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BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.

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PRE-GLACIAL DRAINAGE IN THE VICINITY OF CINCINNATI; ITS RELATION TO THE ORIGIN OF THE MODERN OHIO RIVER, AND ITS BEARING UPON THE QUESTION OF THE SOUTHERN LIMITS OF THE ICE-SHEET.

By GERARD FOWKE.

For more than sixty miles below the mouth of the Little Miami, the Ohio river flows through a tortuous channel. The dial of a compass fixed on a steamer will, in that distance, make a complete circuit under the needle. Much of the way the outer curves sweep over rocky detritus fallen from rugged hills crowned with precipitous bluffs; opposite these the inner curves flow gently over sand-bars bordering terraced bottom lands. The variation in the width of the valley is considerable; at times the upland on one side recedes, and a wide bottom intervenes between its foot and the river; again, the hills approach each other until only a narrow strip of alluvial soil is found.

For fifty miles above the Little Miami different conditions prevail; the valley is more uniform in breadth, the hills have gentler slopes and more symmetrical contours. The geological formation within this area is identical, all of it lying in the Cincinnati or Hudson River group; measured vertically, there is about one foot of compact blue limestone to ten feet of gray or bluish clay. Such a combination does not readily lend itself to the construction of cliffs by atmospheric erosion; while the close texture of the clay and its extension below surface drainage lines, precludes such disintegration of lower strata as would result in cliffs due to great landslides or the downfall of large masses of rock. The topography above the Little Miami is normal, while the phenomena below that point are quite different from what would be expected. An examination of the region, with a view to learning the reason of this diversity, resulted in some interesting discoveries.

It must be stated, however, that the work of deciphering the earth-written records has not been fully carried out. Many details are yet to be studied before an accurate map of the ancient drainage can be constructed, or a full explanation given of the causes which led to the establishment of the present water-courses. This work I had hoped to do before offering a paper on the subject; but circumstances have made it necessary that I should present an account of the part that has already been accomplished, and indicate the lines along which further investigations are required.

It will aid the reader in following the argument, to state at once that the Ohio, as an independent river, had no existence prior to the glacial epoch. Its present course, in so far as it now needs to be considered, was occupied entirely by a succession of unconnected creeks and ravines. There was a col at the eastern limit of Maysville, separating the waters of Cabin creek and Limestone creek. The former flowed north and east, and either joined Kinniconnick creek or followed Brush creek valley into Paint creek. The waters of Limestone followed their present direction to the mouth of the Little Miami, thence through the broad valley north of Cincinnati (see (A) on the accompanying map), and entered the present Mill creek valley somewhere in the vicinity of Carthage (B). The drainage to the east and north of this section has not yet been worked out.

There was a col between Little Miami and Licking, near the eastern line of Cincinnati, at the point (C); two very short ravines headed here and discharged, one toward either side. Another col, (D), existed at the lower end of Cincinnati. Between these last two cols, (C) and (D), the Licking flowed directly across the Ohio Valley, into Mill creek valley. Receiving old Limestone creek at (B), as above stated the Licking then passed on northward and entered the valley of the Great Miami at the city of Hamilton.

On the west side of the col (D) headed a ravine which followed the present bed of the Ohio to North Bend, the most northern point of this river below the mouth of Kanawha. At North Bend this creek or ravine cut through the hill to the north and entered what is now the bed of the Great Miami. From this point it may have followed the line of that stream northward and joined old Laughery creek in the vicinity of (E); or it may have continued a westerly course and fallen into old Laughery near the point (F). If the latter was the case, another ravine headed near by and flowed north along the Great Miami to (E). Further research will determine this drainage line.

Just west of North Bend was another col, at the point (G); but it seems to have been a continuation of the hill on the south, with a uniform slope across the present bed of the Ohio, forming the water-shed between the last mentioned ravine and old Laughery, and not a low divide between the heads of two smaller ravines tributary to these. Below this point, the mouth of the Great Miami is reached, in an ancient channel whose drainage is now reversed.

Proceeding down the Ohio, it will soon be found that this old stream had two main branches: one of them Laughery creek, now flowing into the Ohio two miles below Aurora; the other a creek rising somewhere near Sugar Creek Landing in Gallatin county, Kentucky, (K). Going up the river from this point, it will be observed that the valley gradually widens to the mouth of Grant's creek (J), where it is much wider than at any other place on the map; from here, high and wide bottoms on the Kentucky side extend as far as Petersburg (H). This greater width does not, however, properly belong to the eroded portion of the valley but is due to the fact that low foothills, produced by several ravines coming in along here, have been covered with glacial drift.

At (I) is "Split Rock," concerning which more is to be said.

Back of Petersburg is an abandoned channel (H), filled with drift and safe from the highest floods.

It is a noteworthy fact that from Sugar creek to Petersburg almost every creek that comes in on either side, whose source is in the hills, flows in a direction opposite to the Ohio until it reaches the bottom land, when it turns in a way to conform to the course of the river. It seems odd while going down the main stream, to look toward the head of nearly every tributary, large or small, whose valley is in the line of vision.

For eight miles below Aurora the Ohio, flowing on a rocky bottom, closely hugs the Indiana side; from Petersburg to some distance below Grant's Landing the ancient channel is now concealed by the drift on the Kentucky side. Laughery creek, after receiving the Sugar creek tributary two miles below Aurora, and Hogan's creek at that town, flowed north into the broad valley now held by the Great Miami; but instead of following the present bed of that stream (with a reversed current, of course), it held the same general direction with which it entered the valley, until on reaching the point (L) it swerved eastward, reaching the Great Miami valley again near the north line of Hamilton county at (E), and followed that valley to the city of Hamilton where it united with the Licking.

Beyond this place no examination has been made; but some ancient channels marked out in the reports of the Ohio Geological Survey indicate that the Licking received another tributary in this vicinity, made a detour to the east of Dayton, then bore northwest, past Troy. Prof. Tight has shown that Kanawha flowed north through the Scioto valley, and turned toward the northwest near Circleville; so Licking must have discharged into it in the neighborhood of Piqua.

THE FORMATION OF THE OHIO RIVER.

It will simplify an explanation to retain for the ancient drainage lines the names of the present streams, using them as they are used above.

The Great Kanawha held its way across Ohio until the glacier had advanced to that part of its valley which extended farthest to the northward. For a time the waters may have skirted the ice-front and recovered their natural channel farther down ; but presently the valley was completely closed and the imprisoned waters found no escape until they had reached the level of the col at (K), on the divide between Sugar creek and Kentucky river.

This narrow pass, however, was much too small to carry off the drainage of many thousands of square miles, and its capacity was still further decreased by ice-bergs carried hither by the currents and gorged between its walls so the water accumulated until only the tops of the higher hills remained above its surface. Blocks of ice, broken from the glacier front, floated about in the lake, most of them depositing within a comparatively short distance the glacial debris which they carried ; others, much smaller perhaps, drifted many miles before they grounded on a drowned hill-top and left a boulder or a mass of gravel to puzzle a future geologist by its isolated position, so far from any moraine.

As the lake rose, other outlets would be reached at various levels higher than the col at Sugar creek ; finally the overflow would balance the accumulation. When the new channel was cleared of ice, and torn wider and deeper by a torrent like Niagara, the lake would begin to recede, the minor outlets would be abandoned, and all the discharge pass through the Sugar creek gap.

At this stage began the readjustment of drainage channels. The first change was in that part farthest west. Kanawha, shut off from its natural outlet toward the west, turned into Licking ; followed that valley southward to Hamilton ; turned into Laughery creek ; and thus reached the gorge at (K). But the stream was to have short tenure of its new quarters ; the advancing ice soon choked up the mouth of the Licking, and Kanawha was again deprived of an outlet. A second lake was formed, including the basin of Kanawha and all its tributaries east of Licking. The Monongahela, in pre-glacial times, had its outlet in the present Lake Erie ; it, too. had been shut off, and compelled to break a way from its old bed at Beaver, Penn., to the Kanawha at Huntington, West Va. At whatever time this occurred, it was certainly previous to the formation of the second lake in Kanawha ; so this additional amount of water was also to be disposed of. Consequently it would require only a short time for the resulting lake to find its way up Kinniconnick creek to the mouth of Cabin creek, or to the col separating those two streams, break over into Cabin, fill that valley and then rush over the divide between it and Limestone creek and follow the latter to its junction with Licking at the point (B), north to Hamilton, thence out Sugar creek.

In the course of time the steadily encroaching glacier covered the country about Hamilton ; and for the third time a lake was formed. Both Kanawha and Licking were now shut off; their waters rose over the col at (D), and pushing through the narrow valley beyond, made their way out to Laughery creek at either (E) or (F), or possibly in both directions for a time ; for even had the original point of discharge for this ravine been at (E) the glacial floods would by this time have torn a way through and thus established the present course of the Great Miami.

Still a fourth time was Kanawha to have its outlet shut off and its rapid current converted into a tranquil lake. The glacier came to the hills around Cincinnati ; when this happened the old mouth of Limestone at (B) was obliterated, and Kanawha was compelled to make a new course for itself by tearing out the col at (C). Joining Licking again, the two followed their last channel as far as North Bend, and probably out to (F) ; but there is a possibility that before the col at (C) was removed the ice had advanced far enough to reach the hills south of (F). In this case the new lake would have included Licking valley and risen to the level of the col at (G) before it could have begun to drain off.

Note.—How many intervening cols were broken through by the Monongahela in its passage to Kanawha, or how many lakes and lakelets were successively formed and drained, can not yet be told ; but to judge from the numerous sharp bends in that part of the Ohio, they must have been frequent. This is a factor to be taken into consideration, in studying the terraces of the upper Ohio and its branches.

If, however, the col at (C) was worn down in time for the water above it to escape through (F), then a fifth lake covered the upper Ohio valley before the col at (G) was eroded and the present drainage to the mouth of the great Miami established; and there may have been still a sixth lake, though if there was, it was of less extent and shorter duration than any of the others. The abandoned channel (H) back of Petersburg, seems due to a projection or "loop" of the glacier pushing out of Miami valley far enough to act as a dam to the new Ohio—which name is now first applicable to the river—and holding it back until its waters broke over the low divide that stood between old Laughery creek, and the ravine that came into the latter from the point (G). This is the only evidence that the ice ever reached the Kentucky side of the river, and it was not of sufficient thickness to raise the water to the table-land.

It is not to be supposed that each of these successive lakes was drained before the next was formed; it is more probable that the gorge at (K) retained sufficient height to keep the present bottom lands, at least the lower ones, continually submerged until long after the ice had begun its retreat. Neither is it necessary to assume a constant forward motion of the glacier; its advance may have been frequently interrupted, or there may even have been an occasional recession, without in the least invalidating the argument. The effect would be the same in the end, whether there was a continuous progressive motion, or an intermittent action.

As nothing to the contrary has been said so far, it might be inferred that the Ohio, after first surmounting the col at (K) had an unchecked course to the Mississippi; but such was not the case. Kentucky river, Salt river (below Louisville), and possibly others, had a northward trend across the present Ohio valley into the state of Indiana. It is not known as yet, where they may have gone; but it is certain that their outlets were choked up by the ice as were those of Kanawha and Licking. They had to find their way out in the same manner and by the same means. Of this, the canon at Leavenworth is ample evidence; and it is not until the mouth of Green river is reached, near Evansville, that a pre-glacial stream of any importance is to be found in the bed of the Ohio.

THE PROBABLE SOUTHERN LIMIT OF THE ICE-SHEET.

Charts of the terminal moraine represent it as crossing the Ohio River at four different points.

It is doubtful whether the glacier ever reached the left bank of that stream except as a spur from the mouth of the Great Miami.

If this opinion were made in the form of a definite assertion, it would need to be supported by a very distinct record of accurate observations; and these I have been unable to make. It is permissible for me, however, to present the reasons for my belief, leaving them to be confirmed or refuted, as they may deserve, by those who will have an opportunity for making a thorough investigation of the region.

Glacial drift has been found in quantity on the hills about Cincinnati; at "Split Rock;" and about the mouth of Kentucky river. These points have been connected, on some charts, by a line approximately straight; and this line is called the terminal moraine. It may be; I do not wish, at present, to say that it is not. But on such limited portion of the ground as I have had a chance to examine, I can find no evidence that it is a fact. There is no drift in Hogan's creek, at Aurora, at a greater height than it is to be found in the opposite Kentucky bottoms. There is none on the hills just south of that town. There is none in the valley of Laughery creek below the town of Hartford, eight miles from its mouth, except one small mass which is plainly a water deposit. There is none in the ravines or along the hill-sides on the road from Hartford to Rising Sun. Yet the maps show that all this area, except in the vicinity of Rising Sun, was under the ice-sheet. The heavy deposit about the mouth of Woolper's creek, known as "Split Rock" and "Kirby's Rock," (I), which is called the moraine, is not a moraine and has no resemblance to a moraine except at the western face—which part is plainly visible from the river. Fifty feet back from this face, along the south side of Woolper's, the character of the deposit is clearly shown; it is simply a mass of detritus carried by a torrent into a body of dead water. The dead water was the glacial lake created by the col at (K); the torrent was that which poured through the gap back of Petersburg (H) in the final effort of the Ohio to carve out its channel. Following the north side of the base of "Kirby Rock" (which is the proper one for study, "Split Rock" being insignificant by comparison), it will be found that the large stones disappear within a few rods and are succeeded by cobble-stones; these by gravel which grows smaller until it runs out in beds of sand; the sand, in turn, is soon replaced by the finest silt, resting against the limestone hill-side; and above this there is nothing resembling glacial drift, as far as the brow of the hill.

Of what may be on the table-land, I have no knowledge. In the report of the Indiana Geological Survey for 1878, it is stated that the hill-tops south and south-east of Middle creek—which enters the Ohio opposite Rising Sun—are capped with conglomerate similar to that at "Split Rock." I did not know of this at the time of my visit to the locality; it is probably due to ice-berg deposits at the beginning of the overflow at (K). Four miles below Grant's creek (J) the Ohio valley is quite narrow; on the Indiana side evenly stratified glacial material is piled to the height of at least 100 feet. It is of the same general character as the terraces existing throughout the valley of the Ohio and many of its tributaries, and is what is usually classed as belonging to the "Champlain period," following the "glacial period." The name is immaterial; but it is an error to suppose that the one era ended before the other began. On the contrary, they were synchronous; as soon as the outlet of old Kanawha was blocked glacial debris began to settle in the resultant lake-bed. The old river-beds were filled with it to a higher level than it is now to be found. Had there been no subsequent drainage, these valleys would now be plains having practically uniform surfaces. The present streams, however, in winding their way from side to side through them have alternately cut down and filled up, exactly as we may see every day in any little creek, until our existing terraces stand as witnesses to their energy.

At different times and places in the three southeastern counties of Indiana, men who seemed to know what they were talking about, agreed in their statements that from Dillsboro almost exactly south to near Vevay, the hills are capped with boulders and gravel ; and that none is to be found east of that line, except in the streams. Probably this is the real moraine. It remains an open question whether it crossed the Ohio near Vevay ; or whether the material about the mouth of the Kentucky river may not have accumulated in the same manner as at "Split Rock," namely, by ice-borne and torrential deposit in a temporary lake caused by a col below Madison, Indiana.

In all cases where drift is reported as existing on the "high lands," or the "highest hills," the person who essays to complete this unfinished work, should take pains to ascertain just how high they are. The suggestion seems scarcely necessary ; but in reading some of the articles on this matter one would infer that water, instead of hunting the lowest places and flowing through, sought the highest places and climbed over.

Editorial Note.—Since the presentation of Mr. Fowler's article before the Ohio State Academy of Science I have had the pleasure, through the kindness of the Cincinnati Society of Natural History, to visit the region around Cincinnati discussed by Mr Fowke and I take pleasure in stating that I believe Mr. Fowke has presented the best correlation of the complicated topographical features of the Cincinnati district that has been offered up to date. His broad generalizations as to the sequence of events are certainly suggestive of the vast amount of field work yet to be done before the full history can be written.

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THE PALEONTOLOGY AND STRATIGRAPHY OF THE CORNIFEROUS ROCKS OF OHIO.

By J. A. Bownocker.

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THE PALEONTOLOGY AND STRATIGRAPHY OF THE CORNIFEROUS ROCKS OF OHIO.

INTRODUCTORY NOTE.

In this paper the writer has followed Dana's classification of the Devonian rocks. This drops the term Upper Helderberg and uses in its stead Corniferous. On this basis the strata of the Corniferous period compose two epochs, the Schoharie and the Corniferous.

In classifying the faunas the writer has followed Eastman's edition of Zittel's Paleontology, as far as the uncompleted condition of the work would permit.

TIME RANK OF THE STRATA INVESTIGATED.

It is believed that the Schoharie epoch is absent in Ohio. The lithological characters which distinguish that epoch in New York are not present in Ohio, and the faunal characters in this state will not admit of division into two epochs. The Corniferous epoch only is recognized.

GEOGRAPHICAL LOCATION.

The territory in which this study was made embraces the three regions of Ohio in which Corniferous strata are found. The first of these is the central, extending from the southern part of Pickaway county north to the islands in Lake Erie. The second is the northwestern extending in a curve from the western part of Lucas county through Wood, Henry, Defiance, and Paulding counties into Indiana. The third is the western, and is a small outlier confined chiefly to Logan county.

AREA OF EACH REGION.

The central embraces by far the greater area. This is about 150 miles in length from its southern termination in Pickaway county north to Kelley's Island. Its average width is about 12 miles, the maximum 18 miles, and the minimum about 5 and one-half miles.

The northwestern area has a length of over 80 miles, an average width of perhaps 8 miles, a maximum of 13 miles, and a minimum of 3 miles.

The western area is roughly circular in shape. It is chiefly a narrow belt having a width usually of about 1 mile, but this increases in one locality to 6 miles.

STRATIGRAPHICAL RELATIONS.

The strata in the central part of the state may be divided into two horizons, (1) the Lower and (2) the Upper. The two horizons are separated by a persistent layer of fish remains a few inches in thickness and known as the bone-bed. The Lower beds are shown at every locality examined in central Ohio except Delaware and Sandusky. They are frequently called the Columbus beds. The Upper beds are found well developed at Delaware, Marion and Sandusky. Between Delaware and Columbus, in the observed exposures, this division is represented by shales only. It has not been found at all south of Columbus. The division is inconstant. Sometimes it is a formation of importance; at other times a few feet of shales only or, again, it may be absent altogether. These two divisions of the Corniferous differ in fauna, color, and chemical constitution.

The dip of the central division is to the southeast. At Columbus this is 30 feet per mile. Farther north the rate probably decreases as does that of the underlying formations. In some quarries the dip varies greatly. In Evans' quarry at Marion the beds in the two ends of the quarry dip in opposite directions, that is toward each other. A similar state is found at Kelley's Island. At White House the general dip is to the west, but there are many minor variations. In fact the exposures suggest that the surface of the rock in that locality is gently undulating.

Below the corniferous lies the Lower Helderberg or Water Lime, a great series of beds having a maximum thickness of 600 feet. Above the Corniferous the Hamilton is doubtfully found. This is succeeded by the Ohio Shale which attains a thickness ranging from 250 to 3,000 feet.

CHEMICAL CONSTITUTION.

The formation is almost always limestone. The only exceptions are the thin intercalated layers of sandstone found at West Jefferson and a few other points, and the shaly layers lying above the bone-bed at Columbus and other places. These shales, however, are calcareous. The Upper or Delaware beds are less pure than the Lower beds, and contain more iron, alumina, and silica. The average may be taken at 75 % carbonate of lime and 25 % carbonate of magnesia. The magnesia increases as the underlying Lower Helderberg rocks are approached and decreases as the top of the formation is reached. Some of the lower beds contain as much as 35 % carbonate of magnesia, while the top layers may contain 2 % only. The carbonate of lime in the upper Columbus beds reaches 95 %, while in the highest layers at Kelley's Island it exceeds 97 %.[1]

Scattered through the beds are nodules of chert. These sometimes are almost wanting, as at Kelley's Island. At Columbus they form several irregular bands. In France's quarry, Bloomville, there is a series of beds aggregating 18 feet in thickness in which the chert composes 25 % (estimated) of the rock.

THICKNESS.

The maximum thickness of the Corniferous rocks of Ohio "so far as present records show, is between 75 and 100 feet."[2]

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[1] Edward Orton, Geol. Surv. of Ohio, Vol. VI, page 753.

[2] Geol. Surv. of Ohio, VII, page 18.

In the Taylor and Bell quarries near Marble Cliff the Lower or Columbus division is worked to a depth of 60 feet and at Delaware the Upper beds are worked to a depth of about 30 feet. The minimum thickness given by Prof. Orton is 25 feet. The thickness must vary considerably, owing to the partial or entire removal of the Upper or Delaware beds and also the partial removal of the Columbus beds. Other things being equal the greatest thickness should be found where the upper beds are well preserved, as at Delaware.

THE FAUNAS.

The faunas herein discussed were collected at the 12 following points, the location of which may be noted on the accompanying map. Pl. II.,—(1) Deer Creek, (2) Harrisburg, (3) Columbus, (4) Marble Cliff, (5) Dublin, (6) Delaware, (7) Radnor, (8) Marion, (9) Sandusky, (10) Kelley's Island, (11) White House, (12) Bellefontaine.

The faunas are rich and varied. Almost everywhere the strata contain abundant fossils. However, the Lower or Columbus beds are much superior in this respect. The faunas range from protozoans to vertebrates, though the *latter are not considered in this paper.* All branches of the animal kingdom have one or more representatives, *vermes* excepted. The coelenterata, mollusca, and molluscoidea especially are well represented.

In the discussion of the faunas the order from south to north will be followed, except in the case of Marble Cliff which will be considered first. The latter fauna has been collected with more care than any other, and hence will be used as a basis for comparison.

The Marble Cliff Faunas. These were collected in Price's quarry where the Columbus beds are worked to a depth of more than 30 feet. Above them the Delaware beds are represented by a maximum exposure of 12 feet of shales.

A section of the Lower horizon at this point is shown on Plate III. For convience the workmen's nomenclature is used. This in most cases is self-explanatory, but sometimes the names are not significant. Collections were made here with a view of determining the vertical range of the species. On tabulating these, it was found that the most common specimens usually range throughout the entire series below the bone-bed, while the less common ones have a more restricted range. Further the species may be divided into three groups, one occupying the upper 10 feet and terminating with the "smooth rock"; the second occupying all below this, and the third ranging through both. These points are shown on the accompanying tables, Plates III and IV. The following lists show the species that are found in each horizon :

Top Beds. From bone-bed to 10 feet below.—÷ Cladopora sp., Clathropora sp., Eridophyllum verneuilanum. E. & H., Eridophyllum simcoense. Bill, Heliophyllum halli. E. & H., Hadrophyllum d'orbignyi. E, & H., Zaphrentis gigantea. Leseur., Zaphrentis ovalis. H., Zaphrentis prolifica. Bill., Nucleocrinus verneuilanum. Troost., Codaster pyramidatus. Snum., Leptaena rhomboidalis. Wilch., Productella spinulicosta. H., Orthotetes chemungensis. Con., Spirifera acuminata. Con., Spirifera fimbriata. Mort., Spirifera gregaria. Clapp., Pentamerella arata. Con., Glyptodesma erecta. Con., Sanguinolites (?) sanduskyensis (?) H., Platyceras dumosum. Con.

Bottom Beds. Lying beneath Top Beds.—÷ Stromatopora sp. Cystiphyllum americanum. E. & H., Rhipidomella livia. Bill., Stropheodonta concava. H., Stropheodonta demissa. H., Spirifera raricosta. Con., Modiomorpha perovata. M. & W., Paracyclas elliptica. H., Pterinea pinguis. H., Murchisonia desiderata. H., Isonema humilis. M., Callonemal ichas. H., Euomphalus decewi. Bill., Gomphoceras eximium. H., Gyroceras ohioensis, Phacops cristata. H.

Both Horizons. From bone-bed to bottom of quarry.—÷ Favosites hemisphericus. Troost., Atrypa aspera. Schloth., Atrypa reticularis. Linn., Chonetes mucronatus. M. & H., Schizophoria propinqua. H., Stropheodonta hemispherica. H., Stropheodonta patersoni. H., Stropheodonta perplana. Con., Spirifera manni. H., Conocardium cuneus. Con., Dalmanites aspectans. Con.

These lists show that the brachiopods and corals are most abundant in the top beds, and that the blastoids are restricted to these beds ; that the lamellibranchs are divided about equally between the two horizons ; that the gastropods are nearly all found in the bottom beds, and that the cephalopods are restricted to this division.

By reference to the section on Plate III, it may be seen that three prominent faunal zones are located, the bone-bed, the reef-building coral, *Eridophyllum*, and *Spirifera acuminata*. These are all quite constant and have been traced across the state. Similar faunal zones are found above the bone-bed at Delaware and Marion, and will be further referred to when the faunas of those localities are reached.

The determined range of the fossils at Marble Cliff offers a means of correlating the faunas found at other localities and also of placing the strata in their proper place in the vertical scale, the latter point being shown by diagrams in Plate V.

The Deer Creek Fauna. This fauna was collected at the extreme southern limit of the Corniferous rocks of Ohio. It was obtained on the farm of B. Adkins, one mile S. W. of Deer Creek P. O. Formerly the rock was burned here in a small way for lime, and is reported to have been quarried to a depth of 10 feet. The rock which supplied the small kiln resembles that found at other points in central Ohio and is highly fossiliferous, but a few hundred yards up Deer Creek it is a "*bastard*" rock and is sparingly fossiliferous. The fauna named below was collected from small fragments of rocks lying around the old kiln. If a suitable exposure of the strata were had at this point, the fauna would, in all probability be much larger.

Anthozoa. Epidophyllum verneuilanum. E. & H., Favosites gothlandicus. Lam., Zaphrentis prolifica. Bill.

Brachiopoda. Atrypa reticularis. Linn., Chonetes mucronatus. M. & H., Nucleospira concinna. H., Rhipidomella livia. Bill., Schizophoria propinqua. H., Spirifera gregaria. Clapp., Spirifera manni. H., Spirifera ziczac. H., Stropheodonta patersoni. H., Stropheodonta perplana. Con., Stropheodonta sp.

Lamellibranchiata. Conocardium cuneus. Con.

Gastropoda. Bellerophon sp.

Crustacea. Proetus crassimarginatus. H.

The most abundant species is *Favosites gothlandicus.* The brachiopod *Spirifera gregaria* is interesting because of its unusual width. One individual was found having a width of 1 1-8 inches. Hall gives the maximum width of the species 7-8 of an inch. These forms also have less curvature of the ventral beak than other Ohio specimens. They have 10 ridges on each side of the fold and sinus. The unusual width and diminished gibbosity of these individuals give them an abnormal appearance.

The common species *Artypa aspera* and *Leptaena rhomboidalis* are here conspicuous by there absence, while *Spirifera ziczac,* which is elsewhere uncommon beneath the bone-bed is rather plentiful.

The section evidently belongs a short distance below the bone-bed. This is best shown by *Eridophyllum verneuilanum.* None of the forms restricted to the lower part of the Marble Cliff section are found here.

HARRISBURG.

The stone is quarried at this place along the banks of Big Darby creek. The exposed section does not exceed 12 feet. The rock is burned for lime and is used for foundation purposes. It is worked on a small scale. The following species were collected :

Ahthozoa. Cyathophyllum corniculum. Cystiphyllum ohioense. Nich., Favosites emmonsii. Rom., Favosites turbinatus. Bill., Heliophyllum halli. E. & H., Michelinia cylindrica. Syringopora tabulata. E. & H., Zaphrentis compressa. Edw., Zaphrentis prolifica. Bill.

Brachiopoda. Amphigenia elongata. Van., Atrypa reticularis. Linn., Miristella nasuta. Con., Pentamerella arata. Con., Rhipidomella livia. Bill., Ryhnchonella tethys. Bill., Spirifera acuminata. Con., Spirifera fimbriata. Mort., Spirifera macrothyris. H., Spirifera manni. H., Spirifera varicosta. Con., Orthotetes chemungensis. Con., Stropheodonta ampla. H., Stropheodonta concava, H., Stropheodonta demissa. Con., Stropheodonta hemispherica. H., Stropheodonta perplana. Con., Terebratula sullivanti. H.

Lamellibranchiata. Conocardium cuneus. Con., Modiomorpha concentrica (?) Con.

Gastropoda. Loxonema pexata. H., Murchisonia desiderata. H., Platyceras dumosum. Con.

The rock at this locality is the most fossiliferous of any of this age in the state. Often it becomes a true coquina. The fauna is quite different from that found at other points, not so much because of the different species found, but because of those that are here the common ones. These are almost without exception comparatively rare elsewhere. Further, the most characteristic species here vary from their normal forms, while two species that are usually common elsewhere, *Leptaena rhomboidalis* and *Atrypa aspera* have not been found at all.

The fauna is characterized by the presence of the two Spirifers, *S. macrothyris* and *S. manni.* The former is much larger than elsewhere in Ohio, having a width of more than 3 3-4 inches and a length of more than 2 5-8 inches. Twelve broad, flat ribs were counted on one side of the sinus. The forms are not as large however, as some that are figured in the New York reports. The species *S. manni* is wider than usual in proportion to its length, its area is lower and more curved, and its ribs more numerous. Fifteen of the latter were counted on one side of the sinus.

The coral, *Favosites emmonsii* is found here in large blocks and the brachiopod *Meristella nasuta* is more abundant than elsewhere.

Gastropods are rare and cephalopods absent.

The species *Michelinia cylindrica* and *Amphigenia elongata* are here reported for the first time in Ohio.

The presence of *Spirifera acuminata* and *Platyceras dumosum* indicates that the strata belong a short distance below the bone-bed. This is further shown by the absence of cephalopods and rarity of gastropods. The absence of *Eridophyllum ver-*

neuilanum puts the top of this section a little below the summit at Deer Creek P. O.

COLUMBUS.

Both divisions of the Ohio Devonian are found here, but the Delaware beds are represented by shales only. The fauna which is given below was collected entirely from beneath the bone-bed.

Spongia. Receptaculites devonicus. Whit., Stromatopora sp.

Anthozoa. Aulacophyllum sulcatum. D'Or., Cladopora sp., Cyathophyllum corniculum., Cyathophyllum halli., Cyathophyllum robustum. H., Cystiphyllum americanum. E. & H., Cystiphyllum ohioense. Nich., Eridophyllum verneuilanum. E. & H., Favosites gothlandicus. Lam., Favosites hemisphericus. Troost., Favosites turbinatus. Bill , Stylastrea anna. Whit., Zaphrentis compressa. Edw., Zaphrentis cornicula. Leseur., Zaphrentis prolifica. Bill.

Crinoidea. Dolatocrinus liratus. H., Megistocrinus spinulosis. Lyon.

Blastoidea. Codaster pyramidatus. Shum., Nucleocrinus verneuili. Troost.

Brachiopoda.. Atrypa aspera. Schloth., Atrypa reticularis. Linn., Chonetes mucronatus. M & H., Chonetes sp. nov., Cyrtina hamiltonensis. H., Leptaena rhomboidalis. Wilck., Pentamerella arata. Con., Productella spinulicosta. H., Rhipidomella livia. Bill., Rhynchonella, carolina. H., Rhynchonella tethys. Bill., Schizophoria propinqua. H., Spirifera acuminata. Con., Spirifera fimbriata. Mor., Spirifera gregaria. Clapp., Spirifera maia. Bill., Spirifera manni. H., Orthotetes chemungensis. Con., Stropheodonta hemispherica. H., Stropheodonta inequiradiata (?) H., Stropheodonta perplana. Con.

Lamellibranchiata. Conocardium cuneus. Con., Paracyclas elliptica. H., Paracyclas lirata. Con., Pterinea pinguis. H., Sanguinolites (?) sanduskyensis (?) M.

Gastropoda. Callonema lichas. H., Euomphalus decewi. Bill., Loxonema pexata. H., Platyceras dumosum. Con., Platyceras multispinosum. M., Platyceras nodosum. Con.

Cephalopoda. Gomphoceras sciotoense. Whit., Gyroceras columbiense. Whit., Orthoceras ohioense.

Crustacea. Proetus crassimarginatus. H.

The formation at this locality is quite highly fossiliferous. The species found here and at Marble Cliff, which lies about three miles north, comprise the great body of the Corniferous forms of this state. However, these species are almost all found at other localities.

Immediately below the bone-bed is found a narrow faunal zone characterized by *Platyceras dumosum.* Below, but close to the above, is a well marked zone of *Spirifera acuminata.* About three feet below the bone-bed occurs a prominent zone of *Eridophyllum verneuilanum.* This attains a thickness of 2 feet.

It is interesting to note that *Leptaena rhomboidalis* and *Atrypa aspera,* both common species at most localities, have not been found south of this place, and that the same is true of the cephalopods.

Crinoids and blastoids are more common here than elsewhere in Ohio. About 100 codasters were picked up in Green Lawn Cemetery in a few hundred feet of red clay that had been stripped from the underlying rock.

This locality is perhaps the best in the state for collecting corals.

DUBLIN.

This is located about ten miles north of Marble Cliff. There are two quarries, one on each side of the river, but both are small. The rock is burned for lime on a small scale. The depth of the exposed sections was not determined with precision, but is probably not far from 25 feet. The following species were collected:

Spongia. Stromatopora sp.

Anthozoa. Favosites emmonsii. Rom., Favosites hemisphericus. Troost., Zaphrentis gigantea. Leseur., Zaphrentis prolifica. Bill.

Blastoidea. Codaster pyramidatis, Shum.

Brachiopoda. Atrypa aspera. Schloth., Atrypa reticularis. Linn., Cyrtina hamiltonensis. H., Rhipidomella livia. Bill., Schizophoria propinqua. H., Spirifera gregaria. Clapp., Spirifera macrothyris. H., Spirifera manni. H., Spirifera varicosa (?) H., Stropheodonta concava. H., Stropheodonta demissa. Con., Stropheodonta inequiradiata. H., Stropheodonta patersoni. H., Stropheodonta perplana. Con.

Lamellibranchiata. Conocardium cuneus. Con., Modiomorpha perovata. M & W., Mytilarca ponderosa. H., Paracyclas elliptica. H., Paracyclas lirata, Con., Pterinea pinguis. H., Sanguinolites (?) sanduskyensis (?) M.

Gastropoda. Bellerophon pelops. H., Euomphalus decewi. Bill., Loxonema pexata. H., Loxonema bellatulum. H., Callonema lichas. H., Pleurotomaria lucina. H., Turbo kearneyi., Turbo shumardi. Vern.

Cephalopoda. Gomphoceras sp., Gyroceras Columbiense. Whit., Orthoceras profundum (?) H.

Crustacea. Dalmanites bifidus. H., Dalmanites calypso. H., Dalmanites aspectans. Con., Phacops cristata. H.

This fauna is characterized by the abundance of lamellibranchs and gastropods and the comparative rarity of corals. The absence of the common species *Eridophyllum verneuilanum*, *Nucleocrinus verneuili*, *Leptaena rhomboidalis*, and *Spirifera acuminata*, all of which are found at Marble Cliff and Columbus a short distance below the bone-bed, indicates that the upper part of the Columbus division is absent, while the presence of many species found in the lower part of this division indicates that that portion of the Marble Cliff section is present. The abundance of gastropods denotes that the base of the Marble Cliff section is here well represented.

DELAWARE.

This fauna was collected from the higher of the two chief divisions of the Ohio Corniferous, and consequently lay above the bone-bed. Because of their dark blue color the strata make a striking contrast with the underlying division. The formation is thinner bedded than the one below. As the section on the Plate IV shows, several beds of impure shaly limestone are found. These with the dark color of the rock render it unsuitable for lime, but it is a fine stone for building purposes, paving, and curbing.

The following fauna was collected in the Campbell quarry, adjacent to the C. H. V. & T. station :

Anthozoa. Cyathophyllum halli (?), Favosites sp., Hadrophyllum, d'orbignyi. E. & H.

Brachiopoda. Lingula manni. H.. Ambocoelia umbonata. Con., Chonetes yandelanus. H., Leiorhynchus limitaris. Van., Leptaena rhomboidalis. Wilck., Meristella nasuta. Con., Rhipidomella livia. Bill., Schizophoria propinqua. H., Spirifera acuminata. Con., Spirifera duodenaria (?) H., Spirifera ziczac. H., Stropheodonta hemispherica. H., Stropheodonta inequiradiata. H., Stropheodonta perplana (?) Con.

Lamellibranchiata. Aviculopecten parilis. Con., Glyptodesma erecta. Con., Grammysia bisulcata. Con.

Pteropoda. Tentaculites scalariformis. H.

Gastropoda. Platyceras bucculentum (?) H.

Cephalopoda. Gyroceras ohioense. N.

This fauna is small and manifestly different from that found at the localities already given, all of which lay below the bone-bed. Species that are found here for the first time in this study are *Lingula manni*, *Leiorhynchus limitaris*, *Grammysia bisulcata*, *Aviculopecten parilis*, *Tentaculites scalariformis*, and *Gryoceras ohioense*. Further, two of these species, *L. limitaris*, and *T. scalariformis*, are among the most common found. Worthy of note is *Spirifera ziczac*, which is rare below the bone-bed, but very abundant here.

Many of the common genera below the bone-bed are here absent,—*Aulacophyllum*, *Cystiphyllum*, *Eridophyllum*, *Zaphrentis*, *Conocardium*, *Paracyclas*, *Callonema*, *Euomphalus*, *Loxonema*, *Orthoceras*, *Proetus*, and *Phacops*.

Farther north at Marion and Sandusky several of these genera appear and the fauna more closely resembles that found below the bone-bed. There are several well marked faunal zones at this point. Those which have been definitely located are shown on the section, Plate IV These zones, as there shown, are composed of two or three species, and these it may be added are by far the most abundant at this locality. Where the three species are found in one zone the brachiopods mingle together and just above or below the tentaculites occur. The latter usually lie on a film of shale, thus showing their shallow water habitat. Nearly always the species are found at the junction of two beds, but sometimes they lie in the middle of a stratum. This suggests that the changing conditions which separated the strata were most suitable for the life composing the zones.

Many of the best fossil fishes found in the Ohio Devonian came from this locality.

RADNOR.

This fauna was collected in the Meredith quarry where the rock is exposed to a depth of 12 feet. As the fauna shows, the section lies below the bone-bed. The rock closely resembles that found elsewhere at corresponding horizons. It is worked on a small scale. The following species were collected :

Spongia. Stromatopora mammillata. Nich., Stromatopora ponderosa. Nich., Stromatopora sp.

Anthozoa. Cyathophyllum corniculum., Favosites invaginatus. Nich., Favosites hemisphericus. Troost., Favosites turbinatus. Bill., Syringopora tabulata. E & H., Zaphrentis compressa. Edw., Zaphrentis gigantea. Leseur., Zaphrentis prolifica. Bill.

Brachiopoda. Atrypa aspera. Schloth., Atrypa reticularis. Linn., Chonetes mucronatus. H., Leptaena rhomboidalis. Wilck., Pentamerella arata, Con., Pholidostrophia narcea (?) H., Rhipidomella livia. Bill., Schizophoria propinqua. H., Spirifera acuminata. Con., Spirifera divaricata. H., Spirifera fimbriata. Mor., Spirifera gregaria. Clapp., Spirifera macrothyris. H., Spirifera manni. H., Orthotetes chemungensis. Con., Stropheodonta ampla. H., Stropheodonta concava. H., Stropheodonta demissa. Con., Stropheodonta hemispherica. H., Stropheodonta inequiradiata. H., Stropheodonta patersoni. H., Stropheodonta perplana. Con., Terebratula sullivanti. H.

Lamellibranchiata. Conocardium cuneus. Con., Modiomorpha concentrica (?) Con., Pterinea pinguis. H.

Gastropoda. Callonema lichas. H., Euomphalus decewi. Bill., Platyeras dumosum. Con., Trochus kearneyi. H., Turbo shumardi. Vern.

Crustacea. Dalmanites aspectans. Con., Dalmanites calypso. H., Proetus crassimarginatus. H.

This fauna closely resembles that found below the bone-bed at other points in central Ohio. The rock is highly fossiliferous, but the small scale on which it is worked does not afford good collecting ground. The species *Zaphrentis gigantea, Stropheodonta ampla*, and *Spirifera divaricata* are more common here and in a better state of preservation than elswhere in Ohio.

The fauna includes species from both horizons below the bone-bed. Further, specimens found at Marble Cliff at the extremes of the section are present here, though the section is only 12 feet thick. This may be due to a shortening of the faunal section at this point, or, to a greater vertical range of the species whereby the extremes approach each other.

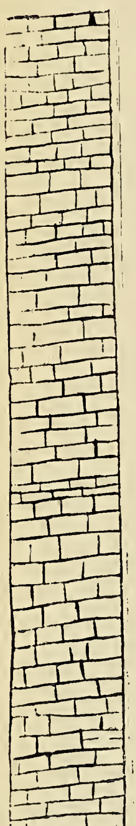
MARION.

The quarries adjacent to this city are the only ones visited by the writer where good sections comprising both divisions of Corniferous are found. The area which is small and is limited to a narrow ridge about one-half mile in length is situated a short distance northwest of the city limit. The southern corner of this ridge is crossed by the C. H. V. & T. railroad.

In the Morris and Christian quarry the strata below the bone-bed are exposed to a depth of 40 feet or more. The rock resembles that found elsewhere at corresponding horizons, but near the base is less compact, and perhaps more arenaceous. In the N. E. corner of this quarry the bone-bed is found. It is there covered by about 10 feet of strata, but to the west it soon reaches the surface.

In the Evans quarry, just across the railroad from the preceding quarry, the strata above the bone-bed are well shown. The bone-bed itself there lies about four feet above the railroad switch tracks. Above this line the formation furnishes good building stone, but toward the summit, however, it becomes quite shaly and of course is worthless.

The following was furnished the writer as a representative section of the Corniferous in this vicinity by Mr. B. F. Waples, Supt. Morris & Christian Lime and Stone Company.



----*1′½ Cap rock, Shaly limestone.*

----*15′-18′. Blue limestone. Layers range in thickness from 3″-18″. Used for building purposes.*

----*Bone-bed.*

----*3′. Flinty limestone.*

----*12′-15′. Gray limestone. Used for fluxing.*

----*2′. Flinty limestone.*

----*25′. Gray limestone. Used for lime.*

The species which are found in the two horizons are given below :

	Above Bone-bed.	*Below Bone-bed.*
Spongia.		
Stromatopora sp.		x
Syringostroma columnaris. Nich., . .		x
Anthozoa.		
Aulacophyllum sulcatum (?). D'Or., .		x
Cystiphyllum ohioense. Nich.,. . .	x	
Eridophyllum verneuilanum. E. & H., .		x
Favosites gothlandicus. Lam., . . .	x	
" hemisphericus. Troost., .	x	x
" turbinatus. Bill., . . .	x	x
Stylastrea anna. Whit., ...		x
Syringopora tabulata. E. & H., . .		x
Zaphrentis compressa (?). Edw., . .		x
" cornicula. Leseur., . . .	x	
" prolifica. Bill., . . .	x	
Blastoidea.		
Nucleocrinus verneuili. Troost., . .	x	
Brachiopoda.		
Atrypa aspera. Schloth., ...	x	x
" reticularis. Linn., . . .	x	x
Chonetes mucronatus. M. & H., . .	x	x
" yandellanus. H., . . .	x	
Leptaena rhomboidalis. Wilck., . .	x	
Rhipidomella livia. Bill., ...	x	x
Rhynchonella tethys. Bill., ...		x
Schizophoria propinqua. H., . . .	x	x
Spirifera acuminata. Con., ...		x
" duodenaria (?). H., . . .	x	
" fimbriata. Mor., . . .		x
" gregaria. Clapp., . . .		x
" maia. Bill., ...	x	
" manni. H., ...	x	
" varicosa. H., ...		x
" ziczac. H., ...	x	

	Above Bone-bed.	*Below Bone-bed.*
Orthotetes chemungensis. Con., . .	x	x
Stropheodonta concava. H., . . .		x
" demissa. Con., . .	x	x
" hemispherica. H., . .	x	x
" perplana. Con., . .	x	x
Terebratula sullivanti. H., . . .		x
" sp.	x	
Brachiopod. (undt.)	x	
Lamellibranchiata.		
Paracyclas lirata. Con., . . .	x	x
Conocardium cuneus. Con., . . .		x
Pteropoda.		
Tentaculites scalariformis. H., . .	x	
Gastropoda.		
Platyceras dumosum. Con., . . .		x
" multispinosum. M., . .		x
Cephalopoda.		
Gyroceras cyclops. H.		x
Crustacea.		
Phacops cristata. H., ...		x

The fauna below the bone-bed is not so prolific as at the preceding localities. Gastropods and cephalopods are almost absent, while the lamellibranchs are represented by two species only. A good representation of corals is found, but brachiopods fall short of their southern representation. Atrypas and Stropheodontas are most common.

The fauna above the bone-bed closely resembles that at Delaware. The species which are most common at one locality are also the most abundant at the other. However, the faunas at the two localities are not identical, as a comparison of the species will show.

About two feet above the bone-bed at this point, the species *L. rhomboidalis* and *S. ziczac* are so abundant as to resemble a coquina. At Delaware there is a similar layer about 3 feet above the bottom of the quarry. If these two beds mark the same horizon, as the evidence indicates, the base of the Delaware quarries lies on or near the bone-bed. About 12 feet above the bone-bed is another zone of *S. ziczac* and *L. rhomboidalis.*

Near the summit of the strata at both Delaware and Marion lies a conspicuous bed of *Tentaculites scalariformis.* Often this shell is so abundant as to cover the surface of the rock.

SANDUSKY.

The formation found within or near this city belongs wholly above the bone-bed. The strata possess marked economic value, furnishing the city with high grade building stone. This retains the character which it possesses at Marion and Delaware. It is not usually worked to a depth exceeding 11 feet, and no observed exposures were found to a greater depth. According to the quarrymen it is not worked deeper because it becomes too thick bedded. This may mean that the beds just referred to belong below the bone-bed, for the layers found in this position are generally thick. Moreover no thick beds were found at any other localities above the bone-bed. The following species were collected :

Spongia. Stromatopora sp.

Anthozoa. Cyathophyllum halli., Cystiphyllum americanum. E. & H., Cystiphyllum ohioense. Nich., Favosites hemisphericus. Troost., Zaphrentis prolifica. Bill.

Brachiopoda. Atrypa aspera. Schloth., Atrypa reticularis. Linn., Athyris spiriferoides. Eaton., Chonetes mucronatus. M. & H., Chonetes yandellanus. H., Leptaena rhomboidalis. Wilck., Pentamerella arata. Con., Schizophoria propinqua. H., Spirifera acuminata. Con., Spirifera maia. Bill., Spirifera manni. H., Stropheodonta concava. H., Stropheodonta demissa. Con., Stropheodonta hemispherica. H., Stropheodonta perplana. Con.

Lamellibranchiata. Glyptodesma erecta. Con., Grammysia bisulcata. Con., Paracyclas lirata. Con.

Gastropoda. Callonema lichas. H., Platyceras attenuatum. H.

Pteropoda. Tentaculites scalariformis. H.

Cephalopoda. Gomphoceras eximium. H.

Crustacea Phacops cristata. H., Phacops rana. Green.

This fauna is the largest found above the bone bed in this State. The corals seem identical with those found below. The brachiopods are also quite similar. but *Athyris spiriferoides* and *Chonetes yandellanus* have not been found by the writer beneath the bone-bed. Among the lamellibranchs, *Grammysia bisulcata* and among the pteropods *Tentaculites scalariformis* are forms which have not been found positively below the bone-bed.

Two species which elsewhere are common above the bone-bed are rare or absent here. These are *L. rhomboidalis* and *S. ziczac.*

KELLEY'S ISLAND.

This island is composed of Corniferous rocks. The best exposures are in two quarries, one on the north side of the island and the other on the southwest. The maximum thickness of the exposed section is about 36 feet. Near the surface the rock is shaly, but it becomes thicker below, and near the bottom of the quarry a bed 10 feet thick is found. This stone is softer than that to the south. It is lighter in color, also, and freer from siliceous impurities.

The bone-bed has not yet been reported on the island and it is not yet certain that it exists there. Professor Orton thinks that the shales at the surface represent the Delaware or Sandusky horizon of the Corniferous.

The fauna is not conclusive on this point. The writer found a single specimen of *Tentaculites scalariformis*, but it was picked up in a pile of fragments and so is of undetermined location. Similarly *Spirifera ziczac* is found, but it appears to extend well down into the section. If this species here extends below the hypothetical line of junction of two great divisions of the Corniferous, why may not the former species do the same? To the writer there is not satisfactory evidence to claim that the upper division is present. The formation is abundantly fossiliferous as the following list of species shows:

Rhizopoda. Saccammina eriana. Daw.

Spongia. Stromatopora mammillata. Nich., Stromatopora sp., Syringostroma columnaris. Nich.

Anthozoa. Cladopora sp., Cyathophyllum corniculum., Cystiphyllum americanum. E & H., Eridophyllum verneuilanum. E. & H., Favosites basalticus. Goldf., Favosites hemisphericus. Troost., Favosites pleurodictyoides. Nich., Favosites turbinatus. Bill., Syringopora tabulata. E & H., Stylastrea anna. Whit., Zaphrentis prolifica· Bill.

Brachiopoda. Atrypa aspera. Schloth., Atrypa reticularis. Linn., Chonetes acutiradiatus. H., Chonetes mucronatus. M & H., Leptaena rhomboidalis. Wilck., Nucleospira concinna. H., Orbiculoidea sp., Productella truncata. H., Rhynchonella tethys. Bill., Schizophoria propinqua. H., Spirifera acuminata. Con. Spirifera duodenaria. H., Spirifera manni. H., Spirifera ziczac. H., Orthotetes chemungensis. Con., Stropheodonta concava. H., Stropheodonta demissa. Con., Stropheodonta crebristriata. Con., Stropheodonta hemispherica. H ,Stropheodonta inequiradiata. H., Stropheodonta patersoni. H., Stropheodonta perplana. Con., Terebratula sullivanti. H.

Lamellibranchiata. Aviculopecten sp. nov., Conocardium cuneus. Con., Modiomorpha concentrica (?) Con., Paracyclas elliptica. H., Paracyclas lirata. Con., Lamellibranch (Undt.)

Pteropoda. Tentaculites scalariformis. H.

Gastropoda. Bellerophon pelops. H., Callonema lichas. H., Euomphalus decewi. Bill., Loxonema pexata. H., Murchisonia desiderata. H., Platyceras carinatum. H., Platyceras dumosum. Con.

Cephalopoda. Gyroceras columbiense. Whit., Gyroceras cyclops. H., Gyroceras matheri (?) Con., Gyroceras ohioense. M., Gomphoceras eximium. H.

Crustacea. Dalmanites aspectans. Con., Dalmanites bifidus. H., Dalmanites calypso. H., Phacops rana. Green., Proetus crassimarginatus. H., Proetus planimarginatus. M.

The following are the principal features of the fauna:

1. Abundance of *Stropheodontas* of the species *perplana* and *hemispherica* and absence of *ampla*.

2. Rarity—almost absence of *L. rhomboidalis*.

3. Abundance of *S. acuminata*, and the comparative rarity of other *Spiriferas*.

4. Rarity of gastropods. Six genera were collected but the number of individuals of each was small, in some cases limited to a single specimen.

5. Abundance of cup corals of the form *Cyathophyllum corniculum*, and rarity of other cup corals.

6. The presence of *Favosites pleurodictyoides* which has not been found elsewhere in the state.

7. The abundance of *Saccammina eriana*.

8. The presence of *Productella truncata*, which is here reported for the first time in Ohio.

9. Absence or rarity of straight cephalopods. The coiled forms are not abundant.

As has already been stated the bone-bed has not been found here. It may be, however, as claimed by Dr. Orton, that the top beds belong above this line. There can be no doubt as to the strata extending at least close up to the bone-bed. This is proven by the presence of such species as *Spirifera acuminata*, *Platyceras dumosum*, and *Eridophyllum verneuilanum*, all of which are found to the south and a short distance below the bone-bed.

WHITE HOUSE.

In Pray's quarry just east of the village the stone is quarried to a depth of about 20 feet. The stone is thin bedded near the top, the layers being usually under ten inches in thickness. Farther down the strata become thicker, and near the bottom of the quarry one layer 28 inches in thickness is found. The upper part of the rock is quite free from chert, but the lower layers have much of it. The lower beds are less compact than the upper, and seem more arenaceous. Sometimes they resemble a sandstone in appearance. Above these layers the stone resembles more closely the ordinary limestone of this period.

The formation does not possess the high utility that it attains elswhere. It serves for foundations, abutments, curbings, etc. Formerly it was burned for lime but this has been discontinued.

The upper beds are by far the most fossiliferous. In this respect they are not excelled by any beds of this age in the state. The following species were collected:

Rhizopoda. Saccammina eriana. Daw.

Spongia. Stromatopora sp., Syringostroma densa. Nich.

Anthozoa. Aulacophyllum (?) sulcatum (?) D'Or., Favosites emmonsii. Rom., Favosites hemisphericus. Troost., Favosites invaginatus. Nich., Favosites limitaris. Rom., Favosites turbinatus. Bill., Stylastrea anna. Whit., Syringopora tabulata. E. & H., Zaphrentis prolifica. Bill.

Blastoidea. Nucleocrinus verneuili. Troost.

Brachiopoda. Atrypa aspera. Schloth., Atrypa reticularis. Linn., Chonetes mucronatus. M. & H., Chonetes yandellanus. H., Cyrtina hamiltonensis. H., Pentamerella arata. Con., Pholidostrophia nacrea. H., Productella spinulicosta. H., Productella truncata. H., Rhipidomella livia. Bill., Schizophoria propinqua. H., Spirifera divaricata. H., Spirifera euruteines. Owen., Spirifera gregaria. Clapp., Spirifera grieri. H., Spirifera macra. H., Spirifera macrothyris. H., Spirifera manni. H, Spirifera oweni. H., Spirifera ziczac. H., Stropheodonta concava. H., Stropheodonta demissa. Con., Stropheodonta hemispherica. H., Stropheodonta inequiradiata. H., Stropheodonta perplana. Con., Terebratula lincklaeni (?) H., Terebratula sp.

Lamellibranchiata. Conocardium cuneus. Con., Glyptodesma erecta. Con., Goniophora perangulata. H., Glosselettia (?) sp. nov., Modiomorpha concentrica. Con., Paracyclas elliptica. H., Paracyclas lirata. Con., Pterinea (?) flabella (?). Con., Schizodus sp. nov.

Pteropoda. Tentaculites scalariformis. H.

Gastropoda. Bellerophon pelops. H., Callonema lichas. H., Euomphalus decewi. Bill., Isonema humilais. M., Loxonema pexata. H., Murchisonia desiderata. H., Platyceras carinatum. H., Platyceras dumosum. Con.

Cephalopoda. Gomphoceras. sp., Orthoceras ohioense.

Crustacea. Dalmanites calypso. H., Phacops rana. Green., Proetus crassimarginatis. H., Proetus planimarginatus. M., Proetus rowi. (?).

The features of the fauna are the following:

1. Abundance of *Tentaculites.* These sometimes almost cover the surface of a stratum, and closely resemble the corresponding layer at Marion. They lie near the summit of the quarry.

2. Abundance of *Productella spinulicosta.* This is the only locality in Ohio known to the writer where this form is common.

3. Abundance of cephalopods of the *Gomphoceras* type. None are well preserved.

4. Abundance of specimens belonging to the genera *Paracyclas, Conocardium, Favosites, and Stropheodonta.*

5. Abundance of *Pholidostrophia nacrea.* This is absent or only doubtfully present in all sections previously reported on. It is often larger than the forms figured in the New York reports. One specimen was found which measured more than 1 1-8 inches along the posterior part, but of this more than 1-8 of an inch was occupied by the cardinal projections. Some times the cardinal extremities are mucronate, sometimes they are rounded. In the last case the hinge line does not represent the maximum width of the shell. Concentric lines of growth are conspicuous, but radiating striae are obscure or absent. The surface shows a nacreous luster, but the metallic hue sometimes seen on the New York form is not present here. The convexity of the ventral valve is usually considerably less than that figured in the New York reports. It is less than some Canadian forms also, with which a comparison has been made. None of the individuals show crenulations on the cardinal area, but the latter is rarely seen on specimens from any locality. The ventral valve only is found. A comparison of the muscular scars on the ventral valve with those figured in the New York reports shows a very close resemblance and leaves no doubt as to the correct identification of the specimens.

6. Absence or rarity of *Leptaena rhomboidalis.*

7. Presence in considerable numbers of *Stropheodonta demissa*, and the unusual size of these. This species, elsewhere in this state, has a width of 1 inch or more, but here it has a width of little more than ½ inch.

The formation and fauna at this place differ conspicuously from those of central Ohio. The rock resembles fairly well that found elsewhere below the bone-bed, but the blue-black stone so well shown at Delaware, Marion and Sandusky is not present here.

However, some of the most common White House species are found elsewhere above the bone-bed. These are *T. scalariformis* and *S. ziczac.* On the other hand, many forms common in the Columbus horizon are abundant here also. These include especially the genera *Stropheodonta*, *Favosites*, *Conocardium*, *Paracyclas*, *Atrypa*, *Isonema*, and *Platyceras.*

In other words, the two faunas of central Ohio appear to mingle in the upper part of the White House section, and hence the two fold division of strata and faunas made in central Ohio cannot be made at this point. However, the summit of this section must be placed at the top of the Ohio Corniferous—above the Delaware or Sandusky beds. It resembles the latter in such species as *T. scalariformis* and *S. ziczac*, both of which are abundant. That it is higher than those beds is shown by *Pholidostrophia nacrea* and *Productella spinulicosta*, both of which are here common, though in New York they are well known Hamilton species.

BELLEFONTAINE.

Several quarries are worked in or near this city, but what is said below refers to the two quarries situated about one-half mile northwest of the "Big 4" station. The rock is here quarried to a depth of about 25 feet. It resembles the light colored stone of this age found elsewhere in the State, but is less compact and has a more arenaceous appearance than any other, White House excepted. The stone is not worked extensively at the present time. It is burned for lime, and is used for foundation purposes.

About 3 feet above the bottom of the quarry is an irregular band of chert a few inches in thickness. This is almost as white as chalk, and when wet is very soft, so that it works almost as easily as chalk. It is highly fossiliferous, as is shown by the fact that of the following species all but 6 came from this band :

Anthozoa. Zaphrentis prolifica. Bill.

Brachiopoda. Atrypa aspera. Schloth., Atrypa reticularis. Linn., Chonetes acutiradiatus. H., Chonetes mucronatus. M. & H., Crytina hamiltonensis. H., Orbiculoidea. sp., Pholidostrophia nacrea. H., Rhipidomella livia. Bill., Rhynchonella carolina. H., Rhynchonella tethys. Bill., Schizoporia propinqua. H., Spirifera acuminata. Con., Spirifera mucronata. (?), Spirifera oweni. (?) H., Stropheodonta hemispherica. H., Stropheodonta perplana. Con.

Lamellibranchiata. Conocardium cuneus. Con., Glyptodesma erecta. Con.

Gastropoda. Bellerophon pelops. H., Platyceras carinatum. H.

Crustacea. Proetus crassimarginatus. H.

The most characteristic fossil at this point is *Glyptodesma erecta.* It occurs in large numbers in the chert band already referred to, but is rare or absent elsewhere. It is found in larger numbers for corresponding thickness of stratum than any other lamellibranch in the Corniferous beds. The genera *Pholidostrophia* and *Orthis* are also common. Of the former the species *P. nacrea* is of special interest since the only other place in the state where it is common is White House. The form *S. perplana* is relatively more abundant here than elsewhere. Of the genus *Orthis*, the species *livia* is by far the most common. This is the only place found where this species is more abundant than *O. propinqua.* The form found is nearly always the dorsal valve, and is smaller than those which occur elsewhere. The *Spirifera* are of considerable interest. The species *S. acuminata* is found and with it a closely related form which has been referred doubtfully to *S. oweni*. It differs from the typical *S. acuminata* in having a length of hinge line that approaches the maximum width of the shell, a broader sinus, and ribs that are not dichotomous. However, it may belong to *S. acuminata*, but if so presents a strongly modified form.

Another point of interest is the rarity or absence of *Leptaenas* and the *Atrypas*.

The strata at this place are the most sparingly fossiliferous of any of this age in Ohio. The brachiopods are fairly well represented but that is the only group. Of the corals one species only is reported and the remaining great divisions present little better showing. Many of the most common forms elsewhere are here absent. The fauna is more closely related to that at White House than to any other. This is shown by the presence at both places of *P. nacrea*, *C. hamiltonensis* and *G. erecta*. These two places are the only ones where the first and last of these species are commonly found. Further evidence of a negative nature is furnished by the rarity or absence at both places of *Atrypas* and *Leptaenas*.

RELATION OF THE FAUNA ABOVE THE BONE-BED TO THAT BELOW.

As has already been stated the faunas above and below the bone-bed are fairly distinct. The difference, however, is not so great as at first appears; for more extensive collections show many species common to the two horizons. This point is well shown in the study of fossils from Delaware, Marion and Sandusky—all above the bone-bed. At Delaware the fauna is strikingly different from that below the bone-bed. This results from the presence of *Lingula manni*, *Chonetes yandellanus*, *Leiorhynchus limitaris*, *Spirifera ziczac*, *Aviculopecten parilis*, *Grammysia bisulcata*, *Tentaculites scalariformis*, *and Gyroceras ohioense ;* also by the absence of genera common below the bone-bed, such as *Eridophyllum*, *Favosites* (rarely present), *Zaphrentis*, *Atrypa*, *Conocardium*, *Paracyclas*, *Callonema*, *Euomphalus*, *Dalmanites*, *and Proetus*.

Proceeding north from Delaware, we find at Marion more of the forms above the bone-bed, which to the south occur below the bone-bed only. Here are found three common species of *Favosites*, two of *Zaphrentis*, two of *Atrypa*, three of *Stropheodonta* and one of *Paracyclas*. Moreover *L. manni* and *Leior. limitaris* are absent here. (See pp. 33-35.) This fauna manifestly more closely resembles that below the bone-bed than does that at Delaware. However, it retains *T. scalariformis* and *S. ziczac* in great numbers and these would be sufficient to place the fauna above the bone-bed.

Farther north yet the distinction becomes still less marked. At Sandusky are fouud *Stromatopora*, *Cyathophyllum halli*, two species of *Cystiphyllum*, one of *Zaphrentis*, two of *Atrypa*, four of *Stropheodonta*, one of *Paracyclas*, one of *Callonema* and two forms of *Phacops*. Moreover *S. ziczac* has not been found for certain at this place. However, *T. scalariformis* occurs, and is re-enforced by *A. spiriferoides*. This fauna resembles more closely that below the bone-bed.

The following shows the number of each class found at the three localities :

	Spongia.	*Anthozoa.*	*Blastoidea.*	*Brachiopoda.*	*Lamell.*	*Scaphopoda.*	*Gastropoda.*	*Cephalopoda.*	*Crustacea.*	*Total.*
Delaware	0	3	0	14	3	1	1	1	0	23
Marion	0	6	1	17	1	1	0	0	0	26
Sandusky	1	5	0	15	3	1	2	1	2	30

This shows that a greater number of species is found as one goes north. However, the Delaware formation is as fossiliferous as that at the other two cities named though the number of species is smaller.

The following species are found above the bone-bed and are not found below : Lingula manni, Chonetes yandellanus, Leiorhynchus limitaris., Athyris spiriferoides., Aviculopecten parilis, Grammysia bisulcata, Gyroceras ohioense, Tentaculites scalariformis.

Of these eight forms four have been found, one each, in one locality only, two in two localities, and four in four localities. (Pls. VI–VIII.)

It appears therefore, that the difference between the faunas above and below the bone-bed in the central Ohio area is not great, that this difference is most conspicuous at Delaware and diminishes to the north, being least at Sandusky.

ON THE CLASSIFICATION OF A FEW SPECIES.

Stylastrea anna. Forms referred to this species have been frequently found at nearly all localities from Columbus to Kelley's Island, also at White House. Various phases of preservation were to be seen. The specimens all agree in not having the septa run to the center.

Blocks containing a hundred polyps failed to show one in which the septa violated the rule just given. Moreover the septa are plainly denticulate. Tabula prominent. The forms in question agree very closely with Whitfield's description.[1]

This species is easily distinguished from *Acervularia* and *Cyathophyllum* by the septa which in these two genera reach the center.

Conocardium cuneus. This name has been adopted by the writer for what has commonly been known among Ohio Paleontologists as *C. trigonale.* Hall names the form in question *C. cuneus var. trigonale*, and states that this name is given to those forms found in the Corniferous limestone.[2]

A large number of specimens of this prolific form have been collected. Their comparison with Hall's plates of *C. cuneus* fails to show any difference on which a new species could be established, or even a new variety. The form of the species varies considerably, but these variations graduate into each other to such an extent that it does not seem advisable to divide the forms.

Dalmanites aspectans. To this species are referred the forms known as *D. helena. H.*, and *D. ohioense. M.* These names were applied to specimens shaped like the pygidium of *D. aspectans*, but differing from this species in having the surface

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[1] Geol. Surv. of Ohio, Vol. VII, page 420, pl. II.

[2] Pal. N. Y., Vol. V, Pt. 1, Lamm. II, p. 410.

smooth. Some years ago, however, forms known as *D. ohioense* were found associated with *D. aspectans.*

Later, specimens were found which were only partially exfoliated. These show in some places characters of *D. aspectans*, and in others characters of *D. helena* or *D. ohioense*. Since *D. aspectans* was established first, this name must be retained for the forms under consideration.

SUMMARY.

This paper shows:

1. The species found in the Corniferous of Ohio, their distribution in the state, something as to their vertical range and variation.

2. That the life below the bone-bed comprises two faunas.

3. The relation between the faunas above and below the bone-bed and the variations found in the former.

4. It places the central Ohio sections in their proper vertical position.

5. That the White House fauna belongs higher in the Corniferous than any other fauna.

6. That the Bellefontaine fauna is more closely related to that at White House than to any other.

7. It gives some evidence bearing upon the classification of several common species.

Geological Laboratory, Ohio State University, Nov., 1897.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.
Vol. XI. Article III. August, 1898.

TABLES FOR THE DETERMINATION OF NEW MEXICO BEES.

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The student should use E. T. Cresson's *Synopsis of the Families and Genera of Hymenoptera of America, North of Mexico*, (1887), to determine the genera. Thirteen genera given herein which are absent from Cresson's work may be determined as follows:

Hemihalictus, Ckll., is black, and resembles *Halictus* in structure, but has only two submarginal cells.

Parandrena, Rob., resembles *Andrena*, but has only two submarginal cells. It was formerly confounded with *Panurgus*.

Protandrena, Ckll., will run in Cresson's table to *Andrena*, but differs in having the marginal cell truncate at the end.

Halictoides, Nyl., has been confused with *Panurgus*, but it has a pointed marginal cell, whereas that of true *Panurgus* is truncate. The long tongue separates it from *Parandrena* and *Hemihalictus*.

Pseudopanurgus, Ckll., has been confused with *Calliopsis*, to which it will run in Cresson's table. The species are black, nearly naked, strongly punctured, with the wings fuliginous; marginal cell distinctly but obliquely truncate at tip; two submarginals, first recurrent nervure joining second submarginal cell no great distance before its middle, second recurrent joining it just before its tip; basal process of labrum large, subquadrate.

Panurginus, Nyl., includes part of what has been known as *Calliopsis*, namely the black species with no abdominal hair-bands, or light marks on the abdomen; and with yellow or yellowish-white on the faces of the males, with few exceptions.

Hesperapis, Ckll., has two submarginal cells, resembles *Phileremus*, but has a short dagger-like tongue. Mr. Ashmead refers it to *Rhophitosdes*, but the tongue is not at all as in that genus.

Neolarra, Ashm., is a Phileremine bee, easily known by its very small marginal cell.

Phileremulus, Ckll., is a minute bee resembling *Neolarra*, but with only one submarginal cell.

Ashmeadiella, Ckll., has been confused with *Heriades*, but is known by its clear wings, small or subobsdete stigma, first recurrent nervure reaching sub marginal cell further from the origin of the first transverso-cubital, and the abdomen of the males ending with four projections.

Anthophorula, Ckll., is like a small *Podalirius*, but has only two submarginal cells. Tip of marginal cell away from costa.

Oxœa, Klug., differs from *Megacilissa* in that the first recurrent nervure unites with the second transverso-cubital instead of with the first. The labrum is very large, and the eyes in the males strongly converge above.

Exomalopsis, Spin., will run in Cresson's table to *Nomia*, but it is a long-tongued bee, in no way related to *Nomia*. The species are short and compact, shiny, with a very large loose scopa on the hind legs of the females.

Family. ANDRENIDÆ.

Subfamily. PROSOPIDINÆ.

COLLETES.

Large, *Andrena*-like species, with dark, often scarcely banded abdomen in the ♀ 1

Large, ♂ only known, black hairs on dorsum of thorax, very large punctures and five white hair-bands on abdomen. Length about 15 mm (Gila R., July.) . . . . . . *gilensis*, Ckll.

Smaller species, with banded abdomen, ... 3

1. No dark hairs on thorax. (Mesilla Valley, March.) *utilis*, Ckll. ♀.
   With dark hairs on thorax 2
2. Tegulæ piceous, punctuation very strong and close, wings smoky. (Sacramento Mts., October,) . *bigeloviæ*, Ckll. ♀.
   Tegulæ rufo-testaceous, punctuation not so close, wings perfectly clear. (Mesilla Valley, late summer.) . . . . . *armata*, Patton. ♀.
3. Distance between eyes and base of mandibles greater than breadth of latter; no black hairs on thorax . 4
   Distance between eyes ead base of mandibles less than breadth of latter, ... 5
4. About 10 mm. long, pubescence of thorax tinged with ochreous. (Sacramento Mts. and Mesilla Valley, July.) . . . . *wootoni*. Ckll. ♂.
   About 7 mm. long, pubescence white or greyish-white, not at all ochreous. (Mesilla Valley, June.) . *daleæ*, Ckll, ♂.
5. Dorsum of thorax with some black hairs; length about 10 mm. (Mesilla Valley, May, at willow blossom.) . . . . *texana*, Cress, ♀.
   Thorax without black hair, ... 6
6. Pubescence of thorax short, the hairs stout, pubescent, moss-like; length about 11 mm. (Santa Fé, July.) . . . . *aberrans*, Ckll., ♀.
   Pubescence of thorax normal, ... 7
7. Flagellum ferruginous beneath, tarsi ferruginous; small species. (Mesilla Valley, May, at flowers of mesquite.) . . . . , *prosopidis*, Ckll., ♂.
   Flagellum dark, . . . , , . 8

8. Vernal species, appearing at willow blossom in May; about 10 mm. long; stigma black. (Mesilla Valley.) . . . . *salicicola*, Ckll., ♀.
Summer and autumn species, ... 9
9. Punctuation of first abdominal segment feeble and sparse. 10.
Punctuation of first abdominal segment strong, . 12.
10. Species with cinereous pubescence, at most feebly yellowish, ... 11.
Small species with dense ochraceous pubescence; tarsi ferruginous. (Mesilla, end of August.) . *annæ*, Ckll., ♂.
11. Length about 8 mm., pubescence greyish-white. (Mesilla Valley, end of September.) . . *louisæ*, Ckll., ♂.
Length about 11 mm., pubescence of thorax with a delicate yellowish tinge. (White Sands, at flowers of *Bigelovia*, October.) . . . *gypsicolens*, Ckll., ♂.
12. Lateral faces of posterior truncation of thorax dull. . 13.
Lateral faces of posterior truncation shining or tuberculate, not minutely roughened. (Watrous, Las Vegas, Santa Fé, Mesilla Valley, &c.) . *americana*, Cress., ♂. ♀.
13. Larger; hind spur of hind tibia barely ciliate. (Ruidoso Creek, July.) . . . . . *kincaidii*, Ckll., ♀.
Smaller; hind spur of hind tibia pectinate. (Santa Fé, August.) . . . *chamæsarachæ*, Ckll., ♀.

Note.—For descriptions, see Ann. Mag. Nat. Hist., Jan., 1897. Some other species have been collected, but await study in the light of more abundant material.

PROSAPIS.

Males.

Upper part of lateral face-marks receding from orbital margin, . 1
Upper part of lateral face-marks continuous along orbital margin, . 4
1. Upper part of lateral face-marks arising away from the orbital margin, ... 2
Upper part of lateral face-marks touching orbital margin at the base, ... 3
2. Wings not brownish, face yellow. (Santa Fé.) . . . *rudbeckiæ*, Ckll. & Csd.
Wings tinged brownish, face yellowish-white. (Ruidoso Creek.) . . . *rudbeckiæ* race *ruidosensis*, Ckll.
3. Small species, with the upward extension of lateral face-marks itself little curved, and not greatly prolonged. (Mesilla Valley.) . . . . *mesillæ*, Ckll.
Larger species, with the upward extenston of lateral face-marks narrow and inclined to be curved; face-marks strongly yellow. (Ruidoso Creek.) . *tridentula*, Ckll.
4. Supraclypeal mark small and narrow; face much narrowed below. (Mesilla Valley.) . *asinina*, Ckll. & Casad.
Supraclypeal mark broad and short. (Ruidoso Creek.) . . , . . *wootoni*, Ckll.

Females.

First abdominal segment distinctly punctured; lateral face-marks shaped like feet on tiptoe, . . . *asinina*, Ckll. & Csd.
First abdominal segment indistinctly or not punctured; small species; clypeus with a light mark, ... *mesillæ*, Ckll.

Note,—Some other species have been collected, but not yet satisfactorily identified.

Subfamily. SPHECODINÆ.

SPHECODES.

Females.

Under 5 mm. long, abdomen long and narrow, orange. (Mesilla Valley.) . . . . . . *semicoloratus*, Ckll.
Larger, abdomen ferruginous, ... 1

1. Small, about 6 mm. long, abdomen black at the tip. (Mesilla Valley.) . . . *mandibularis*, Cresson.
   Large, abdomen not black at tip, nervures and stigma very dark brown, ... 2
2. Mesothorax very strongly punctured, but the punctures separate, showing the shining surface between, . 3
   Mesothorax not so punctured; very shining, with scattered punctures, ... 4
3. 8 to 8½ mm. long, mandibles simple, labrum not notched, head broad, flagellum ferruginous beneath towards end, wings dull hyaline, legs black, spurs of hind tibiæ ferruginous, abdomen punctured only on the basal parts of the second and following segments, except for a few small scattered inconspicuous punctures; basal enclosure of metathorax distinct, semi-lunar, very strongly irregularly wrinkled, so as to be cancellate. (Mesilla Park, N. M., at flowers of *Sophia*, April 12; also at El Paso, Texas, May 13.) . . *fortior*, Ckll. n. sp.
   7 to 7½ mm. long, mandibles with a large tooth within; labrum scarcely produced, not notched; head broad, orbits more converging below than in *fortior*; metathoracic enclosure shorter, with radiating wrinkles, and feebler cross ones; otherwise much as in the last. (Mesilla Park, at flowers of *Sophia*, April 12, also at flowers of plum, March 23,) . . . *sophiæ*, Ckll., n. sp.
4. Considerably more robust than *mandibularis*; 6 mm. long, head large and broad, mandibles dentate within, labrum not produced or notched, flagellum wholly dark brown; mesothorax with very sparse punctures; metathoracic enclosure distinct, semilunar, strongly irregularly wrinkled; wings dusky hyaline; legs piceous, tarsi becoming ferruginous; abdomen sparsely punc-

tured. (Santa Fé, on white umbelliferous flowers, July 16, 1894.) . . . . *asclepiadis*, Ckll., n. sp. (so-called because a pollen-body of *Asclepias* is adherent to the mouth of the type specimen.)

About 7 mm. long; resembles *asclepiadis*, but differs in the broader face, the flagellum more inclined to ferruginous beneath; the metathoracic enclosure with fewer, more radiating wrinkles; the upper port of the sides of the metathorax more bulging and less strongly sculptured; femora black, tibiæ and tarsi dull ferruginous, tibiæ with a suffused dark spot; mandibles simple; labrum inclined to be notched. (Mesilla Valley, at flowers of *Sophia*, April 12.) . *perlustrans*, Ckll., n. sp.

Subfamily. ANDRENINÆ.

HALICTUS.

Females.

Head and thorax black, abdomen rufous, . , . . . 1

Head and thorax black, abdomen black with well formed hair-bands, 2

Head and thorax black, abdomen not distinctly banded, but often pubescent, ... 7

Head and thorax black, with a faint greenish tinge, or quite green, abdomen with well-formed hair-bands; size not over 7 mm., . 9

Head and thorax green or blue, abdomen without distinct hair-bauds, 10

1. Ocelli; extremely large, stigma honey-color, abomen apricot color. (Mesilla Valley.) . *texanus*, Cress, (*Parasphecodes.*)

   Looks exactly like a *Sphecodes*; 7 mm. long, abdomen broad, dark apricot color, basal half of first segment black. Head and thorax strongly and very closely punctured, especially the head; head longitudinally oval, face much longer than broad, clypeus with large sparse punctures, scape thickly punctured, ocelli ordinary, antennæ short, flagellum except the first two joints ferruginous beneath; mesothorax with median and parapsidal grooves distinct; base of metathorax rugose, enclosure not defined, but bounded behind by a smooth shining area; tegulæ amber-color; wings hyaline, nervures and stigma dark sepia; legs dark, with light pubescence, first joint of hind tarsus with a brush of bright orange hair at its tip; abdomen with close small punctures, first segment nearly impunctate. (Santa Fè, Aug. 1, probably either on *Solidago* or *Clematis*, caught by either Myrtle Boyle or Veer, Boyle.) . . . . *ovaliceps*, Ckll., n. sp.

2. Cheeks produced to a prominent angle beneath; rather large species. (Mesilla Valley, Santa Fè. &c.) . *ligatus*, Say.

   Cheeks not produced beneath, . . . 3

3. Stigma honey-color, or at least not dark brown, . 4
Stigma dark brown or black, ... 6
4. Tegulæ dark piceous, larger species, . . . 5
Tegulæ dark testaceous, smaller species, 8½ mm. long. (Mesilla Valley.) . . . . *amicus*, Ckll.
5. Wings tinged yellowish, nervures honey-color. (Ruidoso Creek, Bernalillo, Paraje.), . . *coriaceus*, Smith.
Wings clear, nervures fuscous, hair-bands of abdomen white. (Mesilla Valley.) . . *bardus*, Cresson.
6. Tegulæ testaceous; metathoracic enclosure truncate behind, with a sharp rim. (Mesilla Valley, Watrous.) . . . . *sisymbrii*, Ckll.
Tegulæ black; metathoracic enclosure semilunar. (Mesilla Valley.) . . . . *angustior*, Ckll.
7. Abdomen black, the segments not margined with testaceous; first segment impunctate; lateral white hair-patches present; stigma piceous. (Mesilla Valley, Roswell, Santa Fé.) . . . *pectoraloides*, Ckll.
Abdomen rather brownish, the hind margins of the segments more or less testaceous, first segment punctured, stigma honey color, ... 8
8. Flagellum more or less testaceous beneath, tarsi rufous, first segment of abdomen transversely striate. (Mesilla Valley, Santa Fé.) . . . *subobscurus*, Ckll.
Flagellum wholly dark, tarsi dark, first segment of abdomen not transversely striate, *amicus*, Ckll, (when worn.)
9. Mesothorax blue-black, scutellum and postcutellum dark greenish. (Santa Fé.) . . . *tripartitus*, Ckll.
Mesothorax bronze-green or olive-green. (Mesilla Valley.) . . . . . *meliloti*, Ckll.
10. Very small; tegulæ punctured. (Mesilla.) *pseudotegularis*, Ckll.
Tegulæ not punctured, ... 11
11. Cheeks with a conspicuous tubercle beneath. Length about 6 mm., head and thorax dark bluish-green varying to olive green; abdomen very dark brown, with a distinct green lustre; hind margins of abdominal segments more or less testaceous; legs piceous; pubescence scanty, dirty white; abdomen pruinose-pubesent. Wings hyaline, stigma and nervures honey-color; tegulæ dark brown. Head very large, facial quadrangle about square; apical portion of clypeus purplish-back; front and sides of the face with small close punctures; mesothorax and scutellum with distinct but very sparse punctures; base of metathorax shining, obscurely roughened, with very faint longitudinal wrinkles towards the sides. Abdomen shining, hardly punctured. Allied to *H. connexus* and *H. cephalotes.* (Las Cruces,

May, Miss Agnes Williams ; Mesilla, April 27, at flowers of *Rosa blanda* in cultivation, C. M. Barber.) . . . . *oleosus*, Ckll., n. sp.

Cheeks not tuberculate, ... 12

12. Thorax blue ; stigma pale yellowish, . . 13

Thorax green, ... 14

13. Mesothorax with very large and strong punctures. (Santa Fé.) . . . . . . *semicæruleus*, Ckll.

Thorax small, mesothorax shiny, hardly punctured. (Mesilla Valley.) . . . . *semibrunneus*, Ckll.

14. Abdomen green like the head and thorax. (Mesilla Valley.) . . . . *pruinosus*, Rob.

Abdomen apricot color, often dark at the apex. This species, common in the Mesilla Valley, has formerly been recorded as *H. stultus*, but it differs from that, and resembles *H. nymphalis*, in having the mesothorax strongly and rather closely punctured. It differs from *nymphalis* in the bluer green of the head and thorax, but seems to be only a geographical race of that insect. *nymphalis*, Smith, race *mesillensis*, Ckll., n. race.

Abdomen black or piceous, ... 15

15. Stigma pale honey-color ; metathorax dark blue ; abdomen hoary. (Santa Fé.) . . *perdifficilis*, Ckll.

Stigma dark or light brown, when light a dilute sepia tint, ... 16

16. Tegulæ very dark; clypeus coppery or brassy, contrasting with the face. (Ruidoso Creek, Santa Fé, Mesilla Valley.) . . . . *ruidosensis*, Ckll.

