great prominence of Central Texas as a producer of iron ores.

The building up of a local iron and steel industry is a very different thing, being so largely dependent upon an adequate supply of the proper fuel that no one can estimate results without a knowledge of facts which only the future history of the region can furnish. In my last Report I remarked as follows:

> Speaking as a metallurgist, it is incumbent upon me to put forth cautionary words against an error which has often blighted the prospects of rich iron regions. While Llano County [a small part of Burnet County must now be included] and portions of the adjoining counties of Mason and Gillespie, and perhaps limited portions of San Saba and McCulloch counties, are certainly destined to become extensive producers of iron ores, the erection of smelting plants is not now justified by the situation.

The only modification which the writer, as a professional engineer, feels called upon to make in this connection after another year of investigation is this: The situation may have changed a very little since then; it may possibly change decidedly ere long, by reason of the efforts which are being made to overcome the lack of fuel in the district. The simple business principle, that the ore must practically seek the fuel, has fully as much application now as before; but the resultant of all the forces in operation in the complex struggle for commercial existence in Texas may strike nearer to this district than has been heretofore probable. A great step in this direction has been taken by the demonstration, through the work of the State Geologist, that our vast lignite fields contain stores of fuel superior to that which has been long successfully used in iron metallurgy abroad. If further practical tests now under way upon a large scale confirm those already made, the delivery of this fuel may perhaps be feasible at such cost as to enable local smelting to become profitable. The laying down of gas coal or coke in the district at any price which can maintain competition with distant points now cheaply supplied, is at least a remote possibility, without the construction of many miles of new railroad. Whether this can change the smelting conditions is somewhat doubtful, because there are already so many well established trade centers which can divert the trunk lines from this region.

But without further discussion of this important topic, there are mining and metallurgic issues of moment which are well worthy of consideration by all interested in the iron district. The differences in the value and the cost of working of the several classes of ores are very great under the most favorable circumstances. Below are given some hints which may be useful to those who do not understand the requirements of the furnaces.

1. The pig iron produced in the blast furnace from the hard ores (magnetite and hematite), in order to be generally used in the ordinary (acid) Bessemer steel process, should not contain above .22 per cent of phosphorus (say .5 per cent of phosphoric acid), and that amount is too liberal an allowance for many purposes. This is not saying that ores with higher percentages of phosporus can not be successfully smelted, but ordinarily they would not be found to be desirable, because we have not a class of ores suited to treatment by the basic process, which requires more phosphorus. Our ores are remarkably free from phosphorus, except in localities where they lie near the greensands and in special layers like No. 19, Table III. In the Central Mineral Region the unusually high phosphorus ores can always be separated in the mining, and those which come near the permissible limit can be mixed with the best ores at mine or furnace so as to bring the percentage down below the maximum.

2. The soft ores of our district can be advantageously mixed with the hard ores in the production of different grades of pig iron, but they are less abundant and more difficult to obtain than the hard Bessemer ores. The soft ores frequently contain more phosphorus, especially in their passage through the greensand horizon of the Cambrian System. Suitable mixtures of these will be more difficult to effect at the mines, because the vein product is generally uniform in each locality. But the limit of phosphorus allowable is much higher in iron metallurgy, owing to the wide range of application of the product and the facility with which phosphorus may be expelled in the puddling or other processes of refining.

3. There is little or no application of the Thomas or basic Bessemer pro-

cess in this region on account of the quality of the ores and their very low average contents of phosphorus.

4. Abundant fluxing ingredients can be obtained in most cases in the mining of the soft ores. The hard ores and others will not usually afford such supplies by their immediate environment, but there is so much suitable material of this class within easy reach that its exhaustion is impossible.

5. Sulphur as a contamination is rarely a serious detriment to the ores of the Central Mineral Region, and never so deleterious that a ready remedy can not be applied by mixtures of ores or the use of simple correctives in the charge.

6. Silica, in very many cases, is not present in greater proportions than is allowable in the smelting processes, although some of the ores carry too much for use by themselves without water-jacketing the furnace or composing the charge for a basic slag. In the hard ores, and in most of the sandy ores, the excess of silica can be removed by magnetism, or by jigging with simple appliances. The soft ores and the concretionary ores can not be thus benefited, and the only recourse with them will be to mix the more siliceous varieties with those which carry more iron. From the conditions already described the experienced metallurgist will readily understand that this means the practical prohibition of certain ores reported in our list.

7. The titaniferous ores are not liable to become immediately available, although the progress of iron metallurgy may eventually produce a demand for them, as it has been proved that titanium has important hardening qualities, now regarded as objectionable on account of attendant evils. Worse enemies than this have, however, come to be recognized as friends in disguise by iron and steel producers, and vague hints of this possibility have appeared in certain investigations of late years. But it must be confessed that there is now no known method of employing these ores advantageously. Perhaps the percentages of titanium are rarely high enough to interfere with the successful working of such ores as we have of this class, but they will necessarily require mixing with the other varieties, and very few of them can be cheaply assorted so as to pay to work without washing to free them from sand or quartz gangue.

TABLE III—ANALYSES OF IRON ORES.

MAGNETITES.

No.	Ferric Oxide.	Ferrous Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Total.	Metallic Iron.
1*	70.22	10.49	14.00	4.93	0.66	Trace.	Trace.	......	100.30	57.30
2*	74.14	15.41	3.50	6.25	Trace.	......	1.02	0.24	100.56	63.87
3*	81.31	8.12	4.70	6.17	0.65	Trace.	0.02	Trace.	100.97	63.23
4*	65.40	16.53	5.80	11.07	0.78	Trace.	Trace.	0.18	99.76	58.62
5*	65.70	23.20	4.70	4.44	1.40	......	Trace.	Trace.	99.50	64.02
6*	77.10	16.54	4.65	0.76	Trace.	......	Trace.	0.75	99.80	66.82
7*	62.77	11.94	24.00	1.56	0.10	......	Trace.	0.20	100.57	53.22
8*	68.27	23.03	6.00	3.06	Trace.	......	Trace.	0.17	100.53	65.68
9*	68.64	26.49	5.10	......	0.01	......	......	......	100.24	68.63

*Analyses by J. H. Herndon.

HEMATITES.

No.	Ferric Oxide.	Ferrous Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Total.	Metallic Iron.
10*	80.90	1.45	11.60	5.55	0.66	Trace.	Trace.	Trace.	100.16	57.76
11*	91.19	5.52	1.10	1.70	0.41	......	Trace.	Trace.	99.92	68.12
12*	87.95	2.85	7.90	0.57	0.65	Trace.	Trace.	Trace.	99.92	63.78
13* a	44.32	2.85	41.90	7.55	0.35	......	Trace.	0.01	100.21	33.24
14 †	82.61	......	9.75	......	1.60	Trace.	......	......	100.10	57.83
15*	77.35	......	10.20	9.65	0.53	......	Trace.	0.24	99.97	54.16
16 †	89.70	4.20	6.13	......	Trace.	Trace.	......	......	100.23	62.79
17*	78.03	......	3 50	17.11	Trace.	......	0.54	0.85	100.09	54.62
18 †	79.09	1.12	2.65	14.50	3.05	......	......	Trace.	100.41	55.36
19*	76.93	1.67	5.30	5.90	3.46	Trace.	7.16	0.22	100.63	53.85
20*	91.40	3.42	1.90	1.33	1.73	Trace.	0.09	0.12	100.00	63.98
21 †	87.20	3.22	6.03	......	......	......	Trace.	Trace.	....	61.04
22*	85.68	......	12.60	1.12	Trace.	Trace.	Trace.	0.16	100.03	59.98
23 †	86.22	2.65	8.51	2.45	Trace.	Trace.	Trace.	0.12	99.95	60.35
24 †	86.58	1.40	2.67	.....	......	......	2.21	Trace.	....	60.61

a Loss by ignition, 3.23. Analyses by *J. H. Herndon; †L. E. Magnenat.

SANDY ORES.

No.	Ferrous Oxide.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Total.	Metallic Iron.
25 †	......	12.00	84.30	0.40	1.98	Trace.	1.31	0.27	100.26	8.40
26* a	1.12	24.73	69.50	2.85	1.48	Trace.	0.86	Trace.	100.54	17.31
27* b	......	42.07	47.70	6.53	1.24	Trace.	Trace.	0.24	99.58	29.45
28* c	......	53.82	21.60	7.18	10.54	0.07	1.59	0.34	100.24	37.67
29 † d	......	7.76	61.60	0.04	17.70	Trace.	0.51	Trace.	99.81	5.43
30 †	......	88.48	4.11	5 82	0.40	Trace.	......	0.43	99.24	61.94

a Manganese dioxide, trace. *b* Water, 1.80. *c* Carbonic acid, 5.10. *d* Carbonic acid, 12.20.
Analyses by *J. H. Herndon; †L. E. Magnenat.

TABLE III—ANALYSES OF IRON ORES—*continued.*

SEGREGATED ORES.

No.	Ferrous Oxide.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Total.	Metallic Iron.
31 †	......	83.58	14.00	1.82	Trace.	Trace.	Trace.	0.80	100.20	58.50
32 *	......	65.85	26.70	5.15	2.20	Trace.	0.38	0.34	100.62	46.10
33 *	......	89.96	9.40	0.44	Trace.	......	Trace.	0.03	99.83	62.97
34 * a	Trace.	44.86	47.88	4.14	Trace.	Trace.	Trace.	......	99.39	31.40
35 †	2.36	79.47	13.84	4.62	0.55	Trace.	Trace.	Trace.	99.84	55.63
36 *	......	21.19	46.80	......	......	......	......	......	....	......
37 †	......	78.95	18.60	0.95	1.15	Trace.	0.32	Trace.	99.97	55.27
38 †	......	85.79	9.35	2.51	2.20	Trace.	Trace.	0.65	100.50	60.06
39 * a	......	84.21	8.60	3.79	1.58	0.21	Trace.	0.28	100.77	58.95
40 †	......	79.15	15.70	3.45	1.07	0.29	Trace.	0.80	100.46	55.41
41 *	......	81.89	12.40	4.71	1.23	Trace.	Trace.	0.20	100.43	57.32
42 *	2.18	83.69	12.20	1.61	1.23	......	Trace.	Trace.	100.91	60.28

a Loss by ignition, 2.10. Analyses by * J. H. Herndon; † L. E. Magnenat.

SOFT (HYDRATED) ORES.

No.	Ferric Oxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Loss by Ignition.	Total.	Metallic Iron.
43 *	85.31	2.90	3.49	1.56	......	Trace.	0.13	6.60	99.99	59.72
44 *	77.05	13.80	3.75	1.06	......	Trace.	0.10	4.20	99.96	53.94
45	81.99	3.70	5.21	2.05	0.28	0.38	0.20	7.10	100.82	57.39
46 † a	68.70	23.35	1.90	......	Trace.	Trace.	0.33	3.90	100.18	48.09
47 † b	69.80	21.36	3.10	Trace.	Trace.	......	Trace.	4.40	100.08	48.86
48 †	75.98	7.70	2.82	0.62	......	Trace.	0.47	12.40	99.99	53.19
49 †	57.27	22.70	9.93	0.74	4.47	0.58	Trace.	4.20	99.89	40.09
50 *	57.54	30.30	1.66	0.48	......	0.51	0.82	9.36	100.61	40.28
51 *	73.76	14.40	6.64	0.10	Trace.	0.09	0.53	5.10	100.62	51.63
52 * a	67.39	14.40	8.21	......	0.54	......	......	5.20	....	47.17
53 †	71.67	17.60	0.28	0.81	0.80	Trace.	0.84	8.00	100.00	50.17
54 †	78.83	5.61	3.17	Trace.	......	Trace.	0.06	12.50	100.81	55.18
55 * c	64.77	14.95	7.71	0.61	Trace.	Trace.	0.30	10.10	99.56	45.34
56 †	31.02	46.00	0.68	9.20	0.72	0.62	0.94	10.80	99.98	21.71
57 *	63.74	2.10	3.22	0.98	Trace.	Trace.	0.13	10.20	99.82	44.62
58 *	79.92	6.40	1.48	1.26	......	Trace.	0.13	10.70	99.89	55.94
59 *	79.60	8.50	2.40	1.73	......	Trace.	0.13	......	100.26	55.72
60 *	86.63	5.20	0.17	1.48	Trace.	0.09	0.18	6.60	100.35	60.64
61 *	82.60	2.58	1.60	1.15	Trace.	0.92	0.20	11.80	100.85	57.82
62 † d	16.50	61.00	9.10	0.99	......	0.70	Trace.	9.90	100.12	11.55
63 * e	46.21	41.58	3.61	0.45	Trace.	Trace.	0.35	5.15	100.03	32.35
64 †	79.78	5.05	4.72	0.25	Trace.	Trace.	0.89	9.50	100.19	55.85

a Oxide of manganese, trace. *b* Ferrous oxide, 1.40. *c* Ferrous oxide, 1.12. *d* Manganese trioxide, 1.93. *e* Ferrous oxide, 2.78.
Analyses by * J. H. Herndon; † L. E. Magnenat.

TITANIFEROUS ORES.

No.	Ferric Oxide.	Ferrous Oxide.	Titanium Dioxide.	Manganese Dioxide.	Silica.	Alumina.	Lime.	Magnesia.	Phosphoric Acid.	Sulphuric Acid.	Total.	Metallic Iron.
65 *	82.51	5.82	2.20	0.23	5.52	3.82	0.22	Trace	....	.....	100.32	62.28

*Analysis by J. H. Herndon.

Localities.

No.

1. Babyhead Mountain, Llano County.
2. Iron Mountain, Llano County.
3. Iron Mountain, Llano County.
4. Iron Mountain, Llano County.
5. Iron Mountain, Llano County.
6. Iron Mountain, Llano County.
7. Barder tract (survey 33), Llano County.
8. Barder tract (survey 33), Llano County.
9. North of Llano River (Lodestone), near Johnson Creek (?), Llano County.
10. Babyhead Mountain, Llano County.
11. Lost Hollow, Llano County.
12. Lower Lost Hollow, Llano County.
13. Lower Lost Hollow, Llano County.
14. Near Packsaddle Mountain, Llano Co.
15. South of Packsaddle Mountain, Llano County.
16. Iron Mountain, Llano County.
17. Iron Mountain, Llano County.
18. Iron Mountain, Llano County.
19. Iron Mountain, Llano County.
20. Iron Rock Creek, Blanco County.
21. Pontotoc, Mason County.
22. Pontotoc, Mason County.
23. Near Castell, Llano County.
24. Two miles northwest of Katemcy, Mason County.
25. Lone Grove, Llano County.
26. Brady road, east of Smoothing Iron Mountain, Llano County.
27. North of east of Castell, Llano County.
28. Near Latham's, San Saba County.
29. San Saba River, near Voca, McCulloch County.
30. Caylor's diggings, Mason County.
31. Near Magill Peak, Llano County.
32. Near Latham's, San Saba County.
33. Baumann's, Llano County.
34. West of Christian Schneider's house, near Castell, Llano County.

No.

35. Three miles southeast of Camp San Saba, McCulloch County.
36. Three miles southeast of Camp San Saba, McCulloch County.
37. Tod Valley, Mason County.
38. James River, Mason County.
39. James River, Mason County.
40. James River, Mason County.
41. Near Katemcy, Mason County.
42. Five miles east of Indianapolis, Mason County.
43. Marble Falls, Burnet County.
44. Marble Falls, Burnet County.
45. South of Beaver Creek, Burnet County.
46. West of Lion Mountain, Burnet County.
47. Near Sutton's, Pennington Creek, Llano County.
48. Near Davidson's, Pennington Creek, Llano County.
49. North point of Packsaddle Mountain, Llano County.
50. Garner Crossing, Llano River, Llano County.
51. Babyhead Gap, Llano County.
52. Little Llano Creek, Llano County.
53. Riley Mountains, Llano County.
54. Iron Mountain, Llano County.
55. Cold Creek, Llano County.
56. Latham, San Saba County.
57. Latham Creek, San Saba County.
58. Deep Creek, San Saba County.
59. Deep Creek, San Saba County.
60. Hinton Creek, San Saba County.
61. Heard's diggings, near Camp San Saba, McCulloch County.
62. Survey 746, Mason County.
63. Seven miles west of Mason, Mason Co.
64. McMillan's diggings, near Westbrook, Blanco County.
65. Near Fleming, Mason County.

II. BUILDING STONES.

There is no lack of material within the borders of the Central Mineral Region which is admirably adapted for use in construction. Very few localities exist in which some suitable rock for foundations and superstructures can not be obtained near at hand, although of course some sections are more favored than others in this respect. The magnesian and other limestones of the Cretaceous System lying without the boundary of this district are already much used, and these are readily accessible. By far the most important, commercially, are the granites and allied rocks which are especially characteristic of the tract under view; but many other building materials can be utilized in places where the structure is least confused. The discussion will be taken up topically, according to the simple classification adopted in last year's Report.

The constructive materials within our district have not yet attracted the attention to which they are entitled from their abundance, quality, and variety. Our granites have earned a deservedly high reputation, the marbles have begun to meet appreciation, and some special grades of limestones have found a limited market, to say nothing of the rougher uses for which inferior quarry products have occasionally been locally employed. But with all the popular clamor about the great resources of this character, very little result has followed commercially, and it must be patent to any skilled observer that there is yet a very inadequate appreciation of the stores of wealth awaiting the application of industry impelled by capital.

It is a strange peculiarity of those who have slight knowledge of building materials to expend much energy in excavating rocks in an aimless manner without first obtaining full information concerning their adaptability to economic uses. There are numerous abandoned quarries in the Central Region, but failure to make practical success of such ventures has not deterred others from wasting time and money in further digging in places where no profitable outcome could ever have been reasonably expected. On the other hand there are many square miles of territory in which the outcrops of material for construction are not excelled by any which are now regarded as especially favorable deposits for working. It has been a common belief that Granite Mountain, in Burnet County, monopolizes the granite of commercial importance, but it only represents an iota of the vast treasures of this nature which lie undeveloped in our district. So with the marbles and the tough dolomites which pass for marbles in commercial parlance; the extent and quality of this material are far superior to what is generally believed, notwithstanding the fact that the injudicious foisting of inferior samples upon the market has injured the reputation of all alike. The truth is the quarrying industry in the Central Mineral Region is in an embryonic condition, and so it must remain until markets for the products are made available and cheaply accessible. The census statistics make but a sorry showing, to be sure, although they indicate substantial progress within the past two years, and express in unmistakable figures the superior quality of a part of our product. The appropriations heretofore made have not been sufficient to permit the making of mechanical tests of our building stones. Perhaps no more profitable investment could be made by the State in this district than the supplying of funds for this purpose. The expenditure of a few hundred dollars could be made to reveal a large amount of practical information of the very highest importance to architects, builders, and constructing engineers.

For present purposes a classification by substances is manifestly the most convenient. The granites and marbles are the most important products of this group, but they do not by any means include all the building materials of value.

A. THE GRANITES.

In the absence of tests of strength or of convincing practical records of use of any but the now celebrated "Capitol Granite," it is not possible to suggest a better arrangement of the granites than that which was offered by the writer in 1889 (p. 365.) The new material given here will be largely in the nature of a review of the distribution of the several grades of granite. Arrangements have been made for the intimate study of these rocks by a specialist in microscopic petrography, and the grouping adopted here is therefore subject to such revision as may be demanded after a more complete knowledge is acquired. Although practical men use other methods of determining values and applications, their conclusions, if trustworthy, will invariably be found to tally with those of scientific investigators, and the more we can learn of the composition and textural arrangement of the mineral components, the better shall we be able to determine the economic value of each particular kind of rock.

Dr. William C. Day, in Census Bulletin No. 45 on the "Granite Industry of the United States," issued March 26, 1891, thus aptly remarks:

> Although variations in the nature and proportions of the minerals which constitute the granites have much to do in determining the adaptability of the stone to many purposes, still this fact is not made prominent by granite quarrymen in placing their products on the market. If by actual use a particular granite is found to do well for a certain purpose, it is, in general, correspondingly well received, without inquiry as to its special constitution, which in reality determines its adaptability for such purpose.

The age and geologic environment of each granite in our area are important items in determining conditions affecting quality and quantity, but the study of such matters in the field is too complicated for any but skilled engineers. For general purposes, therefore, a simple classification based upon the tooling qualities of the material will be most practical. Quoting from my report for 1889:

> When numerous quarries are shipping the different grades, a commercial classification may be adopted which will not agree closely with the one here proposed, but there is a kind of textural relationship which makes this provisional arrangement at least of temporary value. Adopting, then, as a basis of affinity the structural character, using texture, color, etc., as a means of further division when necessary, we get seven fairly distinct classes.

* * * Only in a general way may this be regarded as a scientific grouping, but in proposing it an attempt has been made to get as near to the order of formation, or age, as can well be done, etc.

The seven classes of granite referred to are as follows:

1. Gneissic Granites (largely Burnetian).
2. Compressed Granites (intrusives).
3. Block Granites.
4. Friable Granites (perhaps more commonly Texian).
5. Mixed Granites (of Silurian type).
6. Dimension Granites (largely Carboniferous).
7. Fissile Granites (Cretaceous type).

The Economic Map is published upon too small a scale to admit of making these nice distinctions.

1. THE GNEISSIC GRANITES.

It is not strictly true to say that all the gneissoid granites are members of the Burnetian System, and yet the gneisses and granites of that age are almost invariably of this class unless they bear evidence of intrusive origin. We shall, therefore, go very little amiss in defining the areas of outcrop as practically coincident with those of the Burnetian System. Perhaps some Fernandian outcrops may include thin seams of material which would properly come under this same head, but none of those which I have determined to be of that system are liable to possess any important economic value. Within the range allowed for this class of granites there is considerable variation in texture and color as well as in the essential elements which affect the quality of building stones, such as strength, density, porosity, and tendency to lamination or to irregular weathering. Many of them are too brittle, too thinly bedded, or too uneven in texture to afford blocks or slabs which can be applied to any use excepting where ballast or rubble is required. Eventually even this material may meet its destiny, for it is very probable that it could be economically and advantageously employed as the basis of a special concrete or artificial stone, and no tests are needed to prove its admirable qualities as road material. Some of the best natural highways in the world are those in the great Burnetian plain of Llano County, over much of which area the gneissoid granites form the soil. What is locally known as "rotten granite" consists merely of the disintegrated gneiss of the region, which is often thus weathered to the depth of fifteen to twenty feet from the surface. Such material could be cheaply mined, and under favorable circumstances it would bear transportation for long distances. I believe it is destined one day to go far toward solving the now serious road problems of the limestone regions of Central Texas. Although this "rotten granite" is itself a proof of the inherent weakness of such granitic rocks, it need not be taken as a necessary disqualification of the type as a building stone. All over the region of the disintegrated material there is an abundance of tough knolls of apparently equivalent rock, which has escaped degradation, although subjected to similar conditions for ages. So, in hills and mountains like the Spring Creek ridges in Burnet County and the Cat Mountains in Llano County, there are massive outcrops worn into mounds and fantastic forms, the whole exhibiting both the weakness and the strength of this class of granites in different portions of the mass. By judicious selection of the indurated parts and those which have acquired attractive tints by oxidation there may be developed a gigantic industry. One advantage of the working of such fields is that a variety of such granite is liable to be at command, for it is usually in places where later outbursts have occurred that the representatives of this class are hardened enough to thus resist denudation.

There are some varieties of speckled granite, having the minute flakes of black or white mica scattered through a compact base, which merit special consideration. These vary much in character, shading into binary granite without mica upon the one hand, and upon the other into streaked, banded, and laminated gneiss. A few in Gillespie and Blanco counties, and others in Llano and Burnet counties, are particularly noteworthy. Many of these might readily be overlooked by a casual observer, but the skilled collectors of the Geological Survey have added not a few to the Museum collections. These are not to be depended upon, as a rule, for great quantity in any one locality, nor can it be expected that uniformity will show through large masses; but this lack is fully offset by the enhanced value of the local outcrops in consequence.

Too much disturbance may, in some cases, have resulted in cracks and flaws which will unfit these granites for use in large blocks. But, as stated in 1889. page 365:

> If the best of these can be quarried in places where they have been least disturbed by more recent uplifts, as in parts of the Babyhead region, and perhaps also in the Burnet County tract between Spring Creek and Clear Creek, it is probable that excellent speckled and mottled varieties may be obtained. These will frequently polish with good effect, and some outcrops show by their style of weathering that certain oxidation tints of value for ornamentation may be utilized. In working this class, however, great care will be necessary to select only those qualities in which the mica is well distributed and in comparatively fine scales. Otherwise serious blemishes may result from irregularity of "weathering." For paving blocks, foundation stones, and special uses much of this material may be utilized eventually at little cost.

These remarks apply with equal force to a large area in northeastern Mason County, which I have examined in detail only within the last few months. In Llano County there is a very fine-grained red-speckled gneiss of this va-

WEATHERING OF BURNETAN GNEISS, CATS MTS., LLANO COUNTY.

riety in Miller's Creek, southeast of Lone Grove, which may be worthy of investigation. In Yoakum Hollow similar outcrops occur, and a variety of this class is favorably exposed in the Cat Mountains. Four miles north of east from Enchanted Rock, and in much of the surrounding area, some very choice material of the kind may be mined, as well as southward in the northern portion of Gillespie County.

THE COMPRESSED GRANITES.

There are many of the Archean granites which appear as if tightly wedged in between the adjoining strata, although the result is perhaps more often due to the expansion produced by the crystallization of the magma. For this last reason the material is frequently an aggregation of large interlocking crystals, without coherence enough to render the rock useful for any purpose where stress is anticipated. Occasionally some very fine crystals of orthoclase and microcline of immense size, or tough masses of graphic granite admitting of a high polish, occur in similar situations.

There is little to add this year to the above statement taken from page 366 of my former Report. It is not probable that the compressed granites will ever cut any great figure in the production of our region, if surface indications prove trustworthy as criteria for deeper workings, which can hardly admit of doubt.

THE BLOCK GRANITES.

Again I have to quote from my Preliminary Report for 1889, as the designation of this class can not be materially improved after longer study, and the edition of the first Report was limited:

This name is proposed for a class of granites which occur in various parts of the Central Mineral Region, and which may represent more than one uplift. They are not yet fully understood, and there is here no intention of putting them together except for the convenience of treatment. They shade off into dimension granites upon the one hand and into fissile granites upon the other, in a general sense, and yet they are distinctive, more by reason of their texture than their structure. At the same time it is possible that some of the friable granites, or "rotten granites," may be only the block granites undergoing a process of decay. But a commercial classification must necessarily deal with present conditions, and upon that principle this class name is justifiable. I would include under it all those granites which are solid enough to withstand sharp blows from a single-hand hammer without shattering, except along the line of impact, so that they may be readily broken into blocks. But, in addition, they must have definite joint or lamination planes, usually induced by the mode of arrangement of the large crystals of feldspar. Any of the other types, howsoever well they may be broken into shape by careful trimming, do not at once assume the block form characteristic of this class. Thus restricted, there is considerable variation in the solidity of the blocks, even when they are not undergoing rapid disintegration. This difference arises from the irregularity of coherence among the feldspar crystals. Some of the block granites are less ferruginous and paler in color than the classes previously described, but when there is an abundance of siliceous cement this loss of iron does not appear to weaken the combination.

As limited above, the thickness of these rocks varies from a single layer of original crystals to an aggregate of one foot in all. They occur all over the district, but are perhaps most common in the mid-belts of Llano County. In the absence of actual tests it is not possible to state their applicability in the building art, but it is not probable that they will usually withstand great pressure, unless understandingly applied in masonry structures specially planned to distribute the stresses unequally in definite lines. Care should be taken to study the lamination planes and the position in the quarry, and to lay them in equivalent positions in walls. Some of them may be adapted for use in pavements and in buried foundations. Although refractory to a certain extent, they would probably succumb to excessive temperatures, and they are illy fitted to resist sudden changes of temperature. As a rule they are not ornamental.

Some of the Burnetian mounds weather in such a way as to produce a comparatively thin "lift," as quarrymen call it, and this portion affords fair examples of block granite in some places, as at Flat Rock, near Lone Grove, and in certain of the hills of the Cat Mountains. West of Cold Creek, in Llano County, near the road to Field Creek, in the neighborhood of House Mountain, and in the region northwest of Castell, there are examples of the class often varying considerably in strength and durability in the same exposure. At the crossing of San Fernando Creek by the Valley Spring and Mason road, north of Rough Mountain, there is some granite of the "block" type, but its exposures do not give promise of much endurance under pressure. Some of the material south of Katemcy, and perhaps other masses in Honey Creek, both in Mason County, may prove serviceable.

From the base of Enchanted Rock samples of tougher quality have been taken; and generally speaking the more recent granites seem to afford the best specimens, probably because they have been less altered by the ravages of time.

A little granite of this type occurs also in the Beaver Creek outcrops in Burnet County. The quality there is good, but the color is not the most attractive.

THE FRIABLE GRANITES.

Over wide areas as much as twenty to thirty feet of "rotten granite" now forms the surface-cap of material of its own class, being the result of decay *in situ*. As before remarked under the head of the Gneissic Granites, this is very largely of Burnetian age, and the process of rusting has been going on for untold ages. The newer granites are but rarely thus affected, and never to such a depth. But the friable granites here grouped are not of this nature. They are rather what may be called "sandy granites," and are always fine-grained, granular, but loosely aggregated, ordinarily quartzose. These are of abundant occurrence in the Central Mineral Region, for the most part belonging to the Texian System, shading from a quartzose granite into a gneissic or feldspathic sandstone. Their best exposures are along the borders of the great granite basin. As building material they are of no particular value.

THE MIXED GRANITES.

This type is represented in the areas of Silurian granite. It is a distinctive feature in certain localities, and I have always found it to hold the same relations to the Post-Silurian uplifts wherever visible. In the Wichita Mountains, Indian Territory, it manifests identical features. There are some portions which might properly be regarded as forming a separate class of gray granites, and among these some excellent material may be quarried. The ordinary outcrops are made up of a coarse, but tough, quality of rather quartzose reddish granite, in which are inclusions of gray granite, cyanite, black schists, and other material of irregular dimensions. Such masses will not usually prove profitable in the working, although the texture and color of the matrix often leave little to be desired. The indeterminate arrangement of the inclusions makes this material at least of doubtful utility except for local uses. Possibly, however, some very desirable combinations of color for ornamental purposes might be secured at the cost of much labor and time.

The best exposures are in Silver Mine Hollow and Beaver Creek, in Burnet County; in the apparent extension of the same belt in the Pedernales Valley, Blanco County; on Honey Creek north of Packsaddle Mountain, Llano County; and in the drainage area of Upper Honey Creek, Mason County. Possibly the fine exposures of gray granite within a few miles of Enchanted Rock, in Llano and Gillespie counties, may also belong to the same set, but the most of this properly comes under the next head.

THE DIMENSION GRANITES.

Some of the material heretofore described in special situations where it has been hardened by proximity to more recent outbursts, may yield blocks of sufficient size to be used as columns, and for the grosser objects of building and decoration, but such cases are exceptional. The best source of granite for constructive purposes, including foundations, superstructures, and the heavier ornamentation, as well as mural and monumental works, is the "Burnet granite," as it is popularly termed, from the customary source of supply in Burnet County, near Marble Falls. Its general excellence and the wide range of its adaptability, no less than its durability, pleasing appearance, and other admirable qualities, are well exemplified in the Texas State Capitol and in the Alamo Monument at Austin. A very considerable extension of the applications of this granite has been made within the past year. There is an enormous amount of it in the Central Mineral Region, although the fact of its existence in quantity outside of the Granite Mountain area has not been fully recognized by those interested. As stated in the Report for 1889:

This type * * * is undoubtedly to be an incalculable source of revenue. Although enough has already been quarried to exhaust properties of important proportions, there are thousands of times as much awaiting easy extraction. Many believe that the "Capitol granite," as the rock is sometimes called, is confined to one large outcrop near Marble Falls, from which all the material for the State Capitol was taken. This is a grave error, for the outcrops extend over an area of nearly one hundred square miles, and there are others farther west which cover in all nearly as much more territory. Enchanted Rock and its environs, in Llano and Gillespie counties, expose nearly as much, owing to the great height of the peaks, although the horizontal outcrop is less. There is also an area in Mason County, near Katemcy, where about one thousand acres are exposed in a considerable elevation.

