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THE CARBONIFEROUS FORMATIONS AND FAUNAS OF COLORADO

BY

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THE CARBONIFEROUS FORMATIONS AND FAUNAS OF COLORADO.

By George H. Girty.

INTRODUCTION.

In the following pages the geology and paleontology of the Carboniferous rocks of Colorado are discussed from the viewpoint of the stratigraphic paleontologist. This viewpoint is also that of one not personally acquainted with the field in question, except in very small measure. I made or assisted in making a few collections of fossils, and enjoyed the privilege of being connected for a month with a field party under the charge of Mr. Whitman Cross during the season of 1900. Most of the extensive collections which I have studied are the work of others, and the strata, in their characters and mutual attitudes, have been viewed only through the pages of geologic reports. The tendencies of my work are almost exclusively toward the historical geology, for from the nature of the case, even had I wished, it would have been difficult to deal with the structural or economic phases of the subject.

The paleontologic data for this work reside in a rather extensive collection from 200 localities, representing the available resources of the Geological Survey and the National Museum in the matter of Colorado Carboniferous fossils. In the paleontologic discussion the purpose has been not so much to see what or how many species occurred within the limits of Colorado as to ascertain their grouping into local and formational faunas, and to determine, if possible, by means of the invertebrate fossils, the relation to one another of the strata forming the different more or less disconnected and isolated areas of Carboniferous outcrop. Aside from such correlative indications as the study of these collections has furnished, a fact of some interest, though by no means for the first time brought to notice, is the close relation which evidently existed in Carboniferous time between the Colorado seas and those of the Mississippi Valley. Almost the entirety of the numerous fauna recognized in Colorado occurs also in the coal fields of the Ohio and Mississippi valleys, and it has been found necessary to describe but very few species as new.

In a work which has suffered from so frequent and so prolonged interruptions as this, giving opportunity for many changes of opinion—one, too, in which facts are involved so many and so variously related—I can hardly expect to have escaped errors and inconsistencies. The hope is entertained that they will not detract too much from what value this work would otherwise have had. The task proposed has been found a difficult one, appreciation of its magnitude growing as investigations into literature and faunas progressed. It has proved, indeed, that the points in relation to which a demonstration was possible are few, and not, perhaps, very important. The facts are not at hand to determine many of the questions which have arisen at different points of my investigations. I have permitted myself, however, to frame a number of hypotheses, and to suggest a number of possibilities. It would indeed be gratifying to think that in this way the solution of problems whose answers have eluded me has in any measure been facilitated.

It seems desirable to offer a few words of explanation, or it may be of excuse, for several omissions and commissions in the following pages that may be considered serious enough to excite criticism. One license which I have permitted myself is the equalization, for purposes of convenience and simplicity, of zoological groups whose unequal importance is generally recognized. That the difference is of so general recognition is perhaps the greater excuse for this lax usage, this concession to convenience. I refer at present especially to the placing of the Bryozoa and Brachiopoda and the several divisions of the true Mollusca upon a temporary parity with the Protozoa, the sponges, and the other groups having the rank of classes. This arrangement has been observed in the tables and in the discussion of species, and is one which the paleontologist is almost certain to make, mentally at least, in studying a varied fauna. It amounts, in short, to breaking up the larger and more unwieldy groups into recognized subdivisions, from which the master titles are omitted. A slightly different practice is that of the constant use of subgeneric names in a titularly generic sense. For convenience and brevity, each subgenus has been written free, as if it were an independent genus; an indulgence from which I would certainly have abstained had this work been planned upon systematic or biologic lines.

Many are the names which would be mentioned if all were to be set down to whom recognition is due for assistance, great and small, in the preparation of this paper. First, perhaps, should be mentioned the geologists, Messrs. Cross, Spencer, Eldridge, Emmons, Lee, and others, through whose accumulation of material my work was not only made possible but even suggested. Acknowledgments are due also to the Museum of Chicago University, from which, through Mr. Stuart Weller, I have enjoyed the privilege of examining and illustrating some specimens importantly connected with my subject. I have consulted freely with my colleagues, Mr. Schuchert, Mr. Ulrich, and Mr. Bassler, upon paleontologia whenever occasion has

required, and profited frequently by their advice. Mr. Stanton and Mr. Cross have also been consulted upon points connected with the general plan and its execution, and to them and others some of the more far-reaching considerations touched upon have been referred. My acknowledgments should not, however, be brought to a close without an expression of thanks to Miss Frances Wieser and Miss Mary Mitchell, who have executed the drawings by which the paleontologic portion of this work is illustrated.

BIBLIOGRAPHY.

In the bibliography to follow I have endeavored to include all papers which contain information about the Paleozoic, and especially the Carboniferous, rocks of Colorado. It would be hard to overestimate the service which the general bibliographic works on American geology compiled by N. H. Darton and by F. B. Weeks have rendered in this effort. Without them it would have been practically impossible to attain the completeness now reached with comparative ease.

The bibliography as it now stands includes nearly 140 entries, all of which have been examined with greater or less care, as occasion seemed to demand. Only a comparatively few of these, however, were found to contain matter which it is necessary to bring into discussion. On the other hand, the works included in the bibliography form but a small portion of those more hastily examined in the search for matter relating to the subject in hand. Selection was frequently not easy and may not always have been made with discernment and uniformity. Many works, of which the very early accounts of travel form one class and the briefer papers of an economic nature another, touch so lightly upon the stratigraphic and historical sides of the geologic question that it really seems to matter little whether they are included or not. They seldom contribute much, still less often anything different or new, to the subject. I endeavored to select from this material in a uniform manner. If failure has arisen it has been not through any wish, but through an inability, to select impartially.

The earliest publications seen by me in which rocks of Carboniferous age are reported in Colorado are two geologic maps of the United States, one by Hitchcock, the other by Marcou. Both appeared in 1853. Marcou colors in a small area of Mountain limestone in the northern part of the State. Hitchcock represents three areas of Coal Measure rocks, one having somewhat the position of that drawn by Marcou, another apparently occupying somewhat the position of the San Juan Mountains, while a third appears to be situated about where lies the Sangre de Cristo Range. As has long been known, Marcou's Mountain limestone in the West is for the most part really Upper Carboniferous, so that for the State of Colorado Hitchcock's map is rather more accurate than Marcou's, but geologic knowledge of the West at that early day was so imperfect and fragmentary that neither map has more than a historical interest. Hitchcock's map went through several editions without change; Marcou's was republished a number of times and frequently altered. Perhaps its best form is that which accompanied his Geology of North America in 1858. These maps were the precursors of a number of similar attempts which have appeared from time to time and which for the present culminate in the McGee map, the latest and so far the best general geologic map of the United States. Maps of this sort form a rather distinct but small and relatively unimportant branch of the literature relating to the geology of Colorado, and I have made no determined effort to include all of them in my bibliography. The scale to which they are drawn and the unequal character of the information upon which they are based, brought together from a variety of sources, do not permit the eras to be so subdivided or the divisions so represented upon the map as to be serviceable for detailed comparisons. They can not present the facts in the detail of the original reports which furnished them and which form the natural material for a bibliography. J. Marcou and J. B. Marcou[a] and C. H. Hitchcock[b] have published descriptions of the general geologic maps of the United States.

The earliest account of actual geologic exploration in Colorado is that published by Schiel in 1854. Schiel traversed a large tract of country very hastily, one would judge, and his brief account, which in the light of later explorations contains nothing of geologic importance, is of only historic interest. He entered the mountains by the way of the Huerfano River, crossed the Sangre de Cristo Range, traversed the south-central part of the State, and passed on to Salt Lake through the San Juan and Wasatch mountains. He describes the lithologic character of both sedimentary and igneous rocks traversed on this route, which was not one best suited to display the Paleozoics of Colorado, but obtained no fossils from the older rocks of the State, and only in one instance attempted to assign any of them to a definite geologic period. In the Sangre de Cristo Valley he mentions as Cambrian (p. 123) a bluish brittle limestone associated with hard shale and sandstone.

This is clearly not Cambrian, and if not one of the Carboniferous limestones is more probably of Cretaceous or Tertiary age. It would be possible, though certainly unprofitable, by careful comparisons of lithologic character and geologic position, and with the aid of the maps and descriptions of later geologic work, to determine the formations to which many of the beds mentioned by Schiel probably belong, but it has not been attempted. This report was republished in its original form the year following (1855).

The account of the geology of the Upper Missouri, published by Hayden in 1863, though no longer of practical value, on account of more accurate work in the

[a] U. S. Geol. Survey, Bull. No. 7, 1884.

[b] Am. Inst. Min. Eng., Trans., vol. 15, 1887, pp. 465–488.

same field by the same geologist and others coming after, was at the time a real and important contribution to the geologic literature of Colorado. This report, so far as it relates to this subject, deals with the formations exposed along the eastern margin of the Front Range. In 1868 appeared two other papers by the same author dealing with the same subject, which will be referred to in the résumé of historical geology.

Hayden's third annual report, published in 1869 and afterwards reprinted, gives an account of a hasty but extended trip through eastern Colorado and New Mexico, which is reviewed in the résumé, to follow.

In 1874 appeared the first of a series of four reports in which the geology of the entire State was outlined by means of reconnaissance explorations systematically planned. The discussion of the material contained in these reports forms one of the most important parts of my résumé. The one which appeared in 1874 is the seventh of the annual reports of the Hayden survey. It contains reports by Hayden, Endlich, Peale, and Marvine. The same year saw the publication of Ruffner's report on the geology of the Ute country. A topographic map of a large portion of Colorado accompanies this report, the text of which is largely descriptive of geographic and other features. Brief geologic reports by F. Hawn and L. Hawn accompany it, dealing chiefly with the Sangre de Cristo, Elk, and San Juan mountains. This will be discussed in more detail below.

In 1875 was published the third volume of the final reports of the Wheeler survey, containing a description by Stevenson of a very extensive area in central Colorado examined during the year 1873. This will be considered in detail later on. The same is true of a report by Cope on northwestern New Mexico, in which, however, the geology of a portion of Colorado is incidentally considered. Endlich discusses the mines and geology of the San Juan country, in which, though the sedimentary beds are not described in the text, Carboniferous limestone and Carboniferous sandstone are represented, on a map accompanying the report, in the general region of Silverton.

In 1876 was published the eighth annual report of the Hayden survey—the second one dealing particularly with the geology of Colorado. It contains reports by Holmes, Hayden, Endlich, and Peale, all of which are considered in detail in the geological discussion. S. G. Williams described the geology near Canyon; Powell's book upon the geology of the Uinta Mountains, with a paleontologic portion by White, also appeared; and a series of maps by Gilbert, Marvine, and Howell were published the same year.

In 1877 appeared the ninth annual report of the Hayden survey, containing papers by Holmes, Endlich, Peale, and Hayden. These, so far as they concern the subject in hand, are discussed in detail in the résumé. The same year saw the publication of the second volume of the Fortieth Parallel Survey by Hague and Emmons, setting forth the descriptive geology of the territory examined by that organization. Such portions of this work as relate to the Carboniferous of Colorado are discussed below; but the volume by Clarence King on the systematic geology (Vol. I), which was published the year following, is more advantageous in its arrangement and comparisons. The brief discussion by Peale and Stevenson as to the age of the Rocky Mountains is included in my bibliography, because, while not directly bearing upon the historical geology of the Paleozoic, it deals with factors which determine the distribution and characteristics of sediments and faunas.

In 1878 appeared the tenth annual report of the Hayden survey—the fourth and last volume dealing particularly with the geology of Colorado. It contains reports by Peale, Endlich, White, and Holmes, which, so far as they pertain to my subject, are discussed in the résumé. The same year was published the volume on systematic geology of the Fortieth Parallel Survey. In this volume King has assembled with industry and discussed with judgment the facts available from many sources at the time of his writing. The arrangement is such as to make it more convenient for my purpose than the individual accounts upon which it is based, and these, therefore, I have as a rule laid aside in favor of King's more correlated work.

In 1879 was published a preliminary report by Stevenson on operations in Colorado and New Mexico. In Colorado the only Carboniferous area touched on is that on the east side of the Sangre de Cristo Range, from Spanish Peaks to Costillo Peak. The facts upon which this report is based are given in greater detail in a publication which appeared in 1881, and I have not, therefore, given it special consideration. The paper by Henrich on the ore deposits of Leadville, which appeared this year, is the first of the numerous series of short articles relating especially to the economic geology of this great mining camp which were published for some time preceding and immediately following the publication of Emmons's Leadville monograph. I will include these in the bibliography, but not refer to them individually.

In 1880 Dutton issued a publication on the Permian of North America, in which he refers part of the Red Beds of Colorado, etc., to the Permian, the upper portion being Triassic. Hayden expressed somewhat the same view the same year, in describing the Twin Lakes and Teocalli Mountain.

The most important work relating to this subject which appeared in 1881 was Stevenson's report upon examinations in southern Colorado and northern New Mexico, a preliminary account of which was published in 1879. The only Carboniferous area in Colorado discussed in this paper is that along the east side of the Sangre de Cristo Range from Spanish Peaks to Costillo Peak.

A paper which appeared in 1883, "Notes on the geology and mineralogy of San Juan County, Colo.," by T. B. Comstock, so far as it concerns my subject, is largely an abstract of the work of the Hayden survey, in which many of the errors committed by Endlich are repeated. Thus the early Paleozoics are described as having furnished the material out of which the "metamorphic series" was formed, while all the Upper Carboniferous beds, which were later called the Hermosa formation, are referred to the Lower Carboniferous. Probably, however, this term is here employed in the objectionable sense in which it was used by the Hayden survey—to indicate the lower portion of the Carboniferous section of any particular region. Broadhead's paper on the Juratrias, published this year, concerns us in that some of the strata called Juratrias in Colorado are probably Carboniferous. On the other hand, his paper is a summary or digest of the literature, practically without discussion, conclusion, or new matter of any sort. Of a similar bibliographic nature is T. S. Hunt's description of the progress of geology for 1882. It is of subsidiary interest to this résumé as containing an abstract of the results of Emmons's Leadville work. A paper by Hallowell, entitled "Supposed Juratrias of the Front Range," seems to be an effort to prove that no Juratrias exists along the Front Range of Colorado and that the rocks called such actually overlie the Cretaceous.

In 1884 little or nothing bearing upon the matter in hand was published, and in 1885 only papers of a less important kind. In the latter year Emmons, in his report upon the Rocky Mountain division, calls attention to two unconformities, one pre-Jurassic, the other intra-Carboniferous, which had not previously been detected. These were observed in the Elk Mountains, and were later discussed and represented in the Anthracite-Crested Butte folio.

The important event of the year 1886, so far as it concerns this subject, was the publication of Emmons's Leadville monograph. This work will of course receive attention in the résumé. The other publications of the year are of minor importance. Stevens briefly describes the geology of the San Juan region in a report which adds little or nothing to the Hayden survey. Emmons somewhat casually describes the section at Red Cliff in which the Sawatch, Yule, and Leadville formations are said to occur.

In 1887 appeared a number of papers of the less important sort. Comstock described the geology and vein structure of a large area in southwestern Colorado in a paper which will be discussed later on in the résumé. Olcutt described the Battle Mountain mining district of Eagle County, giving the geologic section observed there. To one familiar with the sequence in central Colorado the Paleozoic character of these beds is clear, but the author makes no attempt to correlate them with other sections or to fix their geologic age. Lakes described the geology of the Aspen district in a paper which will be referred to later. A map of the United States by Hitchcock appeared this year, and to this I have already made general reference. Areas of Carboniferous (called Permo-Carboniferous) are shown in Colorado somewhat as in the Hayden atlas. Tilden also describes the ore deposits at Red Cliff, and gives the geologic sequence occurring there. This will be mentioned separately below.