Tegulæ reddish-testaceous ; face narrower. (Mesilla Valley.) . . . . *ashmeadii*, Rob.

Note.—Several other green species of *Halictus* have been collected, but not yet sufficiently studied.

HEMIHALICTUS.

8 mm. long, black. (Lone mtn., at flowers of *Pyrrhopappus* early in the morning.) . . . . . . *lustrans*, Ckll.

AUGOCHLORA.

Entirely bluish-green, very brilliant ; fourth ventral segment of male abdomen not emarginate. (Mesilla Valley, Organ Mts.) *neglectula*, Ckll.

AGAPOSTEMON.

Females.

Abdomen honey-color, ... *melliventris*, Cresson.

Abdomen green, like the head and thorax, . . . 1

1. Mesothorax with punctures of two sizes, *texanus*, Cresson.

Mesothorax roughened, . . . *radiatus*, Say.

These three are all found in the Mesilla Valley ; *texanus* goes north to Embudo and Santa Fé ; *melliventris* to Rincon and Vega S. José. The males of all have yellow abdomens banded with black.

ANDRENA.

Abdomen partly or wholly rufous, ... 1
Abdomen black or dark brown, at most pale-banded, . . 7
Abdomen blue. (Santa Fé, July) . . . *cerasifolii*, Ckll.
1. Pubescence black. (Mesilla Valley, April.) . *prima*, Casad.
Pubescence grey or fulvous, . . . 2
2. Wings clear or almost so; abdomen not closely punctured. (Mesilla Valley, Paraje, April.) *sphecodina*, Casad and Ckll.
Wings clouded at apex at least, . . . 3
3. Clypeus dark, at most with a yellow spot, . . 4
Clypeus yellow, at least in the ♂, . . . 5
4. First segment of abdomen very feebly and sparsely punctured. Mesilla Valley, April.) . . *jessicæ*, Ckll.
First segment of abdomen strongly punctured. (Santa Fé, Aug.) . . . . *argemonis*, Ckll.
5. Dorsum of thorax honey yellow. (Northern N. M.) *mellea*, Cress.
Thorax entirely black, ... 6
6. Second segment of abdomen without a black band. (Mesilla Valley, Paraje, April.) . . *prunorum*, Ckll.
Second segment of abdomen with a black band. (Mesilla Valley, April.) . . . . *casadæ*, Ckll.
7. Pubescence black. (Mesilla Valley, April.) *nigerrima*, Casad.
Pubescence at least partly pale, . . . 8
8. Clypeus and part of sides of face yellow or white, 9
Clypeus only yellow, ... 12
Sides of face yellow, clypeus mostly dark. (Mesilla Valley, Oct.) . . . . *pulchella*, Rob., ♀.
Face all dark, ... 13
9. Wings dusky at apex, clypeus dark at sides, first two segments of abdomen with apical rufotestaceous bands. (Organ Mts., Sept.) . . *aliciarum*, Ckll., ♀.
Wings clear, ... 10
10. Lower edge of clypeus broadly black, *pulchella*, Rob., ♂.
Clypeus cream-color, edge not broadly black, . 11
11. Larger, flagellum dark, lateral face-marks pointed above. (Mesilla Valley, April.) *capricornis*, Csd. and Ckll., ♂.
Smaller, flagellum ferruginous beneath. (Mesilla Valley, April.) . . . *primulifrons*, Casad., ♂.
12. Abdomen with orange color-bands. (Santa Fé.) . . . *aureocincta*, Ckll., ♂.
Abdomen without color-bands, strongly punctured; wings dusky at apex. (Mesilla Valley, April.) *fracta*, Csd. and Ckll., ♂.

13. Pubescence of thorax bright ferruginous; wings very dark, especially at apex. (Embudo, Sept., at flowers of *Bigelovia.*) . . . . *vulpicolor*, Ckll., ♀.
Pubescence of thorax not ferruginous, or wings not very dark, ... 14
14. Hair at apex of abdomen black or fuscous, . 15
Hair at apex of abdomen pale or reddish, . 17
15. Abdomen shining, strongly punctured. (Paraje, April.) . . . *pruniflorís*, Ckll., ♀.
Abdomen microscopically tessellate, . . 16
16. Tarsi with fuscous hair. (Sacramento Mts., Aug.) . . . *apacheorum*, Ckll., ♀.
Tarsi with pale hair. (Mesilla Valley, March, April.) . . *electrica*, Csd. and Ckll., ♀.
17. Abdomen with continuous hair-bands, even on first segment 18
Abdomen with hair-bands more or less interrupted . 19
Abdomen without any distinct hair-bands or well-defined patches, ... 25
18. Pubescence all white. (Mesilla Valley, April.) . . *electrica*, Csd. and Ckll., ♂.
Pubescence strongly yellowish. (Santa Fé, Aug.) *mentzeliæ*, Ckll., ♀.
19. Head very large, keeled behind eyes. (Santa Fé Canon, 8000 ft., Aug.) *platyparia*, Rob ♂. (var. *occidentalis*, Ckll.)
Head ordinary, ... 20
20. Abdomen distinctly punctured, . . . 21
Abdomen more or less tessellate, hardly punctured, 22
21. Wings strongly clouded at apex, . *fracta*, Csd. and Ckll., ♀.
Much smaller, wings perfectly clear, *primulifrons* Casad., ♀.
22. Length 15 mm. (Albuquerque, at sunflowers, Sept) . . . . *helianthi*, Rob., ♀.
Length 12 mm. or less, ... 23
23. Tarsi ferruginous; small species. (Mesilla Valley, Paraje, April.), ... *salicinella*, Ckll.
Tarsi dark, ... 24
24. Pubescence pale grey to white. (Mesilla Valley, March, April.), ... *monilicornis*, Ckll., ♂.
Pubescence of thorax tinged with ochraceous; wings strongly yellowish. (Paraje, April.), *subaustralis*, Ckll., ♀.
25. Abdomen minutely tessellate, . *subaustralis*, Ckll., ♂.
Abdomen distinctly punctured. (Mesilla Valley, March.) . . . . *mesillæ*, Ckll., ♂.

Note.—The species of *Andrena* which fly in spring are to be taken in great number at the flowers of plum trees.

PARANDRENA.

Abdomen red, ... 1
Abdomen black, ... 2

1. Clypeus and sides of face yellow. (Mesilla Valley, Sept.) . . . . . *pectidis*, Ckll., ♀.
Face all black. (Mesilla Valley, April.), *andrenoides*, Cress. (var. *bicolor*, Rob.) ♀.

2. Clypeus and sides of face yellow, flagellum ferruginous beneath, ... *andrenoides*, Cress., ♂.
Face all black, ... 3

3. Length 7—7½ mm., legs wholly black, apex of wings slightly milky. (Mesilla Valley, Sept), *oliviæ*, Ckll., ♂.
Length 8—9½ mm., tarsi of ♂ wholly pale ferruginous. (Mesilla Valley, Sept.), . . *rhodocerata*, Ckll.

Note.—P. andrenoides is the type of the genus; the others are not strictly congeneric, and are placed here provisionally. The last two are referred by Mr. Ashmead to *Rhophitoides*.

NOMIA.

Abdomen ferruginous, or ferruginous and black. (Albuquerque, Mesilla Valley.), . . *nevadensis*, Cress.
Abdomen black, apical margins of segments not greenish; ♀ like an *Andrena*. (Albuquerque, Mesilla Valley.), ... *persimilis*, Ckll.
Abdomen black, apical margins of segments light green or greenish-white, ... 1

1. Size large, 17 mm. long or over. (Northern N. M.) *nortoni*, Cress.
Size smaller, not 15 mm. long. (Santa Fé, Mesilla Valley, Rincon, etc.), . . . *foxii*, Dalla Torre.

EUNOMIA.

Pubescence cinereous, with a yellowish tinge. (Mesilla Valley.), ... *heteropoda*, Say.
Pubescence dull yellowish; tibiæ and tarsi in ♀ more or less fulvous. (Northern N. M.), ... *apacha*, Cress.
Pubescence (♂) brownish-ochraceous, legs shining; ♀ entirely black or brown-black, ... *marginipennis*, Cress.

Note.—E. heteropoda ♂ was taken at Mesilla Park, Sept. 17, in a sandy place. The other two species I have not seen.

Subfamily. PANURGINÆ.

PROTANDRENA.

Large species, 10 mm. long or over, ... 1
Smaller species, less than 10 mm. long, ... 2

1. Stigma ferruginous. (Mesilla Valley.) *mexicanorum*, Ckll.
Stigma very dark brown. (Santa Fé, Albuquerque.), . . *mexicanorum*, race *asclepiadis*, Ckll.

2. Tarsi piceous in ♀. (Albuquerque.), . *trifoliata*, Ckll.
Tarsi rufous in ♀, yellowish-white in ♂. (Mesilla Valley.), ... *heteromorpha*, Ckll.

HALICTOIDES.

Very small, about 6 mm. long. (Organ mts., at *Gymnolomia* fls.), ... *tinsleyi*, Ckll., ♀.

Larger, 8 mm. or over; ♀ with hind margins of abdominal segments testaceous. (Santa Fé, Rinconada, Mesilla Valley, at fls. of *Helianthus* and *Verbesina*, Aug. to Oct.), . . *marginatus*, Cress.

Note.—H. tinsleyi is perhaps not strictly congeneric with *marginatus*.

PSEUDOPANURGUS.

About 6½ mm. long, a shining boss adjacent to the top of each eye; clypeus and lateral face-marks in ♂ yellow. (Albuquerque, Mesilla Valley, Aug., Sept., at *Bigelovia* fls.) . . *rugosus*, Rob.

Larger, without the shining boss at the summit of the eyes. (Mesilla Valley, at *Helianthus* fls.) . . . . . *æthiops*, Cress.

Note.—The first species is my *P. fraterculus;* Robertson says it is his *rugosus*, but I could not so determine from his description.

PANURGINUS.

Face with light markings, ... 1

Face without light markings, ... 7

1. Females, face with only a kidney-shaped yellow mark. (Mesilla Valley.) . . . *renimaculatus*, Ckll.

Males, ... 2

2. Pale color of face confined to clypeus; first recurrent nervure not uniting with second transverso cubital. (Organ Mts.) . . . . . . *townsendi*, Ckll.

Pale color of face not confined to clypeus, . . 3

3. Pale color confined to clypeus and lateral marks, . . 4

Pale color not confined to clypeus and lateral marks, . 6

4. Face-marks yellowish-white, face with long white hair. (Albuquerque.) . . . . *hirsutifrons*, Ckll.

Face-marks lemon yellow, face little or not hairy, . 5

5. Front hairy; lateral face-marks extending some distance above level of top of clypeus. (Santa Fé at fls. of *Rudbeckia.*) . . . . *albitarsis*, Cress., ♂.

Front not hairy; lateral face-marks hardly extending above level of top of clypeus. Length 5 mm., flagellum ferruginous beneath, except at base; eyes dark sage green; wings very faintly dusky, nervures and stigma dark brown. Tubercles with a testaceous spot. (Santa Fé, Aug. 5.) . . *pauper*, Cress., var. *flavotinctus*, n. var.

6. Scape wholly black. (Santa Fé.) . . . . . *boylei*, Ckll. (? var. of *ornatipes* Cress.)

7. Flagellum dark; nervures and stigma testaceous, ... *albitarsis*, Cress., ♀.

Flagellum largely testaceous beneath; very smooth species 8 mm. long. (Las Cruces, at fls. of *Helianthus.*) . . . . *perlævis*, Ckll., ♀.

CALLIOPSIS.

Abdomen bright ferruginous. (Mesilla Valley, at fls. of *Sphæralcea.*) . . . . *semirufus*, Ckll.

Abdomen dark, with or without light markings, . . . 1

1. Face with light markings, ... 2
   Face without light markings, abdomen with white bands. (Mesilla Valley.) . . . *meliloti*, Ckll., . ♀
2. Abdomen with color-bands or spots, . . . 3
   Abdomen without bands or spots, . . . 5
3. Clypeus only partly light, ... 4
   Clypeus all light except the dots and edge, face densely bearded with white hair, . . *australior*, Ckll., ♂.
4. Band on third abdominal segment always interrupted, 5th segment black, with neither band nor spots. (Albuquerque, Mesilla, at *Cleome* fls., &c.) . *australior*, Ckll., ♀.
   Band on third segment usually entire, 5th segment largely pale. (Santa Fè, at fls. of *Cleome.*) . *scitulus*, Cress. ♀.
5. Females, ... 6
   Males, ... 7
6. Clypeus yellow except two cuneiform black marks ; lateral face-marks going nearly to summit of eyes. (Santa Fè, Embudo, Organ Mts.) . . *coloradensis*, Cress.
   Clypeus with a longitudinal yellow mark or band on disk. (Santa Fé) . . . . *rhodophilus*, Ckll.
7. Legs mostly black; a black spot at tip of wing. (Mesilla Valley, at fls. of *Sphæralcea*,) . . *subalpinus*, Ckll.
   Legs mostly yellow ; no black spot at tip of wing. (Santa Fé, at fls. of *Sphæralcea.*) . . *rhodophilus*, Ckll.
   Femora black, pale orange at apex ; tibiæ all pale orange in front, largely black behind, tarsi yellow, the small joints becoming fuscous. Differs from *rhodophilus* in being larger and more pubescent; face-marks cream-color, lateral marks ending in a point above ; eyes light chocolate color; no black spot at tip of wing. (Mesilla, Aug. 21.) . *flavifrons*, Smith, race *coloratipes*, n. race.

PERDITA.

Yellow, without conspicuous markings, ... 1

Yellow or orange, with conspicuous dark markings, . . . 2

Head and thorax dark, with or without light markings, . . 3

1. 8 mm. long, mesothorax pubescent, pleura with a black patch. (Mesilla Valley, Sept., at fls. of *Verbesina.*) . . . . . *beata*, Ckll.
   Not over 6 mm. long, pale yellow, pleura with a black patch. (Near Tularosa, Aug., at fls. of *Mentzelia.*) . . . . . *wootonæ*, Ckll.
   About the size of *wootonæ*, but very bright yellow, pleura without a black patch. (Mesilla Valley, Sept., at fls. of *Bigelovia*, ... *luteola*, Ckll.

About 4 mm. long, head very large, cheeks armed with a stout spine. (San Marcial, June, at fls. of *Larrea.*) . . . . . *larreæ*, Ckll., ♂.
Like *larreæ*, but head not nearly so large. (Mesilla Valley, at fls. of *Larrea.*) . . *larreæ*, var. *modesta*, Ckll., ♂.
2. Extremely small, cheeks armed, mesothorax mostly green. (San Marcial, at fls. of *Larrea*) . *marcialis*, Ckll., ♂.
Not so small, vertex with a black band from eye to eye, thorax with black markings, abdomen with distinct bands. (Mesilla Valley, at fls. of Mesquite.) . . . . *punctosignata*, Ckll., ♂.
Much like the last, but easily known by stigma, white basally, otherwise occupied by a large black spot. (Mesilla Valley, at willow.) , . . *maculigera*, Ckll.
3. Abdomen orange, or orange brown, or pale brown, or ferruginous ; not banded, unless at base, . . 4
Abdomen dark brown or black, or spotted, or banded, 11
4. Head large, abdomen short and broad, ferruginous, marginal cell obliquely truncate, mandibles bidentate ; head and thorax dark green. (Mesilla Valley, at fls. of *Sphæralcea.*) . . . . . *latior*, Ckll., ♂.
Not so, ... 5
5. Cheeks toothed beneath, legs entirely yellow. (Albuquerque, Mesilla Valley.) . *pallidior*, var. *pulchrior*, Ckll., ♂.
Cheeks unarmed, ... 6
6. Face all dark, nervures colorless, abdomen orange. (Mesilla Valley, at fls. of *Bigelovia*, *Solidago* and *Gutierrezia.*) . . . . . *semicrocea*, Ckll., ♀.
Face partly pale, ... 7
7. The pale color confined to clypeus and triangular marks at sides of face. (Albuquerque, Santa Fé, at fls. of *Chamæsaracha.*) . . . *chamæsarachæ*, Ckll., ♀.
Face all light below antennæ, ... 8
8. Vertex smooth and shining, ... 9
Vertex distinctly granular, ... 10
9. Abdomen orange, head and thorax dark olive green, ... *semicrocea*, Ckll., ♂.
Abdomen light brown, head and thorax dark blue. (Mesilla, at fls. of *Sida.*) . . . . *sidæ*, Ckll., ♂.
10. Face very bright yellow, head and thorax green. (Embudo, at fls. of *Bigelovia.*) . . *rhodura*, Ckll., ♂.
Face yellowish-white, head and thorax dark blue, ... *chamæsarachæ*, Ckll., ♂.
11. Clypeus entirely dark (upper edge whitish in *sidæ* ♀,) . 12
Clypeus not entirely dark, ... 22
12. Abdomen piceous with yellow spots or dots, legs with yellow markings. (Santa Fé, July.) . *sexmaculata*, Ckll. ♀.
Abdomen not spotted, ... 13

13. Abdomen black, with pale yellowish bands, or yellow, with dark bands, ... 14
 Abdomen dark brown, with a short white band on second segment; size very small. (Mesilla Valley, at fls. of *Cladothrix.*) . . . *cladothricis*, Ckll., ♀.
 Abdomen not banded, ... 18
14. Stigma brownish, mesothorax hairy; length 7 mm. or over, ... 15
 Stigma pallid; length not over 6 mm., - . . 16
15. Nervures almost colorless. (Mesilla Valley, at fls. of *Sphæralcea.*) . . . *sphæralceæ*, Ckll., ♀.
 Nervures dark brown. (Santa Fé, at fls. of *Sphæralcea.*) . . *sphæralceæ* race *alticola*, Ckll., ♀.
16. Face with pale lateral marks, . . . 17
 Face all dark; abdomen brown-black, with three dull yellow bands terminating abruptly before reaching the lateral margin. (Embudo, Sept., at fls. of *Bigelovia.*) . . . . *subfasciata*, Ckll., ♀.
17. Anterior femora mostly black, abdomen with heavy dark bands. (Santa Fé, at fls. of *Mentzelia.*) . . . . . . *mentzeliæ*, Ckll., ♀.
 Anterior femora entirely pale, abdomen with evanescent bands. (Albuquerque, Mesilla Valley, at fls. of *Mentzelia.*) . . . . . *pallidior*, Ckll., ♀.
18. Head and thorax black, size small. (Organ Mts., at fls. of *Pectis.*) . . . . *solitaria*, Ckll., ♀.
 Thorax black except the green metathorax; head green, front æneous. (Mesilla Valley, at fls. of *Bigelovia*) . . . . *æneifrons*, Ckll., ♀.
 Thorax black except the blue metathorax; head blue; a yellow spot on each side of the clypeus. (San Marcial, at fls. of *Larrea.*) . . . *semicærulea*, Ckll., ♀.
 Head and thorax green, or greenish-blue, . 19
19. Males, 5½ mm. long, clypeus black, supraclypeal area æneous; hind margins of abdominal segments rather broadly hyaline. (Organ Mts., at fls. of *Verbesina.*) . . . . *chrysophila*, Ckll.
 Females, ... 20
20. Abdomen broad, mandibles bidentate, marginal cell obliquely truncate, . . . *latior*, Ckll., ♀.
 Not so, ... 21
21. Small, about 4½ mm. long, nervures brown. (Mesilla Valley, at fls. of *Bigelovia* and *Gutierrezia.*) *phymatæ*, Ckll.
 A little larger, nervures white, upper edge of clypeus whitish, ... *sidæ*, Ckll, ♀.
 Over 6 mm. long, nervures nearly colorless, . . *verbesinæ*, var. *nigrior*, Ckll.

22. Face below level of antennæ all yellow or white, except clypeal dots in some. (Males.) . . 23
Face below level of antennæ not all pale, . 43
23. Face below antennæ white, . . . 24
Face below antennæ yellow, ... 26
24. Abdomen oval, reddish brown, suffused with darker; clypeus tinged with yellow; front nude and very shiny. (Las Cruces, Aug.) . . *crassiceps*, Ckll. var.
Abdomen yellowish-white, banded; face below antennæ pellucid white; first four legs all dull white except a dark streak on middle tibiæ. (Mesilla Valley, at fls. of *Bigelovia*.) . . . . *pellucida*, Ckll.
Last three segments of abdomen rufous, the others banded. (Albuquerque, La Tenaja, at fls. of *Croton*.) *crotonis*, Ckll.
Abdomen dark brown with white markings, . 25
25. Abdomen with about 6 white marks, or fewer yellowish spots. (Mesilla Valley, at fls. of *Pectis*.) *pectidis*, Ckll.
Abdomen with two more or less developed white bands, ... *cladothricis*, Ckll.
26. Anterior and middle femora marked with black, . 27
Anterior femora all yellow, the four anterior tibiæ not all yellow, ... 33
First four legs all yellow, or at least not marked with black or brown, ... 34
27. Nervures pallid, ... 28
Nervures dark, ... 29
28. Stigma margined with brown; venter of abdomen immaculate in middle, . . . *sphæralceæ*, Ckll.
Stigma pale orange, not margined with brown; venter with a series of large black patches down the middle. (Mesilla Valley, at fls. of *Verbesina*.) *perpulchra*, Ckll.
29. Face nearly bare, bright yellow below antennæ, . 30
Face and disc of mesothorax hairy, . . 32
30. Very small, abdomen yellow with pale suffused brown bands. (Mesilla Valley, at fls. of *Pectis*.) *biparticeps*, Ckll.
Abdomen dark with clean-cut interrupted yellow bands, 31
31. Small, 4½ mm. long. (Mesilla Valley, May, at fls. of *Erigeron*.) . . . . *erigeronis*, Ckll.
Larger. (Embudo, Sept., at fls. of *Bigelovia*.) *affinis*, Cress.
32. Head broader than long; distal band on 2nd abdominal segment broadly continued to lateral margin, *sphæralceæ* race *alticola*, Ckll.
Head round: distal band of 2nd abdominal segment failing some distance before lateral margin. (Mesilla Valley, May.) . . . . *hirsuta*, Ckll.
33. Face not all yellow up to middle ocellus. (Mesilla Valley, at fls. of *Bigelovia*.) . . . *maculipes*, Ckll.

34. Legs entirely orange-rufous, abdomen black. (Santa Fé, June.) . . . . . . *foxi*, Ckll.
Legs not orange-rufous, abdomen banded, . 35
35. The yellow entending above antennæ in median line, 36
The yellow not extending above antennæ in median line, 41
36. The yellow extending above across the face, . 37
The yellow extending above only at sides and middle line, 39
37. Larger, about 5 mm. long, face-marking resembling *gutierreziæ*. (Albuquerque, Mesilla Valley, at fls. of *Bigelovia*.) . . . . *bigeloviæ*, Ckll.
Smaller, about 4 mm. long, ... 38
38. Face yellow up to anterior ocellus. (Mesilla Valley, April.) . . . *martini*, Ckll.
Face not yellow up to anterior ocellus. (Albuquerque, at fls. of *Gutierrezia*.) . . . *gutierreziæ*, Ckll.
39. Upward extension of yellow in median line linear; nervures colorless. (Organ Mts., at fls. of *Mentzelia*.) . . . *mentzeliarum*, Ckll.
Upward extension of yellow in median line shaped like a spear-head; nervures brown. (Mesilla Vallew, at fls. of willow.) . . . . . . *salicis*, Ckll.
Upward extension of yellow in median line broader, 40
40. Incusion of blue downward terminating at a right angle; pleura dark. (Mesilla Valley, at fls. of *Bigelovia*.) *nitidella*, Ckll.
Incursion of blue terminating at an acute angle; pleura largely yellow. (Mesilla Valley, at fls. of mesquite.) . . . . *exclamans*, Ckll.
41. Cheeks armed, abdomen heavily banded, . *mentzeliæ*, Ckll.
Cheeks unarmed, ... 42
42. Abdomen not heavily marked, . . *pallidior*, Ckll.
Abdomen heavily marked with broad black bands. (Embudo, White Sands, at fls. of *Bigelovia*.) *townsendi*, Ckll.
43. The pale color confined to clypeus and sides of face, 44
The pale color not confined to clypeus and sides of face, 70
44. Abdomen dark, not banded, or the bands discontinuous, 45
Abdomen with continuous bands, . . 60
45. Larger species, length over 6 mm. . . . 46
Smaller species, 6 mm. or less, . . . 50
46. Mesothorax practically nude, ... 47
Mesothorax hairy, ... 48
47. Abdomen dark brown without pale marks, *nuda*, Ckll., ♀.
Abdomen with creamy-white marks. (Mesilla Valley, at fls. of *Senecio*.) . . . *senecionis*, Ckll., ♀.
48. Female: abdomen more or less spotted. (Mesilla Valley, at fls. of *Verbesina*.) . . . *verbesinæ*, Ckll.
Males, ... 49

49. Head and thorax brassy green. (Santa Fé, Socorro, at fls. of *Lepachys.*) . . . . . *lepachidis*, Ckll.
Head and thorax rather bluish green. (at fls. of *Helianthus.*) . . . . . . *albipennis*, Cress.

50. Abdomen without distinct light markings, . . 51
Abdomen with yellow or white markings, . 56

51. Pale face-marks reduced to a spot on clypeus; nervures brown, ... *phymatæ*, Ckll., var. ♀.
Pale face-marks not so reduced, lateral marks present; nervures pallid, ... 52

52. Clypeus with two large dark patches on hind margin; mesothorax very hairy. (Mesilla Valley, at fls. of *Aster.*) . . . . *asteris*, Ckll., ♀.
Clypeus pale except the usual dots, . . 53

53. Anterior tibiæ black in front; face extremely hairy. (Mesilla Valley, at fls. of *Verbesina.*) *albovittata*, Ckll., ♂.
Anterior tibiæ yellow or rufotestaceous in front, . 54

54. Marginal cell with the substigmatal portion very much larger than than the poststigmatal; size very small. (San Marcial, at fls. of *Larrea.*) . *larrearum*, Ckll., ♀.
Marginal cell ordinary, ... 55

55. Larger (4½ mm.), face less hairy, lateral face-marks shaped like the mainsail of a schooner. (Mesilla Valley, at fls. of *Verbesina*, Sept.) . . *vagans*, Ckll., ♂.
Smaller (4 mm.), hairy, lateral face-marks triangular. (Mesilla Valley, at fls. of *Chrysopsis.*) *vespertilio*, Ckll., ♂.

56. Abdomen with cream-colored bands, interrupted sublaterally, ... 57
Abdomen with 6 or 8 white marks, . . 58
Abdomen with yellowish marks; mesothorax dull, granulated, ... *affinis*, Cress., ♂.

57. Only the broad lower margin of clypeus white. (Mesilla Valley.) (var. *chrysoceras* differs from *callicerata* principally in its large, subquadrate head.) *callicerata* var. *chrysoceras*, Ckll., ♂.
Clypeus entirely cream-color, except the usual black specks, ... *callicerata*, Ckll., ♀.

58. Marks on abdomen straight; clypeus white; length about 5 mm. (Mesilla, at fls. of *Aster spinosus.*) *ignota*, Ckll., ♀.
Marks on abdomen oblique, . . . 59

59. Mesothorax shiny; clypeus dark with a light spot; face-markings white, . . . *pectidis*, Ckll., ♀.
Mesothorax dull; clypeus light with dark spots or bars; face-markings yellowish. (Mesilla Valley, at fls. of *Bigelovia*, etc.) . . . *fallax*, Ckll., ♀.

60. Large species, length over 6 mm., . . 61
Smaller species, 6 mm. or less, . . . 64

61. Males, abdominal bands narrow, inconspicuous, dull yellow, emarginate at sides, ... 62
Females, bands conspicuons, . . . 63

62. Front comparative shining, flagellum blackish. (Mesilla Valley.) . . . *albipennis*, race *helianthi*, Ckll
Front dull, flagellum orange, . . *verbesinæ*, Ckll.

63. Abdomen with, white black bands, clypeus white, with two black dots, ... *perpulchra*, Ckll.
Abdomen dark, with yellow bands, . *albipennis*, Cress.

64. Clypeus hairy, face-marks and abdominal bands white or cream color, ... 65
Not so, ... , . 66

65. Legs black, ... *albovittata*, Ckll., ♀.
Legs black and yellow. (Mesilla Valley, at fls. of *Baileya*). . . . . . *callicerata*, Ckll, ♂.

66. Yellow at sides of face extending above level of insertion of antennæ; size very small. (Albuquerque, Mesilla Valley, at fls. of *Gutierrezia* and *Bigelovia*.) . *austini*, Ckll., ♂.
Yellow or whitish at sides of face only extending to level of insertion of antennæ; size not so small, . 67

67. Abdomen dark, with light bands, . *bigeloviæ*, Ckll., ♀.
Abdomen light, with dark banks, . . . 68

68. Nervures colorless. (At fls. of *Mentzelia*.) *mentzeliarum*, Ckll., ♀.
Nervures dark brown, ... 69

69. Mesothorax very shiny, dark blue-green,. . *nitidella*, Ckll., ♀.
Mesothorax granular, dark olive-green; end of abdomen brownish-orange, . . . *rhodura*, Ckll., ♀.

70. Dog-ear marks absent, ... 71
Dog-ear marks present, or at least represented by dots, 77

71. Abdomen with the last two segments bright rufous, the others white, with black bands, . *crotonis*, Ckll., ♀.
Not so, ... 72

72. Bands of abdomen at least mostly entire, . . 73
Bands of abdomen all interupted, . *affinis*, Cress, ♀, var.
Abdomen dark without bands, . . . 76

73. Stigma solid dark brown or black. (Mesilla Valley, May, at fls. of willow.) . . . *numerata*, Ckll., ♀.
Stigma hyaline, at least centrally, . . . 74

74. Lateral face-marks truncate above, with a linear extension beyond the truncation; femora entirely yellow; length about 7½ mm., . . . *townsendi*, Ckll., ♀.
Lateral face-marks obliquely truncate above; femora partly black, ... *bigeloviæ*, Ckll., ♀, var.
Lateral face-marks coming to a point above, . . 75

75. About 6 mm. long, resembling *townsendi;* ventral surface of abdomen pale yellow; face-marks yellow. (Sacramento Mts., at fls. of *Bigelovia*.) . *stottleri*, Ckll., ♀.

Face-markings pallid. (Albuquerque, Santa Fé, &c., abundant at fls. of *Cleome.*) . . *zebrata*, Cress, ♀.

76\. Head large, quadrate, face very hairy. (Mesilla Valley.) . . *albovittata* var. *laticeps*, Ckll., ♂.

Head ordinary, face not so hairy, . *asteris*, Ckll., ♀, var.

77\. Abdomen black or dark brown, without pale marks, . 78

Abdomen not banded, but with yellow marks, which are small and straight. (Mesilla Valley, at fls. of *Gutierrezia.*) . . . . . *tarda*, Ckll., ♂.

Abdomen distinctly banded, ... 79

78\. Cheeks armed, head large; clypeus with a narrow median line and broad anterior border yellow. (Mesilla Valley, at fls. of *Solidago.*) . . *grandiceps*, Ckll., ♂.

Cheeks unarmed, clypeus all pale except the usual dots. (Albuquerque.) . . . . *crassiceps*, Ckll., ♂.

79\. Males, ... 80

Females, ... 81

80\. Mesothorax granular; face-markings deep yellow, ... *sphæralceæ*, var.

Mesothorax smooth and shining, . . *zebrata*, Cress.

81\. Nervures colorless. (At fls. of willow.) . . *salicis*, Ckll.

Nervures dark. (At fls. of mesquite.) . *exclamans*, Ckll.

Subfamily. NOMADINÆ.

Nomada.

Entirely ferruginous, without light markings. (Mesilla Valley, at fls. of plum.) . . , . *americana*, Kirby, race *incerta*, Cress.

Ferruginous, with cream-colored markings; sides of face cream-color, but clypeus ferruginous. (Mesilla Valley, at fls. of *Gutierrezia.*) . . . . *gutierreziæ*, Ckll.

Head and thorax black, with yellow markings; abdomen banded; legs ferruginous. (Mesilla Valley, Santa Fé.) . . *modesta*, Cress.

Head and thorax black, abdomen black and rufous . . . 1

1\. Clypeus reddish; basal part of first abdominal segment black; legs rufous. (Mesilla Valley, July.) . *pennigera*, Ckll.

Clypeus black; first abdominal segment entirely red; legs black. (Mesilla, July 21, at fls. of *Sida hederacea.*) . . *pennigera*, var. *sidæfloris*, n. var.

Family. APIDÆ.

Subfamily. PHILEREMINÆ.

Hesperapis.

About 6 mm. long; head and thorax black, with short pubescence; abdomen dull ferruginous, with light hair-bands; hind tibiæ and tarsi with very short white tomentum, and long black bristles. (Mesilla Park, April, C. M. Barber.) . . *elegantula*, Ckll.

NEOLARRA.

6 to 7 mm. long, form elongate, abdomen pointed; head and thorax black, abdomen and legs rufous. (Mesilla Valley, Sept., at fls. of *Verbesina.*) . . . . *verbesinæ*, Ckll.

Much smaller, hardly 4 mm.; abdomen shorter, not so brightly colored. (Mesilla Park, May 7, at fls. of *Dithyræa wislizenii.*) . *pruinosa*, Ashm.

PHILEREMULUS.

♂ 3½, ♀ 3 mm. long, ♂ dull black, ♀ with rufous abdomen. (Mesilla Valley, Sept.) . . . . . . *vigilans*, Ckll.

♀ 3½ mm. long, head a little larger, mandibles more rufous, clypeus not white with scales, last joint of antennæ obliquely truncate. (Santa Fé. August.) . . . . . *nanus*, Ckll.

PHILEREMUS.

Less than 6 mm. long, abdomen orange and black, with spots of white pubescence. (Santa Fé, August,) . . . *pulchellus*, Ckll.

Length 6 mm. or over, abdomen with continuous white bands of pubescence. 1

1. Length 6 mm., abdomen subglobose, with no red tinge. (Mesilla Valley, April.) . . . . *mesillæ*, Ckll., ♂.

   Length 9 to 10 mm., abdomen elongate.pyriform, tinged with dull red; legs entirely ferruginous; scutellum with an apical spine. (Mesilla Park, April, at fls. of *Sophia;* Ckll. and Miss J. E. Casad,) . . . . *productus*, Cress., var. *subruber*, n. var. ♀.

Subfamily. MELECTINÆ.

EPEOLUS.

Abdominal bands all interrupted in the middle, the ends on each side of the interruption swollen. (Deming, Mesilla Valley.) . *verbesinæ*, Ckll.

Abdominal bands entire, or some slightly divided, but then the adjacent ends are not swollen, ... 1

1. Small compact species, less than 9 mm. long, tibial spurs ferruginous. (Mesilla Valley.) . . *compactus*, Cress.

   Larger, 10 mm. or over. 2

2. Legs red, ... 3

   Legs black; tegulæ piceous, ... 6

3. Tegulæ black or fuscous; spurs of four hind tibiæ black, . 4

   Tegulæ apricot-color or rufotestaceous, . . 5

4. Length 12 mm. (Mesilla, June.) . *texanus*, Cress., ♂.

   Length 14 mm,, differs from *remigatus* by the red legs; black patch on middle of first abdominal segment nearly an equilateral triangle, but the corners rounded; apex of abdomen not truncate. (Mesilla, June.) . . . . . *texanus*, Cress, ♀.

5. Black space in middle of first abdominal segment semilunar or broadly triangular. (Mesilla Valley.) . *lunatus*, Say.
   Black space in middle of first abdominal segment a transverse band, not triangular. (Santa Fé, Albuquerque, Mesilla Valley.) . . . *occidentalis*, Cress.
6. Clypeus with numerous minute punctures, and sparse large ones, ... 7
   Clypeus strongly, very densely, uniformly punctured, . . 8
7. Apex of ♀ abdomen subtruncate, last ventral segment produced and curved downwards, fifth abdominal segment without lateral patches of light pubescence, ... *concavus*, Cress.
   Apex of ♀ abdomen not at all truncate; last ventral segment broad, not produced beyond last dorsal; fifth abdominal segment with a patch of light pubescence on each side. (Albuquerque.) . . *robustus*, Cress.
8. Antennæ wholly dark. (Mesilla, Aug. 14, at fls. of *Helianthus ciliaris*.) . . *texanus* var. *nigripes*, n. var. ♂.

Note.—What has been regarded as *E. remigatus*, Fabr., in New Mexico seems to be *robustus*. It is possible that the species recorded by Cresson as taken by Lewis many years ago, was true *remigatus*.

ERICROCIS.

Appearance and ornaments much like *Epeolus;* the yellowish-white hair-bands of abdomen, felted as in *Epeolus*, all broadly interrupted; third submarginal cell in ♂ about twice as broad as second, in ♀ hardly broader than second. (Mesilla Park, April 29, 1898, the sexes together on flowers of *Cædalpinia falcaria* var. *stricta*, C. M. Barber.) . . . . *lata*, Cress.

Note.—Although there is a striking difference in the venation of the two sexes, they certainly belong together. A single ♂ of *E. lata* was taken by Mr. A. P. Morse near Little Mountain, Mesilla Valley, July 1, 1897.

MELECTA.

Abdomen with brown spots and a brown patch on a white ground, the white due to pubescence; size small; flagellum very stout. (Mesilla Valley.) . . . . . *maculata*, Cress.
Abdomen black, with clean-cut light bands, interrupted medially, 1
1. Larger, the bands fulvous. (Vega San José, Continental Divide.) . . . . *interrupta*, Cress.
   Smaller, the bands white. (Santa Fé, Mesilla Valley.) . . . . *miranda*, Fox.

BOMBOMELECTA.

Larger, pubescence of thorax and first abdominal segment bright orange-fulvous. (Mesilla Valley, at fls. of *Lycium*.) . . *thoracica*, Cress., var. *fulvida*, Cress.
Smaller, pubescence of thorax and first abdominal segment greyish-white. (Mesilla Valley, at fls. of plum.) . . *alfredi*, Ckll.

Subfamily. CŒLIOXYNÆ.

CŒLIOXYS.

Legs and first abdominal segment red; middle of second to fifth segments smooth and impunctate, or with a few scattered punctures. (Deming.) . . . . *menthæ*, Ckll.
Legs red; first abdominal segment black like the rest; middle of segments punctured. (Mesilla Valley.) . . *octodentata*, Say.
Legs black; tarsi rufous. (Gila R.) . . *gilensis*, n. sp. ♂.

Note.—*C. gilensis* was found in numbers by Prof. Townsend on the West Fork of the Gila R., July 16. Mr. Fox compared it with Cresson's types, and returned it marked, "near *mœsta*." I have a Colorado *mœsta*, identified by Mr. Fox, and *gilensis* differs in the longer lateral teeth of the scutellum; the abdomen with strong, close punctures, as large on the second segment as on the first; and the rufous tarsi. The last segment of the abdomen is considerably more produced than in ♂ *octodentata*.

Subfamily. MEGACHILINÆ.

STELIS.

7 mm. long, or less; black with bright yellow markings; abdomen banded with yellow and black; marginal cell and adjacent parts of wing fuliginous. (Santa Fé, Gila R.) . . *costalis*, Cress.

ANTHIDIUM.

Head entirely black, except a white spot at the summit of each eye. (Northern N. M.) . *emarginatum*, Say, var. *atrifrons*, Cress., ♀.
Face with at least some light markings, ... 1

1. Clypeus all light, or with only the edge dark, . 2
   Clypeus partly dark, ... 5
2. Markings largely ferruginous, legs ferruginous. (Mesilla Valley, Chaves, Albuquerque.) . . . *curvatum*, Smith, (*interruptum*, Say.)
   Colors black and yellow or white, . . . 3
3. Abdomen with the yellow bands notched behind. (Santa Fé.) . . . . *pudicum*, Cress., ♂.
   Abdomen with the yellow bands notched in front, or divided into spots, ... 4
   Abdominal bands entire, not conspicuously notched; legs yellow, tinged with ferruginous. (Mesilla Valley.) . . . . *larreæ*, Ckll.
4. Large, yellow marks rather pale, femora and most of tibiæ black. (Mesilla Valley.) . *maculifrons*, Smith, ♂.
   Smaller, about 10 mm. long, yellow very bright, legs yellow and ferruginous. Flagellum, except first joint, ferruginous beneath. Yellow markings of head and thorax as in *maculifrons*. (Mesilla, June 17, at fls. of *Parosela scoparia*) . . . *paroselæ*, Ckll., n. sp. ♀.

Length about 10 mm., face-markings white; legs black, tibiæ marked with white and with a ferruginous spot at apex, tarsi white, dusky at tips. (Northern N. M.) . . . *occidentale*, Cress., ♂.

5. Abdominal bands not notched or divided sublaterally, but more or less divided in the middle line. (Ruidoso Creek, Aug. 20, 1897; E. O. Wooton.) *perpictum*, Ckll., n. sp. ♀

Abdominal bands divided in the middle, and notched sublaterally behind. (Santa Fé.) *pudicum*, Cress., ♀.

Abdomen with a yellow spot on each side of first segment, a yellow band divided only in the middle on second, yellow bands broadly divided medially and sublaterally on third to fifth, no yellow at all on sixth segment. Size small; legs ferruginous, yellow and black. (Gila R.) . . . . *gilense*, Ckll., ♀.

Larger, abdominal bands entirely divided into distant spots; no yellow on face except two large blotches on clypeus. (Tuerto Mtn., 8025 ft.) . *maculosum*, Cress.

Abdominal bands notched sublaterally in front, or even there divided but then the spots much larger than the intervals between them, ... 6

6. Ventral scopa fulvous; scutellum with two light spots. (Northern N. M.) . . *occidentale*, Cress., ♀.

Ventral scopa white; scutellum with four spots. (Mesilla Valley, Organ Mts.) . . *maculifrons*, Smith, ♀.

Note.—A. perpictum is about 9 mm. long, and agrees in most respects with the Mexican *A. flavolineatum*, Smith. The femora are black; all the knees ferruginous; tibiæ ferruginous suffused with black behind; tarsi ferruginous, hind tarsi strongly stained with black. Sides of clypeus occupied by large triangular patches, of which the upper half is yellow and the lower orange; sides of face yellow up to summit of eyes. Wings quite dark. Ventral scopa white. Tegulæ ferruginous. Scutellum with an interrupted yellow band, but lateral angles spotless.

OSMIA.

Females.

Ventral scopa black, ... 1

Ventral scopa pale fulvo-ochraceous; head and thorax olive green, with white pubescence; tegulæ shining rufotestaceous. (Mesilla Valley.) . . . . *phenax*, Ckll.

Ventral scopa black in middle and yellowish-white at sides; tegulæ black. (Mesilla Valley.) . . . . *prunorum*, Ckll.

1. Length 9½ mm., pubescence of thorax above bright rust-red. (Mesilla Valley.) . . . *cerasi*, Ckll.

Larger, dark blue, pubescence of thorax dull white and black mixed; clypeus broadly and deeply notched. (Organ Mts., Paraje.) . . . *lignaria*, Say.

MONUMETHA.

About 14 mm. long, black; occiput and pleura with sooty hair; thorax above with dull white hair; lateral margins of first two abdominal segments with white hair-patches. (Gila R.) . *borealis*, Cress.

ALCIDAMEA.

About 13 mm. long, black, with white and mouse-grey pubescence. In general appearance like *Andrena electrica*. (Mesilla Valley.) . . . *biscutellæ*, Ckll., ♂.

ASHMEADIELLA.

Abdomen red. (Mesilla Valley.) . . . . *holtii*, Ckll.
Abdomen black, ... 1

1. Legs partly red; length about 5½ mm. (Mesilla Valley.) . . . . *bigeloviæ*, Ckll.
   Legs entirely black, ... 2
2. Large species, over 8 mm. long, . . . 3
   Smaller, under 7 mm.; tegulæ black or piceous, . 4
3. Tegulæ dark ferruginous. (Organ Mts., May, at fls. of *Opuntia*.) . . . . . . *opuntiæ*, Ckll.
   Tegulæ black. (Albuquerque, Sept., at fls. of *Grindelia*.) . . . . *bucconis*, Say.
4. Length 5 mm. (Mesilla Valley, at fls. of mesquite.) . . . *prosopidis*, Ckll., ♀.
   Length about 7 mm. (Santa Fé, at fls. of *Cactus*.) . . . . *cactorum*, Ckll., ♀.
   Length about 6½ mm., head large. (Mesilla Valley.) . . . . *meliloti*, Ckll., ♂.

HERIADES.

Front legs partly red; length about 5 mm. (Mesilla Valley.) *asteris*, Ckll.
Legs entirely black, ... 1

1. First recurrent nervure uniting with first transverso-cubital. (Santa Fé.) . . . *crucifera*, Ckll.
   First recurrent nervure not so uniting, . . 2
2. Length 8 mm. or over. (Organ Mts., at fls. of *Opuntia*.) . . . . *gracilior*, Ckll.
   Length less than 8 mm., punctures on third abdominal segment much larger than those on second. (Santa Fé, Mesilla Valley, etc.) . . . *carinata*, Cress

LITHURGUS.

About 16 mm. long; resembles a *Megachile*. Abdomen with narrow white hair-bands, apex with fusco-fulvous hair. (Santa Fé, Mesilla Valley.) . . . . *apicalis*, Cress.

MEGACHILE.

Males.

Front tarsi ordinary, ... 1
Front tarsi peculiar, ... 2

1. Shape narrow; apex of abdomen notched but not produced. (Gila R.) . . . . *exilis*, Cress.
   Broader; apex of abdomen produced, deeply notched, and bent downwards. (Mesilla Valley.) *townsendiana*, Ckll.
   Broad, 13 mm. long; abdomen subquadrate, apex coarsely serrate and deeply notched, . . *texana*, Cress.
2. Abdomen without hair-bands; last joint of antennæ dilated and flattened. (Ruidoso Creek.) . *wootoni*, Ckll.
   Abdomen with hair-bands, ... 3
3. First joint of anterior tarsi produced to a free apex, 4
   First joint of anterior tarsi not produced to a free apex, 5
4. The free apex like the end of a finger; hair-bands of abdomen fulvous. (Gila R.) . . *fidelis*, Cress.
   The free apex not like the end of a finger; hair-bands white. (Santa Fé.) . . . *pugnata*, Say.
5. Thorax very pubescent, the pubescence more or less ochreous or fulvous, ... 6
   Thorax not very pubescent, the pubescence pale greyish to white, ... 8
6. Flagellum slender, not crenulated beneath. (Santa Fé.) . . . . *latimanus*, Say.
   Flagellum stout, crenulated beneath, . . 7
7. Pubescence of thorax yellowish-grey. (Tuerto Mtn., near Santa Fé) . . . . *comata*, Cress.
   Pubescence of thorax fulvous. (Gila R.) . *fortis*, Cress.
8. Anterior legs slender; anterior tarsi with basal joint merely expanded into a flat lamina at the side. (Mesilla Valley.) . . . . *occidentalis*, Fox.
   Larger; anterior femora stout, subtriangular in section, 9
9. Anterior femur yellow where it touches tibia; pubescence of face yellowish. (Deming, Lone Mtn., Mesilla Valley.) . . . . . *sidalceæ*, Ckll.
   Anterior femur rufous where it touches tibia; pubescence of face white. (Mesilla Valley.) . . *casadæ*, Ckll.

Females.

Large and robust, length 14 mm. or over, . . . 1
Smaller, length under 13 mm., ... 2

1. Ventral scopa pale fulvous, . . *latimanus*, Say.
   Ventral scopa white; black on the last two segments. (Ruidoso Creek.) . . . . *texana*, Cress.
2. Abdomen short and broad; ventral scopa white, black on last segment. (Mesilla Valley.) . . *brevis*, Say.
   Abdomen long and narrow, ... 3
3. Ventral scopa white, black on last segment; tegulæ orange brown, ... *occidentalis*, Fox.
   Ventral scopa entirely dull white; tegulæ piceous, strongly punctured, ... *exilis*, Cress.

Note.—Several other species of *Megachile* have been collected, but not yet studied. It is not certain that what is called *brevis* here is in reality Say's species. A specimen of *M. brevis* from Mr. Robertson has the ventral scopa all white. Say's description does not indicate whether it should be black at the tip or not.

Subfamily. PODALIRIINÆ.

MELISSODES.

Males.

Clypeus black, ... 1
Clypeus yellow, ... 2

1. Larger, antennæ longer than head and thorax; mandibles with no yellow spot. (Mesilla Valley, San Marcial.) *tristis*, Ckll.
   Smaller, antennæ reaching only to metathorax; mandibles with a yellow spot. (Santa Fé.) . *sphæralceæ*, Ckll.
2. Antennæ yellow; thorax with bright fulvous pubescence. (Rincon, Mesilla Valley.) . . *luteicornis*, Ckll.
   Antennæ not yellow, ... 3
3. Flagellum entirely black. (Ruidoso Creek.) *ruidosensis*, Ckll.
   Flagellum more or less ferruginous beneath, . 4
4. Pubescence of middle of thoracic dorsum black. General size and form of *aurigenia*. Pubescence, where not black, dull white to pale ochraceous. Mandibles with no yellow spot. Nervures piceous. (Santa Fé, July and Aug., at fls. of *Grindelia*, *Lepachys* and *Rudbeckia;* also Tuerto Mtn., 8875 ft.) . . *grindeliæ*, Ckll., n. sp.
   Pubescence of thoracic dorsum ochraceous or greyish, (some little black in *montana*.) 5
5. Very large and robust, antennæ only moderately long; mandibles partly yellow, ... 6
   Smaller, with long antennæ, ... 7
6. Abdomen dark, with hair-bands. (Santa Fé.) *obliqua*, Say.
   Abdomen entirely covered with fulvous hair. (Mesilla Valley.) . . . . *townsendi*, Ckll.
7. Last dorsal segment of abdomen with fuscous hair; mandibles with a yellow patch, . . . 8
   Last dorsal segment of abdomen with light hair, 9
8. Scutellum with black hair; base of fourth abdominal segment without black hair. (Gila R.) *montana*, Cress.
   Scutellum without black hair; base of fourth abdominal segment with much black hair. (Mesilla Valley.) . . . . *communis*, Cress.
9. Larger; about 12 mm. long, ... 10
   Smaller; about 10 mm. long, . . . 11
10. Mandibles with a yellow spot. (Santa Fé.) *menuacha*, Cress.
    Mandibles without a yellow spot. (Albuquerque, Mesilla Valley.) . . *menuacha* var. *submenuacha*, Ckll.

11. Pubescence pale grey, with a faint ochreous tinge. (Mesilla Valley, Socorro, Albuquerque.) . *agilis*, Cress.
Pubescence more or less strongly ochraceous. (Santa Fé.) . . *agilis* var. *aurigenia*, Cress.

Note.—The male of *grindeliæ* is readily separated from that of *montana* as follows:

Third and fourth abdominal segments covered, even at base, with very pale ochraceous hair; last segment with fuscous or black hair; mandibles with a yellow spot, *montana*, Cr.
Third and fourth segments with the black surface exposed except on apical margins; last segment with ochraceous hair; mandibles with no yellow spot, . *grindeliæ*, Ckll.

Females.

Hair on inner side of basal joint of hind tarsus black or fuscous, 1
Hair on inner side of basal joint of hind tarsus ferruginous, . 4

1. Pubescence of thorax above bright fulvous, *luteicornis*, Ckll.
Pubescence of thorax above pale, with some black, . 2
2. Some black hair behind ocelli. Head not so broad as in *pallidicincta*, much like *confusa*, for which it has been taken, but hair of legs, except on inner side of tarsi, and somewhat on apices of tibiæ, entirely dull white. (Santa Fé, with the ♂.) . *grindeliæ*, Ckll., n. sp.
Hair behind ocelli all pale, ... 3
3. Larger, head extremely broad, abdomen with conspicuous white hair-bands. (Gila R., Santa Fé, etc.) *pallidicincta*, Ckll.
Smaller, head not so broad. (Mesilla Valley.) *intermedia*, Cress.
4. Very large and robust, about 16 mm. long; pubescence of pleura black, ... *obliqua*, Say.
Smaller, pubescence of pleura ochraceous or grey, 5
5. Scutellum and middle of mesothorax with conspicuous black hair. (Gila R., etc.) . . *gilensis*, Ckll.
Dorsum of thorax without black hair, or with only a few inconspicuous black hairs, . . . 6
6. Larger, pubescence of thorax pale ochraceous, *menuacha*, Cress.
Smaller, pubescence of thorax bright fulvous or at least strongly ochraceous, . *agilis* var. *aurigenia*, Cress.

Note.—Several other species of *Melissodes* have been collected in the female sex, but are not at present named, the material being rather inadequate for satisfactory study. *M. nevadensis*, Cress., has been taken in the Mesilla Valley, but I have no specimens at hand at the present time.

XENOGLOSSA.

Legs, except the tarsi, black; size smaller. (Mesilla Valley.) *pruinosa*, Say.
Legs wholly rufous or fulvous; size larger, . . . 1

1. Abdomen red, very large and stout species. (Mesilla Valley, Gila R.) . . . . . *patricia*, Ckll.
Abdomen black. (Mesilla Valley.) . *strenua*, Cress.

Note.—All these species may be found in the flowers of *Cucurbita*.

Diadasia.

Abdomen with clean-cut hair-bands; bases of second to fourth segments free from pale hairs. (Rincon.) . . . *rinconis*, Ckll.
Abdomen hairy all over, ... 1
1. Rather large; hind tarsi with a large finger-like process. (Santa Fé, June, at fls. of *Opuntia*.) . *australis*, Cress.
Hind tarsi without such a process, . . . 2
2. Very large; ♂ very robust, with more or less distinct abdominal hair-bands. (Mesilla Valley, and by the White Sands.) . . . . *megamorpha*, Ckll.
Little over 10 mm. long; covered all over with yellowish pubescence, very dense and uniform on abdomen. (Rincon, Organ Mts., Santa Fé, Mesilla Valley, Deming, etc.) . . . . *enavata*, Cress.
Very small, about 8 mm.. with pale grey or greyish-white pubscence. (Mesilla Valley, Santa Fè.) *diminuta*, Cress.
About 8 mm. long, differs from *diminuta* by having the pubescence on the abdomen not uniformly dense, but thinner, leaving the apical hair-bands distinct, *apacha*, Cress. ♀.

Synhalonia.

About 15 mm. long, with dull white pubescence, tinged with yellowish on thorax; brush of hind tarsi very bright ferruginous; abdomen black, with first segment covered with greyish-white hair, and hair-bands of the same color on segments 2 and 3, the hair of these bands being appressed and very short. (Mesilla Valley.) *lycii*, Ckll.

Habropoda.

Rather large, robust, with a broad abdomen. Pubescence black and greyish-white mixed. Abdomen with very distinct hair-bands. Clypeus in ♂ with a reversed T in white; narrow white lateral face-marks, reduced to a line above. Face of ♀ black. (Top of Organ Mts.) . . . . . *salviarum*, Ckll.

Podalirius. (Anthophora.)

Hind margins of abdominal segments with chalk-white bands, not due to hair, ... 1
Hind margins of segments without such bands, . . . 4
1. Thoracic pubescence mixed black and mouse-grey; clypeus of ♂ white, with the lateral margins broadly black. (Santa Fé.) . . . . *cleomis*, Ckll.
Thoracic pubescence greyish or ochraceous, with no black hairs, ... 2
2. Clypeus and sides of face yellow. (Deming, Mesilla Valley.) . . . . . *californicus*, Cress.
Clypeus and sides of face white, . . . 3
3. Apical joint of middle tarsi ciliated laterally with black pubescence in ♂. (Vega S. José.) . *walshii*, Cress.

Middle tarsi without any black pubescence. (Lone Mtn. near Silver City) . . . *cardui*, Ckll., ♂.

4. Apical joint of middle tarsus of ♂ with a broad brush of black hair on each side, the whole shaped like the end of a peacock's feather. (Mesilla Valley.) *lesquerellæ*, Ckll.

Not so, ... 5

5. Small species, length less than 10 mm., . . . 6

Large, over 10 mm., ... 7

6. Eyes green; clypeus broadly magined with yellow. (Mesilla Valley, Santa Fé, Embudo.) . *maculifrons*, Cress.

Eyes dark purplish; clypeus white in ♂, black with a very narrow white apical stripe in ♀. (Mesilla Valley; the ♀ discovered April 29 by C. M. Barber.) . *phenax*, Ckll.

7. 15 to 17 mm. long; entire body covered with short, dense, mouse grey to fulvous pubescence; basal joint of hind tarsi of ♂ toothed within. (Santa Fé.) . *occidentalis*, Cress.

Abdomen not fasciate, the first and second segments, and sometimes more or less of the third, clothed with short ochraceous pubescence, the rest black or brownish. (Santa Fè.) . . . . *bomboides*, Kirby.

Abdomen not fasciate, the first and part of the second segments with ochraceous pubescence, the rest of the abdomen black. Large, robust species. Basal joint of hind tarsi of ♂ simple. (Organ Mts., Vega S. José.) . . . , . *ursinus*, Cress.

Abdomen more or less fasciate. . . . 8

8. Abdomen with broad, entire, dense, yellowish-white hair-bands; thorax with mouse-grey hair intermixed with black. (Albuquerque, western base of Organ Mts., Canada Alamosa.) . *urbanus*, Cress., var. *alamosanus*, Ckll.

Abdomen with narrow or weak hair-bands, . . 9

9. Large, about 17 mm. long; abdomen with very narrow hair-bands; clypeus of ♂ pale yellow; eyes green. (Mesilla Valley.). . . . . . *affabilis*, Cress

About 13 or 14 mm. long; tip of fifth abdominal segment in ♀ with dense black pubescence. (Vega S. José.) . . . . . *montanus*, Cress.

12 mm. long; fifth abdominal segment in ♀ covered with black hair. Differs from Cresson's description of *montanus* ♀ in having mandibles not fulvous before apex, pubescence of thorax with black intermixed, apical margins of wings not at all dusky, outer side of tibiæ clothed with silvery-white hair; ♂ with clypeus and sides of face yellow. (Mesilla Valley.) . *vallorum*, Ckll.

Note.—The ♀ of *lesquerellæ* is hard to distinguish from that of *vallorum*, but is rather larger, has rather shorter antennæ, and flies earlier in the year,—in April.

ANTHOPOHRULA.*

About 6½ mm. long, short and compact, like a small *Diadasia* or *Podalirius*, pubescence pale mouse-color, covering most of abdomen with a dense felt, Flagellum fulvous. (Mesilla Valley.) . . . . . *compactula*, Ckll.

CENTRIS.

Males.

Front broad, ... 1
Front narrow, ... 3
1. Length over 14 mm., scape without yellow, . . 2
   Length under 14 mm., scape yellow in front, . *rhodopus*, Ckll.
2. Very large, 21 mm. long, pubescence of thorax mouse-color, abdomen with two more or less distinct reddish bands, ... *morsei*, Ckll.
   Length 16 mm., pubescence of thorax ochraceous. . . . . . *cæsalpiniæ*, Ckll.
3. Abdomen with narrow hair-bands; clypeus yellowish-white, ... *hoffmanseggiæ*, Ckll.
   Abdomen without hair-bands; clypeus lemon yellow, ... *lanosa*, Cress.

Females.

Clypeus crimson, ... 1
Clypeus yellow or orange, the upper border more or less black, . . 2
1. Length over 14 mm.; legs black, . ., *cæsalpiniæ*, Ckll.
   Length under 14 mm.; femora and tibiæ rufous, . *rhodopus*, Ckll.
2. Second abdominal segment pubescent, . *lanosa*, Cress.
   Second abdominal segment bare, . *hoffmanseggiæ*, Ckll.

Note.—*C. morsei* was taken at the end of June; all the others can be found at flowers of *Cæsalpinia* (*Hoffmanseggia*) *falcaria* in May. All occur in the Mesilla Valley.

OXÆA.

Wings on apical half blue-black; legs reddish; abdomen black, on the sides, beneath, and sixth or seventh dorsal segments with fulvous pubescence. Length 22 mm. (Mesilla Valley.) . *gloriosa*, Fox.

Note.—This was described as a *Megacilissa*, but it differs in the venation from that genus. I had referred it to *Oxæa*, and Mr. Friese, to whom I sent a specimen, places it in that genus.

MEGACILISSA.

Wings not or but slightly fuscous apically; abdomen dorsally black, with the apical margins of segments 2 to 4 with white pubescence. (El Rito.) . . . . . , . *yarrowi*, Cress.

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*Since this was sent to press I have ascertained that *Anthophorula* is in reality an *Exomalopsis* with two marginal cells.

EXOMALOPSIS.

Abdomen of ♀ red, of ♂ black. Length 7 to 8 mm. (Mesilla, at fls. of *Sida hederacea.*) . . . . *sidæ*, Ckll.

Rather larger, entirely black, pubescence all pale. (Mesilla Valley, Albuquerque.) . . . . *solani*, Ckll.

Subfamily. XYLOCOPINÆ.

XYLOCOPA.

Over 20 mm. long, very large and robust; dark blue, shining; pubescence black; wings fuliginous. (Mesilla Valley, Lone Mtn. near Silver City.) . . . . . *arizonensis*, Cress.

CERATINA.

Length 4½ mm., shining, very dark bluish-green, brassy-green on mesothorax. A cream-colored clypeal mark. Abdomen ending in a short point. (Mesilla Valley,) . . *nanula*, Ckll., ♂.

Subfamily. BOMBINÆ.

BOMBUS.

Abdomen with an orange-red band, ... 1

Abdomen with a black band, black also at base; thorax with a black band. (Santa Fé Canon) . . . . *howardi*, Cress.

Abdomen with black pubescence at base and apex, fulvous in the middle. (Mesilla Valley.) . . . *americanorum*, Fabr., ♀.

Abdomen with fulvous pubescence, dark brown at tip; wings entirely fuscous, ... *nevadensis*, Cress.

Abdomen with bright yellow pubescence, black at tip (in ♀ nearly the the apical half black); thorax with the same bright yellow pubescence, and no black band; wings fuliginous. (Mesilla Valley, Organ Mts., Lamy, Watrous, Albuquerque, Santa Fé, &c) . *morrisoni*, Cress.

Abdomen with the pubescence entirely fulvous; thorax with a black band, ... 2

1. Abdomen with the pubescence orange on second and third segments, yellowish on first and fourth, black at apex, ... *ternarius*, Say.

   Abdomen with the pubescence orange on third and fourth segments, black on fifth and sixth. (Santa Fè Canon, Ruidoso Creek) . . . . *juxtus*, Cress.

2. Pubescence of thorax, before the black band, yellowish white. (Santa Fé Canon.) . . *appositus*, Cress.

   Pubescence of thorax, before the black band, fulvous like that behind it, . . . *americanorum*, Fabr., ♂.

Subfamily. APINÆ.

APIS.

Not native in New Mexico. Includes *A. mellifera*, Linné, the honey bee. The variety commonly kept in New Mexico is the Italian, distinguished by the abdomen being largely light fulvous.

APPENDIX TO ARTICLE III. VOLUME XI.

Notes on Bees taken at Albuquerque, New Mexico, in September, 1897.

By T. D. A. Cockerell,
Entomologist of the New Mexico Agricultural Experiment Station.

The following list is the result of some collecting done by the writer at Albuquerque during parts of three days in September. Only one of the species has been recorded before from that locality, and a few are new to New Mexico. In Bull. 24 of the N. M. Experiment Station, pp. 22-23, 13 bees are recorded from Albuquerque; the present list brings the number to 28.

(1). *Prosapis asinina*, Ckll. and Casad, 1895, var. *bigeloviæ*, n. var.—Female; differs by having the punctures of the first abdominal segment considerably smaller and weaker, hind margins of abdominal segments broadly rufescent, sides of abdomen with no noticeable white hair, scutellum with a distinct median longitudinal groove (wholly wanting in the typical form). Possibly a distinct species. One at flowers of *Bigelovia wrightii*, Sept. 16. Specimens taken at Mesilla, N. M., Sept. 4, at flowers of *Bigelovia wrightii*, are not *bigeloviæ* but ordinary *asinina*.

(2). *Colletes armata*, Patton, 1879—Sept. 15, two females at flowers of *Bigelovia wrightii*.

(3). *Andrena helianthi*, Rob., 1891—Sept. 16, two females at flowers of *Helianthus annuus*. New to New Mexico. The legs are black, not "dull ferruginous," as Robertson describes; they are also black in a specimen received from Mr. Robertson.

(4). *Nomia nevadensis*, Cresson, 1874—Sept. 16, one male and one female at flowers of *Bigelovia wrightii*. I have also a male which I took in Albuquerque, June 30, at flowers of *Fallugia pardaoxa*.

(5). *Nomia persimilis*, n. sp.—Female, length about 14 mm.; black with short greyish pubescence. Facial quadrangle about as broad as long; head little hairy, sides of face with sparse short hairs; no lateral facial depressions; clypeus bare, subcancellate from close punctures all over, no smooth line; rest of face sculptured like clypeus; vertex strongly and very closely punctured; antennæ short, scape strongly punctured, flagellum wholly dark; mandibles dark reddish in middle; process of labrum subtruncate, very broad and little produced; anterior edge of clypeus with a conspicuous fringe of orange hairs; thorax with very short pale greyish-ochreous pubescence; mesothorax with very large punctures, about as close as it is possible for them to be; enclosure of metathorax bow-shaped, but broader at the sides than in the middle, irregularly subreticulated by raised lines, its boundary a strong ridge; tegulæ rufous; wings yellowish-hyaline, apical margin broadly smoky, nervures dark brown; stigma ferruginous, rather small; legs black; abdomen without hair-bands, strongly and extremely closely punctured, hind margins of segments not at all greenish. The male has the hind tibiæ broad and flattened, the inner apical corner produced into a blunt spine.

I first met with this species on the morning of Sept. 11, 1895, in a sandy place in the Mesilla Valley, near to the Agricultural College. The females were very abundant, flying over the sand like bembecides; making deep, large burrows straight down in the sand, and throwing up quite conspicuous piles of earth. Some were heavily loaded with orange pollen. All were females, and without the male I could not tell whether the species belonged to *Nomia* or *Eunomia*. Next, Prof. L. Bruner sent me a single female collected at Lincoln, Nebraska, in August. In Albuquerque I met with the species between the old and new towns, Sept. 16, and took three males and four females. The males enable me to refer the insect to *Nomia*, of which it is a very distinct new species. It is curious that all the males were on an *Aster* with purple rays, while the females were at the flowers of *Helianthus annuus*, gathering pollen. The females have the strongest possible superficial resemblance to *Andrena helianthi*, which was visiting the same flowers, so that when collecting I had no idea that there were two species before me.

(6). *Pseudopanurgus æthiops* (Cresson, 1872)—Sept. 16, one female at flowers of *Helianthus annuus.*

(7). *Perdita zebrata*, Cresson, 1878—Sept. 15, four at flowers of *Cleome serrulata.*

(8). *Perdita albipennis*, Cresson, 1868, var. *hyalina* (Cresson, 1878.)—Sept. 16, one male and two females at flowers of *Helianthus annuus*. The variety is new to New Mexico.

(9). *Anthidium curvatum*, Smith, 1854 (*interruptum*, Say, 1824, not Fabr.)—Sept. 16, one at flowers of *Helianthus annuus.*

(10). *Epeolus occidentalis*, Cresson, 1878—Sept. 16, two worn examples, one at flowers of *Bigelovia wrightii.*

(11). *Epiolus remigatus*, Fabricius, 1804—Sept. 15, one.

(12). *Podalirius urbanus* (Cress., 1878), var. *alamosanus* (Ckll., 1896)—Sept. 15, four females at flowers of *Cleome serrulata ;* Sept. 17, one female. This was described as a species, but it is only a feebly-distinguished race of *urbanus.*

(13). *Melissodes agilis*, Cresson, 1878—Sept. 16, at flowers of *Helianthus annuus.*

(14). *Melissodes menuacha*, Cress., 1868, var. *submenuacha*, Ckll., 1897—one male, Sept. 17.

(15). *Ashmeadiella bucconis* (Say, 1837, as *Osmia bucconis*)—Sept. 17, one female, at flowers of *Grindelia*, new to New Mexico.

(16). *Bombus morrisoni*, Cresson, 1878—Sept. 15, two males, one female, the latter at flowers of *Cleome serrulata.*

MESILLA PARK, N. M., Dec. 15, 1897.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.
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*PAPERS ON THE GEOLOGY OF NEW MEXICO.

By C. L. HERRICK,
President of the University ot New Mexico.

The following pages are derived from the results of studies carried on at intervals during four years. Several articles in the American Geologist have discussed certain features of the geology of the territory and may be considered to form a part of the present series. The enormous area over which these investigations must extend before they can approach completeness and the interrupted course of the field work unite to prevent any symmetrical prosecution or publication of the work. It has seemed best therefore to print the results in sections covering definite areas more or less cursorily and to leave the task of correlating the data to a later period. These articles then do not presume a knowledge of the geology of the territory at large, as they ought to do in order to be complete, but are materials toward a more synthetic study in the future. It is hoped that this method of publication will serve a good purpose in stimulating further work and in aiding in the practical development of the region.

I.

THE GEOLOGY OF THE SOCORRO MOUNTAIN.

With Plates IX, X and XI.

Probably nowhere in the territory can more suggestive geological data be found in so limited a space as in the small group of mountains lying immediately west of the town of Socorro and bearing that name. The mountain front at the north is prominent and precipitous, while the eastern face is elsewhere broken by intersecting canons and depressions. We here have in epitome the geological history of the entire region. The stratified rocks are represented by a few hundred feet of the lower portion of the Carboniferous limestones with the subja-

*Read before the Denison Scientific Association, Dec. 10th, 1898.

cent quartzite. This series, which must at one time have been continuous with the same formation in the Magdalena region to the west, the Limitar region to the north and the Sandia, Manzana region to the north-east, is here exposed only as a mere fragment in the side of the mountain-escarpment, where its upturned edge is exposed as it dips into the mountain, that is, to the west. Small as is the extent, the exposure is a good one and has afforded a large number of fossils. Near the bottom is the horizon of Productus cora and Spirifer opimus. The section at this place is as follows:

The limestone is capped by flows of brecciated material that speak of explosive volcanic activity. These flows are of trachytic nature but are not the first of the volcanic outbursts to which the mountain owes its origin. The trachyte rears its head to the height of 8000 feet in the form of a high promentory from which a sharp ridge extends westward for over a mile, forming the northern wall of an ancient crater of great extent. The flows from the crater have extended to the northward in descending cascades and gentle streams to the point where the range is abruptly cleft by the Nogal canon. To the north still was another trachyte volcano which has left a mighty spur known far and wide as strawberry Peak. This volcano also had its period of tremendous explosive outbreak as is shown by the great mass of breccia and talus-conglomerate collected in the region to the northeast and laid open by a second canon to the north of Nogal canon.

Even in the amphitheatre of what we take to be the seat of the old trachyte volcano are here and there similar deposits, especially towards the north-east and south-east sides. These breccias and talus conglomerates yield on erosion most fantastic and architectural forms and the castellated peaks and odd mural shapes are characteristic of the deposits. Plate X, from the south side of the great crater-like area refered to and on the south side of the Blue Canon road, gives an idea of the conditions. As already said, the trachyte period was not the earliest stage of eruptive activity. The proof of this assertion is found in certain obscure but important masses of andestite found usually under the later flows. The limestone did not extend south of the principal Socorro peak but is abruptly cut off by a dark mass of andesite. The andesite projects beneath the trachyte and rhyolite of the mountain and has been entered by a number of mining tunnels, notably that of the Merritt mine which has produced at various times considerable silver and gold. Small rich bits of gold-bearing rock are encountered from time to time, though the miners have hardly yet learned that it is derived from the andesite contact alone. To the south the deep cleft known as Blue Canon has cut into the trachyte crater and in so doing has laid bare the andesite to a considerable extent and here we encounter exposures of the unaltered rock so like in its section to the diabase porphyrite of the lake Superior region as to be indistinguishable. Where ever the acid rocks have come in direct contact with the andesite in a state of fluidity and with thickness enough to permit of metamorphism there seems to have been some segregation of ore. In other cases, where the two have been left in juxtaposition and where water has access to the contact there has been extensive kaolinization of the andesite and a certain amount of similar decomposition of the acid rock also. These beds of kaolin which are used in the clay works of Socorro are very instructive as illustrating the effects of interaction of the two rocks even without heat as a factor. The mines of the Socorro mountain are also cases in point in proof of the thesis elsewhere maintained that the segregation of gold and silver ores is closely associated with a particular kind of metamorphism between basic and acid rocks.

The western boundary of the trachyte area is formed by a series of mountains terminating in a single abrupt conical hill of trachyte which we have designated as "pyramid mountain" and which is skirted on the south by the new Blue Canon road. To the west the whole northern part of the range is composed of granite or gneiss. The axis of the main ridge running east and west is nearly as high as Socorro mountain proper and the contact with the trachyte is sharp with some traces of metamorphism but no definite evidence as to the sequence. It may be presumed that the granite outpour was cotemporaneous with that of the trachyte. It may be suggested that the granite is due to metamorphism of preexisting sedimentary rocks fused by the action of the immense volcano. In this case, as in all others of this portion of the territory, the trachyte flows were followed by others of a still more acid nature. It would seem that these latter flows were not so much from the crater as along a great irregular fissure extending south from the vent. A series of waves of such material forming quartz trachyte and rhyolite form the abrupt range facing the river and extending four or five miles southward from Socorro mountain proper. The foot hills are all of talus conglomerate with boulders of various sizes up to 18 inches or two feet in diameter. Appearances seem to show that at this time the surrounding region was under water. Toward the south end of this series a considerable flow of white obsidian is found and obsidian sheets cover poorly cemented detrital material of the same age. The most prominent of the hills of the trachyte series lies west of the smelter settlement known as Park City and from the west affords an abrupt front with basaltiform columns. We have called it Pallisade mountain. Plate XI, Fig. 1. Pallisade mountain from the northwest showing recent strata at 3. The foreground (4) is a granite hill over which the Blue Canon road passes. To the southward a spur passes for a mile or more at a low elevation toward the Magdalena rail road. This projection offers an opportunity for the study of alteration phenomena, of which more beyond. In the south-eastern part of the area no evidence of the oldest or andesite period is revealed but in the south-western angle at Clemou an aphanitic phase of the basic eruptive is left uncovered by the basalt that covers the south-west one fourth of the quadrangle and has been eroded by the arroyo as well as cut by the railroad. Here too is evidence of explosive activity in the form of masses of talus conglomerate (See Plate XI, Fig. 2). 1. Talus conglomerate. 2. basis eruptive. 3. Magdalena Mountains in distance.

The south-west quarter of the area under consideration, as already hinted, is covered with a flow of dark basalt of an average thickness of not more than twenty-five feet which, near the margins, is reduced to five. The area over which this flow is undisturbed is only a fraction of the whole but in a large part of the area there has been extensive undermining of the soft material upon which the lava reposes. Thus the mile or more intervening between the lava sheet and Pallisade mountain has been transformed into a desperate kind of *mal pais* in which the large fragments of lava are upturned in all directions, making it practically impassible. The source of the flow is apparently at a point at present separated from the main sheet, to the west of the "Cactus Plain" through which the rail road passes to Magdalena. The region of "Indian Hill" is also a portion of this flow. In a deep canon in the last mentioned series of hills deeper parts of the flow, apparently in the channel of outlet, are exposed and here the nature of the rock is different from the superficial portions as elsewhere described. From this region the lava seems to have spread to the north and east but it has been removed wholly in the valley of the stream that in wet times skirts the western border of the Socorro mountain region as well as over broad valley intersecting that range from the middle of its western margin and forming the southern boundary of the granite area. The history of the region from the end of the rhyolite period to the overflow of lava, so far as it is recorded, is preserved in a loose fragmental series the materials of which are apparently derived from the adjacent rocks. This is well exposed in the south-eastern part of the region where are a variety of lava-topped cliffs beneath which are sandstones and crags probably of quite recent origin. The flow extended for some distance north along the eastern face of the range and has left outliers in the form of lava-topped buttes of which the most conspicuous is near the springs which supply the city of Socorro with water. The underlying formation is here very largely derived from fragments evidently worn out of the earlier talus conglomerates. In the depressed area in the center of the region here under consideration, at the western foot of the Pallisade mountain, are remnants of the same horizontal strata Plate XI, Fig. 3, and their continuation below the large lava sheet to the west and south-west is easy to follow. These soft strata are easily undermined and as they are removed by percolating water the lava above breaks into irregular fragments under its own weight and ultimately these fragments are indiscriminately dropped into the space beneath.

To the north-east, nearly directly east of the peak known as Strawberry there is an extensive series of sandstone and shales some of which are full of gypsum fragments; these are often tilted, dipping toward the range, i. e. to the west. No fossils have been found and it is at present impossible to tell whether they are of Cretaceous age as the gypsum might suggest, or whether they are of the same age as the other loosely aggregated material of the region farther south. Near the base of the range there are a number of ancient basaltic dykes which bear intrinsic evidence of a greater age than those forming the surface flows. They are interbedded and we cannot say from the exposures seen whether they have been intercallated in the series before the disturbance or whether they too were at one time surface flows, and since that time have been imprisoned under later sediments.

Plate XI, Fig. 3. Panoramic view of the Socorro Mountains from the east, from a series of photographs, as seen from the city of Socorro. The numbers are placed with reference to sources of the rocks examined and will be referred to in the section on petrography. 1. Strawberry Peak; 2. Socorro Peak, between this and 1, Nogal Canon; 3. Promontory Peak; 4. Sharp Peak, north of which a dyke cuts off the limestone seen at 22; 5. similar small peak near which gold discovery has been made; 6. western granitic part of main range; 7. The upper and western of two flows of quartz trachyte flowing over andesite at 27; 8. western wall of the old crater about one mile west of 7; 9. hill forming southern wall of Blue Canon, the lower part of andesite, upper of trachyte and rhyolite; 10 to 13. various trachyte, rhyolite and breccia flows; 14. Pallisade Mountain; 15 to 19. hills of stratified gravel and sand covered with a thin flow of recent basalt; 20. flow of trachytic rock over the limestone; 21. quartzite at base of limestone; 22. Carboniferous limestone, about 400 feet thick; 24 to 26. andesite beneath the trachyte, Merritt and other mines; 26. beds of kaolin from decomposition of andesite and trachyte; 29. Blue Canon; 30. Rio Grande smelter; 31. spring; 32. spring and mill; 33. ranch; 34. clay.

2.

THE LIMITAR VOLCANO.

Limitar mountain is a member of the range bordering the Rio Grande on the west that lies north of the Socorro mountains. The interval between them is filled with lower ridges of the same materials as are seen in the main mountains, chiefly trachyte flows probably from fissures in the of axis upheaval. The stratified rocks are less disturbed. This mountain is about five mills from the river and directly west of the town by the same name so that it is easily visible from the Santa Fé rail road. It may be distinguished by the oblique band formed by a section of tilted limestone laid bare during a late explosion of the volcano. Between the river and the base is a series of sandstones and crags which may be of Pleistocene age or recent, while nearer the base are what may prove to be remnants of Cretaceous sands and shales with a sharp dip to the west and interbedded with ancient basalts. It would appear, however, that the later fragmental series is only mediately related to the eruptives which furnished their materials, for at the foot of the cores of eruption we generally find a different class of fragmentals. In the early history of our volcano, as well as at intervals subsequently, there were periods of explosive activity or else the products of eruption were cast, while still hot into the sea, there to be shaken up violently and detonated by the sudden cooling. There is evidence that both of these methods of comminuting the flows were in vogue at different times. Thus in some cases the resulting product is a coarse breccia with angular fragments and a very small amount of sand in the interstices, while in other cases, the binding material is of the substance of the flow which has caught up the exploded fragments in its course. Some are veritable talus-conglomerates within or near the crater itself, while others are but the selvages of anarachactic or narrow intrusive flows. It is also quite the rule in this as in other similar regions that the massive flows should catch up fragments of the adjacent or perforated country rock and incorporate them more or less completely in the pasty or fluid magma. It then, of course, follows that these fragments are themselves more or less altered while, if the heat was sufficient, the magma is likewise modified by the introduction into it, at various stages of cooling, foreign ingredients. In fact, nature has here performed for us some of the most difficult experiments feebly attempted in modern laboratories of synthetic geology and the study of the alteration phenomena both chemical and physical occurring in the rock fragments and in the "symmorphic" result of the integration of the various disparite elements by secondary fusion promises more for this branch of geology than any method available and yet, curiously enough seems hardly at all worked.[1]

We may picture to ourselves a time when the Cretaceous strata lay in practically undisturbed possession of the region. The time was long past when coal swamps occupied the great basins to the west and south-east and gradual elevations alternating for many years with slight depressions had afforded the conditions necessary to the formation of beds of gypsum and salt.[2] We may suppose that a long period of elevation had passed over the region without leaving any record except in extensive denudation and an occasional local deposit. There were doubtless secular contractions of the crust but at last a time came when the intrinsic strains overcame the rigidity of the crust and great orographic lines of weakness developed in approximately prrallel lines extending north and south over the whole area of the southern Rockies. The present course of the Rio Grande in central New Mexico occupies what may once have been the axis of such a fold, while the intersection of the western declevity with the present general level is marked by

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[1] Cf. Endlich, On the erupted rocks of Colorado. Hayden Survey Report for 1876.