This granite [referring to the whole extent] is probably as well exposed for working as any similar mass in the world, and for many purposes the material is not inferior to some of the best foreign granites. It has a pleasing appearance, whether used "in the rough," dressed, or polished, and it can be quarried in almost any desired form of practically unlimited dimensions.

The color is red or dark reddish gray, and there is a considerable range of choice. In combination with the other granites, by judicious alternations or different modes of treatment, but little is needed to obtain the widest variety of ornamentation of which the darker granites are capable.

There are other exposures of "dimension granites" in situations which make it possible that they belong to a different uplift from that of the Capitol granites. In the Cat Mountain, north of Llano, in Rabb's pasture, a rock of this character has been locally applied with success in building small structures. This has features which place it in a transitionary position between the block granites and the Capitol granites. It has an attractive appearance, being more purple or blue in color than its red-gray compeers.

Dimension granite also occurs in abundance in some variety in the belt which runs through the Archean rocks in Burnet County, extending from Capitol Rock, between Spring Creek and Clear Creek. It is probable that the rough country in this tract is made up of outbursts of different ages. Some quarries have been opened in the area and good material has been obtained, but the demand has not yet caused any extensive development of these resources.

It is a mistake to suppose that the dimension granite is restricted to the Post-Carboniferous uplift, to which the Capitol granite belongs, for there are important outcrops in other masses in various parts of the region.

The investigations of 1890 have fully confirmed these announcements, and more extensive deposits have been discovered which will greatly increase the known resources of this character.

Beginning upon the east, we have first the Burnet County areas, or what may be regarded for practical purposes as one almost continuous but irregular belt extending from Beaver Creek southward nearly to the Blanco County line. Some of the outcrops between Beaver and Morgan creeks and in the Colorado River near Bluffton may afford building material of average quality, but it is not generally tough enough nor well enough exposed for profitable working as a dimension granite.

The tract further south, which is drained by Clear Creek and Spring Creek, is for the most part an extension of the great Burnetian area of Llano County, but there are in it immense masses of dimension granite of very fine quality. Owing to the commingling of the different areas of uplift in this region the outcrops are more or less disturbed, and it is difficult to make a diagnosis which will convey a clear idea of the whole area. There is great variety in the mode of presentation at the different exposures, ordinary specimens thus affording no criteria for determining economic values. In some places what would otherwise be admirable masses are so much shattered by the joint fractures or so completely checkered by vein fillings that serviceable blocks can not be quarried. In other situations very satisfactory results may be had, with the advantage of considerable range of selection as to color and texture. The granite is abundant enough, well situated for working, and with due care in selecting and testing the product there is no reason why profitable quarries may not be established in this tract. Perhaps the eastern edge is most favorably placed, but some very promising exposures occur down near the mouth of Clear Creek and farther south. Capitol Rock and Buzzard Roost, with some other elevations, afford granites which deserve the careful scrutiny of builders The Burnet Steam Granite Company has made successful use of its product from quarries six miles west of Burnet.

In the southern portion of the Burnet County area Granite Mountain and similar mounds of less extent in the neighborhood have hitherto been the only producers of dimension granite. This is the material of which the Texas Capitol is composed.

There are three companies at work not far from Marble Falls, all practically in the same material. The Texas Capitol Granite Company is working the original granite quarries on Granite Mountain, at Granite Mountain Station, on the Austin and Northwestern Railway, two miles northwest of Marble Falls. The Texas Mining and Improvement Company has done considerable work about one mile from Marble Falls. C. O'Keefe's quarry is less than one mile from Granite Mountain Station.

Owing to the heavy expenses incident to all new enterprises, the cost of mining this granite has heretofore been much above the average, and notwithstanding the high value of the product as compared with that of other States, the profits over all have been very light. But the capital represented by lands, even at a very low valuation, forms so large a fraction of the total investment, and it is so sure to carry itself with interest by the enhancement from year to year, that we may properly estimate as net earnings all above annual expenses, including interest on plant and deterioration. This leaves a bare margin with the present business; but the returns are not fairly shown without due consideration of the large amount of rock quarried which is still on hand and practically ready for shipment. In 1889, as shown by the census returns, the granite industry in Texas did not pay expenses; but with present facilities and their constant improvement, added to the rapidly increasing demand for our granites, there is no question that good profits will be made in future, especially as some of the largest quarries have heavy stocks of marketable product which has already been included in the cost tables.

Some dimension granite has been quarried about four miles west of south from Llano by J. K. Finlay and by John Goodman. Rabb and ——— and others have locally used some, which is very attractive, taken from the Cat Mountains northwest of Llano. From Gillespie County granite, besides the small workings of residents here and there, a respectable trade in monumental material has been built up by Frank Teich, of San Antonio.

THE FISSILE GRANITES.

There are numerous granites which occur in narrow dykes and in slabby or fissile plates, although this structure is especially characteristic of the latest uplift in the strike north 50° east. Many of them are useless, owing to their brittle character, or the loose arrangement of the mineral components, and the difficulty of extraction in any considerable quantity. A few may be found which will serve for ornamentation or for some other special application. The material of the Sentinel Rock and equivalent ridges northeast of Enchanted Rock is firmly cemented by a peculiar infiltration of porcelain quartz. This might be utilized, perhaps, in artistic construction, if judiciously selected and polished. So much of the fissile type occurs in close proximity to the large mounds of dimension granite that the quarrying of it in connection therewith might be made profitable, if the crumbling nature of the outcrops does not continue much below the surface.

Some of the tougher gneisses might be included in this category, but it is not probable that they will generally have more than a local application as building material. The fine-grained (euritic) granites of some portions of the areas occupied by this class are very well adapted for ornamental trimmings and to afford contrasts in structural design.

B. MARBLES.

Restricting the term to more or less altered limestones or dolomites, but not excluding certain rocks which the trade would accept, although not strictly such, the marbles may be conveniently grouped in three classes. The differences are easily learned, although the ground of separation in the first place is chiefly geologic. They are treated below in chronologic sequence, beginning with the earliest formed.

THE FERNANDIAN BLUE MARBLES.

Trending usually northwest by southeast (magnetic bearing), but occasionally involved in later uplifts, there is a set of calcareous beds included in the same system with the hard iron ores, but overlying the latter. In the best exposures of these marbles the iron ores are often buried beneath them, but if the dip be nearly vertical the marbles may appear to lie in belts parallel to the magnetites.

Usually the Fernandian marbles are blue, highly crystalline, and at surface very fragile, but there are some which are exceedingly tough and fine-grained. The color is not usually attractive for most purposes, and contamination with spots or thin streaks of *pyrite* often mars the appearance in certain exposures, but there are some outcrops which give promise of a better product. It is always very difficult to determine the wearing qualities and the solidity of masses of marble which have been exposed for ages to corroding agents from a mere examination of surface indications. Our samples in the State Geological Museum at Austin illustrate different grades of the blue marbles, and some of them taken beneath the weathered capping are firm and uniform in color. Usually they are thin-bedded, and sometimes the fractures, due to successive uplifts, are too numerous to admit of securing large blocks. On account of the dark and dull colors these deposits have not received the attention from prospectors which they really merit, and which they may receive when a demand for marble shall arise in the district. There is some variety in the coloring between the light gray and dark blue.

As far as can be judged from present developments the best qualities of this class occur in the southern portion of the Central Mineral Region, where they have been rendered more tough by metamorphism, but there are some very promising deposits of greater extent in Llano County, upon Little Llano Creek between Pecan Creek and San Fernando Creek.

THE TEXIAN WHITE MARBLES.

There is a limited expression of very excellent white marbles in a few areas where the Texian strata have been favorably situated for metamorphism without excessive disturbances. The region about Enchanted Rock and southward has produced the best examples thus far, but there is also a tract south and southeast of Packsaddle Mountain which has good exposures. The vertical hachures upon the Economic Map indicate the places where there is reasonable chance of discovering outcrops of value. In a portion of the district outlined northwest of Mason there are signs of similar deposits. Occasionally the surface croppings are friable and of buff or brown tints.

A few of these exposures may be profitably worked whenever transportation facilities shall enable the product to be marketed. There does not seem to be a prospect of the establishment of a very extensive industry upon this material as a basis, and yet the outcrops are such as to warrant development in a number of cases. Some of the more dense varieties, of a pure snow white hue, will serve well as ornamental stones in the higher type of buildings, and if obtainable in blocks of proper dimensions they may also be employed for heavier construction. It is not probable that the quantity will be found sufficient for the support of a very considerable industry.

THE SILURIAN "MARBLES."

The variety of calcareous rocks in the Silurian System of Central Texas is very great. Many of them are wholly unfit for use in construction except in situations where they are hidden from view. Others, which have little else to condemn them, are often not procurable in large blocks, owing to the numerous joints which traverse the deposits. Still others which can be quarried in good form of suitable sizes are of undesirable color or texture, giving them but limited application in the arts. But in addition to these there are not a few stones which possess great intrinsic value, some of them being highly ornamental. Much of the so-called "lithographic stone" is of this character. Although not always adapted to the very refined needs of the lithographer, the polish which such rock acquires under manipulation may be fully adequate to the demands of the builder's art even in some of its more artistic forms of expression.

The general distribution of the Silurian System is given by the hachures drawn downward from right to left upon the Economic Map herewith. The whole of that tract is not covered by suitable deposits for commercial use, but the area which is not so hachured may be taken as practically free from any occurrences of the kind. The so-called marbles, excepting a few of limited extent, are of the type now known as "Burnet marble," although this term was not, I think, originally employed in so wide a sense. There are some interesting cases of local super-metamorphism and of calcite veins carrying material well enough compacted to serve as marbles. These occur in several places in Burnet County, and from them the general name was probably derived. But they are of restricted distribution, and the more abundant tougher beds of the Hoover Division of the Leon Series are those which are commonly referred to as "Burnet marbles." Some of this material has been quarried in different places in the belief that it might be available as lithographic stone.

The Burnet marbles vary greatly in color, texture, and weathering. They are usually tough and compact, admitting of a fine polish. Some are even-grained and homogeneous in tint, others are variegated. The prevalent hue is buff of several shades, but white, pink, and several shades of gray or blue are occasional. The outcrops most suitable for working are those upon the outer border of the district, where they have usually been least affected by the more recent disturbances. Unlike the earlier marbles, they usually dip at low angles, but in selecting places to work it will be necessary to avoid localities where the rock is much broken by joints. Such imperfections will not improve with depth, and they may possibly increase. Many overlook the sedimentary character of these beds and make excavations upon them like shafts, as if they were veins, hoping that the joints may decrease as the surface effects fade out below. But, aside from the ordinary textural results of weathering, the tendency will be rather towards an increase of structural defects as depth is gained.

Samples of these marbles, in commercially available sizes, have been on exhibition from different parts of the Silurian area. Burnet and San Saba counties, from their proximity to railroads, have naturally made the best showing, but the quality is not inferior in other counties. The Cretaceous rocks cover the Silurian in the south, east, and west of the Central Mineral Region so as to leave smaller tracts of the marbles exposed. In Burnet County the workable area is limited, but considerably more extensive than in any other county within the district, excepting San Saba. Mason County comes next in amount of Silurian outcropping, but much of this is not of the Hoover Division. Blanco County and McCulloch County are about equal in Silurian, with probably more Hoover in the former. Kimble County had some very good exposures, and Gillespie and Llano counties each have small tracts. The pink and variegated marbles have the best natural exposures north of the San Saba River in McCulloch County, the outcrops continuing eastward in San Saba County. Prospecting has heretofore been most vigorous in Hoover Valley, Burnet County, in various parts of San Saba County, and on the Pedernales River, south of Cypress Mill, but in most instances the material sought has been a "lithographic stone," with usually unfavorable results. As in many other cases of this kind, an industry of important proportions is liable to be built up eventually with these marbles, but it will require skill, experience, and detailed knowledge of the trade and the correct methods of quarrying upon the part of those who are to make it a commercial success.

C. LIMESTONES AND DOLOMITES.

There are no general remarks to add this year to what was given in my 1889 Report upon the building material among the calcareous rocks other than marbles. A review by geologic divisions, with reference to localities, may be of service to those who seek such information. The oldest rocks contain nothing which can be properly classed under this head in their present metamorphosed condition. The earliest strata of the kind are of Cambrian time.

CAMBRIAN.

Comparatively few of the Cambrian rocks of our area are suitable for building uses, except as rough foundation blocks, and for rubble, "grouting," etc. Such calcareous material as may occur in the Lower and Middle Cambrian is chiefly but the imperfect cementing ingredient of more or less arenaceous rocks, and the colors are very rarely sightly, usually shades of red or yellow. Few of them are capable of withstanding even moderate stresses in structural work. Exception may possibly be made in favor of the buff dolomites near the top of the middle series, which have not yet been actually tested critically. Examples of these last are exposed in the middle part of the canyon of Bluff Creek, Mason County, and to some extent in the cliffs of the Big Sandy Canyon at the water gap in the Riley Mountains, in Llano County.

The Upper Cambrian contains black dolomites near its middle portion which seem to possess good qualities as building stones for situations not demanding select tints. The general character of these layers is well displayed in the phototype illustration of a cliff in Silver Mine Hollow, Burnet County, accompanying this Report.

These rocks are shaly limestones, or calcareous shales. They are accessible in many places; as on Lion Mountain, Morgan Creek, Beaver Creek, Backbone Ridge, etc., Burnet County; over a limited area about Cherokee, San Saba County; to some extent in the neighborhood of Camp San Saba, McCulloch County; near the base of some of the ridges lying off eastward from Blowout Postoffice, Blanco County, and in the country west and south of Mason City. This material has been successfully used for architectural purposes to a limited degree in small structures, and the prospects are very good for its future usefulness. Houses, stores, mills, and other buildings in Mason, Camp San Saba, and the adjoining country have been built of this rock, and some of them have been standing for many years.

SILURIAN.

Aside from the inferior grades of Burnet marble, which may often serve admirably as simple dolomites, there are many other layers in the Silurian System more or less adapted for constructive work. Taken as a whole, these rocks rank as siliceous magnesian limestones, the majority of them being tough and of lighter hues than the earlier dolomites. Usually they weather more evenly and take on less objectionable tints than their predecessors upon exposure to the elements.

The Beaver Division includes in its Bluff subdivision some thick strata which will afford blocks of very large dimensions. They outcrop in the canyons of the Llano River in Mason County, and in tributary streams from the north in this region, as in the lower portions of Little Bluff, Bluff, and Leon creeks. Good exposures occur in Cold Creek Canyon, Llano County, north of Smoothing Iron Mountain, below Baldwin's Ranch. Their tendency to weather black is against them, but their durability is unquestioned.

The Wyo Division contains little material of this class which can be employed for architectural uses.

The Hoover Division, besides the Burnet marble already described, has near its summit some choice crystalline granular and saccharoidal limestones which will become serviceable eventually, but some care will be necessary in selecting, on account of the undesirable effects of weathering.

A few of the Hinton layers may be worthy of trial, especially those near the base of the division. The Deep Creek Division has also promising material in its basal members, but unless the spongy chert be utilized in special situations for artistic effect, the higher portion of the San Saba series is not liable to be much used in construction.

DEVONIAN AND CARBONIFEROUS.

The rocks which I have provisionally placed as Devonian, and those of the Carboniferous System lying within my district, are not, in the main, such as will attract much attention from architects and builders, although some of the lighter hued limestones may be adapted for their use. The outcrops are very limited, except at the northern border of the Central Mineral Region. The Devonian is usually too dark for most purposes. A little jet black chert, sometimes mistaken for coal, occurs in the Riley Mountains and elsewhere; this might be worked up as an ornamental adjunct, perhaps.

CRETACEOUS.

The Cretaceous limestones along the border of the Central Mineral Region are usually less attractive than some of those farther eastward, but some layers have been successfully used locally in buildings. My examination of this material from an economic standpoint has been but cursory, however.

D. SANDSTONES.

The sandstones of the district are abundant, but they represent few geologic horizons. Aside from very limited exposures of serviceable material in the Carboniferous (chiefly near Hamilton Creek, Burnet County, with a small patch at the great bend of the Pedernales, southeast of Cypress Mill, Blanco

County), there is not much outside of the Cambrian System. Much of this last is friable or nonresistent from weak cementation, but there are localities near the later granitic outbursts where very durable sand rock can be quarried, some of it of attractive appearance. The localities which give most promise are along the southern border, near Enchanted Rock, Gillespie County, in the neighborhood of the Dragon Fangs, and southward on Little Bluff and Bluff creeks, in Mason County. The white and buff hardened sandstones or fine conglomerates of the Lower Cambrian, as on House, Putnam, and Packsaddle mountains, may be used with good effect, and they can be readily obtained in quantity of large dimensions, some of the beds being from ten feet to twenty feet thick. There are special situations where the Cambrian red sandstones have been hardened by semi-metamorphism, but in many cases they are not sufficiently indurated to be serviceable in construction. Often they are highly calcareous, as is shown by the white incrustations left upon surfaces of erosion along the creek beds. This is a very common effect at the north end of the Riley Mountains, in Llano County.

Some of the hardened sandstones or incipient schists of the Texian System which abound in southeastern Llano County and in much of the adjoining region south of Packsaddle Mountain, as well as in the vicinity of Lockhart Mountain, and to some extent north of Mason, in Mason County, may be utilized as building stone, by careful selection. The chief objection to this material is its broken up condition, but this is not always the case.

E. SLATES, SCHISTS, ETC.

There have been no severe tests of material supposed to be adaptable as roofing slate, and yet the outcrops of such rocks are numerous and easily worked. It is difficult now to say whether the Burnetian, Fernandian, and Texian strata include good material of this class, because the essential elements of durability can only be proven by actual practical use. But in places where the Texian and Fernandian have been hardened by the action of imprisoned heat, many exposures occur of strata of suitable color and toughness. Big Sandy Creek, southeast of Packsaddle Mountain, courses for miles through this class of rock. Similar conditions prevail in other regions, as in a portion of the area east of Enchanted Rock. The best districts, however, so far as can be judged from the outcrops, are east of the Riley Mountains and along the valleys of Comanche and Beaver creeks, in Mason County. These are the Texian fields *par excellence.*

The Fernandian and Burnetian schists at surface are rarely slaty; the Texian rocks incline to the block structure, but the chances for discovery of suitable roofing slate are much better among the last named rocks than with the others, which are usually brittle or granular; or if tough they do not commonly break with the slaty fracture. The Texian strata contain less crystalline members, some of which are more argillaceous. The dynamic results within the whole pre-Cambrian area are not in the nature of lateral thrusts, except in such a limited degree as has been requisite for contorting the layers without producing the slaty cleavage.

Some of the more friable schists may probably be utilized some day as the basis of substantial and attractive concretes. Their variety, accessibility, and ease of manipulation leave little to seek for this purpose.

Serpentines and other special products are not exposed in very extensive tracts, but there are some very good deposits in regions of much disturbance, as in the vicinity of Enchanted Rock, on Kuehne Creek, and elsewhere, Gillespie and Llano counties; and in the region of the King Mountains and Bode Peak, Llano and Mason counties. It is not probable that these will furnish vast supplies, although specimens of much beauty may be mined occasionally, and the general product is tough and fairly uniform.

F. CLAYS, CEMENTS, ETC.

Reference will be made to certain refractory materials in another place. The clays of the Central Mineral Region which are adapted for brick and tile making are more abundant than would be inferred from casual inspection. Notwithstanding the general appearance of pure sand which large areas of the soil exhibit, the amount of feldspathic ingredients in the "granite wash" is very considerable; the erosion has been so thorough and the assorting action of water so complete that many accumulations of silted clay occur in all parts of the district. There is as much variety as might be anticipated in the characters which furnish the basis for grading such deposits. Coarse, fine; unctuous, friable, pulverulent; sandy, limy, mucky; red, blue, white, and other hues; all may be found in quantity and in many different situations. Owing to the numerous changes of condition which these accumulations have undergone since the degradation of the original rocks, it is impossible to draw sharp lines of demarkation between the local patches, nor can one safely generalize or lay out the metes and bounds of individual tracts. Often the best material is covered by later soil of a different character, and the conditions are ordinarily so purely local that a test of one spot can not be used as a guide in the search for others. Our work in these surface deposits has necessarily been incidental rather than specific. But enough has been learned to show that there are comparatively few reaches along the flood plains of the larger streams, back from the more recent overflows, in which clays of some kind do not abound. Starting with this assumption, let it be borne in mind that the areas in which the silt is local in regions of shales, and often the reverse in limestone and sandstone districts, is the most liable to yield good clays, and that a little prospecting will usually decide the question of their existence and character. The Llano River valley from about Llano to its mouth, and the Colorado at least below this point, besides the banks of tributary streams running in granite, afford some of the best material, but the choice clays are not restricted to these areas. Generally speaking, the whole granitic area affords occasional deposits of presumable value, very little of which have been practically tested. These clays are perhaps less plastic than some, but they are usually refractory. Occasional banks of kaolinitic clay occur in restricted areas in the Burnetian districts, but they are not very abundant nor extensive.

The rocks above the crystalline strata contain but few members which yield clay by disintegration, but certain of the limestones may possess qualities fitting them for use as cements. These have not been so used as yet and there are no data for forming a reliable judgment. In the Cretaceous some beds are well adapted for conversion into Portland cement, or a near ally. This utility is not, however, confined to our border area, for it is characteristic of a very wide belt of Cretaceous exposures eastward and southward.

G. MATERIALS FOR LIME, MORTARS, ETC.

Many of the limestones of the Cretaceous border and of the Mason Mountain promontory are well adapted for making quicklime, and in many places they are now burned successfully. Some of the Silurian and Cambrian strata might be so employed if necessary, but as a rule these are too siliceous or otherwise unfitted for the purpose. Sands for mortars are extensively abundant in much variety, the Cambrian strata affording the best and most extensive supply. This terrane surrounds the whole region and is at surface in much of the interior. This distribution renders the sands very readily accessible from all points. The decay of the Trinity Sands (Jurassic or Cretaceous) along portions of the border gives a "wash" which has often much the same range of usefulness, this terrane being to a large extent the result originally of the degradation of the Cambrian sandstones.

III. REFRACTORY MATERIALS.

The rocks which are particularly fire-proof belong almost wholly to the interior or pre-Cambrian areas. Soapstone, or steatite, occurs in the Burnetian exposures southwest of Smoothing Iron Mountain, Llano County, also in the northern part of Gillespie County, south and southeast of Enchanted Rock. It is sometimes foliated, but there are some places where it is compact enough to be cut into blocks of sizes suitable for furnace lining. Ordinarily it has but little grit and powders well, so that it is applicable as a fire-proof filling for safes and for similar purposes. Thorough search in the continuation of the Burnetian axes (in a course north 75° west by south 75° east from the outcrops referred to) may reveal other workable deposits. The appearance, however, is that of local metamorphism, and the exposures thus far observed are all in situations where more than the usual amount of plutonic action has been developed. The acidic schists of Burnetian age and much of the quartzite of the Texian System can be utilized as fire resistants, and in adaptable situations the basic schists of all the pre-Cambrian periods can be so employed. There is no lack of refractory materials, and none of them are difficult of access. Asbestos was reported last year as probably absent from the district. A little of this mineral was collected by Mr. G. Jermy, while engaged upon the Survey, in Gillespie County. The amount is not great, but the quality is good. Very much of what passes for asbestos is either fibrolite, aragonite, or chrysolite, all of which minerals occur in the region in crystalline forms not very different from the fibrous asbestos in the eyes of untrained observers. For further descriptions of the refractory products see pages 374, 375 of the Report for 1889.

IV. FICTILE MATERIALS.

The pottery clays may be represented in some of the finer grades of argillaceous material deposited along the stream courses, but few have been tested sufficiently to give any report upon their adaptations. In many parts of the Burnetian areas and elsewhere the feldspathic granites and acidic porphyries yield excellent material by their decay, but it is necessary to find the localities in which the most pure detritus has been quietly laid down by water. Clear Creek, in Burnet County, and much of the region westward, in Llano County; parts of the outskirts south of the King Mountains, and the district south of Enchanted Rock, are among the best situations for such accumulations. The district north of Llano, eastward, may also have some similar tracts, but these will not be traceable across wide intervening areas. See also remarks on pages 375, 376, of 1879 Report, under head of "Materials for Glass and Pottery."

Glass sands are abundant in restricted portions of the Cambrian exposures, as especially over the country north and northeast of Valley Spring, and at the head of Cold Creek west, where pure white sand, as "wash" and as lightly consolidated beach deposits, obscures the surface and forms bluffs and castellated buttes. Untested material of good appearance also occurs in the Trinity Sands along the Cretaceous border. Other supplies might perhaps be obtained, if required, from the disintegration of sandy schists of Burnetian age.

PART III.

SUPPLEMENT.

MAY 15, 1891.

Circumstances entirely beyond my control have prevented the publication of the complete results of the survey of the Central Mineral Region. The plan of this Report, as provided for, included a full review of the geology of the district, illustrated by a colored map outlining the areas of the various stratigraphic systems, a series of sections across the whole region, and a statement of the facts upon which my conclusions have been based. No one can regret more than myself the necessity which compels me to forego, I trust but temporarily, the publication of what has been thus laboriously determined. The map is now on exhibition in the office of the Survey, and this, with the detailed sections, must be appealed to in support of the generalizations which have already been advanced. In this place I can only present such facts as can conveniently be arranged, in addition to the material presented in my 1889 Report. Since the issue of that volume, one year ago, no one has given the area one-thousandth part of the study represented by my survey, and no geologic report has been made by anyone who has gone over one-tenth of the area, even hastily. All the work done prior to 1889 is clearly indicated, without prejudice, in my report for that year.

The remarks which follow are offered simply as a résumé of facts, intended to show in bare outline the foundation for my own opinions, which must stand or fall upon the final verdict to be rendered by those who make themselves as competent to judge by an equivalent amount of study of the facts themselves.

ARCHEAN ROCKS.

THE BURNETIAN AND FERNANDIAN SYSTEMS.

The study of the Archean Systems (Burnetian and Fernandian) has been continued in the field and office since the last Report with as much diligence as other necessary work has allowed. The stratigraphy has been worked out as fully as can be advantageously done until the petrography is studied.* A few general words seem necessary, in order to make clear some portions of my 1889 Report, which perhaps have not been explicit enough.

*Arrangements have been made to put this important work in the hands of a specialist of high repute. When his report is ready, I propose to give a more thorough discussion of the geologic history.—T. B. C.

The evidence upon which my conclusions were originally based is more definite and complete than may appear from the brevity of my statements, and the work in the field in 1890 has confirmed and extended the proofs. This forcibly illustrates the great disadvantage of attempting a clear presentation of such a subject without maps and sections to portray the facts. Some idea of the situation may be gained from an inspection of the nine sections across portions of the mineral districts which are distributed through the text of this Report, but they do not tell the story as completely as the other illustrations which have been prepared. I shall therefore endeavor to give here briefly the proof of the relations existing between the Burnetian and Fernandian outcrops, and of the stratigraphic connection between the Fernandian and Texian systems.

First. Wherever good exposures occur, anywhere in the district, of rocks folded along axes trending north 75° west, a little study will develop five or six later lines of fracture or uplift, the relative ages of which can be made out by the method well known to geologists of determining the ages of intersecting veins. The fracture which is uncut by any of the others is manifestly the youngest of all; the one which has been broken by all the others is the oldest, and the chronologic relations of the remaining lines are determinable from similar premises.

This criterion applied to the system which I have named the Burnetian makes it out the oldest in the region. No other terrane has stratification planes or structural breaks following the course north 75° west but this, and every other axis of uplift is traceable through the rocks of the Burnetian System.

The rocks which I call Fernandian have all the structural (orographic) lines known in the region, with the single exception of the most ancient trend; which proves that this system was formed after the Burnetian rocks were folded.

Secondly. While it is true that there are large patches of the pre-Cambrian rocks which are sadly jumbled by the numerous disturbances, confused by faults, and eroded irregularly, there are also many places where the Burnetian and Fernandian are in juxtaposition, and where their original unconformity can be clearly made out. Notwithstanding the ravages of time, partly because of them, remnants of the old Burnetian highland still exist as pinnacles and mounds, about the base of which are fringing areas of the Fernandian schists. The King Mountains, in Llano County, and the region southwest of Fly Gap, in Mason County, afford good examples, but similar occurrences may be studied in the country southeast of Magill Point, and in the district eastward in the northern part of Llano County, as well as in the tract southeast of Enchanted Rock and over the area north of Blowout, in Gillespie and Blanco counties. As will be seen from the sections (Figs. 1 to 9), the complications in structure are too great to make the study a simple one in all cases, and thus it may be difficult to connect isolated patches with each other by continuous sections in many tracts. Still, familiarity with all the exposures enables one to work out structure which can not be understood except by careful mapping, topographic as well as geologic. This has been done by myself, and my conclusions are based upon a complete knowledge of the field.

Thirdly. The basal members of the Fernandian System are made up in part of material apparently derived from the Burnetian rocks.

Fourthly. There are geologic *foci* where two or more of the orographic axes cross, and often in such places the chronologic relations of the Archean systems are distinctly and unmistakably recorded. On Little Llano Creek, south of Lone Grove, Llano County, and in the region of the Dragon Fangs, on Honey Creek, Mason County, there are very good examples, but many more might be given. I have seen the same evidence beautifully recorded in the Wichita Mountains, in Indian Territory. In situations like these the Burnetian gneisses have often been turned from their normal trend and curved into the northwest trend of the Fernandian axis in such manner as to leave no doubt of the proper relations of the two systems.

Fifthly. The completed Geologic Map and the actual sections made with great care afford the most convincing testimony (in my judgment) that my conclusions are in accordance with the facts.*

EPARCHEAN ROCKS.

THE TEXIAN (ALGONKIAN?) SYSTEM.

The relations of the Texian strata to the Fernandian are deduced from facts of the same character as those used to determine the taxonomy of the Archean systems.

First. The nearly due north-south strike in which these beds are commonly (not always) lying is peculiar to them; the earlier fractures and lines

* In 1889, preparatory to making plans for the survey of this district, I devoted sixteen days to its cursory examination. The general idea thus gained of its geology was as foreign to the results of two years' detailed study as could well be. Several tons of specimens were collected the first year and many boxes the second field season. The topography and geology have been mapped minutely, and the field notes of myself and assistants cover some three thousand pages, in thirty-eight note books. These have been plotted and studied for twenty-four months, without bias of any kind. For these reasons, while some may feel called upon to differ from my opinions, after a run of a day or two across a portion of the district or without seeing the region, I am fully satisfied that upon more detailed investigation my conclusions will be upheld.

of uplift are invariably absent, but the later ones can be more or less distinctly traced through the members of this system.

Secondly. There are enough localities exhibiting the juxtaposition of the Texian with the underlying Fernandian, and their nonconformity, to leave no doubt of the more recent formation of the Texian and the historical separation of the two. In the area south and southeast of Packsaddle Mountain, also in that southwest of Sharp Mountain, and in portions of the country north of Lockhart Mountain, all in Llano County; in the region north and northeast of Mason, and in Beaver Creek valley and elsewhere in Mason County, as well as in other sections, the evidence is unquestionable.