In 1888 Emmons published a preliminary note on Aspen, in which the section in that vicinity is described and compared with the Leadville section. As the statement of fact is little different from that in the Aspen monograph, by Spurr, I shall not give this paper special reference in the résumé. Kedzie briefly describes the ore deposits and geology of the Red Mountain mining district of Ouray, and Siver and Brunton those of Aspen. Brunton's is an able paper, with figures of models showing topography, and a carefully considered section in which the same formations as those at Leadville appear. The Weber formation is referred to the Middle Carboniferous, and the upper beds of the Carboniferous are not considered. Lakes discusses the geology of Colorado ore deposits in a paper which was published in the same form in two places. So far as concerns my subject this paper was too general and elementary, as to both geology and paleontology, to require especial consideration.

Again, in 1889 the geology and mineral deposits of Aspen were treated by Henrich in a carefully prepared paper, published in the Transactions of the American Institute of Mining Engineers. Henrich compared his section with that of Emmons at Leadville, and that of Lakes, published in 1887, and called attention to several errors made by the latter. His section closed with the Weber shales, so called. White described the geology and physiography of the eastern portion of the Uinta Mountains in a paper whose geologic bearing is rather structural than historical. Eldridge described the geologic sequence in the vicinity of Denver from the Archean up. The lowest sedimentaries are, of course, the Red Beds, whose characters are given and whose age is discussed.

In 1890 Newberry published some notes upon the geology of the Aspen mining district. The divisions recognized by him are the Cambrian quartzite, the Silurian quartzite and limestone, the Lower Carboniferous dolomite, the Lower Carboniferous blue limestone, the Middle Carboniferous shale and shaly limestone, the Middle Carboniferous limestone, and the Jura-Triassic sandstones. The equivalence of this section with that adopted by Spurr in his Aspen monograph is too obvious to need special discussion. Apparently Newberry's two Middle Carboniferous formations are the same as the Weber formation, while the Juratrias, of which there are said to be many hundred feet, comprises the Maroon formation and the bright-red sandstone, noted by Spurr in the Lenado Canyon. Emmons's paper on orographic movements in the Rocky Mountains is important to the subject in hand because of its bearing upon the disposition of land and water in Colorado during Carboniferous time and the relation of the Carboniferous faunas and sediments at different points in this State. This subject will be considered at a later place. The same author describes, in McFarlane's Railroad Guide, the Carboniferous of Colorado, but from the nature of the case the discussion is a general one. Eldridge's paper on structural features near Denver contains an incidental description of the Triassic and later beds, and an account of some of the peculiarities of distribution.

A paper by Cannon in 1892 describes the geology in the vicinity of Palmer Lake, along the Front Range. He recognizes the absence of Paleozoics in this vicinity, but calls attention to the prevalence of chert bowlders, both free and in conglomerates, containing Paleozoic types of fossils. He concludes that they represent exposures of certain beds that have long since been eroded. It is from an occurrence similar to those recalled by Cannon that the fossils described by White from a conglomerate in Larimer County were obtained. During the same year appeared papers by Eldridge, Farish, and McMechen, which have little bearing upon my discussion, but are included in the bibliography. This is less true of a paper by C. D. Walcott, who describes the Paleozoic section at Canyon, and gives lists of fossils. So far as Mr. Eldridge's paper concerns us at all it embraces the same strata described by Walcott, whose section is mentioned particularly in my discussion.

In 1893 G. L. Cannon described the geology of Denver and vicinity. The oldest sedimentary strata considered are of course the Red Beds, which he refers to the Triassic and Jurassic, but because they are possibly, in part, of Carboniferous age, this paper comes properly within my purview. The same area has been made the subject of a monographic study by Emmons, Cross, and Eldridge, and I will not, therefore, give Cannon's account further consideration. The itinerary in Colorado of the Fifth International Geological Congress, which took place in 1891, was arranged and described chiefly by S. F. Emmons and Whitman Cross, and their reports were published in 1893, in the Comptes Rendus of this body. They add, however, little or nothing to the present discussion, and it probably will not be necessary to refer to them again.

In 1894 appeared the Pikes Peak and the Anthracite-Crested Butte folios (Nos. 7 and 9 of the Geologic Atlas of the United States). The Pikes Peak folio was the work of Whitman Cross, who contributed to the Anthracite-Crested Butte folio the description of igneous rocks, while G. H. Eldridge described the sedimentary formations, and S. F. Emmons discussed the geologic history of the Elk Mountains. These two volumes form important accessions to the literature which I am considering, and will receive particular discussion at a more appropriate point.

The Geology of the Denver Basin, by Emmons, Cross, and Eldridge, in 1896, deals with the area about Denver, as the title indicates, in which strata belonging to the Red Beds rest directly upon the granites and metamorphics of the Front Range. Though this series is referred by these authors to the Triassic, the probability that part of it belongs to the Carboniferous has made it necessary to include this series and all papers relating to it in my discussion. To this monograph I will therefore refer in the résumé of geologic literature below.

In 1897 appeared a number of minor articles by Lakes, Draper, Rickard, and others. Some of these are included in the bibliography, but require no special discussion. The Pueblo folio, by G. K. Gilbert, which was published the same year, receives consideration in connection with the Pikes Peak and Walsenburg folios in the résumé.

The Aspen monograph, by Spurr, with an introduction by S. F. Emmons, and the Tenmile folio, by Emmons, which were published in 1898, are two works of detailed and monographic character, such as have established sections at a number of points through the State, serving as convenient standards of comparison with each other and with works which have more of the character of reconnaissance. To these it will be necessary frequently to refer.

The same is true of the Walsenburg folio, by Hills, and the Geology of the Rico Mountains, by Cross and Spencer, which appeared in 1900. I have hesitated to include in the bibliography two papers by A. C. Spencer and myself, which were published this year. They deal with the Ouray limestone and its Devonian fauna, and their connection with the present subject consists in the fact that this formation and fauna were for a long time considered of Carboniferous age; that the Ouray limestone does, locally at least, contain a Mississippian fauna in its upper part, though this was not known at the time these papers were written; and that I erroneously referred two specimens of this Mississippian fuana to the Devonian. I shall have occasion several times to refer to these facts, but it will not be necessary to give special discussion to the papers themselves.

In 1901 N. H. Darton read a paper before the Geological Society of America upon a comparison of the stratigraphy of the Black Hills with that of the Front Range of the Rocky Mountains. This paper was never published in full, but identical abstracts of it appeared in the bulletins of the society and in Science. No detail is naturally expected from this paper, but some interesting comparisons and correlations are made between the Front Range section and that of the Black Hills. I will briefly discuss this paper at a later point. Elmer S. Riggs the same year described the Dinosaur beds of the Grand River Valley in southwestern Colorado. To this paper also I shall somewhat briefly refer later on.

In 1902 only two papers have come to hand dealing directly with the Paleozoics of Colorado. Both are by W. T. Lee. In one of them he describes the areal geology of the Castle Rock region. This paper is of interest because it describes one of the rare occurrences of well-defined Paleozoic strata along the eastern margin of the Front Range in Colorado, and I shall make special reference to it in my résumé of geologic literature. In the other he speaks of the Carboniferous beds of the Sangre de Cristo Range, and to this, too, I will give further consideration.

PUBLICATIONS DEALING WITH THE CARBONIFEROUS ROCKS OF COLORADO.

1853.

HITCHCOCK, EDWARD. Outline of the geology of the globe, and of the United States in particular, with two geological maps and sketches of characteristic American fossils, Boston, 1853; second edition, Boston, 1854.

MARCOU, JULES. Geological map of the United States and British provinces of North America, with explanatory text and geological sections, 92 pages, 8 plates, Boston, 1853.

——— Soc. géol. France, Bull., 2d series, vol. 12, pp. 813–936, map plate, under title, Résumé explicatif d'une carte géologique des États Unis et des provinces anglaises de l'Amérique du Nord, avec un profil géologique allant de la vallée du Mississipi aux côtes du Pacifique, et une planche de fossiles.

1854.

SCHIEL, JAMES. Geological report of the country explored under the thirty-eighth and forty-first parallels of north latitude in 1853–54. Report of explorations for the Pacific Railroad on the line of the forty-first parallel of north latitude, by E. G. Beckwith, pp. 120, 8°, Washington, 1854.

1855.

MARCOU, JULES. Geological map of the United States and British provinces of North America, with explanatory text and geological sections, 92 pages, 8 plates. Map in atlas to Voyage dans l'Amerique du Nord, par G. Lambert, Bruxelles, 1855.

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MARCOU, JULES. Geological map of the United States and British provinces of North America, with explanatory text and geological sections, 92 pages, 8 plates. "La vie souterraine, ou les mines et mineurs," par L. Simonin, plates 10, 11, 14, 4°, Paris, 1867.

1868.

HAYDEN, F. V. Remarks on the geological formations along the eastern margins of the Rocky Mountains. Am. Jour. Sci., 2d ser., vol. 45, pp. 322–326, 1868.

——— Notes on the geology of Wyoming and Colorado, No. 1. American Phil. Soc., Proc., vol. 10, pp. 463–478.

1869.

REPORT of the U. S. geological survey of Colorado and New Mexico, under F. V. Hayden, 3d Annual Report, pp. 1–99. Washington, 1869.

Reprinted with first and second Annual Reports, Washington, 1870; pp. 103–199 of reprint.

1870.

HAYDEN, F. V. Sun pictures of Rocky Mountain scenery, with a description of the geographical and geological features and some accounts of the resources of the great West [etc.], 150 pages, 30 plates, 4°, New York, 1870.

1871.

MEEK, F. B. Preliminary paleontological report, consisting of lists of fossils, with descriptions of some new types, etc. U. S. geological survey of Wyoming and portions of contiguous Territories, F. V. Hayden in charge, preliminary, 2d report, pp. 287–318, Washington, 1871. A second edition identically the same as that of 1871 bears date 1872.

1872.

HAYDEN, F. V. U. S. geological survey of the Territories, F. V. Hayden in charge; profiles, sections, and other illustrations designed to accompany the final report of the chief geologist of the survey, and sketched under his direction by H. W. Elliot, 65 plates, 4°, New York, 1872.

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1873.

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RÉSUMÉ OF LITERATURE AND CLASSIFICATION OF AREAS.

Although I had set out to consider only the Carboniferous rocks and faunas of Colorado, it seemed that the relations to each other of the sections situated in different parts of the State could not be intelligently estimated without more or less careful reference to the strata upon which they rest or those by which they are succeeded. As the earlier Paleozoics play but an insignificant part in the sections seen in the State, it proved a comparatively easy task to carry along the entire pre-Carboniferous portions of the different sections; and the supposed Trias and Jura were also held in mind.

Carboniferous rocks are usually seen in Colorado only where brought to the surface by mountain uplifts. Otherwise they lie deeply buried beneath heavy sections of Mesozoic and Tertiary sediments and often beneath igneous flows. Their present outcrop, therefore, consists largely of more or less discontinuous areas exposed along the flanks of mountain ranges or sometimes in the channels of rivers.

As exhibited on the general geologic map of the Hayden atlas,[a] the most conspicuous feature in the distribution of the Carboniferous is a discontinuous band stretching from the northwest corner of the State to the center of its southern border. This is too large a tract to be conveniently considered without subdivision, especially as the geologic section is not uniform throughout.

The northwestern portion of this band of Carboniferous outcrop is formed by the eastern end of the Uinta Mountains; and as it is separated by a considerable extent of Mesozoic and Tertiary beds from the remainder of the Carboniferous outcrop to the southeast, it can appropriately be considered as a distinct area, under the name of the Uinta Mountain region.

Southeast of the Uinta Mountains is a large area of Carboniferous having a very irregular outline, which is chiefly exposed along the White and Grand rivers and their tributaries. No single topographic feature seems to be preeminently distinctive of this area, but I have distinguished it as the Grand River region, giving it the name of the river which divides it in the middle.

Connected with this to the south, and really forming a part of it, is the area produced by the upturned beds of the Elk Mountains. I will, however, speak of

[a] U. S. Geol. Geog. Surv. Terr., Atlas Colorado, etc., 1877.

this as the Elk Mountain region, restricting the name Grand River region to the northern portion.

To the east and southeast of the Grand River and Elk Mountain areas, and separated by the Archean Sawatch Mountains, is a narrow and more linear tract, the northern portion of which lies on the western side of the mountain valley called South Park. This, southward to the canyon of the Arkansas, I shall designate the South Park region.

Practically connected with this, but sending off a long spur to the northwest, the outcrop is taken up by the Sangre de Cristo Range, and from the Arkansas River southward to Costillo Peak, where the Carboniferous exposures cease, it may be appropriately called the Sangre de Cristo region.

Another well-defined area of Carboniferous rocks is found in southwestern Colorado. This may be designated the San Juan area, and the Hayden survey has several times employed for this general country the name Sun Juan region, or San Juan district. Under this title will be included the Paleozoic series of the Rico and the La Plata mountains, as well as the exposures in the valley of the Animas River.

Another interesting series of outcrops occurs in western Colorado along the lower portion of the Dolores River to its junction with the Grand, and along the Grand from this point to beyond the State line in Utah. This series of outcrops, because the name Grand River area has already been made use of, I will call the Dolores River region.

The last and final area is the entire strip of sediments upturned along the eastern margin of the Front Range. The main portion of this outcrop, though here and there containing patches of early Paleozoic beds, consists of the Red Beds usually referred to the Trias; but their Triassic age is not well established, and as reason exists for supposing that part of the series at least is of Carboniferous age, I will speak of this as the Front Range region. This area will begin with the northern border of the State and extend southward to the Huerfano River, including, in fact, the bordering outcrops of the Wet Mountains as well as those of the Front Range.

All these areas have more or less extensive contiguous disconnected outliers, but to these it did not seem necessary to apply independent names, especially as no evidence at hand demanded particular reference to them. Most of these areas are artificial in delimitation and established for the purpose of convenience in treatment. The Uinta area is independent because of its isolated position, and because, perhaps, of the peculiarities of its section.

UINTA MOUNTAIN REGION.

Perhaps the earliest geologic exploration in the Uinta Mountains, the earliest certainly of which I have found note, was made by W. A. Jones,[a] who traversed the

[a] Chief of Engineers U. S. Army, Rept. for 1872, 1873, pp. 1108–1118.

mountains in 1871. He describes the structure of the Uinta Range with some accuracy, though stating that the upheaval took place not long subsequent to the Carboniferous epoch (p. 1112). "The uplifted beds," he says, "as displayed by the lateral erosion, are almost entirely composed of a brownish-red sandstone, rarely, if at all, fossiliferous, of the Subcarboniferous epoch, the color rarely changing into gray. * * * They are of very great thickness, from 2,000 to 3,000 feet, being visible near the summit. Higher up in the series, and lying along the base of the mountains toward Green River, the Carboniferous beds of soft, bright yellow sandstone, coarse conglomerate, blue limestone (quite rare and thin), and gypsum (in thin seams) are exposed. * * * The series above the Carboniferous either do not occur or are overlaid by a highly fossiliferous deposit of Tertiary age. This deposit lies nearly horizontal, and is composed of soft yellow and red marls, greensand, and thin beds of soft limestone and chert" (p. 1113). Apparently the Carboniferous of this account forms part of the Mesozoic of Powell's Uinta Mountains report, and the geologic age, determined as Carboniferous, must have been assigned, I fear, because of its contained coal seams. Jones's Subcarboniferous is with little doubt the Uinta sandstone of Powell's report, and he determination of its age apparently depends upon the fact that it lies under the coal-bearing series thought to be Carboniferous.