[2] Salt springs occur only a few miles north-west of the Limitars and cause the waters of the Rio Salado to be decidedly salt to the taste.

a fracture zone in which lie the chief centres of overflow. Elsewhere the greater igneous activity is on the eastern side though just what the determining circumstances were we are as yet unable to say. It is a well-known aphorism that the crests of greatest elevation, by reason of greater fracture and superior accessibility, become sooner or later the depressions and, *ceteris paribus*, the courses of the streams. Our area is no exception and the moutain ranges of the west bank of the river are considered to be secondary in the sense that they are, in part, the remnants left by erosion from the original uplift. To the preservation of these ridges the frequent and often extensive outpour of eruptive rocks has greatly contributed. At first it might seem that the vent for such overflows should have developed in the axis of the fold but the analogies as well as a variety of theoretical considerations reinforce the other view and sustain the evidence from the field. Thus the shear strains and the thickening and heat increment would be greatest near the sides at the base and the isogeotherms would accordingly be elevated at this place.[1] There is much reason to suppose that the materials of the eruptives are essentially of local origin, in fact that they are derived from the fusion of materials lying at no great depth beneath the site in which they now occur. The agencies of metamorphism being then greatest at the sides near the base and the techtonic strains there having a maximum it follows that the lower portion of the strata are there fused, the support for the rest is removed as a result, there is a faulting of the whole, causing the tilting of the series toward the axis of weakening on the "down" (here western) side and an outpour of fused material at the same time. If the thrust and outflow were violent there would be a second fault of the same sort to the west. This has apparently been the history of our region. The limestone occupying the upper part of the series is relatively infusible while the subjacent acid rocks consisting of sandstone and conglomerate was readily altered—in some cases

[1] Hot springs and secular vibrations still attest the elevation of the isogeotherms in this belt.

to the point of complete fusion. The result has been local thickening of the acid rocks and their conversion into quartzites, hornblendic schists, gneisses and finally granite. This last stage in the metamorphism has been attained by the old sedimentaries in the Limitar range proper while to the north and south the place immediately below the lime is occupied by hornblendic schists with gneissic bands and veins of diorite. Passing south to the next centre of eruption (in the Socorros) the rock is simply a quartzite. At various times the theory has been advanced that granite is properly speaking always protogene and consequently that a metamorphic origin is impossible. But aside from the strong testimony from analogy in the present case, there occurs about half way from the base of the Limitar to the lower surface of the lime a band of limestone included in the granite. This band is about eighteen inches wide and contains, in spite of high metamorphism, some fossil remains, proving conclusively the sedimentary nature of the beds from which the granite has been derived. Below, the granite passes into gneiss and this into hornblendic schist both the latter being broken by diorite. The writer has attempted to show on the basis of the conditions on the north shore of lake Superior, that diorite is essentially paragenetic and not an independent intrusive. The evidence of the region in question is strongly in favor of this conclusion for the diorites all assimilate closely to the gneisses in which they solely occur.

Seen from the south, our volcano appears as a broad-based cone from which skeleton ridges extend to the north-west and south. The entire eastern base is composed of the acid series just described, most characteristic being the red coarse granite with large quartz grains and sparsely and crudely mingled hornblende. Even at a great distance from the south one can detect the broad light stripe of obliquely tilted limestone where it is exposed by some vast eruptive outburst which not only tore open the very vitals of the mountain but plowed an enormous furrow across the lime and thus made good its escape to the south and east. Little is left to show of this flow but the eroded edge of the lime to the north and the tilted and scattered fragments in the hills to the south of the canon formed by it. In the amphitheatre-shaped cavity on the southern slope of the cone there is exposed a portion of a granite lying quite near the heart of original eruption, while above it are the brecciated fragments of the explosive phase of the eruption. The limestone dips into the crater cone at an angle of over 30 degrees and a part of its upper surface was left bare by the out-burst. Farther north, however, we find a spot where the original flow spread out over the lime. Here, in fact, was the theatre of a curious activity. It appears from examination of the fragments contained in this brecciated flow that the lava was essentially an andesite but where it came in contact with the lime a double interchange was affected. In spite of its great infusibility, the upper part of the lime was crystallized, forming a bed of calcite with cherty lammellae. On the other hand, the igneous rock was minutely subdivided and the fragments included in calcite from the lime. The resulting rock almost defies classification. The fragments which may be single crystals of the original rock or small fragments with numerous crystals, are greatly corroded also. About three hundred feet of this tuff overly the limestone. So far as appears from the east, the next step might have been the final one in the active history of the volcano, for the upper three to four hundred feet up to the cones and craters on top is covered with a vast sheet of rhyolite with free quartz which is more or less plainly visible to the eye. Passing now to the summit, the attention is held by a remarkable panorama. Evidently the axis of eruption rather closely correspond with the line of fault and so the declivity is very steep—in places almost sheer several hundred feet to a narrow valley which plainly displays on the opposite slope the up-tilted edge of the limestone in a fault entirely similar to the one which we have just past. Above it still to the westward is a series of hills of rhyolite springing from the fracture on the down throw side. But as we descend the ridge we discover much of buried history. The rhyolite which was the last phase of eruption did not follow directly the explosive stage represented by the andesite tuff but, probably after a period of repose, there had been more than one outflow of trachyte and trachyte pitchstone, These flows extend throughout the valley and to the south are seen underlying minor rhyolite masses. From the plagioclase-bearing and quartzless andesite to the acid rhyolite was a long step but this is partly bridged by the trachyte interval showing that mountains may grow old gradually if not gracefully. But there have been other episodes in the history we seek to follow. The crater during trachyte time must have been near its present site for a great boss of brown trachyte pitchstone still rears it head to the southwest of the crater never having been quite concealed by the flows of rhyolite. To the south of this peak the rugged vertebral column of the range is transversely cut by a dark dyke of small dimensions which, though greatly altered may have been andesite. Its strike suggests that it may have been derived from the great boss protruding from the western face. This rock compromises matters by leaving out the feldspars entirely and may be called a magma basalt or limburgite. It thus appears that the mountain made sundry attempts to restore its youth but its hoary summits attest the victory of the acid series.

At the very summit just south of the highest peak is an oval crater walled on all sides. Its longer axis is about 400 feet long and extends south east, while the shorter diameter of the ellipse is 250 feet measuring in both cases across the top. To the north east of the highest peak is another depression of a crescentic form which probably is also an old crater.

Now passing west to the opposite side of the valley we encounter the same sequence of limestone and shale strata as that on the eastern side of the main range. Near the bottom is a shaley stratum which is quite fossiliferous. Some little distance above this horizon is another of perhaps twenty-five feet with still larger fauna. As we ascend the evidences of life are less profuse being chiefly corals of which massive reefs occur at various horizons. Toward the top the evidences of metamorphism increase till the top becomes compact flint. There is no such interpenetration of the superincumbent rock as in the corresponding situation on the eastern side for the flow is a brown rhyolite. The latter rises to the height of several hundred feet above the top of the lime only to drop away rapidly to the west. At a point some two or three miles further south a section across the axis above desribed indicates that there was much less of igneous outpour but the disturbance is particularly well shown as also the metamorphism of the acid member. The diagram (Plate XI, Fig. 5) illustrates the situation.

Ideal Section through the axis of uplift south of Limitar mountain. 1. Trachyte crater. 2. Laminated margin of trachyte. 3. Porphyry about the margins. 4. Brecciated contact zone. 5. Massive limestone. 6. Shale with Productus cora. 7. Quartzite (20 feet). 8. Shaly limestone with Spirifer camerata. 9. Quartzite passing into the next. 10. Mica and hornblende schist with quartzite bands and phases. 11. Granite. 13. Diorite intrusive (paramorphic). 14. Talus conglomerate in or near the crater.

3.

MOUNT MAGDALENA AND THE BASIC ERUPTIVES OF THE MAGDALENA DISTRICT.

With Plate XII.

The general geological conditions of the Magdalena mountains formed the subject of an earlier paper to which reference is made throughout the following paragraphs.[1] The present paper is devoted to an area immediately adjoining the range on the north and west. It will be recalled that the Magdalena mountains form a compact range extending nearly north and south for a distance of about twenty-five miles and separated from the Rio Grande at the north by the Socorro range. The distance from the river is from fifteen to twenty miles. The mountains rise rather abruptly from the plain some three thousand feet or to the elevation of ten thousand feet above tide. Its northern portion is formed along a fault line extending from

[1] The Geology of a Typical Mining Camp in New Mexico. American Geologist, Vol. XIX, No. 4.

the central peaks, forming a monocline with a dip of about forty-five degrees in a direction twenty or thirty degrees south of west, exposing the carboniferous limestones on the western slope and the underlying metamorphic granite and quartzite on the more abrupt and irregular eastern slope. Toward the northern end the limestone has been removed by the effect of a secondary eruptive which has served to dislocate and fault the limestone series very extensively and to thrust it westward obliquely across the range at a point north of the Graphic property.

North of the Magdalena range the effect of the same orographic line of weakness or fault which made the range proper was felt at a later period and formed the axis of an extensive series of trachyte eruptives. The central portion of the range was the theatre of enormous eruptive activity during the earliest or andesite period. Two craters of this age remain, known respectively as Big and Little Baldy, the first situated at the junction of the southern with the middle third, and the second at the junction of the northern with the middle third of the length of the range. The northern crater, or Little Baldy, is still quite well preserved and the walls of the crater proper expose successive flows of andesite, andesite tuff, and aphanitic phases of the same material. From this crater a most extensive rift seems to have been formed to the northward along the western faulted margin of the stratified rocks of the range, from which fissure, as well as from the crater itself, enormous masses of basic lava flowed to the north and west. Other dykes and flows in different directions intersect the region. It may be said in a general way that, as a rule, wherever these dykes penetrate or influence the limestone series there is a tendency to segregate copper, silver and lead, while in other instances, where the contact is with acid rocks, the selveges tend to carry gold. It is rare to find gold not directly or indirectly associated with these basic eruptives.

South of Little Baldy and connecting with Big Baldy is a series of andesite dykes and bosses, a result of which the limestone has been displaced eastward into the Water Canon region where lead, copper and silver are collected, while near the crest, in dykes of felsite penetrating the andesite, gold has accumulated in appreciable quantities. Andesite areas which are evi-evidently the offspring of Big Baldy give rise to the well-known properties now being developed in the south end of the range. These are immediately associated with the andesites at the foot of Timber Peak, a lofty mountain east of Big Baldy.

On the west side of the range southward from Little Baldy, and extending to the west, north-west and south-west at a gentle inclination for many miles, is a very extensive system of acid flows which seem to have been derived from a fissure or system of fissures somewhat to the westward of the older andesite axis. These flows are of trachyte, obsidian, trachyte tuff and rhyolite. The obsidian is often black and is not infrequently found in brecciated fragments the later or rhyolite flows. Enormous erosion has operated to remove a great part of the flows and to carve the remainder into ribs and butte-like outlyers. The trachyte now seems originally to have extended northward and eastward to the very foot of the range, but this portion has been nearly entirely removed by subsequent erosion, leaving a series of low mountains or buttes at a distance of about a mile from the western foot of the range proper, while the valley in which are situated the towns of Kelly and Magdalena, as well as the Graphic and Iron Mask smelters, intervenes. Two of these isolated hills are prominent and well known landmarks, Elephant butte being the southern and Mount Magdalena the northern. These two are essentially similar in structure and form part of the great overflow which can be traced far to the south-west.

Mount Magdalena (Plate XII) owes its name to a remarkable patch of talus which is circumscribed by oak shrubs forming the perfect outline of a female head. This figure presents itself to the approaching traveler from the east and has been embalmed in the usual myths and legends. In spite of its apparently trivial nature, it seems to have remained practically unchanged for over 300 years, in fact, from the time of the arrival of the Spaniards, whose devout imaginations saw in its pathetic expression the indelible impress of the contrition of the Magdaline. Indian superstition found it impossible to pursue even the implacable duty of vengence under the placid eyes of the lady Magdalena and the spot became a place of refuge.

A special interest therefore attaches to this mountain, whose eastern slope rises abruptly from the valley, though the integrity of the escarpment is injured by a considerable frozen cascade of trachytic lava that curls over the brow of the mountain. It may be that some part of the mountain was the theatre of volcanic activity during the trachitic period but no adequate evidence is at hand to support that view. The base of the mountain is composed of brown and gray andesite to the hight of about 350 feet above the valley. Presumably this is a part of the great flow dating from the time of the eruption of Little Baldy and the extrusion of the great sheet of andesite and other basic eruptives in the region. The same rock crops elsewhere in the valley and we may ascribe the greater hight to which it rises here to the protection offered by the capping of later lavas which the ages of erosion have not sufficed wholly to remove. The andesite is not freely visible, being generally covered by the talus, thus it happens that its possible metallic resources have not been exploited, though the inevitable prospector has recognized the rock as similar to ore-bearing rocks elsewhere and burrowed into the veiny portions at various places about the mountain. The first deposit above the andesite was evidently of an explosive nature and was probable at or near the beginning of the acid period. It consists of banded trachyte tuff containing fragments of the subjacent andesite and also irregular pieces of dark obsidian like that which follows. Some of the pebbles are rounded and it may be suggested that the beds have been deposited during a period of intermittent aqueous flows and explosive eruption. The average thickness of this flow may be about 200 feet. Next above this, and forming evidence of a more placid type of eruptive activity is a bed of impure black obsidian. The lower layer of the obsidian .contains fragments from the tuff, while the upper merge into the trachyte. The obsidian is in some cases porphyritic with crystals which have so far decomposed as to baffle identification but are probably sanadin. Similar beds are seen at various points further west. Above the obsidian is an extensive flow of trachyte in which in some places flowage phenomena bear record of its motility while in others it seems to have crystalized quietly in situ. Quartz trachyte passing into rhyolite is apparently found near the top of the series here as elsewhere. The presence of the explosive type of lava might be taken as evidence that the mountain was itself the theatre of eruption yet such flows often extend many miles and we have found a curious obsidian breccia in a trachyitic or rhyolitic magma at Texas Spring at the distance of at least six miles from a possible source.

Magdalena mountain stands, therefore, as a natural dissection giving a vivid conception of the earlier geological conditions of the region. Passing now to the region immediately north of the main range, we encounter a series of trachytic eruptives of which "Nipple Mountain" is the first and others continue the series to the extensive trachyte crater of Bear Mountain. To the east of this range the Carboniferous limestone lies in the floor of the plain instead of being tilted as in the Magdalena range. Small quantities of lead are found in the veiny and faulted limestone and dykes of "felsite" apparently of the trachyte age passing westward into the great andesite region north of the town of Magdalena seem to have filched the lead to fill in these east and west veins. This andesite area or region of basic eruptives is interesting as probably forming a part of the product of the first Magdalena eruption and probably contains more than seventy-five square miles and may be much more extensive. It includes the Cat Mountain Camp and extends northward perhaps ten miles, while to the south, as already seen, it is for the most part covered by the later acid eruptives. The area is circumscribed to the east and north by the trachytes of the Bear Mountain series and on the west by the southward extension of the Gallinas to the Tres Montosos. At many places trachyte and rhyolite patches remain in situ above the andesite and dykes of felsite and trachytic material cut the rock in a north and south direction, These dykes very commonly carry small quantities of gold and though most of the mines opened have been in very low grade ore the possibility is not excluded that valuable accumulations may occur. It has already been mentioned that in the same area the east and west veins seem to carry lead and the theory is offered that this is due to the fact that dykes in this direction may be in communication with the limestone region to the eastward. The lead is chiefly in the form of galena but, in several cases, a variety of vanadium compounds occur, especially in proximity to the north and south dykes. Several gold properties have been quite entensively worked but none of them in a way to really explore the dykes to an adequate depth.

The whole area north of Magdalena to the Bear Mountain is of the same general character, while the latter seems to be the product of an enormous trachyte crater from which vast sheets have flowed in all directions covering a large area south of the Rio Salado. North of the latter is the margin of the great Cretaceous region of the Mount Taylor district which has been insufficiently explored along the southern margin.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.
Vol. XI. Article V, with a sketch Map. Plate XIII. December, 1898.

*THE GEOLOGY OF THE SAN PEDRO AND THE ALBUQUERQUE DISTRICTS.

By C. L. HERRICK,
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The following pages are the results of a reconnaisance of the area covered by the so-called San Pedro sheet of topography issued by the government and a corresponding area lying west of that district. The country was visited by wagon and no instrumental work was done, distances being read by odometer and elevations by barometer. While a large part of the area has been personally visited and a great deal more material has been collected than can be made available at this time, it seems best to issue these notes as a guide to further work. It is to be expected and hoped that fuller details will be gathered and that the conclusions here reached may be modified by more extended comparison with adjacent parts of the territory. No attempt is made to touch upon the mineral resources, as this subject may be made the basis for a distinct paper. The paleontology and petrography are well under way but it was not thought wise to anticipate the fuller description of the final paper. Much of the area here described would be called a desert in eastern America while other portions are well-wooded and provided with flowing streams. In general, all but the lava beds is capable of supporting cattle and sheep. The southeastern portion is still well timbered. The means not being available to engrave a geological map the accompanying sketch is provided as a guide to the reader. For other contributions to the geology of New Mexico and the particular region under discussion compare a series of articles in the American Geologist, Sept., 1898, April, 1897, and July and Oct., 1898.

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*Read before the Denison Scientific Association, December 10, 1898.

1.

THE AREA WEST OF THE RIO GRANDE.

The triangular area between the Rio Puerco and the Rio Grande is occupied by a nearly level mesa between 700 and 900 feet higher than the river at Albuquerque. This field is nearly level but inclines to the southeast with the inclination of the strata composing it. The dip is apparently not more than ten feet to the mile. The mesa is about three and three-quarters miles wide at a point opposite Albuquerque and increases toward the north as the two rivers diverge. Nearly west of Albuquerque is the group of recent volcanoes previouly described.[1] The cones lie on the eastern margin and consist of a group of three major and as many smaller outlets. The three larger craters rise to about three hundred feet above the mesa or one thousand feet above the river. The material is a dark basalt which was emitted in small amounts intermittantly. The upper surface is vesicular and exhibits the usual appearance of a thin sheet which has cooled rapidly. It extends to but a short distance on the west over the level mesa but extended much further eastward, spreading over the somewhat lower levels in a sheet not generally more than 20 feet thick. It formed a lobed and irregular area which has been little eroded since its outflow. The materials underlying are, so far as can be seen, the same as those forming the mesa and not those of the river valley, though it appears that there was some erosion before the eruption, perhaps by a flow of hot water as in other cases in this neighborhood. This group of cones is only one of a series of basaltic post-tertiary volcanoes which can be traced along the entire length of the Rio Grande in New Mexico.

Professor R. T. Hill has described the later volcano flows of New Mexico in general terms in the Bulletin of the Geol. Soc. of America, III, p. 98. In concluding this paper he says: "It is also evident that eruptive activity has occurred in the Texas-New Mexican region from Cretaceous to the present

[1] Geology of the Environs of Albuquerque, American Geologist, July, 1898.

time, and at least three well-defined epochs are at present recognizable which may serve as guides to future observations, viz:

1. The Austin-Del Rio system, or Schumard knobs; ancient volcanic necks or laccolites bordering the Rio Grande embayment, begun in later Cretaceous time, the lava sheets of which have been obliterated by erosion.

2. The lava flows of the Raton system, which are fissure eruptions of Tertiary time, and which are only partly removed by erosion.

3. The cinder cones and lava flows of the Capulin system, which are late pleistocene and which still maintain their original slope and extent."

The geological structure of the plateau is not a little perplexing. The upper part of all the exposures seen for a thickness of over 50 feet is composed of a finely stratified sandstone and pebble series. In places this is indurated or cemented to form a crag, while in others it is quite loose and friable. The color at a distance is grey in evident contrast to the brown or red of the lower 50 to 75 feet exposed. The latter is a mass of finely stratified clay and fine sand without the pebbly layers. At the summit of the exposure is a band of marl varying from 10 to 25 feet thick with beds of charcoal carrying plant remains. This seems in every respect to be similar to the marl previously described as forming the upper layer in the river valley, though there is a difference of over 400 feet in altitude. It might be supposed that the lower marl was derived from the older or that both had a common origin. This marl is well seen on the western exposure of the mesa facing the Rio Puerco where it extends to a point far to the north of the position of the craters of the eastern slope. It is also seen on the face presented to the Rio Grande a short distance below the craters and data are wanting to determine whether it underlies the flow. It is not found underlying the flows from the craters in the same relative position to the mesa northwest of Bernalillo, nor does it appear under the lava sheets which form the wall of the canon next north of this mesa near the town of Santa Ana. The exposures last mentioned apparently are of the same age as those opposite Albuquerque yet there has evidently been an extensive erosion of the area separating them for the sandy layers below the lava are in places exposed for 450 feet. They consist of grey and red sands with only occasional indurated bands and are covered with sheets of vast extent but usually not more than twenty five feet thick. The thicker portions evidently were nearer the volcanic centre as the sand and clay below has been burnt and indurated and has a bright red color.

The prevailing color is reddish, especially in the lower parts. An exposure in the mesa now in question to the west of Los Corrales and perhaps five miles north of the Albuquerque flow has the same red color but is here capped by the marl which is not encountered beneath the sheets north of Bernalillo. The entire region north of Bernalillo extending west to beyond Santa Ana and extending east and north along the west bank of the Rio Grande to beyond the Indian village of San Filipe is occupied by this formation and is covered by vast sheets of basalt from craters lying to the northwest. One of these has been dissected for examination by erosion and was described as the Bernalillo volcano in a previous paper.[1]

Careful search has so far disclosed no organic remains beneath any of these flows though many miles are exposed to view. The sheets are at various levels and suggest the probability of successive superincumbent layers but, so far, there seems to be no evidence of more than one general period of eruption, for most of the flows at different levels can either be traced to different craters or are connected with other parts of the sheet by declivities or separated from them by displacements of later age. A great deal of base-level undermining is going on and even the small streams at once wear down to the general lower level. There are a few sand dunes upon the western margin of the mesa and it is likely that the major part of the local accumulations here and there found on top of the marl is of the same origin. The mesa proper is bare of trees but supports good grass as the marl is a water-bearer. To the north as the valley

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[1] Amer. Geologist, July, 1898.

of the Jemes arroya is approached and the marl has been removed by extensive erosion, the surface is rolling and the sandy soil supports little beside a scanty growth of juniper. The weathering and erosion of the sandy layers leaves a very characteristic debris of dark flint and jasper as well as fragments of pertified wood.

The valley of the Rio Puerco, about three miles wide at a point west of Albuquerque, is about 725 feet deep and its upper course is carved out of Cretaceous sandstone and shales. On the west side these strata reach the present river bed at the so-called Punta de la Mesa two miles north of the little town of San Ignacia which is north-west of Albuquerque. The river here seems to occupy the site of an anticline, the strata to the southwest, the exposures of which diverge from the river, dip to the southwest by a very small angle, while those on the opposite bank dip to the southeast. In fact, this line of flexure crosses the strata a few rods from the river, which doubles round the point. The most complete exposure at this place is about 325 feet high, the lower 250 feet or so being of dark fissile shales with sandy layers and concretionary and gypsiferous phases. The upper 75 feet or less is of a variable reddish or yellowish sandstone with local white sand deposits. The continuity of the series is much broken by minor faults so that neither the position or dip of the strata is constant over large areas and the lithological characters are also quite inconstant. The upper nodulary phases of the sandstone in some places are quite fossiliferous. Only a short distance below the bottom of the sandstone layers is a more or less constant band of carbonaceous shale which in some places becomes a lignite. Still below this is a zone in which occur large numbers of calcareous concretions. Each of these when broken reveals the presence of a fossil, generally one of the two fine Goniatites figured later, while a few small fossils occur in the shales. To the north of the point the escarpments of the rocks described continue to flank the immediate valley of the river for many miles. On the east side the same series is repeated by faulting and reappears to the east in successive ridges. In these exposures it often happens that the yellow and irregular banded sandstone is substituted for by massive white sand for shorter or longer distances. Above this layer is a conformable bed of yellowish loamy clay which is very finely banded and homogeneous. To the east the inclination of the faulted blocks becomes less, those near the river having a dip of about five degrees. Near the eastern margin of the valley the strata are nearly horizontal and the Cretaceous strata describe above disappear below the surface. Their place is occupied with bands of sand which have the texture of the upper loamy layer mentioned as overlying the Cretaceous near the river. The color is variable however and the strata are so disturbed that it cannot be said certainly that the two are part of the same system. We incline to that view and think that the red sands which appear in the eastern wall of the valley, inclined at a barely perceptible dip, are of the same age as the outliers in the eastern part of the valley and these in turn of the same age as the remnants of fine material on the upper surface of the Cretaceous near the river.

At present we can only conjecture that these sandy beds are of Tertiary or Pleistocene age.

2.

THE SANDIA MOUNTAINS.

This range is the most conspicuous mountain group visible from Albuquerque, directly east of which it lies at a distance of from five to eight miles. The highest point of the range is about 10,000 feet above the sea or a little more than 5,000 feet above Albuquerque. The mountains are part of a great monocline which extends along the left bank of the Rio Grande to the south. This monocline passes into an anticline by degrees, as the Ladrones, Limitar Mt. and Socorro range contain the same formations dipping to the west on the right bank. The Rio Grande may be said to occupy the axis of an anticline or, better still, an axis of disturbance which in various parts has resulted in different geologic structures according to circumstances. These disturbances were inaugurated, so far as the geological record shows, in pretertiary time by the series of andesite eruptions and have continued through a trachytic and rhyolitic period and in post-tertiary time have been supplemented by the basaltic flows now so prominent in the topography of parts of this district. The Sandia range is separated from the continuation of the uplift to the south by Tijeras canon, itself marking, as we shall see, a transverse axis of disturbance. The length of the range is about 20 miles but the deflection of the valley of the Rio Grand to the eastward in the northern part of our sheet causes the western escarpmeut to bear off in that direction and, this being in the direction of dip the height falls off rapidly in this part toward the north. The crest of the range is everywhere a band of Carboniferous limestone 400 to 600 feet thick. The maximum thickness is not preserved, so that the upper horizons of this formation are better seen in the nearly horizontal beds to the east.

The dip being from eight to twelve degrees to the southeast those peaks lying most to the westward are, of course, highest. The age of the limestone is abundantly attested by the fossils, while below them is a vast series of metamorphics the age of which it is impossible to more than conjecture. These metamorphics are of two groups which are distinguished by their lithological character and conditions of formation though they may be practically contemporaneous. In general, the limestone is underlaid by a mass of quartzite of varying thickness. This, where the metamorphism has been slight, is obviously of a sedimentary nature having conglomeritic phases. In other places this quartzite has been perfectly transformed into a granite or gneiss. It thus happens that in many places the limestone reposes on a crystalline granitic rock. In other places the granite is more than fifty feet below the base of the limestone. The second series of metamorphics is found at certain foci of uplift. One such focus is seen in the foot hills to the west of Sandia peak, the high mountain at the north end of the ridge, another just at the mouth of Coyote Canon at the east end of the transverse axis of uplift which forms Tijeras Canon. Another and more important one occurs further south in a similar relative position at the mouth of Canon Largo and forms the geological cause of the Hell canon mining district. These foci of uplift and metamorphism are evidently metamorphic centres also. Taking, first of all that which occurs south of the mouth of Coyote canon, we find here that there is a boss-like area of quartzite around which the remnants of the limestone have clung and these dip in all directions away from the centre. To be perfectly accurate we should say rather that these points have not settled as much as the adjacent parts for here, as elsewhere under the like conditions, the area of greatest plasticity has been a little away from the line of greatest elevation. In this same area too there is the evidence of special secondary metamorphism as there are masses of schist of the most various kinds as well as paragenetic diorite.

The larger focus west of Sandia peak is of essentially similar character though there are no remnants of the superposed lime. The rock has become a schist of various species and is intersected in various directions by large dykes of quartz. The most highly metamorphic phase is diorite and the circumstances are such as strongly to reinforce the theory long since propounded by the writer on the evidence of Lake Superior lithology that the diorites are paragenetic and not independent igneus intrusives. No core of basic eruptive is exposed, though it may exist. It is probable that these metamorphic areas are old and that they may under favorable conditions produce some mineral. The third of these foci in the Hell canon district has been quite carefully studied and the results are given elsewhere. Here the metamorphism has produced large dykes of quartz and diorite, the former carrying some free gold. A little depth however soon converts such metal into sulphides and the present prospect is that sufficiently deep mining may yield some copper in the form of glance and pyrites.

The western slope of the Sandias being quite abrupt, the face is cut by short canons in the granite with deep dells and recesses in which there grow, especially near the summit, a number of plants evidently strays from the far north. The eastern slope, on the other hand, being quite gradual permits the mesa flora to rise to near the summit. A deep canon in the north end known as Placitos canon serves to collect the water from the northern part of the range and forms a most fruitful valley.

The Tijeras canon on the south cuts the range abruptly off and the whole area from this canon to a point some miles south of Canon Largo, a distance of at least ten miles, has dropped out of conformity with the portion of the range both to the north and to the south.

The cause of the fracture in the case of Tijeras canon is not far to seek but consists in a massive upthrust of a quartzose rock which passes obliquely across the range from southwest to northeast, terminating at the western end in the neighborhood of Coyote springs and at the eastern extremity in the vicinity of Whitcomb's springs. It is a curious fact that the opposite ends should give rise to nearly the same conditions, the springs in both cases being highly mineralized. At Coyote especially the springs are highiy carbonated.

The following is the result of the analysis of a sample of Whitcomb spring water by Prof. Randolph W. Tinsley, of the University of Mexico:

Sodium Chloride, grains per gallon	.1927
Calcium Sulphate, grains per gallon	1.4360
Calcicum Carbonate, grains per gallon	8.1896
Magnesium Carbonate, grains per gallon	1.5188
Total	11.3371

The width of this axial dyke varies from 25 to over 50 feet, and it is flanked by metamorphic rocks like hornblende and mica schists and diorite. Near the eastern end of the canon the schist and diorite come into close proximity to the limestone and the latter is greatly faulted and dislocated. At the east end of the canon the strata of the Jura-triassic and Cretaceous abutt upon the Carboniferous, so that the town of Tijeras is on the Jura-triassic area.

3.

THE AREA NORTH OF THE SANDIA MOUNTAINS.

From the northern portion of the Sandia range there is a strong spur or isolated uplift composed of granite and schists intersected with dykes of diorite and of quartz. This spur projects westward toward the river and gives rise to springs and streams of beautiful water. This area has not been sufficiently studied but is evidently the focus of iocal metamorphism as described above. To the south of the spur a small portion of the same formation as that which underlies the lava beds to the north and west of the Rio Grande protrude through the river gravels and consists of the same red detrital materials. Near the river in the neighborhood of Alameda is a deposit of pumice evidently from one of the craters in the neighborhood of Bernalillo. To the north of this place the supposed pleistocene crops in the river bed as it does at several places even further south. It also appears in the hills and seems to be greatly commingled with the river gravels. North of the Sandias to the river and Galisteo creek and eastward to the Jura-triassic area east of Thornton the surface is irregular and is worn by erosion into deep gullies. The material is chiefly unindurated sand and crag with shaly layers. This may, in all probability, be referred also to the Pleistocene. In fact, evidence that this is the case is found in the neighborhood of the little Indian town of San Fillipe where an outlyer of the lava on the east side of the river forms a small isolated mesa about 100 feet above the general level. The river gravels are seen on the eastern aspect rising half way to the top and enabling one to observe the contrast. It would appear that the exposed soft materials have eroded faster than the same strata on the west side of the river where protected by the lava as is also the case in the area opposite Bernalillo on the west side of the river and south of the lava. This eroded country is denominated "the bad lands," but has no relation to the *mal pais* resulting from the breaking down of the lava flows met in many parts of the territory. Going east, the country rises to about 525 feet above.

the river. Here is a bed of marl and crag reminding of the superficial layer opposite Albuquerque. The whole area south of Thornton seems to be similar till the Jura-triassic area at Galisteo creek west of Cerrillos is reached. At the very north end of the mountains the foot hills seem to be of Cretaceous and Jura-triassic but the disturbances have been so great that little has been done in unravelling the complicated relations. A deep canon cuts far into the range from the north, at the mouth of which is the Mexican town of Placitos. The canon is due to the extensive fault in the Carboniferous limestone by which the lime after dipping from the crest to near the general level on the west side of the canon, reappears on the east side in a precipitous cliff of perhaps 600 feet. The valley is cultivated for a number of miles and apparently contains Cretaceous strata. At the extreme northern limit of the eastern wall of the canon there is a series of springs and a very confused area. It here appears as though the limestones of the Carboniferous were followed with only slight disturbance by the beds of the following formation. A limestone occurs which contains fragments of Carboniferous lime together with their fossils commingled with fossils of a different habitus. The remains are poorly preserved and no decision can now be reached as to their age. Among these beds are others composed of red granite fragments, forming a small-grained conglomerate. Red sandstone and shales seem to follow, to be in turn succeeded by banded quartzite and other beds of shale and sand and still other strata of quartzite. The strata all dip to the east and it is hard to determine whether the series (here regarded, on lithological evidence alone, as Jura-triassic) is quite thick or whether it is frequently repeated by faulting. East of these exposures there is a very prominent ridge with its abrupt escarpment toward the west offering the following section: at the base at least 200 feet of red sandstone with irregular layers of vesicular limestone, then 85 feet of saccharoidal white sandstone and on top a band of 15 to 20 feet of yellow limestone. This section is crossed by the road to Tijon where are saline springs. It is probable that the upper part of the section is Cretaceous. The region to the east of this ridge is probably Jura-triassic. Passing south, there are low hills with gypsiferous shales and gray and white sandstones nearly to La Madera which seems to be upon a plateau of limestone, broken in places by granite or other igneous rocks. From San Antonio to San Antonio is a Cretaceous region and along the roadside we find about 50 feet of shales with lenticular masses of limestone topped by an eqal amount of freestone. Between San Antonio and Tijeras the boundary between the Cretaceous and the Jura-triassic is crossed through here the disturbed stratigraphy is difficult to unravel. The valley of the creek from "Uno de Gato" to Alamillo and southward is occupied by the red Jura-triassic. Ascending the creek we encounter horizontally stratified beds of clay possibly of Pleistocene age reposing on older tilted rocks.

4.

CARBONIFEROUS AREA SOUTH OF TIJERAS.

On the east side of the range, south of the town of Tijeras is a region consisting chiefly of rough and rolling country quite densely timbered. Passing south of Tijeras, which is situated on the Jura-trias area, about half a mile, the contact between the Jurassic red sandstone and the Carboniferous limestone is clearly seen. The contact is along a sharp fault extending approximately east and west—a line which may be followed at intervals for many miles. The upturned edge and adjacent parts of the lime are metamorphosed and filled with segregated silica. The dip is to the southwest in the immediate vicinity of the fault while the Jura-triassic on the opposite side dips northeast. To the south of this fault the country is wholly made up of Carboniferous strata. The series is nearly horizontal with slight variation in different directions from the horizontal plane.

Although there seems to be no place where the entire Carboniferous series is exposed from bottom to top the following section is no doubt nearly complete and embraces over 600 feet commencing with dark fossiliferous limestones such as are elsewhere found near the base of the series. The fossils are such as Productus cora, Spirifer opima, Martinia concentrica, etc. The section is about as follows:

First, 225 feet of dark, bedded limestone, followed by 50 feet of shales, then 150 feet of gray massive limestone on which reposes about 25 feet of reddish or yellowish sand-stone. Then follows 100 feet of limestone with a thin bed of shale and a few feet more of lime making up an additional twenty feet. Then follows 25 feet of sand-stone and 25 feet of lime to the top of the exposure. Carboniferous fossils may be found to near the top though it is possible the very upper portions may contain representatives of a Permean fauna. It will be noted that this section contains sand-stone members near the top not seen in sections apparently as complete further east. It is probable that the present section actually reaches higher levels than the latter and that a certain part of the limestone series is below the present section and is to be added to the total thickness.

Passing eastward the strata become practically horizontal and the country more level. The fault line between the Carboniferous and the Jura-triassic is well seen at the little town of De Vaca about two and a half miles east of Tijeras. The limestone and the sands of the Triassic both dip to the northwest but in no place were the two seen in conformity. At this place it is the upper part of the Carboniferous that emerges and it is here filled with bryozoa and a narrow horizon is distinguished by being almost made up of small foraminifera of the genus *Fusulina*.

The Carboniferous extends eastward and apparently covers the entire rolling country to the valley occupying the eastern part of the sheet. At Sedillo it is well exposed and is still nearly horizontal. Further northeast it seems to be uplifted so that the underlying quartzites are exposed two miles northeast of Sedillo. This area is covered with a sparse growth of cedar and pinon and seems to be available farm land where ever irrigation is possible.

An irregular line extending north and south along the eastern third of the sheet is the axis of uplift occupied by the mountains of the San Pedro group, which are, beginning at the south, first, South Mountain with its westward extension of granite hills, which we may call the San Antonito mountains. Next north is the San Pedro peak with its foot hills. Then the Ortiz group and, finally, north of the Galisteo creek, the Cerrillos range. In all these, except the San Pedro mountain, the greater part of the uplift seems to be of granite of the metamorphic series. The Carboniferous limestone skirts the southern border of South Mountain and extends nearly to San Antonito and encloses the area of Cretaceous and Jura Trias extending from Tijeras to the latter place. Directly west of South mountain there is preserved a bold escarpment of the Carboniferous. Here the granite is exposed from time to time below the Carboniferous but the lower 175 to 185 feet is partly covered and partly obscured by an interpolated intrusive. (A section of this rock shows it to be an orthoclase porphyry with hornblende and diallage ?) The upper part of this portion seems to be an earthly limestone. This is followed by ten feet of fine shale such is commonly found within a hundred feet of the quartzite, and this is followed by a fossiliferous shale with the characteristic faces of the lower member of the series. Productus *Spirifer opima* and *Martinia* are abundant. Seventy-five feet of dark bedded lime follow, after which the lime has a vescicular character with nodules of chert for one hundred and ten feet. The next 120 feet is more homogeneous and of a gray color and has a large species of Athyris as the characteristic fossil. The upper twenty feet of this member inclines to be shaly with a yellow color and is filled with bryozoa. At this level too is a belt of Fusulina limestone. The remaining forty-five feet is made up of massive dark gray lime with bryozoa. It is evident that this section lacks the upper portion and the sandy beds noticed in sections further south and west are here absent.

From this exposure to a point west of the Ortiz mountains the limestone is the country rock, though it nowhere rises to so high a level as here. It apparently extends uninterruptedly between South Mountain and San Pedro Mountain and not far east of the town of San Pedro it is sufficiently charged with lead to give rise to productive mines. The ore concentration may be ascribed to the influence of the San Pedro crater and affords a beautiful illustration of the relation of metamorphism from local vulcanism to ore assemblage. On the west the limits of the Carboniferous are marked by an abrupt or even precipitous drop to the area of the valley occupied by a stream flowing north into the Rio Grande north of Bernalillo. Here the red sands and shales ascribed to the Jura-triassic lie in confused dip, the fragments being faulted in various senses. The Carboniferous again appears in irregular patches on the west side of the stream nearly horizontal in position and obviously forming fragments once continuous with the Sandia block. The whole area in this sheet east of the mountains and south of the Galisteo creek is an alluvial valley and seems to be underlaid by the Carboniferous and possibly some of the later strata. It is the only part of this sheet that promises to afford artesian water and should such wells prove successful this beautiful valley will become the garden of the territory.

5.

THE GEOLOGY OF SOUTH MOUNTAIN.

The clustre of peaks by the above name is at the southern end of the series of rather isolated mountains lying east of the Sandias and faces the extensive valley forming the eastern part of the sheet. From this valley it rises abruptly and the granite core soon breaks through the fringe of sedimentary strata at the base, and rises in bare crags to over 8000 feet. A lobe of the valley to the eastward passes westward immediately to the south of the mountain giving to it an isolated appearance from all directions, though to the west it extends in a series of lower hills of granite, schist and gneiss nearly to the town of San Antonito. About the eastern base there are perhaps a hundred feet of red sandstone which probably is of Jura-triassic age. These strata dip away from the main peak at a slight angle. To the west it is the Carboniferous limestone that skirts the base. These limestone strata extend far up the western foot hills and are much titled and faulted. The north and south valley or canon which separates the main range from the western foot-hills exposes a vast series of schists of great lithological variety. Occasional diorites exhibit the extreme of metamorphism but no true intrusives were seen. All portions of the range were not visited and it is possible that some intrusive outbreak was overlooked but in that case it must have been quite insignificant.

6.

THE SAN ANTONIO AREA.

The area east of San Antonio and thence to De Vaca is peculiar and in some respects unique. At De Vaca is a fault extending northeast which is in all probability the extension of the similar fault seen a short distance east of the town of Tijeras. The carboniferous lime is here abruptly cut off and the Jura-trias appears on the west side with a strong dip to the northwest. These strata appear in two ranges of hills to the northwest, beyond which the Cretaceous appears either following in normal sequence or, as is more probable, on the down side of another fault. The country in this neighborhood is very rough, the lower parts of the exposures revealing a dark carboniferous shale, at which horizon coal is occasionally mined, as is the case north of the cabins of Gutierez. The upper members are of a yellowish freestone capped with a more dense white sandstone. An irregular but rather continuous escarpment forms a bluff which is a conspicuous landmark from a distance whence the land ultimately slopes to the region about San Antonito, the interval being filled in with Cretaceous. The dip is generally north and northwest but is modified by at least one north and south dyke. The one in question is of peculiar interest as being probably the last remnant[1] of a volcano that once existed about a mile east of San Antonio. At this place is a large amphitheatre of at least a mile in diameter bounded to the north, east, and west by the escarpment of Cretaceous just mentioned, on the south in part by a low hill of Jura-trias.

This amphitheatre is now a fertile valley but from its northern arc a dyke of basic igneous rock pierces the escarpment to the north which is affected by its forcible intrusion in such a way that it dips away from the dyke on either side. At this place the freestone is filled with impressions of a single species of mollusk. The exposure is as follows : gray, fissile, earthy shale, 75 feet, the upper part being carbonaceous and partings of flags occurring throughout; thin-bedded grey shales, 75 feet; sandy shale with flags, 50 feet ; freestone with fossils, 140 feet; crystalline white sandstone, ten to twenty feet.

Between this amphitheatre and San Antonio the series seems to be twice repeated by faulting and between the later place and Tijeras there is a series of hills containing the Jura-triassic.

7.

THE CERRILLOS AND ORTIZ AREA.

About six miles west of Cerrillos on Galisteo creek a narrow zone of the red Jura-triassic shales and sandstone outcrops. The dip is here east and northeast perhaps 25 degrees. A careful search discovered no fossils. North of the creek the Cretaceous strata rise to a height of about 375 feet above the track. The section at this place is as follows : 50 feet of red shale and sand capped with hard red sandstone, then 175 feet of white sandstone of varying consistency, 75 feet of chocolate shales with concretions in bands, followed by twenty feet of sandy white shales with a band of white sandstone about three feet thick below and a somewhat thicker one above, 30 feet of sands and shales and at the top 25 feet of indurated sandstone or quartzite with conglomerate. The base of this series may be Jura-triassic. Passing eastward, after what seem to be two partial repetitions of this section by faulting, we encounter a section with quartzite at the base which passes into white sandstone, then 20 feet of bluish black shale, a zone of red calcareous concretions and 25 feet of dark fissile shale and 15 or 20 feet of yellow sandstone. After crossing a deep valley the following section is encountered ; 115 feet of gray shales and thin flags with numerous Cretaceous fossils, covered with a sheet of about ten feet of what seems to be a basic eruptive rock similar to that covering a great deal of the region about Cerrillos.

This flow proves to be a characteristic lencite phonolite. From this point to the western foot of the Cerrillos mountains the same fossiliferous shales and flags occur in low hills. Essentially the same sequence occurs south of the creek. The region to the west and south of the mountains are cut by radial dykes which beautifully illustrate the way in which these dykes habitually occur. The intersected rock being in this case for the most part soft and easily eroded, the dykes are left as conspicuous walls rising several feet above the general level, and may be traced for six or eight miles continuously. They vary from two or three feet to twenty feet in width and the same dyke may vary greatly in this respect. The material, so far as can be determined without a section, may be an andesite but in the thicker portions it tends to be replaced by a felsitic material. This may be explained upon the supposition that where the local metamorphism was great the fused acid material expanded the original fissure by disintegrating the walls and, in some instances nearly or quite suppressed or obscured the eruptive.

The alteration phenomena in proximity to the dyke are quite interesting. In particular, the formation of chalcedony and jasper from the siliceous wall rock is plainly seen. The influence of the sheets of the same material, while less pronounced, is no less apparent, for the shales and limestone so covered have become flectuously lammelate and crystallized. The source of the flows as well as of the dykes is no doubt the south end of the Cerrillos mountains which are composed of a similar material. The northern part of the range is of granitic rock which may be later than the old phonolite nucleus. This region gives us the suggestion that the phonolites are probably post-cretaceous. To the northwest of the mountains, about three miles from their base, is a recent basaltic crater from which extensive flows of lava have spread to the west and southwest. Along the southern margin of this sheet there has been very extensive base-leveling erosion exposing from 50 to 75 feet of the soft strata beneath. In the vicinity of the mountain, along its western base such exposures are very instructive and give the surest clue we have so far seen to the age of the several intrusives. Here, for example, at the base of the exposure are 60 feet of dark, horizontal, Cretaceous shales intersected by nearly vertical narrow dykes of what looks like a basalt though much decomposed. The strike of such a dyke about two feet wide near the road to Santa Fe is N. 10 degrees W. Above these shales is a bed of crag and loose material over 50 feet thick. The bowlders at the bottom of this series are of phonolite similar to that of the mountains at the south end of the range. The whole is capped by 25 feet of recent lava from the adjacent cone. The basalt dyke referred to stops short at the top of the shales showing the upper loose zone to be of later date than the intrusive. The shales, which dip to the east at a distance from the mountain, become horizontal as they near the range and, near its base, dip to the west. We may assume that the phonolite uplift, at least the later part of it, occurred after the deposition of the Cretaceous and that the later deposits (perhaps Pleistocene) result from the erosion of the resulting materials. The extensive dykes radiating from the mountains and cutting through the strata may therefore be of the same age as the main mountain uplift. Though the northern and higher peaks of the range are of granite it is probable that this uplift is parasitic upon the basic eruption.

At Waldo, about three miles west of Cerrillos, at a point about a third of a mile north of the track, is a prominent mountain of porphyritic gray eruptive which shoulders its way through the dark Cretaceous shales. From this region a strong dyke extends southward and is apparently the same that intersects the coal workings of the Cerrillos Coal Co., near the breaker, and may be the principal cause of the special metamorphism which has transformed the bitumenous coal to anthracite at this place. This dyke is about twenty feet wide and is a prominent landmark. The other hills of the Cerrillos range between Waldo and the town of Cerrillos seem to be, for the most part, composed of the same basic eruptive as is the country to the northward nearly to the foot of the granite mountains of the northern part of the group. The country for two miles or more north of the town is broken and, while the country rocks seem to be basic, it is intersected with acid dykes that may be derived from the same source as the granite of the northern peaks. These acid dykes in a basic rock carry a small quantity of gold as is the almost universal rule under these circumstances. Extensive superficial prospecting has resulted in opening no important mines thus far. To the east the Cretaceous sandstones and shales occupy the surface for many miles and, in one locality a few miles east of Cerrillos, there is a considerable area covered with the silicified trunks of large trees—in short a buried and petified forest is exposed. The trunks are frequently only partially exhumed by erosion and protrude from the sandy matrix in a horizontal position. The Omera coal banks fourteen miles to the east and south of the railroad have at various times been extensively worked but at present the coal shipped by the Santa Fe comes entirely from the extensive mines at Madrid two or three miles south of Cerrillos. The detailed study of this interesting region is reserved for a special paper. The rocks are of Cretaceous age and consist of about 150 to 200 feet of alternating shales and sandstone. The higher layers are often of a yellow freestone not unlike the Waverly rock of Ohio in appearance.

The whole is much disturbed and faulted and seems to have been covered by a flow of basic material of varying thickness which in some place has given place to a crag of materials derived from the erosion of this sheet. Immediately above the anthracite is a thin bed of a black basalt-like intrusive that seems to have qeen injected between the strata or to have covered the roofing shales of the coal. It may be that this sheet is to be connected with the dyke above mentioned. It is a question whether the superficial sheet of phonolite (?) has had much part in the metamorphism of the coal though that seems to be the local theory. Passing to the south, the gray igneous rock assumes greater importance and occupies all the foot hills to the granitic or gneissic core of the Ortiz range. The Cretaceous bounds the mountain on the northwest and the entire western base is apparently occupied by the Carboniferous.

A deep valley separates the Ortiz from the San Pedro mountain, the former, so far as observed, being composed almost exclusively of granite rocks, while only the northeastern part of the San Pedro mountain is granitic. The latter will afford an interesting field for study as it is essentially an old andesite crater with more or fewer parasitic acid flows. The Carboniferous lies upon its southwestern flank and has been subjected to so great metamorphism that the lead content has been segregated and considerable mines of carbonate exist in the neighborhood of the town of San Pedro. The foot hills near Golden on the northwest of the range are of Carboniferous limestone also but in the valley separating San Pedro mountain from the Ortiz group is a tongue of Cretaceous sand and shale. The crater proper occupies the entire center of the San Pedro mountain, the rim being broken at the northeast at the locality of the Saint Lazarus mine and mill.

West of the Saint Lazarus mine a section of the wall of the crater is as follows: 200 feet of sandy and calcareous material highly metamorphosed and serpentinized. This may have been an earthy limestone with sandy bands. The dip is into the crater, i. e. to the northeast. Next is 100 feet of altered limestone like the lowest horizon, then a sheet of andesite aphanite lying conformably above the sedimentary and serving highly to metamorphose it at the contact. At this contact is a certain amount of copper stain which has excited the curiosity of the prospector. The dark band is visible for miles and has universally been called the "black lime" by the miners. Above the aphanite is a variable amount of acid rock—perhaps a felsite. The south and western rim of the crater are quite sharp and are essentially similar tnough more of the andesite is found in places. In the interior the andesite is more in evidence and is mixed with acid flows giving rise to the conditions for gold collection. As a matter of fact there is gold in the placer gravel within the crater practically everywhere. The contacts of the andesite and the acid rocks are also habitually auriferous and are worked to a considerable extent, the "Gold Standard" mine being quite well known locally. The northern wall of the crater is broken by a massive dyke extending north and south and other dykes extend in various directions into the surrounding country. To the east there have been extensive flows the sedimentary rock having been removed to a great extent and the important flows being of andesite and an acid "felsitic" material. In the vicinity of Golden there has been some extensive placer working, the results of which it is yet too early to ascertain.

The northeastern part of the territory, from a line passing through Raton and Las Vegas and thence southeast, is said by Professor R. T. Hill to have formed a part of the Tertiary continent and not to have been submerged since the Cretaceous. (Bul. Geol. Soc. Am. III, 86, *et seq.*) "The cities of Trinidad, Folsom, and Las Vegas may be considered as bench marks along the northern, eastern, and western boundaries respectively of this region, while Raton, Springer, Maxwell, and other points along the Santa Fé railroad between the Purgatoire, at Trinidad, and the Pecos are located upon it. The southern boundary is the superb escarpment of the Canadian Pecos valley."

"Everywhere is seen the grand result of profound erosion by which the overlapping formations (Dakota, Denison, and Trinity beds) have been stripped from the horizontal red beds, which constitute the valley floor, and has left standing in the valley numerous remnants of the plain in the shape of great circular buttes and mesas, such as El Corazon, The Gavilan, Mesa Rico, Mesa Redondo, the big and little Haarfando Mesa, Tucumcari, and others, every stratum of their red, brown and white beds being visible in horizontal bands for scores of miles."

"The erosion from top to bottom of the successive plains of stratification has partially removed more than 5000 feet in thickness of sedimentary strata."

8.

THE CARBONIFEROUS.

In the Rio Grande region of New Mexico the Carboniferous formation is remarkably homogeneous. It always rests with apparent conformability on a series of quartzites that form the transition into the metamorphic granites and gneiss below and the thickness of the quartzite often seems to depend on the amount of metamorphism to which it has been subjected. In some places the limestone seems to rest diretly on the granite but these cases may be interpreted as instances of extreme metamorphism that have caused the qurtzite to assimilate to the granite. There seems to be every reason to suppose that the band of quartzite is of a different age from the granite as well as to believe that the granite itself is of sedimentary origin. The basal quartzite is usually from fifty to seventy-five feet thick while it may drop to ten or twenty feet. A few fossils have been found in the upper shaly layers but they probably belong rather to the shales which next follow. These shales are frequently highly metamorphic but are fossiliferous. The quartzite has conglomeritic phases with granitic and other pebbles. It reminds one by position and lithological character of the basal conglomerate lying under the coal measures of Ohio and Pennsylvania but no homology is suggested. The conglomerate quartzite is frequently the catch-basin for the leechings of the limestone and sand-stone above and accordingly is of some importance as a collector of intrusive ore. See account of the Caballo mountain ore in another place.

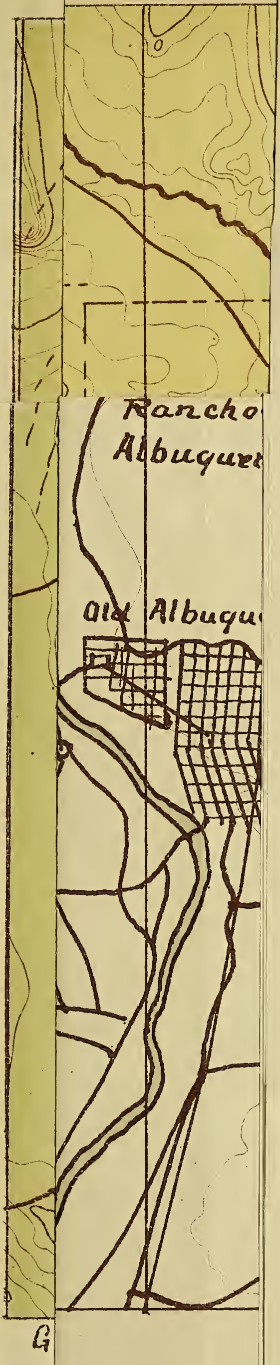
Immediately above the quartzite is usually a band of shale of about ten feet followed by perhaps 150 feet of fossiliferous limestone. It is in the shaly beds in this horizon that the most abundant fossils are to be found. Spirifer opima, Productus cora, Martinia concentrica, etc., are the characteristic species.

In typical sections this lime is followed by about twenty-five feet of conglomerate or sand-stone. There follows about three hundred feet of limestone which tends to grow lighter toward the top. This is not very abundantly supplied with fossils. It may be separated from the next member by a thin band of bandy shale. In many exposures the next fifty feet is the prominent portion of the series it being a specially massive and permanent band of limestone. The next 125 feet is fragile and contain Productus nebrascensis (?) and large Spirifers and a large Athyris as the characteristic fossils. Four to six feet of shale may occur at this point. About 25 feet higher is a peculiar greenish layer with a sandy tendency. Still 60 feet higher is a definite sand-stone layer often characterized by the presence of much feldspar in the sand. This band is about ten feet thick and is followed by about 100 feet of gray lime.

The sandy members are not very constant. The position of the zone of bryozoa and Fusulina bed is probably near the prominent bed of lime mentioned and, as this is often the apparent top of the series, the beds are frequently quite accessible.

The nature of the transition into the Jura-triassic is still obscure. At the north end of the Sandia range is an exposure where the transition apparently can be seen. The extent of disturbance is however a drawback. So far as can be seen the base of the red series is formed by a curious bed of large-grained sand or fine conglomerate the grains being red granitic fragments. There is also a lime conglomerate. Then a band of lime in which is a fauna with a decided Carboniferous facies yet with foreign elements. In fact, the appearance is as though the Carboniferous fossils were in fragments of the Carboniferous limestone while the others were collected with the fragments and cemented together. A perfect specimen of Hemipronites cremistria with both valves was found. Awaiting the opportunity to collect added specimens the age of these beds must be left in doubt with the suggestion that they may prove the missing Permian. No fossils have so far been found in the red beds referred to the Jura-triassic.

A comparison with the section given by Captain E. C. Dutton from the Zuñi plateau (Sixth Annual Report of the U. S. Geological Survey, 1885,) will show that the fragments of the Jura-triassic and Cretaceous encountered in this region are insignificant when compared to the great formations to the west, for 3150 feet are attributed to the Jura-triassic alone in that section. The work of correlation has hardly progressed far enough to make comparisons desirable.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RIO GRANDE
Alluvium Flood Plain
ATCHISON, TOPEKA AND SANTA FE R.R.
Sandia Mesa
Lignite
Basalt Volcanoes
Talus
RIO PUERCO
Flood Plain
Ranchos de Albuquerque
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Pleistocene
Basalt
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Geology by C.L. Herrick
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Tertiary
Igneous
Pleistocene
Cretaceous
Metamorph.
Red Beds.
Contours for 50 ft. From U.S.G.Sur.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.
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*NOTES ON A COLLECTION OF LIZARDS FROM NEW MEXICO.

By C. L. HERRICK, JOHN TERRY and H. N. HERRICK, JR.

The following notes are based on the collections of lizards made by the voluntary geological and natural history survey of the University of New Mexico during the season of 1898, with such additions as were possible from the collections made by the senior writer during several years previous. The area covered is chiefly within the Rio Grande valley between Albuquerque and Socorro and the area of the field-work in geology reported elsewhere in this volume. For specimens from Gallup we are indebted to Mr. Wallace Bowie, and for a few specimens from Magdalena to Mr. James Fitch. The object in presenting these fragments is simply to facilitate the prosecution of this work during the coming seasons and to give to the residents of the territory who may be willing to assist in it the basis for the recognition of the commoner species. None of our lizards are venomous and they are mostly to be ranked with the harmless, if not actively helpful, inhabitants of the plains and mountains. In many cases they are marvelously abundant, especially is this the case with the Holbrookias and smaller honed toads. The latter pass below ground in October and do not reappear till spring, while the smaller lizards may appear during the warmer parts of the day throughout most of the winter. They are, for the most part, subject to a great deal of individual and seasonal variation and many are provided with a remarkable degree of color adaptability in adjustment to the environment, so that, for example, species from the open sands are entirely different in markings and color scheme from those of more pro-

*Read before the Denison Scientific Association, December 24, 1898.

tected stations. They also have the camelion-like power of adapting themselves in a short time to the color of the background.

LACERTILIA.

The lizards may be distinguished from the recent families of reptiles by their scaly bodies, the presence of limbs, the absence of a carapace, the three-chambered heart, the fact that the jaw is not dislocatable from its cranial attachment as in snakes or, more technically, by the following characters: quadrate bone articulated with the skull, parts of the ali- and orbitosphenoid regions fibro-cartilaginous, rami of the madible united by a suture, anal cleft transverse, copulatory organs paired.

KEY TO THE FAMILIES DESCRIBED.

I. Eyes with movable lids.
  a. Pupil elliptical, vertical; head without large plates, its skin freely movable, . . *Eublepharidae.*
  aa. Pupil round; top of head with immovable plates.
    b. A series of femoral pores.
      c. Lateral scales not abruptly smaller than the ventrals in numerous series; tongue not deeply divided, ... *Iguanidae.*
      cc. Lateral scales granular like the dorsals and smaller than the ventrals, which are in 8 longitudinal series, tongue ending in two slender points, ... *Teiidae.*
    bb. No femoral pores.
      d. Lateral scales very much smaller than the dorsal and ventral, usually hidden by a lateral fold; dorsal scales keeled, ... *Anguidae.*
      dd. Lateral scales not much smaller than dorsals and ventrals; no lateral fold; scales smooth.
        e. Scales on body flat, thin and imbricate, *Scincidae.*
        ee. Scales tuberculate, usually bony, with granular interspaces. Poison glands present, *Helodermidae.*
II. Eyes without lids; pupil elliptical, . *Xantusiidea,*

Family. Eublepharidae.

This family is admittedly nearly related to the geckos, from which its members differ in the procœlian vertebrae and single parietal bone. The limbs are slender and the claws are retractile. The rather few species are widely distributed, the family being represented in North and Central America and in Asia. The color patterns among those widely separated species is very similar.

Coleonyx variegatus, Bd., has been found in Texas and in California and so may be expected to occur in southern New Mexico. It may be recognized by the characters of the family and the five dark brown bands crossing the yellow of the back. The eyelids have a series of pointed scales. Males have six to eight preanal pores.

Family. Iguanidae.

A very large family restricted to America and the islands of the Pacific with the exception of two genera from Madagascar. The species are diurnal, the eyes having round pupils and strongly developed lids. The teeth are sub-equal in size and usually conical. Femoral pores are usually present in the North American forms while often absent in those of South America. The form of the head shields is various and affords good generic and specific characters. In this paper the shield formed by the confluence of a number of plates about the parietal eye is called the interparietal and not occipital, as is done in many cases. The tympanum is distinct, except in Holbrookia. The species are generally insectivorous but many are partial to a varied diet and some seem to be strongly vegetarian. Phrynosoma and some species of Sceloporus are oviparous. From the excellent report of John Van Denburgh on the reptiles of California we take the following key to the genera likely to occur within our limits.

Synopsis of Genera of Iguanidae.

I. A low dorsal crest composed of one longitudinal series of enlarged scales, . . . *Dipsosaurus.*

II. No dorsal crest.
  A. Head without spines.
    a. One or more transverse gular folds.
      b. Toes with a lateral fringe of movable spines, . *Uma.*
      bb. Toes without spines.
        c. Supralabial plates strongly imbricated; symphyseal plate smaller than the largest infralabial.
          d. An ear opening, . . . *Callisaurus.*
          dd. No ear opening, . . . *Holbrookia.*
        cc. Supralabials not imbricated; symphyseal not smaller than the largest infralabial.
          e. No large interparietal plate; caudal scales small, not strongly keeled or pointed.
            f. Ear without strong denticulations and neck without spinose tubercles; supercilaries imbricate; tail long and tapering, . . *Crotophytus.*
            ff. Ear with strong denticulations and neck with numerous spinose tubercles on lateral folds; supercilaries not imbricate; tail scarcely longer than distance from snout to vent, . *Sauromalus.*
          ee. A very large interparietal plate; caudal scales large, strongly keeled, and sharply pointed, *Uta.*
    aa. No complete transverse gular fold, . *Sceloporus.*
  AA. Head with large spines posteriorly, . *Phrynosoma.*

Genus. Dipsosaurus.

The single species of this genus, Dipsosaurus dorsalis, Bd. and Gd., has been found in the Colorado and Mojave Deserts and is abundant in the neighborhood of Yuma. It probably does not occur within our limits. It is entirely vegetarian in habit.

Genus. Uma.

The two known species of Uma are not known to occur in our region, they being, like the last and the following, desert loving animals.

Genus. Callisaurus.

Callisaurus ventralis, the only species, within the United

States, was said to occur in Texas as well as in the desert region of southern California and Arizona. It may therefore occur in New Mexico. Stejniger, however, denies that it occurs in either Texas or New Mexico.

Genus. Holbrookia.

Unlike the related genera, this genus is devoid of external ear discs, the tympanum being covered. The dorsal scales small, uniform; head scales small, interparietal enlarged. A long series of femoral pores; two transverse gular folds, the posterior with a denticulated edge; no abdominal ribs; males with enlarged postanal plates. The genus is limited to the southwestern part of North America.

Holbrookia Maculata, Girard.

Plate XIV, Fig. 1.

Holbrookia maculata, *Girard,* Proc. Am. Assoc. Ad. Sci., 1851; Stanbury's Expedition Gt. Salt Lake; *Cope,* Proc. U. S. Natl. Mus. 1880.

var. flavilenta, *Cope,* Proc. Acad. Nat. Sci. Phil., 1883; *Stejniger,* N. A. Flora, No. 3; *Boulenger,* Cat. Liz. Btit. Mus.

approximans, *Baird,* Proc. Acad. Nat. Sci. Phila.

maculata approximans, *Van Denburgh,* Cal. Acad. Sci., V, 1897.

Description: Body depressed fusiform, head short, V-shaped in perpendicular section; nostrils on the upper surface; head plates mostly small and irregular, except the interparietal, which is large, as wide as long; one or more series of axial scales in front of the interparietal larger than the other head plates; supraocular regions covered with small granules; superciliaries strongly imbricated; middle subocular plate very large; eyelids well fringed; about six upper labials, strongly imbricated; lower labials smaller, not imbricate, separated from enlarged sublabials by a row of small scales; gulars flat, not imbricate, but becoming so on the last gular fold; ventral scales larger than the dorsals and laterals, which are granular; a lateral fold between the fore and hind limbs which are short;

femoral pores about 12 ; tail short, abruptly narrowed at about the proximal third.

Color: Upper parts gray yellow or light brown, with two or four longitudinal series of dark splotches and numerous lighter spots ; top of head like back but without definite pattern ; upper surfaces of legs marbled with brown ; throat white or yellowish, sometimes marbled with darker ; tail with a single series of spots ; under parts white or yellowish, with two or three transverse of black laterally behind the fore legs and which do not extend dorsally above the lateral fold and are sometimes edged with blue.

This little species is abundant everywhere in the Rio Grande valley and elsewhere in central New Mexico. It is extremely variable in color and adapts itself both temporarily and permanently to local color conditions. It feeds largely on plants and climbs readily.

Holbrookia Texana, (Troschel), Baird and Girard.
Plate XIV, Figs. 2-5.

Cophosaurus texanus, *Troschel,* Arch. f. Natur., 1850; Holbrookia texana, *Bd.* and *Gd.* Proc. Acad. Phila., 1852; U. S. Bound. Surv.; *Bocourt,* Miss. Sc. Mex. Rep.; *Cope,* Bul. U. S. Natl. Mus., 1880; *Boulenger,* Cat. Liz. Brit. Mus.

affinis, *Baird* and *Girard,* Proc. Ac. Phil., 1852.

Description: Body slender, head as long or longer than head and body ; head very small, V-shaped in vertical outline ; nasal openings dorsal, prominent; head plates mostly small and irrelegular except the interparietal which is not large, and a series of rather large axial plates in front of the latter ; superciliaries large and strongly imbricated ; one of the suboculars very large; eyelids fringed; about seven large imbricated upper labials ; lower labials smaller, not imbricated, bordered below by one or more series of enlarged sublabials ; gular scales flat, not imbricated ; posterior margin of the gular fold feebly denticulate ; ventral scales larger than the dorsals and laterals ; a lateral fold extending from the fore to the hind limb ; femoral pores from twelve to fourteen ; males with enlarged postanal plates ; tail slender ; hind foot very long.

Color: background above pale gray to yellow; upper surface of tail and caudal half of the back marked with transverse bands of brown; anterior part of back with circular spots especially laterally: sides in front of hind leg marked with two deep black crescentic lines extending from the lateral fold toward the median line on a bright yellow field; upper surfaces of limbs with irregular dark markings; under parts white or yellowish; under surface of tail with transverse bars of black; throat and lateral belly patches blue in the male; a dark streak along the caudal aspect of thighs.

This beautiful species has been collected no further north than Socorro where it is not rare. It ranges from northern Mexico into the adjacent states.

Genus. SCELOPORUS.

Head and body somewhat depressed, shorter than the tail; no dorsal crest; dorsal scales keeled imbricate, equal; head scales large, especially the interparietal, usually with a definite pattern; no gular fold; tympanum distinct protected by strong teeth; femoral pores present; superciliaries imbricate.

Sceloporus Poinsettii, Baird and Girard.

Plate XV, Figs. 6-8.

Seloporus poinsettiii, *Bd.* and *Gd.*, Proc. Acad. Phila., 1852; U. S. Bound. Surv.; Sceloporus torquatus, var. C. *Bocourt*; toquatus poinsettii, *Cope*; torquatus cyanogenys, *Cope*; torquatus, var. poinsettii, *Boulenger*, Cat. Liz. Brit. Mus.

Description: Head and body somewhat depressed, very broad; nasal opening near the end of the snout, on the dorsal surface and within the canthus nasalis; upper head plates smooth, convex, not imbricated, irregular; interparietal largest; frontal divided transversely, caudal portion divided into four or more unequal parts, cephalic portion divided longitudinally; supra-oculars forming two irregular longitudinal rows, seperated from the axial head plates by a continuous series of smaller scales; superciliaries large, strongly imbricated, keeled, separated from the supra-occular by an irregular series of granules and small scales, middle sub-occulars as long as the remainder of the series, keeled; rostral plate narrow, nearly rectangular; labials low, upper and lower subequal; symphyseal plate large, pentagonal, followed by a series of plates larger than the gulars, not separated from the lower labials, the latter, however, in a double row; gular scales smooth, flat, bicuspid, strongly imbricated; those of a median portion of the belly not toothed, toward the sides first becoming bicuspid, then strongly denticulate; passing gradually into the dorsals; ear opening large, nearly vertical, protected by a small series of acuminate scales, only two of which are specially modified; scales of back broad, equal, slightly keeled, short-pointed and serrate, in longitudinal series but converging backward toward the median line; dorsals of the lumbar region, smaller than the caudal scales; scales of the sides pointing obliquely upward; no longitudinal dermal folds; a transverse gular fold behind the ear opening; upper surfaces of limbs covered with strongly keeled and long-pointed scales; scales on the posterior surfaces of thigh similar; upper caudal scales not serrate, strongly spined, spines directed obliquely outward; femoral pores varying from eleven to thirteen or more; six to ten dorsal scales equal in length to shielded part of head; number of scales from the interparietal to a line drawn through the posterior surface of thighs about 30; males with enlarged post-anal plates; tail as long as head and body.

Color: upper parts olivaceous brown, head darker; black collar in front of shoulders; distinct, nearly complete rings of dark on tail; back with dark, broad, irregular inconspicuous bands; male much darker than female; under side of throat bluish grey, in the male darker and more highly colored; bluish longitudinal bands on either side of abdomen in both sexes, merging into a dark spot in front of the thighs; under parts yellowish white; spines of upper surfaces of limbs dark-tipped.

Measurements: Total length, 215 mm.; Length to anus, 105 mm.; Length of tail, 110 mm.; Snout to ear, 26 mm.; Width of head, 27 mm.; Fore leg, 42 mm.; Hind leg, 70 mm.; Base of fifth to end of fourth toe, 20 mm.

This species has been found living upon rocks at an elevation of about 6,500 feet in the western part of the Magdelena mountains and is reported also from Socorro though no specimens are available from that place. Our specimens were kindly secured for us by Mr. James Fitch, of Magdalena. This species seems to be shy and restricted to rocky places in our range.

Sceloporus Magister, Hallowell.

Plate XVI, Figs. 9–11.

Description: Head and body little depressed, sub-cylindrical; nasal opening nearer the end of the snout than the orbit; upper head plates smooth, often somewhat convex, usually slightly imbricated; interparietal largest; frontal divided transversely, two portions sub-equal or caudal part larger; parietals and fronto-parietals not separated from the enlarged supraoculars; latter very broad as are the strongly imbricated superciliaries: middle sub-occular long, narrow and strongly keeled; rostral plate wider than high; labials long but very low, inferior longer than superior; symphyseal plate large, followed by several plates larger than the gulars, separated from the lower labials by one to three rows of narrow sub-labials; gular scales smooth, flat, bi-cuspid, strongly imbricated, as are those of the belly; ear opening large and nearly vertical, protected by a series of very long accuminate scales, four of which are specially modified and not keeled projecting backward and slightly downward; back with equal, keeled, strongly pointed scales bearing a spine on either side of the point, arranged in nearly parallel longitudinal rows; 14 rows of keeled dorsals; scales of sides ranging obliquely upward, merging gradually into the smooth ventrals. No longitudinal dermal folds; upper surface of the limbs provided with strongly keeled and pointed scales; scales on the poster surface of thighs large, accuminate, strongly keeled, and long pointed; upper caudal scales similar to the dorsals but longer pointed; femoral pores varying from 11 to 15 on each side; five to ten dorsal scales equal in length to the shielded part of the head; number of scales from interparietal to line connecting posterior surfaces of the thighs varying from 29 to 35; males with enlarged post-anal scales.

Color: back grey, yellow or brown, with indistinct mottlings of brown anteriorly; a black bar or collar in front of each shoulder; head nearly uniform; faint brownish rings on the tail; central patch of blue on throat of adult males; lateral band of blue bordered with black; a dark area in front of thighs; under parts white or yellowish.

Measurements: Total length, 194 mm.; Length to anus, 85 mm.; Lengh of tail, 109 mm.; Snout to ear, 20 mm.; Width of head, 18 mm.; Fore leg, 39 mm.; Hind leg, 54 mm.; Base of fifth to end of fourth toe, 23 mm.

Scelopus Clarkii, Baird and Girard, Proc. Acad. Nat. Sci. Phil. 1852.

Baird, U. S. and Mex. Boundary Surv., 1859; *Cope*, Proc. Acad. Nat. Sci. Phil., 1866; *Cope*, Check List, 1875. *Coues*, Synopsis of the Reptiles of Arizona, 1875. (Fig.) *Yarrow*, Check List of N. Am. Reptilia, 1882. *Stejniger*, N. Am. Fauna, No. 7. *Van Denburg*, Cal. Acad. Sci., V.

The relation between this species and Sceloporus magister, which is confessedly very close, has been discussed *in extenso*, in N. Am. Fauna, No. 7, by Stejniger, who claims that the two species are constantly distinguished by a difference in the spines guarding the ear openings; these modified spines being smaller and less acute in S. clarkii. There is said to be a difference in habit also and although the habitats overlap in south-eastern Arizona, the stations affected by the two species are said to be different, S. magister affecting an arboreal life while S. clarkii is found upon the rocks. It is probably that this species will be found in the extreme south-western part of the territory.

The species extends into Mexico an unknown distance. Farther south, it is said to be replaced by S. boulengeri, which is similar to S. clarkii but has fewer femoral pores, short and broad ear spines and a very broad interparietal. S. acanthinus is said to be modification of the same type still further to the south.

Sceloporus Occidentalis, Baird and Girard. (?)
Plate XVII, Figs. 12–14.

Description: Head and body somewhat depressed; nasal openings nearer the end of snout than the orbit; upper head plates smooth, somewhat convex, somewhat imbricated; interparietal largest; frontal divided transversely, cephalic portion larger; parietals and frontoparietals separated from the enlarged supraoculars by a series of granules; latter in the single series, very broad and convex, separated from the narrow, imbricated superciliaries by a series of granules, middle suboccular long and keeled; rostral plate broader than high; labials long and low, the upper and lower nearly equal; symphyseal plate very large, followed by a row of enlarged plates on either side, which are separated from the lower labial by a single row of sublabials; gular scales smooth, flat, some of them bicuspid; strongly imbricated; ear opening of moderate size, protected in front by about three enlarged scales; back with equal, keeled, short-pointed scales in longitudinal parallel rows; about 22 or 24 rows of keeled dorsals; scales of sides ranging obliquely upward, passing gradually into the smooth ventrals; scales of the dorsal surfaces of the limbs like those of the back, those of the posterior surfaces of the thighs smooth, no longitudinal dermal folds; scales of the tail like those of the back, but larger; femoral pores 16 to 18; about ten dorsal scales equal in length to the shielded part of the head; number of scales from the interparietal to a line connecting the posterior aspect of the thighs 40 to 42; males with enlarged postanal scales.

Color: Brownish or grayish above, with a lateral light stripe on either side, crossed a zig zag line of dark brown which usually does not cross the median line but may cross the light lateral bands and merges with the darker coloring of the sides; head marked with brown, especially a transverse line connecting the supercilaries and another in front of the eyes; a dark line passing through the eyes; upper surfaces of legs marbled with dark; tail obscurely ringed with dark; lower parts light; male with two spots on the gular region, not confluent on the median line; flanks blue, passing into black; black spot in front of shoulder.

Measurements: Length of anus, 57–55 mm.; Snout to ear, 15–13 mm.; Width of head, 12–11 mm.; Fore leg, 28–27 mm.; Hind leg, 34–32 mm.; Base of fifth to tip of fourth toe, 15–14 mm.

With the materials at hand it is impossible to discriminate S. occidentalis from S. biseriatus. The basis of separation offered by Van Denburgh in the coloration of throat, which in males of S. occidentalis said to have two dark lateral spots, while in S. biseriatus they may be confluent. He says "I have examined many hundreds of specimens of S. occidentalis and biseriatus and have not found a single male of the latter with two blue throat patches. Highly colored male of S. occidentalis are sometimes found in which the two blue patches have extended to end even merged on the median line, but by securing very young or less brilliantly colored males, there should be no difficulty in determining which species occurs in a given locality." Unfortunately he omits to say how he knew that he was dealing with a given species while determining the validity of the sole criterion. S. occidentalis is said to be the more northern species. It may be that the best plan is to accept Boulenger's suggestion and call all the phases of this exceedingly variable group varieties of S. undulatus. This form, whatever it is, is extremely abundant in the Rio Grande valley and the range of individual variation is enormous.

Sceloporus Consobrinus, Baird and Girard.

Description: Head and body little depressed, fusiform; nasal opening nearer the end of the snout than the orbit; upper head plates smooth, somewhat convex, not obviously imbricated; interparietal largest; frontal divided transversely, cephalic portion much larger than the caudal; parietals and fronto-parietals separated by small granules from the enlarged supra-oculars; latter broad (but not so broad as in S. magister) and separated by a number of scales from the narrow, imbricated superciliaries; sub-occular keeled; rostral plate wider than high;

internasals large labials long but narrow, the inferior larger than the superior; symphyseal plate larger than the rostral, followed by several plates larger than the gulars, separated by one row (or two incomplete rows) of sub-labials from the lower labials; gular region with scales smooth, flat, bicuspid, and strongly imbricated like those of the belly; ear opening large and nearly vertical, protected by three or four small, acute, modified scales; back with moderate-sized, keeled, simply-pointed scales in parallel rows; scales of sides ranging obliquely upward; about 45 scales in a dorsal series from cephalic plates to a line drawn through the posterior border of the thighs; transition from the lateral to ventral scales gradual; no longitudinal dermal folds; upper surfaces of the limbs with keeled and pointed scales, like those of the back; scales of the posterior surfaces of the thighs not enlarged; upper caudal scales similar to the dorsals; about 14 femoral pores; about 8 to 12 dorsal scales equal in length to the shielded part of the head.

Color: pale olivaceous brown; head darker and uniform; back with narrow whitish bands one on either side and separated by a broad area in which is a double row of dark, irregular blotches which may be edged with lighter; sides passing gradually into the white of the lower aspects; a dark line from the posterior canthus of the eye to upper angle of ear opening and thence bordering the lateral light line laterally to the tail; upper and lower labials darker than adjacent parts; limbs marbled with dark brown; tail with obscure dark rings. (The above description refers to the female, the male being more highly colored.)

Measurements: Total length, 145 mm.; Length to anus, 71 mm.; Length of tail, 74 mm.; Snout to ear, 15 mm.; Width of head, 14 mm.; Fore leg, 27 mm.; Hind leg, 41 mm.; Base of fifth to end of fourth toe, 18 mm.

This species seems not to be uncommon in the Rio Grande valley near Socorro. Collected by John Terry and Harry N. Herrick.

Sceloporus Gratiosus, Baird and Girard.

Description : Head and body somewhat depressed; nostrils opening much nearer to the end of the snout than to the orbits; uppear head shields smooth, moderately large, and slightly convex, interparietal largest; frontal usually divided transversely; parietal, frontoparietal and frontal plates separated from the supra-occulars by a series of small plates of granules; superciliaries long, wide, and strongly imbricated; middle subocular very long, narow strongly keeled; rostral plate very wide and rather high; labials long, low, and almost rectangular; below lower labials series of large sublabial plates; symphyseal arge, pentagonal; gulars small, smooth, imbricate, frequently emarginate posteriorly, about the size of the ventrals; ear opening large, slightly oblique, with an anterior armature of from four to seven accuminate scales; dorsal scales equal, keeled, pointed, and arranged in longitudinal parallel rows; scales on sides similar to those of the back, but directed obliquely upward; no longitudinal dermal folds; superior surfaces of the limbs with keeled scales; posterior surfaces of thighs with small smooth scales; ventrals smooth but usually bicuspid; caudal scales very much larger than the dorsals, heeled and strongly pointed; femoral pores varying in number from twelve to twenty; eleven to seventeen dorsal scales equal in number to the shielded portion of the head; scales in the longitudinal row from parietal plate to a line connecting the posterior aspects of the thighs varying from 45 to 66; males with enlarged postanal plates.

Color: above, brown, olive or bluish or greenish gray; with one dorsal and two lateral series of closely set brown spots on each side, spots sometimes more or less confluent, forming longitudinal bands separated by narrower bands of the lighter ground color; tail usually with trace of darks rings; males with a blue spot, sometimes bordered with black, on each side of the belly; throat more or less washed with blue which has a tendency to form narrow oblique lines.

This species is closely related to S. consobrinus, but is smaller. It occurs in the mountains of California, Utah and

Nevada and will doubtless be encountered in the northwestern parts of New Mexico.

After careful comparison of descriptions by various authors we incline to believe that this but a smaller mountain-loving race of S. consobrinus. One of our specimens of the latter species is but 130 mm. but otherwise resembles the types.

Genus. PHRYNOSOMA.

The horned toads are among the most characteristic of lizards and form a rather compact American group which are not to be confused with any other. Their bizaire spiny, disc-like bodies and short horned heads which they know well how to use in the defensive and even in offensive struggles are eminently characteristic. The plates of the head and body are heterogeneous and tend to assume the spinous form while the existence of strong bony spines from the back of the head is a universal character. The tympanum is distinct and may or may not be covered with scales. There is a transverse gular fold and usually a series of peripheral spines along the lateral margins of the body. Femoral pores are present. The tail is short as are the legs. The digits have keeled lamellae below. Lateral teeth subcoincal or indistinctly tricuspid ; no pterygoid teeth. No abdominal ribs. A large sternal fontanelle. Other osteological characters may be gathered from the figures.

In our region (eastern New Mexico) we have been able to distinguish but three species though there is a considerable range of variation which may serve to invalidate some so-called species. These animals are essentially insectivorous and sluggish and rely upon their spinous armature for protection as well as upon their very considerable power of modifying the color of the skin to conform to the color of the station. This power is due to the capacity of the chromatophores to alter their form in obedience to nervous stimuli of varying kinds.

They protect themselves from the extremes of heat and cold by burying themselves in the earth. We have never been able to observe that they construct burrows but they sink into the sand in such a way as to completely cover the body and may be seen after a cold night imerging from the sauce-like depression so made.