Thirdly. The derivative character of certain of the Texian beds is a most marked feature.

Fourthly. The distinctive character of the intrusives, and their transection of the earlier rocks where the record is visible, as well as the bending of the Fernandian schists at times into the later Texian trend at junction points, all attest the correctness of the interpretation put upon the facts in these pages.

Fifthly. The distribution of the Texian exposures and their relations to the existing topography are shown by the Geologic Map and sections to admit of no other explanation than that here given, notwithstanding the remarkable exigencies to which the region has been subjected all through the ages since the deposition of these strata.

PALEOZOIC ROCKS.

The field work of 1890 included the mapping of the Paleozoic outcrops as far as the Cretaceous border upon the east, south, and west, and to the Carboniferous border upon the north. A few patches of Carboniferous intruding within the tract thus outlined were also worked in to avoid the necessity of special excursions to the region by colleagues upon the Survey. These last will be briefly noticed in this sketch.

THE CAMBRIAN SYSTEM.

In the last Report the Cambrian strata were provisionally divided into three series. The facts upon which this arrangement was based were given, and it was admitted that no conclusive paleontologic confirmation had been obtained. The subject stands very much in the same situation now, although such evidence as I was able to glean in 1890 has served to strengthen somewhat my belief in the unconformities reported. The chief difficulty with such problems in our field is that the present dip of the strata is often a resultant of several movements, including at times three or four more recent than the close of the Cambrian Period. The contacts of the Cambrian base and summit are very irregular, as regards the horizons involved, and the faults are very numerous and confusing. It will require very close study to finally settle knotty questions of this character.

Dr. Cooper Curtice, in the discussion of a paper upon a different subject read by Prof. R. T. Hill before the American Geological Society, December 30, 1890, refers to contacts of the Potsdam sandstones with granites, but his observations being very limited in time and area, he did not see the numerous other contacts in which the Cambrian strata of different horizons are in smooth contact with granites, over which they dip steeply in conformity to the "set" of the granite. Previous observers have usually discussed "the granite" of this region, as if whatever conclusion might be drawn from any one exposure, or one class of exposures, must necessarily apply to all the granitic masses of the whole district. In the Report for 1889 I endeavored to make very clear the fact that there are various granites of different ages, and that discussions based upon anything but intimate knowledge of the entire Central Mineral Region are profitless and misleading. The Geologic Map, when published, will show this diversity in a striking manner. There are pre-Cambrian granites, but there are also those of later origin, and the complications resulting from their commingling through successive uplifts are not such as can be worked out in a brief period. This Survey has made only a beginning of the study as yet, although it has done many times the work of any previous organization or individual.

THE SILURIAN SYSTEM.

But little can be added here to what was announced in 1889 concerning the subdivisions of the Silurian. The field work of 1890 gives no new divisions, but confirms those previously announced. Very much interesting material was gathered, however, with reference to the distribution of the Silurian System as a whole, it being found that large uncovered tracts lie beyond the limits previously defined, besides a very considerable area along the Pedernales River, in Blanco and Gillespie counties, from which the Cretaceous strata have apparently been removed by erosion. These hitherto unreported tracts present chiefly the Hoover and Wyo beds at surface, but there is also an expression of the Deep Creek Series in the southeast in Burnet County, south of the Colorado River.

THE DEVONIAN SYSTEM.

The debatable fossils, some of which I have previously noted as Devonian, some which have been claimed as Carboniferous by other workers, and perhaps a few which Mr. R. S. Tarr regards as sub-Carboniferous, have been sent to Dr. H. S. Williams, of Ithaca, New York, for identification. Awaiting his report, which can not appear herewith, I retain the term Devonian provisionally, and merely add that the superficial extent of the terrane has been materially extended since the 1889 Report. The rocks included lie as an inner fringe about the edge of the known Carboniferous, being well developed on Wallace Creek and westward, and on the lower part of Cherokee Creek, in San Saba County, somewhat also in Lampasas County, and more than anywhere else in the hills south and southwest of Marble Falls, between the Colorado River and Slick Rock Creek, on the road from Marble Falls to Llano. The same terrane outcrops below Marble Falls near Double Horn, also at Marble Falls and back of it on the hills, as well as in the river bed itself, being in juxtaposition, along fault lines, with Silurian and Carboniferous strata.

THE CARBONIFEROUS SYSTEM.

The Carboniferous rocks have been studied by other members of the Survey where they touch this district upon the north. I have examined only such exposures as could not be observed by them. These consist of isolated patches, chiefly upon the south.

If the Devonian be a reality, as assumed in this Report, there is as yet an uncertainty regarding the horizon which must be taken for its summit An interesting series of black shales overlying the fossiliferous beds has usually been considered Carboniferous, but mainly from its supposed parallelism with a higher set of fossiliferous shales outcropping along the northern border. We have not yet the data for correlating the separated exposures, but it is very possible that the Hamilton Creek shales here referred to should rightly be included in the Devonian. They are, however, closely related in age to the beds which contain a thin (two inches to six inches) seam of coal in this region, and it will be best still to relegate them to the Carboniferous. The exposures are mainly in the lower valley of Hamilton Creek and along the Colorado River below this, running up a short distance into Panther and Coal creeks, and the creeks coming in from the opposite bank of the Colorado, all in Burnet County. Some of the same rocks occur in an isolated patch southeast of Cypress Mill, in the Pedernales Canyon, in Blanco County; a limited and insulated outcrop is peculiarly exposed in Honey Creek Cove, in the Riley Mountains, Llano County, and there is also a patch, chiefly of higher Carboniferous beds, in the Llano River valley below the old Beef Trail Crossing, above the mouth of Big Saline Creek, in Kimble County. Included in many of these areas are strata of undoubted Carboniferous age. I have also had occasion to examine certain exposures in the San Saba River valley, at the mouth of Five Mile Creek, in Mason County, and others upon Wallace and

Latham creeks, in San Saba County, but these are so directly connected with the main tracts falling under the eyes of my colleagues upon the Survey, that I do not think it necessary to discuss them here.

There has been a question regarding the age of some limestones involved in a narrow uplift in southwestern Burnet County, known as the Shinbone. Professor Robt. T. Hill, who visited the locality in 1888–89,* has regarded the rocks Carboniferous. My own opinion has been that the strata chiefly involved in the uplift are Silurian, but I think it not improbable that Carboniferous strata not far east may have been thrown up also, as the disturbance was post-Trinity, involving the Cretaceous strata as well off to the southwest and northeast. There are so many faults and such unconformities in this region, accompanied by igneous action, that it would be hazardous to deny the occurrence of Carboniferous rocks in the tilted section simply because I have not seen them, although there is very little of the area which has been left unexplored. Hoping for an opportunity to settle this minor point in 1891, it is proper to state that there has been no intention to deny the existence of limited outcrops of post-Silurian strata in the Shinbone uplift, for it was very plainly stated in my 1889 Report † that the Silurian rocks observed in the ridge were lying in an axis of later origin than the Carboniferous. Those who have worked in this area, other than myself, have given hours to the study where I have given many days, with careful topographic and geognostic work, and the complications increase with deeper study. It is absolutely impossible to unravel the history of any part of the region outside of the Cretaceous exposures without accurate topographic data and the most detailed stratigraphic work. Conclusions based upon anything less, or upon isolated observations, are worthless for scientific or practical purposes in this area of complex history. Very much has been left for future private workers, for it would require months of field work to settle some of the interesting problems which our Survey has made apparent in the restricted area around Marble Falls alone. Even since the field work of 1890 I have discovered extensive outcrops of Paleozoic strata most confusedly jumbled in the very path of this Shinbone uplift southeastward; and there the doubtful Devonian is the prevailing surface rock in one part, with Silurian and Cambrian in another. Northeastward, I am well aware that the Cambrian, Silurian, and Carboniferous are all involved in the movement, but with most irregularly faulted contacts. As far as has been possible these facts are accurately portrayed upon the Geologic Map.

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*See "A Portion of the Geological Story of the Colorado River of Texas," by Robt. T. Hill, American Geologist, Vol. III, 1889, pages 287–299.

† Pages 314, 315, First Annual Report Geological Survey of Texas, 1889.

THE JURA-CRETACEOUS SYSTEM.

It is not proper for me to speak with much detail concerning the geology of the post-Carboniferous border of the Central Mineral Region. My studies have not extended far enough into that area to give me an adequate knowledge of its stratigraphy very much beyond the contacts with the earlier strata. At the same time, it has been necessary to study some features with care in order to interpret the structural and dynamic history of the area more immediately under review. Thus the determination of the age of the latest prominent disturbance in the inner tract required that all the rocks involved in that dynamic action should be seen, at least to a reasonable distance beyond the border. Having ascertained that a large area of uncovered Silurian rocks lies along the Pedernales River within the Cretaceous area, and being obliged to traverse large tracts of the latter strata in visiting special Paleozoic outcrops and in going to and coming from the field, considerable information was gleaned regarding the later terranes, much of it from districts not previously examined, at least since the date of Roemer's visit.

The dynamic event recorded in the Central Mineral Region by lines of uplift, fracture, and faulting, trending north 50° east, extends out into the Jura-Cretaceous border area upon the north, east, and south, and apparently upon the west also, although it seems to me to be less evident in the region of Menard, Concho, and western Kimble counties. Whether it includes what Mr. Hill defines as Upper Cretaceous, I can not say, because there are no remnants of that terrane within our field.

In using the term Jura-Cretaceous instead of Lower Cretaceous in this place there is no intention of asserting a belief in any particular chronology, but rather a desire to place the matter exactly where the able workers in these strata have seemed to leave it, i. e., undecided.

We are dealing here chiefly with the Trinity and Fredericksburg divisions, the former being well exposed upon the east and southeast of the district, but thinning out gradually upon the west until it is wholly absent in certain contacts. In most places where the Trinity-Fredericksburg contact is well displayed the two terranes seem to be somewhat unconformable, but in the absence of very explicit study I am unable to do more than to report this fact as an observation of some possible stratigraphic moment.

The conclusion announced in 1889 that the Cretaceous sea did not cover the whole of the Central Mineral Region has been strengthened by the observations since made. The evidence is not easily summarized in the space allotted here, but a brief outline is given below.

First. Over an area of several thousand square miles there are no remnants whatever of the Cretaceous rocks, not even in the form of Quaternary float, although this last is very abundantly made up of fragments of the older rocks.

Secondly. The Cretaceous beds along the borders, even including the fossiliferous limestones, in large degree, are chiefly shore line deposits composed of material of local origin.

Thirdly. The dip of the Cretaceous strata is not uniform in amount or direction, the contacts with other terranes are very irregular, and there is no relation of continuity between certain widely separated exposures. In other words, if the restoration of the strata be attempted upon the theory of continuity, impossible conditions of folding and twisting must be conceived in order to explain the present relations.

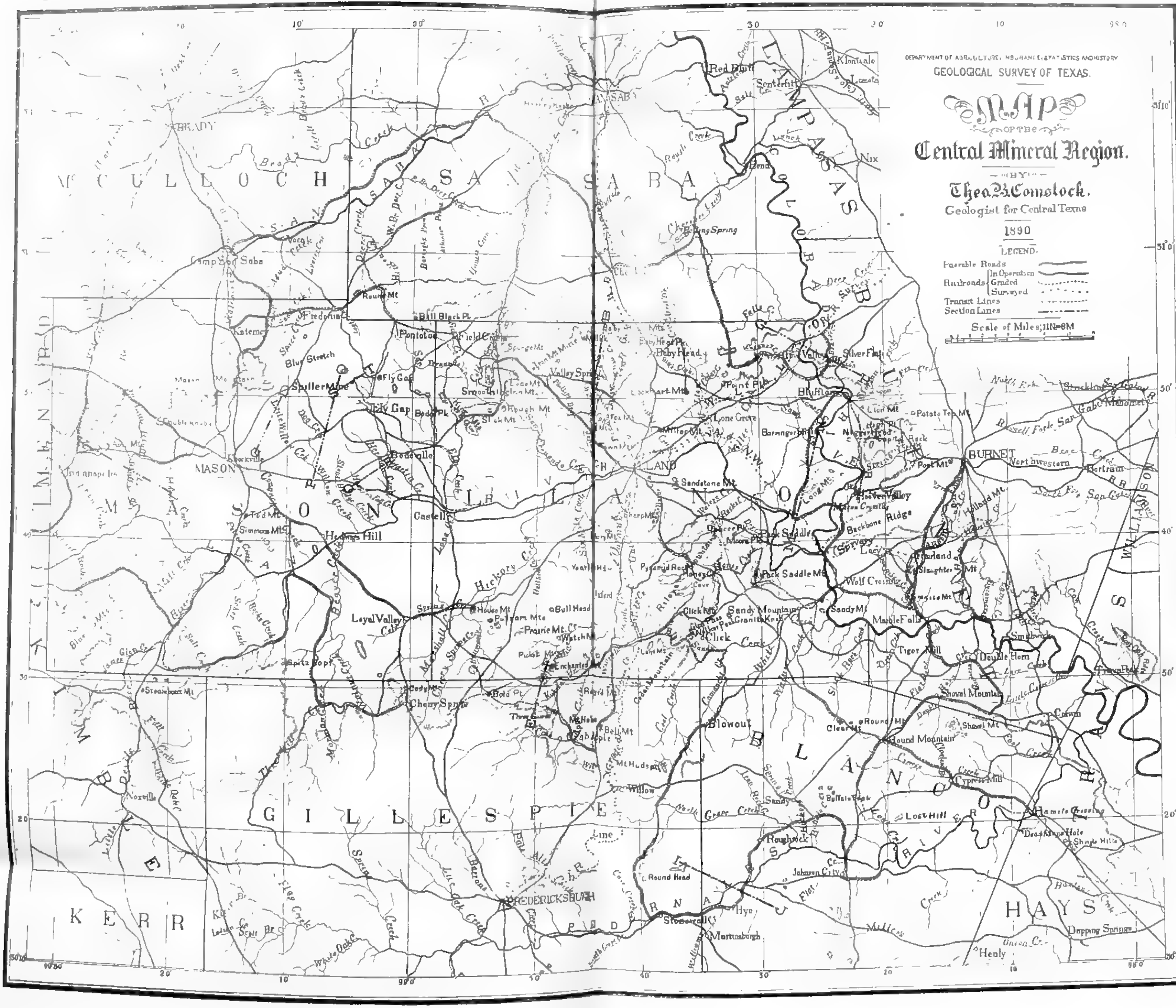
Fourthly. There are numerous and important faults crossing the *Cretaceousless* area, which faults have had such effects upon the lower rocks as must have certainly preserved some remnants of any capping terrane, and yet over all the area there is nothing later than Carboniferous, and *very little indeed* of that.

Fifthly. The pre-Cretaceous faults raised portions of strata of very much earlier date to positions elevated enough to leave them after ages of denudation as high as the summit, or higher, of the Cretaceous strata afterward deposited about them.

Sixthly. The inferior contacts of the Cretaceous are various, showing that much erosion had occurred prior to their deposition. Moreover, the amount of denudation in the region is vastly greater and its time equivalent far more lengthy than could possibly be required for the removal of Cretaceous only, and this erosion is far in excess of what has taken place in the Cretaceous area.

Seventhly. Old stream-courses are numerous, and the dominance of the older stratigraphy in the drainage is the most prominent feature of the district, in striking contrast to that of Cretaceous areas, even when denuded, as in parts of the Pedernales Valley.

Eighthly. In numerous places outside of the area referred to here the Quaternary deposits are largely made up of Cretaceous debris, and in all those sections where erosion has exposed the lower rocks, buttes, hills, and patches of Cretaceous attest the former presence of that terrane across the denuded tract. (Compare *First.*)


DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS AND HISTORY
GEOLOGICAL SURVEY OF TEXAS.
MAP
OF THE
Central Mineral Region.
BY
Theo. B. Comstock.
Geologist for Central Texas
1890
LEGEND.
Passable Roads
Railroads { In Operation, Graded, Surveyed
Transit Lines
Section Lines
Scale of Miles; 1IN=6M
McCULLOCH
SAN SABA
LAMPASAS
BURNET
MASON
LLANO
GILLESPIE
BLANCO
KERR
HAYS
KIMBLE
WILLIAMSON
TRAVIS
BRADY
SAN SABA
MASON
LLANO
BURNET
FREDERICKSBURGH
Johnson City
Marble Falls
Pontotoc
Castell
Stonewall
Round Mountain
Cypress Mill
Dripping Springs

REPORT

ON THE

GEOLOGY AND MINERAL RESOURCES

OF

TRANS-PECOS TEXAS.

BY

W. H. von STREERUWITZ.

CONTENTS.

REPORT

ON THE

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TRANS-PECOS TEXAS.

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CHAPTER I.

The present Report refers principally to the area mapped, topographically, between longitude 104° 55′ and 105° 35′ and latitude 30° 55′ and 31° 10′, covering the east and west slopes of the Quitman Mountains (formerly Sierra de los Dolores) to the El Paso stage road; the Malone Hills; the southwestern part of the Sierra Blanca group, with Sierra Blanca Peak; the southwestern spur of the Sierra Diabolo; the western part of the Carrizo Mountains; and the northern foothills of the Eagle Mountains (Sierra del Cola del Aguila); the hills of the Devil's Ridge (sometimes called the Devil's Backbone); and the hill ranges between the Sierra Diabolo, Carrizo, Eagle Mountains, and the Quitman Range, with the intervening extensive flats. It refers also, as far as geography is concerned, to a part of the Trans-Pecos Texas which up to this time has not been worked up topographically and geologically, but which I have touched by reconnoitering, such as the Guadaloupe Mountains, extending southward from New Mexico toward the foothills, and northern slope of the Davis (Apache or Limpia) Mountains, between the San Martin Springs and Van Horn.

This southern extension of the Guadaloupe Mountains connecting with the Davis Mountains extends through the Paisano and Mount Ord range to the Sierra St. Jago (Sa. Contrario), which runs down to the Rio Grande, forming the divide between the Pecos (Rio Puerco) and Rio Grande above the mouth of the Maravillas Creek.

We find on the eastern slope of this divide not only more surface water in the shape of springs and creeks holding water all the year through, but also more favorable artesian conditions.

The two main forks of the Black River (Rio Azul) originate from numerous springs on the east side of the Guadaloupe Mountains, which after uniting drain the northeast slope of the Guadaloupe Mountains in New Mexico. The northeastern slope is drained by the Delaware Creek, which also originates from numerous springs (mostly of good water) but in its lower course becomes contaminated with alkalies and sulphur, and runs into the Pecos River about two miles north of Pope's Crossing.

A number of smaller and larger springs on the north side of the Davis Mountains join near Saragossa to form Toyah Creek, which after passing a salty lake reaches the Pecos River below Pecos City.

Smaller creeks having their sources in the Davis range disappear after leaving the mountains.

From Toyah Creek to the mouth of the Pecos the country has hardly any creeks worth mentioning. The most important direct tributary of the Rio Grande from the east side of this divide is the Maravillas, having its principal sources in the rain water coming down from the Mount Ord range, the Comanche Mountains, the Pena Colorado, and Pena Negra ranges, and in some springs, of which the one at Pena Colorado and Thompson's are the most important.

On the western slope of this divide we find as tributaries to the Rio Grande the Tornillo, draining the valley between the Sierra St. Jago and the Rosillas, Corazones, and Chisos Mountains.

West of the three last named mountain groups, the Tarlinga (Treslinguas) takes its course toward the Rio Grande, and some smaller creeks, the names of which I could not ascertain (most of which seem to be only drainage beds for rain water), may be mentioned on this side of the Sierra Bofecillos.

At Presidio del Norte the Cibolo Creek joins the Rio Grande. This creek, though dry at its mouth and for many miles above it, carries considerable water at Shafter (Plazuela) and above, supplying the Shafter silver mills with water and leaving a good surplus, though the greater portion of the water runs under gravel and sand. No tributaries of the Rio Grande exist above Presidio, with the exception of water courses wet only in rainy weather. Green River and Glenn's Creek, which drain larger areas than any other of the streams laid down on the maps, are in dry weather as dry as they are on the maps.

There are also a small number of springs of limited capacity in this part of the country, some of which, being supplied only by the rainfall in the mountain range, run nearly dry during the dry seasons.

Trans-Pecos Texas is a mountainous country. The mountains rise from the flats of the plateau which extends into New Mexico, sloping gradually down in a southwestern and southeastern direction from the divide (Guadaloupe Mountains and their southern extension).

West of the Guadaloupe Mountains the Wind Mountains rise and extend into Texas from New Mexico. The elevations of the Tinaja Pinta rise about ten miles below the thirty-second parallel, in a southeasterly direction, with an extension sloping gently toward the Salt Lake valley. This extension connects with the Sierra Prieta, from which the steep cliffs of the east side of the Sierra Diabolo run down to about eight miles north of the Texas and Pacific Railway at Allamore, turning in a western direction at the Hazel Mine.

A mountain ridge extends nearly parallel to the eastern cliff side of the Sierra Diabolo which is partly capped and flanked by metamorphosed stratified rocks, tilted by the igneous upheavals. This mountain range extends to about twenty-five miles from Allamore, in a northeasterly direction, and the eruptive rock which, like that of the "Tumbled Mountain," breaks through the stratified layers in large serpentinous dykes, is probably related closely to the rocks of the Carrizo Mountains. These Carrizo Mountains disappear for a distance of about eight miles below the flat east of the Eagle Mountains, and reappear in a spur of the Van Horn range, where we meet again the crystalline schists and granitic rocks, partly capped and flanked by metamorphic Cretaceous limestones. These schists also outcrop through the limestones in the ravines west of the Van Horn Wells, and like those of the Carrizo Mountains show fair indications for argentiferous copper.

A flat about ten miles wide extends between the Van Horn and Davis mountains, and slopes slightly towards Van Horn Station. From this flat, near Chispa, on the Southern Pacific Railway, a mountain group arises, evidently of volcanic origin, which extends towards the Davis range. The flat widens out from these mountains towards Valentine, leaving the railroad at Valentine nearly in the middle between the Davis Mountains and the Viejo Pass, a distance of about twelve miles from either place.

The flat assumes a more hilly character (similar to the rolling prairies of the east) southeast of Valentine near Marfa, with the Davis and Paisano mountains north and east and the Capote and Chinatti mountains south and west.

East of Presidio del Norte we meet the Sierra Bofecillos, with some good springs. These extend in a northerly direction into the Sierra Refugio and in a southwesterly direction to the Rio Grande, which here in a number of rapids rushes down between the cliffy shores.

Southeast from the Bofecillos towards the extreme southern point of the great bend of the Rio Grande we find located the Tarlinga (Treslinguas) Peak, the Rosillas, Corazones, and Chisos (Specter) mountains, east of which, nearly parallel in their general direction, are the St. Jago (Sierra Contrario)

Mountains. These are continued towards Alpine, in the Cathedral Mountains and Mount Ord group.

We find the Comanche Mountains east of the Davis Mountains, separated by a depression. They gradually slope down toward Fort Stockton, and though mostly stratified in their northern part, terminate south in a granitic upheaval about four miles north of Marathon Station, on the Southern Pacific Railway. The hills east of the Comanche Mountains extend about thirty miles. They form the flinty Pena Colorado and the more basaltic Pena Negra range east of the Sierra St. Jago.

If and how far the more northern and eastern stratified elevations are intersected by eruptions, intrusions, and protrusions, and if they contain any useful minerals, is yet to be ascertained.

LITERATURE.

Of the various publications about Texas only a limited number refer to the Trans-Pecos portion of the State, particularly that part which I have had the opportunity to work, up till now.

The explorations for a route for the Pacific Railroad were carried on in a more northern latitude (not lower than 32°) and although giving valuable information about the Staked Plains, the report on the geology of the route by Mr. Wm. P. Blake makes only short mention of the mountain ranges extending from New Mexico into Texas, saying: "This region (Trans-Pecos Texas) is intersected by three ranges of mountains, nearly parallel to each other, and having a general direction of north-south."

The report mentions briefly the Franklin Mountains, and passes on, mentioning that the next easterly mountain range is that of the Huecos, which extends much farther to the south and unites itself a short distance above the thirty-second degree of latitude with the Sacramento and White Mountains. It also calls attention to the Guadaloupe Mountains as the most easterly range, located one hundred and eight miles from the Rio Grande and fifty-four miles from the Pecos River, which, although higher and more rugged than either of the others, seem isolated from any connection with the (other) mountains, a very natural error, since Mr. Blake, following the line of the proposed railroad, had not the opportunity to make observations about the more remote portions of the Guadaloupe Mountains.

About a prolongation or connection of the Guadaloupe chain toward the Wichitas, which Mr. Blake supposes to exist, he seems himself more or less skeptical. Although he favors the supposition of an existing connection on the strength of a supposed "general trend of the granitic axes or elevations of this region," he admits "we should thus expect to find either more outcrops of granite between the end of the Guadaloupe and the Wichita mountains, or a very perceptible modification of the Llano (Estacado)."

I abstain from making numerous quotations from "Chapter II, Geology of the Mountain Ranges," since the conclusions in this chapter seem to be based mostly on specimens, which leave reasonable doubts as to determination of location and character. We read for instance, page 13, "it is not impossible that these dark gray blocks (mentioned in Capt. Marcy's Report, 1849), although resembling sandstone, were the compact and fine-grained granite just described, or possibly Carboniferous limestone."

With the exception of hurried reconnoitering for water, I have not yet had the opportunity to extend my observations to the Hueco Mountains, and I shall therefore neither confirm nor contradict Mr. Blake's supposition that the Hueco Mountains are principally granite and metamorphic, and that stratified rocks occur on the flanks only. To decide whether these are Carboniferous strata or not is of course impossible without having specimens at hand; but I am inclined to believe that the stratified rocks flanking and capping the range are Carboniferous, since I found fragments of Carboniferous fossils (*encrynites* and *productus*) in the southern extension of the Hueco Mountains.

Mr. Blake mentions also the Cornudos, evidently from hearsay, quoting Mr. Bartlett: "This wonderful mountain, of which it is impossible to convey any adequate idea by description, is a pile of red granite boulders of gigantic size thrown abruptly in the plain." The very same may be said of part of the Quitman Mountains, and I am of the opinion that a connection of the Cornudos and Quitman Mountains might be proved a good deal easier than between the Guadaloupe and Wichita mountains, which Mr. Blake seems to know only from what Mr. Bartlett and Capt. Marcy says about them, adding to conclude with, "and there is little or no doubt of the stratified character of these mountains."

Mr. Blake regards these rocks as Carboniferous, and he is probably right as far as parts only are considered. His opinion that probably granite could be found in these mountains has since been confirmed.

Major Emory's Report of the Boundary Survey of 1856, although mostly confined to the line along the Rio Grande, gives a more general idea of the geologic features of Trans-Pecos Texas, where more than anywhere else the absence of continuity of the mountain ranges (hinted at in Major Emory's report) manifests itself.

Major Emory says:* "That range (Sierra Nevada), as well as the Sierra Madre and the Rocky Mountains, about the parallel of 32°, lose their continuous character and assume the forms that are graphically described in the

*Boundary Survey Report, p. 44. General description of the country.

western country as 'lost mountains;' that is to say, mountains that have no apparent connection with each other. They preserve, however, their general direction northwest and southeast, showing that the upheaving power that produced them was the same, but in diminished and irregular force. They rise abruptly from the plains and disappear as suddenly." A better description in short words can not be given of the character also of the Trans-Pecos Texas. They rise abruptly from the flats (which are three to four thousand feet above the sea level) and disappear as suddenly, losing seemingly their continuity and being (seemingly) without connection with other mountain ranges.

The same report mentions also the discovery of silver ores in West Texas, and refers to the (then known) sporadic occurrence of gold-bearing rock in the Rocky Mountains, the material of which if not identical with is very similar to that of Trans-Pecos Texas.

The observations made about soil, climate, conditions, and eventual development of the western country in general can partly also be applied to Western Texas, with the modification that if irrigated the soil is well adapted not only for the culture of grapes but to fruit raising in general, and to raising of wheat, corn, vegetables, and feed plants, such as alfalfa, etc. I do not know if cotton can be raised on irrigated land, but if so the climate would be better adapted for this kind of crop than the moisture loaded atmosphere nearer the seashore.

The description of the geological features of the Rio Grande valley from El Paso to the mouth of the Pecos River, by Mr. C. C. Parry, is surprisingly clear, but confined merely to the Rio Grande valley proper. The observations made along the line of his trip from San Antonio to El Paso are less definite, as he named Davis Mountains, also some other ranges; for instance, the Sierra Diabolo, which, though built up of sedimentary, metamorphic, and igneous rock, is a separate range, different from the Davis (Limpia, Apache) Mountains, and I think it would be hard work to establish the continuity from one to the other. Others, as the Carrizo, Eagle, Quitman, and Sierra Blanca, are mentioned as bearing the same character as the Limpia Mountains. Correct, no doubt, as far as sedimentary, metamorphic, and igneous material can be found in every one of these ranges, though evidently different in form, combination, and probably age.

The elevations laid down in publications of Dr. G. G. Shumard (so far as I have them at hand) are confined to the Pecos valley and the more northern portion of the State, mentioning the Guadaloupe, Cornudos, Sierra Alta, Hueco, and El Paso (Franklin) mountains, of which no closer investigations have been made up to this time. But there is no doubt that the Silurian of Dr. Wislicenus and Dr. Shumard in the Franklin range will stand proven. I found on a hurried run across this range a well defined specimen of *Halysites catenulatus* in the rock.

Dr. Shumard, as well as Prof. Hall, recognized the Carboniferous strata which form also the cliffs of the Sierra Diabolo north of the Carrizo Mountains, and probably also at least the flanking and capping of the mountain range east of the Diabolo, running down from the Guadaloupe Mountains. But though in the Eagle Mountains and north of El Paso on the Mexican side of the river some coal (?) was found in small quantities, I join Prof. R. T. Hill when he says: "The Trans-Pecos area belongs to the great deposit of the non-coal bearing marine Carboniferous of the west."*

William Kennedy's "Rise, Progress, and Prospects of the Republic of Texas" refers half way reliably only to the eastern portion of the State, and the maps attached to this publication show plainly that Trans-Pecos Texas was then entirely *terra incognita*.

Ph. Dr. James P. Kimball, in the American Journal of Science and Arts, November, 1869, Article xxxvii ("Notes on the Geology of Texas and Chihuahua"), expresses the opinion that the Limpia (Davis) Mountains are altogether metamorphic, denying the igneous character. But traveling along the old stage road from Fort Davis to El Paso in daytime the geologist can not miss seeing granites, lava, and other igneous rocks, although metamorphic and stratified portions can clearly be seen besides the igneous rocks. It seems Dr. Kimball, like other travelers through West Texas, took the Davis, Van Horn, Carrizo, and Diabolo mountains as the same range. But even if so, it is hard to comprehend how the presence of igneous rocks could have been overlooked.

Dr. Kimball, however, recognized that orographically the Limpia Mountains form part of the great divide between the Pecos River and the Rio Grande, and his supposition (in contradiction to Mr. Arthur Schott's opinion) that the southern continuation of the Limpia Mountains in Mexico is not the Sierra Ricca, but the Sierra Carmen, must be accepted as true. The continuity can be traced down the Mount Ord range to the Sierra St. Jago, and the ranges east of the last named mountains, the Rosillas, Chisos and Corazones, to the Sierra Carmen.

He calls the rock of the Limpia Canyon a porphyritic quartzite, supposing it to be a metamorphic sandstone on account of its seeming stratification, but even superficial examination shows it to be trap of Rhyolitic character.