A report by Powell upon the geology of the Uinta Mountains, published in 1876, and the reports of the Fortieth Parallel Survey which appeared almost immediately after, discuss the geology of considerable Carboniferous areas in northwestern Colorado, and remain at the time of writing almost the only accounts, as they are certainly the most comprehensive ones, of the subject. These reports, together with one by White published subsequently and that by Jones already referred to, constitute the entire literature of the Uinta area, and it is all too meager and contradictory.

In the case of the Fortieth Parallel Survey the actual explorations were made by Hague and Emmons,[a] whose accounts constitute volume 2 of that series. The volume on systematic geology by King (vol. 1), however, which is a restatement of their facts and a general discussion based upon them, is a more convenient and suggestive form in which to consult these data.

Powell's observations, as already said, are embodied in the volume upon the geology of the Uinta Mountains,[b] which contains a relatively lengthy paleontologic discussion by C. A. White, who subsequently published in the Tenth Annual Report of the Hayden Survey an account, based upon independent observations, of the geology of a part of the Colorado Uinta area, and also several briefer papers recapitulating much of the same matter.

The title of Powell's work is somewhat misleading, as his discussion is mainly of

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 2, 1877.
[b] U. S. Geol. Geog. Surv. Terr., Powell's Rept. Geol. Uinta Mountains, 1876.

the geology of the Plateau province as a whole, and but 75 of the upward of 200 pages comprised in it deal directly with the geology of the Uinta Mountains, and that only of the eastern portion. Through his presentation of the subject it thus happens that while the typical exposures of the Red Wall and of the upper and lower Aubrey groups are in northern Arizona, the same names are employed for formations in northwestern Colorado, and that the geology of the latter area, historically at least, is intimately connected with that of the Grand Canyon country. In a similar manner, since Emmons and King describe the Uinta sediments in connection with those of the Wasatch Mountains, recognizing the same formations and employing the same names in both, the Uinta section can not well be considered apart from that of the Wasatch Mountains.

I am especially concerned only with the strata of Carboniferous age in the Uinta Mountains. These are described on page 57 and again on page 146 of Powell's work, while the general section and description for the Plateau province occur on pages 40 and 54. The faunal characters of the Carboniferous are outlined and discussed on pages 76, 79, and 88.

Over 5,000 feet of strata in the Uinta Mountains are referred by Powell[a] to the Carboniferous, and four subdivisions of Carboniferous beds are recognized. These are called in ascending order the Lodore group, the Red Wall group, the lower Aubrey group, and the upper Aubrey group. The Lodore group, 460 feet in thickness, consists of sandstones and shales with conglomerates at the base. The Red Wall group is 2,000 feet thick and consists chiefly of limestones separated by thin sandstones. The lower Aubrey comprises 1,000 feet of rather soft sandstones with intercalated limestones. The upper Aubrey is composed of two members—a massive, homogeneous, light-gray sandstone at the base, called the Yampa sandstone, which has a thickness of 1,000 feet or more, and above 150 to 200 feet of cherty limestone for which the name Bellerophon limestone is employed.

These four Carboniferous formations are conformable with one another, but according to Powell they are separated by a profound unconformity from the underlying beds, which have been called the Uinta sandstone. The unconformity is one both of dip and erosion. The difference of dip between the Lodore group and the Uinta sandstone is about 4 degrees, the lower formation having the greater inclination to the south. Cliffs of the Uinta sandstone formed prior to the deposition of the Lodore project in some instances 400 feet into the mass of superimposed sediments (page 144).

The upper Aubrey formation is succeeded by the Juratrias groups, which received the names of the Shinarump, Vermilion Cliff, White Cliff, and Flaming Gorge groups. No unconformity was observed between the upper Aubrey and the

[a] Powell mentions the constituent members of his Carboniferous series in several places, and each time with a different thickness. The above is the sum of the thicknesses in a detailed section, aggregating in all 5,305 feet.

Shinarump groups, but as the lowest beds of the Mesozoic are of very friable material, the exact junction was rarely seen (page 150). At the same time, that an interruption in sedimentation did occur at the top of the upper Aubrey group is indicated by the following passage, quoted from page 69:

"The plane of demarcation between the Shinarump group and the summit of the Carboniferous is always well marked. Soft, gypsiferous shales are found at the base of the upper group, and either a pure limestone, a cherty limestone, or a homogeneous sandstone at the summit of the Carboniferous. In places, however, a conglomerate is found at the base of the Shinarump group, its coarser fragments being composed of cherty limestone which contains Upper Carboniferous fossils. So in some places, at least, the epoch of change was a period of erosion."

Accompanying the report upon the geology is a paleontologic report by C. A. White, which forms an important part of the volume under discussion. He gives faunal lists from the different formations of the Plateau province from which collections were obtained, discusses the ages of the beds and describes many new forms. Carboniferous faunas are cited from the Red Wall and the upper and lower Aubrey groups. His conclusions in regard to the Carboniferous faunas are expressed in the following words (page 79):

"A large proportion of all these fossils are specifically identical with well-known forms in the strata of the Carboniferous or Coal-Measure period in the States of the Upper Mississippi Valley; and all but two of them belong to such types as we might naturally expect to find in the equivalents of those strata. These two belong to the two genera, respectively, *Archimedes* and *Amplexus*, the former of which especially has been regarded as an exclusively Subcarboniferous genus; and yet they are found in the lower Aubrey group, nearly 3,000 feet above the base of the Carboniferous series, and also above and mingled with types that have not hitherto been found in strata so low as the Subcarboniferous.

"Few or none of the fossils of the collections are of such a character as to suggest the Permian age of the strata from which they were obtained, not even those of the upper Aubrey group. I have elsewhere shown[a] that the prevalence of certain types which have been relied upon to prove the Permian age of the strata containing them may be due to peculiar physical conditions, and I therefore regard it as not improbable that the time of the Permian period may be represented in the Plateau Province by the upper Aubrey group, although the distinguishing types are wanting there. In view also of the mixture which we find, of Carboniferous and Subcarboniferous types in the same strata, it seems probable that the time of the whole Carboniferous age, including its three periods, Subcarboniferous, Carboniferous, and Permian, is collectively represented by the four groups in the Plateau Province."

No fossils are cited from either the Lodore or the Uinta formations. The latter, however, is provisionally referred to the Devonian by Powell (pages 70, 141), while the Lodore group, which overlies it unconformably, is included in the Carboniferous.

[a]Geology of Iowa, 1870, vol. 1, p. 249.

Between the Flaming Gorge group, with a fauna identified as fresh-water Jurassic, and the upper Aubrey, which is Carboniferous, intervene three formations whose age was not ascertained—the Shinarump, Vermilion Cliff, and White Cliff groups. These belong to the Red Beds series and have been placed with the Juratrias. There is some reason to believe that the upper limit of the Carboniferous should have been placed at a somewhat higher horizon, and it is possible that the upper portion of the Uinta sandstone should have been included in the same period. These points will be discussed further on.

Both lithologically and faunally the geologic sections in northeastern Utah and northern Arizona are sufficiently unlike, so far as the Paleozoic strata are concerned, to cast suspicion upon the correctness of Powell's correlations. The lower Aubrey and Red Wall groups, as described by Powell in the different sections, seem to present pretty much the same lithologic characters, but the upper Aubrey group is more variable. "To the southward, in the Grand Canyon country, these beds are a series of cherty limestones. At the junction of the Grand and Green they are a series of sandstones with intercalated cherty limestones, with a homogeneous sandstone at the summit 150 feet in thickness. In the Uinta Mountains we have a homogeneous gray sandstone which we call the Yampa sandstone, from 1,000 to 1,200 feet in thickness, capped by a bed which is believed to be the equivalent of the one mentioned as found at the summit of the series at the junction of the Grand and Green, and varies from 150 to 200 feet in thickness. On the south side of the Uinta Mountains it is an indurated, calciferous sandstone, but on the north side of the mountains it is a cherty limestone, and on both flanks it is characterized by a species of *Bellerophon*. Here we have called it the Bellerophon limestone." (Page 55.) The Lodore group, which is typically exposed in the eastern Uintas, does not extend far to the south, nor was the Tonto group, which, in the Grand Canyon region, underlies the Red Wall group, traced far to the north. Because of a certain similarity in stratigraphic position Powell wished to correlate these two formations and to employ for both the name Tonto group (page 56). Walcott, however, has shown that the Tonto group is of Cambrian age,[a] while the Lodore group can, with great probability, be referred to the Carboniferous.[b]

In the Uinta Mountains the Lodore group is underlain unconformably by the great mass of the Uinta sandstone, 12,500 feet in thickness, of which the Uinta Range is mainly composed. The age of this series was not ascertained, but it was referred tentatively to the Devonian (page 70). The Uinta sandstone rests uncomformably upon the Red Creek quartzite, of which 10,000 feet are reported without the bottom having been seen.

In the Grand Canyon region, uncomformably below the Tonto sandstone, is found

[a] Am. Jour. Sci., 3d ser., vol. 26, 1883, p. 439.

[b] Powell states that Carboniferous fossils have been found in the Lodore group (pp. 56 and 147), but apparently none were collected (p. 79).

the Grand Canyon group, 10,000 feet of sandstones and conglomerates, and this in turn rests unconformably upon the Grand Canyon schists. The Grand Canyon schists and the Red Creek quartzite Powell regards as of Eozoic age, and the Grand Canyon group he refers to the Silurian (pages 56, 70). Upon this construction of the facts the Grand Canyon schists and the Red Creek quartzite would be in a manner correlated, and the Grand Canyon group of the Grand Canyon area would underlie the Uinta group of the Uinta area, neither great series being represented in both regions. It would appear from this that in Paleozoic time at least the two regions passed through very different geologic histories. In fact, however, it appears to me more probable that the Grand Canyon group is to be correlated with the Red Creek quartzite and that both are Algonkian.

A critical study of the paleontologic evidence reveals discrepancies well nigh as marked as those shown by the comparison of the geologic sequence.

But a single Carboniferous species is cited by White as having been obtained in Colorado itself, but more or less extensive collections were made in portions of the Uinta Mountains which lie beyond its confines in the State of Utah. No fossils are cited from the Red Wall limestone in the Uinta Mountains, but three collections were made in the lower Aubrey formation and one in the upper Aubrey. The only faunas known from the Red Wall group were collected at two stations situated close together southeast of the central part of Utah. From Gypsum Canyon were obtained *Chætetes milleporaceus* and *Syringopora multattenuata*, and from Cataract Canyon an undetermined species of *Campophyllum*. These faunas, so far as they go, are quite dissimilar, but are yet so limited that they might readily have come from the same bed, somewhat the more because the zoologic relations of the three species are all with the same class, the corals. On looking up the collections upon which this report was based the specimens referred to *Ch. milleporaceus* could not be found. The original material of *S. multattenuata*, as well as it could be identified, consists of an external cast, and can not be definitely determined. The *Campophyllum* is probably that form from the Diamond Mountains figured by Meek in the reports of the King survey.[a] The evidence therefore, whether of the lists or of the fossils, is inconclusive, but so far as it goes is coincident in indicating Upper Carboniferous.

In the detailed section at Cataract Canyon, given by Powell on p. 60, the Red Wall group is described as buffish lavender, friable, fine-grained sandstone; base not seen. This is not at all the character of the real Red Wall limestone, and these beds more probably belong above the Red Wall, in the lower Aubrey series. Thus the stratigraphic and paleontologic evidence agree in discrediting Powell's identification of the Red Wall at this place. At the same time it should not be lost sight of that the upper half of the typical Red Wall belongs in the Pennsylvanian.

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 4, 1877, p. 57, pl. 5, figs. 2, 2*b*.

The lower Aubrey group furnished most of the fossils collected, and an extensive fauna is cited, obtained chiefly at three localities. One of these is not far from the stations at which the Red Wall fossils were found. The two others, Echo Park and Split Mountain Canyon, are close together in the Uinta Mountains in the extreme northeastern part of Utah. From Echo Park are cited *Amplexus zaphrentiformis*, *Fenestella* sp., *Archimedes* sp., *Chonetes platynotus*, *Productus longispinus* (?), *Productus costatus* (?), *P. costatus* var., *Productus muricatus*, *Hemipronites crenistria*, *Seminula subtilita*, *Spirifer rockymontanus*, and *Phillipsia* sp.; and from Split Mountain Canyon are cited *Amplexus zaphrentiformis*, *Chætetes milleporaceus*, *Acervularia* sp., and *Spirifer rockymontanus*. It thus appears that two of the four species collected at Split Mountain Canyon occur also at Echo Park, and there seems to be no reason for suspecting that the two lists do not represent the same fauna. The specimens upon which some of the listed species were based appear to have been lost from the collection, and while I do not agree in every case with Professor White's identifications, I think the fauna shown, whether by the lists or by the specimens themselves, must be taken as indicating Upper Carboniferous. On the other hand, the assemblage is not quite that of one of the common Upper Carboniferous faunas of the Mississippi Valley, so that to a certain extent Powell's statement is borne out—that in the Great Basin region the grouping of fossils is peculiar (loc. cit., p. 4). It is with this fauna that there is said to occur the anomalous association of Lower Carboniferous types, such as *Amplexus zaphrentiformis* and the genera *Lithostrotion*, *Acervularia*, and *Archimedes*, with an Upper Carboniferous fauna, a fact to which attention was directed by White in a passage previously quoted. The survival into the Upper Carboniferous of the already long-established genus *Amplexus*, which is known in America as late as Upper Mississippian time, would not necessarily occasion surprise, nor even possibly that of the Devonian genus *Acervularia*, which is also known in the Carboniferous, but the case is somewhat different with *Archimedes.* A striking and highly specialized scion of the fenestellid stock, this type makes its earliest appearance in the Keokuk epoch; it attains its maximum in the Chester, and has never before, I believe, been cited in association with an Upper Carboniferous fauna. For my own part, I should wish to see the occurrence verified in the present case, and am even inclined to invoke an accidental, or some other than an actual faunal, association. Unfortunately, and the circumstance may not be without significance, the representatives of both *Archimedes* and *Acervularia* are missing from the collection as it now stands.

On the other hand, as the Lower Carboniferous is supposed to be missing in the eastern Uintas, the whole Paleozoic section above the Uinta sandstone being referred to the Upper Carboniferous, if these specimens of *Archimedes* really were obtained from this area and from beds now in place, it seems that the peculiar association noted by White must be accepted. In a condition thus unsatisfactory, without having attained to more than the probabilities, it seems necessary to turn from this point until fresh evidence is obtained.

From the upper Aubrey group in the Uinta Mountains only a meager fauna is known. White cites *Bellerophon carbonarius* var. *subpapillosus* from Junction Mountain and near Diamond Peak, in northwestern Colorado; and in Utah, from near Echo Park, *Bellerophon carbonarius* var. *subpapillosus*, and from Beehive Point, near Horseshoe Canyon, *Discina* sp., *Hemipronites crenistria*, *Spirigera subtilita*, *Spirifer rockymontanus*, and *Bellerophon carbonarius* var. *subpapillosus*. This fauna, so far as it goes, indicates again the Upper Carboniferous, without any suggestion of Permian, as White also has remarked.

Gypsum and Cataract canyons, where the only collections from the Red Wall limestone were made, and the junction of the Grand and Green rivers, where the largest collections representing the lower Aubrey group were obtained, are close together, southeast of the center of Utah. In this region, as the Lodore group was not, I believe, identified outside of the Uinta Mountains, the Red Wall group is the lowest of the Carboniferous formations. Its fauna has already been spoken of, and the opinion expressed that it indicates in an inconclusive but at the same time an unambiguous manner the age of the Upper Carboniferous.