Like many others we long regarded the statement that these animals sometimes discharge a qauntity of blood from their eyes when disturbed as a fable. Upon a single occasion however we have had an opportunity to verify this statement. So far as we could discover the animal was not injured and we have handled others much more roughly without such a result but in this case (P. cornutum) a large drop of a red fluid was thrown out from the eye and moistened its head as well as the hands of the intruder.

Although the most peaceful of animals, the horned toads defend themselves with energy. The writer once witnessed a contest between two large lizards (Crotophytus) and a very large specimen of P. douglassii. The toad threw himself into the most amusing posture of defense by kneeling down with the legs of one side while standing on tip toe with the opposite set and thus presenting the shield-like dorsal surface to the enemy. With a single opponent these tactics succeded well and the lizard received some shrewed thrusts with the powerful horns, but when there were two foes it was easy for one to take advantage of the weaker side and sieze the toad in the soft region under the neck where he hung with a grip not to be shaken off.

KEY TO THE GENUS PHRYNOSOMA.

The following key is largely a compilation from various sources and we suspect that there may be synonyms or at most geographical races among the species enumerated. It is hoped that the table such as it is may nevertheless be serviceable.

A. Nostrils opening on or near the lines connecting the supra-orbital ridges with the end of the snout (canthi rostrales).

a. Gular scales small, nearly equal in size; a series of enlarged scales below, but not larger than, the lower labials.

b. Head spines short (variable); occipitals shorter than the transverse diameter of the eye ball. *P. douglassii.*

bb. Head spines moderately large, occipitals as long as the transverse diameter of the eye; gular scales perfectly smooth, . . *P. orbiculare.*

aa. Several longitudinal series of enlarged pointed gular scales; a series of large spinose plates below the lower labials; head spines long.

b. Gular scales spinose.

c. Head shields convex and almost smooth. *P. blainvillii.*

cc. Head shields flat, with numerous ridges and granulations, ... *P. frontale.*

bb. Gular scales feebly keeled.

c. Occipital spines extend upward and outward. . . . *P. boucardii.*

AA. Nostrils opening in the line of the canthi rostrale or slightly above; several longitudinal series of enlarged gular scales; a series of very large bony shields below the lower labials.

a. Occipital spines directed obliquely upward, like the temporals; ventral scales smooth, . *P. coronatum.*

aa. Occipital spines vertical, erect; ventral scales keeled. . . . . . . *P. asio.*

AAA. Nostrils pierced within the canthi rostrale; gular scales small, equal or with one series of enlarged ones on either side.

a. Tail longer than the head.

b. Head bordered posteriorly by a series of contiguous large spines, of which four are occipital. *P. regale.*

bb. Two occipital spines larger than the other head spines, with an interval between their bases and those of the temporal.

c. Enlarged dorsal tubercles spinose, erect; tympanum naked, ... *P. cornutum.*

cc. Enlarged dorsal tubercles flat, or feebly raised; tympanum covered with scales; occipital spines as long as the horizontal diameter of the orbit; two or three series of peripheral spines; 18–20 femoral pores, . . . *P. platyrhynus.*

ccc. Enlarged dorsal tubercles flat or feebly raised; tympanum covered with scales; occipital spines shorter than the transverse diameter of the eye; peripheral spines a single series or nearly absent; 6–12 femoral pores; more than three sublabials enlarged,. . . . *P. platyrhynus.*

cccc. One series of peripheral spines; 7–10 femoral pores; only three sublabials enlarged. . . . . *P. goodei.*

bbb. Two occipital spines not longer than the longest temporals, ... *P. modestum.*

c. Tail not longer than head.

d. Occipital spines a little larger than the temporals. . . . *P. braconnieri.*

dd. Occipital spines much smaller than the temporals. . . . . *P. taurus.*

The following probable synonyms are indicated: P. planiceps is a variety of P. cornatum., P. brevirostris is P. douglassii., P. ornatissimum is P. douglassii., P. solaris is P. regale.

Sp. 1. *Phrynosoma Douglassii*, Bell.

Plate XVIII, Fig. 15.

This is the common species in she mountains and upland mesas in northern New Mexico.

Description: Nostril opening on the canthi rostrales; gular scales small, near equal in size; a series of enlarged sublabial scales which are not much larger than the infralabials and are separated by several rows of granules. Infralabials (in a large specimen) 16 on a side, increasing toward the angle of the mouth and there ending in a large spine; sublabials 9 on a side; supralabials not enlarged and passing laterally into small granular scales; head spines rather small, about equalling the transverse diameter of the orbit; four temporals, one occipital and one postorbital spine on a side; other head scales small and irregular, roughened with ridges and granulations; one or two gular folds; tympanum not covered with scales; back covered with sharp, keeled, tubercular spines, which are irregularly distributed; a single row of sharp spines along the sides; tail with a lateral and two dorsal rows of spines; scales on the breast, belly and proximal aspect of the tail smooth, but those on the terminal part of tail keeled; in a large specimen the latter bands, as well as the blotches of dark on the back often indistinct; lower surfaces pure white.

Measurements: Length of anus, 40 mm.; tail, 20 mm.; snout to eye, 10 mm.; width of head, 16 mm.; length of occipital spine, 3 mm.; fore leg, 25 mm.; hind leg, 35 mm.; base of fifth to end of fourth toe, 10 mm.

Sp. 2. *Phrynosoma Cornutum,* (Harlan) Gray.

Plate XIX, Fig. 16.

This seems to be the commoner form in the valley of the Rio Grande.

Description: Head as broad or broader than long; nostrils opening the canthi rostrales; tympanum naked; gules scales keeled, with a longitudinal series of enlarged pointed scales on either side of neck; gular folds several, irregular, a series of very large projecting sublabial scales; infralabials head spines large, the occipital being much larger than the three temporals and directed obliquely upward and outward; interoccipital and postorbital present.

Back with very large erect spinose tubercles, the longest of which form a series of three or four on either side the vertebral line; two lateral series of spines of which the upper are longest; pectoral and ventral scales more or less distinctly keeled; femoral pores twelve on a side not extending upon the preanal region; no enlarged postanal scales. The body is one and a half times as long as the tail. Scales of head pustulose or longitudinally striate, spines ribbed.

Dorsal surface of head isabelline brown, mottled with white with two black cross bands between the canthi rostrales, a band from the eye to the angle of mouth, another black band from eye to temporals, about the mouth and cheeks ochraceous brown; under parts of head mottled with black as also the lateral margins of body below; dorsal surface with 4 longitudinal rows of dark spots edged with lemon yellow, bright yellow patch on shoulder; narrow white median dorsal line; 66 rows of scales on belly; long series of femoral pores nearly meeting in front of anus; two groups of slender spines behind the tympanum.

There are four rows of black spots on the back; each spot bordered by strips of white and yellow; space between the spots ocheraceous; tail with six double rows of black spots; underneath white often mottled with numerous black splotches.

Measurements of large individuals.

Length to anus,	100 mm.	80 mm.	42–100 mm.
Length of tail,	31 "	30 "	17– 40 "
Snout to ear,	28 "	20 "	10– 21 "
Width of head,	30 "	24 "	12– 27 "
Length of occipital spine,	4 "	2 "	1– 2 "
Length of fore leg,	42.5 "	32 "	18– 35 "
Length of hind leg,	56 "	43 "	23– 45 "
Base of fifth to end of fourth toe,	14 "	12 "	7– 15 "

Coloration of specimen from San Pedro mountain at 7000 feet. Upper surface of head mottled with brown and white; six pairs of vandyke to umber brown blotches on neck and body, the two middle pairs double as by confluence of two, spots bordered behind by a dark band shading into brown, this still bounded posteriorly by a narrow band of brilliant orange; intervals between spots irregularly shaded with orange, yellow and brown; numerous white spots on the side; irregular gray bands on either side the median line; tail with seven dark bands, belly burnt sienna with numerous small dark spots, whitish on sides with brown bands and spots.

Sp. 3. *Phrynosoma Platyrhynus,* Girard.
Plate XX, Fig. 18.

This species is excessively abundant in the valley of the Rio Grande and elsewhere at lower levels in the eastern part of the territory. It is rarely seen of a large size and is greatly exposed to the attacks of its enemies though it possesses the power of changing color to a greater extent than the others.

Description: Nostrils opening above the canthi rostrales; gular scales small, granular; one gular fold; a series of large, spinose sublabial scales which increase posteriorly; infralabials not separated from sublabials (in small specimens at least) by a series of scales but the two series in juxtaposition; two groups of weak spines on either side of neck; head spines rather short, consisting of from five to seven temporals, one occipital and postorbital; three scales in front of the occipital larger than the remaining head scales which are roughened with granulations and ridges and, except those in front of the occipital and temporal spines nearly flat.

Back, tail and upper surfaces of the limbs covered with scattered, slightly elevated, keeled, tubercular scales; one series of peripheral scales which disappears behind or is obsolescent; tail edged with small spines; scales in front of arm large, pointed, strongly keeled; those on breast, abdomen and proximal part of tail smooth; tympanum covered with scales; femoral pores nine on a side, invading the preanal region; males with enlarged postanal plates.

General color above, gray, yellowish brown, etc., variously marbled with slaty, brown or blackish; a large dark area on either side of the neck often extending back to in front of hind legs, tail transversely banded.

Genus. UTA.

Head and body moderately depressed and shorter than the tail; tympanum distinct; no dorsal crest; dorsal scales small, keeled, either uniform or heterogeneous; head plates large, the interparietal being larger than the ear opening; one or more transverse gular folds, the anterior one with denticulated edge; labials not imbricated; superciliaries imbricated; femoral pores present; lateral teeth tricuspid; no pterygoid teeth; a large sternal fontanelle; no abdominal ribs; males with enlarged postanal plates. This is a genus confined to Mexico and the southwestern states of the Union.

KEY TO THE AMERICAN SPECIES.

I. Dorsal scales uniform, larger than those of the flanks.
  a. Dorsal scales not imbricate, smooth, a narrow black band from shoulder to shoulder above, . . . *U. mearnsi.*
  aa. Dorsals imbricate, keeled, no black band from shoulder to shoulder, a round blue spot behind the axilla, . . . *U. stanisburiana.*
II. A band of six or eight longitudinal series of equal enlarged scales along the middle of back.
  b. A lateral line of special scales, . *U. ornata.*
III. Dorsal scales heterogeneous.
  c. Slender, tail more than twice as long as head and body, enlarged dorsals sub-equal, *U. gratiosa.*
  cc. Stouter, tail less than twice as long as head and body, largest dorsals in four series, *U. symmetrica.*

Uta Ornata, Baird and Girard.

Uta ornata, *Bd.* and *Gd.*, Proc. Acad. Sci. Phila., 1852; U. S. Mex. Bound. Surv.; *Boulenger*, Cat. Liz. Brit. Mus.

"This species may be distinguished from U. stanisburiana, of which it has the general appearance, by a dorsal space covered with five or six rows of scales larger than those on the sides of the body. Along the middle of the sides there exists one row of small scutellae imitating the lateral lines of fishes. The ground color is reddish brown, with transversely elongated black patches all along the upper part of body and tail. The belly is unicolor in the female while it is blue in the male." The range is said to be from Texas to California. It has not been encountered by our collectors.

Uta Stanisburiana, Baird and Girard.

Plate XXI, Fig. 19.

Uta stanisburiana, *Bd.* and *Gd.* Proc. Acad. Nat. Sci., Phila., 1852; Stanisbury's Exp. Gt. Salt Lake, 1853; *Boulenger*, Cat. Lizards Brit. Mus.; *Van Denburgh*, Bul. Cal. Acad. Sci. V.

Uta elegans, *Yarrow*, Proc. U. S. Natl. Mus. 1882.

Description: Head and body depressed; head truncately pointed in front; head plates flat smooth; interparietal largest; frontal plate divided transversely, followed in a cephalic direction by an irregular series of enlarged plates; three to five supraoculars enlarged and separated from the frontals by small granules; superciliaries imbricate, few, projecting; central subocular large keeled; rostral and supralabials long and low; the other plates of the upper surface small or granular; symphyseal plate rather small, followed on either side by larger smooth plates which are separated from the infralabials by one to three series of sublabials; gular region covered with small, smooth, nonimbricating scales; gular fold with a series of projecting spines; tympanic opening with an armature of three enlarged spines; lateral dermal folds present; back with keeled scales hearly uniform in size but graduating into those of the side, on the neck and sides granular scales; scales of tail large, keeled and pointed; femoral pores from twelve to seventeen.

Color: Upper parts with a ground color of brownish or yellowish gray densely spotted with darker and lighter; a more or less distinct light band on either side of the back, most distinct anteriorly; the small spots of the upper surface tend to be blue or green and often give to the animal a prevailing tone of that color; tail often with dark rings; upper surfaces of limbs spotted like the back; toes of hind feet with dark bands; under parts light, variously marbled with dark; throat blue with light spots; an irregular blue spot behind the fore leg which is surrounded by a light band; usually a brown spot in front of the shoulder; sides marked with large light spots.

This graceful species is abundant in the Rio Grande valley at Socorro and further north. It is active and restricted to the ground.

Genus. Crotophytus.

Head and body depressed or sub-cylindrical, much shorter than the very slender tail; no dorsal crest; a gular fold; tympanum present; all the head plates small; labials not imbricate; dorsal scales small and nearly uniform; a long series of femoral pores; males with enlarged preanal plates; lateral teeth tricuspid; pterygoid teeth; no sternal ribs; no sternal fontanelle. These large and very active lizards occur in the southwest states and northern Mexico. They are predaceous and even cannibal in their habits. Two species are known to occur in New Mexico.

Crotophytus Wislizenii, Baird and Girard.

Crotophytus wislizenii, *Bd.* and *Gd.* Proc. Acad. Sci., Phila., 1852; Stanisbury's Exp. Salt Lake, 1853; *Baird*, Mex. Bound. Surv. 1859; *Boulenger*, Cat. Liz. Brit. Mus.; *Van Denburgh*, Bul. Cal. Acad. Sci. V.

Crotophytus gambelii, *Baird* and *Girard*, *l. cit.*

Description: Body slender and strong; head large, depressed and broad behind; head plates small, larger toward the snout; snout convex; three to five longitudinal rows of shields between the supraocular regions; nostrils nearer the end of head than the orbit; superciliaries small, imbricate; a long subocular plate; rostral plate very low; supralabials of nearly equal size; lower labials somewhat larger than the upper, bordered below by several series of small plates larger than the gulars; symphyseal plate large; tympanic opening large oblique; one strong gular fold with sometimes two additional ones; back and sides covered with small granules merging into the larger scales of the belly; latter imbricate and sometimes keeled; irregular lateral dermal folds; tail cylindrico-conical, more than twice as long as the head and body; males with enlarged postanal plates.

Color: Upper parts browish gray, the head darker, with creamy white lines surrounding the orbits and in the supraocular regions and the snout; back crossed with alternating light lines; between each pair of which a round spot of brown; the proximal part of tail like the back, the distal part ringed with dark; upper surface of limbs marbled or spotted. With age the spots on the back break up, the bands disappear or become more marked and the whole color fades. No two specimens are exactly alike. There is a change during the breeding season, especially in the females.

This species seems to occupy the entire territory at suitable stations but does not ascend into the mountain canons, where its place is taken by C. Collaris. So far from being sluggish, we have found it the most active and wary of our lizards. It will fight viciously and devours other species of lizards and upon occasion, young of its own species.

Crotophytus Collaris, Say.

Plate XXII, Fig. 20. Plate XXIII, Fig. 21.

Agama collaris, *Say*, Long's Exped. Rocky Mts., Harlan. Med. Phys. Res.

Crotophytus collaris, *Holbrook*, N. A. Herpetology; *Wiedman*, Nova Acta, 1865; *Baird*, Pacific R. R. Surv. Pl. XXIV; *Cope*, Proc. Acad. Phila., 1866; *Boulenger*, Cat. Liz. Brit. Mus.

Description: Head large, depressed, much swollen posteriorly, especially in the males; body fusiform; tail long and terete; legs very long and strong; plates of head all small, two or more series between the granules of the supraocular regions; nostrils large and opening laterally; superciliaries small and imbricate; supralabials of about equal size; a large subocular plate; ear opening large, oblique, without prominent armature; symphyseal plate large, followed by two short rows of somewhat enlarged plates; one or two well-developed gular folds; back and sides covered with small granules; ventral region with larger scales; femoral pores from sixteen to twenty-two.

Color: Upper surfaces olive or browish gray, quite variable and variously spotted and barred with lighter color; two intensely black transverse shoulder bands which do not meet above, the anterior one being interrupted by a V-shaped sepia band on the nape; under parts white, the throat and sides mottled with darker; tail near the end with dark rings. The form living in the mountain canons seems to be darker than that occuring on the upland mesas and the spots are larger and interrupted by transverse bars. The following description of a living specimen illustrates a common type of coloration:

Head above light brownish gray irregularly bloched with sepia; about seven blotches of orange red back of ear; band of coral red in scapular region; first pair of scapular bands of black separated above by a V-shaped band of sepia; back sepia gray with small yellowish white spots; upper aspects of legs greenish; upper surfaces of hand and fingers yellow three or four spots of coral red on sides; hind legs of lighter color than back with numerous spots of sepia brown; sides of thighs yellowish green; tail ringed with alternate bands of slate color and sepia; under parts white with pale brown spots on under surface of head.

This species is not found in the immediate valley of the Rio Grande, or, if at all, very rarely, but is a resident of the lower parts of the mountain canons and the mesas adjoining. In habits it is similar to the preceding species. It is a beautiful and sprightly animal. How the C. baileyi, Stejniger is to be distinguished from this common form we are unable to say at this writing.

Family. Anguidae.

Tongue composed of two distinct portions, a principal posterior part covered with villiform papillae, and a small anterior portion, which is thin, emarginate and retractile into the basal part. The body is protected by bony plates underlying the scales, the latter being imbricated and tuberculate. An occipital plate is present. The teeth are variable and bear some resemblance to those of the Gila monster. Skull with distinct nasals, single parietal. Abdominal ribs absent. Limbs sometimes rudimentary. This family is most abundantly represented in Central America and the West Indies but is represented by the slow worm of Europe and by a few closely allied species in North America.

Genus. Gerrhonotus.

Limbs well-developed, pentadactyl; lateral fold present; scales squarish or rhomboidal, forming transverse series; eye large with a round pupil; no femoral pores or enlarged postanal plates; ear opening distinct; no gular fold. A group of closely allied species of this genus occupies the entire western coast of North America, G. Cœruleus (G. scincicaudata) being the type.

Boulenger says this species extends as far east as Texas and also describes G. kingii from Deming in southern New Mexico. The latter is regarded by Dr. Gunther as a variety of G. cœruleus. The following description is taken from Van Denburgh in part.

Gerrhonotus Scincicaudata, Skilton.

Description: Body long and rather slender, with short limbs and very long tail; head pointed, with flattened top and nearly vertical side, temporal region often swollen in old specimens; rostral plate rounded in upper outline, preceded by a pair of small internasals, a pair of small frontonasals, very large azygous prefrontal, a pair of large prefrontals, a long frontal, a pair of frontoparietals, two parietals separated by an interparietal, a pair of occipitals, and (usually) a single interoccipital; two series (of 5 and 3) supraocculars and a series of small superciliaries. Upper labials much rarge than lower, below the latter two series of large sublabial plates, lower larger; gular scales smooth and imbricate; scales on the upper surfaces large rhomboidal, strongly keeled, arranged in longitudinal and transverse series; about 14 longitudinal series of dorsals and number of transverse series to back of thighs from forty-one to fifty-two. A band of granules under the lateral folds; ventral plates about the size of dorsals, imbricate, smooth, the grayish or brownish color of the back crossed by from nine to sixteen continuous irregular dark bands; lower parts white or yellowish with brownish or grayish suffusions.

G. knightii is said to differ in having only six or eight of the dorsal series of scales keeled. It will require further study to determine the value of this distinction.

(Family. ANNIELLIDAE.)

The student should be alert for the discovery of subterranean species of this family which, so far as now known, is confined to California. The body is cylindrical and snake-like and the external limbs are absent.

Family. Helodermatidae.

The Gila monsters are the only lizards with venom-secreting glands but they are fortunately so sluggish as to rarely strike even when disturbed. They may be recognized by their large size, tubercular skin and snake-like dentition.

Genus. Heloderma.

Characters of the family.

Heloderma Suspectum, Cope.

Description: Large, heavily set, clumsy in form, with short legs and tail; nostrils large, opening laterally between three plates; eye small; ear opening large oblique; rostral and symphyseal plates large; a pair of internasals; three pairs of plates behind the symphyseal; gular region with the small tubercles passing into the plates of the belly; upper parts covered with smooth convex tubercles, separated by granules, lateral tubercles passing into the squarish plates of the belly; a pair of enlarged preanal plates.

Color: Upper parts variously and irregularly marked with dark brown and salmon color; tail sometimes ringed; belly orange or salmon, with tessalted markings of brown.

The Gila monster probably occurs in this territory only in the southwestern portion.

Family. Teiidae.

New world lizards related to the true lizards of Europe (Lacertidae). Head shields free from the cranial ossifications; nasals double, frontal are parietal single; tongue slender and ending in two smooth points; head covered with large, regular plates; ear opening and eyelids usually present; femoral pores may be present. A very large family represented within our limits by a single genus.

Genus. Cnemidophorus.

Four pentadactyl limbs; head plates large; two frontoparietal plates; back and sides covered with small uniform granules; ventral plates large and serially arranged; eye lids and ear openings present, pupil round; two or more gular folds; femoral pores numerous.

Cnemidophorus Sexilieatus, Gray.

Plate XXIV, Figs. 23, 24.

Description: Slender, agile; head nearly flat above, with nearly vertical sides; snout slender; rostral plate large, high, triangular; nostrils opening within the large nasal plates which are partly enveleped by the rostral; posterior nasal nearly quadrangular, articulating with the anterior nasal, first, second, and third labials, loreal, frontal, and prefrontal plates; four enlarged supraoculars, the two in the middle largest, all of them separated from the superciliaries by a row of granules; superciliaries not imbricated, the anterior two large; supraoculars separated from parietals and frontoparietals by granules; occipitals in two or more irregular transverse bands; about five superior and six inferior labials to middle of eye; inferior labials larger than the upper; sublabials very large, connected with the symphyseal by a large azygous plate, separated from the lower labials by three or four large plates and a short series of granules in front of them; intermandibular region of throat with larger scales than the throat behind the ears to the first gular fold, behind the latter larger scales merging into those of the throat; ventral scales large, in eight longitudinal rows; upper surface with small equal granules; ear opening large, semicircular; external aspect of upper arm and cephalic aspect of fore arm with enlarged scutes; *ventral aspect of fore arm with a patch of enlarged scales below the elbow;* scales of ventral aspect of hind legs very large; *femoral pores from 16 to 18;* scales of tail strongly keeled; about three enlarged preanal scales.

Color: Above dark olive brown, passing into clear olive on the head and greenish olive on the tail; back marked with three narrow, distinct yellowish white lines on either side and sometimes a faint median stripe on the median line, the latter more distinct anteriorly; upper surfaces of limbs faintly marbled; sides of head and under parts immaculate.

Only a few specimens of this species, which is referred to

C. sexlineatus only doubtfully have been found among the numerous individuals of the next and nothing can be said of its range or habits. It is true that it seems to vary in the direction of C. undulatus but the forms seen are easily distinguished from that species.

Cnemidophorus Undulatus, Hallowell.

Plate XXIV, Fig. 22.

This is perhaps the commonest lizard in the Rio Grande valley and is everywhere in evidence. It differs from the preceding species in the absence of the patch of enlarged scales on the under aspect of the fore arm and in the colors. The back is marked by from seven to nine wavy dark bands which, in the older individuals, break up into irregular blotches to the almost entire suppression of the longitudinal arrangement; the sides of the head are distinctly marked with dark spots but the spots on the throat are small and scattering; head and tail olive. We have not seen typical specimens of C. tigris but they no doubt occur and will be recognized by the almost entire absence of the black markings on the sides of the head and a suffusion of gray on the throat. The color of the back is more minutely broken up.

Family. Scincidae.

Tongue slightly notched at the tip; head covered with large regular plate scales on body and tail of moderate size, imbricate, supported by bony plates; eyelids present; pupils round; dendition pleurodont; no femoral pores.

Genus. Eumeces.

All the scales are thin, smooth and imbricate. There is a distinct ear opening and the gular and lateral folds are absent, limbs pentadactyl; nostril penetrating the nasal plate; digits not denticulated laterally. The skinks are of world-wide distribution and three species at least have been reported from New Mexico but as we have but once encountered a representative and have no authentic material it seems best to reserve the mention of these till material shall have been collected. It is to be sought in moist places as under stones near springs and in deep woods.

DEFINITION OF TERMS.

Azygous.—Not paired.

Canthus rostralis.—The ridge from above the eyes to the extremity of the snout.

Femoral pores.—Gland openings along the lower surface of the thighs.

Frontal plates.—One or more plates on top of the head between the supra oculars.

Frontoparietals.—Plates on top of head between the parietals and the frontal.

Gular fold.—Fold of skin crossing the throat.

Gular scales.—The scales of throat.

Infralabials.—Scales of lower lip.

Internasals.—Plates of snout behind the rostral.

Interparietals.—The plate on top of head in which is the pineal or parietal eye.

Labials.—Scales of the edge of lip.

Occipitals.—Plates behind the parietals and interparietal.

Parietals.—Plates on either side of the interparietal.

Rostral.—Plate on end of snout.

Sublabials.—Plates below the lower labials.

Superciliary.—Plates on upper aspect of orbit of eye.

Supraocular.—Scales over the eye mesally of the superciliaries.

Symphyseal.—Scale at tip of lower jaw.

EXPLANATION OF FIGURES TO ARTICLE VI, VOL. XI.

Fig. 1. Holbrookia maculata.
Fig. 2. Holbrookia texana.
Fig. 3. Holbrookia texana, top of head.
Fig. 4. Holbrookia texana, side of head.
Fig. 5. Holbrookia texana, anal armature of male.
Fig. 6. Sceloporus poinsetii.
Fig. 7. Sceloporus poinsetii, ear armature.
Fig. 8. Sceloporus poinsetii, top of head.
Fig. 9. Sceloporus magister.
Fig. 10. Sceloporus magister, top of head.
Fig. 11. Sceloporus magister, ear armature.
Fig. 12. Sceloporus occidentalis.
Fig. 13. Sceloporus occidentalis, top of head.
Fig. 14. Sceloporus occidentalis, anal aamature of male.
Fig. 15. Phrynosoma douglassii.
Fig. 16. Phrynosoma cornutum.
Fig. 17. Phrynosoma. position of nasal opening.
Fig. 18. Phrynosoma platyrhynus
Fig. 19. Uta stanisburiana.
Fig. 20. Crotophytus collaris.
Fig. 21. Crotophytus collaris.
Fig. 22. Cnemidophorus sexilineatus, genital plates of male.
Fig. 23 Cnemidophorus sexilineatus.
Fig. 24. Cnemidophorus sexilineatus, ventral aspect of foiearm.

ERRATA.

The authors of the article on Lizards of New Mexico do not wish to be held responsible for the fact that the specific names in the titles are capitalized but confess to the comma seperating the specific name from the authority. In explanation of the latter, in spite of various usage and authority for the omission of the point, we preferred to obey the unambiguous dictates of rhetoric rather than the divided and arbitrary authority of zoologists.

On page 126, line 2, instead of Scelopus, read Sceloporus.

On page 145, line 3, instead of Sexilieatus, read sexilineatus.

On page 146, line 1, instead of sexlineatus, read sexilineatus.

Plate XVI, instead of MAJISTER read MAGISTER.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.

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BACTERIA IN CHEESE.*

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Within the last few years the literature on our subject has accumulated at a rapid rate so that a complete review of the work done and results attained would be out of place here; but a brief summary of the historical aspect together with a statement of the present status of the problem is of interest to most readers.

Up to the time of Pasteur's memorable studies in fermentation, the latter process was universally considered as a purely chemical phenomenon having no relation to organized life. His convincing results opened the way to many new fields of investigation, among which was the curing of cheese. The latter being considered a species of fermentation was naturally explained as due to organisms. Besides this Pasteur had proved that the lactic fermentation or souring of milk was due to bacteria. What could be more plausible than that the changes occurring in ripening cheese should be due to similar causes?

Cohn,[1] who fell under the influence of Pasteur's work, reopened the cheese problem at the point where the chemists had left it, by demonstrating bacteria in the rennet used in cheese-making, and concluded on this meager basis that the process was due to bacteria. But the first real work in our field, which has now become classical, was done by Duclaux, an assistant of Pasteur's and who was, beyond doubt profoundly

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*Thesis accepted for degree of Master of Science by the University of New Mexico, 1898. Presented at the meeting of the Scientific Association, March 11, 1899.

[1] Cohn, Ferdinand. Beitrage zur Biologie der Pflanzen, Bd. I, 3 Heft. p. 191.

influenced by Pasteur's great discoveries in the field of fermentation. Duclaux[1] in 1878, lent support to Cohn's conclusion in that he found that cheese made from sterilized milk failed to ripen. This certainly appeared as conclusive proof that the phenomenon in question was due to germs, although it is now certain that his results were due to quite different causes.

Soon other experimenters followed in this newly opened field, whose results quite uniformly lent support to the fermentation theory.

Swiss or Emmenthaler cheese was examined microscopically by Benecke[2] and was found to contain a certain bacillus especially abundant during the ripening stage, which he considered as the particular germ that ripened the cheese. About the same time methods for isolating germs and growing them in pure cultures were being discovered, and Duclaux,[3] making use of these, succeeded in isolating ten species of bacteria from cheese, seven of which he found to be aerobes, and three anaerobes. He designated these as Tyrothrix forms, because of their occurrence in chains or threads. All these germs were peptonizers, in that they liquefied gelatin and digested the casein of milk. A peptonizing ferment was also isolated from the products of their growth, which changed the casein of cheese into soluble peptones. Thus his theory appeared established on a secure foundation.

However the above work antedates the discovery of solid media such as gelatin and agar, and a doubt may be expressed as to the validity of this work. From our present knowledge of cheese bacteria, it appears quite remarkable that all these separate forms should have such similar characteristics, and that none of the non-peptonizers were discovered. True, his meth-

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[1] Duclaux, Fabrication, maturation et maladies du fromage de Cantal. Annales agromomiques 1878.

[2] Benecke and Schulze, Untersuchungen über den Emmenthaler Kase und über einige andere schweizerische Kasesorten. Landw. Jahrbucher XVI, pp. 317–400.

[3] Duclaux, Le Lait, etudes chemiques et microbiologiques. Paris 1887. (Deuxieme tiragu augmenta 1894.)

ods were not adapted to the isolation of the latter class but we now know that peptonizers are not abundant nor are the species numerous in most kinds of cheese. Hence it is quite possible that several, if not most of Duclaux' species, were duplicates of each other.

For nearly a score of years little progress was made. A more accurate knowledge of the chemical products of the curing process was obtained; also a better knowledge of the bacterial flora. From the latter point of view, Adametz'[1] work deserves especial mention, for he isolated nineteen species of bacteria from Emmenthaler cheese—six micrococci, five sarcina and eight bacilli. These different species were described, and their physiological activity noted. He found too, that soft cheese contained a greater numerical percentage of germs than hard varieties; that the number increased as the cheese ripened, reaching as high as 850,000 per gram of cheese. Where disinfectants were added to the cheese the germ content decreased and ripening proceeded more slowly or ceased entirely. This latter observation the writer has not been able to corroborate and remains quite inexplicable in the light of our present knowledge.

Of yet greater importance was the able work of Von Freudenreich,[2] who also investigated Emmenthaler. He isolated a number of species, and made quantitative determinations of the germ content. Earlier investigators had found numerous peptonizing bacteria, with relatively few non-preptonizing forms. Von Freudenreich found on the contrary, that the former class was relatively small in numbers and belonged to the classes of Hay and Potato bacilli; the latter class predominated and frequently constituted the only bacteria present. These he found to belong to the class of lactic-acid-producing germs. Thus it appeared that if cheese was ripened by bacteria, the former theory was no longer tenable; that casein digesters took

[1] Adamatz Bakteriologisch Untersuchung über den Reifungs prozess der Kase. Laudw. Sahrbucher XVII, 1897, pp. 227–269.

[2] Von Freudenreich, Weitere bakteriologische Untersuchungen über den Reifungs prozess des Emmenthaler Kases. Land. Jahrbucher des Schweiz. VIII, 1894, pp. 207–239.

no part in the curing process, but that this function must be ascribed to the non-peptonizing lactic-acid—producing germs.

To this, however, he was loathe to subscribe, for how could the acid-producing germs which did not affect the casein in milk cultures, except to precipitate it, produce such profound changes in the cheese? New media and methods were tried to develop bacteria which had perhaps been overlooked or lost entirely. In these attempts one or two anaerobes were found, but no important phenomena could be connected with them.[1]

Besides the above a number of other investigators had contributed data to our problem, but none which advanced materially toward an explanation of the ripening process. Pammel[2] had discovered an aromatic bacillus in cheese, while Russell[3] had isolated gas germs which caused "huffing" or swelling of cheese. Lloyd[4] of England claimed to find B. acidi lactici in English cheddar.

This was essentially the situation when the writer, then a student under Dr. H. L. Russell of the Wisconsin University and Experiment Station, first took up the problem. Some of the observations had been made by means of a microscopical examination of cheese; others had been carried out before the time of solid media; the most recent labors had been accomplished without uniform or established methods and while tending to overthrow proposed theories afforded no solution to the question.[5]

Our first attempt was to find a suitable method for isolating the bacteria and at the same time to obtain reliable quanti-

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[1] Von Freudenrich, Forschung auf den Gebiete des Kasereifungsprozesses. Cent. fur Bakt. II Abt. I 1895, No. 17, 19.

[2] Pammel, An Aromatic Bacillus of Cheese. Bul. No. 21, Iowa Exp. Station. Ripening of Cheese. Ibid.

[3] Russell, Gas-producing bacteria and the relation of the same to cheese. 12th An. Reports Wis. Exp. Station 1896, p. 139.

[4] Lloyd, Observations on Cheddar Cheese-making. Bath and W. Eng. Soc. Reports for 1891, 2 and 3.

[5] Russell and Weinzirl, Cent. f. Bakt. II Abt. Bd. 3, pp. 456-467, 1897.

tative data. This was no easy task, for the cheese had to be brought into solution or finely divided so as to thoroughly separate the germs. The latter course was the only one which seemed feasible. The cheese could not be satisfactorily triturated in water, so sterilized sand and finally sterilized sugar was tried. Although not entirely satisfactory, the sugar readily dissolved in the water in which the dilutions were made. A gram of cheese was taken as the unit of weight, and all vessels and instruments used were thoroughly sterilized. The glassware and media were sterilized by heat; the cheese-trier, mortar, etc., by flaming; and the sugar by the addition of ether for one or more days. Heat was not used for the latter purpose for it tended to caramelize the sugar or even melt it when the temperature rose above 140° C. The ether gave very satisfactory results and could be easily applied.

Some time was spent in preliminary experiments and testing of methods after which a cheddar cheese (Flat) was made in the University Dairy School and analyzed bacteriologically at suitable intervals. For this purpose ordinary neutral peptone gelatin was used, although other modifications of gelatin and agar were employed as checks upon the work. No material advantages were gained by the latter, however.

Petri dishes were used in these analyses and three plates, using appropriate dilutions as suggested by experience and the age and condition of the cheese, were regularly made. These were allowed to develop from five to ten days and the colonies counted and pure cultures made. New cheese were made and similarly treated. A great amount of time was absorbed in these laborious countings, computations, and making of cultures, the results of which, for the sake of simplicity are tabulated. See page 154.

It will be seen from an inspection of the table, that the germ content of our cheese was very much higher than any figures reported by previous investigators, reaching at times scores of millions. Whether these results are due to improved methods of analysis or to differences in the kind of cheese, we

TABLE I.

No. of Bacteria per gram in Cheddar Cheese at different stages of the Ripening Process.

	Age of cheese	Total no. bacteria pr. gr.	Lactic acid bacteria pr. gr......	Gas producing bacteria pr. gr.....	Casein digesting bacteria pr. gr....	Inert bacteria pr. gr.....	Percentage of lactic acid bacteria in sample....
Cheese I	10 c c milk	53,180,000	40,068,000	6,070,000	6,330,000	100,000	76.5
made 18, VI.	5th day	Analytical	results lost	owing to	liquefac-	tion of	gelatin
1895. Rip-	13th day	68,015,000	67,470,000	400,000	145,000	------	99.2
ened at 18° C.	24th day	69,485,000	69,270,000	210,000	5,000	------	99.3
	36th day	16,996,000	16,996,000	34,000	2,000	------	99.7
	52d day	11,500,000	11,470,000	25,000	----------	------	99.7
	74th day	6,700,000	6,652,000	9,000	----------	------	99.8
	94th day	4,183,000	4,158,000	25,000	----------	------	99.4
	120th day	2,352,000	2,352,000	--------	----------	------	100.
	155th day	207,000	207,000	--------	----------	------	100.
	183d day	380,000	380,000	--------	----------	------	100.
	197th day	377,000	377,000	--------	----------	------	100.
	237th day	86,000	86,000	--------	----------	------	100
Cheese II	10 c c milk	95,000,000	82,600,000	6,030,000	6,180,000	190,000	84.8
made 10. VII 1895 ripened	1st day	7,644,000	6,103,000	959,000	581,000	------	79.
20° C.	5th day	95,640,000	94,300,000	1,243,000	----------	------	98.6
Cheese III	10 c c milk	262,000,000	52,400,000	78,600,000	131,000,000	------	20.
made 24, IX	4th day	115,400,000	115,130,000	271,000	----------	------	99.8
1895, ripened	10th day	64,350,000	64,286,000	64,000	----------	------	99.9
at 20°—24°C.	18th day	43,264,000	43,259,000	5,000	----------	------	99.9
	30th day	36,887,000	36,882,000	5,000	----------	------	99.9
	53d day	5,304,000	5,299,000	5,000	----------	------	99.9
	86th day	15,223,000	15,210,000	--------	----------	------	99.9
	108th day	7,084,000	7,080,000	--------	----------	------	------
Cheese IV	4th day	110,146,000	110,136,000	10,000	----------	------	99.9
Pasteurized	10th day	53,976,000	53,976,000	trace	----------	------	100.
milk with lac-	18th day	38,842,000	38,842,000	--------	----------	------	100.
tic acid made	30th day	23,400,000	23,400,000	--------	----------	------	100.
24, IX, 1895	53d day	1,075,000	1,072,000	3,000	----------	------	99.7
ripened at 20°	86th day	21,000	21,000	--------	----------	------	100.
—24°c.	108th day	5,000	5,000	--------	----------	------	100.
Cheese V.	10 c c milk	665,220,000	664,600,000	--------	----------	620,000	99.9
Normal	Curd	158,320,000	156,000,000	--------	2,320,000	------	99.8
milk and sour	2d day	82,414,000	82,134,000	--------	280,000	------	99.6
milk starter	4th "	95,200,000	94,770,000	--------	430,000	------	99.7
made 14 XII	7th "	102,750,000	102,750,000	--------	trace	------	100.
1895, ripened	10th "	84,617,000	84,617,000	--------	trace	------	100.
20°—23° C.	13th "	24,024,000	24,024,000	--------	----------	------	100.
Cheese VI	10 c c milk	2 7,800,000	211,680,000	1,180,000	14,800,000	200,000	92.8
Normal	Curd	26,532,000	22,560,000	180,000	3,792,000	------	85.
milk made 26	1st day	21,060,000	20,176,000	52,000	832,000	------	95.9
II, 1896 ri-	5th day	43,716,000	39,680,000	36,000	4,000,000	------	90.8
pened at 18°	7th day	46,440,000	45,760,000	80,000	600,000	------	98.5
C.	10th day	98,080,000	97,280,000	160,000	640,000	------	99.1
	13th day	97,240,000	96,800,000	176,000	264,000	------	99.5
	15th day	76,400,000	76,000,000	200,000	200,000	------	93.4
	19th day	48,139,000	48,000,000	77,000	62,000	------	99.6
	22d day	16,000,000	15,633,000	349,000	----------	18,000	97.7
	36th day	11,171,000	11,000,000	158,000	13,000	------	98.3

are unable to say. It is to be noted, however, that the Swiss Emmenthaler and the American Cheddar both belong to the same general class of firm cheese. That the numbers should be high in our analysis of milk and cheese in its early ripening stages is not so surprising, when we consider that all the mechanical steps in the manufacture of cheese are such as to offer the most favorable conditions for development of bacteria. The milk is ripened at nearly blood heat and the curd is also developed at a comparatively high temperature.

The most striking fact of our analyses is the overwhelming preponderance of the class of germs we have designated as the lactic acid bacteria, while the casein digesters are relatively few in numbers, and soon disappear from the cheese entirely. This practically confirms the conditions found by Von Freudenreich in Swiss cheese. The preponderance of acid-producing germs is readily explained, in that the art of cheese-making consists largely in producing those conditions which favor the development of these very germs to the exclusion of others. It is the cheese-maker's constant care to produce sufficient acid to make the curd "string on the hot iron," and it is these germs which change the sugar of the milk into the highly desirable lactic acid. Naturally, the question will be asked, what is the use of this acid?

At first thought, it would seem that the curing of the cheese is causally related to this acid or to the acid germs. Von Freudenreich,[1] in a recent article so concludes. By adding chalk to sterilized milk, which was inoculated with a pure culture of a lactic germ, the acidity of the milk was neutralized and the germ could endure for a much longer time than in cultures without the addition of this material. It was found that under these conditions, which he assumes to be parallel with those found in cheese, a certain amount of breaking down of the casein took place, but less than occurs in the cheese normally. This evidence, though strong, is not conclusive, for

[1] Cent. f. Bakt. 2nd. Abt. Bd. III, p. 234.

why should there be this difference between his culture and normal cheese? And when we seek an explanation of the curing process, the case is not at all clear. The ripening consisted in the conversion of the insoluble casein into soluble peptones or allied products. That the acid is not produced by the activity of the germ upon the casein, can scarcely be questioned. Its only source is in the milk sugar. Is the acid produced, then, to react upon the casein and break it down? No such action is known to chemists, but what are the facts? To test this question a special experiment was devised. Lactic acid was added to curd made from pasteurized milk, and the same was made into cheese. No evidence could be obtained that the acid produced the change in question. Can there be a difference in action between commercial lactic acid and that produced in the cheese, especially in the nascent state?

The problem was then attacked in another way. If the acid production in the cheese could be inhibited, would the process of curing also be inhibited? To test this ether, chloroform, etc., were added to newly made cheese and the same were kept in an atmosphere saturated with these anæsthetics. These cheese cured, apparently, quite normally. Bacteriological analyses revealed bacteria, but in greatly reduced numbers—too small to account for the curing. That bacteria were present is readily explained, for they were not killed by the anæsthetics but their vital activities were inhibited. But the breaking down of the casein and curing of the cheese still remains to be explained. If the bacteria are inhibited in their vital activities, then no acid can have been produced to affect the casein. But the casein underwent its characteristic change. Plainly there is an unknown factor which is the cause of this phenomenon. That factor is not related to bacterial life.

It was at this stage of the problem that Drs. Babcock and Russel[1] sought to apply chemical tests to determine the unknown factor. It is here that their brilliant work in isolat-

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[1] Babcock and Russell, Unorganized ferments of milk: a new factor in the ripening of cheese. 14th Rept. Wis. Agrl. Stat. 1897, p. 161.

ing an unknown ferment from milk, was accomplished. They demonstrated conclusively that this unorganized ferment is not produced by bacterial activity, but is inherent in the milk itself. This ferment was found to have the power of changing casein into soluble peptones under asceptic conditions. It was further found that heat destroyed this ferment and this explained the fact why Duclaux was unable to ripen cheese made from sterilized milk, which experiment we had repeated and found to be correct. From their experiments they incline to the belief "that the ripening of hard cheese, instead of being due solely to bacteria, is caused by the joint action of both organized (bacteria) and unorganized ferments (enzymes). The breaking down of the casein is undoubtedly due, in larger part, to the action of enzymes." Thus, after half a century the pendulum has swung back to the side of the chemists. However, the new theory agrees with that of Ducleaux, in so far that both are based upon the action of enzymes; the difference being as to their origin. The former considered them bacterial, the latter finds them to be inherent in the milk.

However, to explain the cause of the curing phenomenon, is not the only nor even the essential part of this paper. There still remains to be explained the fact of the enormous numbers of these lactic germs and the relatively few germs of the other types. That the inert forms should be few or absent is what might have been expected. Undoubtedly they gained entrance from the air; but falling in a medium not especially adapted to them, they were crowded out or, so to speak, smothered, by the growth of the acid forms. The absence of the casein digesters is readily explained by the fact that they are inhibited by the activity of the lactic acid organisms. If the latter class is destroyed as in pasteurization, the digesters, having a free field, develop in abundance.

As to the gas germs, it is a fact that these are, as a rule, also moderate producers of acid. That they are correspondingly more numerous and stand next in number to the purely acid forms, is readily understood. But these same gas germs are the bane of the cheese-maker, and how he is able to keep them down in his product is still a question. That he frequently fails to prevent their development, much of our product bears a sad testimony. That the gas produciug germs are largely associated with filth and general uncleanliness in the dairy, is quite well established. This enables us to apply a ready and all desirable remedy, namely, to remove all traces of filth in all stages of the work. "The Wisconsin curd test"[1] gives still other means of combatting this evil, for by it the sources of the infection can be readily traced.

Apparently the casein digesters may be at times quite harmless, but many of them induce fermentations resulting in bitter by-products which are very undesirable and undoubtedly prevent the product from reaching the highest grade, if indeed, it is not ruined by them. A more detailed study of the various germs of this class is necessary before we can ascribe to them their due importance in the manufacture of cheese.

However, we have still to explain the presence of the acid germs in such enormous numbers. It is quite certain that they are not concerned, at least to any great extent, in the changing of the indigestible casein into the digestible products. Their function as acid producers is no doubt important in communicating to the ripened product that peculiar flavor, so indescribable but so highly desirable, and which lends to cheddar cheese its own peculiar qualities. If this is true, these germs should be found in all cheddar cheese, no matter in what section of the country it is made. So far our investigations were largely limited to cheese made at the Wisconsin Dairy School. We now directed our study to the state at large and finally to other states, to determine the presence of these germs and at the same time to make as detailed a study of the cheese flora as possible. The results of these investigations so far as they related to cheddar cheese are tabulated below:

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[1] Babcock, Russell and Decker,—Factory tests for milk. Bul. 67, Wis. Agrl. Exp. Station.

TABLE II.

Showing the relative percentages of the different classes of germs in cheese from different states.

No of cheese	Where made	No. of species	Lactic acid Bacteria %	Gas producing Bacteria %	Casein digesting Bacteria %	Neutral Bacteria %	Remarks.
1	Patch Grove, Wis.	4	Predominated	Present	Present	?	Plates partly liquified. Computations not made Age of cheese 6 days
2	" " "	2	58	42	------	------	Age of cheese 22 days
3	" " "	3	80	3	17	------	Age 18 days
4	" " "	2	75	25	------	------	Made from gassy milk. Age 32 days
5	?	3	50	48	------	2	Cheese "off flavor"
6	Avoca, Wis.	3	37	54	9	------	"Off flavor"
7	Hortonville, Wis.	3	18	82	trace	------	3 mos. in cold storage. Fine cheese
8	Plymouth, Wis.	3	53	47	"	------	Gassy cheese
9	Manitowac, Wis.	4	present	pr's'nt	trace	pr's'nt	Computations not made
10	Plymouth. Wis.	4	27	70	trace	3	Gassy and "off flavor"
11	Plain, Wis.	4	66	33	trace	1	"Off flavor"
12	Trim Belle, Wis.	4	98	------ 1	trace	1	Age 51 days. Fine cheese
13	Cayenovia, Wis.	3	83	13	4	------	Pinholey and bad odor
14	" "	3	95	4	1	------	
15	Wisconsin.	1	100	------	------	------	Age 15mos. 4,030 germs per gram. Lowest no. found
16	Binghamton, Wis.	3	not numerous	many	trace	------	Computation not possible
17	Verfkind, Wis.	3	present	pr's'nt	pr's'nt	------	Plates partly melted. No count
18	Boving, Wis.	1	"				Plates melted. Yeast also present
19	Wisconsin.	4	90	10	trace	------	Age 8 days
20	Hortonville, Wis.	4	57	38	1	4	
21	Wisconsin.	3	23	75	2	------	Age 12 days. Quality not noted
22	" "	2	48	51	------	------	Age 2 wks. Yeasts=1% Quality not noted
23	Tonet, Wis.	3	82	17	------	1	Very fine cheese
24	Peebles, Wis.	3	72	27	1	------	Slightly "off flavor"
25	Ahnapee, Wis.	3	57	42	1	------	Age 22 days
26	Rio Creek, Wis.	3	70	30	------	------	Age 22 days
27	Illinois.	3	82	18	------	------	
28	Ontario, Can.	2	29	17	------	------	Yeast=54%. Yeast assimilated properties of acid germs
29	Minnesota.	5	85.7	10.5	3.5	0.3	
30	New York State.	3	99	0.5	0.5	------	
31	Michigan.	2	39	61	------	------	Poor flavor
32	" "	4	40	59	1	------	Fine cheese
33	Dakota.	4	63	22	5	11	Fine cheese. 2 mos. old
34	Pennsylvania.	3	95	5	trace	------	
35	Meadville, Pa.	3	98	1	------	1	
36	Colorado.	3	100	trace	------	trace	

Before proceeding to a consideration of our data, it should be stated, that the samples were obtained by the use of a cheese borer or trier, the core of cheese placed in a sterile glass test-tube, and this was sent to the Laboratory in a wooden case, usually by mail. Through the kindness of Mr. J. W. Deeker of the Wisconsin Dairy School, most of the samples were so obtained, together with many important data. In all cases, one or more days intervened between the time of sampling and that of analyzing the sample. Although the exterior of the plug was carefully removed by means of a sterile knife, and only the center used, yet it is possible that the normal distribution of the cheese bacteria may have been altered in some degree by the removal of the sample from its natural conditions and the consequent drying. Samples 33-36, however, were obtained directly from fair sized portions of the cheese. It would perhaps have been fortunate, if more of the samples had been so taken, so as to admit of a comparison.

Usually three peptone gelatin Petri plates were made, using three dilutions of the cheese. The first contained, approximately, ½ gr. of cheese added to the tubes of gelatin and finely triturated by means of a sterile glass rod ; the second contained from 3 to 5 drops taken from the first; and the third 3 to 5 loopfuls taken from the second. In this way a wide difference in seeding was obtained, and one of the three plates usually presented favorable conditions for counting regardless of the age of the cheese. In old cheese, colonies were usually limited to plate No. 1. New cheese gave the most favorable results on plate No. 3, etc. A special advantage in this method lay in the fact that moderately scarce germs, which would have been missed in Nos. 2 and 3 were brought out in No. 1. This was particularly the case with the liquefiers or digesters, of which there was usually a trace on plate No. 1, but none on the other two plates.

Table II comprises 36 analyses of cheese, 26 of which were Wisconsin product and 10 from other states—a total of nine states being represented, which included a wide range of territory, extending from New York and Pennsylvania on the east to Colorado on the west and Canada on the north. Within this area is included the cheese belt of our country, and although the analyses are not as numerous as could be desired, they are sufficiently so, to show at least, the main characteristics of the cheese flora. In this work 13 species of bacteria were isolated and grown in pure cultures. These do not include single colonies found on the plates, which we are inclined to believe should not be considered as forming a part of the true cheese flora, but rather as accidental, possibly gaining admmission in the manipulation of the analysis. At any rate no special importance could be attached to such rare colonies, granting that the germs may have existed in the cheese. It is conceivable that all the bacteria of the air and even of water, might be found in cheese, but we do not consider these an integral part of the cheese flora proper.

Of these species, of which the limits of this paper will not permit a description, the lactic acid producing germs are found to be present in all the analyses, and furthermore are the most numerous class in three-fouths of the cheese. The germs producing gas were present in all samples with one exception, (No. 15) and were most numerous in approximately one-fourth of the cheese. In three of these cases (Nos. 6, 10 and 31) the preponderance of gas germs was associated with "off flavors" in the cheese; in two cases, (Nos. 21 and 22) no note had been taken, while in two, (Nos. 7 and 32) the cheese were apparently fine, one of which (No. 7) had been kept for a number of months in cold storage which may have exerted a repressing influence on the multiplication of the lactic organisms.

The bacteria affecting the casein of milk were entirely absent in one-third of the samples, while the germs of a neutral action were present in one-third of the cases. These facts are quite in harmony with our former observations, and while not as striking in many respects, yet remembering the wide area of our field and the varied character and quality of our product, the figures are, on a whole, as uniform as could have been expected. The presence in relatively small numbers or entire absence of the digesting and neutral classes, confirms our conclusion that these play no important function in the cheese and are present in it only because they were present in the milk, perhaps by accident or carelessness in handling the product, but never really flourish in the cheese medium.

The well-nigh universal distribution of the gas germs is striking and important. That these bacteria are a serious detriment, the cheese-maker and numerous experiments bear convincing testimony. Although the above data were not obtained with any special reference to this subject, yet in most cases we find bad flavors associated with a high content of gas organisms. Their universal presence is explained, perhaps, in that most of these species are also acid producers, hence they find a favorable medium in the cheese. From an economical aspect, to overcome these germs is a very important problem on which considerable labor has been spent. The use of pure cultures of lactic organisms, in one form or another, has been recommended and if practiced in accordance with bacteriological methods, would undoubtedly be of considerable help; but preventative measures should also be adopted. Pure cultures cannot overcome the effects of slovenliness in any of the departments of the dairy. Fortunately, the Wisconsin curd test furnishes an important aid in determining any abnormal and extreme abundance of these germs and thus the blame for much of our inferior product may be located.

To recur to the lactic acid type of organisms, there can scarcely be any question that they are directly beneficial, although playing no important rôle in changing the casein into soluble products. Their general distribution and preponderance in the cheese both indicate their usefulness. Further, as we have already stated, the cheese-maker's art is an empirical attempt to produce these very germs, at least such is the case with cheddar cheese. It would be interesting to know whether they are also present in other kinds of cheese. Some analysis that we have made would seem to indicate that they are essential to many other varieties, but our data are not sufficient to warrant such conclusions. A more detailed study of the cheese flora is in progress the results of which may be expected in due time.

What then is the rôle of these acid germs? As has been suggested, they probably furnish much of the flavor, peculiar to our best cheese. The acid may give to the cheese that sharpness or "twang," so highly prized by cheese connoisseurs. Possibly, also those more delicate flavors and aromas are due to particular species of this class. However, too little is as yet known concerning this subject, to warrant any positive assertions. A careful and accurate study of the cheese flora accompanied by tests of the various germs in cheese making may lead to discoveries which when put into practice will redeem much of the inferior product now found in the market.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.

Vol. XI. Article VIII. With Two Maps—Plates XXV-XXVI. March, 1899.

MODIFICATION IN THE JONATHAN CREEK DRAINAGE BASIN.[1]

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My attention was first called, by a map study of the restored pre-glacial drainage of the state, to the possible existence of a preglacial drainage line extending from Zanesville, in Muskingum county, southwest along the line of Jonathan creek in the direction of the Licking reservoir. An extensive examination was made of this region during the fall of 1897, in company with Prof. W. G. Tight, of Denison University, the valley of Jonathan creek was carefully traced throughout the entire course.

The areas drained by this stream and its tributaries, as shown by the map (Plate XXV), include Newton, Harrison and Hopewell townships of Muskingum county, Clayton, Madison, Hopewell and Thorn townships of Perry county and Bowling Green township of Licking county.

The heavy broken lines represent the county limits, the small continuous lines those of the townships. Black wavy lines mark the course of the present drainage system of Jonathan creek and its tributaries. A portion of the north branch of Rush creek is shown near the bottom of the map. At the extreme upper right hand corner a section of the Muskingum river is represented, showing the entrance of the Licking river at Zanesville and that of the Moxahala river some miles below. Heavy broken lines outline the preglacial valley walls. A part of the Licking reservoir is shown to the left.

Jonathan creek rises on a broad, level, drift, plain near the eastern extremity of the Licking reservoir. At Thornport, which is situated upon the drift deposit, gas borings show a depth of drift of over 200 feet.

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[1] Accepted as a thesis in Geology in Denison University.

Rising as a small stream, winding its course over a broad alluvial deposit, Jonathan creek flows in a southeasternly direction past Glenford in Hopewell township of Perry county, through Madison township, into Newton township of Muskingum county. Eight miles below Zanesville it unites with its south branch to form the Moxahala river. The river formed at this point flows north for a distance of about 3 miles when it turns to the right through a rock gorge and empties into the Muskingum river.

The valley at Thornport is quite broad and filled up with silted material. Here the valley is 2 miles wide, and is bounded by gentle sloping hills rising to the height of 150 feet to 200 feet above the alluvial flood plain.

A view from the north side of the valley just to the east of Thornport, looking toward the west, shows the broad drift plain on which the Licking reservoir is situated extending many miles to the west. A view to the east from the same point shows the valley extending eastward and occupied by Jonathan creek. A broad valley, deeply filled with drift, its surface strewn with cat-swamps and bounded by sloping rock-walls so characteristic of the old preglacial valleys of the state.

Proceeding eastward the valley gradually narrows. The rock-walls preserve their sloping character and the creek continues to flow in a shallow trough cut through the silted deposit. At Glenford the valley has become quite narrow and 1 mile east of that place the valley is only ½ mile wide. Here is found the last of the glacial till within the valley. Just south of the town a hill with rock nucleus and capped with glacial till rises to the height of 110 feet above the flood plain of the creek. This accumulation extends off toward the northeast forming what at first sight seems to be another distinct glacial deposit, but which in reality proves to be a continuation of the same deposit, cut through and worn down by the small but erosive stream.

Numerous drift deposits occur at various levels along the valley from Thornport to Glenford, but to the east of Glenford none were observed in the immediate valley above the terrace plain of the creek. A view from the summit of this glacial hill at Glenford, looking to the east, shows the valley still occupied by the creek, which continues to flow in a shallow course through an almost level alluvial flood plain. The valley is much narrower however than at Thornport and the walls have become quite steep.

East of Glenford a tributary from the north enters Jonathan creek. This stream has its source in Hopewell township, of Licking county, in the vicinity of Flint ridge. It is a small stream flowing in a deep, narrow valley, a form characteristic of the many tributaries.

One mile below Glenford and between the junction of this tributary and the town an outcrop of rock projects out from the north side of the valley wall. Immediately to the east of this rock promontory and on the same side of the valley, a deposit of drift material reaches an elevation of sixty feet above drainage. This deposit is composed of stratified layers of fine clays, silts, sands, gravel, flint and moranic material.

The valley of Jonathan creek filled to this level with glacial waters, washing with tremendous force against the side of the projecting rocks caused an eddy to be formed in the stream of glacial waters just below the projecting rocks. In the still waters thus produced the clays, sands and glacial gravels, carried along by the icy torrents, were deposited. The tributary from Flint ridge, flowing into this ponded water periodically deposited its load of material consisting of flinty gravels, thus aiding in building up the accumulation of heterogenious material. The interstratification of the local and glacial material is well marked. The finer quality of sand from this deposit is used by the railroad company in their locomotive sand-domes. An excavation has been made into the deposit for the laying of a track exposing a fine section.

On the north, at this point, the valley wall rises to an elevation of 200 feet. Looking eastward and southward from this elevation the view extends for many miles over an apparently broad, level cretaceous peneplain ; in reality much disected by drainage channels.

Four miles to the east another tributary enters the valley from the south. Rising near Somerset in Perry county and flowing northward through Hopewell township of the same county. To the east of this southern tributary several more smaller streams flow into Jonathan creek from the north.

Near the county line between Muskingum and Perry county a very much larger tributary enters the valley from the south. This stream rises in Clayton township of Perry county, flowing northward through a part of Madison township of the same county, and enters Jonathan creek a mile and a half west of the Muskingum and Perry county line. Its valley is similar to and continuous with the valley of Jonathan creek, while just to the east the valley of Jonathan creek is very much smaller and narrower. From Thornport east Jonathan creek flows in an old valley filled up to a great depth with silt.

From a width of 2 miles at Thornport the valley gradually narrows toward the east. At Glenford the valley is about one half mile in width. The valley continues to narrow from this point on to the east and near the Muskingum and Perry county line, the valley is not over 500 feet in width. Passing east from Thornport the valley walls loose their gently sloping character and assume a more rugged and precipitous form. At Mt. Perry the valley is 300 yards wide. A short distance from this place, and almost at the county line the valley walls are 150 yards apart at flood plain. Soon the valley comes to have the appearance of a veritable gorge. The gorge extends for 3 miles with a width varying from 150 to 500 feet, bounded by rock walls, which rise to the height of 200 feet above the flood plain of the creek, as is shown on the map of the col. (Plate XXVI.)

The light continuous lines on Plate XXVI represent 50 foot contour lines measured from the flood plain. The heavy black wavy line shows the present course of Jonathan creek through the gorge; the broken line indicating its abandoned course. The Columbus, Shawnee and Hocking railroad is mapped in as a continuous line with numerous intersecting short lines. Points heavily shaded mark places where rock cuts have been made to allow for the railroad and creek beds.

In the three miles represented on the map there are seven rock cuts. Five for the railroad and two for the creek. The course of the creek through the gorge has been so changed by the railroad company that at present it runs in a much different course from that which it formerly occupied. The abandoned portions of the old channel still remain and are partially filled with water, supplied by surface waters and springs.

At the point A, at the beginning of the gorge the railroad makes a narrow cut through the rock and then parallels the creek for a short distance. At B, the rock wall projects out from the south side of the gorge and through this the railroad makes another rock cut. A new course for the creek has also been made through the rock at this point. The abandoned portion of the channel at B, has a width of 300 feet with a rock wall rising quite precipitously to an elevation of 200 feet on the north side. On the opposite side of the gorge at this point the ascent is more gradual but to an equal height. At C a cut similar to that for the railroad at B is made through the rock, projecting from the north side of the gorge. But this rock projection the creek flows in its natural course, but is soon forced to leave this and pass parallel to the railroad through a cut in the rock at D.

To the north of D the old channel is 250 feet in width and partially filled with water. At D, the same fact is noticeable as at B, that on the opposite side from the rock projecting into the gorge the wall rises much steeper than on the same side of the projection.

At E the creek flows in its old channel. On the south side of the gorge at this point the rock wall rises 250 feet in height at a very steep angle. The railroad again cuts through the rock at E. The creek continues to run for some distance from E in its natural course but is turned from the course before reaching F by the road bed of the railroad and flows around the rock projecting from the north side of the gorge.

The old channel between E and F has a width of 500 feet. Throughout the entire gorge Jonathan creek runs on rock bed, the walls rising to an elevation of over 200 feet on each side at high angles. Proceeding eastward from the gorge the valley increases in width. This gorge certainly marks the position of an old col.

One half mile east of Fultonham Buckeye creek enters Jonathan creek from the south; flowing in a broad open valley with rock walls sloping gradually down to the flood plain of the contained stream. Buckeye creek rises in Harrison township, of Perry county, flows northward into Newton township of Muskingum county, where it joins Jonathan creek.

At the entrance of the valley from the south a broad gravel terrace stretches across Jonathan creek valley and extends up the valley of Buckey creek. This terrace has an elevation of 25 feet above drainage. Jonathan creek has cut its way down through this deposit and is now running on a rock floor at this point. From the junction of Buckeye creek west to the col, Jonathan creek valley is narrow and gorge-like in appearance. To the east from this point the valley is broader and gives evidence of being a direct continuation of Buckeye creek valley.

From Newtonville to the Moxahala river the valley is filled in many places with gravel terraces.

The south fork of Jonathan creek rises in the southeastern part of Perry county, receiving numerous tributaries it flows north through a broad open valley to its junction with its west branch below the village of Darlington. The Moxahala river at this point flows northward in a broad valley continuous with the valley of the south fork.

At Darlington the river leaves its preglacial valley and breaking through a gorge empties into the Muskingum river three miles south of Zanesville. The abandoned valley of the Moxahala river filled up with gravel, continues north to Zanesville and opens into the Muskingum at the mouth of the Licking river.

Three miles south of Zanesville, between the buried channel of the Moxahala river and Muskingum river and just to the north of the Moxahala gorge, Observation Knob rises to the height of 260 feet above the flood plain of the Moxahala.

A view to the east from such an elevation shows the narrow valley of the Muskingum. To the west Jonathan creek valley winds its way among the carboniferous capped hills. Across the Muskingum numerous smaller valleys open toward the river with northward direction of discharge . To the northwest the valley of the Licking is outlined.

As indicated on the map, Plate XXV, broken crossed lines trace the divides through a portion of the country represented.

In the western part of Perry county a divide separates the Jonathan creek drainage in Hopewell and Thorn townships from the Rush creek drainage. Almost at right angles to this, another divide running through Reading and Clayton townships of Perry county, and continuing down into Morgan county, separates the drainage of Jonathan creek from that of the east branch of Rush creek. The C. and M. railroad tunnels through this divide near New Lexington, as does the B. and O. near Somerset.

Beginning in Hopewell township of Licking county a divide runs southeast through Hopewell township of Muskingum county. Following the county line between Muskingum and Perry counties it continues south into Clayton and Harrison townships of Perry county, intersecting the Rush creek divide near New Lexington. It is in this divide that the Jonathan creek col is located.

Let us now look for some explanation of the topography of Jonathan creek valley. The whole succession of events accompanying the first advance and final recession of the great ice sheet is considered and an explanation attempted on such a basis. Before the advance of the ice sheet, whose front extended to the north and south line through Licking and Perry counties, represented on the map, Plate XXV, with a lobe of ice running up the Jonathan creek valley as far as Glenford, Jonathan creek comprised two small streams heading on the opposite side of a north and south divide. The stream flowing to the west rising in Clayton township of Perry county, coursing northwest past Glenford, emptied into the old preglacial Muskingum valley near the Licking reservoir.[1]

The other stream on the east side of the divide flowed east past the Moxahala gorge through the now buried channel of the Moxahala river and emptied into the preglacial north-flowing Muskingum at Zanesville.

When the ice sheet invaded Ohio, covering the central and western parts of the State, that portion of Jonathan creek flowing from the western side of the divide was filled with glacial waters. Its current was reversed and the great volume of water poured down from the tongue of ice extending into the valley, ponded up against the divide. At the point indicated by the col on the map, the glacial waters cut through the divide, uniting the two drainage systems into one present, continus system. The geological structure of the divide amply allows for the consideration of such a theory. The narrowness of the valley immediately to the east of the col, the silting up of the valley from the col west to Glenford, the furrowed out character of the valley east of the col all lead to such a conclusion.

Attention should be called to the form of the section of the valley east of the gorge. At the top it has the appearance of the old preglacial valleys: broad, with sloping sides. The lower portion, however, is deeply furrowed out, evidently the result of recent water action. Before the torrents of glacial waters poured over the divide, the stream then occupying this portion of the valley, coursed through a broad open valley. The volume of water which came down from the ice field, loaded with eroded material, cut down the old valley to a great depth, leaving it in its present form.

The preglacial channel of the Moxahala river from where it leaps through the divide, between the south fork of Jonathan creek and the Muskingum river to Zanesville, has a depth of filling of 50 feet above the flood plain of the Moxahala.

When the rivers of glacial waters forced the north-flowing preglacial Muskingum to change its direction of flow, the coun-

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[1] Bulletin Vol. VIII, Pt. 2.

ter currents sent up the old valley checked the flow of the Moxahala river then coursing through it. In the backed up waters the great accumulations of gravel now filling the valley were deposited. Too strong a current was sent up the old valley for the Moxahala river to stem. As a result the Moxahala broke over the divide existing between the south fork and the Muskingum river, and finally cut its course down to the present level.

After the recession of the ice sheet these cols remained in use, having been worn down to a sufficient depth.

These conclusions in reference to Jonathan creek are in harmony with the restored preglacial drainage of the neighboring territory and thus aid in establishing the truthfulness of those restorations.

The south fork of Jonathan creek in its northern direction to Zanesville conforms to the north flowing Muskingum. The west fork of Jonathan creek, from the col, westward to the Licking reservoir, formed a lateral tributary to the preglacial Muskingum in its course from Dresden Junction through the old abandoned valley to Newark and thence southwestward past the Licking reservoir on its way to the Scioto basin.

With these references it is hoped that one more item, though small it may be, is added to the knowledge of the restored preglacial drainage of Ohio.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.

Vol. XI. Article IX. With a Map and Plates XXVII-LVIII. June, 1900.

THE GEOLOGY OF THE ALBUQUERQUE SHEET.[1]

By C. L. HERRICK and D. W. JOHNSON.

In pursuance of the plan outlined in the first volume of this series we present the first instalment of detailed geology of the territory. The area selected is that covered by the United States topographical "Albuquerque Sheet" surveyed in 1888. The topography upon this map is by R. H. Phillip and W. W. Davis of the United States topographical corps. We desire particularly to acknowledge the courtesy of the Director of the United States Geological Survey by whose permission the contours from the Albuquerque sheet have been used upon our map. Dr. Walcott also kindly enabled us to reproduce a number of the plates of Cretaceous fossils from the report of Mr. Stanton in Vol. 106 of the Bulletins of the Survey. For this and other courtesies at the hands of the survey we here desire to make acknowledgement, as well as to Mr. W. F. Cummins of the Texas survey, Professor Charles S. Prosser of the Ohio State University, the directors of the geological surveys of Illinois and of Minnesota, and especially to Messrs. H. O. Brooks and T. A. Bendrat, of the volunteer corps of our survey.

It is no disparagement of the excellent topographical work which has been done by the United States survey to admit that the present sheet, as one of the earliest to be completed, is not entirely reliable and may be employed with safety only in following the main topographical outlines. These inaccuracies, are, however, of less importance upon this sheet than in most parts of the

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[1] Appearing simultaneously in the BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY, Vol. XI, and the BULLETIN OF THE UNIVERSITY OF NEW MEXICO, Vol. II.

territory because of the unusual simplicity of the geological features and the broad lines upon which they are expressed. There are no intricate problems of geological topography and the economic significance of slight deviations in contour is practically nil. It has been decided that the present sheets will be sufficient for our immediate purpose and that whenever it seems best to undertake a more accurate delineation of the topography it will be desirable to employ a larger scale for portions of the sheet.

The reason for the selection of this area lies primarily in the question of convenience. It would appear at first sight that it would be more profitable to undertake an area with more important economic interests and, as a matter of fact, most of the work of the survey has been directed in such lines. But Albuquerque, as the largest city of the territory and the point from which our survey proceeds, seems to have a prior claim. Moreover the very fact that in this region a large number of the important geological problems are expressed in lowest terms makes it important that this area should be mapped and studied before attempting the presentation of the more difficult areas adjoining. This sheet is in a sense the key to the neighboring mining areas and the knowledge of this terraine is the foundation on which the later reports will be built.

The sheet includes the area bounded by the meridians of 106° 30′ and 107° west and the parallels of 35° and 35° 30′ north, forming a rectangle of about 35 miles by 28.5 miles. This area of nearly a thousand square miles we have examined very minutely during the past three years but it must be confessed new facts of interest develop in each excursion. The broad outlines here laid down will require the work of years to fill in.

No high mountains occupy this area but the fringes of three systems cross its borders. On the east rises the abrupt western escarpment of the Sandias and from the northern part of this range a spur of schist projects beyond the border. The great fault line which gave rise to the Sandias lies wholly to the east of the sheet and the knob of schists may be supposed to be either a secondary product of metamorphism or a portion of the uneroded cap of the granite forming the axis of the range. To the north-east the Cochiti range of augite-andesite (diabase) and trachitic tufa rises above the Tertiary plain here largely covered by a broad apron of recent basalt. Further west the granite ridge forming the Nacimiento range projects over the Jura-triassic and Cretaceous plains but the only influence of this range upon our sheet is visible in the fault and monocline which extends southward from its southern extremity and forms the eastern boundary of the Cretaceous in the Puerco valley.

The Albuquerque Mesa.

The central and largest portion of the sheet is formed by a large, low, triangular mesa bordered on the east by the valley of the Rio Grande, on the west by the Rio Puerco valley and on the north by the valley of the Jemes river. This mesa which faces Albuquerque on the west has been considered by Captain Dutton a part of the Zuñi plateau but the Captain seemed to have but the vaguest ideas of the geography of the country he so eloquently described in his monograph of the geology of the Mount Taylor region and supposed that the Rio Puerco flowed into the Rio Grande some miles above Albuquerque instead of at La Joya fifty miles south of it.[1] This mesa we may call the Albuquerque mesa and the basaltic peaks which form its most prominent feature the Albuquerque volcanoes. Opposite Albuquerque the mesa rises to 5700 feet or 750 feet above the river level. The dip of the underlying Tertiary strata is in the vicinity of 50 feet to the mile to the south-east so that the western rim of the mesa is three hundred feet higher than the eastern and at the northern portion the western bluffs attain a hight of about 6750 feet above the sea. The dip is greater in the northern portion of the mesa, doubtless as a result of the proximity of the axis of uplift south of the Nacimiento range.

[1] The passage reads as follows : "There are unfortunately within the limits of the region covered by the map given herewith two rivers named Puerco. One runs north-east of Mt. Taylor and empties into the Rio Grande a few miles north of Albuquerque." It may be added that the geological delineations are also incorrect in many particulars.

Three horizons can be recognized in the Tertiary composing this mesa, the uppermost being a layer of marl varying from ten to over twenty-five feet thick and found over all parts of the mesa where this level is reached. In some places, immediately beneath the thin surface loam or sand, what seems to be buffalo wallows have been excavated in it for the basis of which it was adapted by its impervious character. Thin layers of vegetable charcoal are occasionally seen in connection with the marl justifying the idea that they are of lacustrine origin. No study has so far been made of the organic remains but they will no doubt prove interesting. A curious question arises as to the relation of this supposed Tertiary marl to the so-called Albuquerque marl described in the American Geologist, Vol. XXII, page 34. The latter is evidently fluviatile in origin and it may be suggested that, inasmuch as there are fragments of the Tertiary marl scattered through the river materials, it is possible that the superficial marly layer is due to erosion and redisposition of the older formation. The diference in height of these marls is over 400 feet. The existence of a barrier in the Rio Grand valley below Albuquerque is suggested very evidently by the relations of the present to older river channels between Albuquerque and Socorro. These points are, however, reserved for another occasion. Beneath the marl is a sandy series which rarely is much indurated but is definitely stratified. The upper portion of this for perhaps seventy-five feet is of a reddish color, while the lower portions are lighter in color and contain less of gravel. The gravel is largely of chert and flint and may be traced to the Cretaceous while there are also granite fragments and andesite and trachyte pebbles. It is probable that the whole series from the infra-carboniferous granite and schist to the Cretaceous has been laid under contributions for the materials of the Tertiary sands but it is noticeable that in the vicinity of the red bed (Jura-triassic) these layers are prone to assume the red character of that formation and that in the neighborhood of the great tufa sheets of the Cochiti, for example, the materials are largely of a tufaceous and obsidian nature. Strata that may be the chronological equivalent in the vicinity of the bases of the Scorro mountains are made up of trachyte and rhyolite fragments and the coarseness of the material diminishes with the distance from these sources. No estimate is now possible of the entire thickness of the Tertiary as seen in the exposures of this sheet. West of the mesa in the Rio Puerco valley we may secure sections like the following: White marl, 25 ft.; gray sands and gravel, 25 ft.; red sand, 40 ft.; whitish sand (unknown); hiatus; concretionary yellow sandstone, 25 ; flags and sand, 50 ; yellow flags, 5 ; gray sand and gravel, 65 ft.; coarse gravel. 12 ft.; pinkish crag, 40 ; crag with basalt (fault ?) 25 ft.; crag, 50 ft.; lime sinter, 25 ; pinkish sand with flags, about 200 ft.; reddish brown concretionary sandstone, 35 ; white concretionary sand, 25 ; yellowish-pink sand, 75 ft.; white sandstone, unknown ; fault, beneath which are sands and lignites of the upper Fox Hills group.

The portion of the mesa lying within the limits of our sheet is broken by only one intrusive, that which forms the Albuquerque volcanoes above mentioned. These basaltic cones or necks are prominent objects from the valley at Albuquerque from which they are distant less than eight miles. The five necks plainly evident in the series lie in a north and south line evidently along a fracture or line of weakness. It is not difficult to determine that this series is but a detached portion of a system extending along the entire Rio Grande valley. To the northward is the small Bernalillo volcano described in the American Geologist, Vol. XXII, page 40, Still beyond is the great San Phillipe lava sheet derived from the craters near the south end of the Cochiti range. Still further north vast flows occupy the Tertiary mesa south-west of Santa Fe and portions of these flows having poured into the narrow valley of the Rio Grand at White Rock cañon accummulated in terraces and superposed flows. At the north end of the cañon these Post-tertiary flows may be found penetrating and altering the tufa of the east side of the Cochiti range. North of Santa Clara begins an enormous flow of similar age and character covering thousands of square miles. Evidence of a post-tertiary dam and lake may be seen about San Ildefonso.

To the southward the series consists of a multitude of isolated peaks like those of Peralta, Los Lunas, Isleta, La Joya, Socorra, San Marcial, and others. Much time has been expended in the effort to determine the precise age of these basalt sheets and the results seem to be unambiguous. The fact that these lavas flow over the bases of the trachyte and rhoylite mountains and flows as at Socorro, and burst through and are interbedded in the tufa sheets as at the Cochiti district shows the basalt period to follow the trachyte period of eruptive activity. Direct superposition on the Tertiary sands in numerous places indicates their Post-tertiary age. Often the Tertiary strata are much altered and reddened by the contact, being baked and indurated in those places where the flow was thickest but less altered by the thinner portions of the sheets. The question as to the period that may have elapsed since these flows is more difficult of solution. We have so far failed to find an instance where the lava has flowed over the river deposits of supposed Pleistocene age. Wherever the river valley encroaches on the sheets of basalt the talus is smoothly removed for the most part. A very interesting instance is that of the Peralta volcano which is situated on the east side of the river opposite Los Lunas. Here the cone must at one time have been covered under the river deposits. No vestige remains of the lava sheet and the neck itself has been partly uncovered by later stages of the water. On the other hand, in those cases where the cones have burst through the Tertiary only they spread out in large sheets. It has been repeatedly stated that these lavas are of recent date and that they cover remains of human industry. So far as this portion of the territory is concerned this may be emphatically denied. Specimens of maize imbedded in what was presumed to be lava have been displayed in proof of the statement that man existed prior to these lavas. It is not denied that recent igneous flows have occurred in various parts of the West, but it seems very improbable that even the latest of these basalts could have been cotemporaneous with man in New Mexico. An analysis made by Mr. D. W. Johnson of the so-called lava containing corn proved it to be highly acid and to have a composition impossible for basalt or an ordinary slag. It was not till our attention was called to the nature of the clay resulting from the disintegration of the trachytic tufas in the Bland and Jemes district that the matter became plain. We heard much of an ancient smelter at the mouth of Pino cañon in the Cochiti range. After much search we found a portion of an arch composed of brick which were in some places so completely vitrified that the broken surface could be told from obsidian breccia in the adjacent range only upon careful inspection. Further search proved that the so called prehistoric smelter is a portion of a brick kiln burned a few years ago to supply a stamp mill in the neighborhood and that the project had to be abandoned because of the vitrification of the brick. Still later we were able to duplicate the supposed lava with the corn imbedded near the village of San Isidro in the Jemez valley where either the Pueblo potter had the same misfortune or a fire in the granery not only charred the grain but fused the adobe and imbedded the grains therein. At any rate the artificial origin of the "lava" is perfectly plain.

The thickness of the lava flow from the Albuquerque volcano is rarely more than 25 feet and the inclination of the sheet is sharply toward the river and in one place toward the north end of the sheet it appears that there was a flow over the declivity formed by the bank of the then existing river, as a fragment of the flow occupies a lower level and is nearly buried in the sand of the flood plain. To the west the flow extended but a short distance from the craters. The northern border of the mesa is formed by the valley of the Jemez creek which is wholly excavated out of the Tertiary sands. The declivity is gradual and exhibits extensive and irregular erosion, while on the west side the mesa often presents a rather abrupt escarpment with fantastic battlements and bastions.

The mesa is entirely without water except such as is retained by the marl from recent rains but this suffices to sustain a good growth of gramma grass and accordingly affords grazing for herds of horses from the ranches in the river valleys. In those portions of the mesa where the marl has been eroded the sand supports very scant vegetation and only about its margins a dwarf growth of cedar. The western slope is sparsely wooded affording fuel, some of which finds its way to Albuquerque.

The San Filipé Mesa.

The extreme north-eastern part of the sheet is occupied by a portion of the San Filipe mesa which fills the V-shaped area between the Rio Grande and the Jemes river. Nestled at the south-western margin is the picturesque Indian village of Santa Ana, while the similar village of San Filipe has a corresponding position at the south-eastern foot and the thriving town of Bernalillo lies east of the river opposite the point of the V. This mesa is really a part of the Albuquerque mesa and is similarly composed. It is simply severed from its ancient connection by Jemez river which we may surmise is a geological after-thought of recent origin, and capped by an independent lava sheet from cones lying to the north beyond the limits of our sheet. There is the appearance as of several superposed flows but so far as can be gathered these appearances are due, for the most part at least, to differences of level resulting from erosion prior to the flows, though there is evidence that there were waves of the lava which represent intermittent phases in the flow. The isolated vent which forms the Bernalillo volcano has been eviscerated by the subsequent erosion of the river and now exposes to view the neck and radiating dykes as well as the effects of metamorphism on the soft strata as explained and illustrated in Vol. I of this series.

The Sandia Mesa.