How far Dr. Kimball is correct in calling the underlaying arenaceous material the "Cantera" of the Mexicans I can not decide, as I am not familiar with this rock.

*See also earlier statement of this fact by Prof. James Hall, United States and Mexican Boundary Survey Report, p. 124.

Of other publications of older date, such as D. Woodman's "Guide to Texas Emigrants;" David R. Edwards's "The Emigrant's, Farmer's, and Politician's Guide," provided with maps, the notes about the country west of the Pecos, even west of the Colorado River, are perfectly worthless, the maps not much better than fictions.

The life and adventures of L D. Lafferty, by A. H. Abney, claiming to be truth, mentions the presence of gold in Texas. Other publications, though some of them are quite interesting, do not extend their narratives west of the Staked Plains, and state more the adventures of the parties (surveyors and hunters) than the approximately correct (geographical, etc.) character of the country.

CHAPTER II.

DESCRIPTIVE GEOLOGY.

Until the present time the closer examinations in the Trans-Pecos country of Texas have been confined to the extensive mineral districts of El Paso County. Before going into geological details it is absolutely necessary to have reliable topographic maps, which, with the limited assistance at my disposal and the extraordinary difficulties which have to be overcome, is slow work.

There is no summary way to deal with the intricate geological problems of this part of the State. The only short and easy method of getting out of the complications and difficulties from the fragmentary observations made up to the present time might be to take suppositions for facts; to base conclusions on suppositions and fictions, and to tell what we do not know and can not know about it. Therefore I shall only attempt to give a general description of the geological features of a part of Trans-Pecos Texas, basing this description on the closer observations mentioned above, on the observations of a flighty reconnoitering trip, made in behalf of the State Geological Survey during the winter of 1888 and 1889, and on the experience of a number of private exploring excursions which I had made before that time (since 1878) to different localities in the western mountains.

The most northwestern mountain range of Trans-Pecos Texas is located north of El Paso and known as the "Franklin Range." It extends from El Paso in a northern direction about twenty miles, and although isolated by a depression from the Sierra Soledad of the Organ Mountains in New Mexico, it must be regarded as a continuation of this range.

The southern part of the Franklin Mountains is limestone overlaid by a quartzitic rock (metamorphic, semi-fused sandstone) which rests on granitic and porphyritic rock, with intrusive basaltic dykes. This southern part dips towards El Paso (south). Farther north we find sandstone and shale strata of considerable thickness dipping north, and it seems that the granitic and porphyritic peaks about midway between El Paso and the gap between the Organ Mountains and the Franklin range must be regarded as the eruptive centre of the Franklin Mountains.

The limestone capping of the granitic and porphyritic rocks is, according to Prof. Shumard, of Silurian age, which seems confirmed by fossil fragments found there, among which is distinctly recognizable *Halysites catenulatus.* East of the Franklin range is a flat ("The Mesa") about twenty-five miles wide, extending towards the Hueco Mountains and northward into New

Mexico. The material of which this mesa is composed, judging from the character of its southern slope, from borings, and the general aspects of its surface, consists to a considerable depth of only slightly consolidated sand, clay, gravel, and calcareous cementing, resting probably on rock relating to that of the Hueco Mountains and their southern extension towards Findlay, where, about eight miles north of this station, we find Carboniferous rocks, which evidently constitute the flanking and partly the capping of the Hueco Mountains. In their southern outrunner these Carboniferous strata are tilted in every direction by crystalline hornblendic rock, seemingly the same which by intrusion between the stratified sandstone uplifted the cones of the Sierra Blanca group two thousand feet above the surrounding flats and Cretaceous hills (about seventy-two hundred feet above the sea level).

East of the Sierra Blanca group, which seemingly is of laccolitic character, a number of Cretaceous hills rise, tilted by a porphyritic rock of light reddish color, which also caused the tilting of the Cretaceous hill groups south and southwest between Sierra Blanca Junction and the Quitman Mountains. In the group of hills one mile west of Sierra Blanca Junction these porphyries in their contacts with crystalline limestones show a number of iron outblows, which a few feet below the surface are distinctly copper stained, and show the same character as the outcrops of the Hunter district. They also contain uranium, which is one of the characteristic properties of the ore of the Hunter district. The green garnet leads found at the foot of these hills, and in the prospects higher up, are the same as those in the northern part of the Quitman Mountains, and would prove the relation of these two elevations even if the porphyritic, chloritic, and hornblendic rocks which tilt the overlying strata were not so plainly exposed.

In the northern part of the Quitman Mountains, the highest peak of which rises to seventeen hundred feet (barometric measurement) above the flat between this range and the Sierra Blanca Peak, the reddish granite prevails.

Bowlders from two to twenty feet in diameter and rounded by weathering are piled upon and against each other on the slopes, covering the solid rock in many places from twenty to thirty feet deep, making it difficult, in many places impossible, to ascertain the limits where the granites of different ages meet and where the porphyritic intrusions, extrusions, and protrusions are in contact with the granites.

Neverthless it can be ascertained that the northern part of the Quitman Mountains is built up of three granites, different in strike, grain, weathering, and, no doubt, also in age.

The oldest, mostly of very coarse grain, partly decomposed, has a nearly true north-south strike. It forms the foot of the mountains, and only now and then rises to a few hundred feet above the level of the flat.

A newer granite protrudes and extrudes through this, including frequently bowlders from one-half inch to four feet in diameter, of a dark gray color, with magnetic iron sand. This granite strikes nearly east-west, and in its contacts with the intrusive light colored porphyries most of the ore indications, outcrops, and prospect holes are found. Most of the bowlders covering the slopes are fragments of this granite, and frequently show semi-globular holes left by the included gray bowlders which, loosened in weathering, rolled out, and are found around the reddish rocks, particularly on the northern slopes near the contacts between the light colored porphyry and the granite.

The second range of the Quitman Mountains is separated by a flat valley about one mile broad in its widest part from the first one. The greater part of the bottom of this valley consists of the oldest granites, with occasional protrusions of later ones and intrusions of a light colored porphyritic rock.

In the second range of the Quitman Mountains, besides the oldest granite (probably identical with the Burnetian of the Central Mineral Region) and the second one (which might range with the Fernandian), intrusive granitic dykes appear, which strike north 30° to 50° west. This intrusion shows locally a seemingly gneissoid structure, evidently the effect of strong pressure. This structure is visible also in an outrunner from the first range. In some places crystalline limestone older than the Cretaceous is thrown up on the hillsides conformably to this granite. This limestone is so completely marbleized that not even the slightest traces of fossils can be detected.

The intrusive granites, together with the porphyritic intrusions, seem to be the principal cause of the bowlders covering the mountain slopes.

The ore gangues of this range (in its granitic part), like most of the first one, are on contacts between the granite and porphyry, and the outcrops are indicated by kaolinized streaks. On the southwest side of the second range, besides the kaolinized streaks there are a number of outcrops like those of the Hunter district, and on the hill group one mile west of Sierra Blanca they are strongly ferruginous, particularly so nearer the foot of the mountains and in the gulches.

Two and one-half miles east of the most northern end of the second range, south of Zimpelman's Pass, the Quitman Peak rises, a mountain of many-colored porphyritic rocks, and south from this main peak to the Quitman Pass a number of lower peaks of alternating granitic and porphyritic rocks, with frequent metamorphic limestone layers, greenstone and basaltic dykes, show numerous promising prospects, particularly in the Big Gulch, which again forms a kind of pass over the second Quitman range.

In and near the Quitman Pass the granites give place to, or rather disappear under, strongly altered sandstones and less metamorphosed Cretaceous limestones, tilted in every direction and flanking both sides of the pass.

From this pass to the river the mountains extend in a southeast direction about twenty-five miles, and are flanked and partly capped by stratified rocks; but the tilting, the rugged cliffs and ravines, and the hot springs at the southern end show clearly the igneous character of this mountain range. In the flat east of the Quitman Mountains Cretaceous hill groups rise and extend toward the Eagle Mountains.

The rocks of the Eagle Mountains are porphyries, porphyritic, vesicular, and compact lavas, with occasional deposits of volcanic breccias, siliceous, oolitic, and different metamorphic rocks, with numerous basaltic and retinite dyke intrusions. The porphyries of these mountains are different in color, fracture, lustre, and combination from those of the Quitman Mountains. There is also a difference in the structure of the mountains.

In the Quitman Mountains the porphyries are solid and massive, the various colors blending and changing into each other, the fracture being uneven, in places sub-conchoidal. They are hard, but more tough than brittle, and though taking a fine polish, the fracture has a dull aspect. The colors of the matrix show numerous shades of gray, greenish, reddish, brown, purple, to black, and the included crystals, whatever the color of the matrix may be, are of whitish color, nearly lustreless, and frequently look as if their sharp edges and corners were fused and worn.

The porphyry mountains of the Eagle group show in most places a kind of stratification. A dark reddish and brown porphyry overlies a stratum of yellowish porphyritic rock with sanidin and andesite(?) crystal inclusions. This lighter porphyry has in many places the appearance of an excessively metamorphosed sandstone, and were it not that in places where it appears intrusive in the limestone the limestone itself shows also excessive metamorphism, its peculiarities would justify the hypothesis that it is really a sand or sandstone stratum altered by overflowing igneous eruptive rocks. The foothills on the eastern side of the Eagle Mountains are Cretaceous sand and limestone strata, dipping toward the mountains (west).

The foothills on the north side near Eagle Spring are formed by Cretaceous sand and limestones, intercepted by a small area of metamorphic Carboniferous limestone, and run out on the west side into the Cretaceous Devil's Ridge, which extends into the Devil's Backbone (also a Cretaceous ridge), flanked on the south side by a series of brecciate conglomerate hills, between which and the Quitman Mountains a flat four miles wide extends south of the pass. This flat, which connects with the large, level basins extending north and east of Sierra Blanca Junction and the flats between Etholen and the northern part of the Quitman range, is covered with fertile soil.

In its southeastern part, which opens and falls towards the Rio Grande as it approaches the river, the mostly dry water courses of the Green River and

LOWER OUTLET, CARRIZO CAÑON.

the side ravines are cut through loosely cemented gravel hills and mesa-like elevations extending between the southwest and southern slopes of the Eagle Mountain group and the southern outrunner of the Quitman Mountains, which consist of, or at least are flanked and capped by, metamorphic sand and limestone and partly decomposed shales similar to those found in and west of the Eagle Mountains. The flat on the east side of the Eagle Mountains, which is also level and to the greater part covered with fertile soil, in its northern extension terminates toward the Rio Grande in rugged gravel hills and elevations between the southeast foothills of the Eagle group and the Van Horn Mountains, and is similar to the flat west of the Eagle group. The igneous rocks of the Van Horn Mountains disappear about two miles south of Van Horn Wells below a capping of stratified rock, flanked on the west side by moderately altered limestone hills. I have not yet had the opportunity of determining their age.

A spur of the Van Horn Mountains branching off about ten miles south of Bass' Canyon in a northwesterly direction shows strongly micaceous granite breaking through micaceous schists. It is flanked on its east side by metamorphic Cretaceous limestone, which also forms the northern outrunner of this spur. Want of water and grass rendered it an impossibility to make a closer examination; nevertheless I have no doubt that the red and greenish schists cropping through the limestone in the gulches of the Van Horn Mountains are connected by this spur with the Carrizo Mountains. The elevation above the surrounding flats of this mountain range (the Carrizo) is not as high as that of the Quitman Mountains. It extends in a north (slightly east) direction about twenty miles and is about six miles wide. The western limits of the southern part of these mountains are near the 105th meridian at its crossing with the Southern Pacific Railway, and its width to its eastern slope is a little over six miles. This southern part of the Carrizo Mountains is built up of reddish, gray, and lighter and darker greenish crystalline schists, with numerous intrusive quartz dykes, tilted and upheaved by this quartz and by granitic and granitoid rocks, which on the north and northwest side protrude through the schists. On the south side these schists disappear under limestones, and these under the recent soil of the flats and gravel hills. These limestones, denuded of the overlying strata, are fully exposed to view about two miles west of Haskell Station in the ravines draining through Glenn's Creek the east and north slope of the Eagle groups and the south slope of the Carrizo Mountains.

The crystalline schists cross the Texas and Pacific Railway near Allamore, running into a low ridge, which six miles west of Van Horn Station disappears in the flat at the foot of the Carboniferous cliffs, which rest on non-fossiliferous red and brown sandstones and grit. The grit consists of rounded red sandstone and quartz grains imbedded in a red sandy matrix. It is distinctly stratified, tilted only near the serpentinous and other intrusions. Its grain diminishes in size in the different layers, changing deeper down into a fine-grained dark brick-red sandstone, which only now and then faintly shows stratification, and weathers into globular bowlders. This red sandstone, judging from the float, also appears on a western slope of the Van Horn Mountains in the valley south of Haskell, and may contain opals. The grit in its most southern exposure in the Carrizo Mountains occurs in the Round Mountain at Allamore, rising above the flat and the low Carboniferous limestone hills that run parallel with the Texas and Pacific Railway to about one mile west of Allamore.

On the east side of this gritty butte the red schistose rocks disappear under the grit strata, reappearing occasionally in the more northern part of the Carrizo Mountains, together with serpentinous, basaltic, and greenstone intrusions; and it does not seem at all improbable that they are the excessively metamorphosed fine-grained sandstones on which the grit rests unconformably, and which, arranged in wavelike hills, covers the basins between the cliffy (shore) lines of the Sierra Diabolo range, the Carboniferous limestone cliffs of the northern part of the Carrizo Mountains, the metamorphic cherty limestone elevations north of Allamore, and those forming the western dam of this basin. The same red sandstone extends along the foot of the southern cliffs of the Sierra Diabolo and reappears again under the group of brecciatic conglomerate hills northwest of the carbonic limestone cliffs near Eagle Flat, which cliffs rest partly on micaceous schistose rocks similar if not identical with those of the Carrizo Mountains, partly on a reddish granitoid rock. Both the schist and granitoid rock are traversed by white and by ferruginous quartz dykes with nearly east-west strike. The western outrunners of the Diabolo red sandstone hills parallel to the Diabolo cliffs undergo a gradual change into a brownish quartzitic sandstone. South of these hills, seemingly resting on them and parallel with them, we find ridges of strongly metamorphosed cherty limestones, with ferruginous quartz layers and siliceous iron veins containing up to forty-six per cent of iron, and two to four ounces of silver, and traces of gold.

These cherty limestones extend between the Carboniferous cliffs west of the Eagle Flat and the cliffs of the Sierra Diabolo, sloping down to the large basin east of Sierra Blanca. They are traversed by and partly resting on the slopes of a group of brecciatic conglomerate hills with igneous intrusions. In some places of these conglomerate hills appears the red sandstone of the Diabolo, but here it is distinctly stratified in finer and coarser gritty layers, and it shows ripple marks occasionally, and the different weathering seems to indicate a lesser degree of metamorphosis. These sands are non-fossiliferous, like those of the Sierra Diabolo, and have an average dip of 30° south and southwest.

The Carboniferous strata rest non-conformably on the conglomerate and sandstone, with few exceptions (probably slides), in horizontal layers, and the few insignificant folds indicate that post-Carboniferous disturbances in the Sierra Diabolo group, as far as the examination goes up to this time, were confined to the part south of the cliffs toward the Carrizo uplifts and the Eagle Mountains, where we will have to look for the cause of this disturbance.

At the south slope of the conglomerate hills a gangue of clay slate strikes nearly west with a general dip of about 35° south between the cherty limestone strata, which are cut by numerous ferruginous quartz veins. These limestones, sandstones, and igneous intrusions alternate with Carboniferous limestones, and extend north to the cliffs of the Diabolo proper, which on its west side slopes down gradually to the basin (flat) east of Sierra Blanca.

On the south and east sides the cliffs of the Sierra Diabolo fall nearly perpendicularly two hundred feet from the top to the sloping accumulations of debris, which lean under an angle of 35° to 45° about four hundred feet high against the perpendicular walls of the Carboniferous strata. The Carboniferous limestone forming the top part of the Sierra Diabolo rests on a silty copper and silver bearing layer about six feet thick where exposed to sight, and this on an amygdaloid conglomerated deposit, which, getting finer in its lower parts, changes to the grits mentioned in the Carrizo Mountains which rest on the Diabolo sandstone. If and how far the Carrizo schists extend under the Diabolo Mountains can not be determined at present. Above the cliffs of the Sierra Diabolo Mountains, rounded hills, also Carboniferous, rise to about eighteen hundred feet above the cliffs. Synclines and anticlines appearing occasionally, particularly in the gulches, seem to be caused by slides. The Sierra Diabolo, as far as examined up to the present time, is a monocline, deflecting in a southerly direction; and judging from a view taken at these mountains from the nearest high points, no breaks or disturbances of any consequence will be found in the southern half of the Diabolo range.

The south cliffs of the Sierra Diabolo begin opposite and about eight miles northwest of Eagle Flat Station, on the Texas and Pacific Railway, extending in an easterly direction, slightly deflecting to the south, taking at the Hazel mine a sharp turn to the northeast, and they run in this direction eight miles to a rough gulch, or ravine, about two miles wide at the mouth, and extending far back into the mountains. From there for about eight miles they follow a northerly direction, and then they turn about 45° to the northwest, getting lower as they approach the Sierra Prieta, and assume the character of a mesa sloping toward the Salt Lake valley. The projection of this last course points towards the Tinaja Pinta, Alamo, and Wind mountains and the Cornudas, the Carboniferous rocks forming the cliffs of the south and east side of the Sierra Diabolo slope, and run out on the west side into decomposed rock and newer deposits.

East of the Diabolo and Carrizo range opens a broad valley towards the Salt Lake basin, into which open a number of extensive draws or valleys, evidently the drainage channels of the mountains and formerly existing (Cretaceous) sea basins of New Mexico, probably to the White Mountains and all the ranges and groups east of the drainage area of the Sacramento River. This valley, between the Diabolo and Carrizo mountains and the southern extension of the Sierra Guadaloupe, widens from six miles at the northern end of the Carrizo Mountains to about fifteen miles at the end of the Sierra Diabolo, and is bordered on the east side by cliffs similar to those of the Sierra Diabolo, with many deep cut ravines. How deep the bottom of this valley is covered with debris of the igneous rocks of the New Mexico mountains, the Carboniferous strata of the high plateaux bordering the valley, and probably also Cretaceous and Quaternary material, can not even be guessed at present, but it seems probable that the original erosion reaches to the crystalline schists, which probably extend from the Carrizo Mountains towards the Sierra Guadaloupe.

With reference to the petrographic character the Davis Mountains differ in many respects from the more western mountain ranges and mountain groups. True we find there hornblendic rocks similar to those of the Sierra Blanca group, granites resembling those of the Quitman Mountains, the lavas of the Chispa range and only slightly differing from those of the Chinatti Mountains, also sand and limestone partly excessively metamorphic, partly only slightly altered; but conspicuous before all others are the flinty siliceous ridges which, beginning at the former Barrel Spring Station on the old Fort Davis and El Paso stage line, were known by the name of Marble Hills. They extend in a northeast direction about two miles, rise in beautifully (yellow, pink, purple, etc.) colored cliffs above Gaines Ranch, and appear as occasional intrusions through and above the stratified metamorphic rocks.

Coarse trachytic rocks rise in sharp saw-tooth like ridges over seven thousand feet high above the sea level, and slope very steeply down into the narrow valleys, which, not filled in to any considerable depth with debris, show more springs and creeks than the valleys of the other Trans-Pecos mountain ranges.

Near Fort Davis porphyritic trachytes rise in steep, frequently perpendicular cliffs, resting, in many places exposed to view, on a yellowish sandstone. These trachytic rocks are also found east and south of Fort Davis, along the Limpia Canyon, which at Dog Canyon opens into a more flat country (Cretaceous and newer) about twelve miles east of Fort Davis. In this canyon

DIABOLO MOUNTAINS, EL PASO COUNTY.

the sandstone is scarcely in sight. Occasionally we find in view the sandstones along the Mosquez Canyon on the road to Alpine. As far as the ore bearing is concerned, it will be probably confined to the outer portions and foothills or where the igneous rocks are in contact with the limestones; the parts where the lavas and kindred rocks prevail are not promising to prospectors.

As far as slightly reconnoitering discloses, the vesicular lavas extend through the Chispa Mountains towards the Viejo and Capote mountains down the Chinatti range. They are also found between Marfa and the Chinatti Mountains, where numerous agates and onyx veins are contained in the coarse vesicular lava.

In the tributary water courses of the Cibolo Creek south of the Saocito and below Humphries' sheep camp, glassy lava, resembling opalized wood and retinite, cover many square miles and extend in many places to and into the Chinatti Mountains, where granitic, trachytic, and metamorphic rocks alternate with each other. The ores prevailing in the Chinatti Mountains in their southern portion on the east and west slopes seem to be lead ores with varying quantities of silver, mostly also containing bismuth and frequently antimony. On the eastern slope free milling ores seem to prevail; on the western slope lead sulphides and carbonates with silver and bismuth.

The examination of the Chinatti Mountains was not carried far enough to lead to any but the general conclusion that the Chinatti Mountains must be regarded as eminently ore bearing in those places where the plutonic, eruptive, lime, and other metamorphic rocks are in contact; that, however, the volcanic portions where the lavas, basalts, and trachytic rocks prevail can not be recommended so well to prospectors, though it is claimed that gold was found in the vicinity of trachytic rock.

I did not have the time to pay closer attention to the Sierra Capote and the Viejo Mountains, but judging from the trip I made in 1886 across the Viejo Pass I suppose that the basaltic and other volcanic rocks predominate in that portion of Trans-Pecos Texas, and that in all probability they are second in value to the Chinatti prospects and the Quitman and the Carrizo mountains, as far as ore bearing is concerned. The Sierra Bofecillos and Refugio, east of Presidio del Norte, are very rough and rugged. Trachytic rock rests on a yellowish sandstone, and the formation at least very much resembles that of the Limpia Mountains near Fort Davis; but to the present time I have not had the time for the necessary analytical and microscopical work to confirm this supposition. No prospecting was done in the Bofecillos and Refugio, but float pieces of strongly ferruginous quartz and iron, not less iron stained and decomposed leads which can be traced not infrequently for miles, make it advisable to classify both mountain ranges with the mineral districts; still more so as according to a Mexican tradition quicksilver was found there.

The country east of the Bofecillos is broken and very rough. Vesicular lava and trachyte cover the surface, which is cut by the basalt intrusions and decomposing retinite. Nearer to the Alamo Cesario Springs bowlders of very light vesicular lava and pumice stone fragments demonstrate the volcanic character of the mountains in this vicinity. Evidently the eruptions broke out through fissures, and the lava extravasation and overflow seems to extend over the greater part of the Bofecillos and Refugio into the Limpia range and the intervening mountains.

Similar extrusive and extravasated rocks appear also east of the Sierra St. Jago and the Pena Colorado, which last is a range south of Marathon about twenty-five miles and extends about fifteen miles in a northeast direction from this railroad station in gently sloping hills of quartz and quartzite, strongly metamorphosed limestones, and semi-fused, small-grained, siliceous conglomerations. The rock of the Pena Colorado Mountains is a ferruginous quartzite, with occasional basalt intrusions frequently faced by metamorphosed limestone. And since east of the Comanche Mountains some of the hills are composed of slightly indurated marine sand, similar to that found by boring at Marfa twelve hundred feet below the surface, I think it justifiable to suppose that the quartzites of the Pena Colorado range are the same sands, fused and thrown up by the same protrusive volcanic rocks which farther west and north appear as extrusions and extravasations.

True, there is four miles north of Marathon an isolated granitic upheaval covering about four square miles, but its appearance indicates that it was considerably disturbed by later eruptions, probably the forces which rent obliquely the mountains of West Texas and Mexico, opening the channel by which the Rio Grande emptied the Cretaceous basins of West Texas and Mexico through a canyon sixteen to eighteen hundred feet deep and about twenty miles long. Besides, the Carbonic strata of the Comanche Mountains, even in close proximity to the granitic upheavals, are nearly horizontal, and exclude the thought of disturbance by the granite, and it can not be doubted that the metamorphosis of the Pena Colorado rocks was effected in post-Carboniferous times when the Rio Grande broke through the Canyon of San Vincente.

Desirable as it is to examine this canyon, its exploration can not be effected without preparations, the expenses of which go beyond the means of our appropriation.

All I could learn was from a trapper (Mr. Stringfellow) who, with a companion, had made a trip through this canyon on a boat brought from El Paso. He describes the canyon as a narrow "split," mostly through a blackish rock. This split, he tells, is frequently not more than six feet wide, with numerous short turns around sharp corners. Through this channel the river rushes (in some places at least one hundred feet deep) over rapids till it reaches a place where it falls over a precipice into a basin with a small island of bowlders and smaller debris. From these the river flows with tremendous velocity into a broader channel.

On a reconnoitering trip in 1889 I tried to approach this island from the lower end of the canyon, but I found it impossible. Owing perhaps to a rise in the river there were no banks, and I had to desist from forcing my way up the stream, as no boat can be had in this unsettled country. Judging from the statement of the trapper, the velocity of the flow is too great, the light is too dim, and there being no places to effect a landing, it would seem impossible to make satisfactory observations from a boat floating down the river. If attempted at all, an exploration trip down the canyon ought to be made during a high rise in the river, when the rocks in the rapids are sufficiently covered with water. This description of the canyon, as well as the remarkable fact that the river here cuts obliquely through high mountain chains, confirms the supposition that this channel, draining the Cretaceous basins of Trans-Pecos Texas, part of Mexico and New Mexico, was opened by very forcible volcanic action, which extended far west and north and elevated these countries without the subsequent subsidence following in Eastern Texas.

The Rio Grande changes at right angle its southeast course at the canyon to northeast and follows this course, cutting crossways through the mountain ranges. Turned once in this direction it was quite natural that the water, after having passed through the high St. Jago (Sierra Contrario) range on the Texas side and its continuation in Mexico, cut its way through the softer material of the lower country east of the St. Jago Mountains, probably following already existing drainage channels to the bed of the Pecos, from where, joining this river, it resumed again the southeast course.

To confirm this supposition it will be necessary to make careful examinations of the Chisos and Corazones mountains, the lower St. Jago range, the mountains on the Mexican side of the river, also the country east of the Sierra St. Jago and Sierra Carmen. The mountains of Foley and Buchel counties, such as the St. Jago, Chisos, Corazones, Rosillas mountains, the Mount Ord range, are hardly well enough known to demonstrate even their existence as separate ranges. The metamorphism is so complete, the eruptive dykes so frequent, and protrusions so detached, that at present it is impossible to say where the beginning or the end of the chains and groups is, or whether they belong to one and the same system.

All that may be said is, they are built up of igneous (plutonic and volcanic) rocks and more or less metamorphosed limestones, sandstones and shales.

From the few inhabitants of these counties, which cover thousands of miles, no information can be had except perhaps as to a trail or water hole.

CHAPTER III.

MINERAL RESOURCES AND IRRIGATION.

It can not be denied, nor even doubted, that the mountain ranges and mountain groups of Trans-Pecos Texas are continuations of those mountain chains in Mexico and New Mexico where the mineral resources are partly developed; their existence at least proved by numerous mines, prospects, and outcrops.

It also can not be doubted that the same forces which acted to build up these mountains in Mexico and New Mexico were active in building up the mountains of West Texas; that, judging from the petrographic character of the rocks, our western mountains are similar, as a whole—we dare say, with local modifications, identical—with those of Mexico and New Mexico; and that therefore we are justified in supposing that the identity and similarity of the character extends also to the ore bearing, even if we had not the actual proof of the existence of valuable minerals by numerous outcrops, prospects, and a few successfully worked mines.

True, frequently it requires only slight modifications of the conditions or of the character of the rock to change entirely the character of gangues and veins, the investigation of smaller or larger districts; but we have some general rules, based on the experience of centuries, by which we may determine or at least suppose the possibility and probability of the ore bearing of rocks and mountain ranges. Granites, syenitic rocks, amphibolite, diotite, greenstone, and greenstone porphyries, as well as other porphyries, gneiss, mica slates, talco slates, clay slates, some serpentinous rocks, crystalline limestones, etc., were centuries ago regarded as ore bearing rocks, and are regarded so now.

In the Quitman Mountains we find granite of evidently three ages in contact with porphyritic rocks and crystalline limestones, greenstone, and serpentinous rocks. In the Carrizo Mountains prevail talcose crystalline schists, underlaid by granitic eruptive rocks related to those of the Quitman Mountains. We find these schists and feldspathic rocks under the Carboniferous strata of the Eagle Flat cliffs, together with greenstone and serpentine dykes; probably also under the cliffs of the Sierra Diabolo in their whole extent. The same crystalline schists and feldspathic rocks we find in the large western spur of the Van Horn Mountains and in the valleys of the Van Horn range, in the Eagle, Davis, Chinatti, and in the more eastern and southeastern mountain ranges of West Texas; in the Chisos, Corazones, Rosillas, etc., mountains, with metamorphic and marbleized limestone, etc. We do not only find these rocks, which are acknowledged the material forming ore bearing mountain ranges, but we find in the rocks and in the mountains built up of such, outcrops and well defined leads of different varieties of quartz, carbon, and other spars, mica, chlorite, talcose, and serpentinous rocks, garnets, .amphibol, schorl, and numerous other rocks generally associated with ores forming the lead.

We find other signs which, as experience teaches, may be regarded as indications of the presence of ore deposits, such as decomposed streaks of country rock, which can be traced over hill and dale for many miles, decomposed, discolored, or highly colored contacts, iron outcrops, which in different countries under different names, as gossan, eiserner, hut, pacos, colorados, almagres. etc., in all mineral districts of the world are regarded very favorable indications of ore deposits, especially of sulphides.

Still better indications than these abound in the mountains of Trans-Pecos Texas, such as direct outcrops of lead, copper, and other ores containing more or less precious metals; and nearly all of the numerous prospects, however little work may have been done on such, prove more the want of experience of the prospectors and of means than the absence of ore, and are of eminently promising character.

In the following list of mines and prospects, I enumerate and mention only those located in that portion of Western Texas to which I could pay closer attention up to this time; and in enumerating the metallic contents of the ores I confined myself to naming only such as can be recognized without a thorough analysis by their appearance or by hurried blow pipe tests, as I had no other means of determination at my disposal.

But I dare say that, judging from the character of the rocks, careful analyses of the specimens which I collected and sent in from Western Texas, besides the metals mentioned, the presence of bismuth will be demonstrated at least in the Chinatti Mountains, and that the serpentinous rocks and those in contact with them of El Paso County in all probability will show some platinum. If in paying quantities is a question to be decided by prospecting and careful analyses. There is also no doubt of the existence of traces of tin in some of the ores from the Quitman Mountains. I found traces of tin last year in West Texas ores, and an analysis made by Prof. Everhart confirmed the presence of this metal in some ores from the older rocks from this western part of the State; and I am fully convinced that by rational prospecting and careful analyses the presence of tin in workable, I do not say in paying, quantities (this will depend on local conditions and circumstances) will be found in the older rocks of Trans-Pecos Texas just as well as in those of Central Texas, in which, as well as in the granites on Harney's Peak in the

Black Hills of Dakota, I had ascertained and stated the presence of tin and wolframium, nearly always associated with tin, long before any larger leads were discovered.

HUNTER DISTRICT.

HUNTER MINE (OR RATHER PROSPECT).

Outcrop, silico-ferruginous, in contact between crystalline limestone and granitic porphyry. One shaft with well showing walls, timbered where necessary. Ores, a combination of iron, copper, lead, zinc, nickel, uranium, silver bearing, with traces of gold. Lower down, zinciferous; at the bottom of the shaft, one hundred and fifty feet, zincblende.