From the lower Aubrey group at the junction of the Grand and Green rivers a considerable and characteristic fauna is cited, as follows: *Fistulipora* sp., *Syringopora* sp., *Lophophyllum proliferum*, *Archæocidaris cratis*, *Archæocidaris trudifer*, *Erisocrinus typus*, *Scaphiocrinus carbonarius*, *Eupachycrinus platybasis*, *Polypora* sp., *Productus punctatus*, *P. longispinus* (?), *P. prattenianus*, *P. semireticulatus* var. *ivesii*, *P. nebraskensis*, *P. multistriatus*, *Chonetes granulifer*, *Hemipronites crenistria*, *Meekella striaticostata*, *Seminula subtilita*, *Spirifer cameratus*, *Spiriferina kentuckyensis*, *Myalina recurvirostis*, *Allerisma subcuneatum*, *Edmondia aspinwallensis*, *Pleurophorus* sp., *Schizodus wheeleri*, *Bellerophon* sp., *Euomphalus* sp., *Pleurotomaria excelsa*, and *Naticopsis remex*. This fauna has no uncertain significance, and evidently belongs in the Upper Carboniferous.

At the same locality, but in the upper Aubrey group, was obtained the following fauna: *Spiriferina kentuckyensis*, *Myalina* sp., *Edmondia* sp., and *Bellerophon montfortianus*. Though scanty, this fauna is indicative of Upper Carboniferous, and such a determination is in line with its position in the section above a well-characterized Upper Carboniferous fauna. In the four species cited there is nothing to lead one to assign the horizon to the Permian.

The comparison of these faunas with those in the Uinta Mountains supposed to come from the same beds is full of interest. Of the thirty species which are cited from the lower Aubrey group at the junction of the Grand and Green rivers, but three are common to the list from the beds called by the same name in the Uinta Mountains, and these three (*Hemipronites crenistria*, *Productus longispinus*, and *Seminula subtilita*) are such as, having in common acceptation specific limits of the broadest, have also the longest range, which may be said to have been synchronous with all Upper Carboniferous time. Two Upper Carboniferous faunas of equal extent could scarcely have less in common than the two listed here. The same is true of the meager faunas known from the upper Aubrey group in the two areas. These faunas, as cited from the Uinta Mountains and from the confluence of the Grand and Green rivers, contain not a single species in common, but it is noteworthy that the fauna of the upper Aubrey in the Uinta Mountains is practically the same as that of the lower Aubrey in the same region, and a similar resemblance may be pointed out between the faunas of the upper and lower Aubrey groups at the confluence of the Grand and Green rivers.

Of the geology of the Grand Canyon region, whence Powell derived the names by which the formations in the Uinta Mountains are denoted, but little need be said. Powell himself cites no Carboniferous fossils from this region. Gilbert first gave local names to the Carboniferous series in the Grand Canyon region,[a] dividing it into the Aubrey limestone, the Aubrey sandstone, and the Red Wall limestone. He cites from the Aubrey limestone (the upper Aubrey of Powell) an Upper Carboniferous fauna not unlike that which the latter obtained in the homonymous beds at the junction of the Grand and Green rivers. In the topmost strata *Schizodus*, *Pleurophorus*, and *Bakewellia* were found, an assemblage not noted by Powell, and one "suggesting the Permo-Carboniferous of the Mississippi Valley."[a] The Aubrey sandstone contains few fossils, "but an intercalated limestone, below the middle of the series at Canyon Creek, bears the familiar Coal Measure shells."[a]

In the Red Wall limestone fossils are said to be "abundant near the top, but difficult to find in the lower portions."[b] The lowest horizon from which fossils were obtained was a trifle below the middle of the series. They were doubtfully referred by Meek to the Lower Carboniferous. "The fauna of the upper portion is rich in species, and, while differing from that of the Aubrey limestone, is equally referable to the Coal Measures."[b]

In describing the Paleozoic section in Kanab Canyon, Walcott[c] identifies Silurian, Devonian, Carboniferous, and Permian strata. These are separated from one another by planes of erosional unconformity, and in addition the Permian is divided into two portions by an erosion period, and the Upper Permian is succeeded by another. To the Carboniferous Walcott refers the Red Wall limestone and the upper and lower Aubrey groups. His Lower Permian is the Permo-Carboniferous of Gilbert,

[a] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875, p. 177.
[b] Ibid., p. 178.
[c] Am. Jour. Sci., 3d ser., vol. 20, 1880, p. 222.

and his Upper Permian seems to be a portion of the series which Gilbert, lacking paleontologic evidence, referred to the Trias.

Frech[a] has briefly described the geologic section in Congress Canyon on the occasion of an excursion of the International Geological Congress in 1891. He refers the Red Wall group to the Lower Carboniferous and the Aubrey group to the Upper Carboniferous.

It thus appears that the three reports which have been cited agree in referring, on paleontologic evidence, the Red Wall group wholly or in part to Lower Carboniferous time. Walcott carries the Carboniferous (Permian) above the top of the upper Aubrey group. The following statement from Gilbert is also of interest:[b]

"The classification adopted for the Carboniferous rocks in the Grand Canyon and along the southern margin of the Carboniferous plateau is of local value only. Seventy-five miles to the west, in the Spring Mountain Range, I was unable to correlate the series in detail, and eastward, from Canyon Creek to Camp Apache, the progress of a rapid transformation can be traced."

It seems that we can accept Powell's section of the eastern Uintas with some modifications, but not his correlations with the Grand Canyon section in the case of the lower beds. Powell seems to fix the thickness of the upper Aubrey, lower Aubrey, Lodore, and Red Wall groups of the Uinta section at over 5,000 feet. King allows only 2,000 to 2,500 feet for the same interval. White, as will appear later, places the thickness at 3,100 feet, which, as it is intermediate between the figures given by Powell and King, is perhaps nearer the true thickness.[c] It might be inferred also that Powell had overestimated the extent of the unconformity between the Lodore and Uinta formations. King seems to discredit it altogether, and White states that in his area it was slight and easy to be overlooked.

All available evidence points to the conclusion that Powell's Red Wall limestone of the Uinta section is wrongly correlated, and with it several other beds. The lower part of the real Red Wall is without doubt of Mississippian age. This has been the opinion held more or less tentatively by Meek, Walcott, and Frech, and we have a Mississippian fauna from it. On the other hand, it is almost certain that the "Red Wall" of the Uinta Mountains belongs entirely in the Upper Carboniferous. The few fossils collected from it by Powell at Gypsum and Cataract canyons indicate Upper Carboniferous. The Uinta sandstone, which underlies it, seems to be rightly correlated with the Weber quartzite, which carries Upper Carboniferous fossils. The Uinta sandstone itself has probably furnished a few fossils of the same age. Powell mentions Carboniferous fossils as occurring in the Lodore group, and

[a] Cong. Géol. Internat., 5th sess., Compte Rendu, 1893, p. 476.

[b] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875, p. 179.

[c] This measurement is exclusive of the Lodore group, which White says was not present in his area. At the same time, as the Lower and Middle Carboniferous are said to be so like one another and so like the Uinta sandstone as to be sometimes difficult to distinguish, it may be that he merely failed to discriminate the Lodore. If really absent an overlap would be indicated above the Lodore, as well as an unconformity below it. Its thickness is but 465 feet.

as it is highly probable, from its lithologic composition, that the Lodore does not belong to the Mississippian limestone series of the West, it must be of Upper Carboniferous age. King cites a few species of unmistakable Pennsylvanian age from 60 feet above the Weber quartzite, a horizon which must be in the Lodore group and below the Red Wall limestone of the Uinta section.

I shall later offer some evidence tending to show that the lower portion of the Uinta sandstone is Cambrian and the upper portion Upper Carboniferous (Weber quartzite). If this is so, the Grand Canyon series of the Grand Canyon section would probably be equivalent to the Red Creek quartzite of the Uinta section, and the Tonto sandstone to the lower part of the Uinta sandstone, while the Devonian and the true Red Wall limestone would probably be wanting. It remains to find the equivalent in the Grand Canyon section of the Pennsylvanian portion of the Uinta sandstone and of the beds which Powell called the Lodore group, the Red Wall limestone, and the upper and lower Aubrey groups. On the whole it seems to me most probable that the four formations last mentioned represent the Aubrey group of Gilbert. The lithologic character of the series is not unlike, and in a general way Powell traced their equivalence in the field. The paleontologic evidence is partly favorable and partly adverse to this correlation. From the Aubrey group Gilbert cites *Productus ivesii*, *Productus semireticulatus*, *Spirifir lineatus*, *Seminula subtilita*, *Meekella* sp., *Derbya* sp., *Aviculopecten* cf. *occidentalis* (p. 177). Most of these are well-known Pennsylvanian species of the Mississippi Valley section; but I am inclined to question the exact identity in some cases. Newberry, however, had previously described a number of species from this horizon, namely, *Archæocidaris longispinis*, *Archæocidaris ornatus*, *Archæocidaris gracilis*, *Meekella occidentalis*, *Meekella pyramidalis*, *Chonetes verneuilanus*, *Productus costatoides*, *Productus ivesii*, *Productus occidentalis*, *Productus costatus*, *Productus semireticulatus*, *Spirifer lineatus*, *Seminula subtilita*, *Aviculopecten coloradoensis*, *Allerisma capax*, etc.[a] Many of these species are new and are not known to occur in the Mississippi Valley. To this list may be added *Productus subhorridus* Meek, which is found at this horizon. From the lower Aubrey group, at the junction of the Grand and Green rivers, White cites some of the same forms, among them *Productus ivesii*, which appears to be especially characteristic of the Aubrey formation. As associated with it is mentioned also *Productus multistriatus*, a species whose horizon in the Wasatch Mountains is in the Upper Coal Measure limestone, a series which I provisionally regard as correlated with the Aubrey group of the Grand Canyon country, and with the four formations of the Uinta sandstone now under consideration. This evidence is of course very slender, and must be reenforced by a full consideration of all these faunas, a task to which I shall address myself at some future

[a] Ives's Report Colorado River of West, Senate Ex. Doc. No. —, Thirty-sixth Congress, first session, 1861, pp. 116–129.

time. As I have already shown, the faunas from the eastern portion of the Uinta Mountains, supposed to come from the same horizon, are almost entirely different. The peculiar and striking forms, whether of the Aubrey group of the Grand Canyon, or of the Upper Coal Measure fauna of the Wasatch Mountains, seem to be absent.

Another circumstance adverse to the correlation consists in the thickness of the formations supposed to be equivalent. The typical Aubrey group has a thickness of but 1,800 feet, while the Lodore, Red Wall, upper Aubrey, and lower Aubrey groups of the Uinta Mountains, according to Powell, amount to 5,000 feet, though, as already noted, White assigns 3,100 feet and King but from 2,000 to 2,500 feet to the same formations. It is a fact not perhaps without suggestion, that if to the Aubrey group be added half the thickness of the Red Wall limestone, the upper portion of which is known to be of Pennsylvanian age, the total (3,070 feet) is almost precisely the same as White's measurement in the Uinta Mountains, which is nearly a mean between King's and Powell's. Upon this point—whether the Pennsylvanian portion of the Red Wall limestone is missing from the Uinta section, or is represented by part of King's Upper Coal Measures, there is very little evidence. There exists, however, such an analogy between the sections of the Wasatch Mountains, the Grand Canyon region, and central Colorado, where each shows a limestone series which is in part Mississippian and in part Pennsylvanian (the Wasatch limestone in the Wasatch Mountains, the Red Wall limestone in the Grand Canyon, and the Leadville and Weber limestones in the Crested Butte section), that I am disposed to assume uniformity in other respects, and to believe that the whole of the Red Wall limestone is missing in the eastern Uintas, just as all the Wasatch limestone and the Leadville and Weber formations are supposed to be. According to this correlation, then, the Devonian, Mississippian (lower Red Wall), and lower Pennsylvanian (upper Red Wall) wedge out as the eastern Uintas are approached,[a] while the Weber quartzite, which is supposed to come above them, disappears southward. The unconformity which Powell noted between the Lodore group and the Uinta sandstone might be cited as a cause for the removal of this series in the Grand Canyon region.

The occurrence of great Algonkian (?) masses in the Grand Canyon series of the Grand Canyon, in the quartzites of the Needle Mountains in Colorado, and in the Red Creek quartzite of the Uinta section, suggests that a band of this series, having an approximate north-south trend, may extend through this region.

The year following the publication of Powell's report upon the Uinta mountains appeared the second volume of the reports of the Fortieth Parallel Survey.[b] In discussing both in this place and later the import of the data collected by this organization, it will not be necessary to contrast and distinguish between the views

[a] Probably owing to the same agency which destroyed the supposedly equivalent series still exisiting in northern Utah and central Colorado, erosion prior to the Weber quartzite.

[b] U. S. Geol. Expl. 40th Par., Rept., vol. 2, Descriptive Geology, 1877.

and statements set forth in this volume and in the résumé by King of the results in systematic geology of the work of this survey[a] published the year later, so far as they are in agreement.

The work of the Fortieth Parallel Survey embraced a strip of territory adjacent to the fortieth parallel of north latitude, including considerable areas in northern Colorado and Utah. Here are dealings, not only with the eastern portion of the Uinta Mountains, which Powell described, but also with their western extension, which he had not carefully studied (Powell, p. 61), and of the Wasatch Range, which adjoins them on the west.

The section of the Wasatch Mountains which King uses as a reference section consists of the following formations:[b]

Section of Wasatch Mountains.

	Feet.
Permo-Carboniferous	650
Upper Coal Measures	1,700-2,100
Weber quartzite	5,000-6,000
Wasatch limestone	7,000
Ogden quartzite	1,000-1,500
Ute limestone	1,000-2,000
Cambrian shales	75-600
Cambrian quartzite	12,000
Lower Cambrian slates	800

The Ute limestone is reported as containing Quebec fossils. The Ogden quartzite has as yet furnished no fossils, but is referred to the Devonian on the strength of correlation with sections farther west, where its supposed equivalent is defined by fossiliferous horizons above and below. The Wasatch limestone is reported as having Devonian forms in the lower part, with Waverly fossils above and Coal Measure faunas running down to 1,600 feet above its base. The Devonian species cited in the Wasatch Mountains are, however, few,[c] and occur also in the Waverly fauna. I have never seen any Devonian fossils from the Wasatch Mountains, and in one case at least (Rock Canyon, back of Provo) the very basal beds of the Wasatch limestone carry a Waverly fauna. There seems to me, therefore, to be no evidence for referring any portion of the typical Wasatch limestone to the Devonian. Farther west, however, in Nevada, in the Tucubits, White Pine, and other ranges, abundant and well-marked Devonian faunas are found, but the limestones in which they occur are evidently not the Wasatch limestone, but another formation underlying it, which is not found in the Wasatch section. From the Ruby and Egan mountains[d] faunas are cited as from the Wasatch limestone which have a peculiar facies that is believed to be distinctive of the limestones which come above the Weber quartzite in the

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 1, 1878.
[b] Ibid., p. 155.
[c] *Streptorhynchus inæquale* and *Proetus peroccidens*, ibid., p. 177.
[d] Ibid., p. 203.

Wasatch Mountains; and it seems to me, therefore, that King's correlations of the Wasatch Mountain and Nevada sections are not to be relied upon.

The facts at hand seem to indicate that the Ute limestone is probably of Ordovician age; the Ogden quartzite Devonian or older; the Wasatch limestone Mississippian in its lower portion, with more than half above Pennsylvanian; the Weber quartzite and overlying limestones Pennsylvanian. More recent collections taken from the Permo-Carboniferous of King have introduced an uncertainty as to whether this series is really Permian or Mesozoic. The component formations of the Wasatch Mountain section have not all the same distribution, for in Rock Canyon, back of Provo, I found Waverly fossils at the base of the Wasatch limestone only a few hundred feet above thin blue limestones carrying Middle Cambrian trilobites.