The Sandia Mesa occupies the south-eastern part of the sheet and rises from the Rio Grande flood plain which bounds it on the west to the base of the Sandia mountains. The inclination to the west may average about 75 to 100 feet to the mile. The slope is for the most part gradual and only slightly modified by arroyos of recent erosion. The mesa is treeless but supports a moderate growth of nutritious grass. The abrupt escarpments presented to the river face increase to the southward being low hills at Bernalillo and bluffs perhaps seventy-five feet high at the mouth of the Tijeras arroyo. At the north the Tertiary sands emerge from under the Pleistocene gravels, as about Bernalillo, but to the south these exposures disappear. A shoulder of schist from the granitic series forming the base of the Sandia range is thrust into the mesa at its north-eastern corner and about this some Tertiary elments may be detected. The Pleistocene deposits have been described in some detail in the first volume.[1] In that paper the mistake was made of tentatively referring the stratified sands beneath the river deposits to the Cretaceous. It appears that these beds must be as late as Neocene Tertiary though as yet no positive identification can be made in the absence of distinctive fossils. The lowest member of the river series is what we called the Rio Grande loess and this horizontally stratified deposit of fine silt and sand occupies the valley of the river as far south at least as to near La Joya. It contains fragments of marl which may have been derived from the disintegration of the Tertiary marl deposits. It is impossible at present to decide as to the depth of the deposit but presumably it does not extend much below the water level in the river. A well driven at a point rather south of east and about four miles from the city is 370 feet deep. The lower 25 feet is in a water bearing zone the foundation of which is clay. Except at the top the material passed through was fine grained loess. This depth would correspond pretty well with the level of the river and as no bed of clay is known in the Tertiary it may be supposed that this well reaches the bottom of the Pleistocene series. Another well not more than two miles east of town is said to have a depth of 214 feet and to pass through the same loose materials. The loess is well seen in the bluff of recent erosion on the west bank of the river opposite the court house. Here some 75 feet are exposed in a single perpendicular wall. From the top of this bluff looking eastward there may be readily seen a layer of gravel about 25 feet thick which occu-

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[1] The Geology of the Environs of Albuquerque. American Geologist, July 1898. Reprinted in Bulletin Univ. New Mex., Vol. I.

pies a place in the loess exposure on the east side. This gravel may be found in some places on the west side on top of the bluff mentioned. This gravel bed evidently marks the period of high water and rapid erosion for it is deposited very irregularly in eroded areas of the loess. It may be conjectured that this was a period of melting of glacial ice to the northward. The materials of the gravel can be traced to the northern ranges and adjacent Tertiary and Cretaceous strata. The Albuquerque marl occupies the upper portion of the mesa over much of its surface and has many of the characters of the Tertiary marls of the Albuquerque mesa. It is however less regular and may be supposed to be composed of the material eroded from that formation during a period of comparative quiet. It may be traced southward along the river to the vicinity of La Joya.

The Sandia mesa receives a great deal of float from the mountains and accordingly, near the foot of the range there is an abrupt increase in the angle of inclination marking a talus portion. But even at a distance the coarser elements evidently derived from this source are more abundant at the surface than in the deepor portions. The eastern or major fault line forming the monocline of the Sandias runs at no great distance from the base of the mountain escarpment, as is shown by the fact that at a distance of from half a mile to a mile west of the immediate foot hills there appear portions of the formations above the Carboniferous either nearly horizontal or inclined gently to the east. One such fragment is composed of earthy limestone impregnated with calcite and lies about a mile north of the mouth of Tijeras cañon but does not appear upon the sheet. Another nearly west of the mouth of Hell cañon consists of red sandstone apparently of upper Permian or Jura-triassic age. The total throw of this single fault must have been at least 4000 feet.

The small spur of schists which projects into our sheet from the east should be considered in connection with the Sandia range of which it appears to be the off-shoot. It is in reality cut off from the main range by the great Sandia fault and is to be regarded as a resultant of localized metamorphic activity incident to that great seismic disturbance. The material of this spur with its numerous peaks is schist of various descriptions much seamed and veined with quartz. Somewhat extended search has failed to discover any true igneous rocks in the vicinity. The schists are largely hornblendic with chlorite alteration phases, but there are mica and hydro-mica phases and gneisses. The contact with the granite of the foot of the Sandias is not simple but there is a large area of slicken-siding and evidence of disturbance. Further north the fault cut off part of the Permo-carboniferous and superjacent strata and dropped them in various positions 4000 feet or more and the whole northern part of the range was shattered. The metamorphism was excessive. Essentially the same sequence of strata is found here as near the mouth of Coyote cañon further south and the coal measure limestone with its typical fossils is found near the base of the limestone series while the red beds follow in orderly succession as will be explained in connection with the San Pedro sheet. The fauna of the Permian is nearly obliterated by metamorphism, but traces remain. It would be expected that if the limestone originally contained lead there would be some segregation and along or near the contact of the lime and granite some mining operations have been carried on with indifferent results so far and there is little reason to expect much. The possibilities of copper would seem to be good theoretically but we have so far seen no evidence that the Jurassic or Permian has segregated copper within reach, though copper is reported. In the schists the numerous quartz veins have been opened here and there, chiefly in places where the decomposition of hornblende has produced a quantity of chlorite. In the absence of further information it would look as though the prospectors had mistaken chlorite for stain of copper or silver as often happens in this region. The veins are very white and clean and have what a miner calls a "hungry look" but very likely carry some traces of gold. The association is however distinctly unfavorable unless there are basic intrusives that eluded our search. Such intrusives occur in Hell cañon farther south. Tourmaline is the most common of the accessory minerals of the schists and there are few interesting mineral accummulations even from a mineralogical point of view.

In all probability the Sandia fault was only one of a series of faults all with a dip to the east. It is probable, for example, that the axis of weakness indicated by the series of basaltic volcanoes marks the position of another fault. And the line separating the Tertiary from the Cretaceous upon the map is also another such line, as will be seen. A result of this system of monoclines is to leave a depressed area that may have formed a Tertiary sea or estuary occupying the entire width from the foot of the Sandia mountains to the west bank of the Rio Puerco. In the soft Tertiary strata of this sunken area the two rivers had no difficulty in excavating their Pleistocene and their present valleys.

The Rio Puerco Valley.

The valley of the Rio Puerco, after passing along the western foot of the Nacimiento range and skirting the west side of the Prieta mesa enters the sheet from the north-west in the midst of the Cretaceous area. It would appear that the lava-covered Prieta mesa was so far protected from erosion as to preserve a large series of strata which in the part of the valley covered by this sheet have suffered erosion and removal.

On the eastern border of Prieta mesa is another valley which receives numerous tributaries from the east forming deep and narrow gorges with precipitous sides cut in the hard sandstones of the Cretaceous.

Whether this east Prieta valley occupies a monocline must be left in doubt but a mile or more east of the eastern escapment bordering this valley the nearly horizontal strata are broken by a sharp monocline, one of a series of approximately north and south faults, found on the west side of the Albuquerque mesa. The break is sharp and in many places the resulting scenic effects are quite picturesque. The same fault continues southward along the Rio Puerco and as a result the strata about San Francisco, for example, dip to the south-west on the west side while on the east side of the river they dip to the south-east or east. The discordance seems to fade out to the south or is rendered less apparent by the disappearance of the Cretaceous strata under the Tertiary on the east side of the stream. Above San Francisco the stream is flanked by Cretaceous hills leaving a rather narrow valley. The lowest horizon of the Cretaceous appears above the river level near the point where the valley enters the portion mapped.

The Cretaceous Area.

The entire portion of the sheet west of the Rio Puerco is composed of the fringe of the great Cretaceous and Jura-triassic series of the Mt. Taylor region. In the immediate vicinity of the Rio Puerco these shales and limestones dip gently away from the river to the south-west while in many places the exposures east of the river dip to the south-east and farther north the dip is to the north-east. The bottom of the Cretaceous is nowhere well exposed upon our sheet but the white and yellow sandstone lying above the vermilion division of the red beds appears to the east of the river near where it leaves the sheet to the north-west. No single exposure affords an opportunity to measure the thickness of the Cretaceous in our region but the sequence has been pretty well made out.

At the bottom is a well-defined bed of granular sandstone which is often quite pulverent though upon occasion it may become well indurated. The lower portion is white and attains a thickness of from 25 to 50 feet while the upper portion is more indurated and of a yellowish color. These two we shall include under the term "basal sandstone beds" and find them a useful bench-mark for the base of the Cretaceous.[1] The basal sandstone is followed by a series of dark, sometimes lignitic shales with a thickness of over forty feet which near the top contain bands of flags or sandstone impregnated with iron. Usually one of these layers at least is fossiliferous and has been termed the Gasteropod zone. Among the fossils so far identified in this bed are the following: Ostrea translucida, Exogyra

[1] Farther to the westward this band reposes on the Dakota Sandstone or may perhaps be said to form a part of it.

laeviscula, E. Columbella, Liopistha concentrica, Comptonectes symmetricus, Baculites gracilis, Prionocylus woolgari.

About ten feet of flags follow the dark shales, which are followed by about 75 to 100 feet of yellowish gray shales passing upward into yellow sandstone about 75 feet thick. In the lower layers of sandstone or in the upper sandy part of the shale below it there are frequently developed large concretions often with a cement of iron. These concretions may be over four feet in diameter and often become conspicuous objects in the landscape. They have been found at so many places in the same place in the series that we have come to attach considerable importance to them as a means of identifying horizons. The concretions occur in the same relative place to the east of the Sandia mountains but there by reason of the great distortion and metamorphim, have been distorted and flattened. Several species has been recovered from the concretions though they are not usually fossiliferous. At the top of this Tres Hermanos sandstone is a rather constant band of pinkish sandstone which preserves a uniform thickness and weathers separately from the underlying massive beds. When freshly broken this sandstone is saccharoidal and nearly pure white. Its greater consistency and convenient and uniform thickness may make it available for quarrying at some future time.

Above the sandstone is a large series of very friable sandy shales which are everywhere so readily eroded as to leave their thickness somewhat obscure. They are broken by small layers of ferrugineous sandstone which are somewhat fossiliferous affording for the most part broken fragments. In the neighborhood of (sometimes above but oftener below) this series of sandstone layers is a very widely distributed and conspicuous zone of concretions characterized by the abundance of calcite crystals and the occurrence of a plentiful fauna. These calcareous and septaria concretions often abound in large ammonite shells and large species of Pinna and Baculites which weather out in a very good state of preservation. This zone has been found in the region of Cabezon mountain, south of the Nacimiento range and near Una de Gato east of the Sandia range always with the same peculiar concretions and identical fauna. From this bed we have recognized a considerable series of fossils mentioned in the list given beyond. Above the cephalopod zone and the sandy shales overlying it is another large band of dark and yellow earthy shales at least 100 feet thick capped by massive sandstone perhaps 50 or 75 feet thick. This we have called the Punta de la Mesa sandstone because of its prominence at the place so called north of San Ignacio in the Rio Puerco valley.

The upper part of this series which is separated from the lower by a shaley portion has a varied fauna though the state of preservation is not all that could be desired in most cases. The Punta de la Mesa sandstone is undoubtedly of Fox Hills age though it has been very incompletely studied. Above it is an extensive series of mostly loose yellow sandstone with shaly phases which is not easily estimated. The section given on Plate XLVIII, No. 1 is from the east side of Prieta mesa north of our sheet but does not reach the top of the series. The fossils so far as preserved seem to be identical with those of the Punta de la Mesa, with others so far only found in the lignitic division above. We may estimate this series of Prieta sandstones at 1000 feet thick. It is well exposed in the low hills east of Punta de la Mesa on the east side of the Rio Puerco and here is followed by the upper or

The Lignitic Division.

This group is best seen east of the locality last named north-east of San Ignatio some three miles. The strike is south-west and the same series is thus exposed west of San Ignatio, the continuity of this area with the previously mentioned being broken by the intervening Puerco valley and flood plain. The series as exposed at the northern part of this area is as follows: The Prieta series occupying low hills east of the river for perhaps one quarter of a mile. These yellow sands and flags are greatly weathered and do not enable us to give an accurate section. They are followed by fifty feet or so of white sandstone with ferrugineous layers, 35 to 40 feet of lignite, 5 feet of white sandstone, 35 to 50 feet of brown lignite, 30 to 40 feet of white sand with lignite bands, 75 feet of lignite with ferrugineous layers and in the latter numerous impressions of deciduous leaves and fruits, 10 feet of yellow sandstone, 25 feet of white sandstone, 2 feet of ferrugineous sandstone with many fossils, 25 feet of loose white sandstone and fossils, over 300 feet of white and ferrugineous sandstone with few remains. At this point is a fault along which lignite appears and also white sandstone as though overthrown, but farther study will be necessary to disentangle the confused relations. This we suppose to be the upper limit of the exposed cretaceous for the series following dipping to the south-east is part of the Tertiary section given above.

The fault mentioned is that of the Isleta mesa monocline and may be traced for many miles north and south. A similar fault occurs about three miles west of San Ignatio. To the west of this the lower part of the series is visible and rises in the higher hills to the Punta de la Mesa sandstone but to the east of it the lignitic series occupies the entire area. The fauna of the sand above the lignite is abundantly illustrated beyond and seems to be closely allied to the Punta de la Mesa if not identical with it. It is a marine fauna and of Fox Hills age. Thus our first impression and the prevailing opinion of geologists who have seen these lignites that they are Laramie is overthrown. The leaves also, of which a large collection may be made, are not identifiable with familiar Laramie species. This same sequence is detected east of the Sandia mountains but we are prepared to find this series followed by fresh-water or brackish Laramie at that place when sufficient exploration is possible. Near the Isleta Mesa monocline fault is a bed of shark's teeth and similar remains are found east of the Sandias at the same horizon (near Una de Gato). Time does not permit a discussion of the flora and vertebrate fauna of this formation.

South-east of the lower end of Prieta mesa there are several isolated mesas which rise from the base-leveled valley like islands in a desert sea. One such in particular is a most conspicuous object in the large valley which opens into the Rio

Puerco valley at the point where that river enters the sheet. This remarkable mesa we have called in our notes the Island Mesa (Mesa Isleta). Passing northeastward from the Mesa Isleta one enters a picturesque confusion of eroded and dismantled bluffs of Cretaceous shale and sand. Some four miles distant is an excellent exposure of the contact with the Tertiary. The fault is very marked. The Cretaceous strata are tilted to an angle of about 45 degrees and the upper Cretaceous sandstone is brought to view with its abundant fauna. Above this is a yellowish sandstone and below it bands of lignite and gypsiferous shales. The monocline is very well marked and a part at least of the Tertiary strata seem to be involved in the up-lift. The red beds of the Tertiary bluffs on the west side of the Albuquerque mesa may be traced to the monocline without change of level but here they are abruptly titled. Under them and lying in contact with the inclined beds of the Cretaceous are beds of soft white sandstone with remains of vertebrates which we presume to be representatives of lower Tertiary strata than those elsewhere exposed to view. It is evident that the later stages at least of the movement causing the anticline took place after the Tertiary and this exposure therefore gives us no clue to the original relation between the Tertiary and the Cretaceous.

This monocline in some adjacent places exhibits less of the evidence of disturbance, the slip being abrupt with little alteration of level in the strata on either side. The Tertiary red sands are curiously modified in the neighborhood of this monocline for there are enormous areas covered with concretions of small and uniform size often in botryoidal masses. A few miles southwest of the south-west corner of the Zia reservation the lignites are exposed by the erosion of the Tertiary. The details of distribution of the surface exposures have not been studied nor have the economic conditions but the lignites are no doubt the same as those at the Isleta Mesa monocline farther south and there has been a considerable disturbance and dislocation which may be referred to the influence of the axis of the Nacimiento range.

The area immediately north of this sheet from the Zia reservation westward is very much broken by the erosion directed toward the Rio Salado. Deep defiles have been cut through the high escarpments looking toward the stream and much faulting has disturbed the uniformity of the exposures. Here it is possible to study the upper layers of the red series and the lower portion of the Cretaceous to good advantage in spite of the displacements referred to.

The proximity of the gypsum and salt to great lignite beds is of great commercial importance for it will hasten the time when these resources can be made available.

Resume of the Cretaceous.[1]

The American Cretaceous is essentially a transitional period; and, although its general paleontological features agree with those of Europe, its upper and lower limits cannot be as definitely defined. In Europe the Tertiary is nearly everywhere unconformable upon the Cretaceous, in America this lost interval is represented by the transition group known as the Laramie, while at the bottom of the series we have the transition group known as the Trinity.

The American Cretaceous period is usually divided into the Upper and Lower Cretaceous, these, however, do not correspond to the Upper and Lower Cretaceous of Europe, but are based entirely upon conditions found in this country. It was at first thought that the Lower Cretaceous was wholly wanting in America and that a great gap existed here; but recently it has been found in several widely separated localities; namely, in Texas (Comanche Grp.); in California (Shasta Grp.); in Canada (Kootanie Grp.); and on the Atlantic Border (Pomac Grp.).

The Cretaceous beds in England consist of

Upper Cretaceous	Chalk beds, with flint.

[1] The following notes were compiled for the present paper by Mr. H. O. Brooks.

Middle Cretaceous	Upper green sand and a few other beds.
Lower Cretaceous	Known collectively as "Lower Green sands" consisting of green sands and other arenaceous beds. (Dana, 312.)

In North America the beds are made up of green sand, and thick sand beds of other kinds; also beds of clays, shell beds, and in some of the states, especially Texas, limestone. The thickness of the beds in New Jersey is about 500 ft., in Alabama, 2000 ft., in the Upper Mo. Region, 2000 to 2500 ft., east of the Wahsatch, 9000 ft., while in Texas, the general thickness is about 800 ft. of nearly solid limestone.

The Cretaceous strata in America were evidently mostly deposited by shallow seas or along coasts, while much of the strata of Europe at this time were of deep sea origin, as is shown by her chalk formations.

Although comparatively speaking the Cretaceous rocks are not found very extensively in North America, yet, in several localities, they have important geological features and cover several large areas, which have been divided by White into the following regions:

Atlantic Border Region.
Gulf Border Region.
Texan Region.
North Mexican Region.
South Interior Region.
North Interior Region.
Pacific Border Region.

The South Interior Region and the North Interior Region are sometimes known as The Great Interior Region.

The Atlantic Border Region. The Atlantic Border Region includes portions of Pennsylvania, New Jersey, New York, Delaware, Maryland, Virginia, and South Carolina; also some islands off the coast of New England.

The formations are composed principally of gravels, clays, sands, and marls. Only in a few instances are they of sufficient hardness to furnish an exposure of any great value. The aggregate thickness of all the strata of this region will not exceed 1000 ft., and even this thickness is not found in any one locality.

The Gulf Border Region. This region includes portions of Albama, Mississippi, Georgia, Louisana, Tennessee, and Kentucky. The geological features of the region are so similar to those of the former, that there is probably no Cretaceous stratum found in the one that does not also occur in the other. Although the rocks so closely resemble those of the Atlantic Border Region, they are on the whole of a harder character, and the aggregate thickness is greater, being about 2600 ft. We select the following section as being a typical one of this region :

Hilgard's Misssissippi Section.

Coffee Group.	Sands. Blue or reddish clays. Some beds of lignite.	300 to 400 ft.
Rotten Limestone Group.	Soft clays. Whitish limestones. Calcareous clays.	1200 ft.
Ripley Group.	Sandy limestones alternating with beds of dark marl.	300 to 350 ft.

The Texas Region. This region includes portions of Missouri, Arkansas, Louisiana, Indian Territory, and much the greater portion of Texas. In this region we have the whole Cretaceous Period from the Trinity formation to the Laramie formation. It is remarkable for its exposure of the Comanche series, which is probably the best representative of a great division of the Lower Cretaceous in North America. Its fossil fauna, such as Rudistae, Chamidae, and *Radiolites austinensis*, would seem to indicate that it was similar to both the Lower and Upper Cretaceous of Europe; but, from its position so far below the Dakota, it is placed in the North American Lower Cretaceous. The series consists of limestones, calcareous shales, and earthy calcareous material with stony concretions.

North Mexican Region. The geology of this region is very imperfectly known, but it is of great importance. Its boundaries lie mainly within Mexico, but it also includes portions of southern New Mexico up to the mouth of the Pecos River and southern Arizona; also a little of western Texas. Charles A. White found the whole upper Cretaceous in this region from the Dakota to the Laramie, while nothing lower than the Comanchie has ever been found in the Lower Cretaceous. The most important exposure of the Comanchie formation has been found in Sierra San Carlos in the Mexican State of Chihuahua. Here Dr. Parry found an exposure of over 4000 ft. containing Comanchie fossils throughout, and consisting of bluish-gray compact limestones, comparatively pure, but, in part, argillaceous.

The Great Interior Area. The following table gives the Upper Missouri River Section of Meek and Hayden, also the modification of the same as adapted by C. A. White this region (See Rev. of the Cret. Form. of N. A.):

Upper Mo. River Section.	Modification of Same.
No. 5. Fox Hills Group. No. 4. Ft. Pierre Group.	Montana Formation.
No. 3. Niobrara Group. No. 2. Ft. Benton Group.	Colorado Formation.
No. 1. Dakota Group.	Dakota Formation.

The Laramie formation is not included under any of the above heads, but it is found in different localities throughout the whole of the Great Interior Region. It is probable that no true marine fauna occurs in this formation, but brackish water mollusks, such as Ostrea, Anomia, Corbula, Corbucula, and Neritina, and such fresh water forms as Unio, Anomia, etc., have been frequently found.

There has been some question as to whether this formation should be placed in the Cretaceous or the Tertiary. It is now, however, usually considered as a transitional period, but referred to the Cretaceous formations. (See White's "Review of the Cret. Formations of the N. Amer., p. 148.)

South Interior Region. This region comprises the whole of Colorado and portions of Kansas, Nebraska, Wyoming, Utah, Arizona, New Mexico, and north-western Texas. The strata, except a small portion in southern Kansas, are entirely of the

Upper Cretaceous, ranging from the Dakota to and including the Laramie.

Newberry estimates the total thickness of the strata in New Mexico to be about 3500 ft. and divides it into the Upper, Middle, and Lower Divisions, corresponding respectively to the Montana, Colorado, and Dakota formations given above. (See Macomb's Expl. Exped. Geol. Report, pp. 121, 122.)

In the Colorado and New Mexico Cretaceous strata it was found very difficult to discriminate between the shales of the Ft. Benton and those of the Ft. Pierre Groups. For this reason Mr. Clarence King proposed the new term Colorado Group "for the great clay group" of the Cretaceous in this region. But it has been found that it is just about as hard to apply the lithologic classification of the formations to this new group as it was to the older ones of Meek and Hayden. For this reason Dr. C. A. White in describing the Cretaceous formations of Colorado used the same nomenclature as Mr. King, but applied the term Colorado Group only to the Niobrara and Ft. Benton Groups, and placed the Ft. Pierre in the Fox Hills Group. This has been further improved upon by Mr. G. H. Eldridge, who adopted the same divisions as Dr. White, but changed the Fox Hills and Ft. Pierre Groups to that of the Montana Group, thus doing away with the confusion caused by using the term Fox Hills Group in two different senses. (See Eastern Colo. Section, below.)

The Pacific Border Region. This is a very long and narrow strip running along the coast from the southern boundary of California through Oregon and Washington into British Columbia. Both the Upper and Lower Cretaceous are represented. The following section is the one which was adopted by the California State Survey:

Upper Cretaceous	Tejon Group. Chico Group. Wallala Group.
Lower Cretaceous	Shasta Group.

The following section, Meek and Hayden's Upper Missouri River Section, we give in full. This section has long been considered by most geologists as the standard for the classification of the Upper Cretaceous formations in America:

Upper Missouri Section. (Meek and Hayden.)			Estimated Thickness.
Upper Series.	Fox Hills Grp. Form. No. 5.	Gray, ferruginous and yellowish sandstone and arenaceous clays, containing Belemnitella bulbosa, Nautilus dekayi, Placenticerus placenta, Scaphites conradi, Baculites grandis, Auchiera americana, and a great number of other mulluscan fossils.	500 ft.
	Ft. Pierre Grp. Form. No. 4.	Dark gray and bluish plastic clays, containing Nautilus, Placenticeus placenta, Baculites ovatus and compressus, Scaphites nodosus, Inoceramus sagenus. Middle zone nearly barren of fossils. Lower fossiliferous zone, containing Ammonites complexus, Baculates ovatus B. compressus, several species of Heteroceras, Inoceramus tenuilineatus, bones of Mososaurus, etc. Dark bed of very fine unctuous clay, containing much carbonaceous matter, with veins and seams of gypsum.	700 ft.
Lower Series.	Niobrara Div. Form. No. 3.	Lead gray calcareous marls, weathering to a yellowish or whitish chalky appearance above. Containing remains of fishes and Ostrea congesta, also several species of Textularia. Passing down into light yellowish, whitish limestone, containing numbers of several species of Inoceramus, as well as Ostrea congesta, fish scales, etc.	200 ft.
	Ft. Benton Grp. Form. No. 2.	Dark gray laminated clays, sometimes alternating near the top with seams of light colored limestone. Fossils, Inoceramus problematicus, I. tennicostatus, Ostrea congesta, Veniella mortoni, Prionocyclus woolgari, Scaphites warrenanus, Nautilus elegans, etc.	800 ft.
	Dakota Grp. Formation No. I.	Yellowish, reddish and white sandstones, at places with alternations of various colored clays and seams of impure lignite. Fossils, Pharella? dakotensis, Trigonarca siouxensis, Cyrena arenarea, Margaretana nebrascensis, impressions of leaves, etc.	400 ft.

The following correlation tables are compiled from those given by C. A. White in his Review of the Cret. Formations of N. Amer., pp. 211-245, inclusive:

		Newberry's New Mex. Section	King's Section	Eastern Colorado Section	White's Colorado Section	North Interior General Section
Eocene	Y Z					
Upper Cretaceous	A B		Laramie Group	Denver Deposits and Laramie Formations	Laramie Group	Laramie Formation
	C D E F G H	Upper Cretaceous	Fox Hills Group	Montana Formation	Fox Hills Group	Montana Formation
	I J K		Colorado Group			
	L M N	Middle Cretaceous		Colorado Formation	Colorado Group	Belly River Formation
	O P Q R S T U V W					Colorado Formation
	X Y Z	Lower Cretaceous	Dakota Group	Dakota Formation	Dakota Group	Dakota Formation
Lower Cretaceous	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z					Kootanie Formation
Jurassic						

In his earlier work in New Mexico Professor J. J. Stevenson followed Professor Newberry in dividing the Cretaceous into upper, middle and lower divisions. In later papers (100 Meridian Surv. Vol. III, supplement) he united the Fort Benton, Niobrara and Fort Pierre groups under the name Colorado

Group but included the Fox Hills division with the Laramie, presumably because of the presence of important lignite beds in both groups.

Captain Dutton has given sections of the stratified rocks of the Zuñi plateau which would be of great value if they rested upon any adequate paleontological foundation. He obviously is in error in his identification of the Triassic, to which he ascribes a thickness of 1600 feet. At the base of the Cretaceous as here exposed he places the Dakota sandstone with a thickness of 250 feet. The Colorado shale series is said to measure 1200 feet and it is followed by 900 feet of lower Fox Hills and this in turn by 550 feet Upper Fox Hills and this by 800 feet of Laramie. Each of these divisions is separated from its neighbors by a bed of massive sandstone from 125 to 175 feet thick which is not reckoned in nor ascribed to any group. The total thickness of the Cretaceous, including the Laramie is made to foot up to 4125 feet.

Holmes had given in Hayden's report for 1876 a section of the San Juan valley in which from 500 to 800 feet of variegated marls and soft sandstone beneath the hard sandstone of the Dakota had been added to that group but it is obvious that these marls belong to our Vermilion beds or Jurassic group.

In Vol. IV, of the report of Surveys West of the 100 Meridian Professor Cope, in his introduction to the report on Mesozoic vertebrate fossils, offers a brief account of the stratigraphy of the region north of the Nacimiento range and, while it is difficult to follow his description and numerous inaccuracies appear in his estimates, it is yet interesting to see how this region impressed the great paleontologist in 1876.

The exploration was carried on from the valley of the Rio Grande to the region of the Gallinas and head waters of the Puerco via the Rio Chama. In the cañon of the Cangilon he encountered our red beds with the gypsum horizon apparently in the same relative position as in the Nacimiento region. Beneath it are the red and yellow sand and a thin layer of shale. The gypsum is in places 50 feet thick and is separated from the lowest Cretaceous by an interval of about 850 feet. This interval is in some places filled by a mud-brown sandstone which Cope regards as the equivalent of Cretaceous No. 1 of Hayden's section at Colorado Springs.

Below the gypsum is a band of lemon yellow and still below this beds of vermilion red sand. It seems probable that Cope overlooked the upper two-thirds of the red bed series and that the 850 feet is greatly over-estimated, yet it must be admitted that there is still room for a very unusual development of the Dakota sandstone in this interval. The great variability in the thickness and frequent absence of this horizon is one of the remarkable peculiarities of the New Mexico Cretaceous. In the Nacimiento region adjoining that described by Cope the sandy series at the bottom of the Cretaceous is never as thick as 100 feet, and consists of yellowish and white sandstone of a massive but very pulverent nature while south of Mt. Taylor there comes in a bed of yellow sandstone of about 200 feet thickness below this horizon.

The gypsum is supposed to mark the top of the Jurassic, the thickness being given at 600 feet, while below it is the Triassic to which 1000 feet are ascribed, though the bottom was not seen. Cretaceous No. 2 with a thickness of 1500 feet follows the gypsum. It is composed of shales and contains the fossils of our "Gasteropod Beds" and probably also the "Cephalopod Shales" though it is not possible to determine what limits were selected in Cope's classification. To this division a thickness of 1500 feet is ascribed and it is followed by the sandy Cretaceous No. 3, also 1500 feet thick. This probably embraces our Punta de la Mesa sandstone and part of the Prieta Mesa section above it.

The thing that strikes one in reading Professor Cope's paper is the enormous exaggeration of all estimated heights. It is probable that the total thickness on the Mesozoic strata which he gives at 5600 feet must be halved. It has been our experience that an estimate made at a distance of the heights of exposures of these bright-colored rocks is invariably too great. We have amused ourselves by making such estimates at a distance of five and then of one mile and even then found it necessary to divide the distance when it was actually measured.

The lower beds of the red series Professor Cope refers to the Trias and reports that they are of fresh-water origin as they contain Unios and saurian remains. It may be doubted if the Unios actually came from the beds in question. If they did, a curious light may be thrown upon the occurrence of the copper so constantly found in this part of the series. The variegated beds of marl and sandstone are thus separated from the sands immediately beneath the anhydride, though there seems to be no special reason for such separation.

Professor Cope also mentions the fact that the Jurassic beds contain conglomerate lime strata and copper, all of which facts induce us to believe that he had actually in mind our lower red-bed division. It would then be convenient to use the gypsum horizon as the upper limit of the Triassic but this leaves us in doubt as to the lower limit and as to the place of the Permian.

PALEONTOLOGY OF THE CRETACEOUS.

The purpose of the following list[1] is to serve as a running commentary on the plates accompanying this paper. It would be impossible at this stage of our study to present an adequate idea of the richness of the fauna of the upper Cretaceous and it would be presumptious to attempt even a full description of the collections already made without the means of broader comparison than we have at present. Nevertheless it is necessary to afford the student an opportunity to verify so far as possible the conclusions to which we have come and to supply the means of checking this part of the work. Several species which seem important as determinants of the several horizons have been collected and found undescribed so far as can be told at present. In a few cases new names have been proposed for these in order to facilitate reference though we should have preferred to defer the paleontological work till greater progress has been made.

For those whose chief interest in geology is economic it is

[1] The assistance of Mr. H. O. Brooks in the preparation of this paper requires special recognition.

hoped that the plates will prove useful for the determination of the rocks actually found in the field. Even though the engineer may lack the discriminating knowledge of the trained paleontologist he can in many cases satisfy himself of the position of a stratum by the simple inspection of the plates while others may be induced to carry the study farther by recourse to the published reports.

For the study of the upper Cretaceous as exposed in central New Mexico and Bernalillo county particularly the student will receive much assistance from "The Colorado Formation," by T. W. Stanton in Bulletin number 106, Meek's "Invertebrate Paleontology of the Upper Missouri," forming volume IX of Hayden's survey, and White's report in Vol. IV of the Survey West of the 100th Meridian.

Mollusca.

Ostrea prudentia, White.

A form resembling White's figure is from the monocline north-east of Island Mesa and south-east of Prieta Mesa where it is associated with upper Fox Hills species.

Ostrea sannionensis, White.

This species occurs abundantly in the Punta de la Mesa sandstone and in some cases forms extensive layers in company with several other species. A form has been found with cruciate outline (see figure) due to the unusual development of the upper plicae but it is not thought necessary to institute a new name for it.

Ostrea lugubris, Conrad.

The typical form is found in the cephalopod shales in Rio Puerco valley. It would seem that the evidence is now complete that this species should include both O. blackii and O. belliplicata which have been found in the Eagle Ford group of Texas. We have specimens of the larger form from Una de Gato east of the Sandia mountains in the uppermost Fox Hills strata, which closely resemble White's figures of O. belliplicata.

Ostrea glabra, White.

Plate XXXIV, Figs. 1, 2.

Numerous well-preserved specimens of this Laramie species were found east of the Caballo mountains in connection with the coal beds and what seems to be a somewhat different form of the same species occurs at Cerrillos but the association was not sufficiently close to determine the age of the beds of coal.

Ostrea translucida, Meek and Hayden.

Plate XXXIV, Figs. 7, 8, 9 and 10.

Ostrea pellucida, Meek and Hayden.
Ostrea pellucida, White.
Not Ostrea pellucida, Defrance.

A very thin-shelled Ostrea is represented by numerous specimens which are probably from the "gasteropod zone" beneath the Tres Hermanos or large concretionary sandstone in the Rio Puerco valley. Our figures are from casts of the interior. It may prove that they indicate a new species. It would appear that the shell from Carthage figured on Plate XXXIII, Fig. 7 is of the same species. The plications are sometimes obsolescent but the general form is fairly constant.

Ostrea franklini, Coquand ?

Plate XXIX, Fig. 8.

Two casts of the interior from the sandstone of the monocline east of Island Mesa may belong to this or a similar species. Upper Fox Hills group.

Exogyra laeviscula, Roemer.

This species occurs very abundantly beneath the Tres Hermanos or large concretionary sandstone in the Rio Puerco valley and at Gallup with E. columbella.

Exogyra columbella, Meek.

Not uncommon in the "gasteropod zone" below the Tres Hermanos sandstone in the Rio Puerco valley and at Gallup.

Exogyra texana, Roemer.

Specimens apparently of this species occur in sands above the lignite in Rio Puerco valley.

Exogyra winchelli, White.

Fragments from the upper Fox Hills group near Una de Gato east of the Sandia range have been referred with some hesitation to this species.

Gryphaea vesicularis, Lam.

Plate XXX, Fig. 3.

This is a common species. Elaborate discussions by Gabb, Hill and other writers seem to have brought no agreement as to its synonomy. Gabb, in 1869 referred this form to G. pitcheri of Morton and identifies it with G. dilata var. tucumcarii of Marcou. Whitfield reported it in 1885 from the lower green sand marls of New Jersey though insufficient care on the part of collectors prevented him from determining the sequence of the varieties. The species probably has a large vertical range. There are large quantities of these shells exposed by the weathering of shales below the Punta de la Mesa sandstone east of Mount Taylor. This is the locality from which it was reported by White in 1875. Meek also received it from the Fort Pierre group of the Black Hills.

Inoceramus fragilis, Hayden and Meek.

Plate XXX, Fig. I and Fig. 2. Plate XXXIV, Figs. 3, 4 and 5.

Our specimens vary greatly in form and size but scarcely more than those figured by Stanton and White. Very common in the cephalopod shales and the Punta de la Mesa sandstone just above them. Figure 2 of Plate XXXV is from a cast of the interior and differs from the others in form but is associated with other casts which are more elongate and in other characters resemble this species. These are from shales east of the Caballo mountains.

Mactra formosa, Meek.

Plate XXXIII, Fig. 6.

Small specimens from Carthage are referred to this species which is said to occur in the higher portions of the Fox Hills group.

Mactra pulchella, sp. n.

Plate XXX, Fig. 5.

Shell small, oval-subtrigonal, compressed, somewhat longer than high, nearly equilateral, or with anterior side longer; basal margin a semi-elliptical curve, rather rapidly curving anteriorly and abruptly flexed to the posterior margin. Umbones approximated, incurved ; anterior and posterior margins nearly straight and nearly at a right angle with each other ; posterior umbonal slope obscurely angular ; lunule and escutcheon well-marked.

The surface is ornamented by strongly raised concentric plications which are relatively more conspicuous on small shells. Length of large specimen, 1.25 inches. In general form this species resembles Mactra emmonsi, Meek. The generic characters are not distinct but there is apparently an external ligament.

From yellow sandstone above the Punta de la Mesa horizon, east of the Sandia mountains, near Una de Gato.

Mactra (?) *subquadrata*, sp. n.

Shell small-ovate-subquadrate, compressed, considerably longer than high ; anterior side much shorter ; basal outline a uniform semi-elliptical curve abruptly narrowed behind, broadly rounded in front; beaks small, approximated, distant more than one third the length of the shell from the anterior margin ; shell thin, marked by fine concentric striae.

Length five-eighths of an inch, height one half an inch. The general form is much as in certain Carboniferous species of Edmondia. This very pretty shell occurs in the calcareous concretions of the cephalopod shales or in the "gasteropod zone."

Tellina (?) *perlata*, sp. n.

Plate XXXII, Fig. 5.

Shell transversely and broadly sub-ovate in outline, compressed; anterior margin more broadly rounded, posteriorly sub-acute. (The figure shows the posterior angle somewhat more acute than usual).

The beaks are slightly nearer the anterior margin, small. Hinge characters unknown, except that the casts show an impressed line anterior and posterior to the beak near the hinge. Shell thin, marked with numerous fine concentric lines. Length of large individual, 2.5 inches, height 2 inches. This appears to be a common species in the upper part of the Fox Hills group but we have thus far found no description of it. The name may be regarded as provisional.

Tapes cyrimeriformis, Stanton.

Plate XXXII, Figs. 6 and 7.

This beautiful shell is represented by two specimens, one from the valley east of Prieta mesa and the other from the cephalopod shales near San Francisco. The figure does not show the ligament which is probably broken. At first we supposed this to be a Callista.

Caryates veta, Whitfield.

Plate XXX, Figs. 6 and 7.

The specimens referred to this species are from septaria concretions in the cephalopod shales, Rio Puerco valley.

Tellina equilateralis, Meek.

This shell occurs in the higher layers of the Cretaceous above the lignite. Upper Fox Hills.

Idonearca (?) *depressa*, White.

Plate XXXV, Figs. 2-7.

From the same region in the Rio Puerco valley as that from which the original specimens came we have a variety of forms which have the hinge characters of Idonearca together with the form of Trigonarca depressa. There are two varieties, one being shorter (figures 4 and 5) and the other more oblique. None of these agrees in form with the species of Idonearca figured by Meek and Hayden though the hinge structure agrees. The figure by Stanton for the hinge of T. obliqua does not apply to our forms though the casts are apparently identical with those figured by him on Plate XX, Figs. 5 and 5. There is abundant material from the horizon above the lignite beds in various parts of the territory but we are unable to decide that that there is more than one species.

Cardium pauperculum, Meek.

Plate XXXIII, Fig. 11.

What appears to be the species cited is abundant above the coal horizon at Carthage and in the Upper Fox Hills layers east of the Sandia mountains. We have also found it in the walls of the depression surrounding the Zuñi salt lake in western Socorro county. The figure illustrates a specimen in which the posterior slope is unusually angulate. Considerable variation occurs but the costae are simple and nearly uniform in all cases.

Cardium, sp. ?.

Plate XXXV, Fig. 1.

This fine large species we have so far failed to identify but not having access to all the descriptions we are unable to state whether it is new or not. It is not rare in the upper Fox Hills layers east of San Francisco in the Rio Puerco valley.

Pholadomya subventricosa, Meek and Hayden.

Plate XXX, Figs. 1 and 2.

Several specimens of this species were found in the septaria concretion of the cephalopod shales near San Francisco in the Rio Puerco valley.

Pinna petrina, White.

Plate XXXI, Fig. 5.

A large series of this striking species found near the original locality in the Rio Puerco valley and elsewhere in Bernalillo county permits us to add a few details to the original description.

Our specimens are mostly in the form of casts of the interior derived from the septaria concretions of the so-called cephalopod zone which seems to lie near the base or perhaps below the base of the Fox Hills division.

The texture of the shell, where preserved, is lamellar and prismatic, the inner nacreous layer being frequently preserved. Strong lines of growth lie parallel to the anterior margin, which is more nearly straight than the posterior, but turn by rather an abrupt flexure, parallel to the curved free margin to an oblique union with the lateral carina.

The strongly curved posterior margin is joined abruptly by the free posterior lip, which is strongly arched rather than straight as represented by White. The striae of the posterior portion of the shell are parallel to the outline of the lip. The radiating striae are relatively inconspicuous and the beak is more abruptly acute than represented by White.

Legumen (?) *appressum*, Conrad.

Shell transversely elliptical, over twice as long as high; valves depressed, thin; shell narrowed anteriorly and acute at the anterior extremity; posterior end broader but sharply rounded at the middle of its height; hinge line long; ligament groove long and deep; surface marked with fine even concentric striae.

We at first considered this a new species but it may more probably be identical with the one quoted. Upper sandy layers above lignite in Rio Puerco valley.

Liopistha concentrica, Stanton.

Plate XXXIII, Fig. 5.

(Including L. elongata, Stanton.)

A number of specimens from the gasteropod zone in the Rio Puerco valley resemble L. concentrica closely but they are mingled with others of somewhat larger size that have the outline of L. elongata. These large ones, however, have the concentric markings as well developed as the smaller and some of the smaller ones have nearly the form of L. elongata and have the surface preserved, showing it to be almost pustulate by reason of nodes developed upon the concentric striae. We doubt the possibility of separating these forms. The L. elongata form occurs also at Carthage (See Plate XXXIII, Fig. 5).

Camptonectes symmetricus, sp. n.

Shell small, not over three fourths of an inch in length; broadly oval in outline; hinge line imperfectly seen, apparently longer than half of the width of the shell; valves convex; cardinal slopes from the beak forming with each other nearly a right angle, straight; surface of valves marked by very fine, numerous, irregular, hair-like radiating striae which curve strongly upward toward the margin, and also by fine concentric striae.

In the gasteropod zone below the Tres Hermanos sandstone in the Rio Puerco valley. None of our specimens preserve the hinge characters or extremities of the ears but the character of the sculpture is similar to C. burlingtonensis.

Dosinia sp?

A cast from the same bed as the above is referred to Dosinia on the basis of a superficial resemblance to D. erecta, Whitfield.

Gasteropoda.

Chemnitzia coalvillensis, Meek.

Plate XXVIII, Fig. 5.

A small species, our specimens of which are insufficiently preserved, may be referred here. From the upper Fox Hills layers above the lignite.

Chemnitzia sp.

A somewhat larger form than the above, which we cannot at present determine, is from the septaria concretions near San Francisco.

Gyrodes depressa, Meek.

Plate XXIX, Fig. 7a, b.

The figure is not exactly correct in the representation of the expansion of the lower part of the body whorl. Most specimens agree well with the figures given by Stanton, particularly with the form with the more elevated spire. From the upper sandy layers above the lignite.

Turritella whitei, Stanton.

Plate XXVIII, Fig. 6.

The specimen figured is not well preserved but material discovered since the engraving was made show a shell of the size and characters of the Colorado variety of the species described by Stanton.

The revolving striae are unequal and nodose and there are not more than five large ones separated by small hair-like ridges.

Vanikoropsis tuomeyana, Meek and Hayden.

Plate XXIX, Fig. 4.

It is with considerable doubt that two specimens found as float in the Santa Fe marls west of Albuquerque mesa are referred to this species. Meek states that the aperture is wrongly figured on his plate. Our figure is somewhat restored and the spire is probably higher than the cast would indicate. The shell is very thick and beautifully sculptured. There seems to be no doubt that the specimens are from the upper layers of the Fox Hills above the lignite.

Priopsis bairdi, Meek and Hayden.

Plate XXXIV, Fig. 6.

We have but two specimens that can be referred to the present species, one being a cast of the interior and the other a nearly perfect shell, the surface of which, however, has been much injured by abrasion.

In form and, so far as can be seen, in surface characters it appears to resemble P. bairdi more closely than it does P. coloradoensis, Stanton. With the former it also agrees in coming from a high horizon associated with Fox Hills species. Sandstone above lignite, east of San Francisco. Also at Carthage in sandy shales above the coal.

Rostellites ambigua, Stanton.

Plate XXIX, Fig. 1.

A number of fragments seem to have the characters of the species quoted though they indicate a larger form than that described by Stanton. With that species it agrees in having two folds in the Columella. The surface is strongly ribbed and also has fainter revolving striae on the body whorl.

The species was originally described from the Pugnellus zone of Colorado, a horizon occupying a position above the Fort Benton series. Our form is abundant in the cephalopod shales at the foot of the Fox Hills division, or immediately below it.

Rostellites dalli, Stanton.

Plate XXIX, Figs. 3 and 5 ; Plate VII, Fig. 8.

This species is apparently common in the sandstone above the lignite east of San Francisco and at the monocline east of Island mesa. Fig. 3 is faulty in not showing the full height of the spire. Other and larger specimens are more characteristic though the revolving striae are more pronounced upon the upper part of the body whorl than in the type. The folds of the columella are nearly obsolete. The same species has also been found in the shales above the coal at Carthage.

Anchura (?) *fusiformis*, Meek.

Specimens from various places in the Rio Puerco valley, the original locality, show the revolving striae and general characters but are insufficient to verify the suspicion expressed by White that the generic reference is incorrect.

Volutomorpha (?) *nova-mexicana*, sp. n.

Plate XXIX, Fig. 2.

This beautiful species is abundant in the sandstones above the lignite in the upper Fox Hills at Una de Gato, east of the Sandias and at the monocline east of Island mesa. Not having seen the whole length of the columella the generic reference remains doubtful.

Shell of rather large size, elongate ovate in general form ;

spire conical moderately elevated, consisting of five volutions; volutions convex, strongly lobed by the transverse grooves, about 16 of which are found on the second volution of a full-sized specimen; body volution nearly thrice the length of the spire; aperture long and rather narrow; columella, as far as seen, unmarked by folds; surface of body volution marked by strong transverse plicae which are strong near the upper aspect but increase by intercallation below so that they are there about of the same size as the revolving striae with which they produce a beautiful cancellated appearance. Near the upper (sutural) margin is a strong groove which separates a part of the whorl as a prominent band which continues to the spire. The upper volutions are more strongly lobed and on them the revolving striae are obsolescent. Shell thick; cast smooth. The species is more robust than any species of Volutomorpha known to us but the absence of the columella folds seems to prevent its reference to Volutiderma, or Voluta. Length about 3.5 inches.

Sigaretus textilis, Stanton.

Several specimens with about the size and form of this species and with the cancellated surface have been taken from the gasteropod zone east of San Francisco. The spire in some cases is proportionally larger than shown by Stanton but the individuals vary among themselves.

Harpa (?) *occidentalis*, sp. n.

Plate XXVIII, Fig. 4.

This beautiful shell cannot be definitely referred to any Cretaceous genus but seems to belong in the Harpidae. Body whorl enlarged; spire low, conical; aperture elongate, rather narrow, notched and curved below; inner lip smooth, covered with a callus; outer lip thickened. The surface is marked by broad, flattened, transverse ribs separated by narrower depressions with a square cross-section. The lower part of the body whorl has about five revolving grooves like those separating the transverse ribs. There is a shallow revolving groove near the suture. Length about three fourths of an inch. The figure is from a specimen in which the spire has been partly abraded away but is otherwise apparently perfect. There are no teeth upon the inner lip. Upper layers of the Fox Hills near Una de Gato, east of the Sandia mountains.

Cephalopoda.

Baculties gracilis, Shumard ?

Our specimens agree with those doubtfully referred to B. ovatus by White and which have been identified as B. gracilis by Stanton. In the lowest fossiliferous horizon (gasteropod layer, in Rio Puerco valley).

Baculites asper, Morton ?

A large species with distant nodes as in B. asper occurs in sandstone above the lignite east of San Francisco.

Buchiceras swallovi, Shumard. not [illegible]

Plate XXVII, Figs. 1-4.

This beautiful species occurs in vast numbers in septaria concretions of the so-called cephalopod shales in the Rio Puerco valley where it is associated with Sphenodiscus lenticularis, Placenticeras placenta, Pholadomya subventricosa, and other lower Fox Hills species. The typical form as described by Shumard is abundant and is accompanied by a variety or possibly a distinct species characterized by the absence of nodes about the umbilicus, the greater lateral compression of the shell and the almost complete absence of the ribs. The paired dorsal nodes, though present, are inconspicuous. The sutural pattern is the same except that the serration of the lobes is less marked. Individuals with more prominent ribs and slight development of the umbilical nodes indicate the possibility of a transition to the type. The variety may be known as var. puercoensis. Plate XXVII, Figs. 3-4. It would seem that the two forms occur together wherever the species occurs.

Sphenodiscus lenticulare, Owen (sp).

Not common in the septaria concretions of the cephalopod zone, Rio Puerco.

Placenticeras placenta, Dekay.

This delicate species is also from the septaria concretions in the Rio Puerco valley.

Placenticeras costata, sp. n.

Plate XXVIII, Figs. 2-3.

Shell lenticular, compressed, of moderate size; umbilicus very small; volutions deeply embracing, widest a little distance from the umbilicus; dorsum flat or slightly channeled, crossed by a continuation of the nodes; surface marked by numerous irregular subtriangular and curved ribs, the larger ones extending from the dorsum to the umbilicus and separated by one or more short oblique ribs originating on the dorsum where they give rise to small elongate nodes; aperture apparently narrowly cordate, flaring on either side of the volution embraced by it; septa moderately distant, siphonal lobe wider than long, with lateral divaricating branches; first lateral lobe small with two lateral projections and trifid terminal portion; first lateral sinus much broader than the lobe, composed of four portions, the median one five-digitate at the end and with a spur at either side, two small branches on the peripheral side and a small trifid branch on the umbilical side; second lateral sinus broken by two small spurs; third lateral lobe with five terminal and two lateral projections; remainder of sutural pattern unseen. This shell resembles in many respects Placenticeras placenta, from which it differs not only in sutural pattern but also by the presence of well-defined ribs. In this respect it resembles the Mexican form reported by Gabb, Pal. Cal., Vol. II, Fig. 258, which seems not to be Ammonites piedernalis, von Buch. Diameter of only specimen seen 95 mm. maximum thickness 21 mm. In septaria concretions of the Rio Puerco valley associated with Buchiceras swallovi, Placenticeras placenta, etc.

Scaphites nodosus, Meek and Hayden.

Our material is all of too fragmental a character to admit of more than doubtful identification, but indicates a rather large species with the nodose surface characteristic of the species quoted. East of Sandia mountains, at San Antonio in a horizon above the Cephalopod shales.

Scaphites sp ?

Associated with the above are fragments of a smaller shell like S. nicolletti but agreeing with S. nodosus in the presence of node-like elevations near the umbilicus.

Prionocyclus woolgari, Mantell.

Plate XXVIII, Fig. 1.

This species occurs apparently in the Tres Hermanos sandstone above the Gasteropod zone in Rio Puerco valley. This seems to be about the equivalent of the Fort Benton division.

VERTEBRATA.

In the sandy layers above the lignite in the Rio Puerco and also east of the Sandias at the same horizon are numerous teeth of sharks, among them specimens of Otodus as figured by Cope on Plate XXII of his Extinct Vertebrata of New Mexico. Part of the carapace of a turtle was found in the same beds.

PLANTAE.

Numerous plant remains are found in the shales accompanying the lignite in the series above the Punta de la Mesa sandstone, but it does not seem desirable to attempt to discuss them at present. They do not seem to be of the Laramie flora and there are numerous marine fossils in the sandstone above the lignite belonging to the Fox Hills fauna and closely resembling the fauna from the Punta de la Mesa itself.

THE PERMIAN.

Review of the Literature.

D. W. JOHNSON.

Before referring to the work done in the Permian of New Mexico it may be well to review the literature hitherto published on the Permian of various localities at home and abroad. Probably no geologic age has claimed more attention and given rise to more bitter controversies in recent years than has the Permian. The fact that the Permian is essentially a transition period accounts for much of this lack of unanimity of opinion, while the scarcity of fossil remains increases the difficulty of accurate correlations. Some geologists have sought to escape these difficulties by abandoning the Permian system altogether, merging it with the Carboniferous. But the fine development of this system in various localities, and especially in the Texas beds in this country, shows that the Permian is a great and widely distributed system, even though the scarcity of palaeontological evidence often renders it difficult of identification.

Palaeontologically the Permian is most closely related to the Palaeozoic rocks, and most geologists have followed Murchison in regarding it as belonging to the Palaeozoic era. The fact that Marcou and others have classed it as Mesozoic has been explained as the result of a mistaken idea that Murchison included in his Permian a large part of the Triassic.[1]

Stratigraphically the Permian is more closely allied to the Carboniferous in some localities, and to the Triassic in others. In some portions of the west it would appear that there had been continuous sedimentation from the Carboniferous through the Permian into the Triassic. Without entering further into the discussion of the correlation of the Permian with the Palaeozoic or Mesozoic, we prefer to follow the lead of those who place it in the former era.

Permian in Russia and India.

In 1841 Sir Roderick Murchison carried on extensive studies of the rocks of Russia, and proposed the establishment of the Permian system, named for the ancient kingdom of Perm, to include the later Palaeozoic rocks. This system is well defined and extensively studied in Europe. In India, Waagen has made an extensive study of the Permian, and described it more elaborately than any other writer. He divides the system into three groups,—Permo-Carboniferous, Rothliegendes and Magnesian

[1] Notes on the Geology of Northwestern Texas, W. F. Cummins, 4th Ann. Rep. Geol. Surv. of Texas, p. 213.

Limestone, placing the red and gray sandstones and shales of Nebraska City under the second, and the Wichita division (Cummins) of Texas at the base of the third.

United States.

In the United States the Permian apparently occupies a place in the geological chronology not represented by any strata in Europe. Hence all attempts to correlate the Permian of this country with that of Europe have proven futile.[1] Permian was first reported from this country by Jules Marcou in 1853, west of Zuñi in Arizona, and in Indian Territory.

In *West Virginia* and *Pennsylvania* over 1000 feet of the Upper Barren Measures (1044 feet in Monongalia county, West Virginia) have been referred to the Permian upon evidence of the flora. The beds are there known as the Dunkard Creek Series, and are conformable with the lower series.[2] The Wasatch Section, *Utah*, constructed by the Geological Survey of the 40th Parallel, shows 30,000 feet of conformable strata of which the upper 650 feet, characterized by clays, marls and limstones, have been referred to the Permian.[3] The Kanab Section, *Arizona*, constructed by Walcott, shows 710 feet of Upper Permian characterized by gypsiferous and sandy shales and marls, with impure shaley limstone at the base. Also 145 feet of Lower Permian, characterized by more massive limestones.[4] Permian has also been studied in Illinois, Indiana, Nebraska, Missouri and Indian Territory. Also in Nova Scotia, New Brunswick and Prince Edward's Island. But in Kansas and Texas the work done in the Permian is so extensive and important as to deserve a more detailed account.

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[1] 4th Ann. Rep. Geol. Surv. of Texas, p. 220.

[2] Bull 65, U. S. Geol. Surv., Chap. II, p. 20. Also 2nd Geol. Surv. of Penn. Report P. P., Chap. III, pp. 105, 120.

[3] 3rd Ann. Rep. U. S. Geol. Surv. '81-'82.

[4] 3rd Ann. Rep. U. S. Geol. Surv., '81-'82.

Permian in Kansas.

Professor Prosser in his "Classification of the Upper Palaeozoic Rocks of Central Kansas"[1] has reviewed the work of Swallow and Hawn, Meek and Hayden, Newberry and others, the earlier writers on the Permian of Kansas. Shumard, Hitchcock and Marcou described rocks in the Canadian-Red River district which have been correlated with the Cimarron Series of Kansas, Marcou referring them to the Permian and Triassic, and Shumard and Hitchcock to the Carboniferous.[2] Beds still higher in the series were studied by Prof. St. John in 1886, and referred doubtfully to the Triassic. The later excellent reports on the Permian of Kansas by F. W. Cragin and C. S. Prosser are referred to more in detail below.

Professor Cragin gives the following:

"*Classification of the Rocks of the Permian System in Kansas.*"

II. Cimarron Series, 1100 to 1250 feet.

Divisions.	Formations.
Kiger, 250 feet.	Big Basin Sandstone, 12 feet or less. Hackberry Shales, 15-20 feet. Day Creek Dolomite, 1-5 feet. Red Bluff Standstones, 175-200 feet. Dog Creek Shales, 30 feet.
Salt Forks, 900-1000 feet.	Cave Creek Gypsum, 50 feet. Flowerpot Shales, 150 feet. Cedar Hills Sandstones, 50 to 75 feet. Salt Plain Measures, 155 feet or more Harper Sandstones, 650 feet.
	I. Big Blue Series, 900 to 1100 feet.
Sumner, 550-800 feet.	Wellington Shales, 250-450 feet. Geuda Salt Measures, 300-400 feet.
Flint Hills, 400 feet.	Chase Limestones (Prosser), 265 feet. Neosho Shales (Prosser), 130 feet.

The following generalized section is compiled from Professor Cragin's article in Vol. VI, Colorado College Studies:

[1] Jour. Geol. Vol. III, Nos. 6 and 7, 1895.

[2] Colorado College Studies, Vol. VI, p. 1.

Cretaceous --

Cimarron Series.	Kiger Division	Big Basin Sands	Sandstone, red and greyish white.
		Hackberry Shales	Maroon colored shales.
		Day Creek Dolomite	Dolomite.
		Red Bluff Sands	Light red sands and shales.
		Dog Creek Shales	Dull red argillaceous shales with 2 ledges of unevenly lithified dolomite in upper part.
	Salt Fork Division	Cave Creek Gypsum	Gypsum (Medicine Lodge). Red clay shale. Gypsum.
		Flowerpot Shales	Gypsiferous clays, variegated colors, red prevailing.
		Cedar Hills Sands	Massive concretionary, fine grained, bright red sandstones.
		Salt Plains	Red shales, some sandstones, with saline impregnations.
		Harper Sands	Brownish red argillaceous and arenaceous sands and shales. Copper carbonate occurs.
Big Blue Series.	Sumner Division	Wellington Shales	Bluish grey shales, with beds of impure lime, gypsum and dolomite.
		Geuda Salt Measures	Shales of variegated colors, also gypsum, rock. salt, gypsiferous shales, thin lime beds.
	Flint Hills Division	Chase	Some shales, massive lime, including three zones of flinty lime.
		Neosho	Shales and thin bedded, often marly, lime.

A few feet lower is the Fusulina lime of Swallow.

As will be seen, Professor Cragin places all of the Red Beds, or Cimarron Series of Kansas in the Permian, and recognizes no Jura-Trias. For a detailed account of the former series, see Professor Cragin's paper on "The Permian System in Kansas," Colorado College Studies, Vol. VI, 1896. Professor Prosser, in a series of excellent papers on the subject, gives the following :

"*Classification of the Upper Palaeozoic Rocks of Kansas.*"

Cretaceous --

		Division.	
Permian.	Cimarron Series 1150-1400 feet	Kiger	Sands, shales, dolomite ; red color prevailing.
		Cave Creek Gypsum	Gypsum and shales.
		Salt Fork	Shales and sands, red color prevailing.
		Wellington 200-450 feet	Shales.
		Marion	Colored shales and marls. Marls and shales with gypsum. Thin buff lime and shales.
	Permo-Carb.	Chase 265 feet.	Massive limes and flint, beds of variegated shales. Three flint horizons.
		Neosho 130 feet	Grey lime and variegated shales.
Upper Coal Measures.		Cottonwood 20 feet	Yellowish calcareous shales. Cottonwood, Alma or Manhattan stone, a massive yellowish to light grey lime.
		Wabaunsee 575 feet	Massive lime, calcareous and argillaceous and arenaceous shales, occasional thin stratum of coal.

. . . . . .

Missouri formation (?) of Keyes.

The Geuda Salt Measures of Cragin are correlated with the Marion of Prosser. Professor Prosser objected to the ten divisions of the Cimarron Series as made by Cragin, on the ground that the differences between the numerous formations were largely local, and could not be recognized over any considerable extent of territory.[1] He regarded the two *divisions* of Cragin as *formations*, and assumed the Cave Creek Gypsum as the dividing line between the two. The Big Basin Sandstone, the uppermost formation of Cragin's Permian, is correlated by Prosser with the Comanche.[2] He follows Cragin in referring all the Red Beds to the Permian.

The Cretaceous and Tertiary in Kansas are unconformable on the Red Beds, while in some places the whole Cimarron

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[1] Kansas Geol. Surv., Vol. II.

[2] Kansas Geol. Surv., Vol. II.

Series is lacking and the Dakota sandstone is deposited unconformably on the lower formations of the above classifications. The line between the Upper Coal Measures and the Permian or Permo-Carboniferous is arbitrarily drawn, and is based wholly on palaeontological evidence, the strata being conformable.

Concerning the age of the Cimarron Series of Kansas much has been written. It has been referred in turn to Permian, Permo-Trias, Jura-Trias, Triassic, and even to Cretaceous. Prof. Cragin correlated the Kansas Cimarron Series with the Texas Permian, and Prof. Prosser accepted this correlation, provisionally. In a more recent paper Dr. Williston says, "That these red beds are not contemporaneous with the Texas Permian would seem assured, and I feel yet more confident that they are what they were first considered to be, of Triassic age." Prof. Grimsley regards the Red Beds as marking the transition from the Permian to the Cretaceous. Mr. Vaughan, of the U. S. Geological Survey, studying the Upper Palaeozoic and Cretaceous of Oklahoma and Indian Territories and Southern Kansas, spoke of the Red Beds as Permo-Trias. In several localities fossils have recently been found in the Red Beds, and it may not be long before the question as to the age of this series will be definitely settled.

Permian in Texas.

The finest development of the Permian system of this country is found in Texas. As defined by Professor W. F. Cummins it includes "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." (In a more recent paper Prof. Cummins states that the Albany Beds have proved to be but another phase of the Wichita Beds, or lower Permian. The dividing line between the Permian and Coal Measures then becomes the contact of the Cisco division with the overlying Wichita—or Albany—Beds.) The rocks of the series in Texas are similar to those of the Kansas Permian, comprising limestones, sandstones, shales, red and blue clays, and gypsum beds. As in Kansas, there is a slight difference in dip between the older and later strata in the same series, while the Permian is conformable with the Coal Measures below, and unconformable with the Triassic above. The Permian in Texas attains a thickness of at least five thousand feet.

Permian was first reported in Texas by Jules Marcou in 1853-54.[1] Dr. William De Ryee (1868), Prof. Jacob Boll (1880), Prof. C. G. Broadhead, Prof. E. D. Cope, and Dr. C. A. White referred the Texas beds to the Permian, while Prof. Edward Hitchcock in a report based on the notes of Capt. Marcy's exploration of the Red River in 1852 referred them to the Cretaceous.[2]

Prof. Cummins divides the Permian of Texas into three divisions, under the names of Wichita Beds, Clear Fork Beds, and Double Mountain Beds. The Wichita Beds (1800 feet) are composed of sandstones, clay beds and a peculiar conglomerate, while the portion formerly referred to the Coal Measures under the name of Albany Beds, consists largely of limestones and clays. The Clear Fork Beds (1975 feet) are composed of limestones, clay and shale beds, and sandstones, and the Double Mountain Beds (2075 feet) of sandstones, limestones, sandy shales, red and bluish clays, and thick beds of gypsum.

The Shinarump Conglomerate of Major Powell, which Mr. C. D. Walcott places as the divisional line between the Permian and Triassic, seems to be a very constant horizon, and is reported by Dutton from the Grand Cañon district. Prof. Cummins adopts this horizon as the line between the Permian and Triassic of north-western Texas.

Fossils have been found in all three divisions of the Red Beds of Texas, Triassic types occurring in the lower beds along with Coal Measure and Permian forms, while characteristic Permian forms have been found within 300 feet of the top of the Double Mountain Beds. No systematic attempt has been made to correlate these beds with strata in other localities, although

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[1] Texas Geol. Surv., 2nd Ann. Rep. p. 398.

[2] Texas Geol. Surv., 2nd Ann. Rep. p. 400.

Prof. Cummins in a paper read before the Texas Academy of Science, June 15, 1897, says, "The *Phacoceras dumblei*, Hyatt, has been found only along a very narrow horizon in the Texas Permian. . . This fact will assist materially in correlating the Texas and Kansas beds, as that fossil has been reported only from one locality in the Kansas area, where it is associated with the same fossils as in Texas. It is quite certain that the Fort Riley horizon is the same as the Wichita division of Texas, and is at the very top of the division. With one horizon definitely established, it will be easy enough to correlate the other parts of the formation in the two areas."

An extended discussion of the Red Series is not necessary in this place as we have recently printed extended descriptions of the surface geology of the Red Series as seen in the region of the white sands in Otero county (current volume of the Journal of Geology) and also an article covering the present region in the American Geologist. From these it will be gathered that the three-fold division of the series is sustained and that on paleontological evidence the lower division (red beds proper) may be assigned to the Permian. The gypsum is often the upper limit of these beds though evidence is lacking to prove that it is constant in position where present. The chocolate division we assign to the Triassic solely on stratigraphical grounds and similarly assign the upper loose marls and sands (vermilion beds) to the Jurassic. The correlated sections (Plate XLVIII) will illustrate the sequence. On the Albuquerque sheet very limited portions of the Red Series appear. The vermilion beds occur in the valleys at north-western portion beneath the Cretaceous. Everywhere the saline and gypsiferous character is preserved and the region south and west of the Jemes mountains is a good illustration of the lurid colors and desolate landscape of the saline areas. Along the fault line west of the north-west corner of the Albuquerque mesa a low series of hills lying east of the fault line and consisting of red and white sandstone tilted sharply to the east represents a metamorphic portion of the Red Series but the sequence cannot be made out with certainty.

The Fauna of the Pleistocene.

Little has been done in the collection of material for the study of the fossil remains of the pleistocene period. From many parts of the territory remains of the mammoth have been collected. In depressions of the great San Augustine plains east of Datil large numbers of teeth and bones are found where the great mammals were mired while drinking. It would appear that the period during which these elephants roamed our plains has not long passed. In the flood plain of the Rio Grande near Bernalillo several teeth have been found and one fine example is in the university museum. Several small gasteropod shells were taken from the river clays near Algodones and among these Mr. E. H. Ashman identified Sacciura overa, Say and Leucocheila fallox, Say. Doubtless many interesting forms will reward a diligent search.

Petrography.

In the region covered by the map there are comparatively few eruptive rocks and these belong to the later series.

Basalts.

Remarkable uniformity characterizes the basalts of this region though they pass from the extreme of scoriaceous to massive and amygdaloidal types. The chemical composition seems to have been very constant. Dutton and other writers report two distinct periods of basaltic flow but we have so far encountered no evidence of such an interval between the later and earlier flows as he indicates, in this region. The flows are all post-Tertiary and well preserved. Successive flows occurred and intervals are filled with volcanic sand and tufa but there is no evidence of long periods intervening.

1. *Basalt from the Albuquerque volcanoes.* These cones, as described above, are conspicuous features in the landscape as seen from Albuquerque and break the uniformity of the western horizon.

The sample is somewhat vesicular but between the blebs the structure is compact and but slightly amygdaloidal. The color is black to dark brown with small phenocrysts of plagioclase and grains of olivine. In the section the largest elements are polysomatic grains of the plagioclase with conspicuous albite twins. The mineral is fresh and in definite crystal form. The extinction angle at right angle to the albite twinning plane is near 35° and indicates a composition like anorthite but the optical behavior is negative and the high colors of polarization suggest laboradorite. Smaller lath-shaped crystals of plagioclase fill the deep colored magma. Next to the first order plagioclase, the most conspicuous elements in the section are the brilliantly polarizing grains of olivine some of which preserve their crystalline form. The olivine is remarkably fresh and contains few inclusions. The augite which is of the basaltic type plays a very insignificant rôle being restricted to grains scattered in the interstices of the small plagioclase crystals. The magma is granular and opaque and contains much magnetite and brown suffusions. Amygdules of isotropous and amorphous materials occur sparingly.

In order to show the extremes of structure the following descriptions are appended derived from basalts found along the Rio Grande east of the Cochiti range selected to show the latest and earliest of several flows at that place. It will be seen that there is evidence of some alteration in the lower member. The intervals are irregularly filled with volcanic and scoriaceous material.

No. 495. Lowest Member of a Series of Basaltic Flows in White Cañon, south-west of Santa Fé. A somewhat vesicular massive basalt with numerous spots of reddish decomposition, imparting a rusty color to the entire rock, strongly contrasting with the fresh and glossy black appearance of the upper flows of the same series. In many places large zeolitic inclusions occur, having a radiated structure and a whitish or greenish color, which determines it, apparently, as analcite. The less altered portions show the feldspathic elements to be unaltered. The whole crystalline body of the rock is made up chiefly of plagioclase of two distinct orders. Those of the first order are large, well-formed crystals, exceeding those of the magma many times in size. These larger crystals are mostly fresh and unaltered, with high extinction angles, suggesting anorthite. The twinning phenomena are very well developed, according to both the Albite and Carlsbad laws. The mass of the rock, however, is made up of small, lath-shaped crystals, having the same optical characters as those first described. These smaller crystals betray a tendency to a fluidal arrangement, and the larger plagioclases are sometimes broken by transverse fracture lines, apparently as the result of internal tension. Next in point of abundance are scattered irregular crystalline grains, often in polysomatic groups, which are of an intense red color and permeated by irregular crevices. This mineral polarizes in shades of red and brown, behaving much like hematite. In a few cases there is a suggestion of the original olivine. The augite consists of minute scattered grains in the interstices of the second order of plagioclases. Grains of magnetite are freely scattered throughout the section. The cavities are frequently partially filled in with amorphous material.

No. 504. Massive portion of the uppermost flow at White Rock Cañon. Hand-sample an intensely black, homogenous rock with a splintery fracture and occasional gas pores. To the unaided eye, the ingredients appear quite unaltered. Portions of this flow are laminated and break into schistose fragments. Thin section densely sprinkled with minute black granules, giving to the section a peculiar opaque character. The largest ingredients are well formed, tabular crystals appearing in section as elongated rectangles, having a rough surface, brilliant polarization, and intersected by conchoidal crevices, tending to lie transversely to the longer axis. These crystals are often much broken and penetrated by the magma. The sections extinguish parallel to the longer axis and are little altered or decomposed, and constitute a remarkable occurrence of olivine. Occasional crystals of the same material have truncated planes. Plagioclase is abundant in crystals of two orders: the larger being very generally corroded and filled with intersections of the ground mass and particularly augite grains; the plagioclase of the second order is in small, lath-shaped crystals, is less altered, and forms the bulk of the section. Both series seem to be of anorthite. The augite, as in the preceding instances, is chiefly in scattered grains; although larger crystals are not wanting. Magnetic iron is scattered throughout the ground mass; and, in a few instances, hematite is encountered. The granular suffusion from the ground mass renders a minute study of the rock difficult.

Isolated Trachyte Cones in the Rio Grande Valley.

The isolated volcanoes of the Rio Grande valley are nearly all basaltic and it has usually been assumed that all such minor peaks are of this character. After noticing that there are at least two classes as regards the relation of these lavas to the Tertiary strata of the valley the enquiry was natural whether there might not be a distinction in composition between those that are found in connection with superficial flows and those that have been buried under Tertiary sands and marls. The larger ranges like the Socorro and Limitars toward the close of their active existence passed through a trachyte-rhyolite stage and rocks of the silicious series are found perforating the earlier andesites but the apparent relations of the small isolated volcanoes spoken of is with the recent basalts and it is not always easy to determine a difference between the materials and those of altered portions of the basalt cones.

An instance of such a buried cone is afforded by a volcanic cone on the west side of the Tertiary mesa west of the Rio Grande opposite Albuquerque. This hill has evidently been buried by the material of which this mesa was formed and has been re-excavated by the Rio Puerco. Unlike the recent volcanoes on the east side of the mesa on the banks of the Rio Grande, some six miles distant, this cone is not associated with superficial flows but all such evidences of overflow have been removed by erosion, apparently prior to the deposition of the Tertiary sands and marls. The subsequent denudation has left exposed the irrregular neck and boss-like protrusions from the base.

A considerable variety in the rock is apparent to the eye and the relations of the intrusive to the surrounding stratified rocks may prove a matter of much interest. The latter are sandstones usually of a whitish color but, where in contact with the igneous rocks, often greatly reddened and altered. The mutual influence of the two elements is seen on the one hand in the production of jasper and other forms of silica, and on the other by the hastened decomposition of the igneous rock. This volcano is marked on the land office map as "red sandstone hill." The typical rock of the series is a red trachyte, number 577. This sample is taken from a large boss near the base but is characteristic of the main elevation as well. The hand sample is of a purplish to brownish red or reddish grey color with yellowish flecks and glistening phenocrysts of feldspar. Phases of the rock are a deep brick red. The texture is rough, with numerous small irregular openings and spongy portions. Evidence of some disintegration of the feldspars is patent to the unaided eye.

The section is fairly typical of a trachyte without free quartz but with feldspars of two or three orders, and a small amount of scattered mica. The largest crystals are of relatively little altered plagioclase usually occurring in large polysómatic groups. These are not numerous but are very striking. The measured angles on either side the twinning plane were 14–16 and 15–17 in the two cases where most satisfactory readings were taken, suggesting, in connection with the association, albite and with this agrees the positive optical behavior. Next in order of size are orthoclase crystals which tend to be much altered and filled with interpositions. Some of these crystals seem to be almost completely altered to a granular material but they have not lost the polarization nor twinning phenomena. Frequently the vacuolization and interpenetration of the orthoclase has only proceeded to an irregular area in the centre of the crystal where the substance is unaltered. In other cases the alteration zone is strictly limited to a band near the periphery of the crystal. Zonary structure, which in some cases simulates the plagioclase twinning, is frequent and seems to pertain to the albite. The smaller rods which fill the magma seem to be chiefly orthoclase though plagioclase twinning can be seen in many of them and it is probably unsafe to draw definite conclusions from the absence of such twinning in small crystals. Next in importance is the bronze mica which occurs both in large crystals and smaller scales, but neither is abundant. In the smaller scales the mica is nearly completely altered. Iron lined cavities with ribs of the iron preserve the outlines of what may have been hornblende crystals but no recognizable specimens were seen. The granular magma is pale red or yellowish, evidently iron-stained. Scattered magnetite is present throughout the section.

No. 574 from the central portion of the peak is a typical trachyte but evidently has suffered much alteration. Kaolinization of the feldspar is apparent to the eye while the mica stands out in evident scales. The section bears out the testimony of the hand sample. The mica is in delicate, often flexuous plates and polarizes with almost unexampled brilliancy. The feldspars are mostly altered, often leaving cavities filled with kaolin, or if not so completely altered, the polarization is lowered so that the transparent contents react almost as if isotropous. Orthoclase is the only identifiable feldspar.

Number 578 is a very porous light-colored rock lying near the contact with the penetrated sandstone. The disintegration has been very complete so that the orthoclase has been nearly wholly removed leaving cavities that are usually unfilled. Under the microscope a few grains of the orthoclase remain visible and mica flakes are scattered through the relatively homogeneous magma. The dark ingredients are in minute dots in the magma and the magnitite is less abundant. The micas are paler and less pleochroic than in number 577.

Number 576 is a very light brecciated phase near the sandstone and is like the above in a highly disintegrated state. The mica is nearly entirely altered to a black aggregate.

Several other sections of various phases of these rocks show not only stages in the process of disintegration but show that proximity to the country rock was a very important element in that process. A section of the sandstone adjacent to the cone, which is a moderately coarse white sandstone apparently of Cretaceous age, exhibits rounded grains of quartz mixed with similar grains of orthoclase having the twinning and other optical characters well preserved. Some of the feldspars have undergone saussurritic disintegration while others are quite clear. The abundant cement is a reddish brown (ferrugineous) material but seems only to impart a yellowish cast to the hand sample. Occasionally the feldspars preserve the rectangular contours of the cleavage fragments.

Rio Grande and Rio Puerco Flood Plains.

The flood plains of the Rio Grande and Rio Puerco contain many thousands of acres capable of cultivation. This land is of inexhaustable fertility and is adapted to the production of a fine variety of fruits and vegetables. It is especially adapted to the raising of alfalfa and grain. When the new irrigation now in process of construction shall be complete it is estimated that it will bring over 20,000 acres under irrigation between Algadones and Albuquerque and the same system will be extended southward to Isleta. An organization has been affected for the establishment of a reservoir system in the Rio Puerco valley. The great difficulty here will be the enormous amount silt which would tend rapidly to fill and so destroy any reservoir system. The land is remarkably fertile and the presence of lignite and probable existence of oil will ultimately make this a prosperous region.

For the following notes on building materials and practice we are indebted to architect C. E. Cristy.

Building Materials.

The materials used for building in Albuquerque consist of wood, stone, brick and adobe.

Dimension lumber is brought from the saw mills about Albuquerque and also from Glorieta and in special cases Oregon pine is brought in. Some of the finishing lumber comes from Chicago, some from Arizona and some from California. Most of the sash and doors come from Chicago. California redwood shingles are entensively used.

In the mountains east of the city is found an abundance of granite building rock that is used for foundations but it is so hard that the difficulty of dressing it prohibits its use in anything but ordinary rubble work and door sills. Sandstone may be obtained in any quantity and of various qualities and colors within a comparatively short radius from the city.

As to the brick problem, it has not yet been solved to the satisfaction of those who have given long years to the faithful study of the clays and the best way of mixing them and the drying and burning of the brick. Most of the brick buildings are built of a hand made mud brick, the fuel for burning being wood. There are some buildings faced with a handsome pressed brick, brought from either Kansas City or Golden. A sample of Santa Fé brick has been shown here but at this date there are no completed buildings made from it. Socorro bricks are coming more into favor because of the improvement in the evenness of their color. They have always received the highest award as a hard, homogenous, well-burnt brick, but the uneven color has been against them. Once this is overcome they will furnish as fine a building material as could be asked for.

Adobe is made from a clay that is wet and pressed into moulds, the usual size being 4x8x16 inches. They are turned from the moulds upon the ground and sun dried. Sometimes straw is put into the mud. These adobes are laid up, for the most part, in mud mortar and plastered over with the same material; but in some cases they are laid up in lime mortar and plastered. The outside walls are made 16 inches thick while the inside partitions are laid the eight inch way.

A good supply of fresh burnt lime can be had from kilns near the city and any standard brand of plaster can be obtained through local dealers. Frame houses, properly built are very comfortable and durable but where the siding is put directly on the studs and the sills rest on posts the result is a very hot summer house and a cold winter one. In brick veneer houses the same may be said, that is, if properly constructed they make a fine appearing structure and are perfectly solid; the unseemly cracks showing in some cases are due to faulty construction and not to our material. A comfortable but expensive method has been used where an adobe house has been completely sided, making a cool interior, and giving to the exterior the appearance of a frame structure.

Thus it may be seen that while we have not the unlimited variety of building materials that are to be found in larger, older cities, yet we are not without a choice when the amount to be expended is commensurate with the requirements of the proposed building.

To the above we may add a few notes upon building materials :

Clay. Little has so far been done in the study of our clays but enough is known to make it clear that the territory is well supplied with clay for all purposes. The base of the brick so far made in the Rio Grande valley is what is locally called asequia clay, that is clay collected in the flood plain. There is the greatest diversity in different deposits due to the fact that at different stages of water material is brought in from different tributaries as thus in one case a clay high in clay base may be deposited while in another the alkalis may be dangerously high. Disintegration of the trachyte tufas make a very fusible clay while many of the clays are highly siliceous. The color is also variable even in adjacent beds so that the one may furnish the material for a light buff or cream brick and an adjacent one for a red or brown brick. In the neighborhood of Albuquerque, clays are derived from two sources. First, the flood plain or asequia clay beds and, second the mesa beds. The latter are very pulverant and crumble easily but have a dark color in local favor. The mesa clays, however, contain large quantities of marl in fragments of various size and as no pains is taken to screen the clay the lumps of lime disintegrate on the addition of water and the bricks burst. This "popping" is a constant source of disfigurement and will result in destroying some expensive buildings which, through the criminal neglect of the builders, have been constructed of such material. The mesa clay is sometimes used to temper the asequia clay and by this means the color is heightened. When screened to remove the marls the addition is unobjectionable but the color desired may be secured by adding iron oxide in the form of one of the red earths on the market. The natural color of the best flood plain clays is a rather pretty "golden buff" but other clays in the same flat where thoroughly impregnated by alkali produce a white or creamy buff brick. One serious objection to all the brick burned from the valley clays grows out of the discoloration in burning. In those parts of the brick exposed to the air in drying or in a kiln a white crust or film is formed which gathers on the exposed surface in an irregular and most disfiguring manner. Finger marks where pressure was brought to bear on the brick while wet will be discolored in the same way. The discoloration has ruined the sale of otherwise perfect brick for many years in the Rio Grande valley. The film has been supposed to be due to fumes in the kiln during burning but it is noticeable that the color is worse in pressed brick and that the brick exposed to rapid drying or to the moist vapors in the kiln are the most seriously affected. Where the brick are covered or protect each other the color is absent. Where brick have been made from the mesa marl, as has been attempted in ignorance of the composition, the whole kiln will be affected. On the newly scraped clay beds the efflorescence appears in a few hours and in the neighborhood of the clay for white brick shallow pools are saturated with saline and alkaline materials composed of chloride of sodium, chloride of potassium, sulphate of soda, sulphate of potassium (?), nitrate of potassium and calcium chloride (?). The nitre is quite abundant in some cases. The same difficulty has been encountered at Socorro where the brick are of excellent quality otherwise. The clay of the flood plain is tempered with from one third to two thirds sand, being an excess but apparently necessary in these cases. The heat is estimated by the kiln men at about 1200 degrees and they state that fusion takes place at about 1300 degrees. The addition of some good clay base would improve the product and such material would be found in the Cretaceous clays on the Rio Puerco or perhaps near Coyote cañon. Kaolin such as is used at Socorro seems not to be within reach at Albuquerque. This material is found in Socorro mountains for example as the product of interaction between the andesites and the overlying trachyte. At Socorro also are found very good clays in a peculiar zone of the Carboniferous. Fire clay beds are found in immediate proximity to shales with lepidodendrids like those shown in Plate XXXIII. Red clays from the Permian or Jura-triassic also supply a useful variant. At Las Vegas the bluish shales of the Cretaceous form an excellent base for a light red or buff brick although precaution is necessary to remove the bands of pyrites and fat clay to prevent discoloration. The following analyses of local clays will be useful. The analysis of clay No. 24 shows it to contain excess of clay base and it would probably be a useful addition to many asequia clays. Only small quantities would be needed as it is deficient in free silica.