Ores partly oxidic and carbonic, partly sulphides. No thorough analysis was made. Shipped some ore. Claimed to be on private land located by Mr. Barlow, defunct, of Sierra Blanca. No work done for two years.

A number of shallow diggings in the flat on the same and parallel gangues, dipping nearly perpendicular and following the general east-west strike, like the main prospect, show veins from one-half to three inches thick, of seemingly the same combination as that of the main prospect. Besides these diggings in the flat there are a number of holes, mostly mere surface scratchings, on the northern slope of the Quitman Mountains, opposite the Hunter.

BONA (PROSPECT).

One-half mile north of the Hunter. Outcrop, siliceous iron, in contact with lime and porphyritic rock. Lead, silico-ferruginous, with silver bearing galena in streaks and pockets; some nickel with the iron. A rough shaft about thirty-five feet deep. The vein will probably carry the same combinations as the Hunter in greater depth. Some ore was shipped, but the work has been abandoned.

About three-fourths of a mile northeast of the Bona, across the railroad, a nameless prospect, on strongly ferruginous outcrop in brecciatic conglomerate, drifting forty feet and ten feet into the mountain slope. Strongly ferruginous material on dump which has not yet been analyzed. This has been abandoned.

STOKES PROSPECT.

About two miles northwest of Etholen, on the south side of the railway, a number of holes, the deepest of which is about twenty-five feet. Siliceous iron outcrop in contact with lime and porphyritic rocks, impregnations, and smaller pockets of argentiferous galena; also sulphides and chlorides of silver in silico-ferruginous matrix, with strains of uranium. One or two car loads of ore were shipped. It is probably located on railroad land. It has been abandoned.

UNNAMED PROSPECTS.

On the east slope of the same hill another prospect hole, showing material of seemingly similar combination, with more plain uranium stains. No assays have been made of these ores, and the shaft has been abandoned.

There are a number of shallow holes on iron stain in this neighborhood on both sides of the railroad, some of them sufficiently promising to justify prospecting.

On the northern slope of the first range of the Quitman Mountains is the Correales prospect at the foot of the mountains. The gangue outcrop is a strongly ferruginous decomposition of the granites. It changes in greater depth to a more siliceous material, with walls appearing more distinctly, silver bearing galena in thread-like impregnations, and small pockets of silver bearing galena. The depth of the shaft is about fifty feet.

Higher up on the mountain slope are a number of shallow holes on the same and on parallel leads, some of them showing galena at the outcrop, with ferruginous decompositions. No work was done here last year.

On the eastern slope of the first Quitman range are a number of shallow prospect holes on ferruginous stains in limestone and on ferruginous decompositions of contacts, which it is claimed carry gold. This shaft has been abandoned, or at least it was not worked last year.

BONANZA DISTRICT.

BONANZA MINE.

Near the road from Sierra Blanca to the Bonanza mine, on an isolated granite hill, a prospect hole has been put down about ten feet on a ferruginous decomposition of the granite, showing a beginning vein of iron stained and copper stained material, with occasionally small specks of galena. No assays were made for precious metals, and the prospect has been abandoned.

The north side of the valley, forming what I call the Bonanza district, shows only a few shallow prospect holes, although the leads on the slopes on the south side of this valley may be traced over the west by any halfway experienced prospector.

On the south side of the valley, and on the northern slope of the second range of the Quitman Mountains, we find the Bonanza mine. The outcrop of the lead is a strongly siliceous outblow in contact with granitic and porphyritic rock. The working shaft, nearly perpendicular, follows the vein ninety feet to a drift east and west, from which drift a winze is sunk one hundred and ten feet deep.

The ore vein, which is plainly visible in the drift, is from an inch to one foot and more thick, with pockets, on which some stopping was done. It seems as if west of the gangue worked another gangue runs in close proximity. No cross cuts have been made up to this time. At the bottom of the winze the water rises about ten feet in twenty-four hours if not hoisted. The ore of the upper part of the vein is mostly galena, with twenty to thirty ounces of silver, zincblende, and a ferruginous combination of both metals, with occasional copper stains.

Mr. Stevenson, the owner of the mine, claims to have shipped several hundred car loads of ore. As far as has been reached in the lower part of the mine the zinc (blende) seems to predominate. Many tons of zinc ore are buried in the dump, which in itself partly consists of low grade ores. The shafts and drifts on the slope above the working shaft are on the same lead and to no practical purpose.

A shaft about seventy-five feet deep farther down in the valley is on a lead of a similar if not identical character. The two prospect holes about two hundred yards east of the Bonanza shaft are on parallel leads. One is about thirty and the other is about twelve or fifteen feet deep. The material on the dump shows some silver bearing galena, besides molybdate of lead crystals, which frequently fill the cavities of formerly existing galena crystals.

The gangue is silico-ferruginous. No assays as far as I know were ever made of material from these diggings.

Still farther east, on the saddle of Zimpelman's Pass, are some very shallow holes on outcrops of siliceous iron breaking through lime.

PARLIN BROTHERS' PROSPECT.

The prospect of Parlin Brothers, southeast of Zimpelman's Pass, is at or near the contact of the granitic range and the dark porphyritic rocks of the Quitman Peak, where a number of leads run through the mountains. In all these leads the silico-ferruginous character prevails, and seems to represent the gossan of the Cornish, the eisernen hut of the German miner, more plainly than at some of the other prospects.

A drift of about fifteen feet in length shows some copper stains and holds some silver with the iron, also some molybdate of lead. The upper or main prospect has a shaft two hundred feet deep, with a drift nearly as long in the gangue, which, however, does not seem to be the main lead. A cross cut in the direction of the main lead (running parallel) has not yet reached the same. Argentiferous galena and molybdates are the principal ores, which in the workings done last show some zinc. The gangue is strongly siliceous and ferruginous. The shafts and drifts of this prospect are well timbered, ventilated by a fan, and provided with horse-power hoist. The assessment work for this year is done. A number of prospect holes show on dump the silico-ferruginous gangue, containing more or less sulphides and molybdates of lead with, no doubt, adequate traces of silver. No recent work has been done on this prospect.

ALICE RAY MINE.

The lower tunnel of the Alice Ray mine, on the southwest slope of the second range of the Quitman Mountains, is on the same lead as the Bonanza, opens about four hundred feet above the shaft of the Bonanza on the other side of the mountain crest, running about two hundred feet into the mountain. One hundred feet above this tunnel another drift about one hundred feet in length is driven in, and at the mouth of this drift a shaft is sunk. The gangue, as in the Bonanza diggings, decomposed ferruginous material, is found with an ore vein of from two to twelve inches and over, which is plainly visible at the roof of the tunnels, and at the bottom where the same is not covered by dirt.

The ore is mostly argentiferous galena and zincblende and so-called carbonates, in part a ferruginous silver bearing silicate. Copper stain sets in now and then. Considerable quantities of ore were shipped from this mine, and many car loads are ready for shipment. Between the Bonanza and Alice Ray, on the Nickelplate prospect, a shallow shaft is sunk in the park, as a flat on the mountain tops is called in West Texas. The Bonanza on the eastern, and the Alice Ray on the western slope, bring in sight the ore of the same lead, with a difference in the level of over five hundred feet.

Farther down the slope another tunnel is driven, and a winze sunk from this drift to a depth of at least one hundred feet. The material on the dump seems less promising than that of the Alice Ray. Some small holes and drifts show iron stained streaks, but are not carried on far enough to form an opinion on their merits.

QUEEN ANNE PROSPECT.

Nearly at the foot of the slope below the Alice Ray is the Queen Anne prospect, with a drift of about one hundred feet and a shaft from seventy to seventy-five feet deep. The walls of both show plainly, and the prospect looks very favorable. The assessment work has been done.

UNNAMED PROSPECTS.

Only a short distance northwest of the Queen Anne are some shallow holes which show a good deal of copper stained material.

Some diggings on the slope above these are too shallow to show other material than the surface outcrop. Farther northwest, between the old Fort Quitman and the mountain slope, a number of holes (Baker's prospects) are abandoned. None of them are over twenty feet deep. The outcrops are siliceous iron bowlders and ferruginous decompositions of the granite, in some cases in contact with serpentinous dykes. The material on dump is partly solid, partly porous, silico-ferruginous, with quartz, heavy iron ore pieces, decomposed bronzite, and even thoroughly kaolinized feldspar. Still farther northwest, one of Baker's shafts in the flat at the foot of the mountains is sunk to a depth of twenty to thirty feet, in decomposed granite, colored a bright red by oxide of iron. Another shaft about forty feet up on the mountain slope on a contact between granite and talcose rocks, both strongly colored by iron and including a ferruginous gangue. I could not ascertain if any assays were made. The prospects are encouraging, but no assessment work for 1890 had been done to the middle of September.

About three hundred yards south of the Queen Anne, half way up the mountain slope, on contact between greenstone and porphyritic material, in a gangue of red and brown, partly spongy, partly solid iron silicates, a vein of carbonates and pyrites of copper begins to show, and was followed down a few feet between the well defined walls, and several hundred feet below that a shaft is sunk to about thirty-five feet. I found on dump, besides greenstone and porphyries, copper pyrites, carbonates of copper, quartz, garnets, and a number of indefinite mineral specimens. Good assay results are claimed for the material of these diggings, seemingly of select specimens, but I can not but pronounce the prospect encouraging. No assessment work for 1890 was done up to the middle of September.

BIG GULCH, OR SILVER KING, DISTRICT.

SILVER KING.

The outcrop is siliceous iron and iron stained surroundings. The lead is a contact gangue between limestone and porphyritic rock; the ore is silver bearing galena and argentiferous siliceous iron, more or less oxidized. A number of shafts, the deepest one hundred and fifty feet, are sunk only a few feet from each other. (The purpose of this is incomprehensible, unless it was to spend money.) With the exception of the assessment work nothing was done up to the middle of September. Some ore was shipped, until the work was stopped for want of money.

BELLE PROSPECT.

At the Belle prospect two shafts have been sunk to the depth of about fifty feet. The gangue is in contact between limestone and porphyritic rock. The ore is similar to that of the Silver King, though seemingly carrying more carbonates, oxides, and copper stain.

J. HARRISON'S PROSPECT,

About one-fourth of a mile west of the Silver King, high up on the slope, also in contact between porphyry and limestones, shows galena and a ferruginous gangue at a depth of forty feet. A shaft dug in the valley by the same prospectors carries galena in a contact gangue, with well defined walls, at a depth of twenty-five feet. No work has been done lately.

EUREKA SHAFT.

The Eureka shaft is on the same lead with the Silver King; shows no galena at a depth of seventy five feet. How far the material on dump is silver bearing has never been ascertained by assays. No work was done to September 25.

EMMA CLARK TUNNEL.

A tunnel of about one hundred and fifty feet in length (Emma Clark) has about a ton of ore on dump. Other smaller tunnels and shafts, though some of them show promising indications, even ore, are abandoned. Among them is the May Belle and some diggings of Kyle Brothers.

ZIMPELMAN'S PASS DISTRICT.

On the pass where it crosses the crest are some shallow holes between limestone and green garnet rock. There is a quantity of strongly copper stained material on the dumps. No work has been done here in the last two years.

A number of shafts are found on a very large iron outcrop. I could not ascertain the depth of the shafts, but judging from the dump pile they may be seventy-five or one hundred feet deep. The gangue is strongly iron bearing, with occasional galena strings and small pockets. The value, as far as I know, was not ascertained at all, or at least only superficially, by assays. No work has been done here for the last two years.

There are a number of diggings in the valley on both sides of the mountain range. With the exception of one which is sunk on a quartz outcrop, all are on iron outcrops in contact between granitic and porphyritic material. Farther southwest, on the road side of the Quitman Mountains, we find the

"Mule prospect," about four hundred feet up the slope. The shaft is one hundred and fifty feet deep, contact on the surface, true vein in porphyritic rock deeper down. Outcrop is iron outblow. Some good galena was found with the siliceous iron gangue, which is partly vesicular or rather spongy and like pumice stone, with occasionally velvety surfaces of a rich brown. Careful analysis will probably show uranium and molybdenum besides the silver bearing galena and the iron.

A number of smaller prospect holes on the same and parallel leads show the same material as at the "Mule."

SIERRA BLANCA JUNCTION.

On the Hill group, one mile southwest of Sierra Blanca Junction, are a number of prospects on siliceous iron outblows and discolored streaks of the country rock. Though most of them seem on the surface in contacts between limestone and the porphyry, they ought to be regarded the outcrops of fissures, as indicated by the character of the gangues and the arrangement of the gangue material, which is more or less oxidized iron garnet, kaolinized porphyry, etc., with rich copper stains such as green and blue carbonates, copper velvet ore, and manganese in the shape of wad, lampadite, and other combinations of manganese with uranium, copper, and iron. One of the prospects near the foot of the hill crops out in a brecciatic quartz lead with bright copper stain. The hole seems a few feet sideways from the lead.

Though all the outcrops in this locality show copper, the probability is that deeper down lead and zinc will be the prevailing ores.

On the west side of these hills is a prospect shaft thirty-five to forty feet deep. Here we find in the siliceous iron gangue streaks and pieces of galena, and the analysis of the ferruginous gangue material will probably show nickel and uranium.

EAGLE MOUNTAINS.

There are only two small prospects in the Eagle Mountains, one showing galena poor in silver, the other one so-called carbonates in limited quantity. Hardly any work is done on these prospects, and only qualitative analyses have been made. More work has been done on the so-called coal mine, which, however, I found full of water and partly caved in, and therefore could not examine the coal. The specimens which I found on the dump burn freely, but leave so much ashes that the material, if it should be there in unlimited quantity, could find only limited use, particularly as a gas coal. Besides also the quantity is questionable, and it seems that to work this coal would be connected with great difficulties and heavier expenses than would be justified by the output.

EAGLE FLAT CLIFF.

On the northeast side are some prospects in quartz between talcose schists; none of the shafts reaching a depth of twenty feet. The quartz leads are two to three feet wide on the surface, rapidly widening out deeper down, and traceable across the hills. The quartz is strongly colored by iron and shows copper stain. No reliable assays of this material were made, but it is claimed that it contains gold, which is not improbable, judging from the character of the quartz and of the country rock.

Similar quartz leads are more fully exposed on the surface upon the northern slope of the Carrizo Mountains, also in talcose schists. With the exception of a hole about three feet deep, there is no prospect, but in the Carrizo Mountains, three miles south of Allamore Station, Texas and Pacific Railway, a number of prospect holes are sunk in talcose schist, on a strongly ferruginous outcrop with copper stain. The prospector claims gold and silver as assay results.

Of an iron lead close to the railroad, about four miles east of Allamore, some, mostly oxidic, iron was shipped to be used as flux.

A number of small diggings, hardly scratching the surface, may be found in this neighborhood, all in crystalline schist, partly on ferruginous outcrops, partly on quartz.

HILLS BETWEEN THE TEXAS AND PACIFIC RAILWAY AND THE CLIFFS OF THE SIERRA DIABOLO.

THE HAZEL MINE.

The Hazel mine is located at the foot of the cliff. The outcrop is copper stain and limespar in a fine-grained red sandstone. The gangue material is a more or less siliceous limestone with a pay streak of silver bearing copper sulphides, mostly copper glanz, silver chlorides, and native silver, with occasional native copper. The thickness of this pay streak varies from an inch to a number of feet (last winter about twelve feet). The gangue has no walls proper, but changes gradually into the red sandstone in which the fissure runs, and is frequently impregnated with sulphides of copper and silver.

Over two hundred car loads of ore were shipped from this mine, and vast quantities of low grade ores are on dump, though the work done up to the present time was confined more to shafting and drifting to develop, than to the stopping between the levels. The deepest shaft is between five and six hundred feet, at which depth the gangue, which at the two hundred feet level is over thirty feet, contracts to a few feet, with a pay streak of about two inches of ore yielding about thirty ounces to the ton. There are no great difficulties to be overcome in working this mine, but all of the low grade are waste ores, since they can not be concentrated on account of scarcity of water and fuel.

BLACK SHAFT.

The so-called Black Shaft, which is about fifty deep in clay slate, shows in the partly decomposed dump pile blue and green carbonates of argentiferous copper impregnations; in material fresh from the gangue probably also sulphides. Quartzose streaks penetrate the slate and seemingly increase in number and thickness as the depth increases.

This lead shows well defined walls and can easily be traced over three miles in length.

SANCHO PANZA AND DON QUIXOTE.

The Sancho Panza and Don Quixote prospects on the road from Allamore station to the Hazel mine, with its numerous diggings, show only pockets close to the surface. It is claimed that ore to the value of about ten thousand dollars was shipped. At present considerable quantities of low grade ore (green and blue carbonates, sulphide impregnations, etc.) form the scattered dumps.

UNNAMED PROSPECTS.

A number of smaller holes are scattered between the Sancho Panza and the Black Shaft on pockets with copper stain, but no connection between these pockets can be ascertained, and it seems as if they were mere sedimentary deposits, deriving their copper from a silty deposit running between amygdaloid conglomerations and the overlying carboniferous limestones of the Sierra Diabolo Cliffs, which deposit carries in prospected places silver and copper. Some prospects on the so-called Tumbledown Mountain show promising impregnations of carbonates and sulphides of copper on leads in contacts of serpentinous, eruptive, and limestone and sandstone country rocks.

Farther west numerous shallower and deeper prospect holes are scattered over the metamorphic limestone hills, showing streaks and impregnations of carbonates and sulphides of copper; and Mr. Abbott, of Fort Davis, claims a strong vein of silver bearing copper glanz for his prospect, a shaft about sixty feet deep, drowned by the strongly water carrying gangue.

All the prospects in this district are abandoned, and numerous outcrops which might justify prospecting are not touched at all; partly because the prospectors are afraid their claims might fall on railroad or private land, partly because they have not the money to pay twenty dollars to the surveyor and to risk the fifty dollars to be paid in advance if the claim is on public land.

ORNAMENTAL AND BUILDING STONES.

Other valuable minerals besides the above mentioned metals deserve the fullest attention.

Coarse and fine-grained marbles, some of them so finely grained that they might be compared to the so-called Mexican onyx, of white color, and of yellowish, pink, purplish, and grayish shades, plain, striped, and mottled, crop out in many places. These outcrops are found from five to fifty feet wide, frequently covering whole hill slopes, interrupted only by streaks of serpentinous rocks. The surfaces seem to indicate that these marbles resist atmospheric influences very well. The greater part of the fine and coarse-grained granites show similar resistance to weathering.

The porphyries and porphyritic breccias of the Quitman Mountains appear in numerous tints and shades, from a pale grayish color through various shades of yellow, green, reddish, brown, purple, to nearly black. They are hard, resist weathering, and take a beautiful polish.

Some of the sandstones of the Sierra Diabolo and the hills northeast of Allamore show nearly the color of the highly appreciated brown stone, con spicuous in the fashionable streets of New York.

All these building stones are within short distances from the Texas and Pacific and Southern Pacific railways (one-half to six miles), and roads fit to carry the heaviest dimension rocks can be built in some cases at a merely nominal cost.

Between the Quitman Mountains and the Malone range, not more than one-half mile from the railway, a large gypsum deposit appears, which on the surface consists of a loose material, ready to be shipped as a fertilizer without grinding. Below this loose surface material crystalline gypsum appears in the thickness of several hundred feet. This and the selenite deposits will make excellent plaster of Paris; the finer granular varieties are fit for works of art.

Agates can be gathered by the wagon load between the Davis and Chinatti mountains. They are the milky, cloudy banded varieties, from the size of peas to six, eight, and occasionally even more inches in diameter, and might be cut to marbles, ornamental work, and mortars for chemical laboratories. In this vicinity we also find true onyx, with parallel layers of white and a dark honey color, eminently adapted for cameos and similar ornamental work. This onyx evidently was mined in former times. A deep water hole of about twenty feet in diameter, in the Smuggler's Cave ravine, was seemingly an onyx mine.

West of the San Jago Pass numerous moss agates, some of great beauty, are found, and south of Pena Colorado I found in the maravillas gravel amazon stones of very fine color, as float, which also can be worked into ornamental stones; not less the siliceous conglomerations from the foot of the Comanche Mountains, which conglomerations resemble mosaic work, are very hard, and take a beautiful polish.

Up to this time I have found no fire or honey opals, but comparing the matrix in which opals are found in Mexico and Hungary with some of our metamorphic West Texas rock, and considering the conditions under which the metamorphoses probably took place, it may be only a matter of time and careful prospecting to find opals also in West Texas.

We may also predict that the fine-grained and multi-colored marbles known as Mexican onyx, which since a short time have also been mined in New Mexico and converted into ornamental and art works, will be found and worked in West Texas, and that even the massy dark green and brown serpentines will be by and by utilized.

IRRIGATION.

It is not so much the want of rain as the lack of rainfall in the season when it is needed that makes irrigation the prime condition for the utilization of these flats and for the raising of agricultural and horticultural products.

The average rainfall for the period between 1879 and 1889 amounted to about twenty inches (19.9) at the observation station at Fort Davis annually, and about thirteen inches for the station at Fort Bliss. There is no doubt that the observations for the stations are correct, but the peculiar meteorological conditions of West Texas will not allow one to make conclusions as to the general average rainfall from the observations of two or three stations located about two hundred miles from each other. The observations made in Fort Davis and Fort Bliss (El Paso) are correct and hold good for the immediate neighborhood, but not for the country ten or fifteen miles off. During the months of September and October last year I measured eleven and five-sixteenths inches of rain in one camp at the foot of the Quitman Mountains; during the same time in Sierra Blanca Junction, about seven miles east of this camp, the rainfall hardly amounted to two inches; and about six miles southeast of this place the rainfall was heavier than at the camp. General rains spreading over large areas are hardly ever observed, and if so they very seldom last over twenty-four hours. The rains come mostly down in heavy showers, particularly along the mountain slopes, and the water runs off as quickly as it pours down, and not even a superficial observer will fail to mark that the average rainfall is higher than the average of the two observation stations.

But taking the average rainfall observed at Fort Davis (19.9) with that at

Fort Bliss (13) to be only sixteen inches, we get in a round number thirty-seven millions of cubic feet, or two hundred and seventy-seven million five hundred thousand gallons of water to the square mile, which, if stored, may be regarded sufficient to irrigate several square miles, even if we allow one-half for evaporation and imbibition by the soil. The moisture of the evaporated water will benefit a considerable part of the country surrounding the storage reservoirs. I found this confirmed by comparing the atmosphere in valleys where permanent water holes or small streams exist with the atmosphere on the large waterless flats. The vegetation of such valleys and the adjacent hill slopes at places where they are entirely outside the beneficial influences of direct irrigation above or below the surface, most of the plants are so much stronger, so much earlier in bloom and maturity, that a superficial observer might take them to be different species from those growing in the waterless flats. I had no hygrometer at my disposal, and made my observations about the atmospheric moisture by comparing the weight of hydroscopic bodies, such as salt, sugar, tobacco, etc., and ascertained the increase of the weight of salt at Pena Colorado (located at the Pena Colorado Springs) to rise as high as sixty-five one-hundredths per cent during twenty-four hours, although the tent was standing on perfectly dry ground, on a gravelly hill slope one-half mile distant from the small creek. At the west side of the Quitman Mountains, about five hundred feet above and six miles distant from the nearest water, the Rio Grande, the increase of weight amounted to about twenty-five one-hundredths higher in the morning than in the evening. Here also the tent stood on perfectly dry ground.

The observations made during two years show clearly that in West Texas, as in other places, the clouds mostly follow the stream courses, and as far as the clouds charged with electricity are not influenced in their course by high mountain ranges, they follow such flats where future investigation in all probability will ascertain the existence of subterranean water storage. There, in the driest season, moist clouds (fogs) are forming during the night, which later in the morning are dispersed by the higher rising sun.

The water absorbed by imbibition or by accidental fissures in the rocks will come to the surface at other places in the shape of springs, or it will supply wells, and certainly will not be lost to the country if stored in reservoirs.

There are a number of locations for reservoirs in the mountains of Trans-Pecos Texas, of which I shall mention only a few; for instance, at the Rattlesnake tanks (known also as Mica tanks), on the west side of a spur of the Van Horn Mountains. A reservoir with a dam only twenty-five feet high and about thirty feet long at the top would make a reservoir for about one and one-half million cubic feet, or over eleven million gallons of water. The sides and bottom of this valley are granitic and metamorphic, and would hold water.

The valley of the Carpenter Springs, on the north side of the Eagle Mountains, would also make an excellent location for a reservoir; though the quantity of water supplied by the spring (a mere seep spring flowing only a short time after rains) is very limited, the valley drains enough of the mountain slopes to fill a storage tank of moderate size. The walls and bottom of the valley are metamorphic rock, and would retain water.

In the hills at the foot of the Sierra Diabolo cliffs, about three miles northwest of Allamore Station, on the Texas and Pacific Railway, a dam about forty feet in height and six hundred feet in length at the top would store over sixty million cubic feet of water. An increase of the height of the dam to fifty feet would increase the capacity at least four times. The walls and bottom are metamorphic limestones, very hard brecciatic conglomerates, and igneous dykes well adapted to retain water. The drainage area, estimated from a hurried reconnaissance, is fifty square miles—probably over. This reservoir would be of great value for mining purposes, such as concentration of low grade ores, and its location is high enough for its waters to be utilized to irrigate the valley between the Carrizo and Eagle mountains, and to reach the flat between Torbert, Arispa, and Sierra Blanca—an area of several hundred square miles of fertile soil, the product of decomposed granitic, porphyritic, and lime rocks.

In the Quitman Mountains a number of locations would make suitable reservoirs. I mention only one, at the pass northwest of the Bonanza mine, where a dam of only twenty-five feet in height and three hundred feet in length at the top stores about three million cubic feet of water.

Numerous other locations for larger and smaller storage reservoirs can be found in the Quitman, Carrizo, and Eagle mountains; in short, in most of the West Texas mountain ranges locations suitable for that purpose on account of eventual utilization of the water, solidity of walls and bottom, and extent of area and drainage. But it will never pay to build reservoirs for only one or a few sections of land. Even if for certain purposes—for instance, for the concentration of ores or similar work—the expenses of reservoir building on a smaller scale might be justified, it would be prevented in most cases because the area to be inundated will fall on more than one section, so also the area from which to collect the water, and parties enterprising enough to build such reservoirs would have to contend with injunctions, law suits for damages, trespass, and chicanes of every kind, or they will have to submit to any, even the most exacting, terms. We can not, therefore, expect to see the large areas of very fertile soil of the western flats utilized for farming as long as irrigation is not made possible by abandoning the alternate section system, and by blocking such numbers of sections as will not only make improvements possible, but invite private parties and corporations to incur reasonable expenses and even risks.

These flats, though covered like the hill and mountain slopes with the rich gamma and other nutritious grasses, can not be utilized to even their approximate capacity for cattle raising as long as the present conditions exist. Artesian wells are out of the question. The scarcity of springs, creeks, ponds, in short the scarcity of water, in Trans-Pecos Texas is so well known that it has become, I might say, proverbial. The accumulation and storage of rain water in reservoirs is the only way to make the utilization of the flats possible for agricultural purposes or stock raising. Water storage is also required for the successful working of the mining resources of Western Texas. Every experienced miner will know and must acknowledge the fact that with few exceptions even very rich leads carry, besides high grade ores, a large quantity of lower graded material, which can not stand shipping or which can not be directly worked on account of the proportion of bulk to the value, which, however, if properly concentrated, will pay well if shipped or smelted.

In most cases concentration by water can be effected more successfully and cheaper than in any other way. So it becomes an undeniable fact that the development of the resources of West Texas (that is of an area of about thirty-five thousand square miles), be it farming, stock raising, or mining, can not be expected unless water is provided. The only way to provide water is to build storage reservoirs. This can only be done by larger areas of land being thrown together by abandoning the alternate section system and blocking larger areas together. The blocking of the land will also facilitate correct surveys, particularly since the correct location of the 105th meridian and a number of astronomical points are reliably established by an astronomer, and by a United States Coast Survey party triangulating along the Rio Grande from New Mexico toward the Gulf.

By establishing starting points in the blocks the mineral surveys can be correctly and more cheaply located than from far remote points, the location of which is very doubtful, a fact which no expert surveyor will deny.

DEVELOPMENT.

Numerous indications, outcrops, and prospect holes are found through the mountain ranges of Trans-Pecos Texas, but nearly all are abandoned, like the diggings in the Quitman, Carrizo, Sierra Diabolo, and Sierra Blanca districts, for the reasons explained in my preliminary statement (part of Report of Geological Survey of Texas for 1889) under the headings "Agriculture and Irrigation," page 228, and "Development," beginning at the same page.

The prejudicial idea that the counties west of the Pecos River are a worthless desert, has prevented up to this time the utilization of the resources of this part of the State, and caused the loss of benefits to the public which might have been derived from this neglected country.

Former legislatures and administrations in general were misled by, I will term it mildly, superficial reports, and by information of free grass men, of whom one or the other was the owner of one, perhaps of one quarter, section of land, on which they had water; or of parties who rented or simply occupied one or two sections fronting on the river. They could control from these small patches the grass of more than one hundred miles of pasture without paying any rent; moreover they frequently ruined, for a number of years, the pastures by overstocking, and it was only their interest to point out the drawbacks, and not to show the brighter side of the country. As long as the Indians infested the far West Texas, no sensible commission was over-anxious to extend its personal observations to any distance from safe points, and after the Indians were gone the notion that Trans-Pecos Texas, covering between thirty and forty thousand square miles, was valueless, a mere desert, with the exception of a few hundred square miles of river bottom on the Rio Grande, was accepted as confirmed gospel truth, and no serious attempt was ever made to ascertain the facts, though a good deal of school and university, in short public, lands are located in this part of the State. The same prejudice against the character of Trans-Pecos Texas prevented any attention being paid to alleged old Spanish and Mexican grants, which only ten years ago, even still later, might have been bought, to use a slang phrase, for a mere song; or if suit should have been brought against the claimants, it would probably have been turned over to the State, since the defendants would not have thought it worth defending. Now only part of the Lerma grant, the most valueless part besides, is claimed to be worth about one and one-half millions of dollars, and a law suit is pending to recover damages to that amount.

But even if lawsuits about these grants had been decided against the State, the taxes on nearly two millions of acres, or about three thousand square miles of land (covered by grants), would have paid well for the trouble, court and other expenses, and left a nice surplus, counting only the last ten years. Another drawback to the development and utilization of Trans-Pecos Texas, be it mining, farming, or grazing land, is the division into alternate sections. True, the mineral claims allowed by the Texas mining law (600x1500 feet) cover enough ground to justify prospecting; they are as large as anywhere in the mining districts of the United States, or in Mexico, where the size of a denunciamento (claim) is regulated by the dip of the lead. But in the mining districts of the United States the entire claim necessarily falls on public land, subject to the mining law of the United States and the regulations of the respective State or Territory. The same thing takes place in Mexico under the old Spanish mining law. In Western Texas, however, even admitting the surveys of the alternate sections were correct (which, as every expert and honest surveyor knows and admits, is not the case), the discovery, shafts, or part of the claim may fall on public land. The prospector begins work; he is successful, and as soon as he touches the adjoining railway or private sections he will have to meet injunctions and lawsuits, or will have to submit to such terms as railways and private parties dictate; or *vice versa*, let him start on railway land, and after tunnelling and shafting on such, let him refuse to comply with the dictates of the railway company or private party when he reaches public land with his work, then he will be compelled to sink new shafts, to drive new tunnels; in short, to do such an amount of otherwise unnecessary dead work that he will probably prefer to give up a good mine rather than submit to the exacting terms offered by railway companies or private land holders, or to risk a new shafting and tunnelling for development.