King describes the Paleozoic formations of the Uinta Mountains in the following terms:[a]

"1. A series of siliceous beds 12,000+ feet thick, impure sandstones at the east end of the uplift, but gradually compacted into quartzite in the western portion of the range; these beds are intercalated with groups of clay shales and occasional conglomerate sheets which contain round rolled Archean pebbles.

"2. Conformably, as we believe, over No. 1 is a series 2,000 to 2,500 feet thick of mixed limestone, calciferous sandstones, and cherty limestones, showing great variability in the thickness of bedding, but prevailingly of heavy limestone near the base, with varying thin-bedded intercalations of lime and sand near the top, always capped with a zone of highly cherty *Bellerophon*-bearing limestones. From bottom to top the series is rich in Upper Coal Measures fossils.

"3. From 200 to 500 feet of calcareous shales and argillaceous rocks and clays intervening between the Coal Measures and Trias, conformable to both, and carrying Permo-Carboniferous fossils."

The first paragraph of the preceding quotation refers to the great thickness of beds to which Powell gave the name Uinta sandstone. This Emmons traced westward and identified with the Weber quartzite of the Wasatch Range, and the name Weber formation is therefore frequently employed to designate it. In the second paragraph are collectively described beds which are discriminated by Powell as the Lodore group, the Red Wall group, the upper Aubrey group, and the lower Aubrey group. King frequently refers to this division under the name of the Upper Coal Measure limestone. The upper series described by King in the third paragraph must be the lower portion of Powell's Shinarump group. These two divisions are evidently supposed by King to represent the Upper Coal Measures and Permo-Carboniferous of his Wasatch Mountain section.

Several points of disagreement appear when the account by Powell of the geology of the Uinta Mountains is compared with the review by King of the same subject. One of these is the reference by the latter of a part of Powell's Shinarump group to

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 1, 1878, p. 153.

the Carboniferous. The faunal list on page 146 of King's report comprises *Myalina* (resembling *subquadrata*), *Myalina* n. sp., *Bakewellia parva*, *Pleurophorus* sp., and *Macrodon* sp. King remarks: "These are the only fossils obtained in Uinta Range from the easily eroded beds that separate the lower sandstones of the Trias from the *Bellerophon* cherts which mark the uppermost horizon of the Coal Measures, and are interesting, since the forms as well as the physical condition of the beds are closely allied to the Permo-Carboniferous of Weber Canyon." The fauna does, indeed, tend to confirm King's correlation with the Wasatch section, but, as previously remarked, some doubt exists as to whether it belongs in the Permian or Mesozoic. Another less important instance seems to be the fact that King ascribes to the Upper Coal Measure limestone a thickness of but from 2,000 to 2,500 feet, while this is stated by Powell as 5,305 feet, if I am justified in combining the measurements of the upper Aubrey, lower Aubrey, Red Wall, and Lodore groups given by him on page 57. Furthermore, Powell describes a great unconformity as occurring at the top of the Uinta sandstone which he believes to be pre-Carboniferous in age. The geologists of the Fortieth Parallel Survey did not ascertain the unconformity noted by Powell. They refer this important formation to the Carboniferous, correlating it with the Weber quartzite of the Wasatch section. From the Weber quartzite a fairly satisfactory fauna is known, which proves the age of the formation to be beyond doubt Upper Carboniferous. As to the age of the Uinta sandstone, but little paleontologic evidence exists. Powell found it to be completely unfossiliferous, and the only fossils obtained by the Fortieth Parallel Survey were not found in place. They consist of a crinoid column, half of a ribbed brachiopod, somewhat doubtfully referred by Hall and Whitfield to *Spirifer imbrex*, and a well-preserved specimen of *Spirifer cameratus*. The *Spirifer imbrex* was found upon the slopes of Mount Agassiz, and the horizon is believed to be about 700 feet below the summit, and certainly as much or more beneath the top of the Uinta sandstone. *Spirifers* of the *imbrex* type are unknown in the Devonian, and are especially characteristic of the Lower Carboniferous. It would hardly be safe to infer from this specimen more, however, than that the age of this horizon is probably Carboniferous, without reference to any division of the Carboniferous series. The crinoid column could not be taken to indicate much more than an age probably subsequent to the Cambrian, but in view of local facts of lithologic and stratigraphic occurrence, it may well belong to Carboniferous time. The *Spirifer cameratus* was found in a pebble of red jaspery quartzite near Geode Canyon, and its origin was evidently the Weber quartzite beds of the interior of the range, while the character of the matrix would indicate that the stratum in which it was deposited belonged to the middle of the series.[a] *Spirifer cameratus* is a distinctly Pennsylvanian species, and forms even resembling it are very rare in the Mississip-

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 2, 1877, p. 290.

pian. Both Mount Agassiz and the upper Bear River Valley, where the crinoid column was obtained, are situated in the western part of the Uinta Mountains, but Geode Canyon is in the eastern part. Thus the paleontologic evidence is, as far as it goes, confirmatory of the stratigraphic correlation of the Uinta sandstone (at least in part) with the Weber quartzite. Inasmuch, however, as the Weber quartzite has a thickness of only 5,000 feet, while the Uinta sandstone measures over 12,000 feet, it would seem probable that the latter includes more than the Weber beds.

At two points in the western end of the Uintas, fossils are cited from beds just above the Weber quartzite. King says:[a] "From the foothills of the range, near Kamas Prairie, were obtained, at a point evidently not far removed from the contact with the Weber formation, *Productus semireticulatus*, *Spiriferina pulchra*, *Martinia lineata*." *Spiriferina pulchra* is a peculiar form whose position should not be far above the top of the Weber, so that the faunal evidence confirms that derived from stratigraphy. Again, at Rhodes Spur, from the base of the Upper Coal Measure series, not far above the Weber beds, were obtained[b] *Chonetes granulifer*, *Martinia lineata*, *Syringopora multattenuata*, *Zaphrentis*, *Lithostrotion*, and *Euomphalus*. This list apparently indicates an Upper Carboniferous horizon, but recent collections made from this locality and horizon contain species which determine its age as Lower Carboniferous, and identify the horizon as the lower part of the Wasatch limestone. If the list cited by King be considered in the light of this fact, it becomes evident that *Chonetes granulifer*, which is without doubt a misidentification, is really the only characteristic Upper Carboniferous form, *Syringopora*, *Zaphrentis*, *Lithostrotion*, and *Euomphalus* being rather indicative of the lower Wasatch, where they are common. It would appear, therefore, that in the western Uintas there are two siliceous series so similar lithologically that they were mistaken for the same in the rapid reconnaissance work of the King survey. One of these is very probably the Weber formation, as, indeed, King identifies it. The other is without much doubt pre-Wasatch in age, and represents the Ogden quartzite or some of the Cambrian quartzites, or both, wholly or in part. It is evident that the Wasatch limestone (the supposed upper Coal Measures of one outcrop) must intervene between the two supposed exposures of Weber quartzite.

The 12,000 feet of Uinta sandstone of the eastern Uintas is suggestive, by reason of its thickness, siliceous character, and stratigraphic position, of the Cambrian quartzites, sandstones, and shales of the Wasatch section, which have a combined thickness of about 13,000 feet; but as the Cambrian of central Colorado, which is presumably a continuation of that in Utah, has a thickness of less than 1,000 feet[c] it would be natural to suppose that in the Uinta Mountains the Cambrian would be

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 1, 1878, p. 147.

[b] Ibid., p. 146.

[c] Probably 600 feet in Peale's Eagle River section is the maximum. The thickness averages from 400 to 200 feet, and ranges to complete absence.

somewhat intermediate in thickness, corresponding to its intermediate geographic position.

The Mississippian was so uniformly a limestone-making epoch in the area of these Western States, of which the Madison, Wasatch, Ouray, Leadville, Red Wall, and other limestones are evidence, that I would hesitate to accept an unsupported correlation which would assign to this epoch sands and conglomerates in the area referred to. I would therefore regard the absence of any limestone series in the Uinta sandstone as evidence that none of its beds can be correlated with the Mississippian portion of the Wasatch limestone. If the horizon of the Mississippian Wasatch were conceived as coming below the Uinta sandstone, it is probable that the latter must be taken as the representative of the Weber quartzite, as King supposes. Under this hypothesis it would be necessary to account for the absence of the 13,000 feet of Cambrian beds and 7,000 feet of Wasatch limestone, not to include the Ute limestone and Ogden quartzite, and for the great thickness of the Uinta sandstone, when its supposed equivalents, the Weber quartzite in Utah and the Maroon-Weber interval in Colorado, amount to only 5,000 or 6,000 feet. In the absence of definite knowledge, however, explanation of both these objections can be made. The upper portion of the Wasatch limestone, in amount 5,400 feet, is of Upper Carboniferous age and is not persistently a limestone. The probable equivalents of these beds in the Oquirrh Mountains contain considerable thicknesses of quartzite, and King instances several beds which in their lateral extension vary in an important manner in the relative proportions of the calcareous and siliceous constituents (pp. 142 and 143). It is not unthinkable, therefore, that the Pennsylvanian portion of the Wasatch limestone in passing eastward may lose its calcareous composition and become indistinguishable from the Weber quartzite. The beds would have a combined thickness of from 10,400 to 11,400 feet—not far from that of the Uinta sandstone.

There can be little doubt that the earliest Pennsylvanian sediments were preceded by erosion, at all events in Colorado, for in Colorado the Mississippian portion of the Wasatch limestone, which has in Utah a thickness of 1,600 feet, is reduced to 400 or 500 feet (Leadville limestone),[a] with visible evidence of erosion along its upper plane. In places it has even been completely removed. If the pre-Carboniferous quartzites of the Wasatch section have their equivalent in the Red Creek quartzite of the Uinta section, and if the Mississippian portion of the Wasatch limestone were removed by erosion and the Pennsylvanian portion joined with the Weber in the manner outlined, the difficulties incident to this hypothesis would be in large measure removed.

If, on the other hand, the horizon of the Mississippian portion of the Wasatch be regarded as coming above the Uinta sandstone, the Red Creek quartzite would

[a] 500 feet appears to be about the maximum for this formation, and part of it is of Devonian age.

probably be Algonkian, and the Uinta sandstone would represent the pre-Carboniferous quartzites of the Wasatch section. The Mississippian portion of the Wasatch must needs be absent and not represented by Powell's Red Wall, as is involved in his correlation of the Uinta bed with that in the Grand Canyon region, because Pennsylvanian fossils were found immediately above the Uinta sandstone, as previously noted (*Spiriferina kentuckyensis*, *Seminula subtilita*, and *Meekella striaticostata* found near Ute Peak in the eastern portion of the range). As opposed to this might be urged the very rapid diminution in bulk, which the Uinta series, which seems in full force in the east end of the range, must undergo to find its equivalence in the really insignificant thickness of pre-Carboniferous sedimentaries of central Colorado. There is also the faunal evidence, very slender but not to be overlooked, which would tend to assign the upper portion of the Uinta sandstone to the Carboniferous (and if so, doubtless to the Upper Carboniferous); and the difficulty, in view of the correlation of the other Uinta and Wasatch formations sanctioned by by both stratigraphy and paleontology, of accounting for the Weber quartzite, which really has no lithologically similar correlate in the section of the eastern Uintas except the Uinta sandstone.

A third hypothesis is also possible, and on the whole it seems to me to possess more advantages than the two others. It has been shown that the Mississippian portion of the Wasatch limestone exists, with its characteristic fauna, in the western end of the Uinta Range, and that it there separates two quartzite series of very different geologic ages, but lithologically so alike that they were in one instance at least mistaken for one another. If the Wasatch limestone were removed it is evident that these two formations would come in contact, and would form a series whose members it would be difficult to distinguish, except by most careful scrutiny. To suppose, then, that the upper part of the Uinta sandstone represents the Weber formation, and the lower the pre-Carboniferous, chiefly Cambrian, quartzites of the Wasatch section, would account for the correlation by King of the Uinta sandstone and overlying Carboniferous series with the Weber quartzite and Upper Coal Measures of the Wasatch section, for the probable occurrence of Carboniferous fossils in the upper portion of the Uinta formation, for the probable thinning of the Cambrian in its eastern transit into Colorado, and for other observed facts which have a bearing upon this problem.

The faunal evidence is indecisive for any hypothesis, and is not conclusively favorable to that last advanced. As previously pointed out, the very scanty fauna so far obtained from the Uinta sandstone indicates that its upper portion is of Pennsylvanian age, and tends to corroborate the correlation by stratigraphy of that portion at least with the Weber quartzite. From the Upper Coal Measures, using King's term, of the Uinta Mountains but little paleontologic evidence exists. In the

Wasatch Mountains this division contains some striking and peculiar species. I collected *Productus nevadensis*, *Productus multistriatus*, *Spiriferina pulchra*, and several other forms, few of which probably are known in the Mississippi Valley, from this horizon in Weber Canyon. A somewhat similar fauna is cited by Emmons[a] from Mill Creek Canyon—*Spirifer cameratus*, *Spirifer octoplicatus*, *Spiriferina pulchra*, and *Productus subhorridus*. Some of these forms are cited from the same horizon in the Uinta Mountains. From the foothills bordering Kamas Prairie were obtained *Productus semireticulatus*, *Spiriferina pulchra*, and *Martinia lineata*.[b] This locality, however, is in the western end of the range, and so far as known these interesting forms do not appear east of this point. In the eastern Uintas the fauna of the Upper Coal Measures, except for the Bellerophon limestone, which I shall speak of later, comprises only the usual Pennsylvanian types. From Zenobia Peak[c] are cited *Spirifer lineatus* and *Spirifer opimus;* near Ute Peak[d] *Spiriferina kentuckyensis*, *Seminula subtilita*, and *Meekella striaticostata.*

Emmons also states that Marsh found at this horizon, and apparently very near this same locality,[e] *Zaphrentis stansburyi?*, *Fenestella* sp., *Derbya crassa*, *Productus* sp., *Spirifer cameratus*, *Seminula subtilita*, and *Phillipsia?* sp. These are from the eastern end of the range, and present no seeming departures from the usual faunas of the Mississippi Valley Pennsylvanian.

A somewhat peculiar assemblage of species, however, is found in the Bellerophon limestone, which forms the upper limit of the Upper Coal Measures division of these authors, or the topmost bed of the Carboniferous of Powell and White. From this horizon at Vermilion Creek Canyon are cited[f] *Fusulina* sp., *Nucula parva*, *Sedgwickia concava*, *Pleurotomaria* sp., *Bellerophon carbonarius;* from Section Ridge[g] *Nuculana bellistriata*, *Schizodus curtus*, *Bellerophon carbonarius*, *Orthoceras cribrosum*, *Naiadites* sp.; from Geode Canyon a similar fauna.[h] It should be added that of the species cited *Bellerophon carbonarius* is *Euphemus subpapillosus; Orthoceras cribrosum* is *Dentalium* cf. *canna*, and *Nuculana bellistriata* is *Leda* cf. *obesa*. These stations are all situated toward the east end of the Uinta Mountains. Though this fauna is not cited from the western portion of the range, nor from the Wasatch Mountains, it should not be lost sight of that the horizon is believed to occur in that area. King says:[i] "The prominent capping cherty limestone is quite constant wherever in the Uinta a good section of the whole Coal Measure series is obtained, and it is to be considered as the dividing line between this group and the Permo-Carboniferous." This remark refers to the Uinta Range, while the following is made of Cottonwood Canyon, in the Wasatch Range:[j] "A continuous belt of limestone, about

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[a] U. S. Geol. Expl. 40th Par., Rept., vol. 2, p. 368.
[b] Idem, vol. 1, p. 321; vol. 2, p. 147.
[c] Idem, vol. 1, p. 144; vol. 2, p. 287.
[d] Idem, vol. 1, p. 145; vol. 2, p. 289.
[e] Am. Jour. Sci., March, 1871, p. 197.
[f] U. S. Geol. Expl. 40th Par., Rept., vol. 1, p. 142; vol. 2, p. 274.
[g] Idem, vol. 1, p. 144; vol. 2, p. 285.
[h] Idem, vol. 1, p. 145; vol. 2, p. 291.
[i] Idem, vol. 1, p. 143.
[j] Ibid., p. 171.