Number	22	23	24	789	667	515	496	495
Silica, free	48.33	21.54	9 47					
Silica, combined	28.21	49.12	50 22	64.02	29.72	60.76	44.48	49
Alumina	5.90	14.58	22.26	17.34	11.94	19 69	26.32	20.82
Iron (Fe_2O_3)	3.41	.84	2.07					
Magnesia	trace	——		1.06	1.83	.79	4.43	3.48
Lime (CaO)	1.54	4.75	3.83	1.98	32.11	5.87	13.15	9.61
Water combined	2.	2.75	3.85					
Moisture	4 28	(1.04)	(6.4)					
Carbon dioxide	3.16	.67	2.26					
Potassium	2.43	2.41	2.35					
Sodium	.80	.68	.84					
Clorine			2.53					
SO_3			trace					
Iron Fe_3O_4				5.72		7.54	11.03	13.67
Iron FeO					26.48			
	100.06	100.18	99.68					

Analyzed by D. W. Johnson.

No. 22. Asequia clay from Old Albuquerque. Hon. E. S. Stover.

No. 23. Asequia clay from Buttman's pits. With marl nodules.

No. 24. Red clay (Tertiary) from Bernalillo.

No. 789. Supposed lava containing corn. Fused adobe.

Nos. 667, 515, 496, 495. Partial analyses of basalts from White Rock Cañon.

No. 667. Slag from Rio Grande smelter.

DESCRIPTION OF PLATES.

PLATE XXVII.

Figs. 1-2. Buchiceras swallovi, Shumard. Dorsal and lateral views of gibbous form.

Figs. 3-4. Buchiceras swallovi, var. puercoensis, var. n. Dorsal and ventral views. Both forms occur in septaria concretions of the Colorado formation in the Rio Puerco valley.

PLATE XXVIII.

Fig. 1. Prionocyclus woolgari, Mantell. Sandstones north-east of San Francisco in Rio Puerco valley. Tres Hermanos sandstone above gasteropod zone.

Figs. 2-3. Placenticeras costatus, sp. n. From septaria concretions near Punta de la Mesa, Rio Puerco valley.

Fig. 4. Harpa? occidentalis, sp. n. East of Sandia mountains.

Fig. 5. Undetermined gasteropod.

Fig. 6. Turritella whitei, Stanton.

PLATE XXIX.

Fig. 1. Rostellites ambigua, Stanton.

Fig. 2. Volutomorpha (?) nova-mexicana, sp. n. Una de Gato.

Figs. 3 and 5. Rostellites dalli, Stanton. Fox Hills group.

Fig. 4. Vanikorpsis tuomeyana M. and H. Fox Hills.

Fig. 6.

Figs. 7, a and 6. Gyrodes depressa, Meek. Fox Hills strata.

Fig. 8. Ostrea franklini, Coquand?

Fig. 9. Cf. Ostrea translucida, M. and H. See Plate XXIV, Figs. 7-10. Gasteropod zone below Tres Hermanos sandstone.

PLATE XXX.

Fig. 1. Inoceramus fragilis, H. and M.

Fig. 2. Inoceramus sp. Caballo mountains.

Fig. 3. Gryphaea vesicularis, Lam.

Fig. 4. Inoceramus fragilis? hinge view. Fox Hills.

Fig. 5. Mactra pulchella, sp. n.

Figs. 6 and 7. Caryates veta, Whitfield. Septaria concretions.

Fig. 8. Ostrea sp.

PLATE XXXI.

Fig. 1. Pinna petrina, White. Septaria concretions.

Fig. 2. "

Fig. 3. "

Fig. 4. "

All the figures are one half natural size.

PLATE XXXII.

Figs. 1, 2. Pholadomya subventricosa, M. and H.

Figs. 3, 4.

Fig. 5. Tellina (?) perlata, sp. n. Fox Hills group. East of San Antonio.

Figs. 6, 7. Tapes cyrimeroformis, Stanton. Septaria concretions.

PLATE XXXIII.

Fig. 1. Lepidodendron sp.

Fig. 2. Lepidodendron sp.

Fig. 3. Lepidodendron sp.

Fig. 4. Lepidodendron sp.

The above are all derived from fire clay beds east of Socorro.

Fig. 5. Liopistha concentrica, Stanton. This is the form described by Stanton as L. elongata.

Fig. 6. Mactra formosa, Meek.

Fig. 7. Ostrea translucida (?)

Fig. 8. Rostellites dalli, Stanton.

Fig. 9. Pyropsis bairdi, M. and H.

Fig. 10. Unidentified.

Fig. 11. Cardium pauperculum, Meek.

Fig. 12. Unidentified. Figs. 5-12, inclusive, are from sandstones adjacent to the coal at Carthage.

PLATE XXXIV.

Figs. 1, 2. Ostrea glabra, White. Shales east of Caballo mountains. Laramie?

Figs. 3, 4. Inoceramus fragilis, H. and M.? Casts of interior. Sandstone at Punta de la Mesa, near San Ignatio.

Fig. 5. Inoceramus fragilis? Same locality as above.

Fig. 6. Pyropsis bairdi, M. and H. Above lignite beds. Sandstone east of Punta de la Mesa.

Figs. 7-10. Ostrea translucida, M. and H. Different individuals as casts of the interior. Gasteropod zone below Tres Hermanos sandstone. Rio Puerco valley.

PLATE XXXV.

Fig. 1. Cardium sp. Upper Fox Hills.

Figs. 2-7. Idonearca (?) depressa, White. Upper Fox Hills. Rio Puerco valley.

PLATE XXXVI.

Figs. 1, 2. Plicatula hydrotheca, White. Views of opposite valves.

Figs. 3, 4. Plicatula arenaria, Meek. Under and upper valves.

Fig. 5. Lima utahensis, Stanton. Cast of large left valve.

Fig. 6. Camptonectes platessa, White. Right valve.

Figs. 7-10. Avicula gastrodes, Meek.

PLATE XXXVII.

Fig. 1. Inoceramus deformis, Meek.
Fig. 2. Inoceramus labiatus, Schloth.
Fig. 3. Inoceramus gilberti, White.

PLATE XXXVIII.

Figs. 1-4. Barbatia micronema, Meek (sp.).
Fig. 5. Nemodon sulcatinus, E. and S.
Figs. 6, 7. Goldia subelliptica, Stanton.
Fig. 8. Solemya? obscura, Stanton.
Fig. 9. Nucula coloradoensis, Stanton.
Figs. 10-13. Crassatella excavata, Stanton.

PLATE XXXIX.

Figs. 1-3. Cyrena securis, Meek.
Fig. 4. Cyrena sp.
Fig. 5. Veniella goniophora, Meek.
Figs. 6-9. Veniella mortoni, M. and H.

PLATE XL.

Fig. 1. Donax cuneata, Stanton.
Fig. 2. Donax oblonga, Stanton.
Fig. 3. Tellina modesta, Meek.
Figs. 4-7. Tellina (Palæomœra) whitei, Stanton.
Fig. 8. Tellina isonema, Meek.
Fig. 9. Tellina (?) subalata, Meek.
Figs. 10-11. Siliqua huerfanensis, Stanton.
Figs. 12-13. Pharella ? pealei, Meek.

PLATE XLI.

Fig. 1. Pholadomya papyracea, M. and H.
Fig. 2. Pholadomya coloradoensis, Stanton.
Figs. 3-4. Anatina lineata, Stanton.
Figs. 5-7. Liopistha (Psilomya) meeki, White.
Figs. 8-10. Liopistha concentrica, Stanton.
Figs. 11-12. Liopistha (Psilomya) elongata, Stanton.

PLATE XLII.

Fig. 1. Amauropsis utahensis, White.
Figs. 2-4. Amauropsis bulbiformis, Sowerby.
Figs. 5-6. Sigaretus (Eunaticina) textiles, Stanton.
Figs. 7-8. Mesostoma occidentalis, Stanton.
Fig. 9. Eulimella ? funicula, Meek.
Figs. 10-11. Chemnitzia ? coalvillensis, Meek.

PLATE XLIII.

Fig. 1. Aporrhais (Gonocheila) castorensis, Whitfield.
Fig. 2. Aporrhais (Perissoptera ?) prolabiata, White.
Figs. 3-4. Anchura (Depanocheilus) ruida, White.
Figs. 5-6. Lispodesthes nuptialis, White.
Figs. 7-11. Pugnellus fusiformis, Meek.
Fig. 12. Tritonium kanabense, Stanton.
Fig. 13. Fusus shumardi, H. and M.
Fig. 14. Fusus gabbi, Meek.
Fig. 15. Tritonidea ? huerfanensis, Stanton.

PLATE XLIV.

Figs. 1-3. Rostellites gracilis, Stanton.
Fig. 4. Pleurotoma ? hitzi, Meek.
Figs. 5-8. Actaeon propinquus, Stanton.
Figs. 9-11. Haminea truncata, Stanton.

PLATE XLV.

Fig. 1. Mortoniceras? vernilionense, M. and H.
Fig. 2. Scaphites larvæformis, M. and H.
Fig. 3. Scaphites vermiformis, M. and H.
Figs. 4-7. Scaphites warreni, M. and H.
Figs. 8-10. Scaphites ventricosus, M. and H.

PLATE XLVI.

Fig. 1. Scaphites ventricosus, M. and H.
Figs. 2-4. Scaphites mullananus, M. and H.

PLATE XLVII.

Fig. 1. Allorisma subcuneata, Meek. Upper layers of massive lime (Permo-carboniferous) Dog Cañon. Sacramento mountains.

Figs. 2-3. Spirifer imbrex.	Lake Valley.	Burlington.
Fig. 4. Strophomena rhomboidalis,	" "	"
Fig. 5. Athyris lamellosa,	" "	"
Fig. 6. Rhynchonella,	" "	"
Figs. 7-7a. Spirifer grimesi, Hall	" "	"

Fig. 8. Polypora coyotaensis, sp. n. Flint Ridge shales near Coyote Springs.

Fig. 9. Phillipsia, sp. n. Flint Ridge shales near Coyote Spring.

Fig. 10. Phillipsia major, Shum. Upper layers Permo-carboniferous, No. 654.

Fig. 11. Phillipsia, sp. n. Sandia limestone near Coyote Spring.

PLATE XLVIII.

Correlated sections applicable to the region described and adjacent exposures. Data on the plate itself.

PLATES XLIX-LII (Inclusive.)

These illustrations are intended to accompany the section on building materials and to indicate the use made of the available resources. The churches are for the most part built of local brick or flagstaff sandstone. The Grant block (Plate L) is of Kansas City red brick with buff trimmings. The fine building of the commercial club is wholly built of Flagstaff red sandstone. (Jura-triassic?) The school houses are built of local red brick. Several private residences are shown dating from an earlier period of the city's growth.

PLATE LIII.

Fig. 1. Lignite bands in upper (Fox Hills) cretaceous. Mesa Isleta mono cline, Rio Puerco valley.

Fig. 2. Same as above, showing eroded pinacles of white sand below the lignite.

PLATE LIV.

Fig. 1. Mesa Isleta monocline, from a distance.

Fig. 2. Concretionary zone in Santa Fé marls. West side of Albuquerque mesa, near Fig. 1.

PLATE LV.

Fig. 1. Punta de la Mesa sandstone west of the Coralles-Cabezon road, a few miles south-east of Cabezon.

Fig. 2. Vermilion beds as exposed in valley-south-west of Serrita mesa. Top of chocolate beds showing at base.

PLATE LVI.

Fig. 1. Serrita mesa, southern end of Nacimiento range. Gypsum beds showing at base. The figure does not clearly show the stratification which is very distinct to the eye.

Fig. 2. Upper Cretaceous shales, sands and lignite west of the north end of Albuquerque mesa. In the coal series.

PLATE LVII.

Figs. 1 and 2. Eroded Santa Fé marls, west side of Albuquerque mesa.

PLATE LVIII.

Fig. 1. Tres Hermanos sandstone, showing the large concretions.

Fig. 2. Same sandstone with layer of indurated sandstone above.

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A REVIEW OF THE PANORPIDAE OF AMERICA NORTH OF MEXICO.

JAMES S. HINE.

It is a difficult matter to give characters that will define the forms that are at present placed in this Neuropteroid family. The majority of the members are readily distinguished by the beak-like front of the head. The antennae are long, slender, and many jointed ; there are three ocelli or none, and the compound eyes are rather large. Most of the species have four well developed wings but some are wingless or at most have rudimentary wings. The type of the family is *Panorpa communis L.*, the common scorpion fly of Europe, The American species have been catalogued by Banks in Trans. Am. Ent. Soc., Vol. 19, 1892.

The family formerly included the genus *Nemoptera* which Klug considered, but eliminated from the *Panorpidae* in his Monograph of Panorpatae in Abhandlungen der Academie der Wissenschaften zu Berlin in 1836.

The life history of only a few species is known. In Europe Brauer has done some work which is frequently quoted, and in this country Felt has published a paper in Lintner's Tenth Report of the Insects of New York, in which he records observations on some very young stages of *Panorpa rufescens* Rambur.

The material which I have examined in the preparation of this paper aggregates nearly a thousand specimens. Through the kindness of officers in charge I was permitted to examine the material, both domestic and foreign, in the Museum of Comparative Zoology at Cambridge. I desire to express my obligation to Mr. Nathan Banks of the Division of Entomology, Washington, D. C., for suggestions, and the loan of his collection which contains specimens, with one exception, of all the North American species of *Panorpa*, and also the officers of the National Museum for the loan of their collection in the family. Dr. E. P. Felt and Mr. C. C. Adams and others have assisted me materially in the loan of specimens. After getting this collection together I find that a large part of North America is represented but more material from our southern states would have been desirable.

The following key is offered for the separation of the genera:

1. Ocelli present 3
   Ocelli absent 2
2. Wings well developed, anntennae short, thick, and narrowed at the apex. Appendages of the male very long, with an articulation near the middle, . *Merope.*
   Wings of female rudimentary, of male imperfect, antennae filiform, ... *Boreus.*
3. End of the abdomen in the male developed into the form of a chelifer, antennae long and filiform, . . 4
   End of the abdomen in the male not developed into the form of a chelifer, abdomen cylindrical, antennae shorter, and gradually decreasing in size towards the tips, *Bittacus.*
4. Tarsal claws toothed, abdominal segments 7 and 8 modified, and elongated, rostrum elengated, . *Panorpa.*
   Tarsal claws simple, abdominal segments 7 and 8 of the male short, similar to the preceding segments, rostrum short, triangular, ... *Panorpodes.*

Panorpa Linn.

The species of this genus have four well developed wings, which in our species are banded or spotted with dark brown. The head is produced downward into a beak, and the mouth parts are borne at at the end. The mandibles are slender and two-toothed at the apex; the antennae are only slightly smaller at the apex than at the base; the legs are rather short, and each tibia bears two strong spines at the apex of its inner surface.

The genus was indicated by Linnaeus about 1767 in his Systema Naturae. Species which at the present time are placed in at least four distinct genera, were described as belonging to the genus. Gradually as insects have become better classified, *Panorpa* has been restricted to its present limits.

Besides the considerations which Klug gave in his paper referred to above, Westwood has published a monograph of *Panorpa* in the Transactions of the Entomological Society of London for 1846. Hagen gave descriptions of the then known American species in his Synopsis of Neuroptera in 1861. Mc Lachlan, in the Trans. of the Ent. Soc. of London for 1868, considered the European species, and a number of species from Japan. Banks gave a synopsis of American species in the Trans, of the American Ent. Soc. Vol. 22, 1895.

The members of the genus seem to subsist mainly upon animal matter that they find dead, but Davis has recorded in Bulletin 15 of the Arkansas Experiment Station that he has observed a species of *Panorpa* preying upon the cotton worm. Felt has made the interesting statement, that in his experience they paid no attention to living, healthy larvae, but when he placed a living, injured larva in the breeding cage where specimens of *Panorpa* were confined, they immediately set to work sucking juices from the wound. I have observed a specimen feeding on a Dipteron which from appearances was dead before it was attacked by the *Panorpa*.

The characters which have been used in separating the various species are many; formerly the number of teeth on the claws and the size of the horn on the sixth segment of the male were considered of value, but for American forms these appear to be of little consequence. The characters found in the wings have long been used. The wing pictures although variable are certainly of value and the length of the sub-costa, that is, whether it unites with the costa at the pterostigma, or before it, as used by McLachlan in 1868 in connection with European species is of value, but subject to some variation. In the male, the form of the 7th and 8th abdominal segments, the presence or absence of a horn on the sixth segment, and the genital organs are worthy of consideration.

In this paper I consider fifteen species, which seem to fall naturally into five groups. I offer the following key to aid in separating them. The dark colored apex of the wing is considered as a band.

I. Seventh and eighth abdominal segments and forceps of the male much elongated, no horn on sixth segment; sub-costa uniting with the costa far before the pterostigma, ... Group *lugubris*.

Wings black with narrow hyaline cross bands, *lugubris*.

Large species, wings yellow with three wide black bands, pterostigmal band not forked behind, *nuptialis*.

Smaller species, pterostigmal band forked behind, *rufa*.

II. No horn on sixth abdominal segment of the male, wings with irregular markings, not usually in the form of bands, ... Group *nebulosa*.

1. Sub-costa uniting with the costa far before the pterostigma, 3.

Sub-costa uniting with the costa at the pterostigma, 2.

2. Large species, pterostigmal band of wing entire, *latipennis*.

Smaller species, rarely with any entire bands on the wings, ... *nebulosa*.

3. Radial vein curves inward to form the pterostigma, *maculosa*.

Radial vein nearly straight at pterostigma, . . *banksii*.

III. Horn on sixth segment of the male, wings hyaline, with three entire black bands on the forward pair; from side view a prominent elevation apparent on the basal part of the claws of the male forceps, Group *subfurcata*.

Elevation on the basal part of the claw of the male forceps rounded, about one-half as long as the claw; wings rather narrow, ... *signifer*.

Elevation on the claw of the male forceps oblong, reaching for more than half the length of the claw; wings wider, ... *subfurcata*.

IV. Horn on the sixth segment of the male, wings yellowish with three black bands, basal band rarely interrupted, ... Group *americana*.

Bands on wings regular, wings wide and regularly rounded at the end, - . . . . . *americana*.

Bands on wing irregular, wing narrower, . *venosa.*

V. Wings yellowish or hyaline, but not more than two complete black bands, horn on sixth segment of the male abdomen, seventh and eighth segments rather long, about equal in length, seventh rapidly enlarged above just before the middle, . . Group *confusa.*

1. Wings hyaline, posterior border more strongly curved than usual, the veins dark colored, . . *claripennis.*

   Wings yellowish, markings confused, pterostigmal band interrupted or geniculated at the middle, uncus short reaching but little beyond the base of claws of forceps, . - . . . . *confusa.*

   Wings pale, more yellowish at base, uncus reaching to middle of claws of forceps, ... 2

2. Wing markings of usual extent, larger species, *rufescens.*

   Wing markings reduced, harpes of male not reaching base of claws of forceps, smaller species, . *canadensis.*

Panorpa lugubris, Swederus.

Plate LIX, Fig. 7.

Panorpa lugubris, *Swederus,* Kongl. Vetensk. Acad. Handl. 8-279; *Klug,* Monog. Panorp. 106; *Westwood,* Trans. Ent. Soc. of London 4-188; *Hagen,* Neuroptera of N. A. 241.

Panorpa scorpio, *Fabr,* Ent. Syst. 2-97; *Rambur,* Neuropt. 331.

Bittacus scorpio, *Latr,* Gen. Crust. Ins. 3-189.

Anterior wing 11–13 mm. Head and thorax black; abdomen in the male brown, except the apical segment which is black; abdomen in the female black ventrally, and at the apex; wings black, anterior pair each with an oblique band on the middle, a costal spot before the pterostigma, one on the posterior margin behind the pterostigma, and one or more between the middle band and the base; hind wings similar, but the oblique band is usually interrupted; there is some variation in the width of the bands, and size of the spots on the wings, but the species is one of the most distinct of the genus.

Specimens are at hand from Ga. and Fla. and Hagen reports it from S. Car.

Panorpa nuptialis Gerst.

Plate LIX, Fig. 2 Plate LXI, Figs. 26, 33.

Panorpa nuptialis, *Gerstaecker*, Stet. Ent. Zeit. 1863, 24-178.

Anterior wing 15–18 mm. Light brown to fuscous, color nearly uniform over the whole body; the front femora, and bases of the middle and hind femora are usually lighter than the remaining parts of the legs, although there is some variation from this, at least in museum specimens. The antennae are uniform fuscous with one or two basal joints lighter; the wings are yellow with the apex, a pterostigmal band, a costal spot of more or less extent, an oblique band and some basal markings black; the basal markings are variable, but are usually found along the borders of the wing; the marking on the posterior border reaches from base to first cross band, the one on costa begins at base, widens abruptly, and terminates before reaching the first cross band. The bands on both wings are straight and well defined, and the basal markings are usually of less extent on the hind wings. The 6th abdominal segment lacks the dorsal horn and the 7th and 8th segments are long and slender. The largest North America species of its genus.

Habitat, Texas, Louisiana and Mississippi.

Panorpa rufa G. R. Gray.

Panorpa rufa, *G. R. Gray*, Griffith's Edit. Cuvier's Anim. King. 15-323, Plate 105, Fig. 2; *Westwood*, Trans. Ent. Soc. of London 4-188; *Walker*, Cat. 461; *Hagen*, Neuropt. N. A. 242.

Panorpa fasciata, *Klug*, (in part) Mon. Panorp. 105.

Expanse according to Westwood 12½ lines, according to Hagen 27 mm. Wings elongate, yellow, sub-acute at apex, two basal spots, an oblique band before the middle, a pterostigmal band forked behind, and apex black. Four minute hyaline spots enclosed in the black apex. Abdomen of the male elongate, segment 6 unarmed—From the description of Westwood.

Habitat, Ga.

I have seen no specimens as yet that answer to this description. It is possible that *nuptialis* may be this species but the form that I have identified as *nuptialis* averages nearly ten millimeters larger ; and of more than twenty specimens before me none have the pterostigmal band forked behind.

Panorpa maculosa Hagen.

Plate LIX, Fig. 6.

Panorpa maculosa, *Hagen*, Neuropt. N. A. 245.

Anterior wing 11–13 mm. Wings hyaline, maculate with numerous small, brown, irregular spots ; nearly all the cross veins more or less bordered with brown, first vein uniting with costa near the middle of the wing—far before the pterostigma.

The wing markings in this species are somewhat variable. Some specimens have quite distinct spots, while in others the brown is confined almost entirely to the margins of the cross veins.

Hagen's types, a male and a female, are in the Museum of Comparative Zoology at Cambridge.

Habitat New York ; Del.; Ohio ; Penn.

Panopa nebulosa Westwood.

Plate LX, Fig. 21.

Panorpa nebulosa, *Westwood*, Trans. Ent. Soc. of London 4-191 ; *Walker*, Cat. 464 ; *Hagen*, Neurop. N. A. 243.

Anterior wing 11–13 mm. It is hardly worth while to give a full description of this species ; it has the appearance of *maculosa* and the wing markings pass through the same variations as in that species. The difference which I mentioned in the key, namely; in *nebulosa* the sub-costa reaches the pterostigma, while in *maculosa* in ends near the middle of the wing, is the only distinctive character I offer.

Habitat, Mich.; Penn.; N. Y.; Ohio.

Panorpa banksii.

Plate LXI, Fig. 28.

Panorpa affinis, *Banks*, Trans. Am. Ent. Soc. 1895, 22-315.

Anterior wing 11 mm. Fulvous, abdomen luteous ; wings hyaline, veins fuscous, a slender apical band and an interrupted pterostigmal one,. a middle spot on costa, an interrupted band, and a basal spot brown ; sub-costa runs into costa at middle of the fore wing; the radius does not curve inward as much at the pterostigma as in *P. maculosa* and the wing is less slender than in that species. Abdomen short, second segment not produced behind ; 6th segment tapering, no projection above ; 7th an 8th sub-equal, 7th ob-conical, curved at base, more swollen above than in *P. maculosa,* 8th more regularly conical and not so large ; 9th short and broad ; forceps stout, appendages reaching to base of claws.

Habitat, Sea Cliff, N. Y. Differs from *P. nebulosa* and *maculosa* in shorter and stouter forms.

I have seen only the type specimen of this species. It is a male and is deposited in the Banks collection.

As *affinis* has been used by Leach for a European species, it seems desirable to change the name of the American species, although *affinis* of Europe is not considered a distinct species at the present time.

Panorpa latipennis n. sp.

Plate LIX, Figs. 1, 3. Plate LXI, Fig. 32.

Anterior wing : male 14 mm., female 16 mm. Brown, last three or four abdominal segments lighter, rostrum and basal segments of the antennae brown, remainder of antennae fuscous; coxae fuscous, remainder of legs pale yellow ; wings hyaline, apex, a pterostigmal band geniculated at the middle, and abruptly widened at costa, a costal spot, a band interrupted at middle, and a basal spot brown. The apical patch of brown is divided or nearly divided by hyaline, the basal spot is absent on the hind wings, all the wing markings are very narrow and somewhat broken, and most of the veins are brown. There, is no horn on the 6th segment of the male. A male and female in the Hubbard and Schwarz Collection taken at Detroit, Michgan, June 2, and a female in the Banks Collection taken in New York.

The large size separates this species from others of its group.

Panorpa subfurcata Westwood.

Plate LXI, Figs. 25, 30.

Panorpa subfurcata, *Westwood*, Trans. Ent. Soc. of London 4-191 ; *Walker*, Cat. 464 ; *Hagen*, Neuropt. N. A. 244.

Anterior wing 14 mm. Brown, antennae black excepting two basal joints which are light brown like the head, the apex of the rostrum is dark, and the tarsal joints are annulate with fuscous; wings hyaline, one or two basal spots, an irregular arcuate band before the middle, a costal spot, a pterostigmal band gradually widened before and interruptedly forked behind. and apex dark brown; the basal spots and band before the middle are usually connected on the anterior wing, and reduced and broken on the posterior wing. Forceps of male, when viewed from the side, with a very prominent elevation which ends anteiorly in a short blunt projection.

Habitat, Nova Scotia; N. Y.; Mich.; New Hamp.; and Hudson's Bay.

Panorpa signifer Banks.

Plate LIX, Fig. 8. Plate LX, Fig. 12.

Panorpa signifer, *Banks*, Trans. Am. Ent. Soc. 26-251.

Anterior wing in the male 12 mm. female 13 mm. Color reddish, mouth parts darker, two basal joints of the antennae pale, the remainder dark brown or black; legs the color of the body excepting the tarsi which are darker, all the joints excepting those uniting femur and tibia with dark annulations; wings hyaline, two basal spots, an irregular band before the middle sometimes interrupted, a costal spot, one behind it on posterior border, a pterostigmal band forked behind and abruptly widened before, and apex enclosing some hyaline spots dark brown; on the hind wings the basal spots are usually absent, the band before the middle may be interrupted, and the forks of the pterostigmal band may be disconnected. The male forceps when viewed from the side show a characteristic obtuse prominence above.

This is a well marked species and specimens are at hand from Michigan, Pennsylvania and New York. The type is in the Banks Collection.

The narrow wing and peculiar prominence on the forceps of the male, serve to identify it readily.

Panorpa americana Swederus.

Plate LIX, Fig. 5.

Panorpa americana, *Swederus*, Kongl. Vetnsk. Acad. Handl. 8-279; *Westwood*, Trans. Ent. Soc. of London 4-189; *Hagen*, Neuropt. N. A. 242.

Panorpa fasciata, *Fabricius*, Ent. Sys. 2-98; *Klug* (in part), Mon. Panorp. 105.

Anterior wing 12 mm. Body brown; wings yellowish; an elongate, basal spot, an oblique band before the middle, a dorsal spot, a pterostigmal band, and apex black. The wing bands are straighter, and much more regular than in any other American species except perhaps *nuptialis*. The form of the wing is striking, being broad and rounded at the apex as shown in the figure. The 6th abdominal segment of the male bears a short horn.

Habitat, Ala.; Ga.

Panorpa venosa Westwood.

Plate LIX, Fig. 4. Plate LX, Figs. 18, 23. Plate LXI, Fig. 38.

Panorpa venosa, *Westwood*, Trans. Ent. Soc. of London 4-190; *Walker*, Cat. 463; *Hagen*, Neuropt. N. A. 242.

Panorpa fasciata, *Klug* (in part)Mon. Panorp. 105.

Anterior wing 11-13 mm. Wings yellow, a basal spot, a band before the middle rarely interrupted, a costal spot, a pterostigmal band widened before, and apex black. Horn on 6th abdominal segment of the male, 7th segment ob-conical increasing gradually in size from near the base, 8th segment usually shorter than the 7th.

This species is easily separated from *americana* by the narrower wings with irregular bands, and from the *confusa* group by the form of the 7th abdominal segment, and also in nearly always having three complete bands on wings.

Habitat, Mich.; New Jersey; Va.; Md.; D. C.; Tenn.; Ohio; Penn.; Ga.; Ill.

Panorpa confusa Westwood.

Plate LX, Fig. 13. Plate LXI, Figs. 27, 34.

Panorpa confusa, *Westwood*, Trans. Ent. Soc. of London 4-190; *Walker*, Cat. 463; *Hagen*, Neurop. N. A. 244.

Anterior wing 12 mm. Fulvous; wings uniform yellowish, a median basal spot with one or two small spots on costa above it, an interrupted band before the middle, a small costal spot, a pterostigmal band geniculated or interrupted at middle, a small spot on posterior border and apex black. Many of the cross veins are margined with fuscous. Uncus of the male short, at most not reaching far beyond the base of forceps.

This species agrees with Westwood's description so well that I feel a certain amount of satisfaction in identifying it as *confusa*. Although most specimens have the ground color of the wings uniformly yellowish there is some variation, and specimens are before me that have these parts hyaline, with the veins dark brown or black. The pterostigmal band is often interrupted and in some cases when it is entire, the posterior part is double.

Habitat, Penn.; N. Y.; Md.; D. C.; Ohio; Mich.; Va.; Ill.; N. C.; Mass.

Panorpa rufescens, Rambur.

Plate LIX, Fig. 10. Plate LX, Figs. 11, 22. Plate LXI, Fig. 31.

Panorpa rufescens, *Rambur*, Neurop. 330; *Felt*, Lintners Tenth Report Ins. N. Y. 464; *Hagen*, Neurop. N. A. 241.

Panorpa debilis, *Westwood*, Trans. Ent. Soc. of Lon. 4-191; *Walker*, Cat. 464; *Hagen*, Neurop. N. A. 243.

Panorpa germanica var., *Walker*, Cat. 459 (?).

Anterior wing 11–13 mm. Wings slightly tinged with yellowish, more apparent at base; a basal spot, a band interrupted before the middle, a costal spot, a pterostigmal band and apex black. Uncus of the male long, unusually reaching to the middle of the claws of the forceps; although, this species has somewhat the appearance of *confusa* at first sight, it is quite distinct; the form as well as the markings of the wings is different as the figures show. The uncus besides being longer, is heavier and much more prominent.

I have compared this species carefully with the original description of Westwood and Rambur. I feel confident now that they pertain to the same species, and this one appears to answer exactly.

There is some variation especially in passing from one sex to the other. The males are considerably smaller and slenderer than the females, and as a usual thing the wings of that sex are paler.

Habitat, N. Y.; Mich.; N. J.; Ohio; Penn.; Ga.; D. C.; Md.; Canada.

Panorpa canadensis Banks.

Plate LX, Fig. 24. Plate LXI, Fig. 39.

Panorpa canadensis, *Banks*, Trans. Amer. Ent. Soc. 1895, 22-315.

Anterior wing 11 mm. Reddish, antennae black, black around the ocelli. Legs and abdomen pale yellowish. Wings hyaline ; an apical band broken up on posterior side, a slender geniculate, pterostigmal band, a yellowish costal spot, two spots of a basal band, and a very small basal spot dark brown. Wings a little more slender than in *P. rufescens*, subcosta extending to pterostigma. Abdomen short, second segment not produced behind, 6th segment of the male cylindrical with a stout projection above, 7th and 8th segments sub-equal, 7th with base slender, quite suddenly swollen above, 8th gradually enlarging but not as large as the 7th, 9th short, forceps short, stout, appendages short, not reaching to base of claws.

Habitat, Sherbrooke, Canada and Mt. Washington, N. H.

This species is of the form and appearance of *rufescens*. It is smaller than specimens of that species usually are, and the wing markings are reduced. The type is in the Banks Collection.

Panorpa claripennis n. sp.

Plate LX, Fig. 14. Plate LXI, Fig. 36.

Anterior wing of male 13 mm. General color light brown, darker on notum; apex of tibia and tarsal joints black. antenna black, excepting the two basal joints which are colored like the head; wings hyaline, a very minute basal spot, a band interrupted before the middle. a minute spot in third interspace, an oblique pterostigmal band widened before and behind, some scattered spots, and extreme apex dark brown on the fore wing. Band before middle almost obselete, and pterostigmal band widely interrupted on the hind wings.

The form of the wing in this species is peculiar in that the posterior border is nearly a regular curve from base to apex, making the wing wide near the middle. This is shown in the figure. The type is in the Banks collection.

Habitat, Sherbrooke, Canada.

PANORPODES McLachlan.

The genus *Panorpodes* was founded by McLachlan in the Trans. Ent. Soc. of London, 1875, page 188 for a Japanese insect. The rostrum is short, and triangular; the 7th and 8th abdominal segments are not modified, but of the form of the 6th and previous ones. The tarsal claws are simple, and the wings unicolorous. Only one species has been recognized in North America. I have not been able to procure specimens of this species.

Panorpodes oregonensis McL.

Panorpodes oregonensis, *McLachlan*, Ent. Mo. Mag. 1881, 18-38.

Male very pale yellowish testaceous, the abdomen excepting the apex fuscescent above; ocelli shining blackish; eyes deep black, antennae dusky towards the tips; legs concolorous, the tips of the tibial and tarsal joints slightly blackish; the spinose hairs of tibiae and tarsi few, short and black; puvilli large, rounded, black; maxillary palpi having the 3rd and 4th joints conical not concave within; genae produced downward into a broad triangular tooth on each side of the face below the eyes; mentum with a slight triangular tooth on each side. Cheliferous segment oval, yellowish; claws short and stout, testaceous at the tips. Appendages viewed laterally prominent, thickened and outturned at the tips; viewed in front they con sist of a long band-like piece slightly dilated at the apex, which is provided with two out-turned, slightly foliaceous branches;

the whole structure scarcely extending to the base of the claws. Wings wholly very pale shining flavescent, transparent, without markings, the pterostigmal regions slightly darker; neuration very pale; the transverse nervures conspicuously whitish, if the wings be held against the light; subcosta terminating about the middle of the costa in both pairs. (From the description of McLachlan). Female unkonwn.

Length of body 7-8 mm. Expanse 20-24 mm. Habitat, Mt. Hood, northern Oregon. Described from nine males.

Boreus Latr.

The genus *Boreus* was described by Latreille in 1825 in Cuvier's Animal Kingdom. It contains small dark colored, saltatorial insects. Wings of female rudimentary, of male imperfect; no ocelli present in either sex. The females differ from all others of the family in our fauna, in having a long protruding ovipositor, in some cases nearly as long as the abdomen. Only seven or eight species have been recognized.

Hagen has published a treatise of the genus in the Ent. Mon. Mag. 3–132, 1866. In this paper he considered two European species and the two species from eastern United States.

The following key will aid in separating the four species of our fauna:

1. Ovipositor at most little more than half as long as the abdomen, eastern species, ... 2.
   Ovipositor much more than half as long as the abdomen, western species, ... 3.
2. Legs fulvous with a narrow dark colored annulation at each joint, last three joints of tarsi black, *nivoriundus*.
   Legs and ovipositor black, . . . *brumalis*.
3. Legs and ovipositor brown, joints of the legs dark, almost black, base and apex of the ovipositor dark, *californicus*.
   Legs and ovipositor black, unicolorous, . *unicolor*.

Boreus nivoriundus Fitch.

Boreus nivoriundus, *Fitch*, Am. Jour. Agr. 5-277; *Fitch*, Trans. Ent. Soc. of London, 2nd series 1-96; *Hagen*, Neurop. N. A. 240; *Lintner*, 2nd Rep. Ins. N. Y. 237.

Length male 3½ mm., female 4½ mm. Basal joints of the antennae and middle portion of the rostrum fulvous, remainder of head and its appendages black; thorax and abdomen brown, legs, rudimentary wings and genitalia in both sexes light brown approaching fulvous, joints of the legs feebly black, two or three distal tarsal joints black, plate beneath the genitalia of the male triangular, truncate at the apex; female ovipositor about one half as long as the abdomen.

Habitat, N. Y.

Boreus brumalis Fitch.

Boreus brumalis, *Fitch*, Am. Jour. of Agr. 5-278; *Fitch*, Trans. Ent. Soc. of London, 2nd series 1-96; *Hagen*, Neurop. N. A. 240; *Lintner*, Sec. Report Ins. N. Y. 238.

Length, male 2½ mm., female including the ovipositor 4 mm. Black, metallic, all the appendages dark fuscous, ovipositor one half as long as the abdomen, plate beneath the male genitalia emarginate at the apex.

Habitat, N. Y.; D. C.; and Mich.

Boreus californicus Packard.

Boreus californicus, *Packard*, Proc. Bos. Soc. Nat. Hist. 1871, 8-408.

Length of female 5 mm., male 3½ mm. Head, thorax and abdomen metallic black, antennae and base and apex of rostrum black, middle of rostrum piceous, femora and tibiae light brown with the apices black, tarsal joints black, excepting the metatarsals, which are largely light brown; wing pads of the female, and imperfect wings of the male brown. Ovipositor brown, darker at base and apex; plate beneath male genitalia truncate at apex.

Specimens of this species were received from R. W. Doane, who took them at Pullman, Washington, on the snow in midwinter. He says that specimens have been taken in spring and early summer under stones. Packard's types were procured in northern California.

Boreus unicolor n. sp.

Length of female including the ovipositor 5 mm. Entirely black, without the striking metallic luster of *californicus*, and of *brumalis*. The ovipositor is nearly 2 mm. in length, being longer than any other North American species. The large size and long ovipositor separate it from our eastern forms and the black ovipositor and wing pads distinguish it from *californicus*.

Two female specimens in the Hubbard and Schwarz Collection, taken at Helena, Montana, on the 26th of April.

BITTACUS Latreille.

The genus *Bittacus* was described by Latreille in 1807, in Genera Crustaceorum et Insectorum to receive the European species *italica* Müller, *tipularia* Fabricus, which hitherto had been placed in *Panorpa*.

The head is small, and largely occupied by the conspicuous compound eyes. the mandibles are widest at the base, and gradually narrowed distally, the distal end is curved and pointed and preceded by a sharp tooth. The maxillae are peculiar in the large development of the maxillary palpi in comparison with the other parts; the labium is short bearing two-jointed palps at its distal end. The legs are longer than the wings, which are ample and in most cases without conspicuous markings.

Bittacus stigmaterus the first american species was described by Say in the Western Quarterly Reporter, 1823, 2-173. In 1836 Klug published in Abhandl. Acad. Wiss. Berlin, a description of *mexicanus* from Mexico. In 1841 Westwood described *pilicornis*, *punctiger* and *pallidipennis* in Trans. Ent. Soc. of London 4-195-6. In 1853 Walker described *occidentis* in Cat. Brit. Mus. 469. In 1861 Hagen, in his Synop. Neurop. N. A. 246, described *strigosus*, and on page 248 published for the first time, a description of *apicalis* from Uhler's manuscript; In the same work he announces that *pallidipennis* is synonomous with *stigmaterus*. In 1871 McLachlan described *apterus* in the Ent. Mon. Mag. 8-100, and in 1881 *chlorostigma* in the same periodical, 18-36.

The species of the genus differ in their food habits from the members of the genus *Panorpa*, as it is probable that they eat nothing but what they find living. Various insects are eaten by them, and there is no doubt that their predaceous habits make them of some value from an economic standpoint. Thus as they inhabit shady places along streams where mosquitos abound, it seems probable that mosquitoes form part of their bill of fare.

The following key will assist in locating the eight species of our fauna:

1. Both sexes wingless, ... *apterus.*
   Both sexes with wings, ... 2.
2. Hind femora and tibia thickened, cross veins of wings (except *punctiger*) not margined, . . . 3.
   Hind femora slender, cross veins of the wings margined with fuscous, ... 6.
3. Large dark colored species, pterostigma bright yellow, ... *chlorostigma.*
   Smaller species pterostigma not bright yellow, . 4.
4. Wings at base, and hind femora with black punctate spots, ... *punctiger.*
   Wings at apex fuscous, ... *apicalis.*
   Wings and hind femora unmarked, . . . 5.
5. Male appendages not protruding beyond the last segment of the abdomen, rounded at the distal end, *occidentis.*
   Male appendages protruding beyond the last segment, turned inward at apex, . . . *stigmaterus.*
6. Antennae with long pile, wings tastaceous, with the cross veins narrowly margined with fuscous, *pilicornis.*
   Antennae with short pile, wings pale, with the cross veins broadly margined with fuscous, . . *strigosus.*

Bittacus apterus McLachlan.

Plate LX, Fig. 15.

Bittacus apterus, *McLachlan*, Ent. Mo. Mag. 8-100; *Osten Sacken*, Wein. Ent. Zeit. 1-123; *McLachlan*, Ent, Nach. 19-317; *Hine*, Jour. Cal, Hort. Soc. 13-110.

Length of body 22 mm. male and female dark brown; head lighter in color than the thorax, ocelli prominent. not surrounded by black, but the frontal one surmounted by one or two black spines. Thorax brownish, legs lighter, clothed with short pile and numerous black spinose hairs. Apex of tibial and tarsal joints of hind legs piceous, no wings or rudiments of wings.

Appendages of the male pale, wide, rather long, widest at apex, where superiorly there is a prominent elevation; basal part slightly prominent above, but below it is very strongly narrowed. Length 1½mm. Width at middle 1mm.

Easily known by the absence of wings.

Habitat, California.

Living specimens are said to have a green color agreeing with the plants on which they are found. Dry specimens vary some in color and the markings are somewhat obscured.

Bittacus chlorostigma McLachlin.

Plate LXI, Fig. 37.

Bittacus chlorostigma, *McLachlin*, Ent. Mo. Mag. 18-36; Ent. Nach. 19-317; *Hine*, Jour, Col. Hort. Soc. 13-110.

Male and female shining, reddish; wings transparent, shining, veins reddish, pterostigma yellow.

Appendages of the male lighter than the abdomen, extreme apex piceous, superior edge prominent, regularly concave, superior distal angle rounded, apex straight, inferior distal angle rounded, inferior edge very slightly concave to distal third, then strongly convex toward base making the appendage widest near basal third; 2½mm. in length and 1mm. in width. Anterior wing 24-27mm; body 23-26mm.

Habitat, southern Cal.

This is the only North American species of the genus having a yellow pterostigma, and also may be easily known by its large size.

Bittacus punctiger Westwood.

Plate LX, Fig. 19.

Bittacus punctiger, *Westwood*, Trans. Ent. Soc. of London 4-195; *Walker*, Cat. 468; *Hagen*, Neurop. N. A. 247; *Hine*, Jour. Col. Hort. Soc. 13-113.

Anterior wing 18 mm., length of body 17 mm. Yellowish; posterior femora with small black spots, wings yellowish, basal half with a few black spots, cross veins margined with fuscous.

Male appendages, from side view, not protruding beyond the abdomen, widest on basal half, apical part slightly narrower.

This species is easily known by the black spots on the femora and basal half of wing.

I procured specimens in the District of Columbia at intervals between June 25 and Aug. 1st, 1897, and again at the same place in 1899.

The specimens of this species that I saw, always remained close to the ground. If disturbed they never ventured above the herbage in which they were hiding, but flew a short distance through the foliage, and came to rest again near the surface.

Bittacus apicalis Uhler.

Plate LX, Fig. 16.

Bittacus apicalis, *Hagen*, Neurop. N. A. 248; *Hine*, Proc. Col. Hort. Soc. 13-109.

Body 16 mm., anterior wing 15-16 mm. Yellowish; thorax and abdomen often nearly black, wings hyaline black at apex.

Abdominal appendages of the male clothed with rather long yellowish hair; superior edge from side view, obliquely elevated to basal third, remainder regularly concave, superior distal angle a little less than a right angle, distal edge above nearly straight, below obliquely produced, making the inferior distal angle very prominent, the inner surface of this angle is furnished with numerous black teeth, inferior edge convex; a longitudinal thickening traverses the middle of the appendage for three-fourths of its length.

Habitat, Ark., June,; Ill. June,; N.Y.; Ohio, June-July; Va.; W. Va.

Bittacus occidentis Walker.

Plate LXI, Fig. 35.

Bittacus occidentis, *Walker*, Cat. Brit. Mus. 469; *Hagen*, Synop. Neurop. N. A. 247; *Hine*, Jour. Col. Hort. Soc. 13-112.

Length of body 16 mm., anterior wing 20 mm. Light testaceous, wings yellowish with the veins a little darker, legs usually slightly darker than the abdomen, all of the tibiae black at apex.

Male appendages, as seen from above, reaching the extreme apex of abdomen, oblong, spreading, about the same width for their entire length, rounded, and slightly darker at the tips.

The female is not easily separated from that of *stigmaterus*, but the wings are narrower and usually darker colored. These characters are readily seen by comparing a series of the two species.

Habitat, Del.; D. C.; Ill.; Ind.; Penn.; Can.; Md.

I have examined fifteen males and females of this species. The narrow wings and uniform testaceous color are characteristic; the dark anterior and middle legs in fully matured specimens, is also peculiar to the species. This form has the peculiarity of appearing at lights. In correspondence with A. W. Butler of Brookeville, Ind., I received the following note which I insert with his permission: "About eight o'clock in the evening of Aug. 28, 1896, as I was passing one of the hotels of our city, I was called in to see some queer insects catch flies. I observed that they were very successful in their work, furnishing amusement for the hotel guests and others for a long time."

Hugo Kahl of Lawrence, Kansas, informs me that he took three specimens in his room on the evening of Sept. 25th, 1895.

F. C. Pratt, of the Div. Ent. at Washington, D. C., procured the species at light at Travilah, Md., July 9th, 1899.

Bittacus stigmaterus Say.

Plate LX, Fig. 20.

Bittacus stigmaterns, *Say*, Goodman's West. Quart. Rep. 2-164; Ent. Lec. Ed. 2-173; *Hagen*, Neurop. N. A. 247; *Hine*, Jour. Col. Hort. Soc. 13-114.

Battacus pallidipennis, Westwood; *Westwood*, Trans. Ent. Soc. Lon. 4-195; *Walker*, Cat. 468.

Bittacus mexicanus, Klug; *Hine*, Jour. Col. Hort. Soc. 13-111.

Anterior wing 18-21 mm., body 16-18 mm. Light brown; ocelli surrounded by black, eyes black, rostrum and maxillary palps black, the pile on the antennae is noticably longer than in *occidentis*, veins of wings prominent, hind femora thickened, the outer of the two spines at the end of each hind tibia as long as the first tarsal joint.

Male appendages, from side view, oblong, superior edge strongly elevated at base, nearly straight to apex, inferior edge very gradually approaching the superior, thus making the apex slightly narrower than the base; length of the appendages about 2 mm.

Habitat, D. C.; Ill.; Kans.; Md.; Mo.; N. Y.; Ohio; Ga.

Compared with *occidentis*, the male appendages are entirely different, the pile of the antennae is longer, the veins of the wings are more prominent. and the color of the wings is paler.

In a former paper I separated out a specimen which I called *mexicanus* Klug, principally on account of its larger size. After studying more material I am satisfied that it is *stigmaterus* and that the species is variable in size.

Bittacus pilicornis Westwoord.

Plate LX, Fig. 17.

Bittacus pilicornis, *Westwood,* Trans. Ent. Soc. of Lon. 4-196; *Walker,* Cat. 468; *Hagen,* Neurop. N. A. 246; *Hine,* Jour. Col. Hort. Soc. 13-113.

Anterior wing 19-21 mm., length of body 16-18 mm. Yellowish; antennae clothed with very long pile, wings yellowish, veins darker, cross veins bordered with fuscous, pterostigma prominent, yellowish brown, legs nearly the same color as the wings, hind femora not thickened.

The appendages of the male, from side view, triangular, with the corners rounded.

Haditat, Can.; D. C.; Md.; Mich.; N. Y.; Ohio.

Easily known by the long pile of the antennae. This is one of the two American forms without thickened posterior femora; the corresponding tarsal joints are also slender, and the wings are broad, with the apices broadly rounded.

The species is a strong flyer, and if molested often seeks retreat by flying into trees beyond the reach of collectors. I never have seen it abundant as we often find *strigosus* and *stigmaterus*.

Bittacus strigosus Hagen.

Plate LIX, Fig. 9.

Bittacus strigosus, *Hagen*, Synop. Neurop. N. A. 246; *Felt*, Lintner's 10th Rep. Ins. N. Y. 473; *Hine*, Jour. Col. Hort. Soc. 13-115.

Anterior wing 19 mm., length of body 17 mm. A pale colored species, wings pale, veins darker, cross veins broadly margined with fuscous.

Male appendages, from side view, long, prominent at base, superior edge straight nearly to middle, strongly concave from thence to apex, apex rounded, inferior edge irregularly concave to middle, where there is a prominent projection, nearly straight from thence to base.

Habitatat, Ark.; D. C.; Ill.; Kans.; Mass.; Mo.; N. Y.; Ohio; Pa.

The characteristics of this species, aside from the appendanges of the male, are the broad, pale wings with margined cross veins, and the slender hind femora. It is most nearly related to *pilicornis* from which it may easily be separated by the smaller size, and shorter pile on the antennae. Probably the most abundant and widely distributed *Bittacus* in our fauna.

Merope Newman.

Eyes large, reniform, antennae short, rather thick and pointed at the apex. Legs shorter than the wings, end of the abdomen with very long, two-jointed appendages.

This genus was founded by Newman in the Entomologists' Magazine for 1838, 5-180. Only one species has been described and this is so remarkable that it is questionable as to what family it belongs. Probably it has more characteristics with the *Panorpidae* than with any other group. Westwood after dissecting and studying the mouth parts placed it in this family. Hagen also gave it as his opinion that it should be placed here. Fitch believed that it is most nearly related to insects of the genus *Nemoptera* which at the present time is not considered in *Panorpidae.* It may be mentioned that two arguments which Dr. Fitch produced against placing it in the *Panorpidae* do not seem so strong since we know more of the family. First, the short beak found in *Merope*, is approached by *Panorpodes*, an insect which is near enough to *Panorpa* to have the abdomen ended by a cheliferous segment. Second, *Merope* was taken in the evening at light; at least one species of *Battacus* has been taken at light several times.

Merope tuber Newman.

Merope tuber, *Newman*, Ent. Mag. 5-180; *Westwood*, Trans. Ent. Soc. Lon. 4-190 Plate 14, Fig. 2; *Fitch*, 14th Rep. Ent. N. Y. St. Agr. Soc. 373.

Expanse 28-32 mm; very pale yellowish; wings with numerous cross veins, each anterior wing with a small tubercle 1½ mm. from base of posterior border.

Appendages of the male long, composed of two sections, each section regularly curved, basal section 5½ mm., apical section 3½ mm., latter widened at apex.

The female has the same appearance as the male, but is smaller and has the end of the abdomen furnished with two appendages which are short, and composed of two segments.

Habitat, Orono, Maine; Penn.; N. Y.; D. C.

I have seen two males and three females.

EXPLANATION OF PLATES.

PLATE LIX.

Wing of Panorpa, *1* female latipennis; *2* male nuptialis; *3* male latipennis; *4* male venosa ; *5* female americana ; *6* male maculosa ; *7* male lugubris. Side view of the end of abdomen of male Panorpa, *8* signifer. Side view of end of abdomen of male Bittacus, *9* strigosus. Dorsal view of cheliferous segment of male Panorpa, *10* rufescens, (a) uncus, (b) harpe.

PLATE LX.

Wing of Panorpa, *11* female rufescens ; *12* male signifer; *13* male confusa; *14* male claripennis ; *21* male nebulosa; *22* male rufescens ; *23* male venosa; *24* male canadensis. Side view of end of abdomen of male Bittacus, *15* apterus ; *16* apicalis ; *17* pilicornis ; *19* puntiger ; *20* stigmaterus. Dorsal view of cheliferous segment of male Panorpa, *18* venosa.

PLATE LXI.

Wing of Panorpa, *25* male subfurcata ; *26* male nuptialis; *27* female confusa ; *28* male banksii. Side view of end of abdomen of male Panorpa, *30* subfurcata ; *31* rufescens; *32* latipennis; *36* claripennis; *38* venosa; *39* canadensis. Dorsal view of cheliferous segment of male Panorpa, *33* nuptialis; *34* confusa. Dorsal view of abdominal appendages of male Bittacus, *35* occidentis. Side view of the abdominal appendages of male Bittacus, *37* chlorostigma.

BULLETIN OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.
Vol. XI. Article XI. With Plate LXII. February, 1902.

PRACTICAL EXPERIENCE WITH THE CAPILLARY ELECTROMETER.

A. D. COLE.

The Capillary Electrometer is an instrument whose merits are not generally appreciated either by teachers of physics or by those engaged in research. Though it is now nearly thirty years since the original form of the instrument was first described by Lippmann,[1] few laboratories contain one today.

His paper gives a careful study of the capillary electrometer and the principles upon which its operation depends, but he failed to give it a convenient form for either laboratory or research purposes, a fact which perhaps explains the neglect it has received. Siemens[2] a little later describes a modification especially designed to replace the reflecting galvanometer for electrical measurements on shipboard, a use to which its indifference to mechanical vibrations well adapts it. Quincke,[3] Gore and later Paschen[4] have published careful studies of the instrument. Its merits have been emphasized and brought to the attention of certain classes of workers, especially by Ostwald in Germany and recently by Burch in England. Ostwald[5] recommends it strongly for work in physical chemistry and Burch[6] shows its special value for physiologists and electrical engineers.

My attention was directed to the capillary electrometer by

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[1] Lippmann. *Pogg. Annalen*, Vol. 149, p. 546 (1873).

[2] Siemens. Pogg. Ann., Vol. 151, p. 639 (1874).

[3] Quincke. Pogg. Ann., Vol. 153.

[4] Paschen. Wied. Ann., Vol. 39, p. 43 (1893).

[5] Ostwald. Zeit. f. phys. Chem., Vol. 1, p. 404 (1887). See also his book "Hand-und-Hilfsbuch zur Ausführung Physiko-chemischer Messungen" p. 242–249.

[6] Burch. London Electrician, Vol. 37, p. 380, 401, 435, 473, 514, 532 (1896).

the volume of Ostwald. It struck me that it ought to be a first rate instrument for use in the physical laboratory for a great variety of purposes. An experience of several years, which includes a study of its practical fitness for use in measurements usually made with costly electrometers and galvanometers, has strengthened that first impression. Among the advantages which may be fairly claimed for the capillary electrometer are the following:

1. It is wholly unaffected by any magnetic disturbances in its neighborhood and far less sensitive to mechanical vibrations than any galvanometer or electrometer of equal sensitiveness. So it is possible to use it in the immediate vicinity of powerful dynamos or electromagnets.

2. It far excels any other forms of electrometer, whether of attracted-disc or quadrant type, in sensitiveness. It can be made to show .00001 volt and easily measures .0001 volt. It is also much more free from disturbance by accidental electrostatic changes in the neighborhood than is a quadrant electrometer.

3. It is extremely dead beat, the setting of the instrument requiring only a very small fraction of a second.

4. It is so sensitive that it may replace a high-resistance reflecting galvanometer for many purposes, and with the great advantage, that it takes no current at all from the circuit being measured.

5. It is much smaller, lighter, more portable, more easily and quickly set up—in general more convenient—than any other form of electrometer.

6. It is cheap and readily constructed by the experimenter for himself. It is indeed almost ridiculously cheap in the simplest form. A capillary electrometer costing a dime for materials and a half hour's labor will excel a $250 quadrant electrometer in sensitiveness. Enough of them can be quickly prepared for the use of a large class of students at a nominal cost.

7. The extreme quickness with which it follows fluctuations in potential difference enables it to do some things that

no ordinary form of electrometer or galvanometer can do, as for example, give an instantaneous record photographically of the variations of E. M. F. or current through one or more cycles of an alternating-current dynamo.

My own experience with the capillary electrometer began with the three forms described by Ostwald in the volume already cited. Figures 1, 2 and 3 (Plate LXII) will serve to recall their construction, without detailed description. The instrument consists essentially of two small bodies of mercury separated from each other by sulphuric acid. In each figure:

b is a glass tube of perhaps .5 cm. diameter, one end of which is reduced to capillary dimensions, and which contains mercury electrically connected to one terminal of the instrument.

c is a larger tube or bulb of perhaps 1 cm. diameter, containing the other body of mercury, attached to the second terminal of the instrument. Connection between *b* and *c* is made by

a, the capillary within which mercury and acid come in contact.

e is the anode terminal.

I have made and used about twenty instruments of these three types. The first form is very convenient and sensitive enough for many laboratory experiments. The one I have used most gives about one scale division (about 1 mm.) for .01 volt potential difference, but by using a smaller capillary this type can be made three or four times as sensitive.

The second form is altogether better than the first and is used in connection with a cheap reading microscope to magnify its small deflections. It is an excellent form—the best of the three Ostwald describes—for general laboratory use. The ones that I have used most give a deflection of 14 to 35 divisions on the rotating head of a certain micrometer microscope, 1960 of whose divisions equal one millimeter. In this type it is better to have the terminal platinum wires sealed into the glass at *b* and *c*. (Fig. 2).

The third form is decidedly more sensitive, but is far less convenient to use and gets out of order more easily—so easily indeed that only skilled experimenters can use it with satisfaction. High sensitiveness requires a very fine capillary, of perhaps .02 mm. diameter. So fine a capillary is easily clogged by a minute particle or breaks develop in the mercury column which hours of labor sometimes fail to remove. I have had one which showed a deflection with .00005 volt; another moved 1-5 mm. (375 divisions on micrometer head) with a potential difference of .001 volt. But neither of these remained long in good working condition.

A series of nerve-trying experiences with Ostwald's third type led me to seek some modification which would be highly sensitive and at the same time keep in working order fairly well and be capable of restoration to a sensitive condition if by chance injured through misuse. This was found at length in a modification of a simple form described by Paschen. On reading his paper (Wied. Ann. Vol. 39, p. 43) I noticed that he reached a fair degree of sensitiveness in a form of instrument in which the capillary, (if such it can be called) was of relatively huge dimensions (3 mm. in diameter). His arrangement is shown in Fig. 4. The capillary is one of the limbs of a U-tube. In his instrument one limb was 24 mm. in diameter the other three. As the sensitiveness of the Lippmann and Ostwald forms is nearly inversely proportional to the size of the capillary, it was natural to suspect that a reduction in size of the smaller limb to moderate capillary dimensions would exalt the sensitiveness sufficiently and still avoid the exasperating tendency to clog and stick that inheres in Lippmann's or Ostwald's third form. This proved to be the case.

A number of Paschen instruments were constructed with capillary limbs of varying size. One similar in dimensions to his gave rather low sensitiveness, but as the capillary was made smaller the sensitiveness increased as shown by the following table:

Tube	*Diam. of Capillary*	*Deflection for .001 volt*	
1	3.70 mm.	.0018 mm.=	3.6 divisions
2	1.32	.0038	7.3
3	1.05	.0092	18.
4	.51	.0117	23.
5	.31	.0255	50.
6	.21	.0765	150.
7	.16	.0260	51.

In observing the deflections a microscope with eyepiece micrometer was used, 1960 of whose divisions on the rotating head are equal to 1 mm.

Thus the hope of securing high sensitiveness with this form was realized. Tube 1 was of nearly the same size as that used by Paschen, while tube 6 with a capillary of about one-fifth millimeter, showed a sensitiveness more than 40 times as great. (It should be mentioned in this connection that sensitiveness was not an object in Paschen's research, but it was necessary to have the capillary of large size in order to allow the gas formed by the high voltages used, to escape.)

The most surprising feature of the above table is the indication of maximum sensitiveness for a capillary of about one-fifth millimeter diameter. The extreme sensitiveness of tube No. 6 is however probably due in part to its form, for another of nearly the same diameter but of somewhat different taper gave a deflection only one-third as great. A number of observers have called attention to the influence of the shape of the capillary tip in instruments of Ostwalds third form, and many of my own measurements show it.

No. 6 not only shows great sensitiveness, but (in sharp contrast with those of similar delicacy of the ordinary type) does not easily get out of order and can be taken apart, washed and dried, and show its former sensitiveness when set up anew. To test its durability and constancy under such conditions, the following course was adopted. After its sensitiveness had been measured, it was short circuited, and the next day its constant was redetermined. It was found unchanged. Another wait of two days showed its sensitiveness slightly increased. Several weeks later it was taken apart, washed and shipped to a neighboring state. After eight months it was again set up with different mercury and acid, and the sensitiveness when measured was found to be nearly the same as before.

The resemblance of this type to Ostwald's second form is rather close. The shorter length of its capillary is a considerable advantage however, provided the capillary is fine. Breaking or clogging of the mercury column is less likely to occur and friction is reduced. It is also much more readily cleaned than the other, if occasion should arise. Further, it is much more difficult to blow an instrument of Ostwald's second form, if the capillary is smaller than .5 mm. But the modified Paschen type is readily made with a capillary as small as .2 mm. with a gain in sensitiveness about six fold.

Comparing the best of the latter type with about ten electrometers of Ostwald's third form, I found it three times as sensitive as the best of them. It was exceeded in sensitiveness, it is true, by one of them but this one maintained a useful life only one hour long. A partial determination of its sensitiveness was hardly completed when it suddenly stuck. Two days were wasted in an unsuccessful attempt to wash, dry and refill its capillary. The mercury could not be again forced through it. Its diameter did not much exceed .01 mm. (as against .21 in the Paschen). Such experiences with very sensitive electrometers of the Ostwald third type are not uncommon. The larger capillary in the other instrument prevents this difficulty.

Figure 5 shows the construction of the modified Paschen form, as exhibited by the instrument before referred to as "No. 6." The letters a, b, c, etc., designate the same parts as in the other figures. To give an idea of the dimensions the following will suffice: Internal diameter of capillary *a* .21 mm., of tube *b* 8.2 mm., of the outer containing tube 16 mm. The mercury stands 39 mm. higher in *b* than in *a*. The capillary *a* is drawn down from a thick walled capillary of 2 mm. internal diameter, fused on to the drawn-out end of the large tube *b* in the blast lamp and finally bent into the U-shape by cautiously holding it in the edge of a small Bunsen flame. A sealed-in platinum wire leads from the mercury at *c* to the anode *e*. A paraffined cork (slit to keep it from fitting air tight) serves to support *b* firmly with the capillary close to the wall of the outer tube, also to prevent evaporation or spilling of the dilute acid. Another cork in *b* prevents loss of mercury, keeps out dirt and supports the other terminal wire. The whole is supported by a base of dry, varnished wood.

Some measurements were made to determine the influence on the result of the size of the other limb of the U-tube and also that of the anode surface. To examine the first point a set of three U-tubes was prepared, whose capillary limbs were made from the same piece of uniform thermometer tubing of 1.05 mm. inside diameter. The other limbs measured 3.7, 8 and 12.2 mm. respectively in diameter. They were found to compare in sensitiveness in the ratio of 10 : 18 : 18.4. This indicates that the size of the larger limb is of some importance. It should not be much less than 10 mm., but there is little advantage in making it larger than that. In Paschen's original instrument it measured 24 mm. The large surface of the mercury anode was another peculiarity of his instrument. Following him I at first used an anode surface 62 mm. in diameter. Replacing this by one of 39 mm. made no measurable difference in the sensitiveness.

Practical experience emphasizes the importance of some cautions given by Ostwald and by Burch in the references cited. In particular :

a). Good insulation must be provided.

b). The terminals must be kept short-circuited through a conductor except during the momentary and occasional pressure of a key in taking a reading. Ostwald's short-circuiting key is satisfactory.

c). The acid strength may be considerably varied, say from 1 to 3 up to 1 to 20 by volume. Results are somewhat irregular if the acid is as weak as 1 to 25.

d). Hydrochloric acid is not satisfactory.

e). A new instrument will usually be irregular, and will "crawl" with the key between stops until its terminals have been short-circuited for a day or so.

f). In using the instrument, avoid anodic polarization of the capillary as much as possible. Try to keep it the kathode. The ill effects of too much anodic polarization can be partly remedied by electrolysis.

Several novel forms of capillary electrometer were constructed in connection with the present study. One was suggested by the extraordinary electro-capillary engine described by Lippmann in the paper cited. It consisted of a cylindrical bundle of about 200 capillary tubes, each 20 mm. long and 1 mm. in diameter, bound around a glass rod with fine platinum wire. This was allowed to rest upon a surface of mercury contained in a small glass vessel. The whole was immersed in dilute sulphuric acid in a larger vessel, with enough mercury to cover the bottom. The glass rod was attached to the short arm of a long lever supported on a knife edge fulcrum. The long arm was made very light, 120 cm. in length. It carries a glass scale divided to .1 mm. at its end. When the two mercury surfaces are brought to a different potential the bundle of capillaries rises or falls and with it the lever moves and the divided scale is observed with a low-power microscope. It showed a distinct movement with a potential difference of .0001 volt. With .1 volt, the movement of the big lever was quite impressive. By replacing the lever with a small mirror and reflecting sunlight across the room, the capillary movement might be shown to a large audience.

Another instrument has a separate pressure apparatus with a flexible tube connected to a mercury reservoir capable of being raised and lowered. This is used in connection with a capillary tip of Ostwald's third form, very much as suggested by Burch in the London Electrician articles.

At the suggestion of Prof. Stratton of the University of Chicago, I attempted to replace the lever arrangement of the capillary-bundle form by a pair of plane parallel plates, one being fixed and the other attached to the bundle of tubes, the movement of the latter to be estimated by the movement of interference bands across the plate when the arrangement was illuminated by sodium light. I got some results with this, but my mechanical arrangements were so imperfect that the requisite degree of parallelism of the plates could not be long maintained.

Several forms were made particularly for projection with the lantern, but Ostwald's second form was found to be as good for projection as any of the special ones. It can be very satisfactorily shown on the screen.

To sum up briefly the comparison of leading types of the instrument used: For general use in laboratory instruction and for projection Ostwald's second form is to be preferred. This can be made sensitive to about .0001 volt and is useful for such work as determining resistance by the fall-of-potential method, E. M. F. by comparison with a standard cell, current by the potentiometer, etc. Ostwald's first form may be substituted where the cost of the reading microscope used with the second type is an item of importance, but the superior sensitiveness of the second form recommends it.

For higher sensitiveness, in research work or very exact laboratory measurements, the modified Paschen electrometer with capillary about .2 mm. in diameter is highly satisfactory and better than Ostwald's third form.

The experimental work described in this paper was done at the University of Chicago and at Denison University.

Ohio State University.

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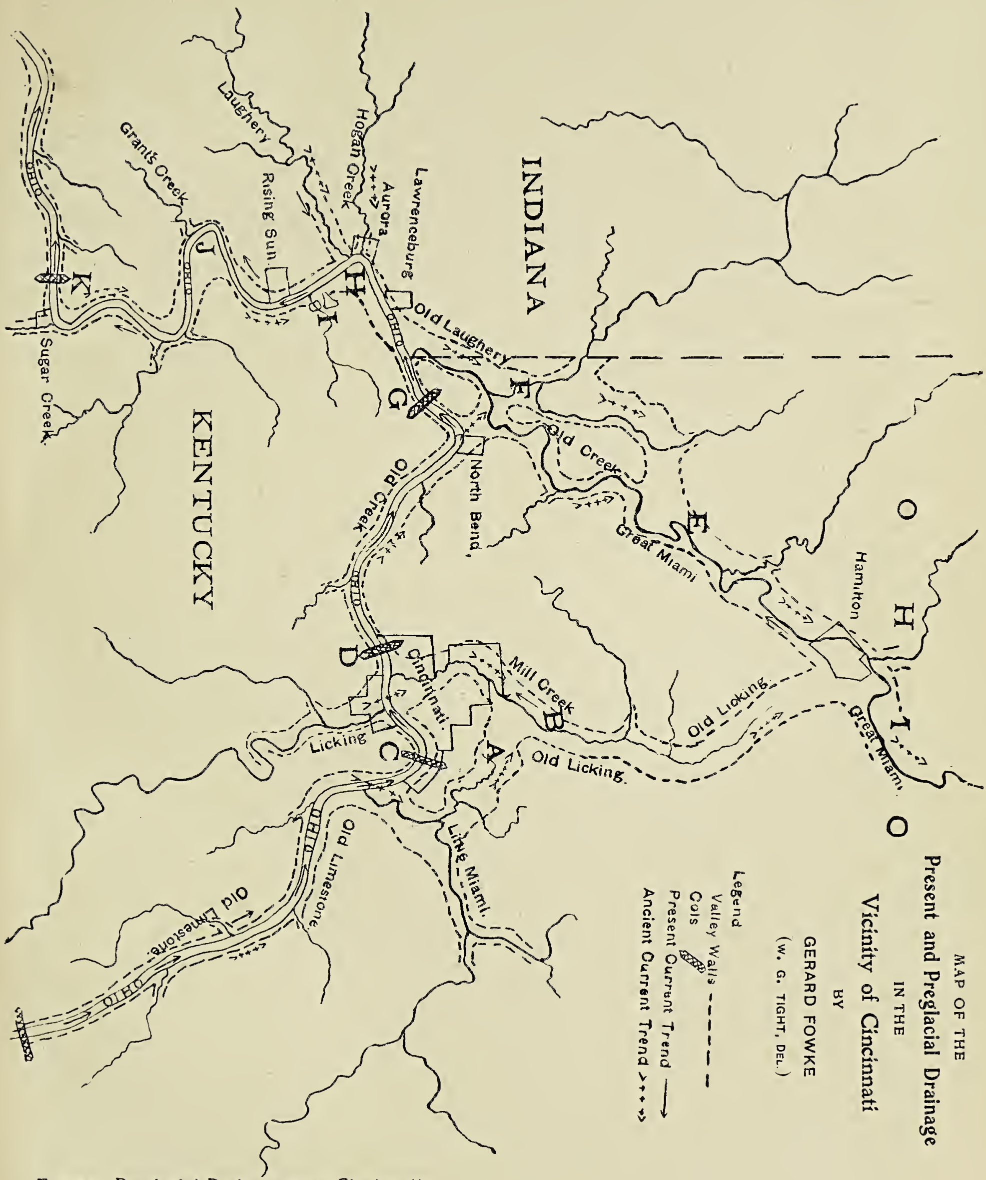


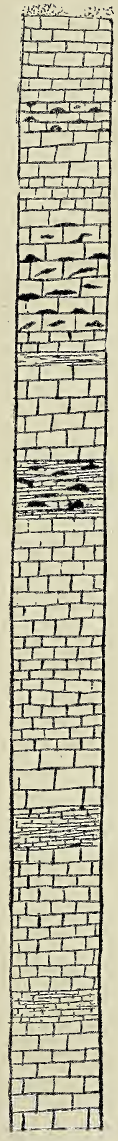
FOWKE—Preglacial Drainage near Cincinnati.

BOWNOCKER—Corniferous Rocks of Ohio.

SHOWING THE VERTICAL RANGE OF THE CORNIFEROUS FAUNA AT MARBLE CLIFF.

	Bone-Bed.	Bastard Rock. 2' 8"	Gray Rock. 2' 10" (Zone of Eridophyllum)	Blue Rock. 3' (Zone of S. acuminata)	Smooth Rock 18"	Top Calico. 12"	Bottom Calico. 7"	Curb Course. 20"	Sheepskin. 9"	Rough Rock. 16"	Ten and Six. 16"	Two Eights. 16"	Nineteen In. Course. 19"	Top Hackle. 14"	Bottom Hackle 13"	Twelve In. Course. 12"	Eleven In. Course. 11"	Two Foot Course. 2'	Two Foot Six. 2' 6"
SPONGIAE.																			
Stromatopora, sp								x											
ANTHOZOA.																			
Aulacophyllum sulcatum, D'Or.					x														
Cyathophyllum, halli																			
Cystiphyllum americanum, E.& H.										x									
Eridophyllum verneuilanum, E & H			x																
Favosites hemisphericus, Goldf				x	x														
Hadrophyllum d'orbignyi, E. & H.	x																		
Heliophyllum halli, E. & H			x		x														
Zaphrentis cornicula, Les																			
" gigantea, Les.					x														
" prolifica, Bill.			x																
BLASTOIDEA.																			
Codaster pyramidatus, Shum.		x																	
Nucleocrinus verneuili, Troost			x		x ?														
BRACHIOPODA.																			
Atrypa aspera, Sch.				x	x					x	x						x		
" reticularis, Linn	x		x	x						x						x	x		
Chonetes mucronatus, M. & H					x					x	x					x			
" yandellanus, H.																			
Leptaena rhomboidalis, Wilck		x		x	x														
Productella spinulicosta, H.				x															
Rhipidomella livia, Bill										x									
Schizophoria propinqua, H.				x	x					x	x					x			
Spirifera, acuminata, Con				x	x														
" fimbriata, Mor			x	x															
" gregaria, Clapp				x	x														
" manni, H		x	x?							x						x			
" raricosta, Con										x							x		
Pentamerella arata, Con.				x															
Stropheodonta concava, H.										x						x			
" demissa, Con										x									
" hemispherica, H.			x	x				x		x						x	x		
" patersoni, H.				x	x			x											
" perplana, Con.			x ?		x					x	x					x			
Orthotetes chemungensis, Con.		x																	
LAMELLIBRANCHIATA.																			
Conocardium cuneus, Con					x					x						x			
Glyptodesma erecta, Con				x															
Modiomorpha perovata, M. & W.										x									
Paracyclas lirata, Con										x		x					x		
Pterinea pinguis, H											x								
Sanguinolites sanduskyensis, M.				x															
GASTROPODA.																			
Callonema lichas, H.								x											
Euomphalus decewi, Bill																			
Isonema humilis, M																	x		
Murchisonia desiderata, H.										x									
Platyceras dumosum, Con		x	x	x															
CEPHALOPADA.																			
Gomphoceras eximium, H.							x												
Gyroceras cyclops, H.							x												
Orthoceras ohioense								x		x									
CRUSTACEA.																			
Dalmanites aspectans, Con					x						x					x	x		
Phacops cristata, H.										x									

SECTION AT CAMPBELL'S QUARRY, DELAWARE.



8′ limestone.

----*L. rhomboidalis, common.*
18″ chert.
----*L. rhomboidalis, very common.*
18″ Limestone.
----*Tentaculites on shaly surface.*
14″ limestone.

39″ cherty limestone.

6″ limestone.

½″ shale.

20″ limestone.

10″ shales and chert.

----*S. ziczac and L. rhomboidalis.*

26″ limestone.

----*S. ziczac L. rhomboidalis and T. scalariformis.*

24″ limestone.

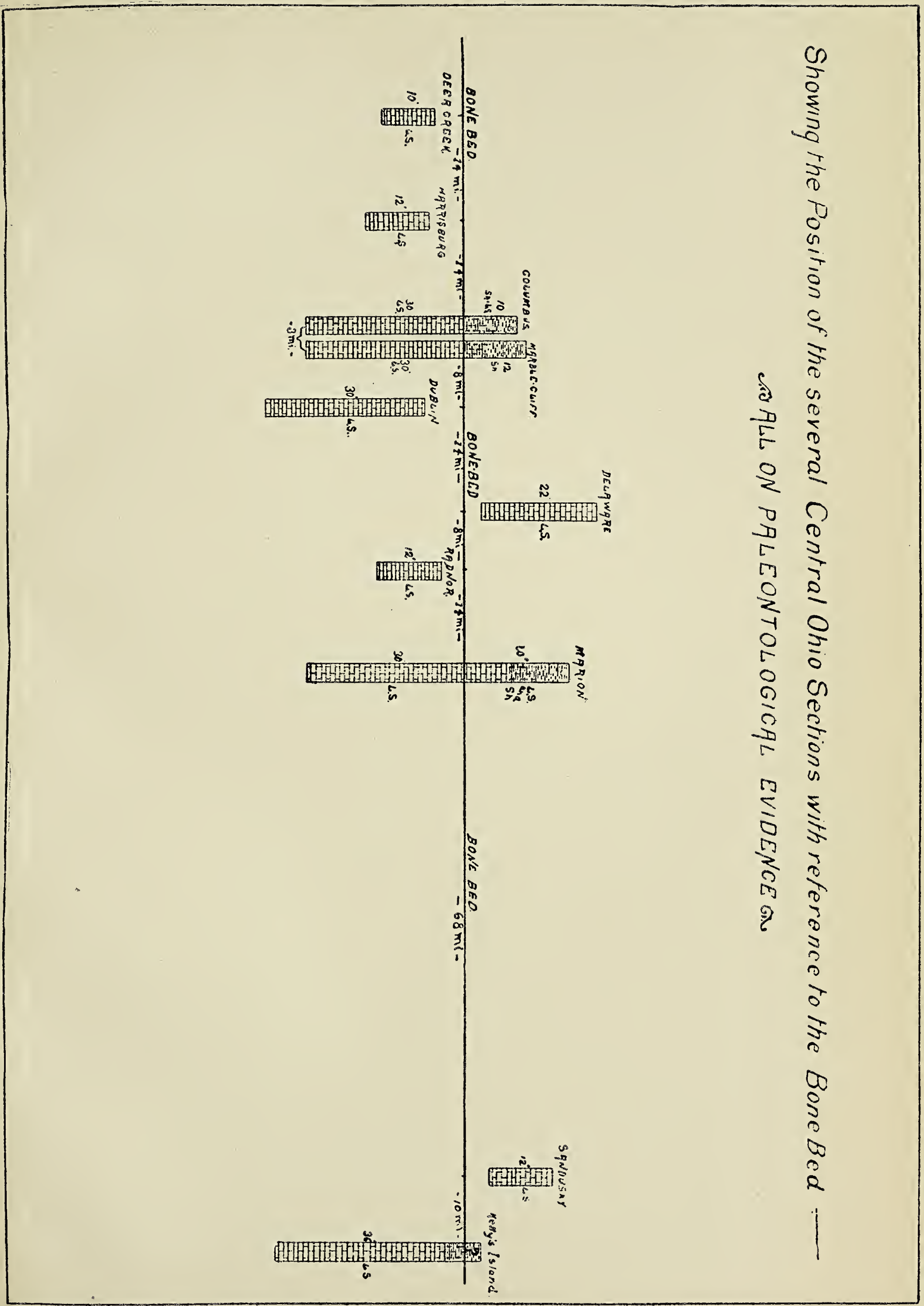
----*S. ziczac and L. rhomboidalis, very common.*
14″ limestone.

5″ shaly limestone.

----*s. ziczac L. rhomboidalis T. scalariformis, abundant.*
24″ limestone.

1½″ shaly limestone.

7″ limestone.


Showing the Position of the several Central Ohio Sections with reference to the Bone Bed —
ALL ON PALEONTOLOGICAL EVIDENCE
BONE BED.
DEER CREEK.
HARRISBURG
COLUMBUS
MARBLE CLIFF
DUBLIN
DELAWARE
RADNOR
MARION
SANDUSKY
Kelly's Island.

TABLES SHOWING THE GEOGRAPHICAL DISTRIBUTION IN OHIO OF THE CORNIFEROUS FAUNA.