Numerous other questions which necessarily must lead to complications will arise if the mining is carried on on the land of different owners, under different contracts and terms. perhaps in contradiction to each other. They are in fact too numerous to be mentioned here, but they are equally fatal to the development of mineral resources on public, railway, and private lands. The alternate sections are not only inimical, if not fatal, to the development of the mineral resources, but also to the development and utilization of the rich soils of the large flats between the mountain ranges.

It would therefore be, mildly stated, premature to express a closer opinion than the supposition that the mountains of these counties are at least partly ore bearing, and ought to be classified mineral districts, since I found numerous float pieces of copper and lead ores, which under the blowpipe show also precious metal, and which, judging from the general features of the country, must have been washed down from these mountains, which probably are built up of the same rocks, at the same time, and under the same conditions as the more western ranges, the ore bearing of which is confirmed by numerous analyses of specimens.

Since my last report was written no great progress has been made in the development of mines. In the Chinatti Mountains, the Shafter Silver Mills had not increased the number of stamps (ten) up to December, 1890, owing, no doubt, to lawsuits with the first discoverers and locators more than to the want of well paying ores.

A number of new prospects were located, and though the presence of workable ores in sufficient quantities in the southern part of the Chinatti Mountains can not be disputed, they are not yet sufficiently developed to count them with the mines; except perhaps the workings at the San Antonio Pass.

The Hazel mine, at the foot of the Sierra Diabolo, was worked last year with a reduced force, doing more preparatory work, such as shafting and drifting to connect the two shafts, than working for ore. Nevertheless, I found a number of carloads of good ore ready for shipment, besides thousands of tons of low grade material (ten to twelve ounces of silver to the ton) on dump, which under present circumstances must be regarded valueless, as the scarcity of water, high freight on coal, and inconvenient conditions of communication with the railway make it doubtful if the concentration of these low grades and the shipment of the concentrates can be recommended at present. But the lower shaft is sunk to about six hundred feet, and enough of working tunnels are drifted to take out the ores, the existence of which between the drift levels reasonably can not be doubted.

In the Quitman Mountains very little work was done in the Bonanza mine and the Alice Ray. Both are working on the same vein of argentiferous lead and zinc sulphides, with occasional small quantities of copper stained material.

Owing to the fact that the smelter in El Paso is not prepared to reduce the zinc, and therefore makes deductions for this metal in other ores, the blende was regarded rather a drawback, and thrown on the dumps, where carloads of zinc ores, assaying from thirty to fifty-six per cent of zinc, were buried to hide them from the sight of parties who might make examinations of the mine with perhaps the intention to invest. Some capital will be required to thoroughly develop this lead, which, as shown by the diggings at the Bonanza on the east slope and the Alice Ray on the west slope, extends about three-fourths of a mile across the whole ridge of the second range of the Quitman Mountains. Moreover, the deepest diggings of the Bonanza are about five hundred feet below those of the Alice Ray, which leads to the conclusion that the vein is of very uniform character for five hundred feet vertically by three-fourths of a mile horizontal length; and there are no reasons or indications whatever that changes for the worse will take place in greater depth. At the Alta and the Silver King, where two years ago considerable work was done, only the assessment work was done last year. Most of the other prospects located in the Quitman and Carrizo mountains were abandoned. This, as mentioned already in my last Report, is due to the defective mining law, the clouded titles in the shape of pretended Mexican grants, and the unreliable surveys.

That these circumstances, together with the want of experience and perseverance, more than the want of encouraging results, caused most of the prospectors to abandon their claims, is clearly demonstrated by the analyses made in the laboratory of the Geological Survey.

The greater number of the analyses made of specimens taken from vein outcrops and from the dumps of prospect holes show, if not better results, at least traces of precious metals. Out of about one hundred and fifty of these analyses, made for gold, silver, copper, lead, zinc, and iron, over seventy show gold from one-half to two and one-half ounces, float pieces even four to five and seventeen and one-half ounces to the ton; copper from two to forty-two per cent; silver from two ounces up to three hundred and seventy ounces to the ton; lead up to sixty-nine per cent; zinc up to fifty-six per cent.

Besides these the analyses showed a trace of platinum and frequent traces of tin. The specimens also contain uranium, molybdenum, wolframium, nickel; and some of the iron ores are equal to the best found in the State. All these outcrops and prospects are in easy distances from the railways.

The parts of Trans-Pecos Texas that I have examined up to this time are also rich in other than metallic treasures. Building stones of the best quality abound inside of two to eight miles of the railway. The porphyries of the Quitman Mountains may be quarried in unlimited quantities. They are susceptible of a very fine polish, and may be selected in all shades of green, purple, brownish, gray to nearly black, the colors pure or mottled and blended into each other.

Marbles of light and dark gray, yellow, pink, purple, some of them so finely grained that they resemble the (erroneously so-called) Mexican onyx, abound in the Sierra Diabolo in many colored, striped, and mottled varieties. These marbles, as well as brown sandstone of good quality, color, and grain, are only one to eight miles from the railway.

A gypsum deposit exposed to more than two hundred feet of depth covers several square miles close to the railway, and this gypsum, in the shape of loose gypsum sand, selenite, granular gypsum (alabaster), can be adapted for fertilizers, plaster paris, and works of art.

The existence of coal of good quality and great quantity in Trans-Pecos Texas is not satisfactorily demonstrated up to this time.

As far as the adaptability to agriculture of the large flats or basins of Western Texas is concerned, I repeat emphatically that the soil is fertile, and that it is not so much the want of rain in general, but the want of rain in certain seasons of the year that makes irrigation indispensable.

Similar conditions exist in New Mexico, Colorado, Mexico, California, and other countries. The drawback of wanting rain in the proper seasons was removed by irrigation, not only from running streams, but also from storage reservoirs.

Numerous locations for such storage reservoirs exist in Western Texas. I regard it my duty to repeatedly call the attention of the people and the proper authorities to the necessity of considering not only the steps to be taken with reference to eventual irrigation, but also to the removal of title clouds in the shape of Mexican grants, covering about two million acres of valuable mining, agricultural, and grazing lands.

It is also an undeniable fact that (more fully explained above) the surveys of land locations in Trans-Pecos Texas are anything but correct, and that the shortest, safest, and most expedient way to remedy this drawback, and to avoid countless strifes and lawsuits, would be to abandon the alternate section system and lay out the lands into larger blocks. The benefit would be equal on the side of the State, of the railways, and of private parties.

Under the present conditions no development can be expected of the rich mineral resources proved by assays to exist, and of the fertile soils of Trans-Pecos Texas, which, covering between thirty-five and forty thousand square miles, represents about one-eighth of the whole State of Texas, containing the locations of hundreds of thousands of acres of public lands which are valueless under the existing circumstances.

CHAPTER IV.

MINERALS OF TRANS-PECOS TEXAS.

The following is a list of those minerals and rocks of Trans-Pecos Texas which up to this time could be classified by their appearance, blowpipe tests, and laboratory work. This list is far from being complete, but it comprises a number of the more important and valuable minerals, building stones, and ores of West Texas, giving the localities where they are found.

Owing to the frequent and excessive metamorphism, more time will be required to classify the large number of specimens on hand awaiting determination by careful microscopic and laboratory studies (which no doubt will lead to the determination of a number of new minerals) than could be spared at present.

Quartz.

Common Quartz, Milky Quartz, and Granular Quartz are found all over the Quitman Mountains, the Carrizo, and the foothills of the Sierra Diabolo.

Mountain Crystal, Sagenitic Quartz (holding acicular crystals of other minerals), Adventurine (with mica inclusions) in the Quitman Mountains, particularly on the contacts between the granitic and porphyritic rocks in the second range of these mountains.

Flinty Quartz prevails in the Davis Mountains, though Smoky, Milky, Granular Quartz, Agates, and Mountain Crystals are also found there.

Agates. Banded, cloudy, and milky agates are found in any desired quantities, loose and embedded in the rhyolitic material, between Marfa and the Chinatti Mountains. Between Sierra St. Jago and the Rossillas moss agates of great beauty and variety are are found.

Onyx is found in streaks in the lava along the road from Marfa to the Saocito ranch.

Amphibolite.

Amphibolite is found in the northwestern part of the Sierra Blanca group, but more sparsely in the northern part of the Quitman Mountains.

Hornblende.

Hornblende is found in the northern part of the Quitman Mountains, in the Sierra Carrizo, at the Rattlesnake tank, in a spur of the Van Horn Mountains, and in the Sierra Blanca group and its northwestern extension; Diorite, Syenite, Tremolite, Aphanite, and related rocks are also found in these mountain ranges.

Granite.

The principal component materials of the northern part of the Quitman Mountains are fine and coarse-grained, red and gray, chloritic, syenitic and ferruginous granites, granite with garnet and graphite, talcose granite (Protogine), Pegmatite, and Granulite. They are also found with the crystalline schists of the Sierra Carrizo, in the Chinatti range and further east in the Chicos and Corazones Mountains, the eastern part of the Davis, and the southern end of the Comanche Mountains. The mountain ranges in the northern portion of Trans-Pecos Texas are also partly granitic.

Porphyries and porphyritic rocks, such as Argylophyre, Melaphyre, Olygopyre, porphyritic trachytes, and trachytic porphyries form part of the Quitman Mountains. Extending east to the Sierra Blanca, they reappear near Eagle Flat, and are found in the Davis, Eagle, Van Horn, and the more eastern and northern mountain ranges of Trans-Pecos Texas.

Mica Schists prevail in the Carrizo Mountains, extending to the Van Horn range, but in the Quitman and other ranges they are sparsely disseminated. Talcose, chloritic, and hornblende schists also prevail in the Carrizo Mountains.

Mica (isinglass) in larger flakes is found in the western spur of the Van Horn Mountains, near the Rattlesnake (mica) tank.

Feldspar is found in a number of species in those parts of West Texas which were mentioned with the granites.

Marbles are found of a dark gray coarse-grained variety on the east and west sides of the Quitman Mountains, while those in the foothills of the Sierra Diabolo are lighter gray and finer grain. There are also marbles found of yellow and peach blossom shades, streaked, and mottled, very fine-grained white and pink, white and purple, and numerous other shades.

Calcites and aragonites are frequently found in leads and outcrops throughout the metamorphic limestones.

Volcanic Rocks are represented by lava, compact and cavernous, basalt, basaltic wacke, obsidian, retinite, and trachytic rocks in the Quitman, Sierra Carrizo, Eagle, Van Horn, and Davis, Viejo, and Chinatti Mountains, and probably at least as dykes in the Guadaloupe, Franklin, and the mountain ranges not yet examined.

Serpentine of brown, oil green, brick red, and also mottled (serpentinous marbles) exist as dykes, and flank the same mountains in the foothills of the Sierra Diabolo.

Iron.

Siliceous magnetite and hematites occur in the Quitman, the foot hills of the Sierra Diabolo, Sierra Carrizo, and Chinatti Mountains.

Sideritic iron is found in the second range of the Quitman Mountains near the contact of the granite and porphyritic rocks. Titanic iron is also found in this vicinity.

Pyrites of iron is found throughout all the mountain ranges of West Texas, some of them carrying precious metals.

Decomposed silicates and sulphides in the shape of gossan or amalgres are very numerous in the Quitman Mountains.

Lead.

Galenite outcrops are very numerous in the Quitman Mountains. The Bonanza mine, Alice Ray, Mule, Alta, Correales, and other prospects in the Quitman Mountains show mostly silver bearing galena in their upper portions. One of the two small prospects in the Eagle Mountains is on galena. The Shafter mine in the Chinatti Mountains produces, besides the free milling silver ores of the upper levels, considerable galena deeper down. Galena is found in numerous prospects in the Chinatti Mountains, and the old Spanish diggings in the Comanche Mountains were evidently sunk for this ore.

Carbonates of lead with silver are worked in the Chinatti Mountains. Zinciferous lead ores with silver are found in the prospects of the Quitman Mountains, with molybdates and vanadates of lead.

Zinc Sulphides (Blende) with silver is mined in the workings of the Bonanza, Alice Ray, and Alta; there is also found pribramite (cadmiferous blende), marmatite and christophite.

Antimony is contained in the ores of the Quitman Mountains and the Sierra Diabolo (Hazel mine).

Nickel exists in the ores of the Hunter and Bona prospects, and probably with the material of most of the Quitman Mountain prospects.

Uranium in the shape of torbernite, uranochre, uranpecherz, etc., is contained in the material of all prospects of the Hunter district (first range of the Quitman Mountains).

Copper.

Copper glanz, tetrahedrite, fahlerz, copper indigo, are found in the Hazel mine.

Malachite and azurite exist in the foothills of the Sierra Diabolo with the outcrops on the west side of the Quitman Mountains, in the Carrizo Mountains, Van Horn Mountains, Chinatti Mountains, and also near the hill range of the Sierra Blanca, in which latter place I found also silicates, velvet copper ore, and copper black.

Black oxide of copper with red and blue carbonates exist in the black lead (foothills of the Sierra Diabolo).

Brown (red) oxide of copper is found in the Boracho Mountains and in some prospects in the Big Gulch district of the Quitman Mountains.

Peacock ore and pyrites of copper are found in many prospects of the Carrizo Mountains, in the prospects of the western side of the Quitman Mountains, and in the mountains between the Sierra Blanca group and the Hueco range.

Chrysocolla, and also atacamite, are found in the foothills of the Sierra Diabolo.

Pseudomalachite (ehlite, dihydrite), occurs in the prospects on the hills west of Sierra Blanca Junction.

Manganese, as wad, psilomelane, lampadite, and crednerite (manganese and copper) crops out in the prospects west of the Sierra Blanca; also in the prospects of the Hunter district, on the Quitman Mountains, where also pyrolusite (gray oxide of manganese) exists.

Silver (native).

Silver sulphides and chlorides are worked in the Shafter mine in the Chinatti Mountains, and also in the Hazel mine in the Sierra Diabolo Mountains.

Gold is found in traces with most of the copper ores of the Carrizo Mountains and with some of the ores of the Quitman Mountains. It is also found in the gravel hills near the Rio Grande, between the Quitman and Eagle mountains, and in float found north of Finlay.

Tin.

Traces of tin were found in material from prospects in the Quitman Mountains, and Platinum, in traces, in a decomposed rock from the west side of the Quitman Mountains.

Quicksilver Ore (cinnabarite) is said to exist in one of the mountain ranges north of the Sierra Carrizo and the Bofecillos, but in spite of my careful examination of the float I have not found any traces of this metal up to the present time.

CHAPTER V.

THE CRETACEOUS DEPOSITS.

BY J. A. TAFF.

The Cretaceous strata which were studied during the present year in El Paso County are embraced within an area of one hundred and eighty square miles, having a width of twelve miles north and south and a length of fifteen miles east and west, with a point one and one-half miles east of Sierra Blanca Junction as the centre of the east side.

The rocks of this formation appear here principally in apparently detached ranges of hills rising above the general level from three hundred to seven hundred feet, usually having their eastern or northeastern faces quite precipitous, a flat top or mesa of greater or less area, and a gradual slope towards the west or southwest down into the surrounding plain. The connection between these different exposures is generally obscured by the drift of the great flats which stretch around them on every side, and adds much to the difficulty of their study. A glance at the map accompanying this Report will give the relative positions of the localities to be described.

Sierra Blanca is the junction of the Southern Pacific and the Texas and Pacific railways, which from that point run into El Paso on the same track. Six miles west of Sierra Blanca the railway passes between two mountain ranges of entirely dissimilar character. The conical peaks north of the railway are the Sierra Blanca Mountains and the rugged range on the south the Quitmans. Three and one-half miles east of the Sierra Blanca Peak is the Flat Mesa, with its long eastward facing scarp stretching southeast nearly to Sierra Blanca Junction. East of the Quitman Mountains and south of the railway are Bluff Mesa, two miles southwest of Sierra Blanca Station, and Yucca Mesa, three and a half miles south of the station and to the east of the pass leading from the Sierra Blanca to the Quitman Pass. The Etholen Knobs are situated one-fourth and one-half mile respectively northwest of Etholen Station, and the Malone Mountains lie west of the Quitmans and directly southwest of Malone Station. Partial studies were also made of the Cretaceous rocks on the eastern side of the Eagle Mountains, at Finney's Ranch, Carpenter's Spring, Eagle Spring, Mica Water Hole, south end of the Quitman Mountains, and in the small buttes one mile northeast of Eagle Flat Station.

The following description of the rocks of this series is only intended as an explanation of their stratigraphy and their correlation, as far as may be, with the rocks of similar age north of the Colorado River, to which area my work of last year was confined. While the co-ordinate branches of structural, dynamical, and economical geology have not been neglected in the field studies, they will only be referred to in general terms at this time. It may be remarked, however, that the dynamic features especially are of surpassing interest and importance, and their correct determination will be of much value in working out adjacent areas. These rocks seem to owe their present exposure, for the most part, to certain disturbances having axes running in directions varying from northwest-southeast to nearly north and south, accompanied by very considerable folding and faulting, which in the Malone Mountains especially has developed some beautiful dynamical effects.

The development of the Cretaceous rocks as studied in El Paso County is very much greater than those of the same formation found in the Colorado River section, and by far the greater part of them belong to the Lower Cretaceous Series, although the Upper is also present.

The same general classification given in the First Annual Report will be adhered to in this Report.*

LOWER CRETACEOUS SERIES.

Development and General Character.—As stated above, the Cretaceous rocks of El Paso County are much beyond those of the same formation yet studied in any other part of the State in the magnitude of their development, as will be seen by evidence given beyond, and yet neither the base nor the highest beds have been found, and there are, moreover, indications that point to greater depths of rock in the region lying towards the southeast.

Much of the rock is very similar to that of the same beds occurring between the Colorado and Red rivers, while others are widely different. The range in lithologic character is wide, including almost every phase from a deep sea foraminiferal massive limestone to a coarse conglomeritic bowlder breccia, and from the same pure limestone through various grades of siliceous limestone to a coarse, shell brecciate, gritty rock. Then there are grades of sandstone from a fine-grained pure glassy quartzite up through coarse false laminated sandstone and grit to a very coarse siliceous conglomerate.

Clay is, however, especially scarce in the Sierra Blanca region, but to the south and southeast it largely takes the place of the more arenaceous beds here.

TRINITY DIVISION.

BASAL SAND BED—ITS RELATION TO THE COLORADO-RED RIVER BED.

This, the lowest bed seen, is not very different from the Trinity sand occurring along the base of the Lower Cretaceous, between the Colorado and Red rivers, and in the Abilene country, except in the degree of metamorphism of the rocks in the different localities. Here are found compact, clear, sharp sands in massive beds and in false laminated strata, the same in general lithologic character as the Trinity beds of Hill.

The relations of this bed to that of the Fredericksburg in the different localities do not lie altogether in the character of the rock, but in its relations to the overlying Texana and Caprina horizons, below which it occurs in complete conformity, or as nearly so at least as a littoral sand bed can conform to that of a limestone.

The principal occurrence of this sand is in Flat Mesa, which is composed of a range of hills beginning one mile north of Sierra Blanca Junction and extending north-northwest about six miles. The central hill has the true mesa features, which is a broad flat top with precipitate sides. The east and northeast sides of Flat Mesa are especially precipitous, while the west side has a gradual descent (but little more than the dip of the rock, which is from five to ten degrees sonthwest) to the basin leading to Sierra Blanca and Quitman Mountains. From the base of the scarp on the east side the almost level basin extends eastward to the Diabolo Mountains.

The cap rock of Flat Mesa is from thick bedded to massive limestone, beneath which extend the Texana bed and Trinity division, as in the following section:

1.	Caprina limestone	40 feet.
2.	Flaggy calcareous sandstone and siliceous limestone, with numerous gasteropods, bivalves and *Exogyra texana*	15 feet.
3.	Brown quartzitic sandstone	35 feet.
4.	Siliceous conglomerate and grit	10 feet.
5.	Brown sandstone	46 feet.
6.	Arenaceous limestone in which are numerous individuals of *Actæonella dolium* and a small exogyra	4 feet.
7.	Brown quartzitic sandstone, disappearing at the base of the scarp beneath the debris of the basin, exposed	100 feet.
	Total	250 feet.

On the northeast side of Flat Mesa the Trinity sand is thrown down by a succession of steep faults until the Caprina limestone, No. 1 of the section, is brought to a level with the basin.

A laccolitic uplift composing the clump of hills at the extreme northwest end of Flat Mesa has brought the Trinity sand up, where by erosion it is beautifully exposed, the dip of the rock being forty-five degrees to the southwest toward Sierra Blanca Peak.

On the east side of this uplift erosion and deposition of basin debris have concealed all stratified rocks, and the surface of the basin passes up against the porphyry core of the laccolite.

At numerous places in the southern half of Flat Mesa dykes of porphyry have broken abruptly across the strata. It is observed too of the dykes that they enlarge downward.

Trinity sand forms the body of the sharp crested hills one-half mile southwest of Sierra Blanca Junction as a gray to yellow quartzite, through which numerous interstratal dykes of porphyry have been injected. In the sand proper no organic remains have been found, and with the exception of the Actæonella horizon in Flat Mesa, no fossil remains were seen within the limits of the sand.

In the quartzite of the hill one-half mile southwest of Sierra Blanca there is a band of fossiliferous limestone occupying about the same relative position as the Actæonella horizon in Flat Mesa, but the fossils are destroyed beyond recognition by metamorphism.

Along the base of the Eagle Mountains, from the Carpenter Spring section southward to Finney's Ranch, there extends a bed of sandstone, with an extensive development of limestone overlying in succession of strata, that shows quite conclusively that the sand is that of the Trinity division. The section at Finney's Ranch will show its relation to that of Flat Mesa:

1.	Massive limestone, with numerous intrusive dykes of porphyry between the strata	450 feet.
2.	Brown mottled quartzitic sand	25 feet.
3.	Calcareous brown sandstone containing small Exogyra resembling young of *E. costata*	40 feet.
4.	Caprotina limestone	10 feet.
5.	Arenaceous limestone	40 feet.
6.	Brown quartzitic sandstone	40 feet.
7.	Limestone, with oysters and gasteropods	1 to 2 feet.
8.	Brown quartzitic sandstone	188 feet.

The Caprotina fossil was found in great numbers, but the Caprina which was found in the limestone below the Caprotina in Flat Mesa was not found in the similarly related limestone at Finney's Ranch. The local metamorphism of the stratified rock is very great in proximity to the porphyry of Eagle Mountain, and a great many of the fossil forms have doubtless been destroyed. The shell of the Caprotina, however, is very refractory. I have seen it clearly marked in granular marble, when almost every other form would have been destroyed.

FREDERICKSBURG DIVISION.

The transition from the Trinity sands to the Caprina bed is through a horizon of fifteen feet of flaggy calcareous sandstone and siliceous limestone, in which are numerous gasteropods and *Exogyra texana*. This is the first and lower Texana horizon, and corresponds to the Texana horizon at the base of the Comanche Peak bed of the Colorado section.

The Fredericksburg division is considered to end with the Caprina bed. This agrees with the division made in the Colorado section, and is especially agreeable with the structure of the rocks in the upper Colorado basin south of Abilene.

By examining the Colorado section the great development of the Fredericksburg division with its Caprotina and Monopleura horizons and its Comanche Peak chalk will be observed. Then by considering the rocks of the upper Colorado basin at the point above cited, it will be seen that the great body of the Fredericksburg is entirely missing, that the development of the Comanche Peak chalk has dwindled down to a mere band, and that the Exogyra texana bed lies immediately below the ever present Caprina chalky limestone.

This is exactly the case in the El Paso beds, as may be clearly seen in the Flat Mesa section.

TEXANA BED.

Across the basin, north of Flat Mesa and about eight miles north of Sierra Blanca Junction, there is a southward facing scarp, which extends westward to the Hueco Mountains and eastward nearly to the Diabolo Mountains. From the crest of the scarp an almost level plain extends northward towards New Mexico.

The best development of the Texana bed is in the face of this scarp, underlying the Caprina and Caprotina limestones which form the cap rocks.

Below is a section of the rocks at this point:

1.	Caprotina limestone	10 feet.
2.	Caprina limestone with flint	40 feet.
3.	Calcareous ferruginous sandstone, with numerous *Exogyra texana*	2 feet.
4.	Ferruginous flaggy sandstone	10 feet.
5.	Siliceous limestone	15 feet.
6.	Ferruginous calcareous sandstone	10 feet.
7.	Limestone, disappearing beneath basin debris, exposed	20 feet.

CAPRINA LIMESTONE BED.

The Caprina limestone reaches a thickness of some forty feet, and with it are flints, but not in great abundance. The presence of flints was observed only in the exposures along the scarp four miles north of Flat Mesa. Tney occur here in a narrow band, are small, and thinly scattered in the limestone. The limestone is blue, hard, compact, and massive, and the change is so complete through the general metamorphism that the original lithologic features can not be readily obtained; but its massiveness and the presence of flints point to a comparatively deep sea origin. So far as observed in the State elsewhere the life is found to be a deep sea form.

The Caprina limestone, besides forming the cap rocks of Flat Mesa and the scarp four miles north of Flat Mesa, forms the crest of the hill one mile southwest, and extends into the basin two miles southeast of Sierra Blanca Station.

It pitches into the basin on the west side of the laccolitic uplift at the extreme northwest part of Flat Mesa. It also appears jutting against the side of Sierra Blanca Peak, seventeen hundred feet below the summit, and outcropping from the base of the peak for one mile in the direction of Sierra Blanca Station.

WASHITA DIVISION.

FIRST CAPROTINA BED.

The first and lowest Caprotina horizon appears here immediately succeeding Caprina limestone, without apparent change in the rock.

The Caprotina limestone is about twenty feet thick, and the fossil occurs principally near the lower edge, where it is abundant, filling the limestone in mass. It is found where the rock is exposed at the localities named for the occurrence of the Caprina bed.

At the southeast side of Eagle Mountain, near Finney's Ranch, there is a horizon of Caprotina limestones that has been correlated with this first Caprotina horizon in Flat Mesa by a parallel section at Finney's Ranch. (See the two foregoing sections.)

ARIETINA BED.

The exact connection between the Arietina bed and the underlying Caprotina limestone is not very clear, as but one link in the chain of facts that may be had was found.

Near the centre of the northeast side of Flat Mesa, where a fault of one hundred and sixty feet has thrown the rocks down to the northward, numberless individuals of a foraminifera, *Nodosaria texana*, are exhibited in a horizon of flaggy siliceous limestone that lies directly above the Caprotina limestone. These same flags, or flags very similar, with the same foraminifera associated with *Exogyra arietina* and a small gryphea, occur in some small hills on the north side of Quitman Mountains, at the Southern Pacific Railway. Immediately under these flags is a massive granular limestone whose structure is completely destroyed by the local metamorphism caused by the contact granite. It is pretty evident that this massive limestone is the first Caprotina bed.

I include in the Arietina bed two horizons, having a total thickness of some forty-five feet. These horizons are in the order: First, the Arietina flags with the characteristic *Exogyra arietina*, and a small gryphea in great numbers. Second, the *Nodosaria texana* horizon, in which are millions of individuals of this unique foraminifera, described by Conrad from the Rio Grande basin near El Paso. The form passes down into the Arietina horizon.

CHARACTER OF THE ROCK.—The rock is decidedly siliceous, especially that of the Nodosaria texana horizon.

The Arietina flags proper are of a compact, blue, fine-grained, slightly siliceous limestone, with occasional thin bands of marl between the strata.

That of the Nodosaria texana horizon occurs in thin siliceous flags, and are yellowish gray to pale brick red in color. Between the Nodosaria horizon and the second Caprina bed overlying there is a band of thinly-bedded pale blue limestone five feet thick, which weathers in conchoidal balls.

The Arietina bed occurs in the small hills west of Etholen Station, and between Quitman Mountain and the Southern Pacific Railway, and at the southern base and on the western flank of Sierra Blanca Peak, north of the railway.

These small hills are surrounded by the debris from the mountains near at hand, and by the silt of the lake basin that occupies the valleys. The rocks of the hills on the south side of the railway nearest Quitman Mountains dip northward away from the mountain, while those on the south, as well as on the eastern and western flanks of Sierra Blanca Peak, dip toward the southwest at nearly the same degree. By referring to the accompanying map these features may be observed.

The *Nodosaria texana* occurs also at the southeast side of the south end of the Quitman Mountain, two miles north of the Rio Grande, where it occupies a fissile, ferruginous, flaggy, calcareous sand, underlying an immense development of shale.

SECOND CAPRINA BED.

This, the second Caprina horizon, is the first known to exist above the Exogyra arietina bed, which bed appears almost at the very top of the Washita in the Colorado section.

It is not in great development here, however, being only ten feet thick. The only known occurrence of this bed is at the south base of Sierra Blanca Peak, where it occurs as a thickly-bedded dark gray siliceous limestone that weathers dull yellowish gray.

Immediately above the Nodosaria horizon cited above, at the south end of the Quitman Mountain, there is a horizon of limestone, but the Caprina was not found. A fragment of a large ammonite was collected from the limestone.

At the south base of Sierra Blanca Peak, the point of the only known occurrence of the second Caprina horizon, the rock is completely metamorphosed, and the fossils are seen only in section in face of the hard rock. The fossil *Caprina crassifibra* is so characteristic in its surface markings that there is no doubt of its being correctly identified.

The bed immediately overlying the second Caprina horizon is found to be a sand outcropping in the bases of Etholen Knobs. This sand, with its oyster breccia horizons, between the second Caprina bed and the Etholen breccias, is given as the equivalent of the gypsum and its associated limestones of Malone Mountain, which is given the name of Malone bed.

MALONE BED.

The Malone bed is so named because of the great development of gypsum which it includes that occurs in Malone Mountain.

All of the gypsum, with its included limestone and the flaggy limestone which underlies the lowest gypsum horizon in Malone Mountain, up to the conglomerates and conglomeratic breccias of the overlying Etholen bed, are included in the Malone bed.

Whether the sand occurring at the base of Etholen Knobs exists beneath the Malone Mountain horizons in Malone Mountain is not known.

MALONE MOUNTAIN HORIZONS.

As was stated in the preliminary remarks, the dynamical effects in Malone Mountain are peculiar and beautiful. The crumplings and contortions of the strata have been very severe, forming double and isoclinal folds, inverting hundreds of feet of rock.

The topography too is typical of this character of geology. Along the northeastern side of the mountain a high, sharp ridge passes the whole extent of the mountain, with the axes of the principal synclinal fold as its centre. On the very crest of this ridge, through a part of its extent, there exists a double isoclinal fold, the planes of whose axes incline toward the centre of the ridge. (See section of Malone Mountain.) A valley with interruption of hills follows the principal anticlinal fold through the centre of the mountain. The main gypsum field extends from the centre of this mountain to the northwest end. The line of broken hills forming the western portion of the mountain are remnants of the western half of the central anticlinal fold. The basin surrounds Malone Mountain, cutting off all direct contact with other stratified rocks.

The lowest rock exposed of the Malone Mountain horizons is a band of pale yellow flaggy limestone. Above this limestone occurs the first horizon of white fissile granular gypsum, having a thickness of forty-five feet. Succeeding this gypsum there is one hundred and seventy feet of massive blue granular limestone. It lies conformably between the first and second horizons.