1,200 feet thick, is here exposed, of which the upper portion is rather finely stratified and shaly, and bears *Bellerophon carbonarius.*"

Another probable occurrence of this horizon is in Weber Canyon, mentioned by King on page 163 of Volume I. Furthermore, in a collection recently made in the western end of the Uinta Range a small fauna like that of the Bellerophon limestone, with similar lithology and stratigraphic position, was obtained.

It seems probable, therefore, that this horizon extends from the eastern end of the Uinta Mountains westward into the Wasatch Range, and that the correlation made by the King survey of the Wasatch and Uinta sections is probably in the main correct. Yet the faunal and stratigraphic evidence alike are so insufficient that it is necessary to proceed with caution and to postpone a final decision until more data have been secured.

The Paleozoic series in the Grand Canyon, as exemplified in the Kanab Canyon section, shows as striking an agreement with that of the Wasatch Mountains as does the section made out in central Colorado. The Cambrian is represented by quartzites, sandstones, and limestones, as in Utah, though the thickness is much less. The Cambrian is followed by a limestone of Ordovician age comparable to the Ute limestone, though always considerably thinner. Then succeed some sandy and limy beds which have been much reduced by erosion and are not persistent. They contain the remains of placoganoid fishes, and Spurr desires to correlate them with the Parting quartzite, which occupies a position in the Colorado section similar to that of the Ogden quartzite of Utah.[a] Except for this brief series, the Devonian is unrepresented in either area, the succeeding formation in Kanab Canyon being the Red Wall limestone, which, like the Wasatch limestone of Utah, has a Mississippian fauna in its lower portion and a Pennsylvanian fauna in its upper. The Mississippian fauna of the lower Red Wall admits its correlation with some certainty with the similar portion of the Wasatch limestone. The Wasatch limestone, however, is greatly thicker than the Red Wall, and probably contains beds of Mississippian age which are wanting in the Grand Canyon region.

The sandstones of the lower Aubrey and the limestones of the upper Aubrey, which next succeed, are suggestive of the Weber quartzite and Upper Coal Measures series of the Wasatch Mountains. I feel that the upper Aubrey can with some probability of correctness be correlated with the Upper Coal Measures of the Wasatch section, and Walcott's Permian in a general way with the Permo-Carboniferous of that area, though doubtless they may not have precisely the same boundaries. Whether the lower Aubrey represents the Weber, or, that formation being absent in the Grand Canyon, goes with the upper Aubrey to make up the southward extension of the Upper Coal Measures, is a point upon which it is impossible to form

[a] U. S. Geol. Survey, Mon., vol. 31, 1898, p. 21.

credible judgment. As a rule the formations in the Grand Canyon are very much thinner than those of the Wasatch Mountains, and are comparable rather to those of central Colorado, where an almost precisely similar succession of beds has been made out.

In 1878 was published a report by C. A. White[a] upon an area in northwestern Colorado whose limits he describes in these words: "The district upon which the following report is made is included within the following boundaries: The eastern boundary is approximately upon a straight line drawn from a point where the meridian of longitude 107° 50′ west from Greenwich crosses White River to where the meridian of 107° 25′ crosses Yampa River. The northern boundary is the parallel of north latitude 40° 30′; the southern is the channel of White River, and the western the meridian of 109° 30′." (Page 5.) Regarding this area he goes on to say: "The districts surrounding the one here reported upon have, within the last few years, been geologically surveyed by different persons. That which adjoins it upon the west has been reported upon by Professor Powell in his 'Geology of the Uinta Mountains.' A geologic map of the district which adjoins this one upon the north has been prepared by Mr. Clarence King during the progress of the United States Geological Survey of the Fortieth Parallel. Reports to be published simultaneously with this are in preparation by the other geologists of the United States Geological Survey of the Territories on the other districts which adjoin this one." (Page 20.) This statement has the appearance at least of being somewhat erroneous, as the maps of both King and Powell cover perhaps the greater portion of the area surveyed by White, and both bound it upon the north and west, but principally upon the north.

White recognizes the following Paleozoic divisions, named in descending order:

"No. 11. *Upper Carboniferous.*—Irregularly bedded light-yellowish sandstones, with occasional calcareous layers, the sandstone layers often containing masses and nodules of chert. Thickness about 600 feet.

"No. 12. *Middle Carboniferous.*—Compact bluish fossiliferous limestone, heavily or thinly bedded, alternating in some places with strata that are sandy and ferruginous. Thickness about 1,000 feet.

"No. 13. *Lower Carboniferous.*—Massive layers of limestone alternating with those of sandstone and sandy limestone, all more or less ferruginous, generally presenting a reddish-brown aspect, and all usually regularly bedded. Thickness about 1,500 feet.

"No. 14. *Uinta sandstone.*—Massive or thinly bedded brick-red or more usually brownish-red sandstones; usually hard and often quartzitic. Thickness, exposed in this district, only about 400 feet; but the group reaches a thickness of nearly or quite 15,000 feet in the Uinta Mountains only a few miles from this district."

Though for No. 14 of this section White uses the name "Uinta sandstone" in the extract above quoted, he elsewhere adopts from King the name "Weber quartz-

[a] U. S. Geol. Geog. Surv. Terr., Tenth Ann. Rept., for 1876, pp. 3–60.

ite" for this series, and employs the term "Uinta group" as King uses it, for one of the Tertiary formations.

In his table of correlated sections on page 22 White represents the Weber quartzite of his section as being the same as the Uinta sandstone of Powell's, his Lower Carboniferous the same as Powell's Red Wall, his Middle Carboniferous the same as Powell's lower Aubrey, his Upper Carboniferous, the same as Powell's Upper Aubrey, and his Triassic(?), which lies above, the same as Powell's Shinarump, Vermilion Cliff, and White Cliff groups.

Regarding the Lodore group, which Powell described as immediately overlying the Uinta sandstone, White remarks: "Furthermore, at all places in this district, as well as within a large area outside of it, the strata of the Lower Carboniferous rest directly upon the Uinta sandstone, those of the Lodore group being absent." (Page 23.) And again: "Although the typical locality of the Lodore group which Professor Powell represents as existing at the base of the Carboniferous series and above the Uinta quartzite is near the northern border of the district here reported on, it does not occur within its limits." (Page 20.) If this is indeed the case, an overlap above the Lodore group is indicated, as well as an unconformity below it.

White was associated with Powell in his geologic investigation of this general region two years previously (1875), and without doubt the correlation indicated is as accurate as may be. White also correlates his section with that of King, whose report had not then been published, and with whose work he was less closely in touch. He parallels his Weber quartzite with King's formation of the same name, his Lower and Middle Carboniferous with King's Upper Coal Measures, and his Upper Carboniferous with King's Permo-Carboniferous. The correlation was made relying upon advance sheets of King's map, unaccompanied by text, and in the case of the Permo-Carboniferous and Upper Aubrey is without doubt erroneous. The Permo-Carboniferous of King, as previously remarked, lies above the bed taken by Powell as the top of his upper Aubrey. It is really part of Powell's Shinarump and the basal portion of White's Triassic. Therefore, not only the Lower and Middle Carboniferous of White, but the Upper Carboniferous as well, go to make up the Upper Coal Measures of King, which also includes the Lodore group where present. White assigns the Red Wall a thickness of 2,000 feet, and the upper and lower Aubrey each 1,000 feet, in the section on page 76 of Powell's Geology of the Uinta Mountains, and it would appear that the Red Wall and upper Aubrey were of diminished thickness in the new area. This is still more striking if the thicknesses in Powell's measured section (2,460 feet and 1,575 feet, respectively) be considered. The rather marked disparity between the thickness (2,500 feet) which King assigns to his Upper Coal Measures, and the 5,000 + feet which are contained in the detailed section in Powell's report, has already been referred to. This is somewhat less marked accordingly in the case of White's section, where these beds aggregate 3,100 feet, though this measurement excludes the Lodore group, which contains 460 feet.

The upper portions of the Weber quartzite are described as so closely resembling the beds of the Lower Carboniferous as to make their satisfactory discrimination in some cases impossible. He says: "The Lower Carboniferous strata are often so very like those of the Weber quartzite in general aspect that a casual observer would be in danger of confounding one with the other, especially if the unconformity should be, as it generally is, slight or obscure." (Page 23.) Referring again to the unconformity which was reported by Powell as occurring at the top of the Uinta sandstone, and which, it will be remembered, the geologists of the Fortieth Parallel Survey were unable to verify, he remarks that it "is usually so slight as to be easily overlooked." (Page 23.)

A resemblance similar to that which is reported between the Weber quartzite and the Lower Carboniferous, appears to exist also between the Lower and Middle Carboniferous, and in some cases, as in Yampa Mountain, "the Lower Carboniferous is not satisfactorily separated from the middle group." (Page 25.) The Upper Carboniferous group, on the other hand, is said to be easily distinguishable from that below.

If the resemblance between these different strata is so great, may not, one is inclined to ask, the absence of the Lodore group be the result of a similar resemblance, owing to which it was merged unrecognized with the Uinta sandstone or with the Lower Carboniferous?

White cites no fossils from any of the Paleozoic formations recognized by him. None, indeed, seem to have been found in the Weber quartzite, which he provisionally places in the Silurian, following Hayden and Marsh, whose reference seems to have been equally unbiased by paleontologic evidence. (Page 23.) Carboniferous fossils were found in the three overlying groups, but these seem to have been altogether of Coal Measure or Upper Carboniferous type, Eocarboniferous or Mississippian and Permian faunas being absent. This inference seems to be justified from the discussion on pages 24, 25, and 26. White says in especial: "I shall regard all the groups that have been named in the foregoing sections and elsewhere in this report as purely stratigraphical divisions, and probably inseparable from each other on paleontological grounds." (Page 24.) Regarding the upper group he says: "Fossils are rare in this group, but a few have been found in its upper strata, and those yet known are not such as to distinguish it clearly from the other two Carboniferous groups." The Carboniferous groups below it "contain fossils that are as closely allied with the Permian of Europe as any that have yet been discovered in the strata of this upper one." (Page 26.) As the divisions recognized by White are entirely stratigraphic, the employment by him of names which have a more or less precise significance in the geologic time scale is extremely unfortunate. Yet he seems to think that these names may have some vicarious significance in a palentologic sense, for he says: "The first of the following groups mentioned, however, is not to be here regarded as distinctively Subcarboniferous, although it may be so in fact, so far as anything is known to the contrary." (Page 25.) To understand this last expression in connection with what has gone before, it is necessary to bear in mind the belief held by this author that the Carboniferous divisions of Mississippian, Pennsylvanian, and Permian are not characterized by faunal differences as in the Mississippi Valley. Later paleontologic research, however, seems to substantiate the theorem that throughout the United States these three periods are distinguishable, where present, by characteristic faunas, and that these faunas, where in the same basin, are characterized in the main by the same assemblages of the same species as occur in the Mississippi Valley, and where in different basins, by assemblages of similar species.

GRAND RIVER REGION.

The great Carboniferous outcrop of the Uinta Mountains, with its outliers in Junction Peak and Yampa Peak, is described in the reports of White, Powell, and King, which have just been discussed. To the southeast of this, and separated by beds of Mesozoic and Tertiary age, occurs another large Carboniferous area of very irregular outline, which is seen chiefly along the valleys of White and Grand rivers and their affluents. The southern part of this area is formed by the "peninsula" of the Elk Mountains, which is connected with the larger mass by a more slender Carboniferous outcrop along the western flank of the Archean Sawatch Mountains. For convenience this can be denominated the Grand River region, from the stream which divides it almost in the middle. As defined in a previous paragraph, however, the Carboniferous outcrops of the Elk Mountains do not form part of the Grand River region.

The mountain region of central Colorado has been visited by many geologists and its geology described in a general or detailed manner, as the case might be, many times. Reconnaissance surveys were made by Peale, Holmes, Hayden, Marvine, and others of the Hayden survey, and by Stevenson of the Wheeler survey, and as it has become the scene of vast and varied mining enterprises it has been the subject of more detailed investigation by the United States Geological Survey in such works as the Leadville and Aspen monographs and the Tenmile and Anthracite-Crested Butte folios, and of many minor reports. The sections established in the four works last mentioned, from their detailed and accurate character, and because the constituent strata are grouped upon lithologic or fossil evidence into named formations according to modern usage, can conveniently be taken as sections of reference in the different areas in which they occur. The Crested Butte section would thus become standard for the Elk Mountain area, the Aspen and Tenmile sections for the Grand River area, and the Leadville section for the South Park area.

The areas of the Aspen monograph and the Tenmile folio are both properly included in the Grand River region, but they are so marginal as to be geographically nearer related, the one to the Crested Butte, the other to the Leadville district. Nevertheless, I will consider the sections described in these reports, and use them as a basis of comparison with other geologic reports covering the Grand River region.

The Paleozoic geologic section is remarkably uniform over this central Colorado area, and essentially the same subdivisions are recognized and essentially the same nomenclature is employed both in the four monographic publications just mentioned and in many smaller papers of later issue which it will not be necessary specifically to consider. In the case of the publications of the Hayden survey and others of an early date, the system at present in use of discriminating lithologic groups and giving to them local names was not employed, and the strata were divided, if at all, into groups supposed to have a definite time value. As, however, paleontologic evidence was often deficient, and as the discrimination of these groups was frequently made on evidence more or less fanciful, and in a different manner by different geologists, the result is far from satisfactory. It is usually possible in these reports to identify by their faunal and lithologic characters certain horizons, such as the Sawatch quartzite, the Leadville limestone, the Maroon formation, etc., when they are mentioned, but seldom to determine satisfactorily, even in the few detailed sections which the early literature contains, what should be the limits in them of the formations now recognized. This is so far true that I have attempted a close correlation of these sections only in a very few instances. Much of the older literature, therefore, adds to our knowledge of the distribution of the formations or of geologic structure, with which I am not so much concerned, but not to the details of their lithology, paleontology, or mass.

The geology about Leadville, especially with regard to its mining industries, was described many times in papers of the briefer sort before the Leadville monograph was published, and an almost equal number followed its appearance. In a similar manner much careful observation had been recorded, and the geologic section was almost as well known as it is to-day, when the Aspen monograph appeared. Lakes in 1887, Emmons, Siver, and Brunton in 1888, Henrich in 1889, Newberry in 1890, and Carlyle in 1893, had all written accounts of varying length and excellence before Spurr brought his work to publication. But since his is probably the most authoritative account, as it is certainly the longest and most elaborate one, I will confine my discussion to it alone and neglect the claims of temporal priority.

The section at Aspen, condensed from Spurr's monograph,[a] is as follows, descending:

[a] U. S. Geol. Surv., Mon., vol. 31, 1898.

Section at Aspen.