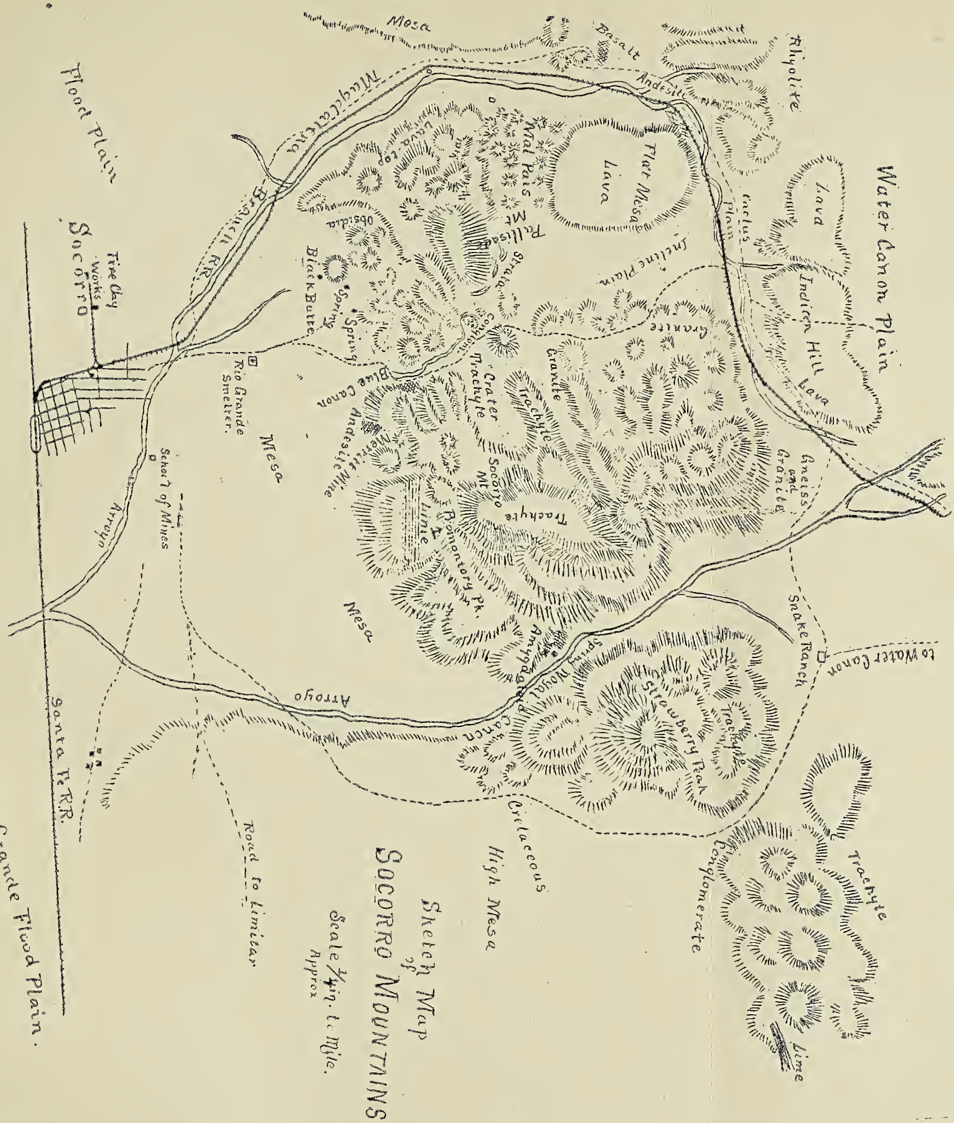
	Deer Creek.	Harrisburg.	Columbus.	Marble Cliff	Dublin.	Delaware.	Marion	Sandusky.	Kelley's Isl.	White House	Bellefontaine	Radnor.
RHIZOPODA.												
Saccammina eriana, D a w	----	----	----	----	----	----	----	----	x	x	----	----
SPONGIAE.												
Receptaculites devonicus, Whit.	----	----	x	----	----	----	----	----	----	----	----	----
Stromatopora mammillata, Nich.	----	----	----	----	----	----	----	----	x	----	----	x
" ponderosa, Nich.	----	----	----	----	----	----	----	----	----	----	----	x
" sp.	----	----	x	x	x	----	x	x	x	x	----	x
Syringostroma columnaris, Nich.	----	----	----	----	----	----	y	----	x	----	----	----
" densa, Nich.	----	----	----	----	----	----	----	----	----	x	----	----
ANTHOZOA.												
Aulacophyllum sulcatum, D'Or.	----	----	x	----	----	----	?	----	----	?	----	----
Aulopra sp	----	----	----	----	----	----	----	----	----	----	----	----
Cladopora, sp.	----	x	x	----	----	----	----	----	x	----	----	----
Clathropora, sp	----	----	----	x	----	----	----	----	----	----	----	----
Cyathophyllum, corniculum.	----	----	x	----	----	----	----	----	x	----	----	x
" halli	----	----	x	----	?	----	----	x	----	----	----	----
" robustum, H.	----	----	x	----	----	----	----	----	----	----	----	----
Cystiphyllum americanum, E.& H.	----	----	x	x	----	----	----	x	x	----	----	----
" ohioense. Nich.	----	x	x	----	----	----	x	x	----	----	----	----
Eridophyllum verneuilanum, E & H	x	----	x	x	----	----	x	----	x	----	----	----
Favosites basalticus, Goldf.	----	----	x	----	----	----	----	----	----	----	----	----
" emmonsi, Rom.	----	x	----	----	x	----	----	----	----	x	----	----
" gothlandicus, Lam.	x	----	x	----	----	----	x	----	----	----	----	----
" hemisphericus, Troost.	----	----	x	x	x	----	x	x	x	x	----	x
" limitaris, Rom.	----	----	----	----	----	----	----	----	----	x	----	x
" invaginatus Nich.	----	----	----	----	----	----	----	----	----	x	----	x
" pleurodictyoides, Nich.	----	----	----	----	----	----	----	----	x	----	----	----
" turbinatus, Bill.	----	x	x	----	----	----	x	----	x	x	----	x
" sp	----	----	----	----	----	x	----	----	----	----	----	----
Hadrophyllum d'orbignyi, E. & H.	----	----	----	x	----	x	----	----	----	----	----	----
Heliophyllum halli, E. & H	----	x	----	x	----	----	----	----	----	----	----	----
Michelinia cylindrica	----	x	----	----	----	----	----	----	----	----	----	----
Stylastrea anna, Whit.	----	----	x	----	----	----	x	----	x	x	----	----
Syringopora tabulata, E. & H.	----	x	----	----	----	----	x	----	x	x	----	x
Zaphrentis compressa, Edw	----	x	x	----	----	----	x	----	----	----	----	x
" cornicula, Les,	----	----	x	----	----	----	x	----	----	----	----	----
" gigantea, Les.	----	----	----	x	x	----	----	----	----	----	----	x
" prolifica, Bill.	x	x	x	x	x	----	x	x	x	x	x	x
CRINOIDEA.												
Dolatocrinus liratus, H.	----	----	x	----	----	----	----	----	----	----	----	----
Megistocrinus spinulosus, Lyon.	----	----	x	----	----	----	----	----	----	----	----	----
BLASTOIDEA.												
Codaster pyramidatus, Shum	----	----	x	x	x	----	----	----	----	----	----	----
Nucleocrinus verneuili, Troost	----	----	x	x	----	----	x	----	----	x	----	----
BRACHIOPODA.												
Ambocoelia umbonata, Con.	----	----	----	----	----	x	----	----	----	----	----	----
Amphigenia elongata, Van.	----	x	----	----	----	----	----	----	----	----	----	----
Athyris spiriferoides, Eaton.	----	----	----	----	----	----	----	x	----	----	----	----
Atrypa aspera, Sch.	----	----	x	x	x	----	x	x	x	x	x	x
" reticularis, Linn	x	x	x	x	x	----	x	x	x	x	x	x
Chonetes acutiradiatus, H	----	----	----	----	----	----	----	----	x	----	x	----
" mucronatus, M. & H.	x	----	x	x	----	----	x	x	x	x	x	----
" yandellanus, H.	----	----	----	----	----	x	x	x	----	x	----	----
" sp. nov.	----	----	x	----	----	----	----	----	----	----	----	----

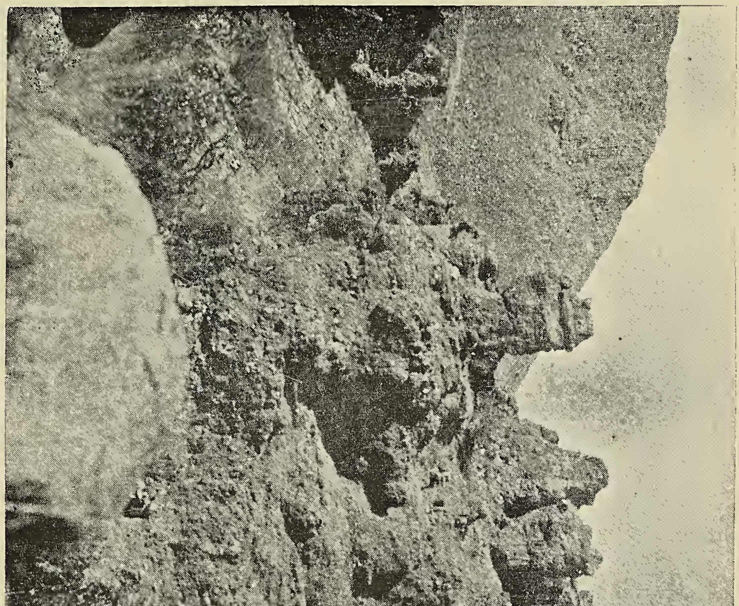
TABLES SHOWING THE GEOGRAPHICAL DISTRIBUTION IN OHIO OF THE CORNIFEROUS FAUNA.

	Deer Creek.	Harrisburg.	Columbus.	Marble Cliff.	Dublin.	Delaware.	Marion.	Sandusky.	Kelley's Isl.	White House	Bellefontaine	Radnor.
BRACHIOPODA—Continued.												
Cyrtina hamiltonensis, H			x	x						x	x	
Leiorhynchus limitaris, Van						x						
Leptaena rhomboidalis, Wilck			x	x		x	x	x	x			x
Lingula manni, M						x						
Meristella nasuta, Con		x				x						
Nucleospira concinna, H	x								x			
Orbiculoidea, sp									x			
" sp.											x	
Pentamerella arata, Con		x	x	x				x		x		x
Productella spinulicosta, H			x	x						x		
" truncata, H									x	x		
Rhipidomella livia Bill	x	x	x	x	x	x	x			x	x	x
Rhynchonella carolina, H			x								x	
" tethys, Bill		x	x				x		x		x	
Schizophoria propinqua, H	x		x	x	x	x	x	x	x	x	x	x
Spirifera, acuminata, Con		x	x	x		x	x	x	x		x	x
" divaricata, H										x		x
" duodenaria, H						x	x		x			
" euruteines, Owen										x		
" fimbriata, Mor		x	x	x			x					x
" gregaria, Clapp	x		x	x	x		x					x
" grieri, H										x		
" macrothyris, H		x			x					x		x
" macra, H										x		
" maia, Bill			x				x	x				
" mucronata?, Con											x	
" manni, H	x	x	x	x	x		x	x	x	x		x
" oweni ?, H										x	x	
" raricosta, Con		x		x								
" varicosa ? H					x		x					
" ziczac, H	x					x	x		x	x		
Orthotetes chemungensis, Con		x	x	x			x		x			x
Stropheodonta ampla, H		x							x			x
" crebristriata, Con.			x						x			
" concava, H		x		x	x		x	x	x	x		x
" demissa, Con		x		x	x		x	x	x	x		x
" hemispherica, H		x	x	x		x	x	x	x	x	x	x
" inequiradiata, H			x		x	x			x	x		x
" nacrea, H										x	x	
" patersoni, H	x			x	x				x			
" perplana, Con	x	x	x	x		x	x	x	x	x	x	x
Terebratula lincklaeni ? H										x		
" sullivanti, H		x					x		x			x
" sp							x			x		
LAMELLIBRANCHIATA.												
Aviculopecten parilis, Con						x						
" sp. nov									x			
Conocardium cuneus, Con	x	x	x	x	x		x		x	x	x	x
Glyptodesma erecta, Con				x		x		x		x	x	
Goniophora perangulata, H										x		
Gosselettia ? sp. nov										x		
Grammysia bisulcata, Con						x		x				
Modiomorpha concentrica ? Con		x							x	x		x
" perovata, M. & W				x	x							

TABLES SHOWING THE GEOGRAPHICAL DISTRIBUTION IN OHIO OF THE CORNIFEROUS FAUNA.

	Deer Creek.	Harrisburg.	Columbus.	Marble Cliff.	Dublin.	Delaware.	Marion	Sandusky.	Kelley's Isl	White House	Bellefontaine	Radnor.
LAMELLIBRANCHIATA—Continued												
Mytilarca ponderosa, H	----	----	----	----	x	----	----	----	x	----	----	----
Paracyclas elliptica, H	----	----	x	x	x	----	----	----	x	x	----	----
" lirata, Con	----	----	x	----	x	----	x	x	x	x	----	----
Pterinea ? flabella?, Con	----	----	----	----	----	----	----	----	----	x	----	----
" pinguis, H	----	----	x	x	x	----	----	----	----	----	----	x
Sanguinolites sanduskyensis, M	----	----	x	x	x	----	----	----	----	----	----	----
Schizodus sp nov	----	----	----	----	----	----	----	----	----	x	----	----
PTEROPODA.												
Tentaculites scalariformis, H	----	----	----	----	----	x	x	x	x	x	----	----
GASTROPODA												
Bellerophon pelops, H	----	----	----	----	x	----	----	----	x	x	x	----
" sp	x	----	----	----	----	----	----	----	----	----	----	----
Callonema lichas, H	----	----	x	x	x	----	----	x	x	x	----	x
Euomphalus decewi, Bill	----	----	x	x	x	----	----	----	x	x	----	x
Isonema humilis, M	----	----	----	x	----	----	----	----	----	x	----	----
Loxonema pexata, H	----	x	x	----	x	----	----	----	x	x	----	----
Murchisonia desiderata, H	----	x	----	x	----	----	----	----	x	x	----	----
Platyceras attenuatum, H	----	----	----	----	----	----	----	x	----	----	----	----
" bucculentum, H	----	----	----	----	----	x	----	----	----	----	----	----
" carinatum, H	----	----	----	----	----	----	----	----	x	x	x	----
" dumosum, Con	----	x	x	x	----	----	x	----	x	x	----	x
" multispinosum, M	----	----	x	----	----	----	x	----	----	----	----	----
" nodosum, Con	----	----	x	----	----	----	----	----	----	----	----	----
Pleurotomaria lucina, H	----	----	----	----	x	----	----	----	----	----	----	----
Trochus kearneyi, H	----	----	----	----	x	----	----	----	----	----	----	x
Turbo shumardi, Vern	----	----	----	----	x	----	----	----	----	----	----	x
CEPHALOPADA.												
Gomphoceras eximium, H	----	----	----	x	----	----	----	x	x	----	----	----
" sciotoense, Whit	----	----	x	----	----	----	----	----	----	----	----	----
" sp	----	----	----	----	x	----	----	----	----	x	----	----
Gyroceras columbiense, Whit	----	----	x	----	x	----	----	----	x	----	----	----
" cyclops, H	----	----	----	x	----	----	x	----	x	----	----	x
" matheri ? Con	----	----	----	----	----	----	----	----	x	----	----	----
" ohioense, M	----	----	----	----	----	x	----	----	x	----	----	----
Orthoceras ohioense	----	----	x	x	----	----	----	----	----	----	----	----
" profundum, H	----	----	----	----	x	----	----	----	----	----	----	----
CRUSTACEA.												
Dalmanites aspectans, Con	----	----	----	x	x	----	----	----	x	----	----	x
" bifidus, H	----	----	----	----	x	----	----	----	x	----	----	----
" calypso, H	----	----	----	----	x	----	----	----	x	x	----	x
Phacops cristata H	----	----	----	x	x	----	x	x	----	----	----	----
" rana, Green	----	----	----	----	----	----	----	x	x	x	----	----
Proetus crassimarginatus, H	x	----	x	----	----	----	----	----	x	x	x	x
" planimarginatus, M	----	----	----	----	----	----	----	----	x	x	----	----
" rowi ? Green	----	----	----	----	----	----	----	----	----	x	----	----


Sketch Map of Socorro Mountains
Scale ¼ in. to Mile. Approx
Flood Plain
Socorro
Fire Clay Works
Magdalena Branch R.R.
Mesa
Basalt
Andesite
Rhyolite
Water Canon Plain
Lava
Indian Hill Lava
Flat Mesa
Lava
Mal Pais Mt
Palisade
Strata
Incline Plain
Obsidian
Black Butte
Spring
Spring
Granite
Granite
Rio Grande Smelter
Blue Canon
Crater
Trachyte
Trachyte
Andesite
Merritt Mine
Socorro Mt
Trachyte
Gneiss and Granite
Lime
Promontory Pk.
Mesa
Mesa
School of Mines
Arroyo
Arroyo
Amygdaloid
Spring
Canon
Strawberry Peak
Trachyte
Snake Ranch
to Water Canon
Santa Fe R.R.
Road to Limitar
Cretaceous
High Mesa
Conglomerate
Trachyte
Lime
Rio Grande Flood Plain.



HERRICK—Geology of New Mexico.

CASTELLATED PEAKS SOUTH OF BLUE CANON ROAD.

X I

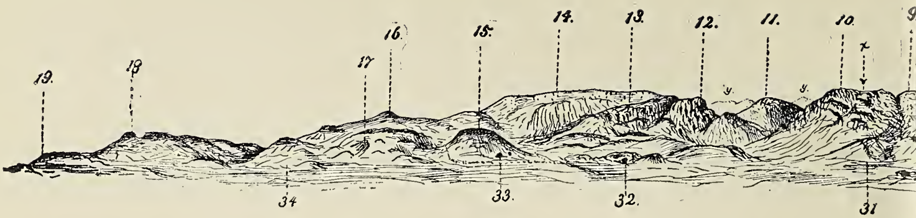


Fig. 3.

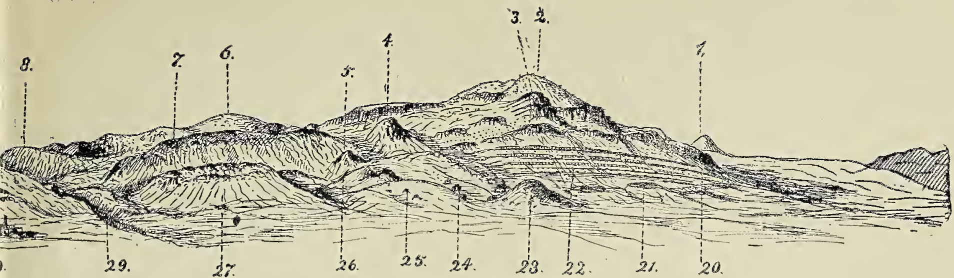
Fig. 1.

HERRICK—Geology of New Mexico.

Fig. 1. Pallisade mountain from the northwest showing recent strata at 3. The foreground (4) is a granite hill over which the Blue Canon road passes.

Fig. 2. 1. Talus conglomerate. 2. Basic eruptive. 3. Magdalena Mountains in distance.

Fig. 3. Panoramic view of the Socorro Mountains from the east, from a series of photographs, as seen from the city of Socorro. The numbers are placed with reference to sources of the rocks examined and will be referred to in the section on petrography. 1. Strawberry Peak; 2. Socorro Peak, between this and 1, Nogal Canon; 3. Promontory Peak; 4. Sharp Peak, north of which a dyke cuts off the limestone seen at 22; 5. Similar small peak near which gold discovery has been made; 6. Western granitic part of main range; 7. The upper and western of two flows of quartz trachyte flowing over andesite at 27; 8. Western wall of the old crater about one mile west of 7; 9. Hill forming southern wall of Blue Canon, the lower part of andesite, upper of trachyte and rhyo-



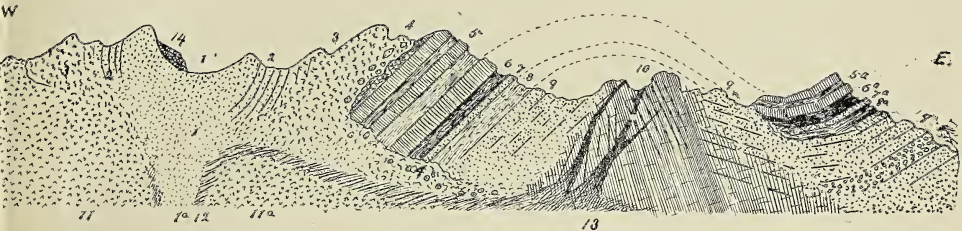


Fig. 5.

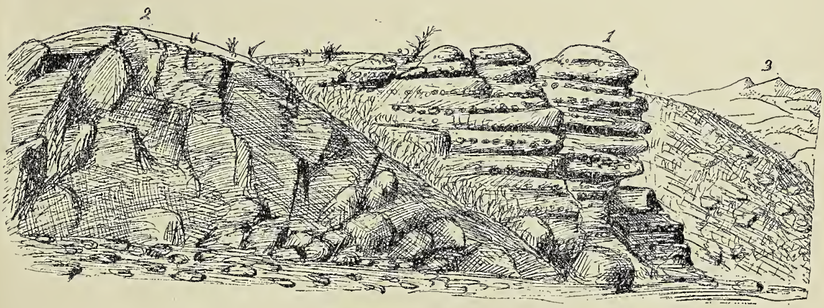


Fig. 2.

lite; 10 to 13. Various trachyte, rhyolite and breccia flows; 14. Pallisade Mountain; 15 to 19. Hills of stratified gravel and sand covered with a thin flow of recent basalt; 20. Flow of trachytic rock over the limestone; 21. Quartzite at base of limestone; 22. Carboniferous limestone, about 400 feet thick; 24 to 26. Andesite beneath, Merritt and other mines; 27. Beds of kaolin from decomposition of andesite and trachyte; 29. Blue Canon; 30. Rio Grand smelter; 31. Spring; 32. Spring and mill; 33. Ranch; 34. Clay.

Fig. 5. Ideal Section through the axis of uplift south of Limitar mountain. 1. Trachyte crater; 2. Laminated margin of trachyte; 3. Porphyry about the margins; 4. Brecciated contact zone; 5. Massive limestone; 6. Shale with Productus cora; 7 Quartzite (20 feet); 8. Shaly limestone with Spirifer camerata; 9. Quartzite passing into the next; 10 Mica and hornblende schist with quartzite bands and phases: 11. Granite; 13. Diorite, intrusive (paramorphic); 14 Talus conglomerate in or near the crater.

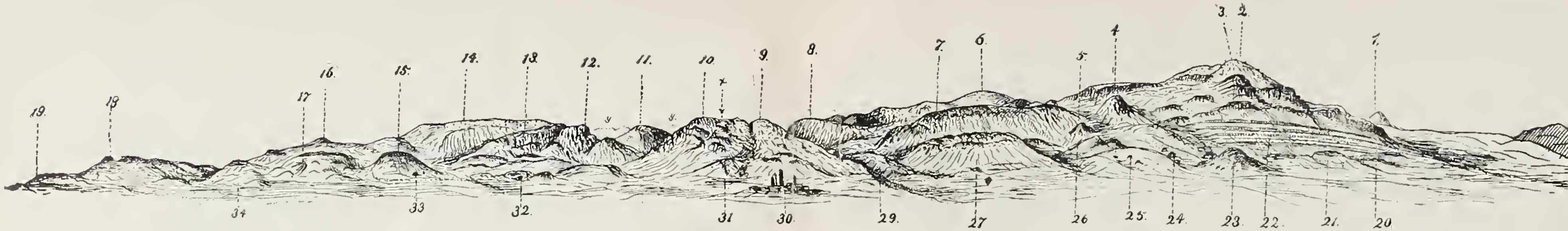
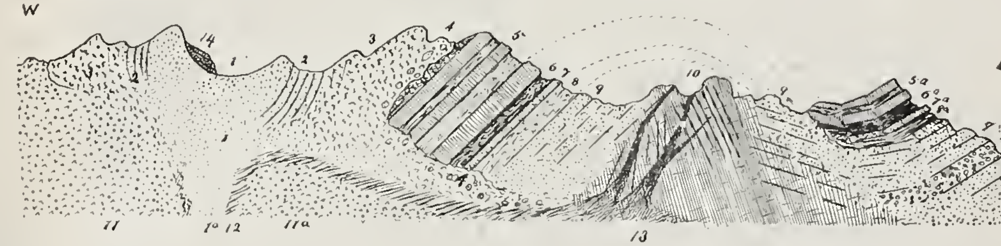


Fig. 3.



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HERRICK—Geology of New Mexico.

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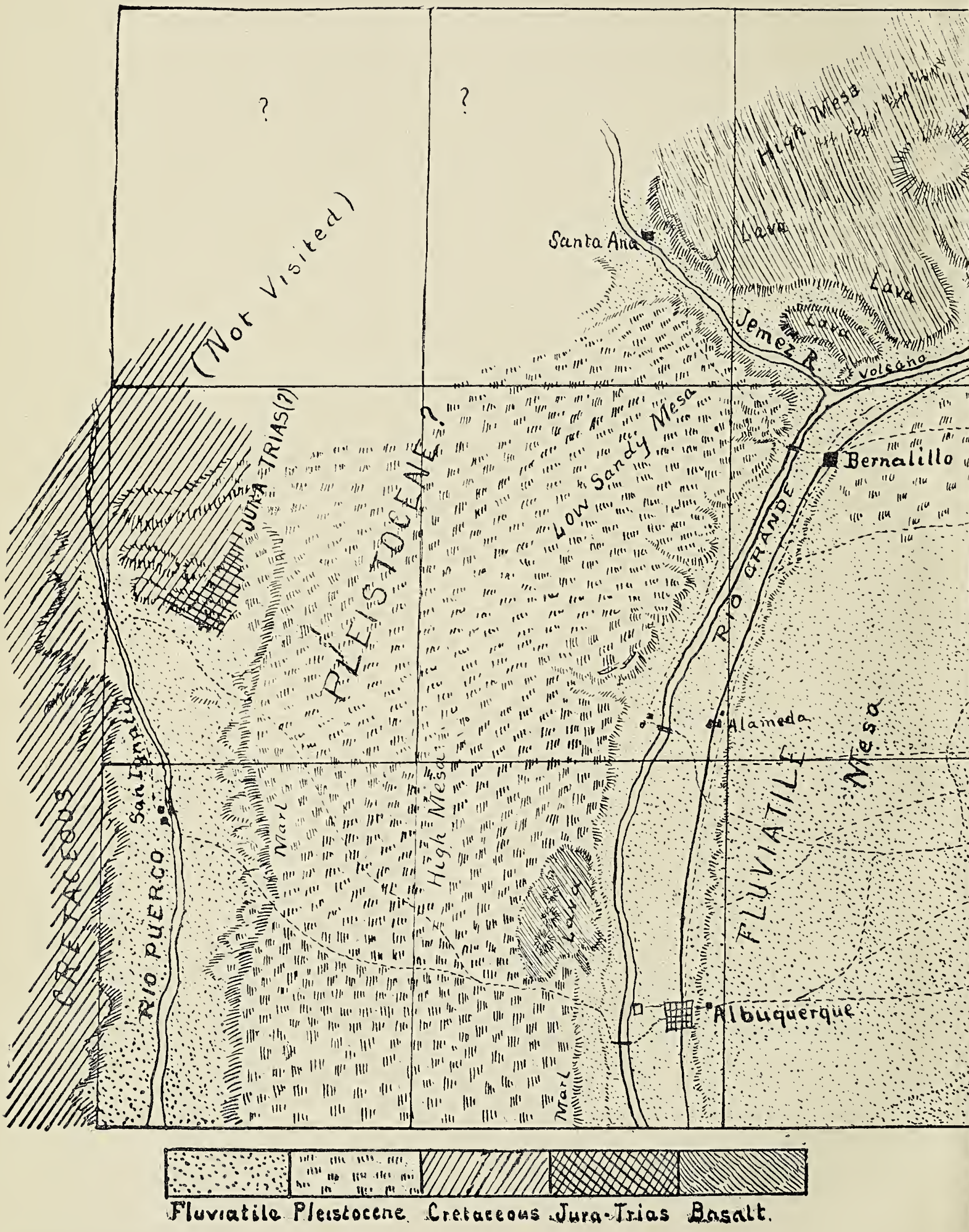
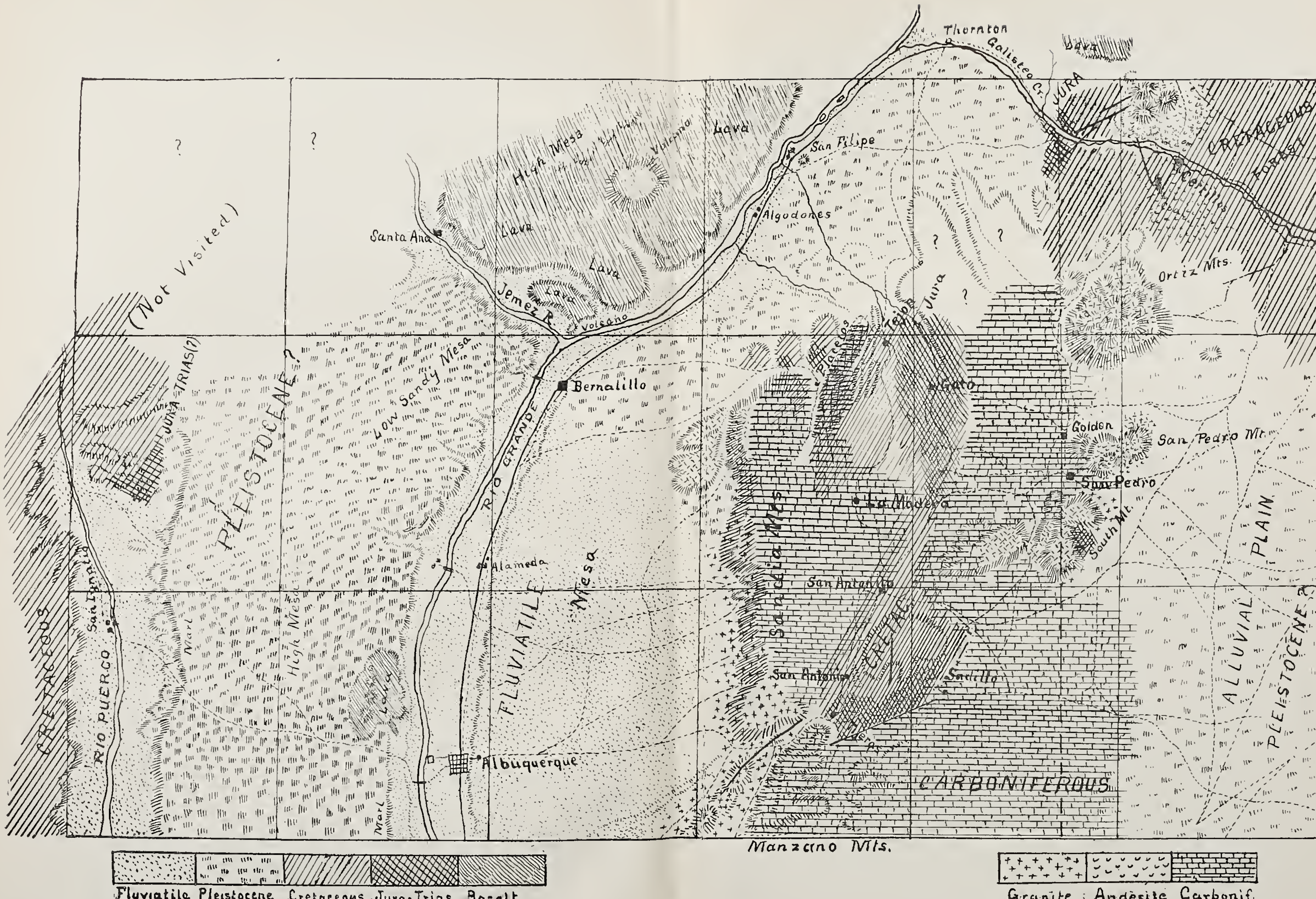
HERRICK—Geology of New Mexico.

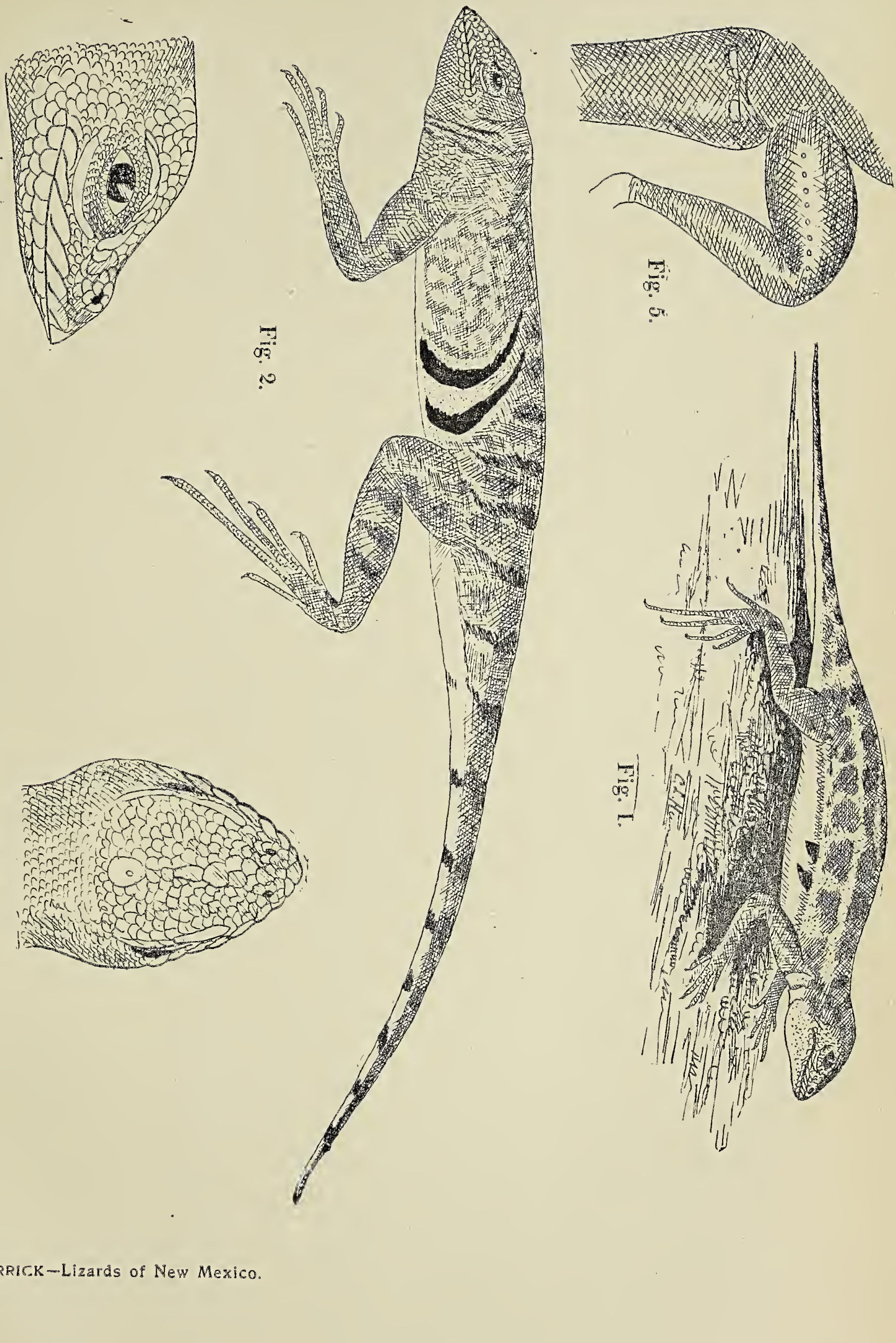
MAGDALENA MOUNTAIN.

XIII


?
?
(Not Visited)
Santa Ana
High Mesa
Lava
Lava
Lava
Jemez R.
Volcano
JURA-TRIAS(?)
PLEISTOCENE?
Low Sandy Mesa
Bernalillo
RIO GRANDE
CRETACEOUS
San Ignacio
RIO PUERCO
Marl
High Mesa
Lava
Alameda
FLUVIATILE
Mesa
Albuquerque
Marl
Fluviatile
Pleistocene
Cretaceous
Jura-Trias
Basalt.


Thornton
Galisteo Cr.
Lava
JURA
CRETACEOUS
Cerrillos
Coal
Forest
Lava
San Filipe
Algodones
Ortiz Mts.
Jura
Placeres
Golden
San Pedro Mt.
San Pedro
La Madera
South Mt.
Sandia Mts
San Antonito
CRETAC
San Antonio
Sadillo
ALLUVIAL
PLAIN
PLEISTOCENE
CARBONIFEROUS
Manzano Mts.
Granite
Andesite
Carbonif.


Thornton
Galisteo Cr.
Lava
JURA
CRETACEOUS
San Filipe
Algodones
Santa Ana
High Mesa
Lava
Lava
Volcano
(Not Visited)
Jemez R.
Ortiz Mts.
Tejon
Jura
Bernalillo
Gato
Golden
San Pedro Mt.
San Pedro
La Madera
South Mt.
PLEISTOCENE?
JURA TRIAS (?)
Low Sandy Mesa
RIO GRANDE
Alameda
FLUVIATILE
Mesa
Sandia Mts.
San Antonito
San Antonio
Sadillo
CRETAC.
CRETACEOUS
San Ignacio
RIO PUERCO
Marl
High Mesa
Lava
Albuquerque
Marl
CARBONIFEROUS
ALLUVIAL PLAIN
PLEISTOCENE?
Manzano Mts.
Fluviatile Pleistocene Cretaceous Jura-Trias Basalt.
Granite Andesite Carbonif.



1. HOLBROOKIA MACULATA. 2. HOLBROOKIA TEXANA.

Fig. 8.

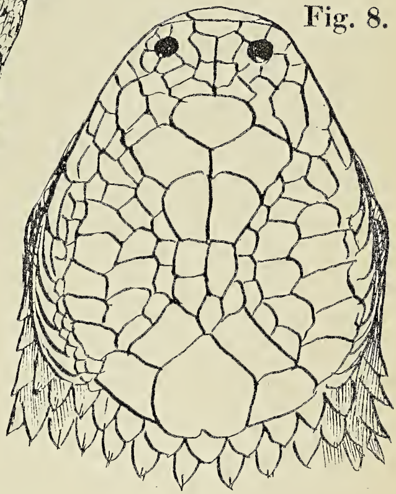


Fig. 6.

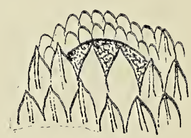


Fig. 7.

HERRICK—Lizards of New Mexico.

SCELOPORUS POINSETTII.

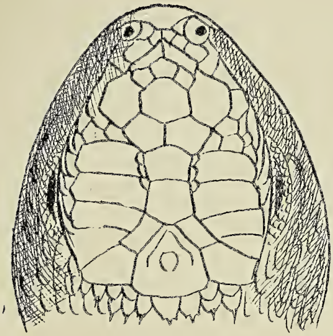


Fig. 10.

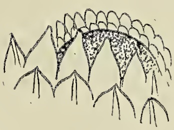


Fig. 11.

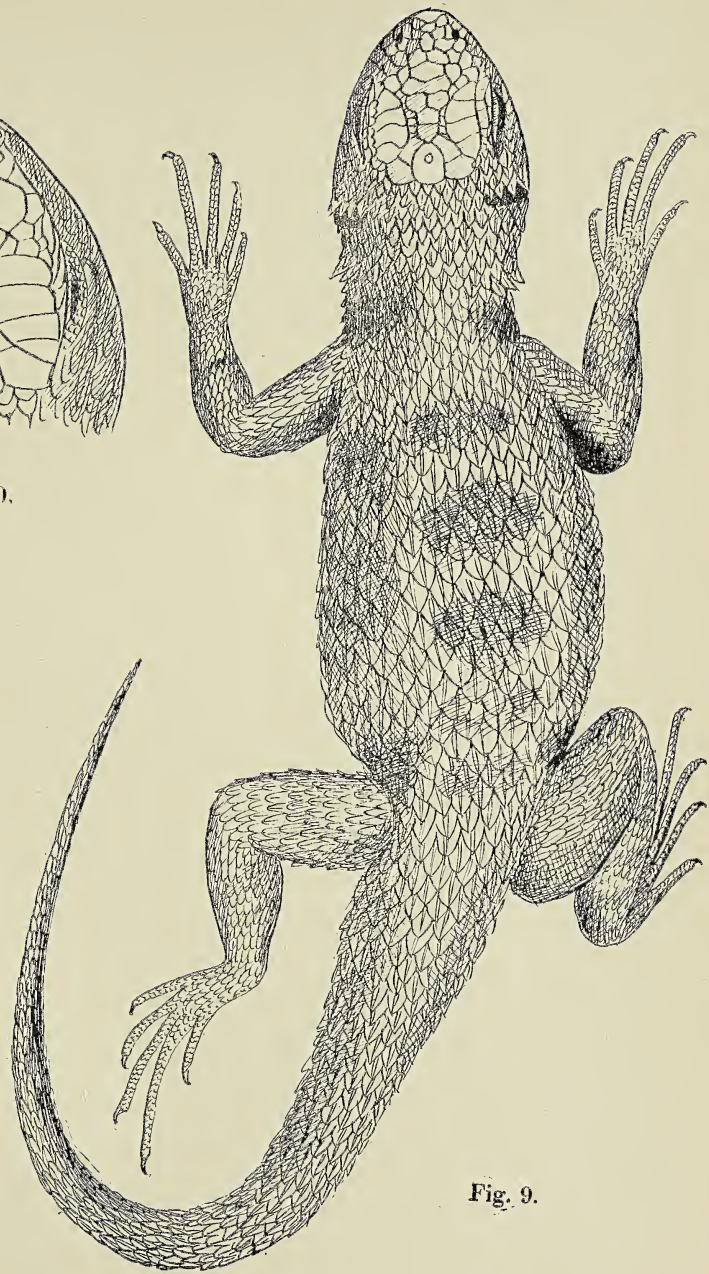


Fig. 9.

HERRICK—Lizards of New Mexico.

SCELOPORUS MAJISTER.

Fig. 12.

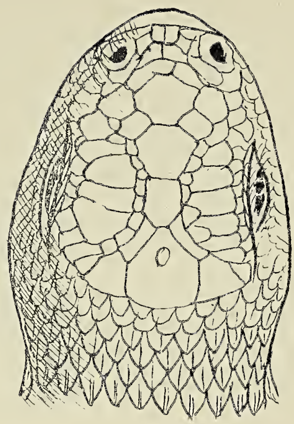


Fig. 13.

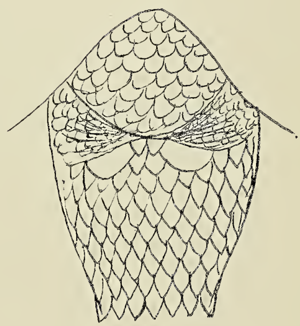


Fig. 14.

HERRICK—Lizards of New Mexico.

SCELOPORUS OCCIDENTALIS.

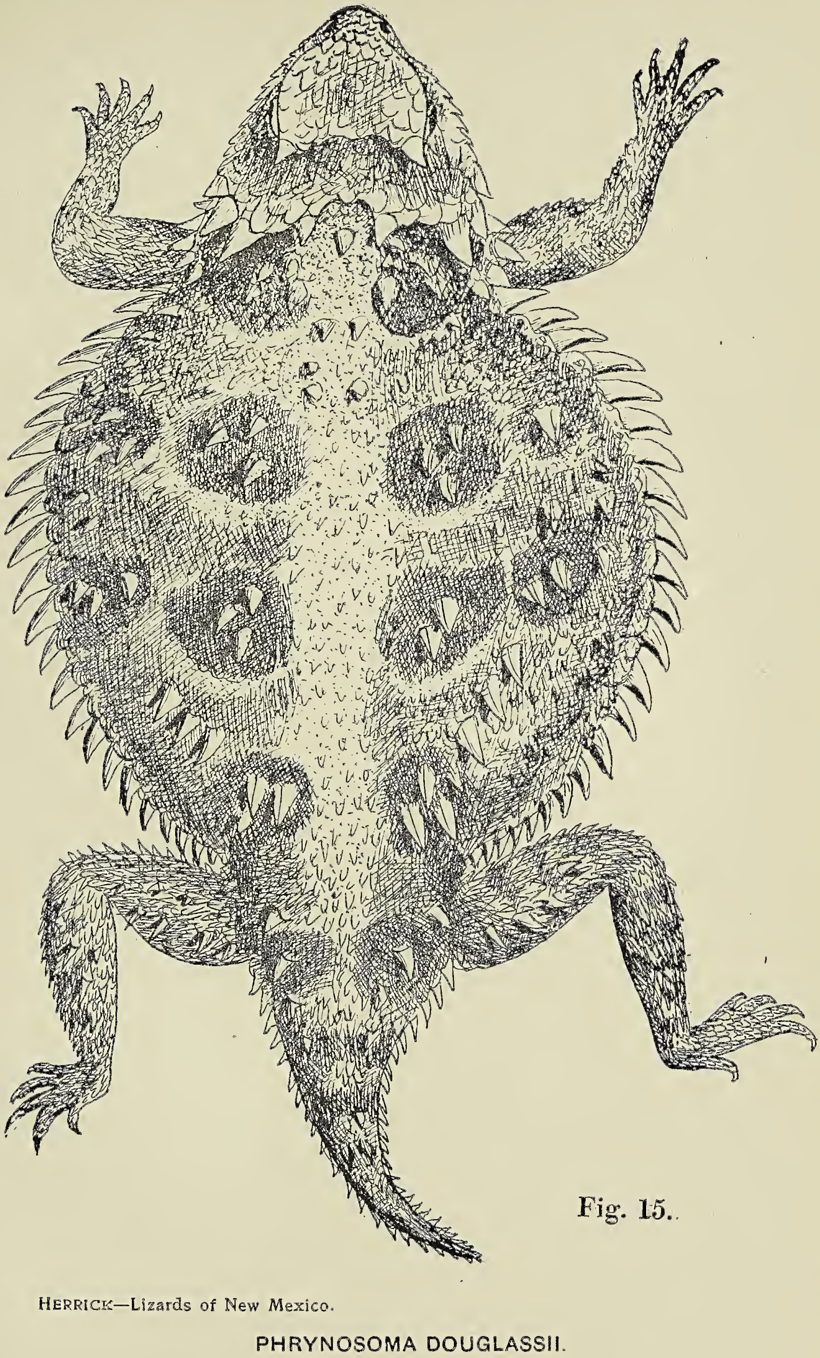


Fig. 15.

HERRICK—Lizards of New Mexico.

PHRYNOSOMA DOUGLASSII.

Fig. 16.

Fig. 17.

HERRICK—Lizards of New Mexico.

PHRYNOSOMA CORNUTUM.

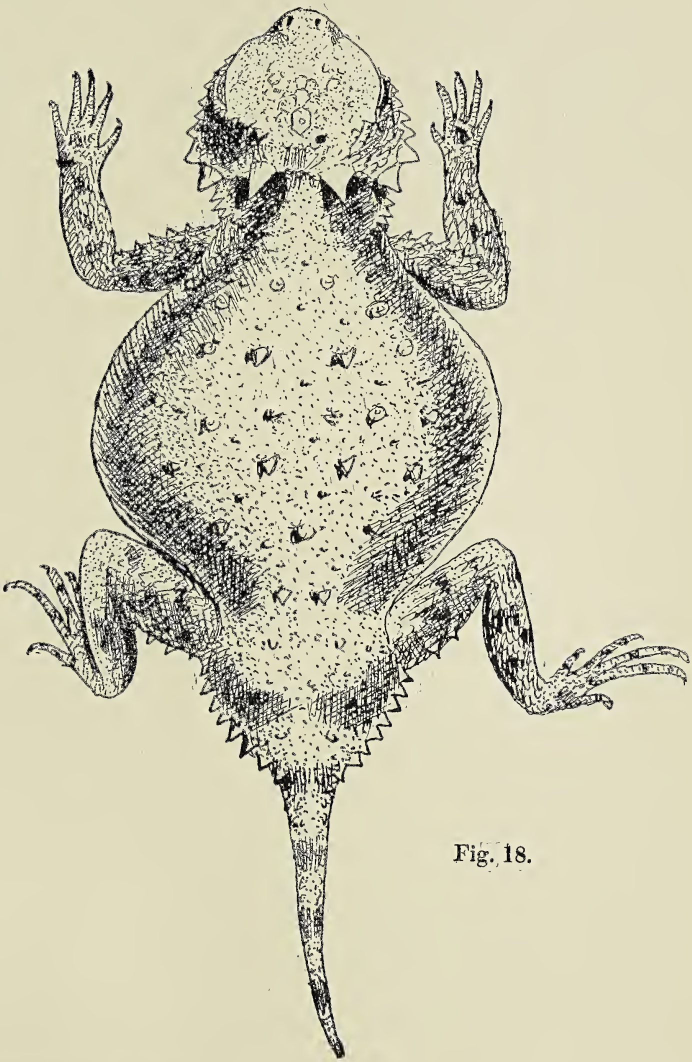


Fig. 18.

HERRICK—Lizards of New Mexico

PHRYNOSOMA PLATYRHYNUS

Fig. 19.

UTA STANISBURIANA.

Fig. 20.

CROTOPHYTUS COLLARIS.

Fig. 21.

HERRICK—Lizards of New Mexico

CROTOPHYTUS COLLARIS.

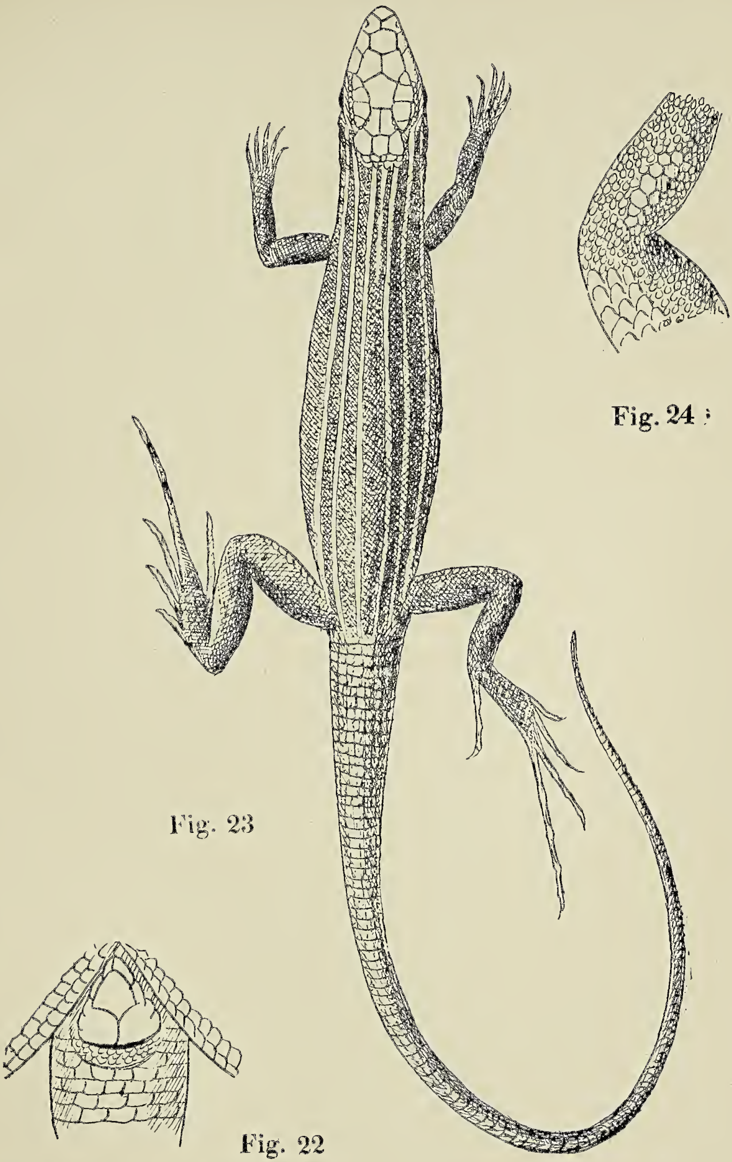
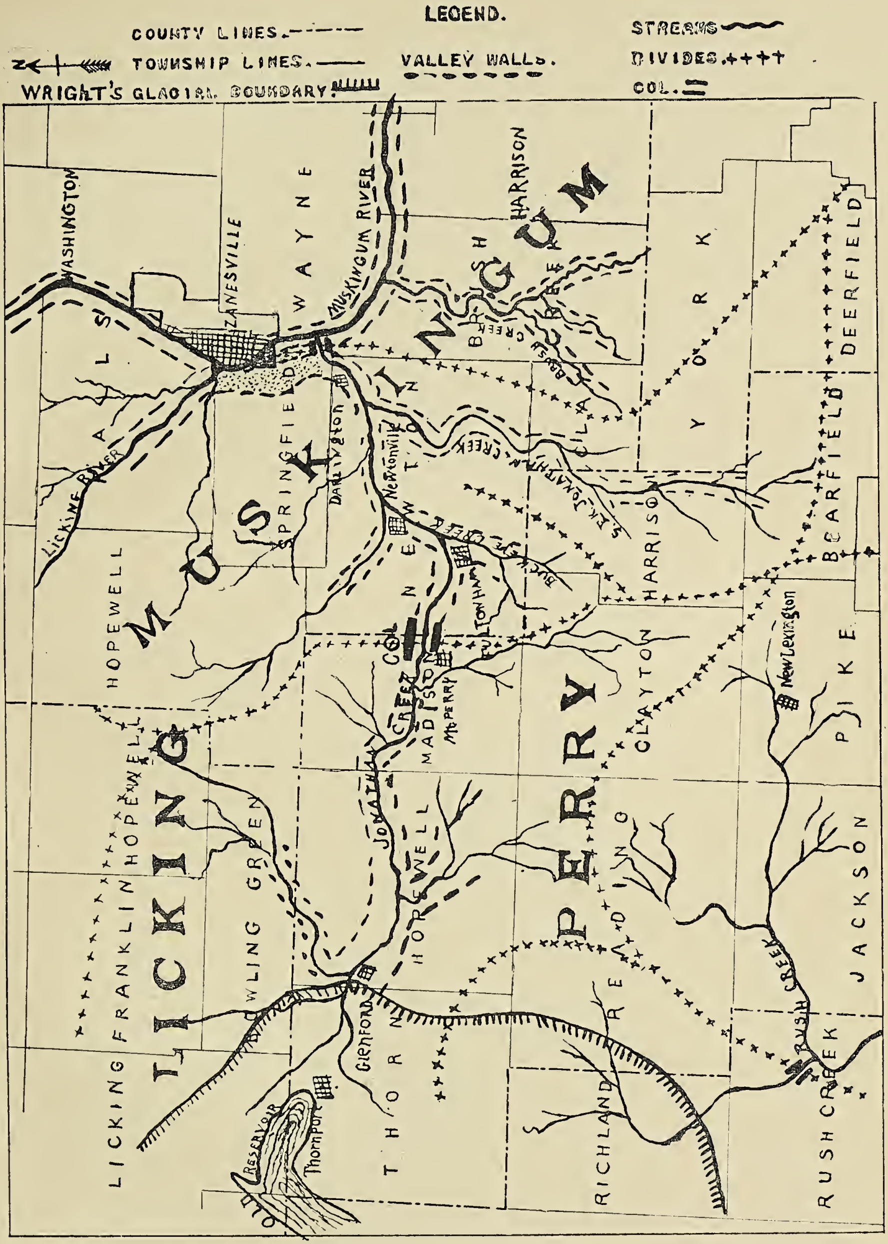


Fig. 24

Fig. 23

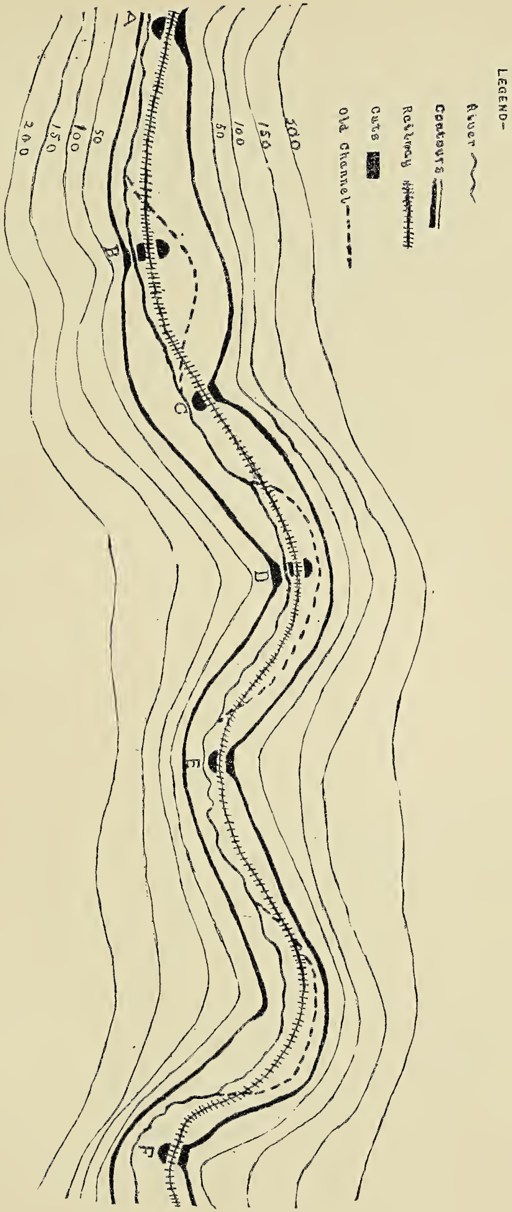
Fig. 22

CNEMIDOPHORUS SEXILINEATUS.



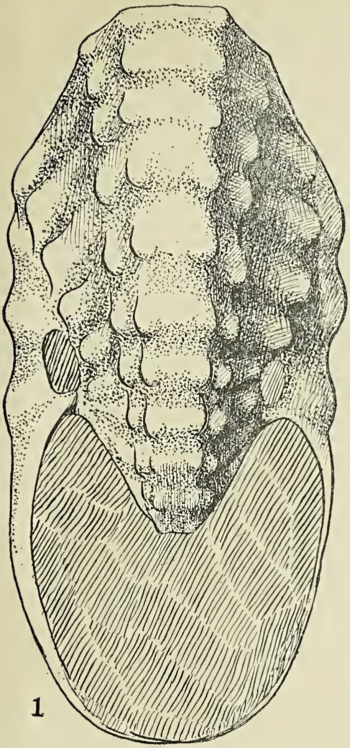
JONATHAN CREEK DRAINAGE BASIN

DAVIS—Jonathan Creek Drainage Basin.



JONATHAN CREEK COL.

DAVIS—Jonathan Creek Drainage Basin.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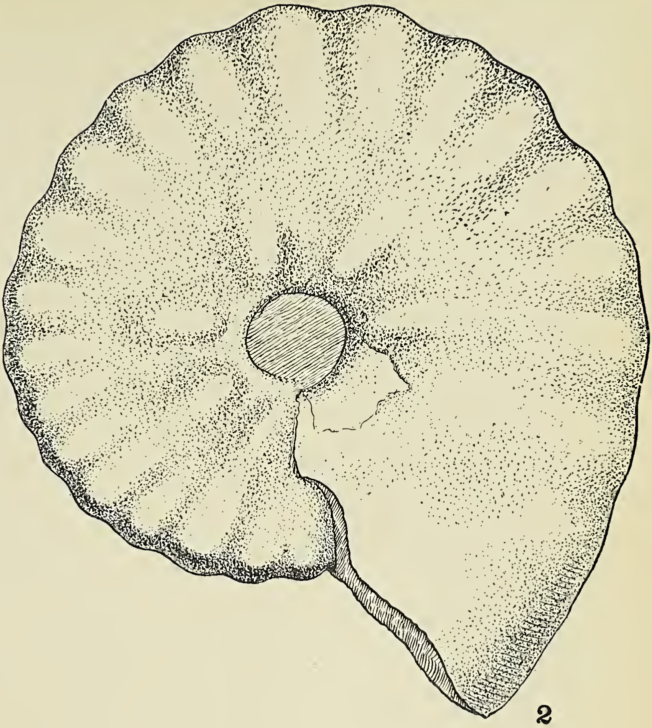
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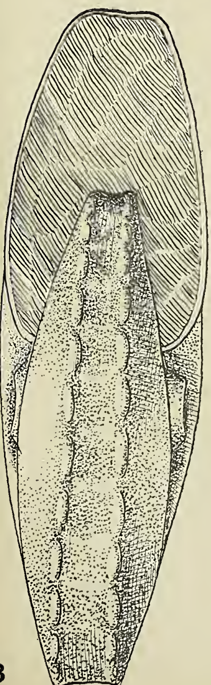
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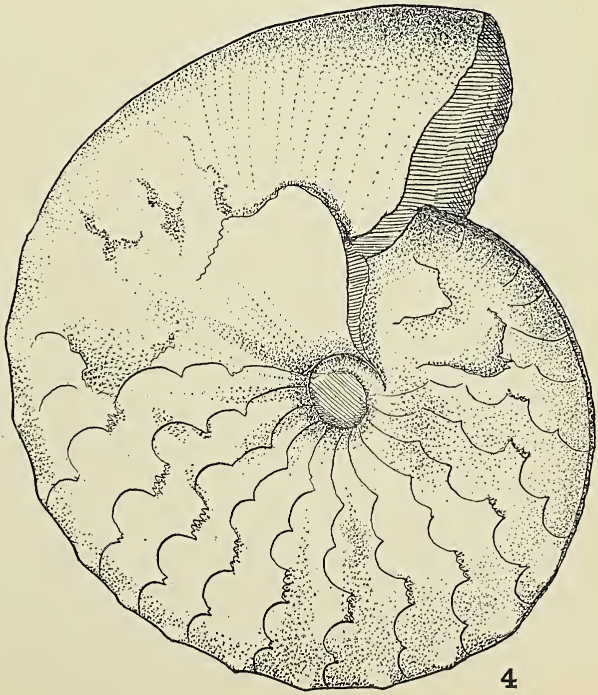
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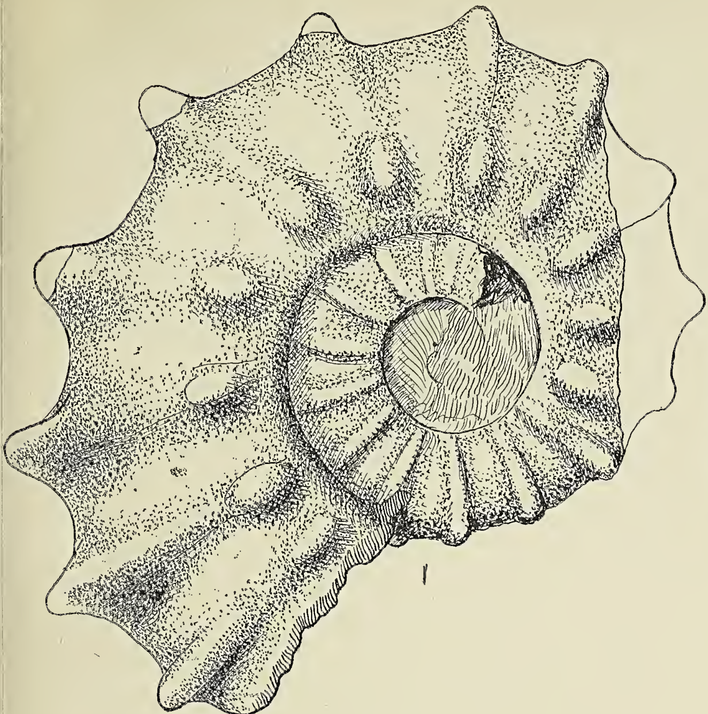

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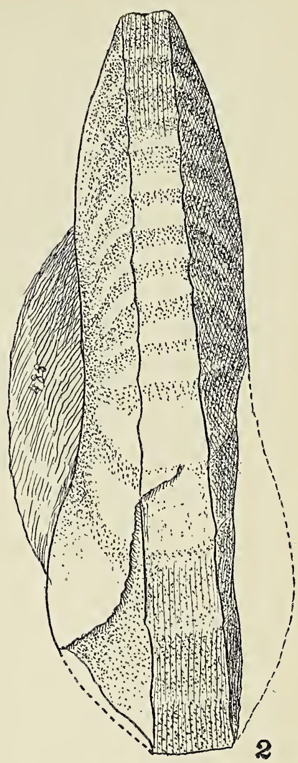

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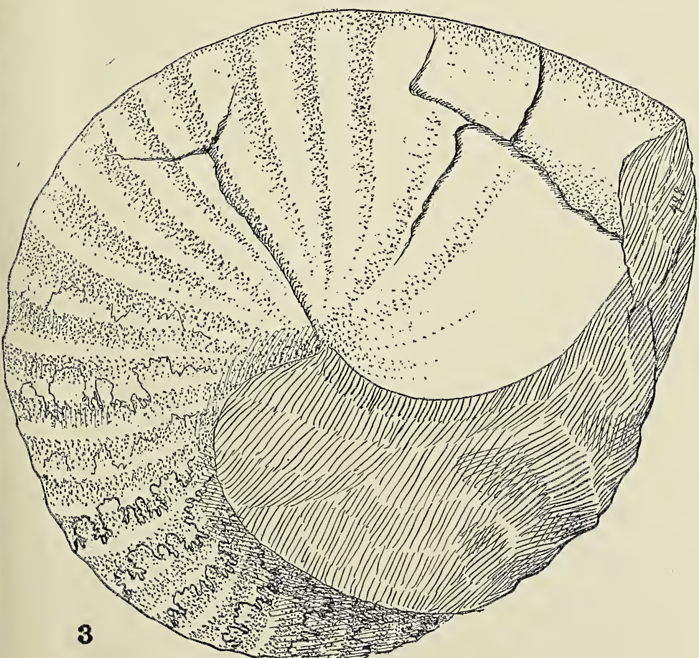

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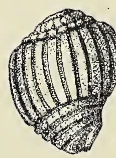

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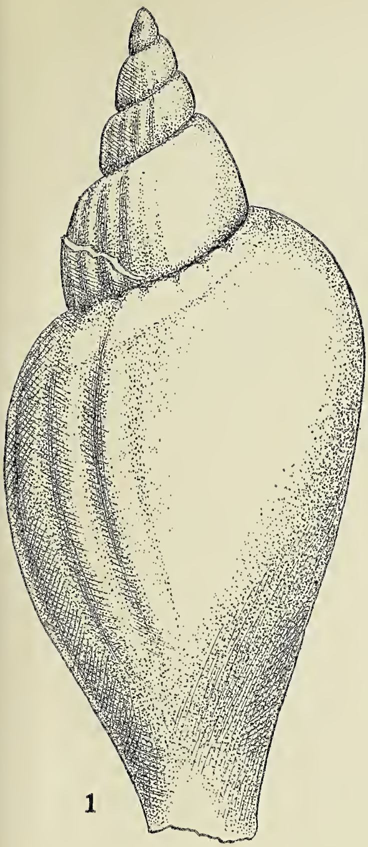

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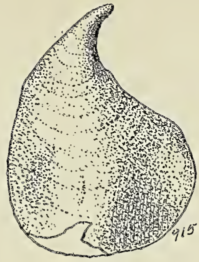

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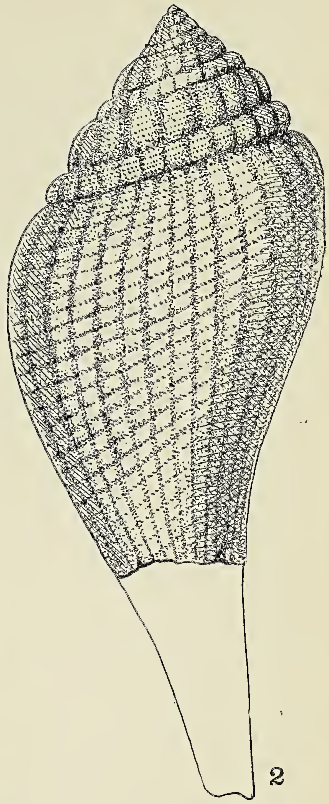

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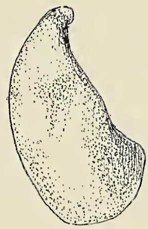

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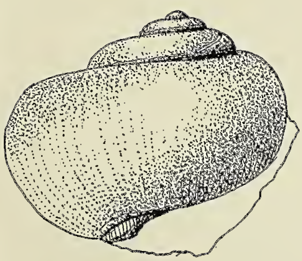

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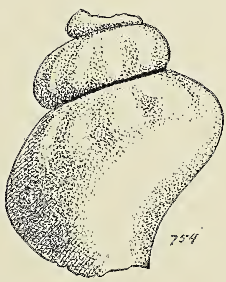

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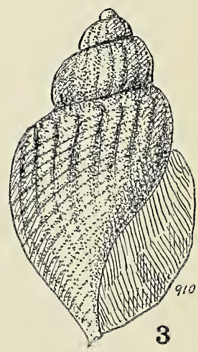

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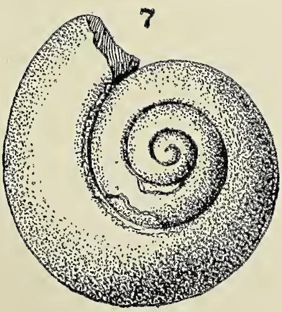

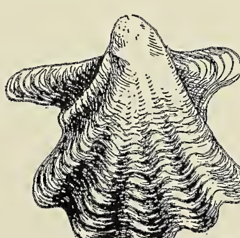

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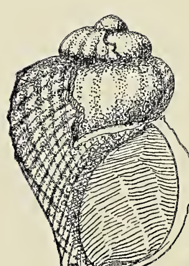

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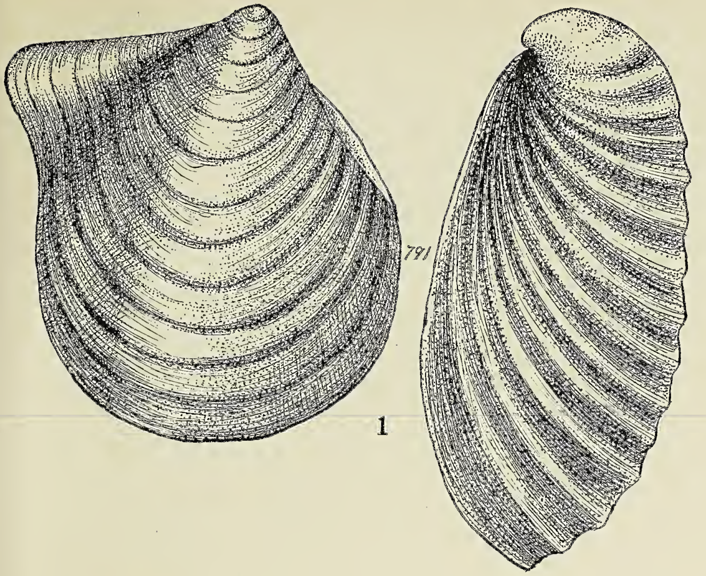

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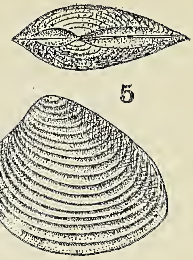

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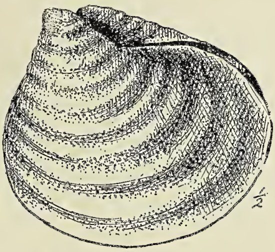

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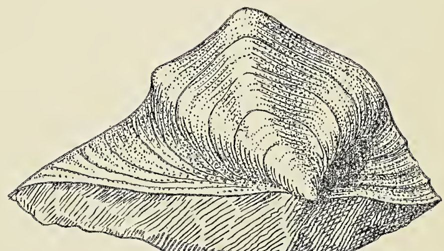

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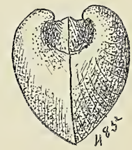

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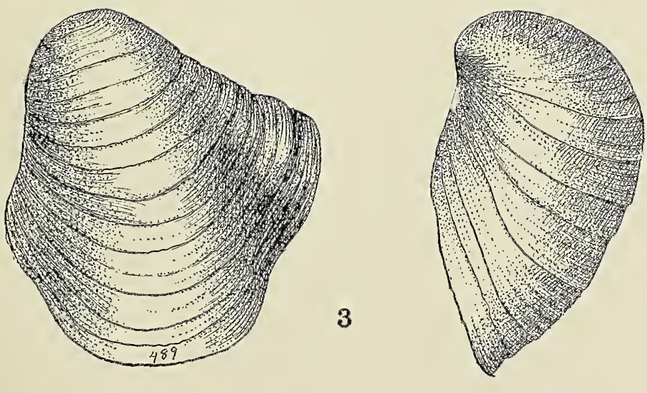

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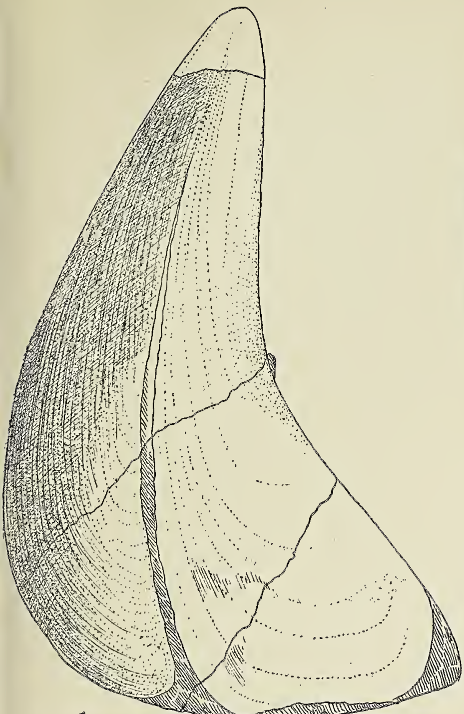

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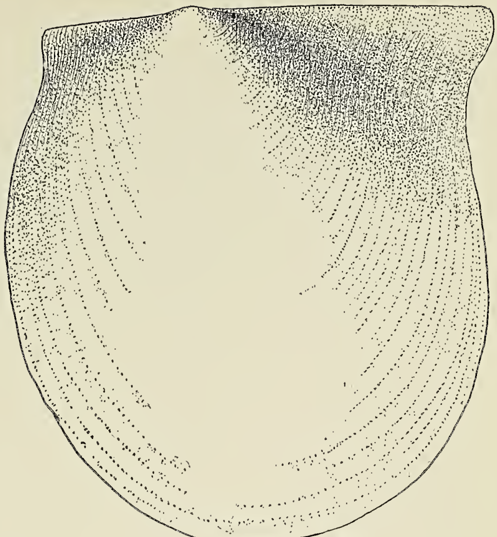

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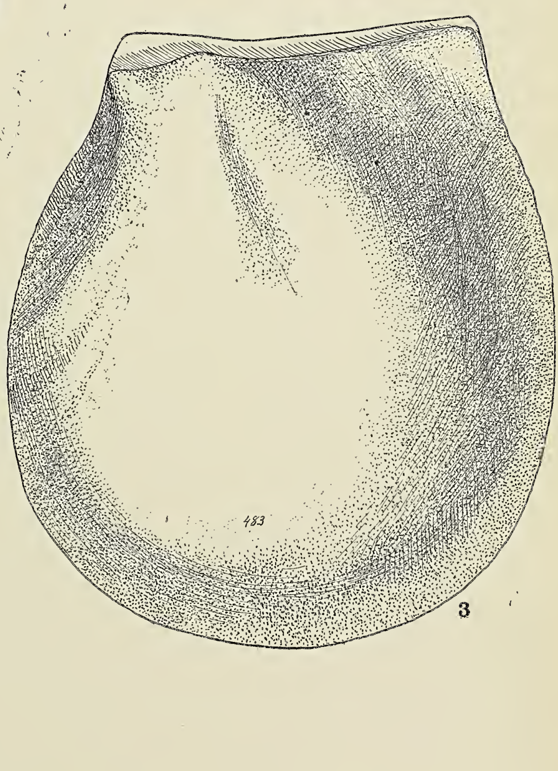

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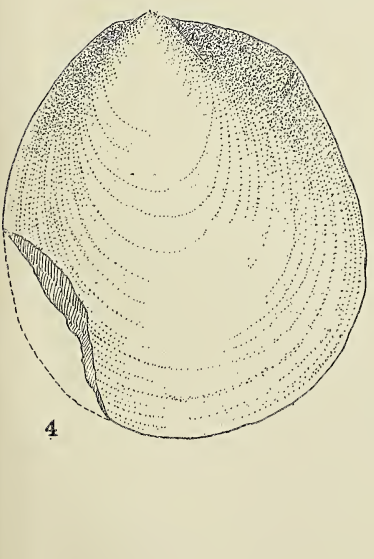

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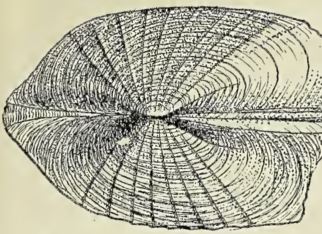

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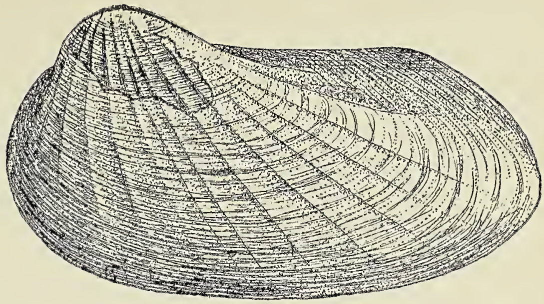

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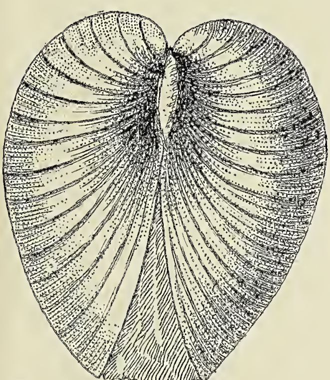

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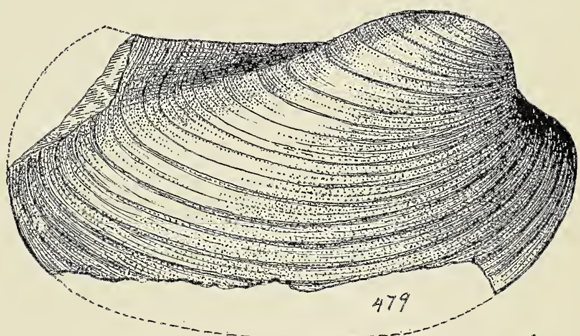

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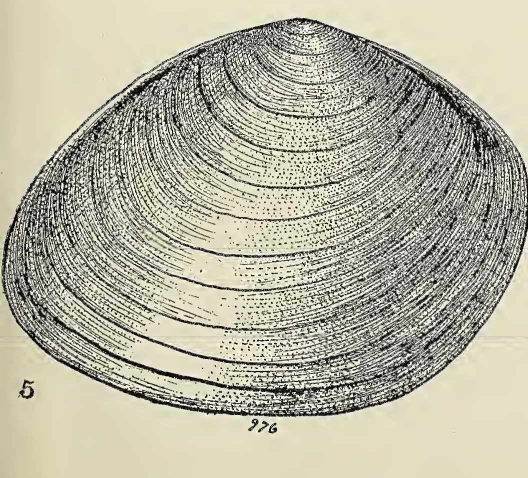

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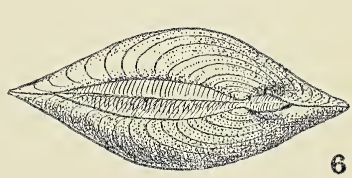

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Fig. 1.


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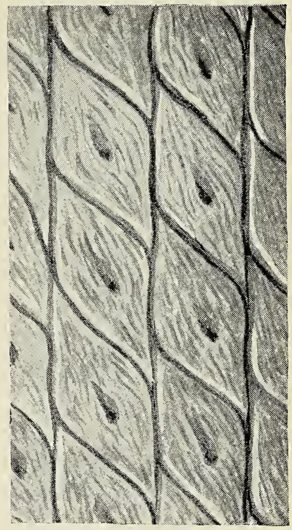
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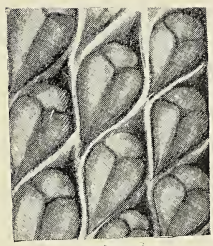
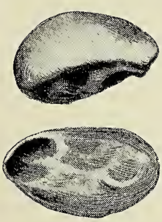


Fig. 4.


Fig. 5.


Fig. 6.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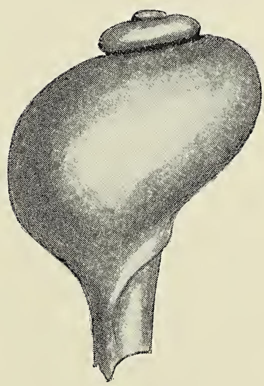
Fig. 9.


Fig. 8.


Fig. 10.


Fig. 11.

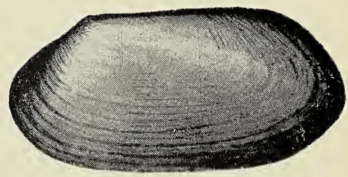
Fig. 12.