Metamorphism has gone on to such an extent that the organic remains have been destroyed, if they have ever existed in it, for in fact the rock is now a marble. Above this limestone comes the second horizon of gypsum, with a thickness of one hundred and ten feet. It is the same lithologically as the first horizon, stratified, nearly pure, friable, granular gypsum. It contains comparatively little earthy matter. On the east side of the southeast end of Malone Mountain there is a development of gypsum, with a surface area of about forty acres, that may be classed with one of these horizons, and from its relations to the overlying conglomerates, it is probably the lowest. The crumpling and displacement of the strata have been so great that it is not possible to correlate positively. In character it is identically the same as that of the second horizon on the west side or centre of the mountain.

These rocks have not been seen elsewhere except in Malone Mountain. If they were continuous over the area of the Cretaceous rocks they would outcrop between Quitman and Sierra Blanca mountains at the bases of Etholen Knobs and follow the basin, passing on the northeast side of Bluff Mesa and down Devil's Ridge to Eagle Mountain.

The occurrence of the overlying breccias and conglomeratic breccias that pass from other areas near at hand over these gypsum horizons, points to the fact that the shore of the gypsum-forming basin was not far away, and that it had passed down over the sands and oyster breccias of Etholen Knobs before the beginning of the deposit of gypsum; for at Etholen Knobs the conglomeratic breccias rest on the sands, while in Malone Mountain, five miles to the southwest, it has been thrown out directly on the gypsum. Three sections were made of the rocks of Malone Mountain, one at the south end, one at the middle, and one at the north end. The middle section is the most comprehensive. This section is given below, that the succession of the strata and the connection of the Malone bed with the overlying rocks may be seen at a view.

MIDDLE SECTION OF MALONE MOUNTAIN, IN DESCENDING ORDER.

1.	Thinly bedded to flaggy, compact, finely crystalline limestone, blue to pale yellow in color, weathering pale yellow to yellow and brown. Same in character as the flaggy beds at the base of Yucca and Bluff mesas	100 feet.
2.	Limestone conglomerate	5 to 10 feet.
3.	Milky white calcite	1 to 2 feet.
4.	Slightly siliceous blue limestone, with small gasteropods and much finely comminuted oyster shell fragments	100 feet.
5.	Calcareous ferruginous sandy grit	5 feet.
6.	Siliceous limestone, with occasional chert and limestone pebbles	45 feet.
7.	Light blue compact limestone or marble, weathers pale yellow	4 feet.
8.	Black conglomeratic calcareous shale, weathers purple	10 feet.

9.	Pisolitic limestone conglomerate, with siliceous matrix, containing some chert pebbles	20 feet.
10.	Siliceous grit and conglomerate	40 feet.
11.	Siliceous gray alternating thinly and thickly-bedded limestone, about	450 feet.
12.	Calcareous grit and cherty conglomerate	10 to 15 feet.
13.	Calcareous sandstone and siliceous limestone	30 feet.
14.	Light blue siliceous limestone, with occasional bands of siliceous shell breccia, about	300 feet.
15.	Massive limestone conglomerate in siliceous lime matrix	150 feet.
16.	Alternating siliceous limestone and limestone conglomerate bands, ten to twenty feet thick	130 feet.
17.	Light blue limestone	40 feet.
18.	White granular gypsum	110 feet.
19.	Dark blue, granular, minutely cleaved limestone, metamorphosed and filled by calcite veins	120 feet.
20.	White granular gypsum	40 to 50 feet.
21.	Siliceous light grey limestone, partially concealed, exposed	25 feet.
	Total	1756 feet.

ETHOLEN HORIZONS.

In Etholen Knobs and vicinity the Malone bed is represented by one hundred and ninety-eight feet of gray to dull greenish yellow sands and gritty sand, with thin bands of oysters and oyster shell breccia. Near the base of the sand there is a narrow band of fragile oyster in mass, and in which are occasional rounded limestone pebbles.

This sandstone is exposed in the bases of the Etholen Knobs, caps the small hills south of the Southern Pacific Railway, southwest of Etholen Knobs, and the small hill at the south base of Sierra Blanca Peak. Elsewhere in the vicinity it is eroded and concealed by basin debris. It belongs in the basin northeast of Bluff and Yucca mesas, and it occurs in the east side of Devil's Ridge on the northwest side of Eagle Mountain, where it underlies the same conglomerates, but in greater development than in Etholen Knobs.

In the sand in Devil's Ridge bivalves, gasteropods, and a small gryphea were collected.

ETHOLEN BED.

The Etholen Knobs form a peculiar feature of the topography in the vicinity of Sierra Blanca and Quitman Mountains. To a casual observer, and to one who has not worked the stratified rock in the surrounding areas, it is quite difficult to determine their origin.

The uplift of Sierra Blanca Mountains to the north of Etholen Knobs, and the uplift of the Quitman Mountains to the south of them, has formed a wide and what is now a shallow synclinal fold extending from the one to the other.

The Arietina bed rests in contact with the porphyry of Sierra Blanca Peak at the south base, and the underlying Caprotina bed is in contact with the granite of Quitman Mountain at its north base, and above these beds rise in their order, first, the second Caprina bed; second, the Malone bed, represented by the sands at the base of the Etholen Knobs; and third, the Etholen bed, which forms the body of Etholen Knobs to the top.

Before the prodigious erosion that has laid bare the very hearts of the mountains, which now stand two thousand feet above the surface of the filled up basins that surround them, the rock forming the body of Etholen bed was widespread, extending from Quitman to Sierra Blanca mountains, and from Malone Mountain through the pass by Etholen Knobs down the east side of the Devil's Ridge to Eagle Mountain. To the east and west of Etholen Knobs erosion has destroyed and the basin debris has concealed the extension of the Etholen bed.

SECTION OF WEST ETHOLEN KNOBS.

1.	Massive limestone—chert conglomeratic breccia	240 feet.
2.	Pale blue compact limestone, weathering light yellow	20 feet.
3.	Grayish dull yellow limestone	30 feet.
4.	Brownish yellow sandstone, with small rounded limestone pebbles	2 to 5 feet.
5.	Grayish dull yellow sandstone, with occasional worn fragments of an oblong oyster two to three inches long	90 feet.
6.	Grayish dull yellow sandstone, with a thin band of fragile *Exogyra?* near the lower edge	10 to 15 feet.
7.	Intrusive porphyry	
8.	Steel-gray sandstone, weathering dull yellowish brown, disappearing beneath basin debris	
	Total	400 feet.

The conglomerate breccia and the included rocks so beautifully represented in Etholen Knobs and Malone Mountain are classed as the Etholen bed.

These rocks are peculiar, appearing as they do high in the Cretaceous. They are massive bowlder breccia and conglomerate, made of Carboniferous limestone and chert, and having a thickness of some two hundred and forty feet in one body in Etholen Knobs.

Lithological Characters.—The rocks range from a very coarse bowlder breccia, some of the fragments being as much as three feet in diameter, through a well worn conglomerate to a calcareous grit. The fragments forming the breccia in Malone Mountain do not appear to be in the least worn, and the body of the conglomerate is formed of sub-angular fragments. In places the material is composed almost entirely of limestone fragments (then the prevailing pebble is chert), and in other places they are well mixed. The matrix is siliceous, gritty lime, and occasionally the body of the rock is grit, with large inclusions or collections of conglomerate, appearing as if they had been thrown into the soft matrix.

Many of the pebbles carry Carboniferous coral, crinoids, etc., and from lithologic evidence almost every pebble can be classed with those carrying the fossils. The top of the bed is not seen in Etholen Knobs.

In Malone Mountain a lenticular horizon of gypsum overlies the conglomerate. Near the southeast side of the mountain it begins as a narrow strip, and when at the northwest end it develops a thickness of ninety feet. The gypsum is the same in character as that of the two horizons below, and no doubt joins them further into the basin.

Of necessity these conglomeratic breccias are local, and doubtless did not extend far to the southwest, or into the gypsum forming basin.

Besides the localities named above for the occurrence of the Etholen beds, they are found forming the low hill immediately north of Etholen Knobs, the clump of hills one and one fourth miles due south of Etholen Station, and the small hill three-eighths of a mile east of Etholen. A clump of the breccia rests upon the flank of Quitman Mountain at the south side of Big Spring Gulch. There is a great development of the conglomerate and breccia in Devil's Ridge, near the northwest side of Eagle Mountain, and they occur in the Devil's Backbone, southeast of Yucca Mesa.

YUCCA BED.

In this bed, named because of its development in Yucca Mesa, is included a series of horizons of flaggy marbles, quartzitic sandstones and grit, calcareous sandstones and arenaceous limestone, and pisolitic limestone conglomerate in alternating layers, beginning at the great breccia of the Etholen bed and culminating in a second horizon of Caprotina limestone fifteen feet thick.

The connection between the Yucca Mesa bed and the underlying Etholen breccia is made in Malone Mountain, where there is a large development of arenaceous limestone between the Yucca marble flags and pisolitic limestone and the great breccia. A section of Yucca Mesa will clearly show the connection when compared with the middle section of Malone Mountain, which was given on page 722.

YUCCA MESA SECTION.

1.	Dimly false laminated arenaceous flaggy sandstone, containing small shell fragments	48 feet.
2.	Calcareous fucoidal sandstone	8 feet.
3.	Arenaceous limestone	2 feet.
4.	Limestone, with large oyster in mass	2 feet.
5.	Massive calcareous shell brecciate limestone	36 feet.

6.	Quartzitic sandstone	10 feet.
7.	Limestone	30 feet.
8.	Brown quartzitic sandstone	12 feet.
9.	Thickly-bedded limestone, with oyster shell fragments and *Exogyra texana* at the base	28 feet.
10.	Brown sandstone	10 feet.
11.	Massive foraminiferal limestone, with *Caprotina* and *Monopleura*	28 feet.
12.	Band of large flat oyster shell	2 feet.
13.	Massive foraminiferal limestone	10 feet.
14.	Brown sandstone	9 feet.
15.	Calcareous sandstone, with much worn oyster shell fragments	2 feet.
16.	Brown sandstone	8 to 10 feet.
17.	Limestone, with fragments of large oysters, siliceous at lower edge	10 feet.
18.	Flaggy quartzitic sandstone	10 feet.
19.	Limestone, with oyster fragments and *Arca* in finely comminuted shell breccia. *Exogyra texana* fossils	10 feet.
20.	Calcareous sandstone	15 feet.
21.	Caprotina limestone, with *Arca*, *Ostrea*, and shell fragments	15 feet.
22.	Shell brecciate siliceous limestone	40 feet.
23.	Brown, yellow, and splotched thinly-bedded conglomeratic limestone	65 feet.
24.	Brown quartzitic sandstone	15 feet.
25.	Argillaceous (?) flaggy limestone, weathers in various colors from brown and yellow to red	50 feet.
26.	Pisolitic, arenaceous, limestone conglomerate	30 feet.
27.	Brown to yellow and red flaggy sandstone, same as 25	60 feet.
28.	Ferruginous quartzitic sandstone	20 feet.
29.	Arenaceous limestone	40 feet.

Lower rocks are concealed by basin debris.

The flaggy marble predominates in Yucca Mesa, giving a development of nearly one hundred feet near the lower edge. It is a bright yellow to purplish-blue rock, weathering in various shades of color from red to pale yellow, which is governed partly by the degree of metamorphism in different places.

No evidences of fossils were found in these flags. The character of much of the quartzitic sandstone is similar to that of the basal sands. It is often false laminated and gritty, evidencing very shallow water at the time of its deposition. The coarse calcareous grit contains worn fragments of oyster shells, and the siliceous limestone carries shell fragments, often in such great abundance that it becomes a shell brecciate limestone. These also show current action in their false lamination.

Thirty feet below the Caprotina horizon a narrow horizon of *Exogyra* (sp. ind.) occurs. The fossils were two to three inches long and resembled *Exogyra texana*. Very near the lower edge of this bed, in Malone Mountain, there is a band of gryphea in dark shaly limestone.

The pisolitic limestone conglomerate is a marked feature of the Yucca bed.

Near the lowest exposures in Yucca and Bluff mesas and in Malone Mountain, very near the upper edge of the siliceous limestone, this conglomerate occurs in a horizon twenty to thirty feet thick. The material composing the conglomerate is pretty well worn limestone and chert pebbles, resembling, in surface appearance, the material of the Etholen breccia. The limestone pebbles are formed of concentric circles or rings of limestone ranging outward from a nucleus at the centre.

SECOND CAPROTINA HORIZON.

This occurs at the top of the Yucca bed, in thickly-bedded to massive limestone fifteen feet thick. The fossil is shown in section in the face of the hard rock. Its hornlike shell structure and its peculiar shape give no doubt of its detection to one who is at all acquainted with the form.

The Yucca bed occurs in the northeast sides of Yucca, Camp, and Bluff mesas, in Quitman Mountain south of Quitman Pass, and in the whole extent of Malone Mountain. Parts of it also occur in the southwest side of Quitman Mountain, south of Big Spring Gulch, as parts of the beds both above and below are there.

Igneous action has been so great in Quitman Mountain that the stratified rock in contact with the granite can not be recognized unless they contain very refractory fossils or other evidence outside the common lithological characters of the rock. Yucca beds in Malone Mountain extends a short distance above the pisolitic limestone into the marble flags, as represented in Yucca and Bluff mesas.

BLUFF BED.

Bluff and Yucca mesas are the northwestern extension of the line of similar hills that pass from Eagle Mountain in a northwesterly direction to within two miles of Etholen Station. Near Eagle Mountain these hills are known as Devil's Ridge, while farther to the northwest they are known as Devil's Backbone. The character of the topography is the same throughout; that is, abrupt steep declivities and bluffs facing the basin leading northeastward to the Sierra Diabolos, flat to southwestward sloping tops, and sloping to steeply inclined sides, following generally the dip of the rock to the basin on the southwest leading south to the Rio Grande and southwest to the Quitman Mountains.

The rocks invariably have a southwestward dip. Strikes range from north 50° to north 60° west. A glance at the section given under Yucca bed on page 725 will show the succession of the strata of this bed and its connection with the rocks of Yucca bed.

As was the case with Yucca series, the Bluff series begins with sublittoral alternating horizons that were laid down in a near shore oscillating bed, giving alternating bands of sandstone and siliceous shell brecciate limestone through a range of sixty-five feet, when the littoral features pass and massive foraminiferal limestone is reached, ending in a third Caprotina horizon with *Monopleura.*

Fifteen feet above the base of the Bluff bed the last horizon of *Exogyra texana* appears in a finely comminuted siliceous shell limestone ten feet thick.

The combined Foraminiferal (*Orbitolina texana*), Caprotina, and Monopleura horizons form the most extensive deep sea deposit observed in the whole Cretaceous section in El Paso County. Their limestones occur in Bluff and Yucca mesas, in massive perpendicular bluffs forty to eighty feet high. At the east entrance of Quitman Pass the foraminiferal limestone is one hundred feet thick. The foraminifera ranges from the base of the massive limestone to the base of the Caprina horizon, near the top, but is more abundant near the base, where it forms the mass of the rock with millions of individuals. Just beneath the Caprotina horizon a narrow band of very large flat oysters occurs. The fossil is eight to ten inches in length and very flat. On weathering in the face of the bluff only sections and fragments could be obtained. In Camp Mesa, near the upper edge of the alternating series of this bed, there occurs a narrow horizon of *Serpula* (var. ind.) The fossil is an eighth of an inch and less in diameter, and seems to be of considerable length.

A part of Yucca bed, including the Orbitolina and Caprotina horizons, rests along the west flank of Quitman Mountain between Big Spring Gulch and Kyle's prospect, where it has been caught up between granite on the west and porphyry on the east, and fused into granular marble. All fossils except the most refractory have been destroyed.

The Serpula, Orbitolina, and Caprotina horizons occur in the gulch on the north, east, and south sides of Kyle's prospect, where they have been greatly distorted and broken. This bed also appears in the hills one mile west of Bluff Mesa. At the foot of the hill one mile northwest of Eagle Spring there is a narrow band of siliceous limestone, with numerous individuals of *Orbitolina texana*, that is considered to belong to the Bluff bed.

QUITMAN BED.

In Quitman Mountain north of Quitman Pass the stratified rocks have, with the exception of an occasional remnant, been removed from the body of the mountain by erosion, leaving bare the granites and porphyries that once formed the heart of the mountain. The stratified Cretaceous rocks, except where concealed by basin debris, extend around the base of the mountain, with their eroded edges projecting upward with the slope of the mountain side.

On every side the rocks dip away from the mountain, except at the south end, immediately north of Quitman Pass, where at least four thousand feet of rock has been sheared abruptly across the strike by the eruptive porphyry and granite. From Quitman Pass southeastward to the Rio Grande Cretaceous rocks form the body of the mountains, rising near the central point to a height of nearly one thousand feet above the basin.

The same conditions of the rock and character of topography exist in South Quitman Mountain as were found in Devil's Ridge and in other exposures, except those of Malone Mountain. With the exception of a small area on the southeast side of Quitman Pass, where a part of the strata is inverted by the excessive igneous action, the rocks dip to the southwestward with a general strike of north 30° west.

The eastward facing mountain side is precipitous and bluffy, while the southwest side is rolling, with a more gradual descent to the Rio Grande basin.

The bluff series is succeeded by an extensive development of false laminated calcareous shell brecciate sandstone, which shows a return to shallow water deposits, calcareous fossiliferous sandstones, thinly-bedded and flaggy and having a depth of two hundred and fifty to three hundred feet.

The fossiliferous sandstone underlies a band of shell brecciate limestone, which is in turn succeeded by a fourth and final Caprotina horizon sixty feet thick. The Caprotina horizon is considered the limit of this series.

SECTION OF QUITMAN BED ACROSS THE MOUNTAIN AT QUITMAN GAP.

1.	Massive Caprotina limestone	60 feet.
2.	Thickly-bedded siliceous shell limestone	20 feet.
3.	Calcareous flaggy and yellow friable sandstone containing large Exogyra and oblong fan-shaped oyster resembling *O. owenana*.	250 to 300 feet.

The fourth and final Caprotina horizon is considered the limit of the Quitman series. The transition from the third Caprotina horizon into the arenaceous horizons, and from this horizon into that of the fourth Caprotina, is very abrupt, from massive deep sea limestone up into a near shore sand, and then down again into a comparatively deep sea limestone.

Near the center of the arenaceous horizon are numerous very large oysters, an oblong thick-beaked oyster, *Pecten*, and a peculiar *Trigonia*-like fossil. The oblong oyster ranges almost throughout the sand.

The transition from the sand upward into the fourth Caprotina horizon is through twenty feet of finely comminuted shell limestone.

The fourth Caprotina horizon resembles that of the third in the character of rock, and it carries the same fossil in great numbers, forming in part the mass of the rock.

The calcareous sand at the base of the Quitman bed forms the cap rock of Yucca and Bluff mesas. The fullest exposure is along the crest of Quitman Mountains southward from Quitman Pass. It occurs also passing through the southwest side Camp Mesa and in the hill one mile southwest of Bluff Mesa.

The oblong oyster that occurs in the sand at the base of this bed appears in the calcareous sand overlying the Orbitolina horizon in the hill one-fourth of a mile northwest of Eagle Spring. At Mica Water Hole, fifteen miles southeast of Torbert Station, the same oyster occurs associated with *Arca* in similar calcareous sand overlying Carboniferous limestone. It is found also in fragments in the small buttes one mile northeast of Eagle Flat Station.

MOUNTAIN BED.

The final Caprotina horizon is succeeded by a great development of oyster shell siliceous limestone, calcareous sandstone, and quartzitic and flaggy marble in conformable horizons, in all four thousand feet thick, forming the most extensive series of rocks yet observed. It was not possible at the time these rocks were examined to make an exhaustive study of them, but during the time they were worked no evidence was found that would give a positive decision upon the exact division to which they belonged. The Mountain bed succeeds that of Quitman in regular conformity of dips and strikes, and the rocks are not materially different lithologically from much of the sandstones, limestones, and breccias of the underlying beds. The series of horizons of the Mountain bed are divided, with their section, as follows:

I. FINAL ALTERNATING HORIZON.

1.	Calcareous sandstone	20 feet.
2.	Concealed	100 feet.
3.	Pale yellow compact limestone	30 feet.

II. UPPER QUARTZITIC SAND.

1.	Red, brown, and gray quartzitic sandstone	280 feet.

III. UPPER ALTERNATING HORIZON.

1.	Very yellow to bright reddish-yellow fine-grained limestone	5 feet.
2.	Quartzitic sandstone	15 feet.
3.	Very yellow limestone, conglomerate	15 feet.
4.	Brown quartzitic sandstone	60 feet.
5.	Pale yellow compact limestone	10 feet.
6.	Brown quartzitic sandstone	50 feet.
7.	Yellow flaggy limestone or marble	10 feet.

8.	Brown sandstone	50 feet.
9.	Pale yellow flaggy limestone	10 feet.
10.	Brown sandstone	60 feet.
11.	Very light yellow flaggy marble	10 feet.

IV. MIDDLE QUARTZITIC SAND.

1.	Red, brown, and gray sandstone	560 feet.
2.	Brown and gray quartzitic sand	60 feet.
3.	Gray quartzitic sandstone, with occasional large siliceous pebbles in thick beds	40 feet.
4.	Brown and gray flaggy sandstone	250 feet.

V. MIDDLE ALTERNATING HORIZON.

1.	Siliceous limestone conglomerate	5 feet.
2.	Brown and gray sandstone, with occasional thin bands of calcareous sandstone	410 feet.
3.	Calcareous sandstone	8 feet.
4.	Limestone conglomerate	2 feet.

VI. LOWER FLAGGY QUARTZITIC SAND.

1.	Brown and gray sandstone	125 feet.
2.	Light brown calcareous sandstone	15 feet.
3.	Brown and gray flaggy sandstone	700 feet.

VII. LOWER ALTERNATING HORIZON.

1.	Alternating siliceous oyster shell limestone and sandstone. The limestone ranges from slightly siliceous to decidedly siliceous limestone and is in thin bands, while the sandstone predominates	800 feet.
2.	Massive fossiliferous siliceous oyster shell limestone	40 feet.
3.	Thinly-bedded calcareous sand and siliceous shell limestone, with occasional thin bands of small oysters as flaggy limestone	250 feet.
4.	Siliceous flaggy shell limestone	100 feet.

The lower alternating horizons are decidedly siliceous, consisting of thickly-bedded to flaggy siliceous oyster shell limestone near the base, becoming more siliceous as the rocks are ascended, until near the top there occur bands of nearly pure gray and brown quartzitic sandstone alternating with flaggy oyster shell siliceous limestone.

In many places there are thin bands of a small fragile oyster, but the rock is so metamorphosed that the fossils do not weather in relief.

QUARTZITIC SANDSTONE HORIZONS.

The lower, middle, and upper sands of this bed do not differ materially from each other. Flaggy to thickly-bedded brown, gray, and reddish brown, nearly pure quartzitic sand and grit compose them. A small per cent of lime pervades the whole.

These sands mark periods of quite long continued shallow water during their deposition. Two hundred and fifty feet above the base of the middle quartzitic sand there is forty feet of massive gritty sandstone, with much coarse siliceous pebbles. No organic remains were found in the sand.

The middle alternating horizon is composed of a thin band of calcareous sandstone with limestone conglomerate, and a horizon four hundred and twenty feet thick of sandstone, with ledges of calcareous sandstone ending in a narrow band of limestone conglomerate.

The upper alternating horizon has thin bands, ten to fifteen feet thick, of flaggy argillaceous red to bluish-yellow marble alternating with thick bands, fifty to sixty feet thick, of flaggy gray and brown quartzitic sandstone.

The final alternating horizon succeeds the upper quartzitic horizon with about thirty-five feet of flaggy pale yellow marble and twenty-five feet of calcareous sandstone, between which one hundred feet of rock is concealed by basin debris. The calcareous sandstone disappears beneath the basin debris, dipping to the southwest. This debris, that everywhere prevails in valleys, conceals higher rocks.

No evidence was obtained that would throw positive light upon the division to which this bed belongs except the superposition of the strata. The presence of such extensive beds of sand points to long continued shore lines near at hand.

OCCURRENCE.—The only known occurrence of the Mountain series is along Quitman Mountain from Quitman Pass southward to the Rio Grande. By the succession of the rocks it occurs in the basin between Devil's Ridge and Quitman Mountain, but basin debris has concealed it, probably hundreds of feet below the surface.

II. UPPER CRETACEOUS SERIES.

1. Eagle Ford Shale or Benton Division.
2. Lower Cross Timber or Dakota Division.

There are certain rocks at the top of the Carpenter Spring section, on the east side of Eagle Mountain, which may be classed in the Upper Cretaceous series. They consist of a series of fissile, black, slightly arenaceous shale, flaggy siliceous shale, siliceous limestone, and cream-colored calcareous clay shale, in all making about eleven hundred feet of strata.

Intrusive and eruptive porphyry of Eagle Mountain has so disturbed the rock at the contact with the underlying Lower Cretaceous rock that the possible conformity could not be told.

These rocks are placed in the Upper Cretaceous series principally by numerous *Inocerami* in the shale and an oyster in the siliceous limestone, that are doubtfully correlated with the lower horizons of the Eagle Ford shales and the upper horizons of the Upper Cross Timber sand of the Brazos River section. In lithologic characters too they very much resemble the Eagle Ford shale and the upper bed of the Lower Cross Timber sand. There is a sudden ascent from the massive limestone which underlies these shales up into the shales, and at the point of contact the character of the rock changes entirely and the fauna of the limestone disappears.

Before taking up the division in detail, it will be well to speak of the manner of the occurrence of the rocks of Eagle Mountain.

Studies were made of the rocks on the north and east sides of the main mountain, and for lack of time these were not worked as thoroughly as is necessary for a complete report of them.

A collection of tall peaks and rugged terrace-like mounts of porphyritic and other trachytic rock, in all extending about four miles in every direction from the center, forms Eagle Mountain. Eagle Peak, the tallest of the group, rises some two thousand feet above the surrounding basin.

Around the base, on the north and east sides, there extends a fringe of Carboniferous and Cretaceous rocks in a series of broken hills.

The striking feature of the Cretaceous and even the Carboniferous rocks is that they almost invariably dip towards the southwest, as is the case with the rocks of Devil's Ridge, Flat Mesa, and Southern Quitman Mountain. In the east side of Eagle Mountain, from the base nearly two miles inward, the Cretaceous limestones, sandstones, and shales, aggregating a thickness of three thousand feet, dip regularly to the westward beneath the mountain, and the porphyry has welled up and cut across the edges of the shale and sands or has overflowed since the rocks have been tilted and eroded. In many places, from the base to the top of the exposed stratified rocks, the porphyry of the mountain has erupted as dykes across the strata, or passed up between the tilted strata as intrusive sheets.

The action of the igneous rock of Eagle Mountain upon the stratified rock has made work on them complicated and difficult, by highly metamorphosing them, destroying the fossil remains, and disturbing the strata.

Three sections were made across the Cretaceous rocks of Eagle Mountain:

a. Finney's Ranch section, at the south end of Eagle Mountain.

b. Carpenter Spring section, near the middle of the mountain on the east side; and

c. Eagle Spring section, at the northeast end of Eagle Mountain.

Upper Cretaceous rocks were found only in the Carpenter Spring section.

LOWER CROSS TIMBER OR DAKOTA DIVISION.

The resemblance of the rocks of this division to those of the Fish Bed (which is the same as the Eagle Ford shale or Benton division in North Texas) division of the Upper Cretaceous south of the Brazos River is very marked. In each fissile yellow clays and flaggy, calcareous, argillaceous sands prevail. They often become dark and decidedly sandy, highly charged with organic matter. The clay shale and flaggy siliceous limestone is considered to belong to this division. There is no stratigraphic break between this and the shale overlying the siliceous limestone, and there was nothing found that makes a gap wider than exists between the Lower Cross Timber sands and Eagle Ford shale in the Trinity or Brazos River section.

In the Brazos River section, very near the division line between the Lower Cross Timber sand and the Eagle Ford shale, there occurs a horizon of siliceous limestone carrying an oyster closely resembling the specimen found here in the siliceous limestone horizon.

The Dakota division separates into four horizons, as follows:

1.	Calcareous flaggy sandstone, with oyster shell fragments	60 feet.
2.	Fissile dark shale, grading upward into arenaceous shale, with bands of argillaceous sand	220 feet.
3.	Fissile brown shale	50 feet.
4.	Cream-colored to brown fissile calcareous shale	30 feet.
	Total	360 feet.

EAGLE FORD OR BENTON SHALE DIVISION.

The lower portion of this division above the arenaceous limestone is materially the same as No. 1 of the Dakota division below the same limestone. Small Inocerami occur in the upper portion of the bed. The upper bed of the division includes the most extensive development of the series. There is four hundred feet of homogeneous fissile black clay shale. Numerous individuals of a small Inoceramus and a small fragile Gryphea were observed.

Lithologically, the Eagle Ford or Benton Shales separates into three beds:

1.	Very fissile, black, slightly arenaceous clay shale, with numerous individuals of a small Inoceramus and a fragile oyster or anomia	300 feet.
2.	Flaggy, fissile, calcareous, argillaceous sandstone, with numerous oyster shell fragments and an Inoceramus at the upper edge	430 feet.
3.	Siliceous limestone with oyster	30 feet.
	Total thickness	760 feet.

Higher rocks have been removed by eruptive porphyry of Eagle Mountain.

On account of the isolated areas into which the stratified rocks of El Paso

County are separated, it is difficult to comprehend the succession of the rocks. The fact, too, that the variation of the same beds, in the character of the rock and manner of their deposition over a comparatively small scope of country. adds still more to the difficulty of the problem. The Malone bed, as illustrated in Malone Mountain and Etholen Knobs, is a striking instance, and if it were not for the more persistent beds on each side of it, its position in the succession of strata could never have been told here.

The following comprehensive section of the rocks worked in El Paso County to the present is given below, that the succession of the rocks may be observed at a view.