		Feet.
Trias	Gunnison formation: A gray or yellow basal sandstone, often calcareous, overlain by reddish, grayish, or variegated shaly sandstones	300
	Red sandstones: Light-red sandstone, more or less grading into the darker beds below	2,600
Carboniferous	Maroon formation: Impure grits, and thin-bedded, shaly limestone; calcareous and thin bedded at first, but more massive and arenaceous above; in color, a peculiar dark red	4,000
	Weber formation: Thin-bedded, carbonaceous limestones and calcareous shales; the typical rock a black limestone; separated from the Leadville limestone by a distinct plane	1,000
	Leadville limestone: Above, a massive blue limestone 100 to 150 feet in thickness; below, a heavy, hard, gray-blue dolomite, with some chert: thickness from 200 to 250 feet	350
Devonian (?)	Parting quartzite: This formation consists of thin beds of quartzite, sandstone, dolomitic shale, and dolomite	67
Silurian	Pure dolomites of a light gray-blue color, with some chert; the thickness varies from 250 to 400 feet, thickening southward	250–400
Cambrian	A fine white quartzite, conglomeratic at the base; the upper third is dolomitic, sometimes glauconitic, and it graduates above into the pure dolomites of the Silurian	200–400
	Like the latter, this formation thickens to the southward, where it measures from 350 to 400 feet. In the north its thickness is 200 feet or less.	
Granite.		

Besides the unconformity which is hinted at between the Leadville and Weber formations, Spurr mentions an important one which occurred at the close of the deposition of the red Triassic sandstones. "This break," he says (page 43), "was probably accompanied by a considerable uplift, for the succeeding beds of the Gunnison formation, which are of late Juratrias age, are probably of fresh-water origin. In the interval between the deposition of the red sandstones and shales there was probably some folding and perhaps a great amount of erosion. The red sandstones appear to be missing in part or wholly in certain areas which closely adjoin the Aspen district."

The determination of the age of the Paleozoic beds is not based directly upon paleontologic evidence, for apparently fossils were not collected except in a few instances, but upon correlation with formations in areas near by whose age is more or less well established. From the Leadville limestone a number of foraminiferal types are mentioned, none of which, however, have come into my hands.[a] They are of little importance in determining the age of this formation, which should without doubt be placed in the Lower Carboniferous. The Devonian age of the Parting quartzite depends upon some scanty and imperfect fish remains, and though this

[a] Lakes cites from this formation at Tourtelotte Park *Syringopora*, *Zaphrentis*, *Pleurotomaria*, and *Straparollus*, and from Fryingpan Creek, *Straparollus* and *Euomphalus*. These fossils are among those studied by me and are referred to in the paleontologic section of this report (Colorado State School of Mines, Bienn. Rept. for 1886, 1887, p. 60.)

determination may be correct, the occurrence at Canyon of fish remains representing types commonly regarded as belonging to the Devonian detracts from the force of this evidence.

The geologic section described in the Tenmile folio,[a] which is not strictly that of the Tenmile district itself so much as of the region immediately surrounding, may be condensed as follows:

Section in Tenmile district.

		Feet.
Trias?	Wyoming formation: Principally sandstone of an intensely brick-red color; limestones are practically absent. "If the Permian is represented in Colorado, the evidence of which appears to the writer as yet very uncertain, it would be included in these beds, which have evidently been deposited in direct and unbroken succession over the Upper Carboniferous"	1,500
Carboniferous	Maroon formation: Coarse gray and red sandstone, sometimes conglomeratic, with many irregularly developed beds of limestone which are generally nonmagnesian; the formation is limited by the Robinson limestone below and the Jacque Mountain limestone above; both these limestones contain an invertebrate fauna of Coal Measures type	1,500
	Weber grits: Mainly coarse sandstone or grits, with a subordinate development of shale and a few thin and nonpersistent dolomitic limestones	2,500
	Weber shale: Transitional between the massive limestone below and the grits above, and consisting of argillaceous and calcareous shale alternating with quartzitic sandstone	300
	Leadville limestone: A typical dolomite of bluish-gray or black color near the top and lighter colored near the base, passing upward into alternations of shale and sandstone; it contains characteristic concretions of chert and is fossiliferous near the top; sometimes much less but never more than 200 leet in thickness	200
Silurian	Parting quartzite: Siliceous beds, generally quartzites; these may possibly belong to the Devonian, but because of an unconformity at the top are left with the Silurian	15–60
	Yule limestone: Light drab-colored, rather thin-bedded limestones, which are often magnesian and always more or less siliceous	120–160
Cambrian	Sawatch quartzite: Remarkably pure, white, evenly bedded quartzite, which is conglomeratic at the base and impure above, passing into argillaceous and calcareous shales	160–200

The correlation of the Aspen and Tenmile sections is indicated in the nomenclature employed for the formations.

In his work at Aspen, Spurr notes a considerable thinning of the Sawatch quartzite to the north, and although the Tenmile region is more to the east of Aspen than to the north, the Cambrian there is only about half its thickness at the former locality. In the shales at the top of this formation Cambrian fossils belonging to the *Dikel-*

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[a] U. S. Geol. Surv., Geol. Atlas U. S., Tenmile District Special Folio, folio 48, 1898.

locephalus fauna are said to have been found. The same is true of the Yule limestone, which though from 250 to 400 feet thick at Aspen only reaches 120 to 160 feet in the Tenmile district. Similarly also with the Parting quartzite, which measures 67 feet in a typical detailed section near Aspen, while here it is said to be from 15 to 60 feet. Emmons maps these beds as Silurian in the Tenmile folio. His position is best defined in his own words, and I quote as follows:

"Near Leadville evidence has been found of an unconformity by erosion between them and the overlying beds. While no fossils have been found which would connect them with either the Silurian or the Carboniferous system, they have hitherto been mapped under the Silurian color, mainly because of this unconformity, which might account for the apparent absence of Devonian strata.

"Within the last few years, however, Devonian fossils, principally fish remains, have been found in other parts of the Rocky Mountains in beds that occupy a stratigraphic position so closely corresponding to that of these quartzites that it has become probable that the latter are of Devonian age also. Nevertheless, in the absence of direct evidence, it has not been judged wise to designate them by Devonian color on the sheet showing structural sections."

Like the earlier beds, the Leadville limestone is thinner in the Tenmile district than at Aspen, varying from 300 feet at the latter to 200 feet at the former, where it is sometimes much reduced. Emmons refers the Leadville limestone to the Mississippian period, and in this he is with little doubt correct.

The Weber shale and the Weber grits are grouped in the Tenmile folio under the name of the Weber formation, which with the series of beds called here the Maroon represents the combined Weber and Maroon formations of the Aspen monograph. It seems fair to infer that the Weber shale of the one is the equivalent of the Weber formation of the other (Aspen). In this case also the decreased thickness of the Weber in the Tenmile region is a peculiar feature. It has there a thickness of 300 feet, while at Aspen it measures but little less than 1,000 feet. In the Tenmile folio the limestones of this formation are said to contain fossils of Coal Measure age, and our collections from both the Leadville and Crested Butte districts confirm this statement.

The upper portion of the Weber formation of the Tenmile folio, or the Weber grits, as it is there called, must, along with the Maroon formation of the same report, represent the Maroon formation of the Aspen monograph. In the case of this formation the thickness, in marked contrast to the formations which preceded it, is the same in both the Aspen and Tenmile districts, being measured at 4,000 feet in both. The Maroon formation in the Tenmile district is divided from the Weber grits below by the Robinson limestone, and its upper limit is taken at the Jacque Mountain limestone. Both of the strata last mentioned are said to contain invertebrate faunas of Upper Coal Measure type.

In the Aspen district the Maroon formation graduates into a bright-red sandstone which Spurr refers to the Triassic. In the Tenmile district the Maroon formation is succeeded by a series of sandstones of an intensely brick-red color. These are correlated upon the evidence of their lithologic position with the Wyoming sandstone of the Front Range, the name being derived from the Denver Basin area. All the evidence except that of a paleontologic nature, since fossils have been found in neither formation, indicates that the Wyoming formation of the Tenmile district corresponds to the Triassic of Spurr's section at Aspen. The latter has a thickness of 2,600 feet in Lenado Canyon, while the Wyoming formation is but 1,500 feet thick; but as the Wyoming is immediately succeeded in the Tenmile area by Quaternary deposits, it is possible that it may have suffered erosion, and that this measurement does not indicate its original thickness. At Aspen the "Triassic" is overlain by the Gunnison formation, with an unconformity between, so that its thickness there also is probably not the original thickness.

Spurr, as we have just seen, places this formation in the Trias, but Emmons groups it with the Carboniferous formations, remarking that "If the Permian is represented in Colorado, the evidence of which appears to the writer as yet very uncertain, it would be included in these beds, which have evidently been deposited in direct and unbroken succession over the Upper Carboniferous." From facts which I will discuss later, it seems to me rather more probable that the Wyoming formation is in fact of Triassic age.

Aside from the two monographic works briefly discussed, but little has been written upon the Grand River region that calls for remark, although considerable literature of an occasional character centers about the mining camps of Aspen, Red Cliff, etc.

Possibly before being diverted to the consideration of some of the earlier literature, it would be well to speak here of the geologic section at Red Cliff, which has been briefly described by Emmons (in 1886)[a] and by Tilden the year following.[b] Emmons speaks of the series as being practically the same as at Leadville. The Blue or Leadville limestone and the Cambrian quartzite are the same in both areas and have the same thickness. The total thickness to the top of the Leadville limestone averages less than 500 feet at Red Cliff, as against 600 feet at Leadville. This is owing chiefly to the White or Yule limestone, while the Parting quartzite was not definitely recognized, though thin siliceous beds occur at about the horizon for it.

Tilden's section, which was made at Battle Mountain, near Red Cliff, in Eagle County, is more detailed and runs as follows:

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[a] Colorado Sci. Soc., Proc., vol. 2, pt. 2, pp. 85–105.
[b] Colorado State School of Mines, Bienn. Rept. for 1886, 1887, pp. 129–133.

Section at Battle Mountain, Eagle County.

	Feet.
Cambrian white quartzite	125
Fine-grained sandstone	100
Silurian white quartzite	5
Conglomerate quartzite	8
Blue dolomitic limestone	250
Black siliceous limestone	300
Carboniferous limestone	1,000
Leadville quartz-porphyry	200

Over the ridge 1,000 feet and more of Weber grits, sandstones, shales, and quartzites were found.

Probably the four lower members of the section, aggregating 238 feet, should be considered as representing the Sawatch quartzite. This formation is 160 to 200 feet thick in the Tenmile district, and in the Aspen district from 400 feet in the southern part to 200 feet or less in the northern part, so that Tilden's measurement is not excessive. The next two divisions, amounting to 550 feet, have the position and character of the Leadville limestone. If they be taken to represent the Leadville, however, no equivalent of the Yule and the Parting quartzite can be found. It is clear from Emmons's remarks that these formations are not normal at this locality. If a portion of the blue dolomitic limestone belongs to the Yule, the Parting quartzite would still be missing. Tilden seems to suggest that the third member of the section, which he designates the Silurian quartzite, is the Parting formation. If this is indeed the case, the Yule limestone as such is absent. The next bed, consisting of 1,000 feet of limestone, would appear to represent the Weber formation of the Aspen district and the Weber shale of the Tenmile district. The Leadville limestone and the Weber here are comparable in thickness, and seemingly in character, with their equivalents in the Aspen[a] and Peale's Eagle River sections. In the Tenmile district these formations have a thickness of but 200 and 300 feet, respectively. In the Crested Butte quadrangle they measure 400 to 525 feet and 100 to 550 feet, respectively. At Aspen, however, they attain a thickness, the one of 350 feet and the other of 1,000 feet, while on Eagle River their combined thickness is somewhere near 1,500 feet.

The area assigned to Marvine in 1873[b] is a rectangle included between parallels 39° 30′ and 40° 20′ north latitude and meridians 104° 45′ and 106° 30′ west longitude. In the southwestern corner of this area is the most eastern portion of the Grand River Carboniferous area, but apparently Marvine was not able to push his work into this tract, for I do not find it described in his report. In the year following his survey was extended to the area west of that which he examined in 1873. This territory Hayden described in the following words:[c] "The main portion is bordered

[a] Not in thickness in the case of the Aspen section, however.
[b] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 83–192.
[c] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 2.

by the Park Range on the east, south by the Eagle and Grand rivers, and north by the Bear River. Westward the work extends nearly to longitude 108°." The area thus bounded includes within its limits the larger portion of the Grand River Carboniferous outcrop, and it is much to be regretted that owing to Marvine's untimely death his geologic report never reached publication. There is very little literature aside from this upon the geology of the Grand River area north of the line made by the Grand and Eagle rivers, and our information concerning it is almost restricted to such facts as are deducible from the maps of the Hayden Atlas of Colorado,[a] together with the section (B, Sheet XVII), which passes just north of parallel 39° 45′ north, and from such inferences as may be framed from consideration of the geology of adjacent territory. From the maps and sections the Paleozoic rocks are seen to consist of Silurian, Lower Carboniferous, Middle Carboniferous, and Upper Carboniferous, the latter being followed by those of Triassic age. The character and thickness of these formations can not be ascertained from this source.

Peale in 1873 was assigned to the South Park district,[b] which is defined as being limited on the north by the parallel of latitude 39° 15′, on the south by parallel 38° 30′, on the east by the eighth guide meridian of the land survey, and on the west by the one hundred and seventh meridian. In 1874 Peale surveyed the territory to the north and west of this,[c] with the following boundaries: "Commencing at the intersection of meridian 109° 30′ and the Grand River, the line runs northeastward up the Grand River to the junction of the Eagle River; thence up Eagle River to the mouth of Roche Moutonnée Creek; thence westward along the northern boundary of last summer's (1873) work to its intersection with meridian 107°; thence southward along the western side of last summer's work, approximately on the one hundred and seventh meridian, to parallel 38° 30′; thence westward on this parallel to the intersection of meridian 109° 30′; and thence northward on this meridian to the intersection of 109° 30′ with Grand River." This area not only adjoins his own work on the north, as has already been set down, but it is conterminous also with Marvine's district of the same year.