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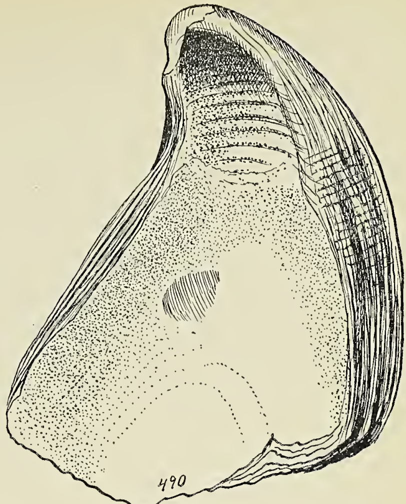
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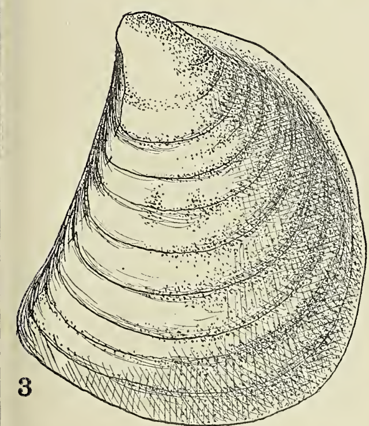
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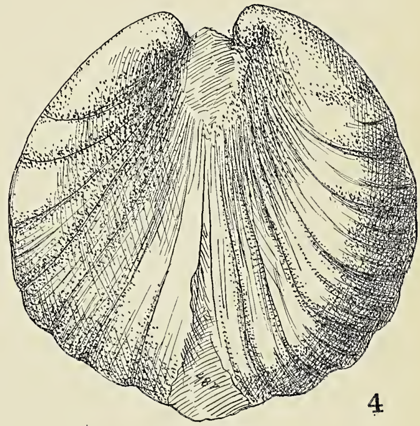
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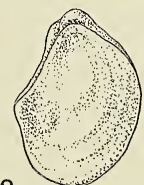
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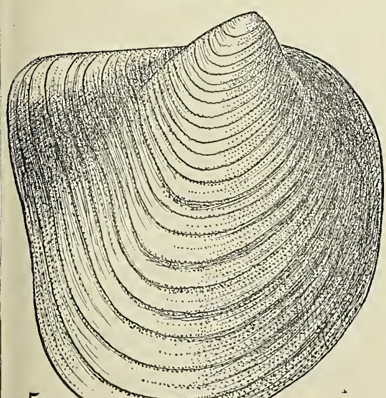
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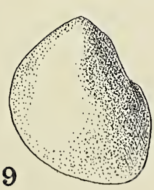
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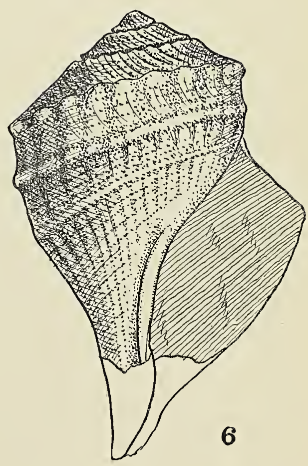
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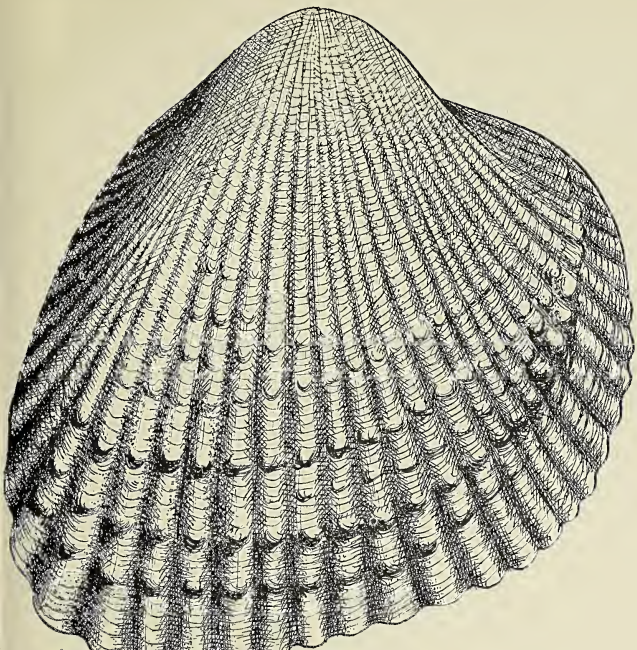

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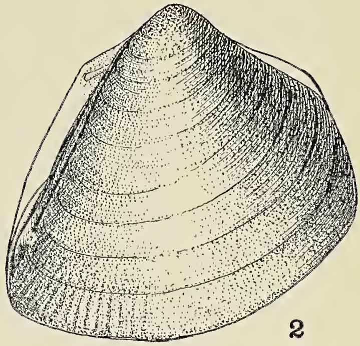

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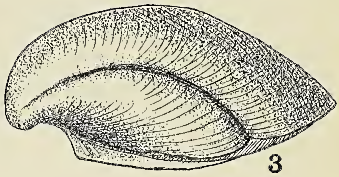

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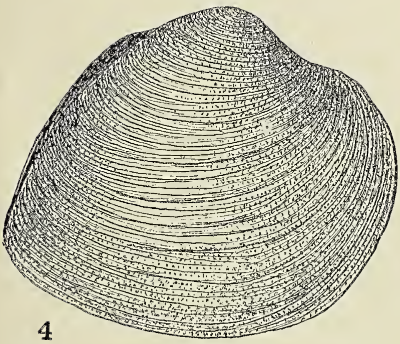

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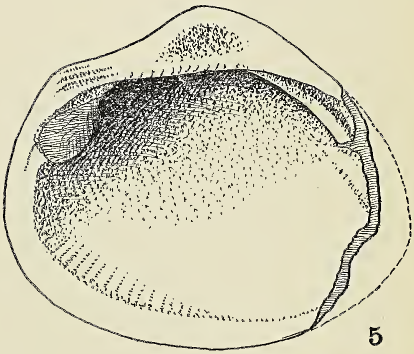

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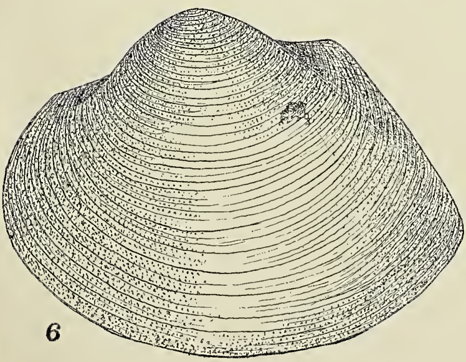

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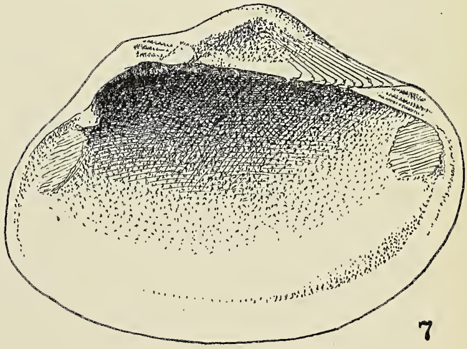

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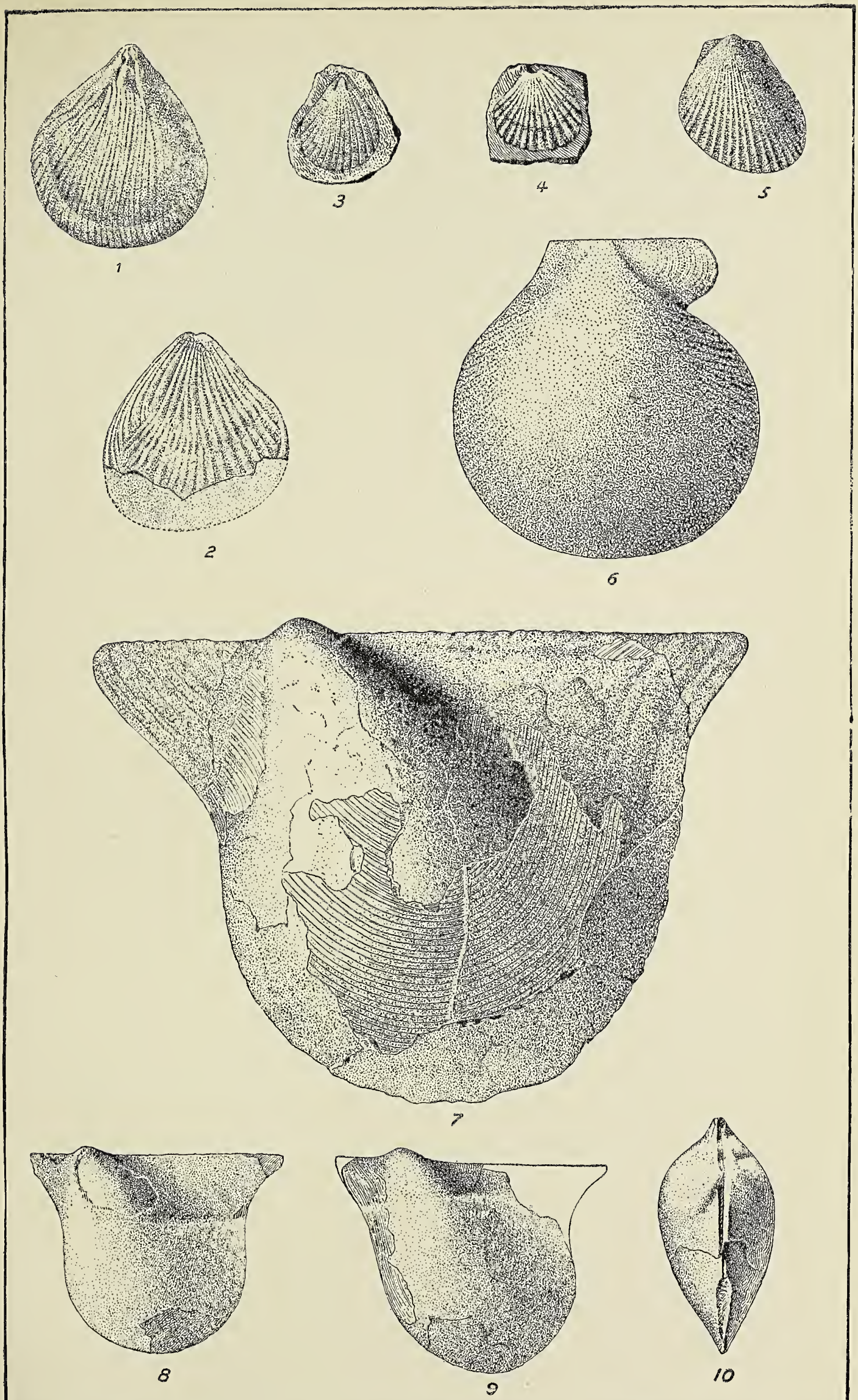
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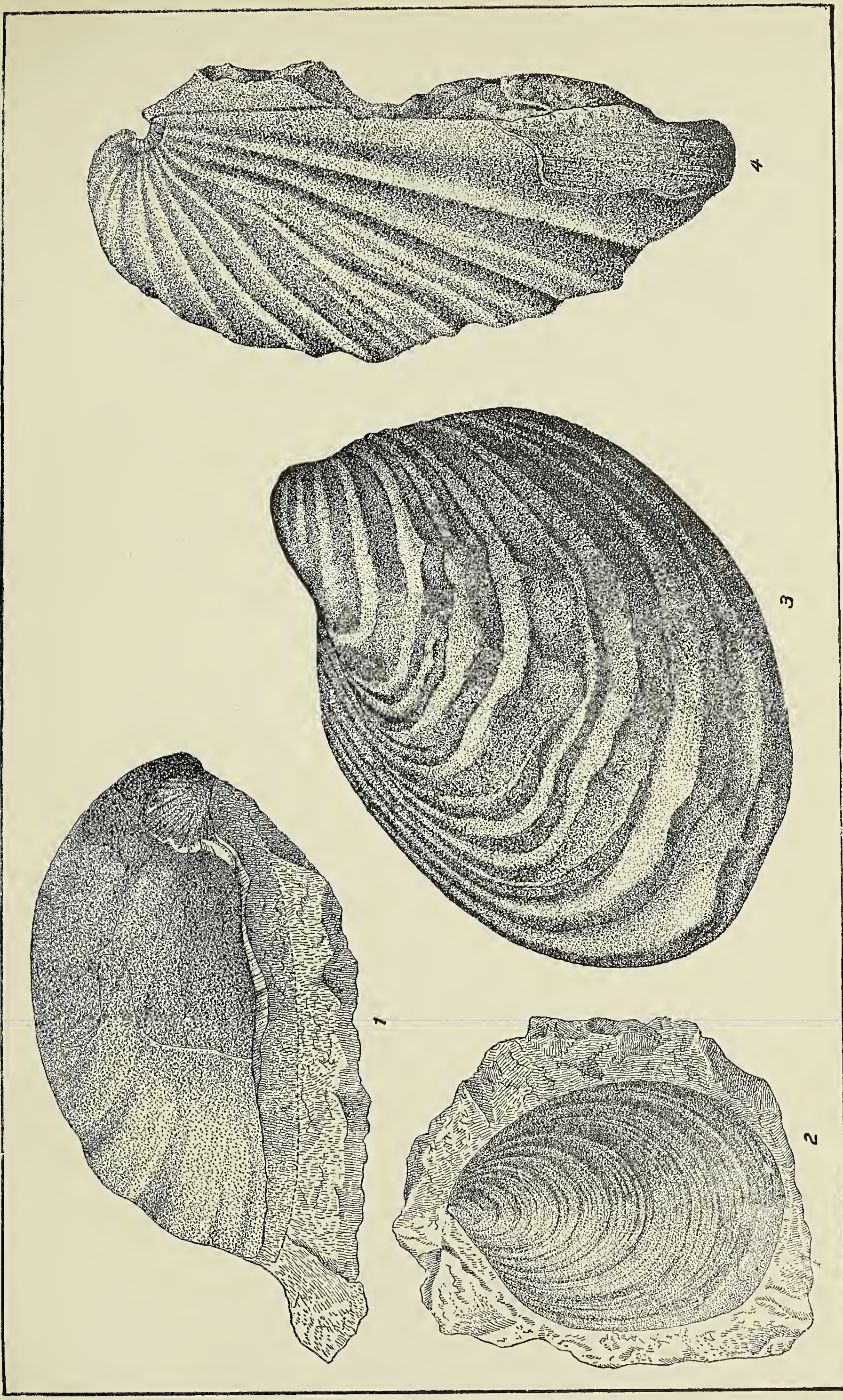
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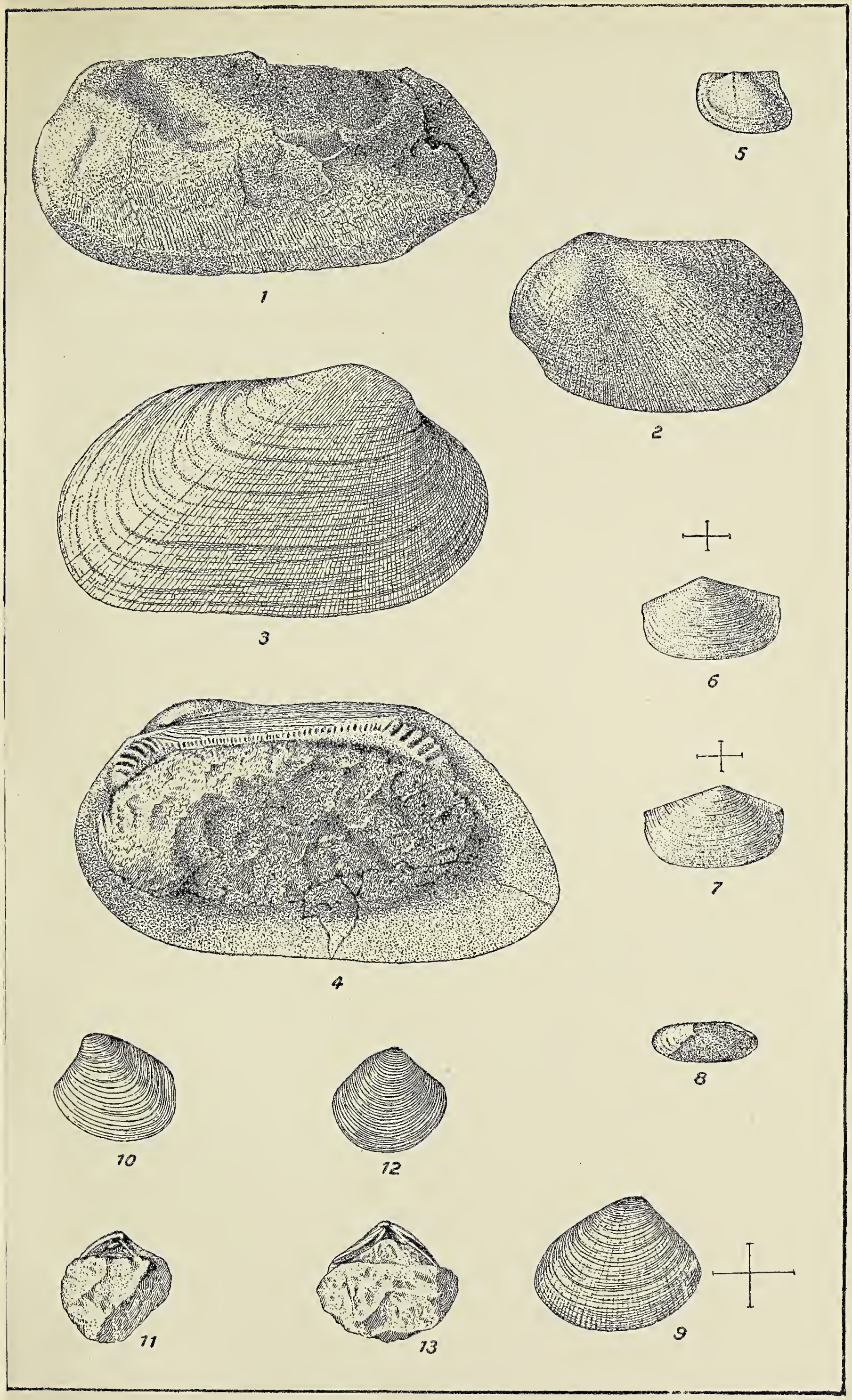
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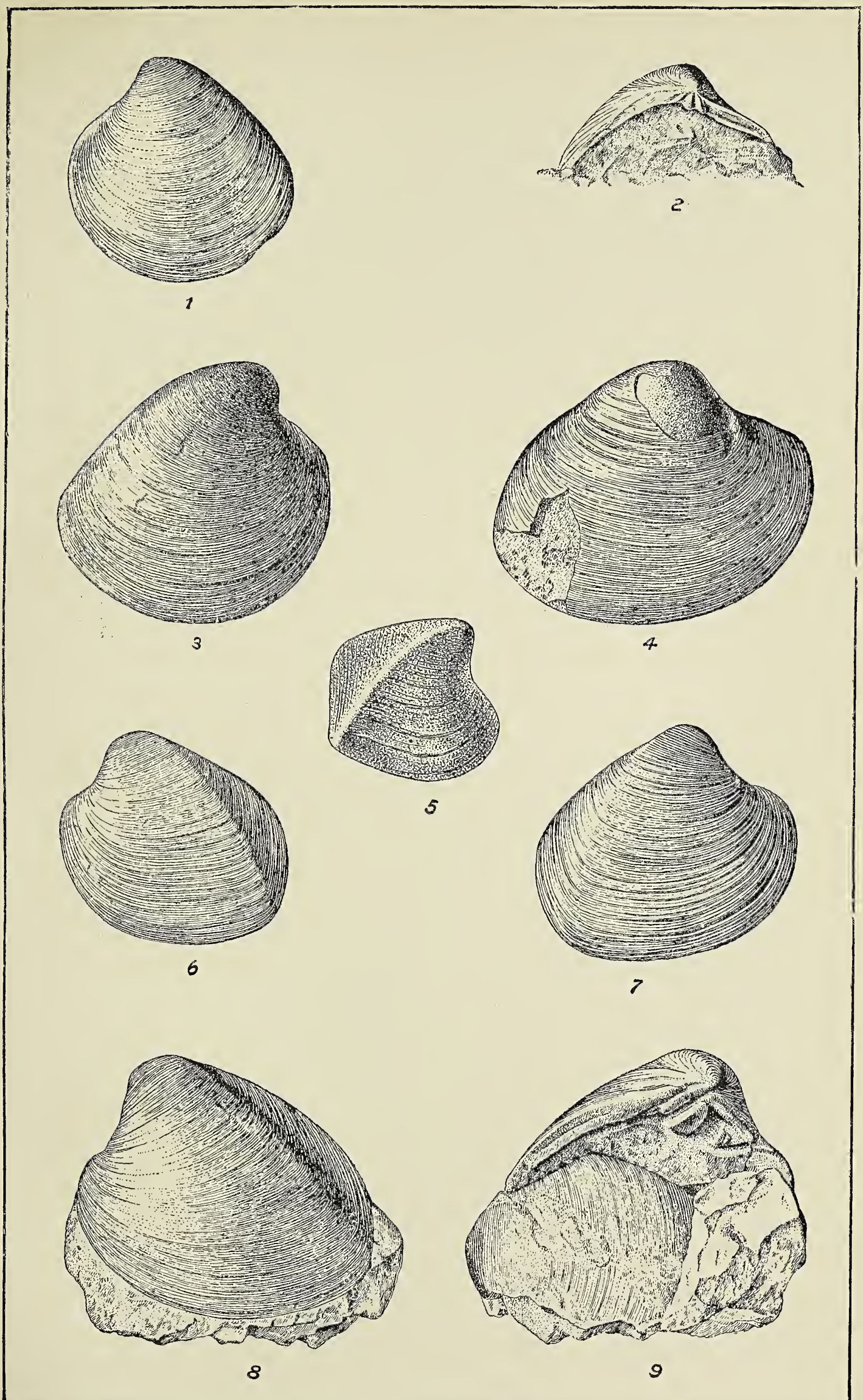
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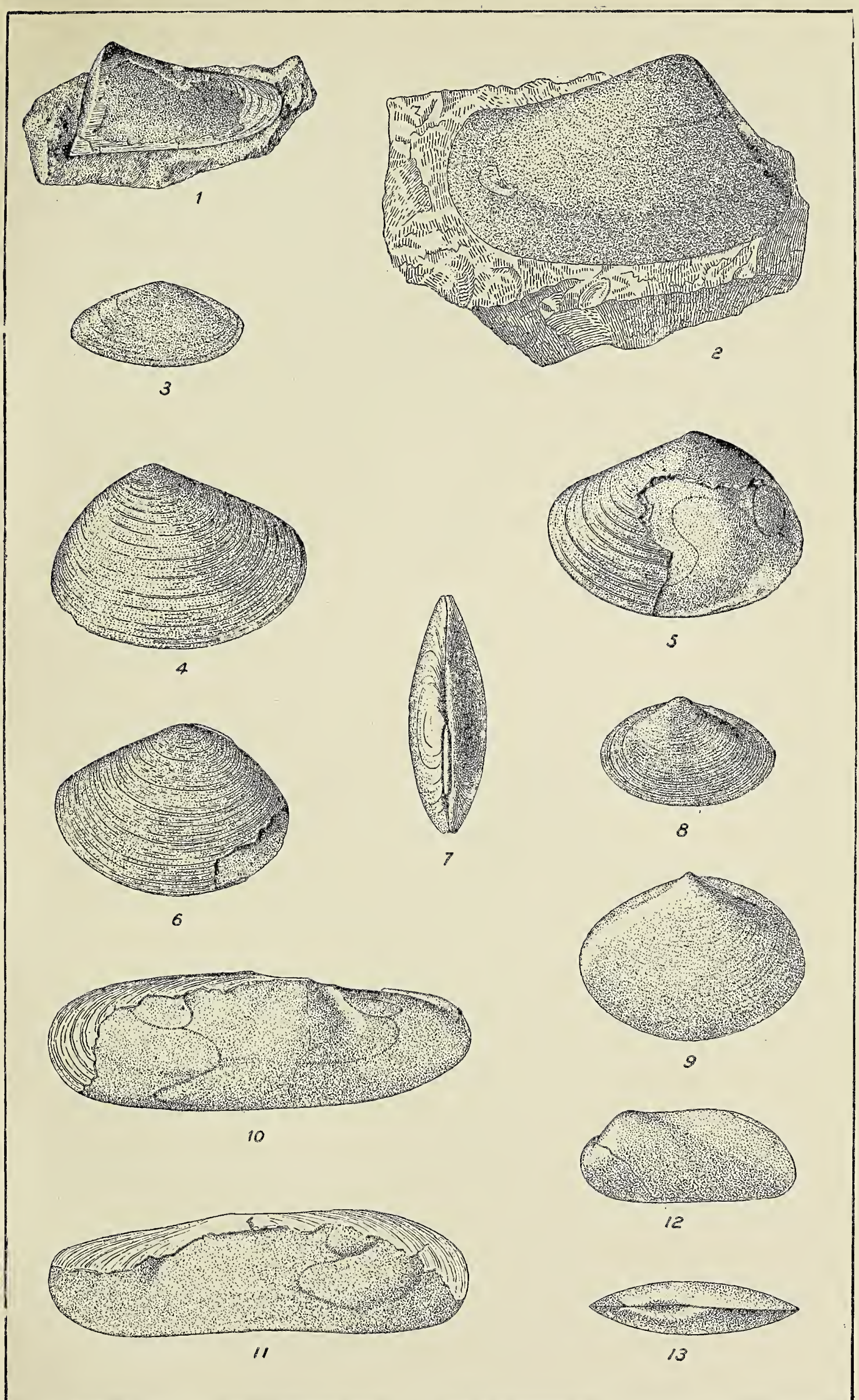
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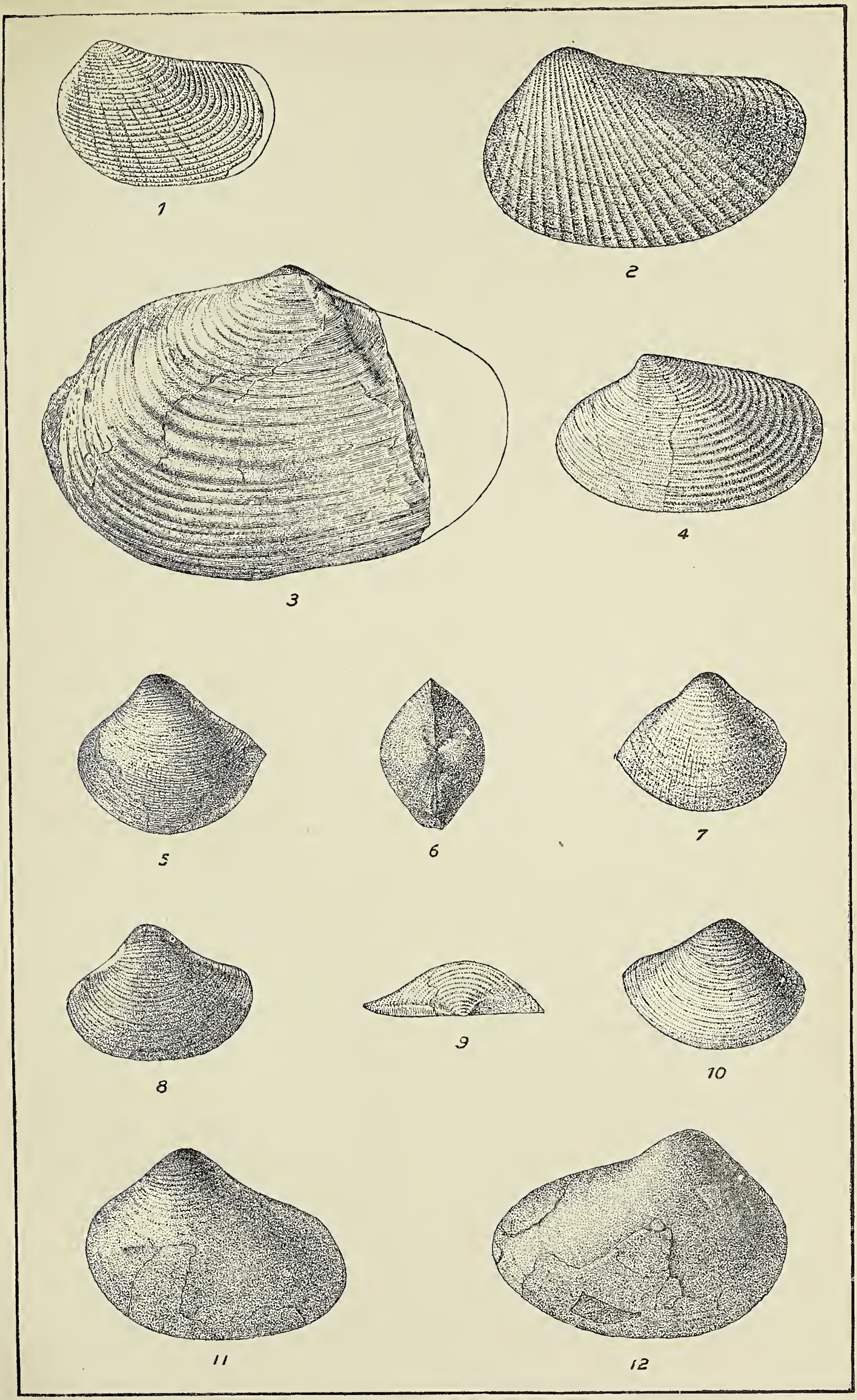
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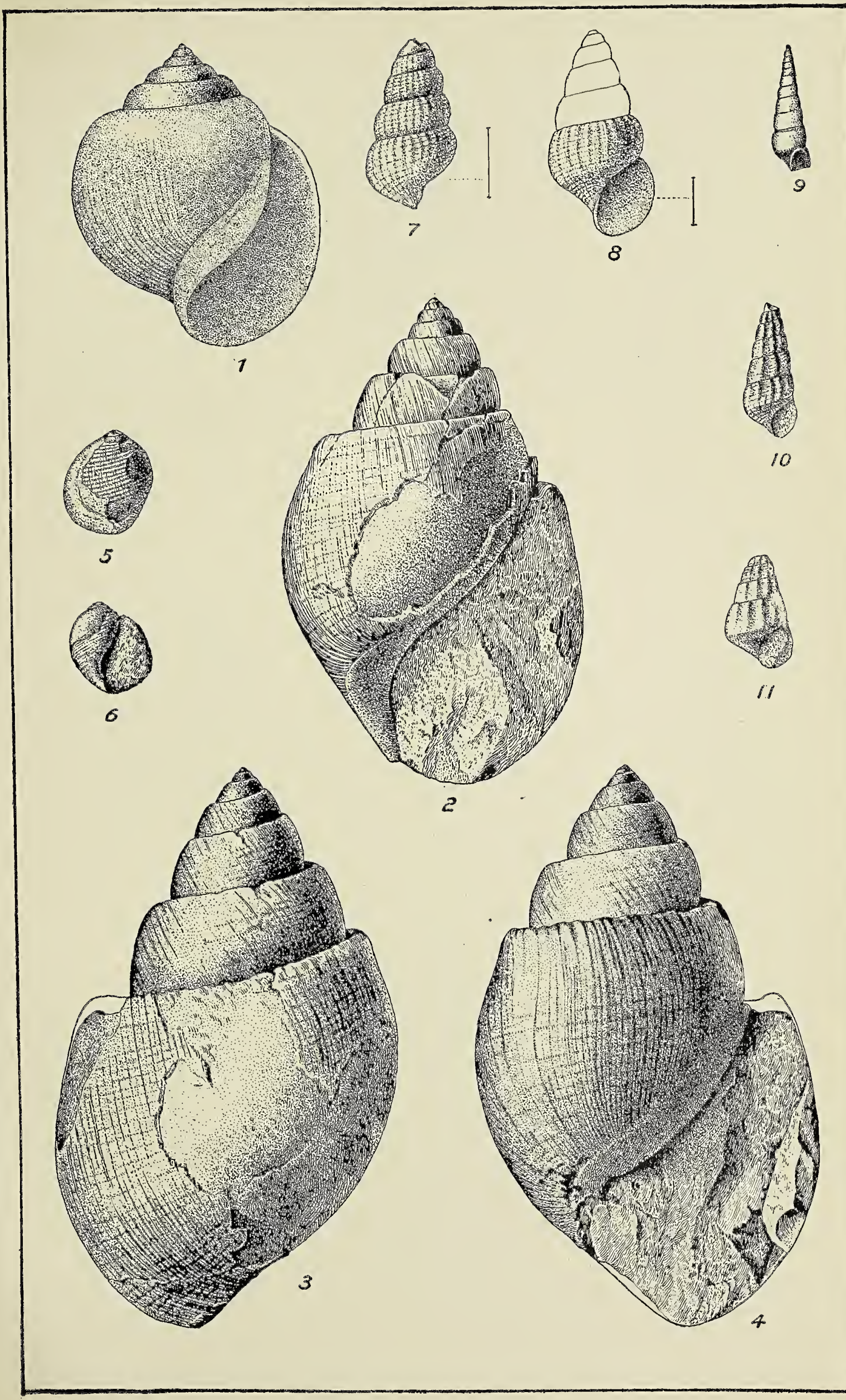
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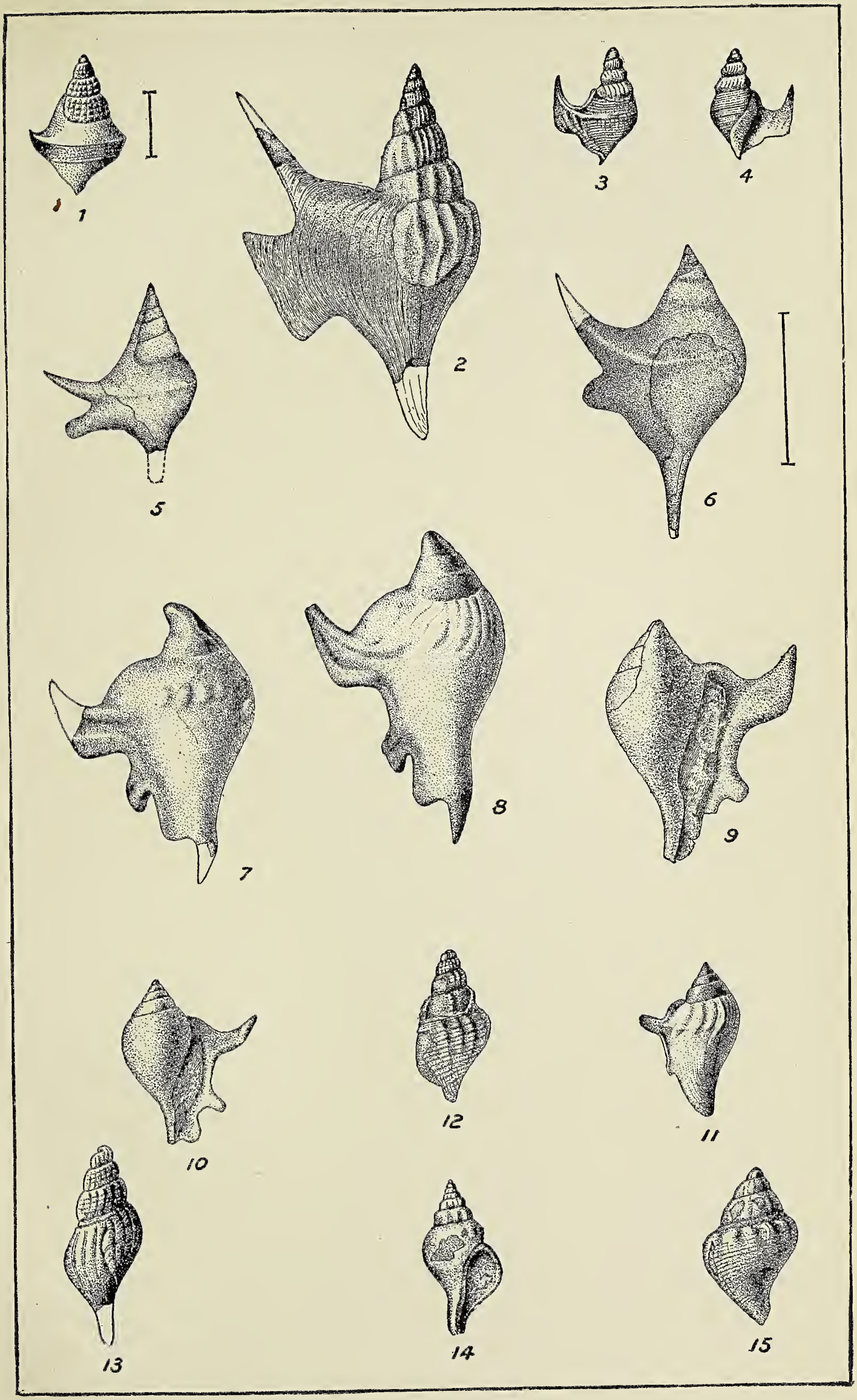
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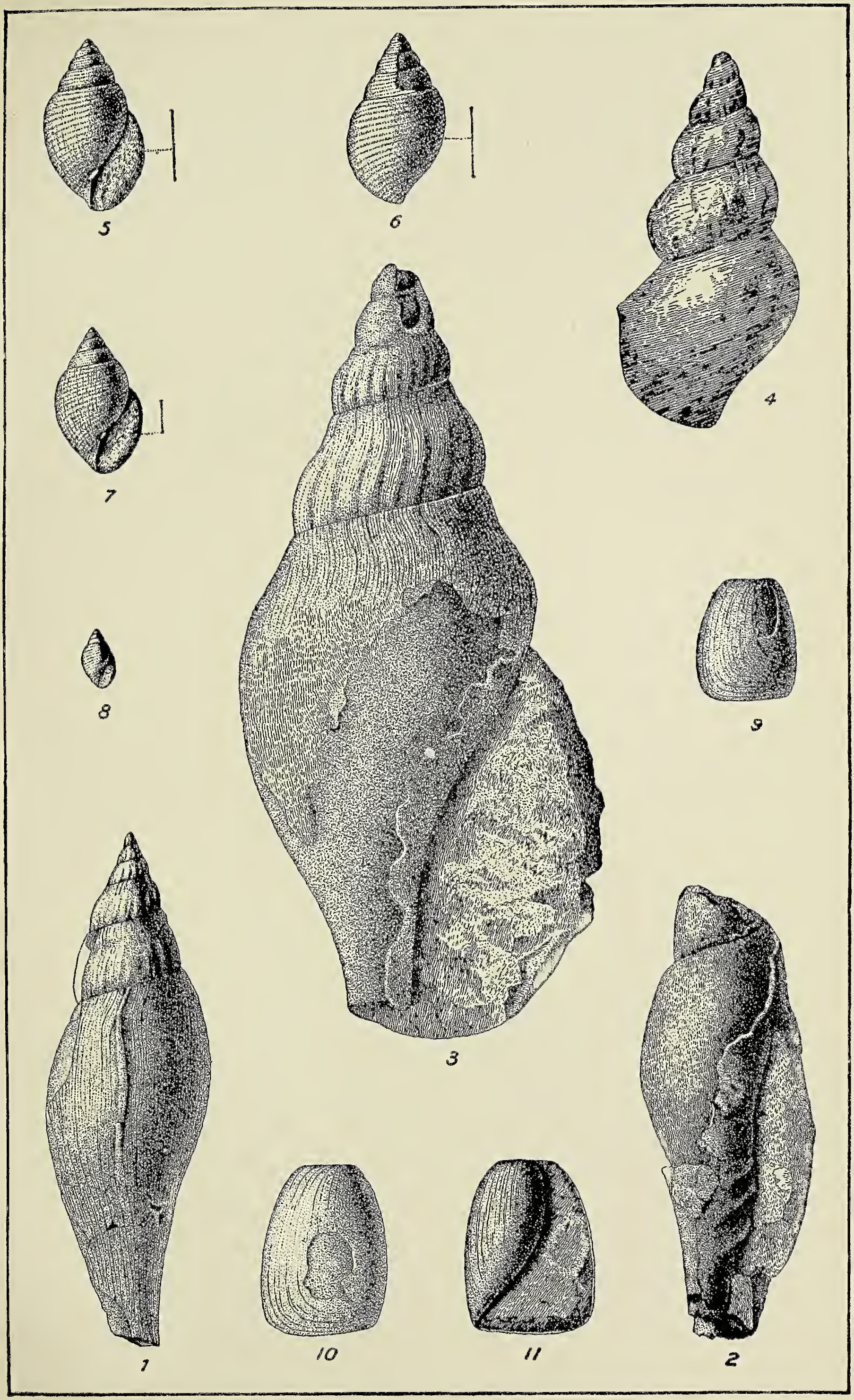
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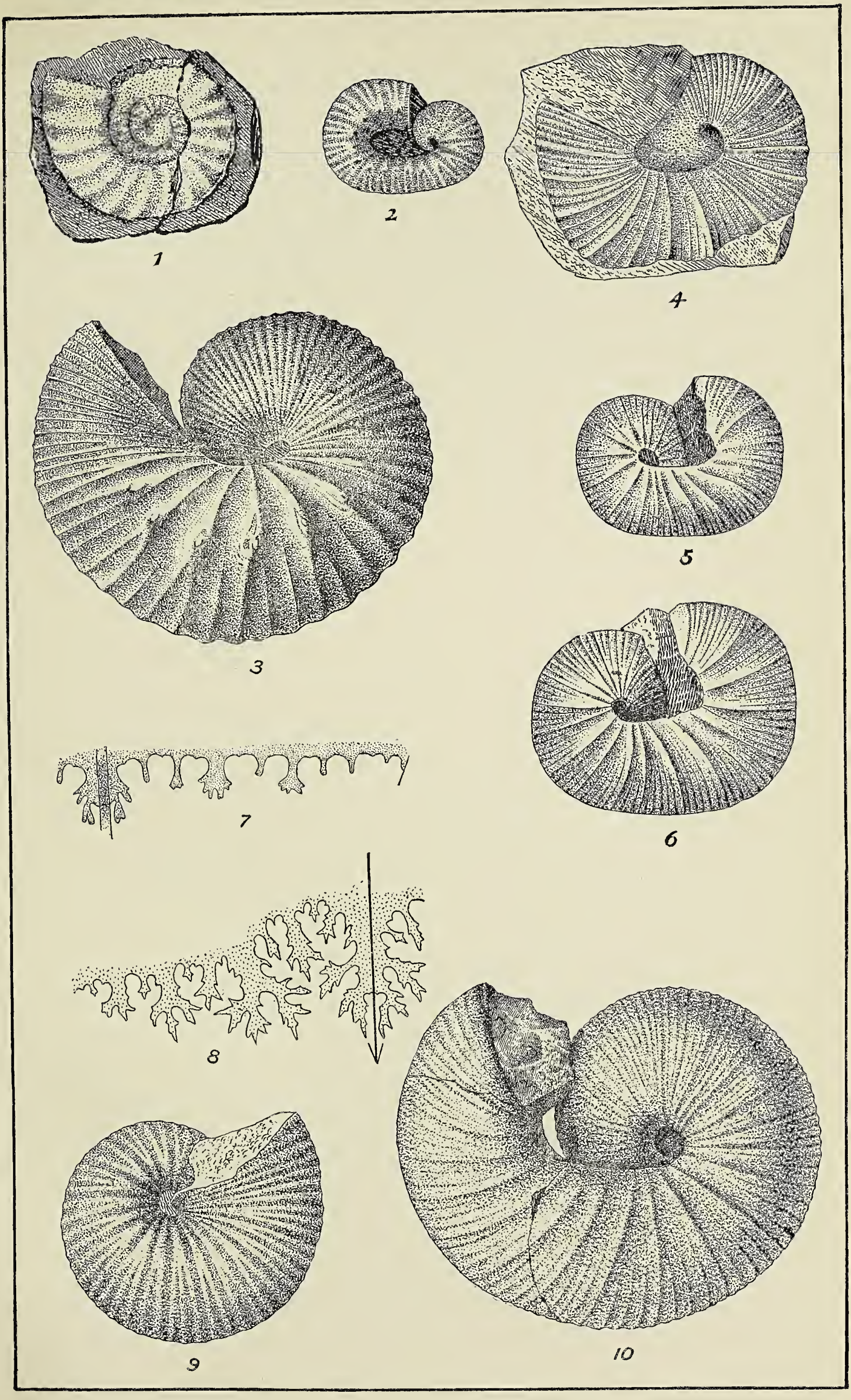
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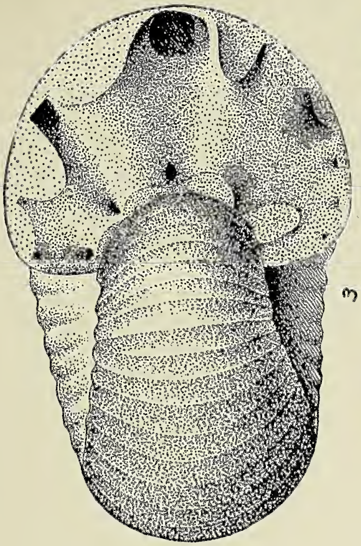

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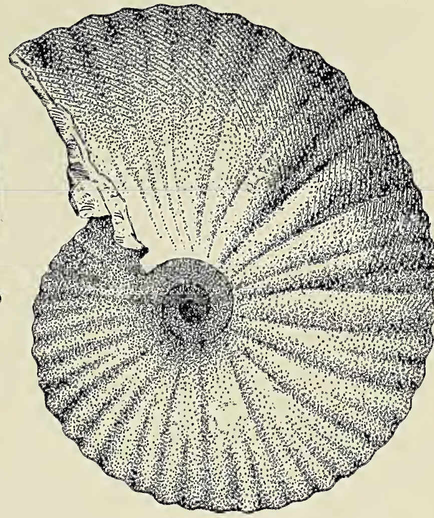

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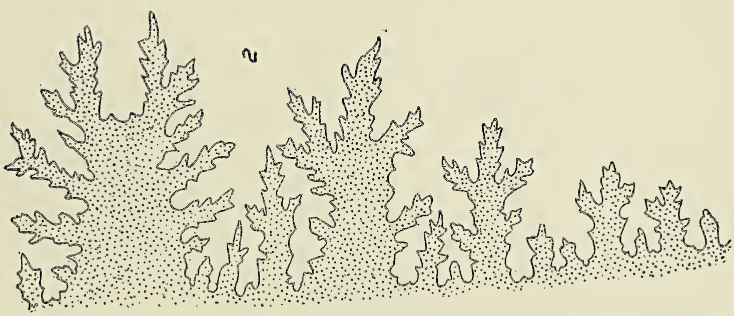

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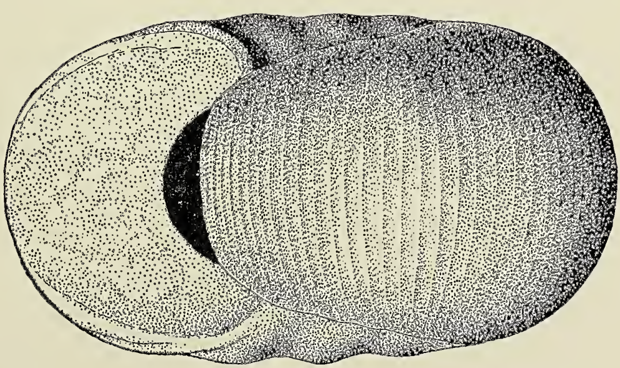

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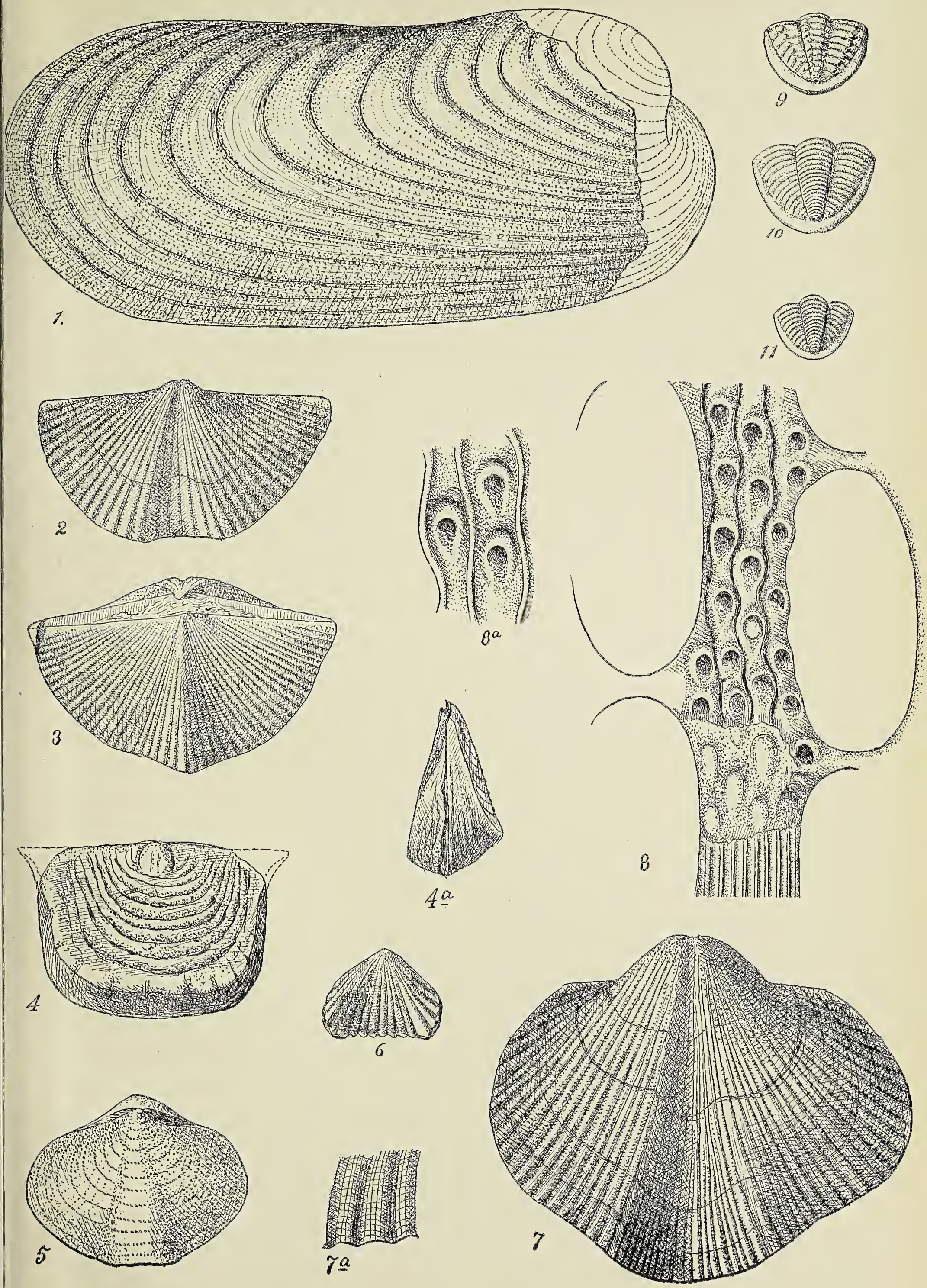
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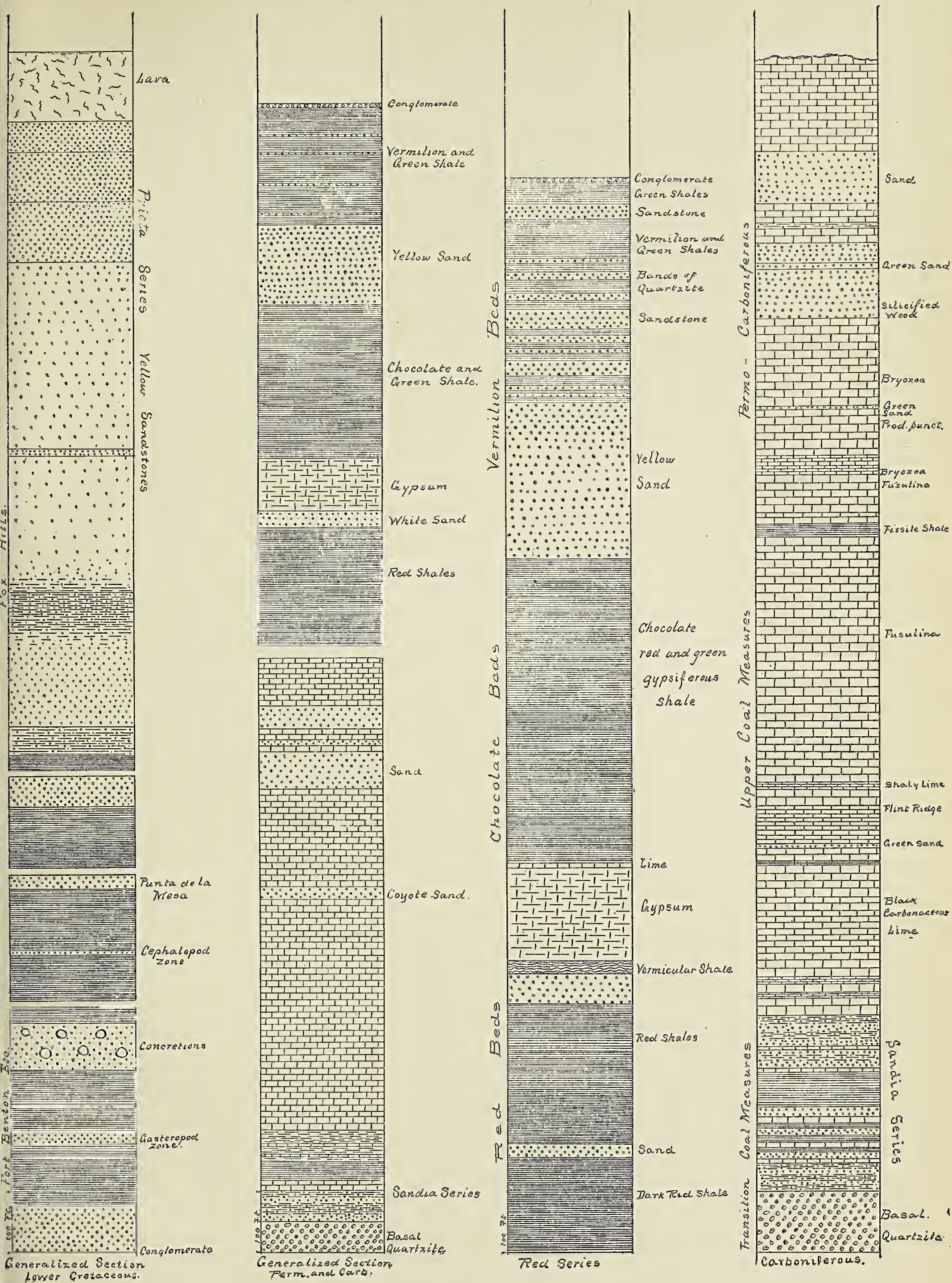
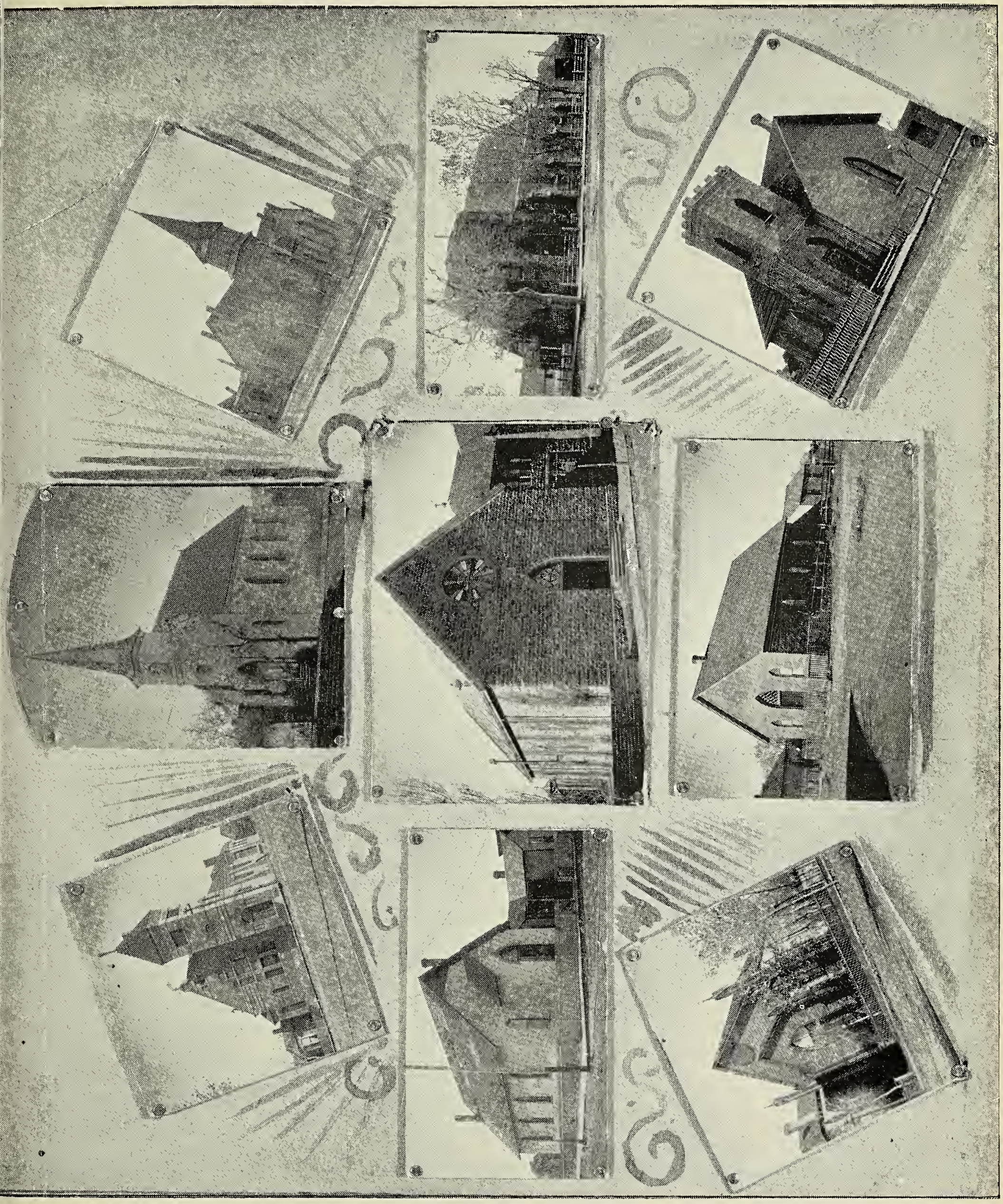
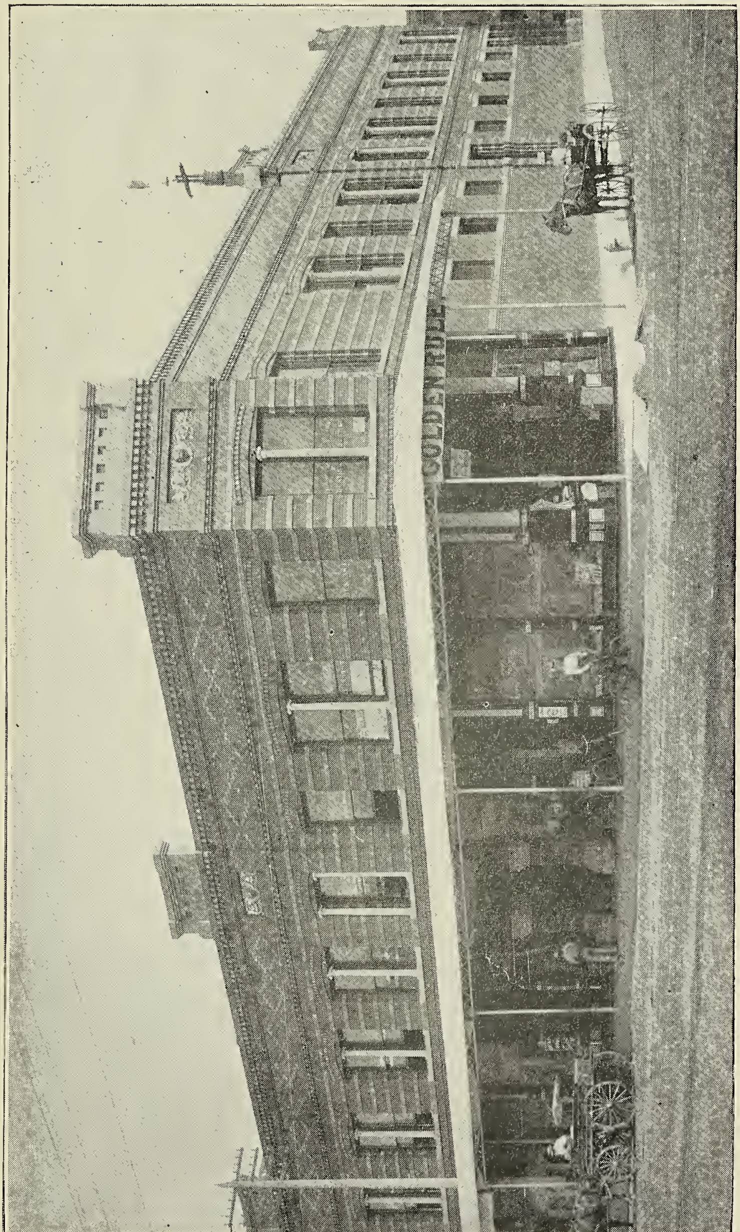

Lava
Prieta Series
Yellow Sandstones
Fox Hills.
Punta de la Mesa
Cephalopod zone
Concretions
Fort Benton Etc.
Gasteropod zone.
Conglomerate
100 Ft.
Generalized Section Lower Cretaceous.
Conglomerate
Vermilion and Green Shale
Yellow Sand
Chocolate and Green Shale.
Gypsum
White Sand
Red Shales
Sand
Coyote Sand.
Sandia Series
Basal Quartzite
100 Ft.
Generalized Section Perm. and Carb.
Vermilion Beds
Chocolate Beds
Red Beds
Conglomerate
Green Shales
Sandstone
Vermilion and Green Shales
Bands of Quartzite
Sandstone
Yellow Sand
Chocolate red and green gypsiferous shale
Lime
Gypsum
Vermicular Shale
Red Shales
Sand
Dark Red Shale
100 Ft.
Red Series
Permo - Carboniferous
Upper Coal Measures
Transition Coal Measures
Sand
Green Sand
Silicified Wood
Bryozoa
Green Sand
Prod. punct.
Bryozoa
Fusulina
Fissile Shale
Fusulina
Shaly Lime
Flint Ridge
Green Sand
Black Carbonaceous Lime
Sandia Series
Basal. Quartzite
Carboniferous.



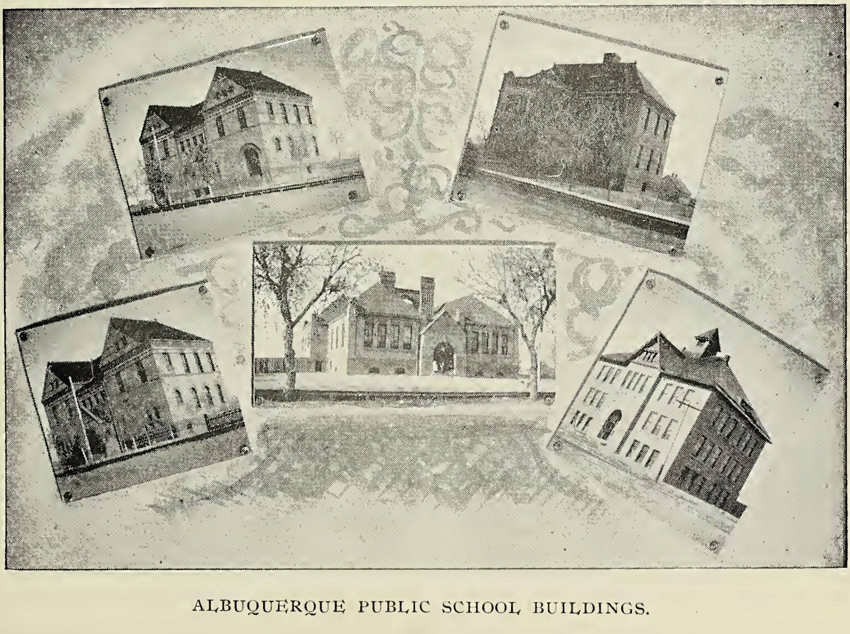
ALBUQUERQUE CHURCHES.

FIRST BAPTIST CHURCH.	GERMAN LUTHERAN CHURCH.	CONGREGATIONAL CHURCH.
LEAD AVENUE M. E. CHURCH.	IMMACULATE CONCEPTION CHURCH.	ST. JOHN'S EPISCOPAL CHURCH.
HIGHLAND METHODIST CHURCH.	AFRICAN M. E. CHURCH.	FIRST PRESBYTERIAN CHURCH.

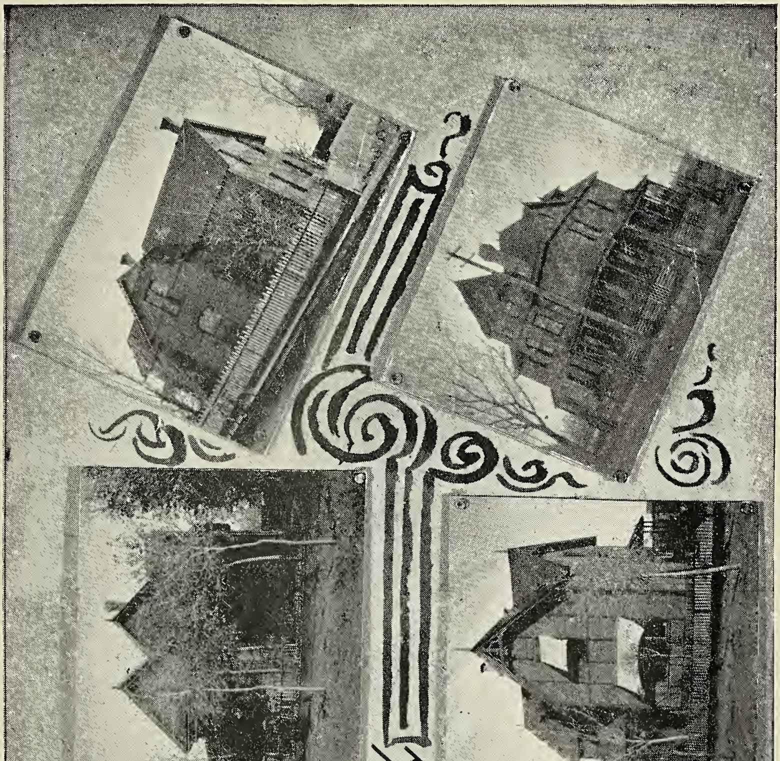


THE NEW GRANT BLOCK, CORNER RAILROAD AVENUE AND THIRD STREET.

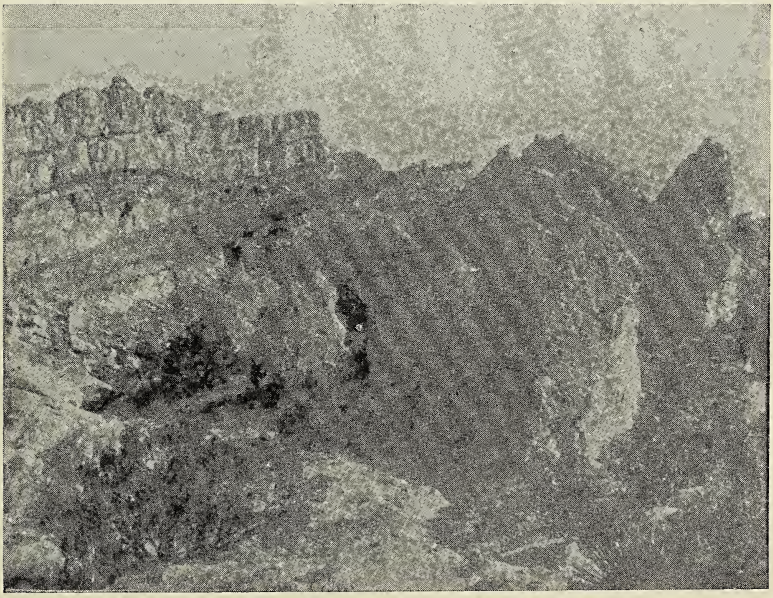
COMMERCIAL CLUB BUILDING, FOURTH STREET AND GOLD AVENUE.

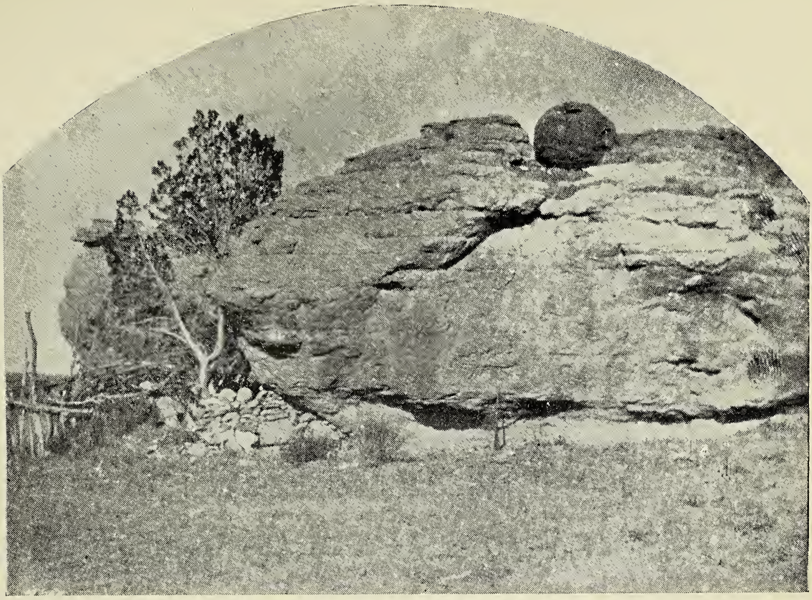


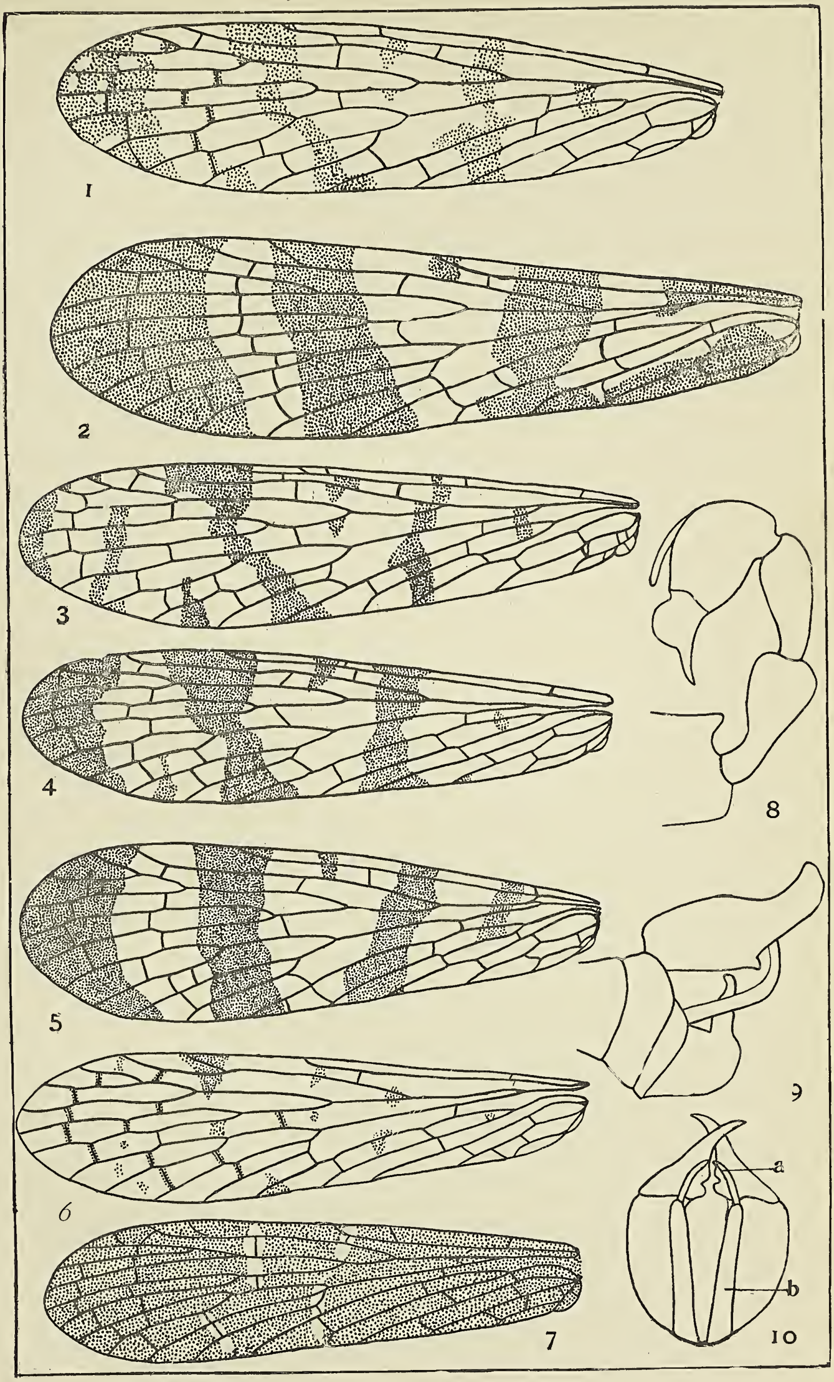
ALBUQUERQUE PUBLIC SCHOOL BUILDINGS.



ALBUQUERQUE HOMES.



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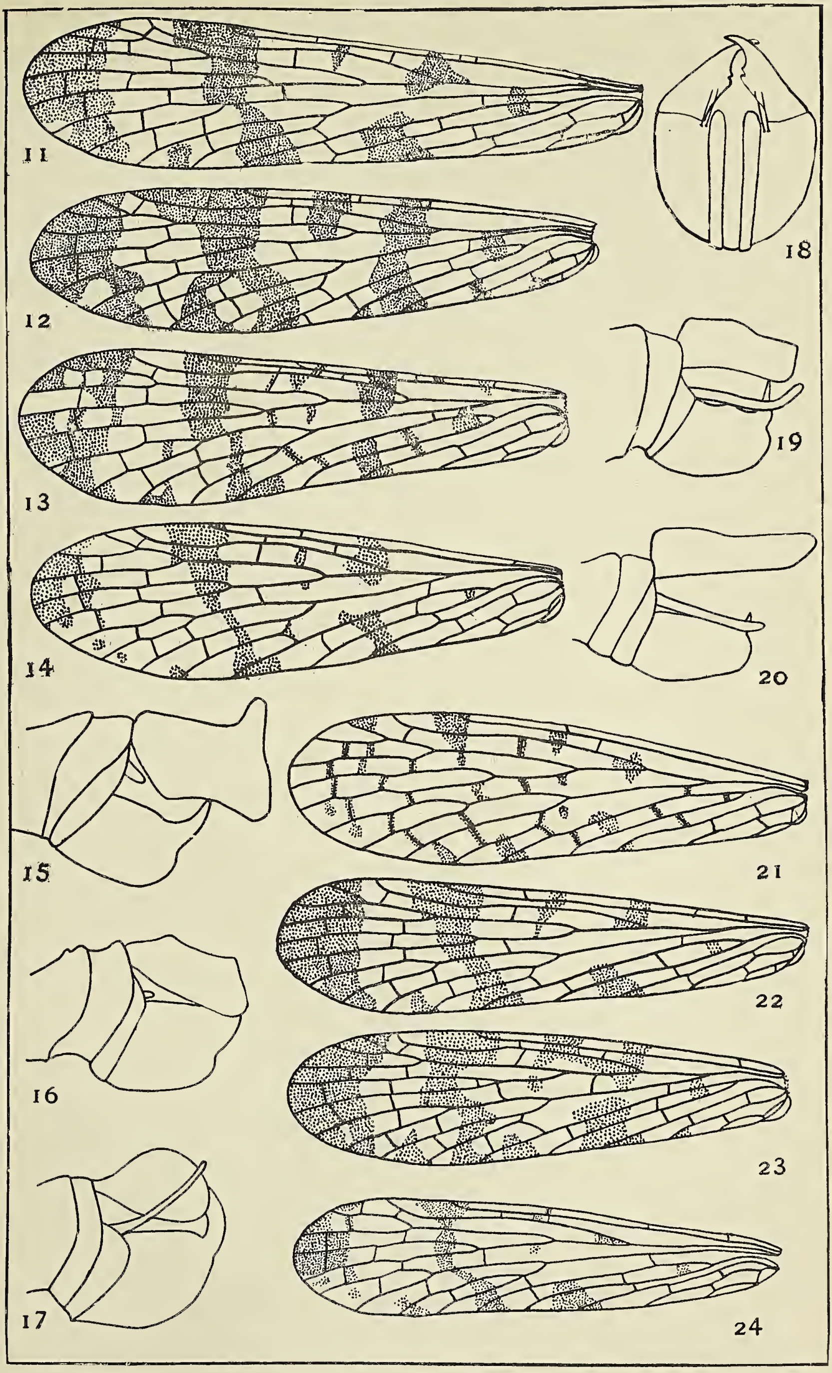
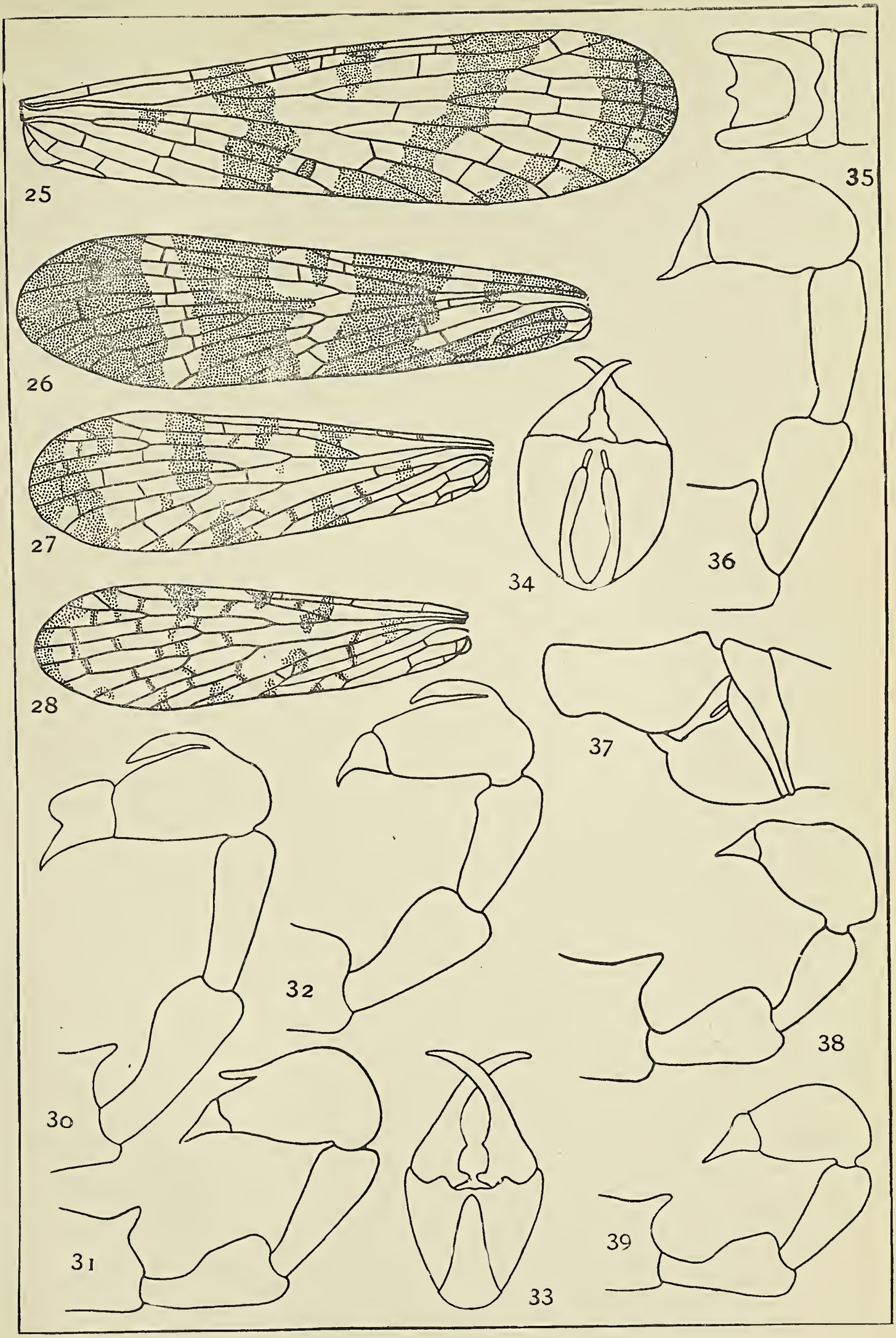


HINE—A Review of the Panorpidae of America North of Mexico.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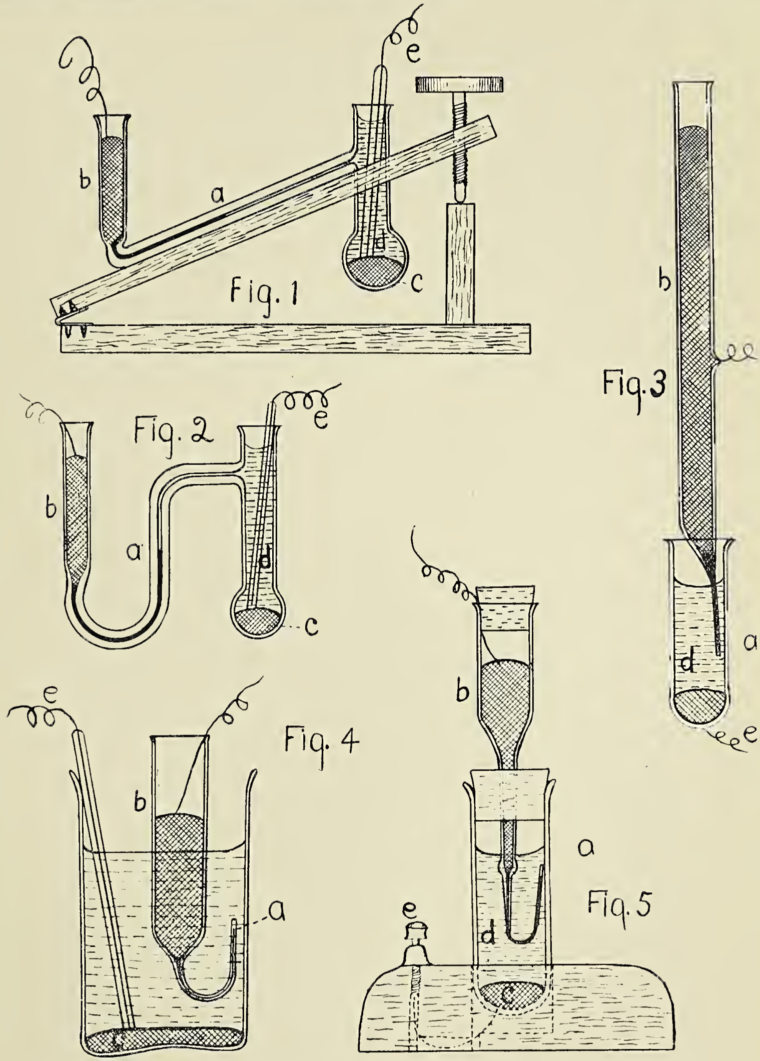

Cole—Practical Experience with the Capillary Electrometer.