Section of Cretaceous rocks investigated in El Paso County to the present:

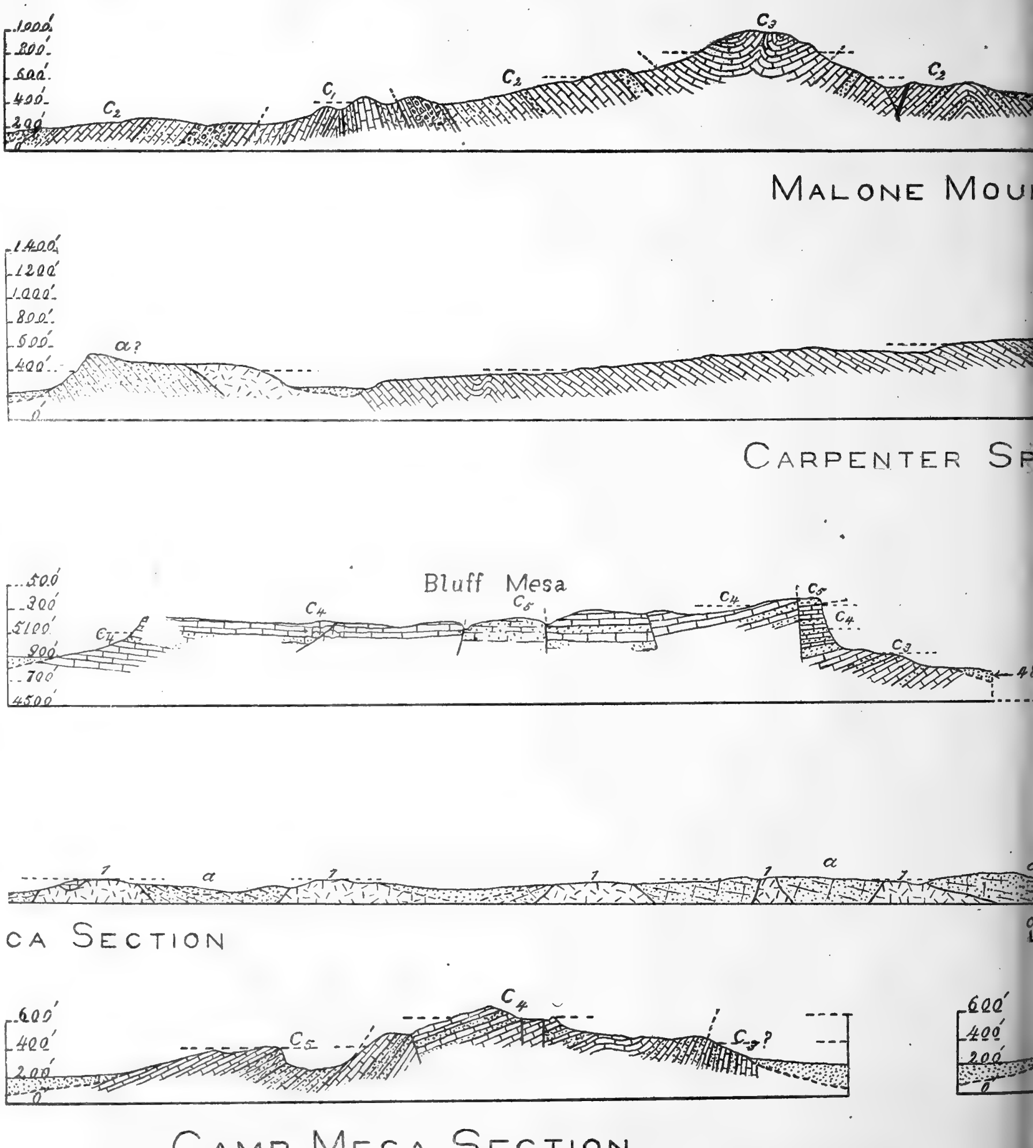
PROGRESS SECTION OF THE CRETACEOUS SYSTEM IN EL PASO COUNTY, AS DEVELOPED BY THE WORK OF THE FIELD SEASON OF 1890.

Upper Cretaceous.

Division.	Bed.	Horizon.	Locality.	Thickness.
				Feet.
Eagle Ford or Benton Shale.	Carpenter.	Shale with *Inocerami*. Arenaceous flaggy shale. Arenaceous lime.	Carpenter Spring, east side of Eagle Mountain. Eagle Spring.	760
Lower Cross Timber or Dakota Sand.	Eagle.	Upper calcareous sand. Lower yellow clay shale.	Carpenter Spring, east side of Eagle Mountain.	360

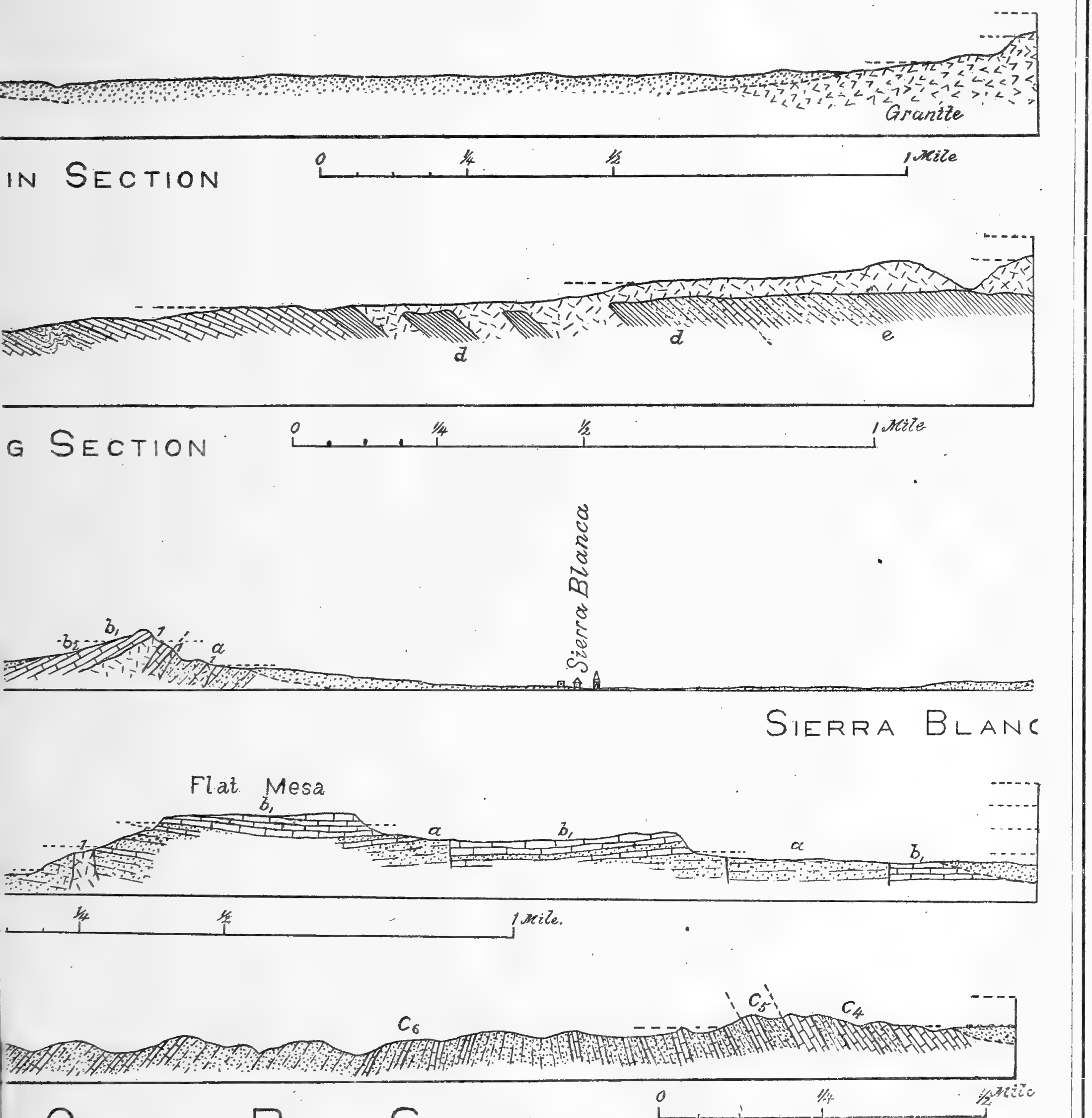
Lower Cretaceous.

Division.	Bed.	Horizon.	Locality.	Thickness.
				Feet.
Washita.	Mountain.	Flaggy marble. Upper quartzitic sand. Upper alternating flags. Middle quartzitic sand. Middle alternating flags. Lower quartzitic sand. Lower alternating flags.	Quitman Pass, Quitman Mountains.	4060
	Quitman.	Caprotina Limestone (fourth horizon). *Exogyra.* } Sand. *Ostrea.* }	Quitman Pass. Bluff Mesa. Yucca Mesa. Camp Mesa.	330
	Bluff.	Caprotina (third horizon). *Monopleura.* *Ostrea.*	Quitman Pass; Camp Mesa; Yucca Mesa; Bluff Mesa; Kyle's prospect; southwest side Quitman Mountain.	
		Orbitolina texana.	Quitman Pass; Camp Mesa; one and one-half miles northeast of Quitman Pass; Kyle's prospect; southwest side of Quitman Mountain, south of Big Spring Gulch. Bluff Mesa, Yucca Mesa, and Eagle Spring.	
		Alternating limestone and sandstone.	Bluff Mesa, Yucca Mesa, Camp Mesa, Kyle's prospect, and southwest side of Quitman Mountain, south of Big Spring Gulch.	235
	Yucca.	Caprotina (second horizon) Limestone.	Yucca Mesa. Bluff Mesa.	
		Alternating sands, grits, arenaceous limestone, pisolitic conglomerate, and flaggy marble.	Yucca Mesa. Bluff Mesa. Quitman Mountain, south of Quitman Pass. Malone Mountain.	
		Final *Exogyra texana.*	Yucca Mesa. Bluff Mesa. Quitman Mountain, south of Pass.	1145
	Etholen.	Gypsum.	Malone Mountain.	
		Limestone boulder breccia. Limestone conglomerate. Flaggy marble.	Etholen Knobs. Malone Mountain. Hills one mile south of Etholen. Quitman Mountain, south side of Big Spring Gulch. Etholen Knobs.	240
	Malone.	Gypsum. Limestone. Gypsum. Flaggy limestone.	Malone Mountain. Malone Mountain. Malone Mountain. Malone Mountain.	
		Sandstone and oyster shell breccia.	Etholen Knobs.	350
	Caprina.	*Caprina crassifibra* (second horizon).	South base Sierra Blanca Peak.	10
	Arietina.	*Foraminifera.* (*Nodosaria texana.*)	South base Sierra Blanca Peak. Flat Mesa. Railway cut, north side of Quitman Mountain. South end of Quitman Mountain.	
		Exogyra arietina and *Gryphea.*	Railway cut, north side of Quitman Mountain. South base Sierra Blanca Peak.	85
	Caprotina.	Caprotina Limestone (first horizon).	One-half mile southwest of Sierra Blanca Station. Two miles southeast of Sierra Blanca.	15
Fredericksburg.	Caprina.	Caprina (first horizon).	One-half mile southwest of Sierra Blanca Station. Flat Mesa. Scarp four miles north of Flat Mesa.	25
	Texana.	*Exogyra texana.*	Flat Mesa. Scarp four miles north of Flat Mesa.	15
Basal (Trinity?) Sand.	Trinity.	Sand.	Near Sierra Blanca. Flat Mesa.	
		Conglomerate. Sand. *Actaeonella.* Quartzitic sand.	Flat Mesa. Flat Mesa. Near Sierra Blanca. Flat Mesa.	195



a. Trinity Sand.
b1. Caprina Bed, Fredericksburg Division.
b2. Caprotina Bed, Fredericksburg Division.
c1. Malone Bed, Washita Division.
c2. Etholen Bed, Washita Division.
c3. Yucca Bed, Washita Division.

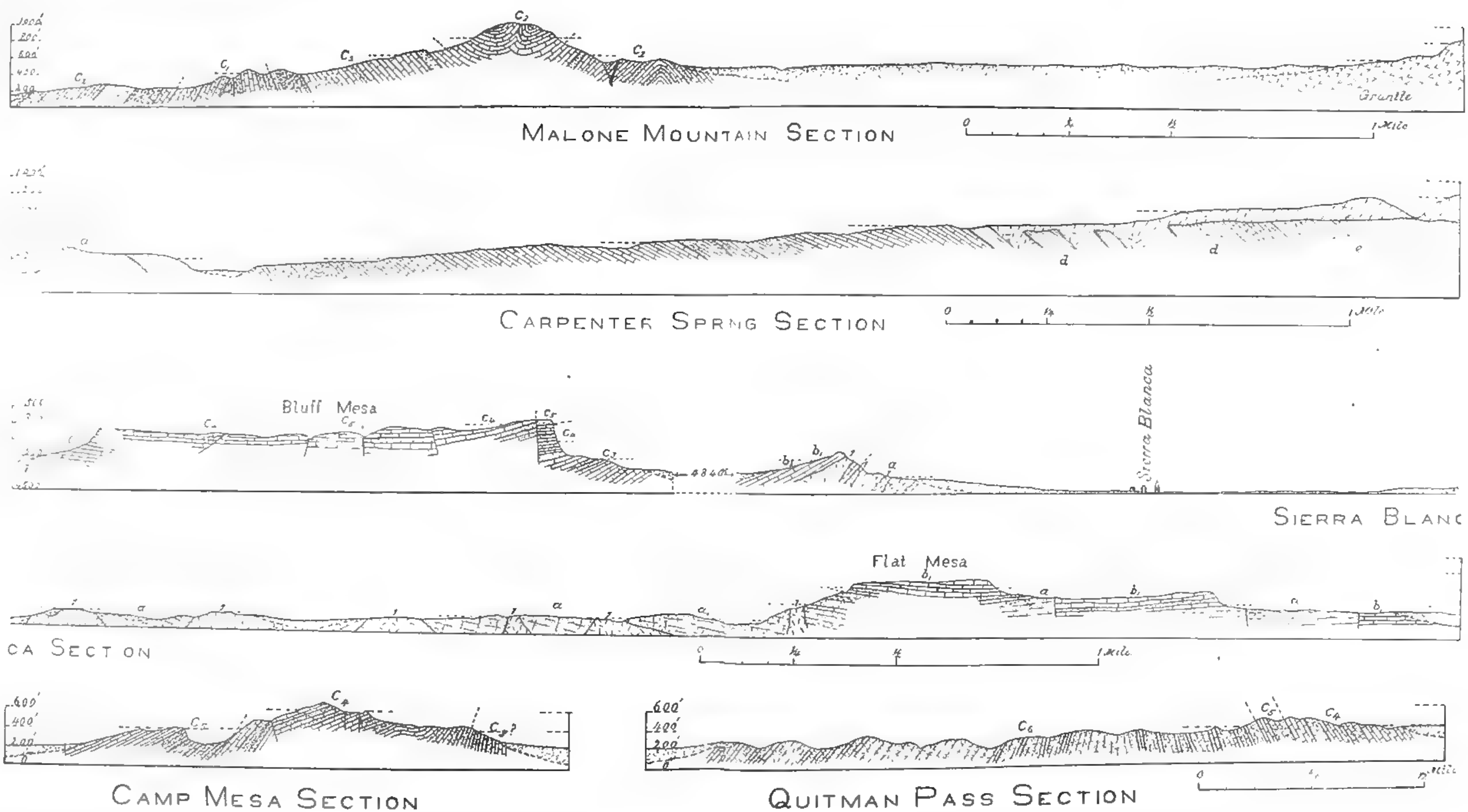
SECTIONS OF CRETACEOUS



Bluff Bed, Washita Division.
Quitman Bed, Washita Division.
Mountain Bed, Washita Division.

d. Lower Cross Timber or Dakota Division.
e. Eagle Ford Division.
1. Porphry.

EL PASO COUNTY, TEXAS.



a. Trinity Sand.
b1. Caprina Bed, Fredericksburg Division.
b2. Caprotina Bed, Fredericksburg Division.
c1. Malone Bed, Washita Division.
c2. Etholen Bed, Washita Division.
c3. Yucca Bed, Washita Division.
c4. Bluff Bed, Washita Division.
c5. Quitman Bed, Washita Division.
c6. Mountain Bed, Washita Division.
d. Lower Cross Timber or Dakota Division
e. Eagle Ford Division
1. Porphyry.

SECTIONS OF CRETACEOUS IN EL PASO COUNTY, TEXAS.

CONCLUDING REMARKS ON THE DYNAMIC FEATURES OF THE CRETACEOUS ROCKS WORKED IN EL PASO COUNTY.

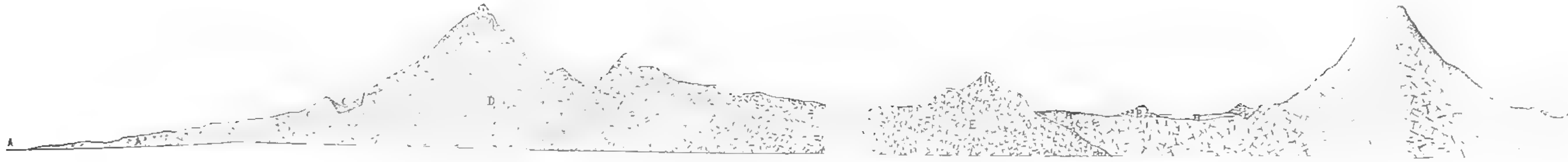
It is observed that in all the uplifts and disturbances noted as being connected with the Eagle, Quitman, and Sierra Blanca mountains Cretaceous rocks are affected. It is observed also that there are four principal trends or lines of fracture of the strata in these uplifts, with many subtrends or local disturbances. One of the principal uplifts extends from Eagle Mountain in the line of Devil's Ridge to the Sierra Blanca Mountains, bearing about north 55° west, magnetic. This line, if extended, will approach the Hueco Mountains, which are suspected of being in the same trend. Another is that of South Quitman Mountain, extending from the Rio Grande northward, including the porphyritic portion of the mountain north of Quitman Pass, bearing about north 30° west, magnetic. These two uplifts are the same in character. The remarkable feature of them is that the rocks almost invariably dip to the southwestward, even in spite of eruptive mountains of porphyry and basaltic rock two thousand feet high. It is pretty evident that there are fault lines or immense isoclinal folds, and that in their formation there was a major stress from the southwest. If they were isoclinal folds the axes are now hidden by the basin debris that occupies the valleys.

A third trend is that of North Quitman Mountain. There is evidence going to show that this is the oldest uplift. Rocks on the west side of North Quitman Mountain strike north 20° west, magnetic. If the extensive folds of South Quitman, Eagle, and Sierra Blanca mountains had extended over the area now occupied by Quitman Mountain the dip would undoubtedly have been different. Around the bases of North Quitman Mountain the rocks wherever exposed dip regularly away from the mountain, and do not show indications that they were broken by the uplift of South Quitman Mountain. The most southerly exposed trends of Devil's Ridge break up on approaching Quitman Mountain, while those on the north side of the ridge pass on through Sierra Blanca Peak.

The fourth principal uplift is that of Malone Mountain. This uplift conforms in part to both the uplift of North Quitman and of the Eagle-Sierra Blanca uplift. The strike of the rocks in the southeast end of Malone Mountain agree nearly with that of North Quitman Mountain, while that of the northwest end of Malone Mountain conforms to that of the Eagle-Sierra Blanca uplift.

The sharp isoclinal folds, with southwestward dipping axis planes and inverted strata toward the northeastward on the northeast side of the mountain, plainly indicate that the Malone Mountain is the result of thrusts from the southwest into the obtuse angle of the North Quitman and Eagle-Sierra Blanca trends.

There are many local disturbances and faultings, the principal of which are in Devil's Ridge and Flat Mesa, that are incident to the eruptions of Eagle, Sierra Blanca, and Quitman mountains, but it is not expedient to go into detailed explanation of them now.

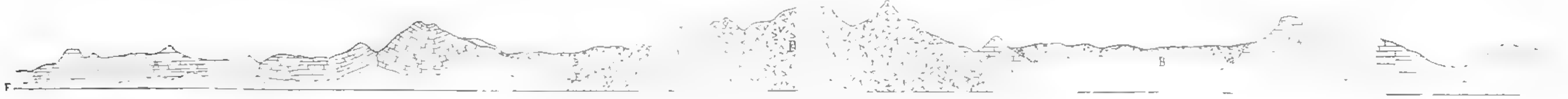


SECTION THROUGH THE QUITMAN MOU[illegible] AND SIERRA BLANCA PEAK.

A, Metamorph[illegible] Sandstone Quartzite. [illegible] Cretaceous Limestone. [illegible] Crystalline Limestone [illegible] Schists. D, Porphyritic Re[illegible] Rock. [illegible] Rock, [illegible] strongly Metamorphosed Sandstone. H, [illegible] Cretaceous.

SECTION THROUGH THE QUITMAN MOUNTAINS FROM THE PASS TO [illegible] MALONE STATION ON THE SOUTHERN PACIFIC RAILWAY.

A, Granite. B, Porphyritic Rock. [illegible] Metamorph[illegible] Limestone and Sandstone [illegible]. D, Cretaceous and Post-Cretaceous Deposit. E, Cretaceous Limestone.

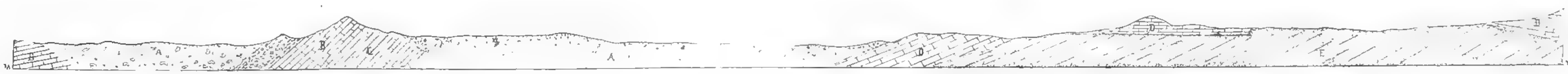


SECTION THROUGH THE QUITMAN MOUNTAINS FROM THE SECOND MESA TO THE MALONE RANGE.

A, Cretaceous Limestone. B, Granite [illegible] Metamorphosed Cretaceous Sandstone. D, Newer Granite. E, [illegible]

SECTION THROUGH [illegible] HILL RANGE EAST OF SIERRA BLANCA PEAK.

A, Post-Cretaceous Deposit. B, [illegible] Sandstone. D, Porphyritic [illegible]

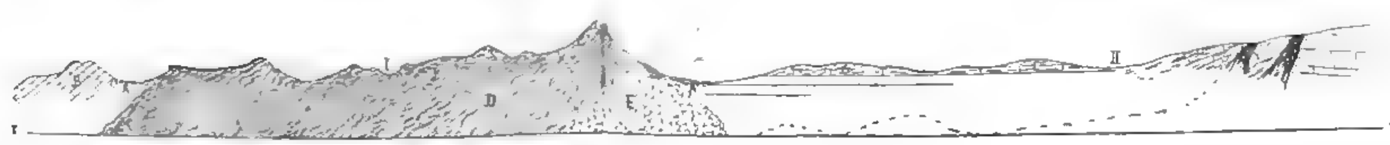


SECTION THROUGH DEVILS RIDGE AND FOOTHILLS OF SIERRA DIABOLO CROSSING THE FLAT ABOUT THREE QUARTERS OF A MILE WEST OF [illegible]

A, Gravel, boulders, sand, and clay of unknown thickness (by boring at Torbert no rock reached at 1010 feet). B, More or less Metamorphosed Cretaceous Limestone. C, [illegible] Metamorphosed Cretaceous Sandstone. D, Carboniferous Limestone [illegible] coal bearing deposit. E, Red Sandstone (no fossils found till now). F, Brecciated Conglomerate (cemented by silico ferruginous material).

SECTION FROM THE FOOTHILLS OF THE EAGLE MOUNTAINS TO THE FOOTHILLS OF THE SIERRA DIABOLO, NEAR EAGLE FLAT.

A, Southern Pacific Railway. B, Texas [illegible] Railway. C, Post-Cretaceous Deposit (no rock struck at 1050 feet). D, Cretaceous Limestone. [illegible] Carboniferous Limestone. F, Conglomerate of Metamorphic and Serpentinous Rock cemented by ferruginous [illegible] matter. G, Red Sandstone. H, Talcose and Mica Schist.



SECTION THROUGH CARRIZO MOUNTAINS (I) AND FOOTHILLS OF SIERRA DIABOLO (II).

A, Newer Deposits. B, Cretaceous Limestone. C, Non-Coal bearing Marine Carboniferous. D, Crystalline Schists. E, Granitoid Rock.

SECTION THROUGH CARRIZO MOUNTAINS AND FOOTHILLS OF SIERRA DIABOLO.

A, Newer Deposits. B, Crystalline Schists. C, Red Sandstone and Grit. D, Carboniferous.

SECTION THROUGH MESA SOUTH OF SIERRA BLANCA TO HILLS NORTH OF SIERRA BLANCA.

A, Post-Cretaceous Deposit. B, Cretaceous Limestone (resting probably on Sandstone). C, Porphyritic Intrusions.

COMPARATIVE SECTIONAL SKETCH OF THE CLIFFS OF THE LIMPIA (A) AND BOFECILLOS MOUNTAINS (B).

C, Trachytic Rocks. D, Yellow Sandstone. E, Debris.

W. H. STREERUWITZ, GEOLOGIST FOR WESTERN TEXAS.

SECTIONS ALONG LINES INDICATED ON TOPOGRAPHIC MAPS OF TRANS-PECOS TEXAS.

INDEX.

C.

F.

G.

H.

N.

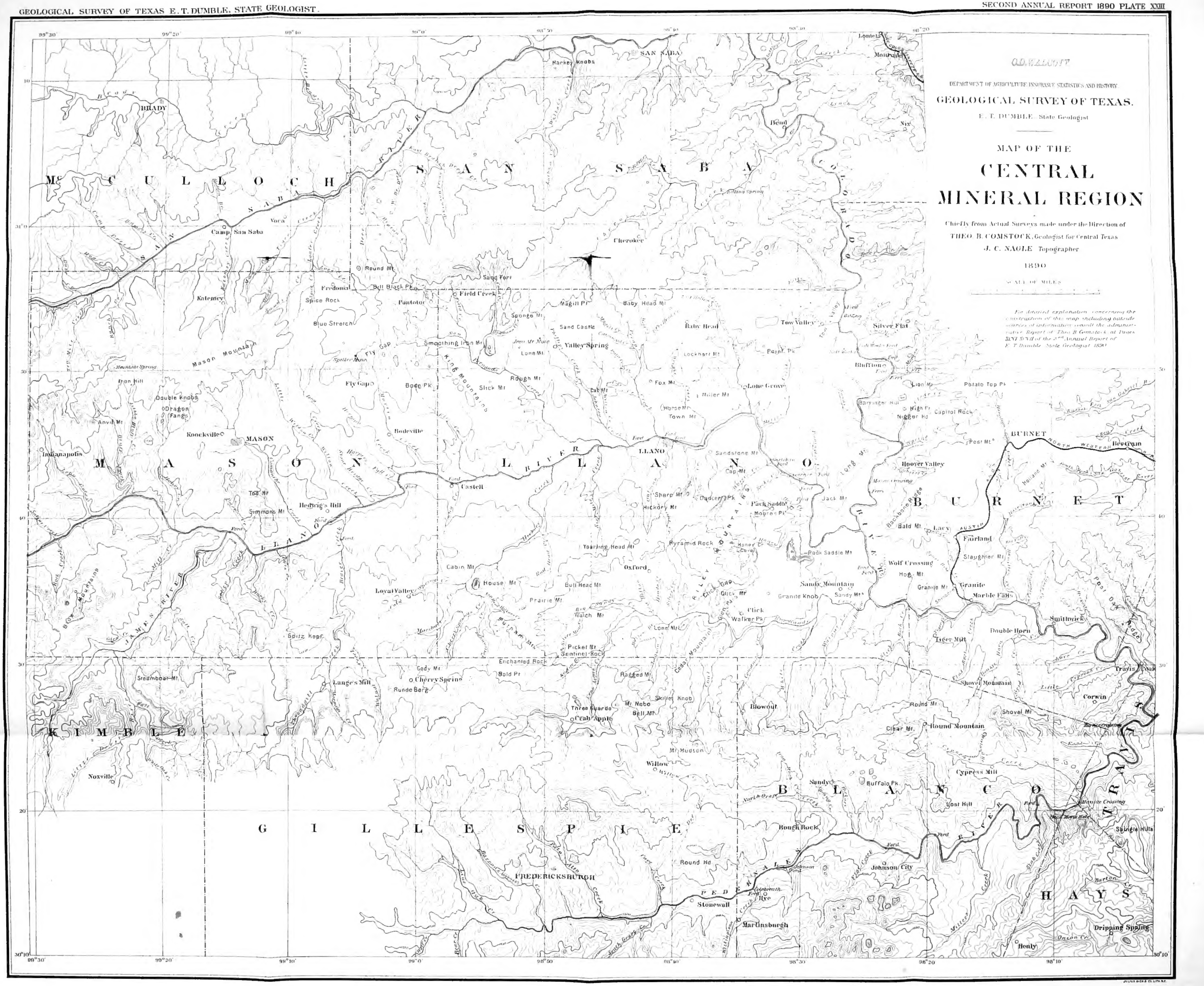
O.

V.

W.

Y.

Z.

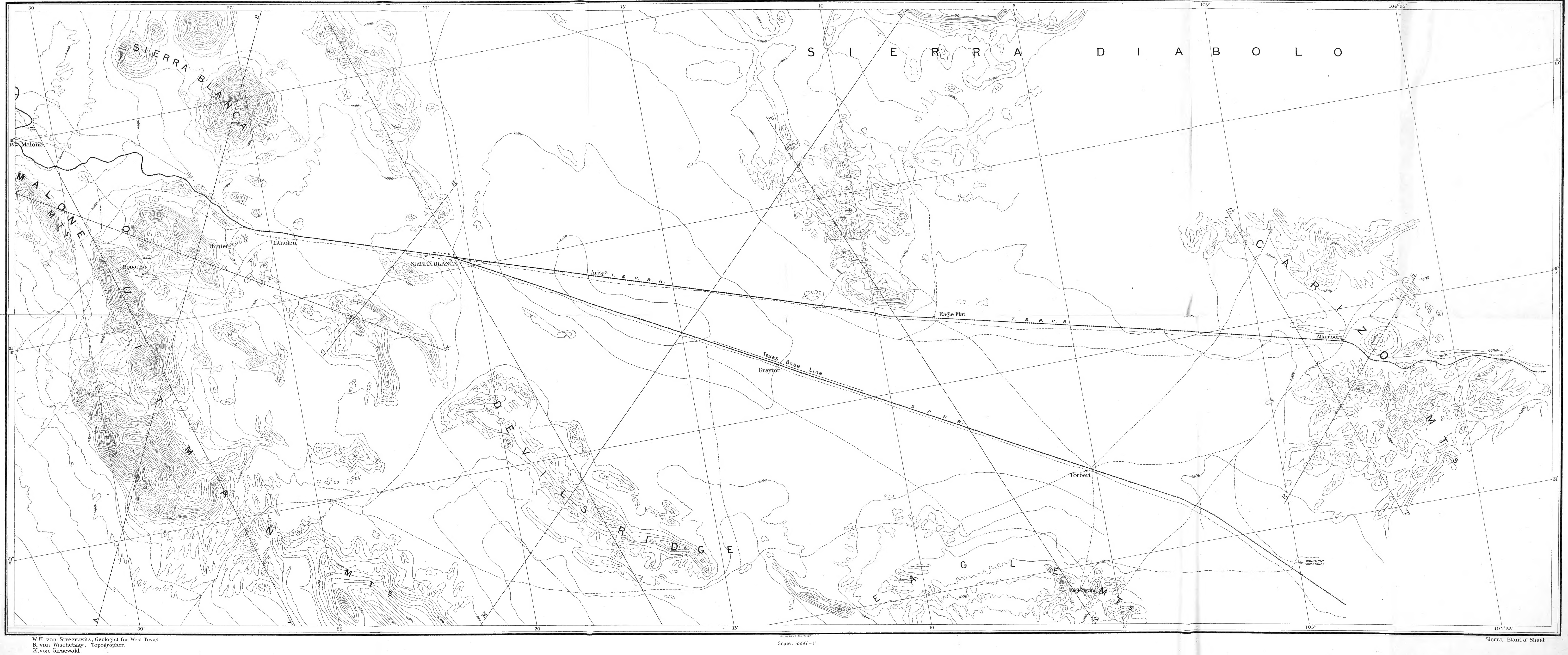

DEPARTMENT OF AGRICULTURE INSURANCE STATISTICS AND HISTORY.
GEOLOGICAL SURVEY OF TEXAS.
E. T. DUMBLE, State Geologist
MAP OF THE
CENTRAL
MINERAL REGION
Chiefly from Actual Surveys made under the Direction of
THEO. B. COMSTOCK, Geologist for Central Texas
J. C. NAGLE Topographer
1890
SCALE OF MILES
McCULLOCH
SAN SABA
MASON
LLANO
BURNET
KIMBLE
GILLESPIE
BLANCO
HAYS
TRAVIS
BRADY
SAN SABA
MASON
LLANO
BURNET
FREDERICKSBURGH
Johnson City
Marble Falls
Dripping Spring

GEOLOGICAL SURVEY OF TEXAS E. T. DUMBLE, STATE GEOLOGIST.

TOPOGRAPHIC MAP OF TRANS PECOS TEXAS.

C.D. WALCOTT

SECOND ANNUAL REPORT 1890 PLATE XXVIII



W. H. von Streeruwitz, Geologist for West Texas.
R. von Wischetzky, Topographer.
K. von Girsewald, "

Scale: 5556' = 1"

Sierra Blanca Sheet