During the operations of these two years Peale made several sections on Eagle River, which it is of interest to compare with the sections of the Aspen and the Tenmile districts already considered. The most important of these sections appeared in three different forms. It was originally published in the annual report for 1873, where it is incomplete. In the report for 1874 it is repeated, with some additions, and in the report for 1875 it is summarized for comparison with other sections, similarly prepared, of different areas surveyed by the same author. In each case the series is subdivided, upon evidence more or less indifferent, into the great time

[a] U. S. Geol. Geog. Surv. Terr. Geol. and Geog. Atlas of Colorado, etc., 1877.
[b] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 194–273.
[c] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, pp. 73–180.

divisions which are supposed to be represented. I have repeated the section of 1874 and 1875, returning it in the former case to its original continuous form, but retaining Peale's grouping. The following is the Eagle River section as it appears in the report for 1874:

Section of Permian or Permo-Carboniferous strata on Eagle River. (After Peale.) [a]

	Thickness. Ft.	In.
7. Space probably filled with sandstones and shales reaching to the summit of the hill back from the bluffs, containing a thickness of about	500	0
6. Rather coarse gray sandstones, in thin beds, fossiliferous and weathering of a rusty color	342	4
5. Massive sandstones, generally of a gray color with a greenish tinge. They are mostly fine grained and generally micaceous. Some of the beds are pebbly, and near the bottom is a band of black shale with carbonaceous material. This band is from 6 to 8 feet in thickness. These sandstones are exposed in a bluff, in the upper part of which they are conglomeritic and darker in color than below	205	10
4. Coarse gray sandstone with interlaminated shales	145	0
3. Very hard, irregular-structured blue limestone, of a brownish color on weathered surface	10	0
2. Greenish-gray micaceous sandstone shales, with bands of very hard sandstone	45	11
1. Coarse white conglomerate	27	3
Total thickness about	1,276	4

Section of Carboniferous strata on Eagle River. (After Peale.) [b]

	Thickness. Ft.	In.
1. Pink conglomeritic sandstones	37	5
2. Conglomeritic sandstones and gray shales	92	9
3. Light-gray shales with hard sandstone bands	3	9
4. Blackish micaceous shales	3	9
5. Sandstones and interlaminated micaceous shales, some of the sandstones conglomeritic	367	2
6. Sandstone conglomerate with pebbles of quartz from 1 to 2 inches in diameter. This bed is the base of a bluff-like wall, and is 10 feet in thickness. Above are beds of shale and coarse sandstone in alternation. On top is a greenish micaceous sandstone	252	0
7. Coarse, grayish sandstone, with interlaminated shales; near the top is a layer of red sandstone, succeeded by a conglomeritic layer	25	1
8. Fine-grained, reddish-brown sandstone	27	4
9. Coarse-grained, hard sandstone, spotted with green, general color gray	4	0
10. White and greenish-gray conglomerates and shales. First we have a conglomeritic sandstone, and then green micaceous shales with black carbonaceous layers; followed by more conglomeritic layers, above which is about 15 feet of hard sandstone, with interlaminated soft shales; then 5 feet of compact gray micaceous sandstone. Next are very soft greenish-gray micaceous shales, extending for about 10 to 12 feet of alternating shales and sandstone (some of the latter conglomeritic) in beds from 2 to 4 feet in thickness. Above these are conglomeritic sandstones with shales in the center. The total thickness is about	511	0
11. Coarse white sandstone, with a band of hard fine-grained sandstone near the top. The micaceous character is marked between the layers	40	0

[a] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 118.

[b] Ibid., p. 115.

	Thickness. Ft.	In.
12. White conglomeritic sandstone	5	0
13. Red conglomeritic sandstone	38	8
14. Dark-red micaceous shaly sandstones	6	8
15. Brownish-red sandstones, conglomeritic	30	10
16. Fine-grained sandstone, generally white, but becoming pink in places, with two or three layers of gray micaceous shale, each from 2 to 4 inches thick	4	0
17. Coarse white sandstone, with grains of quartz and some decomposed feldspar	71	3
18. Soft greenish sandstone in fine layers, with a few hard bands, each a few inches in thickness	99	3
19. Red sandstone	11	4
20. Brownish sandstones	99	8
21. White granular brown-spotted sandstone	8	0
22. Greenish-gray micaceous sandstones, partially conglomeritic	352	0
23. A space in which the beds were so much concealed that it was impossible to make a detailed section; the upper portion is probably filled with a prolongation downward of the micaceous shales and sandstones, while the base is limestone. In the latter I found *Aviculopecten*, *Pleurophorus*, and an *Avicula* or *Bakevellia*. The total thickness of strata as indicated by the space is	408	4
Total thickness of supposed Carboniferous	2, 504	20

The remainder of the section to the beds I included in the Devonian? is as follows:

	Feet.
24. A laminated trachytic rock	15
25. Space probably filled mainly by limestones	[a] 1, 000–1, 500
26. Black, flinty limestone, with pieces of pyrite and fragments of *Spirifer* or *Spiriferina*	

Section of Silurian strata on Eagle River. (*After Peale.*)[b]

	Ft.	In.
7. Light-bluish limestones on weathered surfaces, white and yellow. It is in bands from 3 to 8 inches thick, with a cross fracture and nonfossiliferous. A great portion of these limestones are probably magnesian. At the top they are crystalline	219	6
Calciferous group:		
6. Space, in the upper portion of which there is an outcrop of metamorphosed conglomerate, seemingly composed of pieces of white quartzite and brown sandstone. The masses are irregularly shaped. The outcrop is only a few feet in thickness and the remainder of the space is probably filled with sandstones and quartzites, with perhaps a few shales. The space was so covered that the beds were all concealed. The entire thickness is	68	4
5. Milk-white quartzite, similar to that of No. 1	4	9
4. Space probably filled with sandstones	22	8
3. Grayish-brown laminated sandstones with a greenish coating and mud marks on the surfaces of the laminæ	98	6
2. Fine-grained, rather compact, glauconitic sandstone, somewhat laminated, dark brown and greenish gray	10	0
Primordial group:		
1. Milk-white quartzite	400	0
Gneiss:		
Total thickness of Silurian about	819	9

[a] Estimated.

[b] U. S. Geol. Geog. Surv. Terr., Eighth Ann. Rept., for 1874, 1876, p. 113.

In the same volume is published another series of sections made on Eagle River at a point considerably below the foregoing, which represents the higher beds of the series, as that does the lower ones.

Section of Jurassic, head of second canyon, Eagle River, south side. (After Peale.)[a]

	Thickness in feet.
1. Space probably filled with sandstones and marls, about	500
2. Laminated sandstones and blue limestones	190
3. Light-yellowish brown sandstone	
4. Blue limestone	50
5. Gray shaly sandstones with interlaminated marls and thin bands of blue limestone	200
Total about	940

Section of Triassic on Eagle River at second canyon. (After Peale.)[b]

	Feet.
8. Massive light-colored quartzitic sandstone	10–20
7. Red sandstones somewhat laminated	300
6. Pink quartzitic sandstone	
5. Red sandstones, more massive than the lower layers, although there is some lamination	375
4. Coarse white sandstone	5
3. Red and brown laminated sandstones, some of the layers being seemingly calcareous	193
2. Purplish sandstones	15
1. Red sandstones, somewhat laminated	70
Total thickness	978

Section of Permo-Carboniferous. (After Peale.)[c]

	Feet.
1. Gypsiferous shales and sandstones. The gypsum occurs in great quantity and is rather impure. The sandstones are laminated and generally of a pink or red color. I was unable to get the exact thickness, but the outcrop was from	500–800
2. Shales, sandstones, and limestones, alternating colors, pink, brown, gray, yellow, white, cream color, and blackish. These beds are best shown on the north side of the river. They incline generally about 60°. In some places they are inclined past the vertical, especially in the upper portion. The thickness is about	500
3. Pink, brown, and gray shaly sandstones with interlaminated thin beds of blue limestone. These beds resemble those I noticed in 1873 in South Park, which are given in the report of 1873, in sections 9, 10, and 11. The thickness on Eagle River is about	200
Total thickness	1,500

The first section contains beds referred to the Silurian, Carboniferous, and Permian; the other to the Permian, Triassic, Jurassic, etc. It is not clear from the context that the Permian portion of the latter is continuous with the Triassic and the Jurassic series, but this appears to be the case. The following is the summarized

[a] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 119. [b] Ibid., p. 122. [c] Ibid., p. 125.

section, based apparently upon both of the foregoing ones, which he published in the annual report for 1875. It includes only strata believed to belong to the Eocarboniferous, Coal Measures, and Permian. There appear to be important departures from the original section from which the summary was derived.

Generalized section on the Eagle River, district of 1874. (After Peale).[a]

	Feet.
PERMIAN.	
Micaceous sandstones and gypsiferous shales of variegated colors, with thin beds of limestone at the base. Fossils: *Calamites suckorii, C. gigas, Stigmaria ficoides, Spirifer, Productus, Orbicula*	2,000
COAL MEASURES.	
White, greenish, and reddish, laminated, micaceous sandstones and black shales, with patches of carbonaceous material; near the base are limestones,[b] with *Avicula, Aviculopecten, Pleurophorus*	2,500
SUBCARBONIFEROUS.	
Limestone, somewhat shaly above, but massive as we descend, about	500
Total	5,000

The first section quoted was made, as I have already stated, along the upper portion of the Eagle River, the Carboniferous beds being chiefly exposed near the mouth of Roche Moutonnée Creek. This section is northeast of the Aspen district and northwest of the Tenmile district, the three points forming a triangle with nearly equal sides. This section is subdivided into a Silurian, a Carboniferous, and a Permian series, with the possibility that a thin Devonian series may be included with the Carboniferous. In the section quoted it is apparent that the lowest group, consisting of 400 feet of quartzite, which Peale refers to the Primordial, is the Sawatch quartzite of the Tenmile and Aspen sections, and that the 200 feet of magnesian limestone at the top of his Silurian section, which is otherwise unclassified, belongs to the Yule limestone. The question then presents itself of the disposition of the 200 feet of siliceous beds which he refers to the Calciferous group. It is possible that the bed of glauconitic sandstone which Peale cites just over his Primordial quartzite can be correlated with a similar bed which Spurr described as occurring in the upper portion of his Cambrian quartzite. The two beds agree with singular closeness in thickness, lithologic character, and stratigraphic position.[c] The strata which overlie the glauconitic quartzite at Aspen and are transitional to the Silurian dolomite are also similar to the Calciferous group of Peale's section.[d]

[a] See sections, Report of 1874, pp. 115–119.

[b] This layer may possibly be Subcarboniferous [Peale].

[c] Spurr calls attention to the wide extent of this glauconitic horizon on page 7 of the Aspen monograph, Mon. U. S. Geol. Surv., vol. 31, 1898.

[d] The upper, transitional portion of the Sawatch quartzite of the Tenmile district is not unlike Peale's Calciferous group, although very much thinner. The latter also resembles the lower or quartzite member of the original Yule.

The most satisfactory course seems to be to consider the latter an expansion of the upper or transitional portion of the Sawatch quartzite. Described as it is in Peale's section, this series would hardly be regarded as part of the Yule limestone of the Aspen section. At all events, the siliceous beds at the base of the section have a greater development on the Eagle River than either at Aspen or in the Tenmile district. The Yule limestone, though thicker than in the latter area, is somewhat thinner than at Aspen. Taken together, the Cambrian and Silurian beds, 823 feet in thickness, are slightly in excess of the combined maximum measurements of the two series at Aspen, and greatly more than their combined measurements in the Tenmile district. It would appear that the lower portion of the section, especially the siliceous part, is thickening rapidly toward the northwest. This inference receives confirmation from a remark by Peale[a] to the effect that "there was a much greater development in Mr. Marvine's district." This statement refers to the Silurian beds, under which term it must be remembered are included both the quartzitic and the calcareous strata mentioned above.

The limestones at the base of the Carboniferous portion of the section occur just above those given in the section of the Silurian. The lowest of these evidently belongs to the Leadville limestone, and the beds above, which appear to be mainly calcareous, must represent the Weber formation or Weber shales of the other sections. In spite of the fact that Peale says, referring to beds 25 and 26, that "The remainder of the section to the beds I included in the Devonian? is as follows," indicating that the Devonian occurred below bed 26, it is quite clear from remarks on the opposite page[b] that beds 25 and 26 are the ones which are regarded as belonging to this period. The reference of these beds to the Devonian seems to be largely hypothetical, and is in part certainly erroneous, while it may be in part also correct.

I am satisfied, from the lithologic character, the position in the section, and to a certain extent from the fossils, that bed 26, whose thickness is not given, is the Leadville limestone of later reports. This formation is known at so many and so widely separated localities to contain a Devonian fauna in its lower portion that it is probable the same occurrence will be found at this point also.

Bed 22, from its lithologic character and relative position, can safely be referred to the Maroon formation, or Weber grits, as it is alternatively called. As the 408 feet of beds immediately below, which are said to be concealed for the most part, consist of micaceous shales and sandstones in the upper portion, with limestone at the base, it seems probable that a portion of bed 23 also belongs in the Maroon. From the limestone is cited a fauna which is probably of Upper Carboniferous age. As the Leadville limestone contains a Mississippian fauna it is necessary to conclude that the base of 23 belongs in either the Weber or the Maroon formation, the age of

[a] U. S. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 110. [b] Ibid., 114.

both being Upper Carboniferous. It seems probable that beds 26, 25, and possibly also a portion of 23, represent the Leadville-Weber interval, using the term Weber as it is employed in the Aspen monograph. This leaves the formation without any determinable boundaries and with a thickness only approximately determinable. Beds 25 and 26 have a combined thickness of from 1,000 to 1,500 feet; and if to this be added 100 or 200 feet from the base of 23, we obtain 1,200 to 1,700 feet as the approximate thickness of the Leadville and Weber formations. In the Aspen district these formations have an aggregate thickness of 1,350 feet, while in the Tenmile district their thickness is only 500 feet. It thus appears that Peale's Eagle River section in the matter of the two formations mentioned above is close to the Aspen section, but differs widely from that of the Tenmile district.

The remainder of Peale's Carboniferous series, with an aggregate thickness of about 2,300 or 2,400 feet, corresponds in position and character to the lower part of the Maroon formation of the Aspen district. There seems to be, however, a much smaller proportion of dark-red or brownish members. This series also is similar to and probably represents the Weber grits of the Tenmile district, and as the thickness is nearly the same in each case, it may be that the horizon taken by Peale as the top of his Carboniferous series about corresponds to the line dividing the Weber grits from the Maroon formation of Emmons's section.

The Carboniferous series continues upward into one which Peale calls Permian. The evidence for this reference consists of three species of plants, one of which is exclusively Permian, the two others being especially Coal Measure, though ranging up to or into the base of the Permian. As the evidence of invertebrate fossils found elsewhere at the same horizon[a] indicates that the geologic age is not Permian but Upper Carboniferous, it would be desirable to have the paleobotanical evidence reviewed and a larger flora collected. Of the Permian, in the section under consideration, Peale gives 1,276 feet before the top is reached. This Permian series is lithologically similar to that called Carboniferous, and like it, I believe, represents the Maroon formation, belonging to the upper portion, which was not differentiated by Spurr, but to which Emmons restricts the name Maroon.

Peale's other Eagle River section, made near the second canyon, comprises series referred to the Permian, Triassic, Jurassic, etc. The two Permian sections are by no means strikingly similar lithologically, and I doubt if any more than the basal portion of the second corresponds to the top of the first. Possibly they are even entirely superimposed. Indeed, Peale remarks[b] that "Farther down Eagle River, where the Red Beds are present, the strata immediately beneath are so changed that I could not positively recognize any of the beds of the section made further up the

[a] Probably about the Rico formation of the San Juan and the upper Maroon of the central part of the State.
[b] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 118.

river." So far but about 3,600 feet have been correlated with the Maroon formation, which at Aspen has a thickness of 4,000 feet, as the equivalent series has in the Tenmile district. It is quite clear to me that strata are included in the Permian of the lower Eagle River section that are higher than the highest of the Permian of the upper section, but just how great a thickness, if any, is equivalent, and whether the superjacent portion belongs to the Maroon formation or to the Red Beds, are questions difficult to answer. I shall return to this point presently.

Peale's Dakota group seems to correspond to that to which Spurr applied the same name at Aspen. His Jurassic is marked by characters similar to those of the Gunnison formation of that region, and I think that they will be found to be equivalent. If, as seems probable, the unconformity which preceded the Gunnison in the Crested Butte and Aspen regions was present where Peale obtained his section, it appears to have escaped his notice. Peale's Triassic is the well-known Red Beds series, and can probably be correlated in a general way with the Triassic of the Aspen and with the Wyoming sandstone of the Tenmile district, but the former has a thickness of 2,600 feet, and the latter of 1,500 feet, while Peale's Triassic, which is represented only in the lower Eagle River section, measures less than 1,000 feet. If, however, to this series be added the upper portion of that which underlies it, called Permian by Peale, the thickness becomes more normal, viz, 1,500 to 1,800 feet; and if we can grant that the lower part of the Permian of this same section, whose upper part has been joined with the Triassic, is not really the equivalent of the Permian of the upper Eagle River section, but largely overlies it, the equivalent of the Maroon will be increased from 3,600 to 4,300 feet. It is objectionable to depart from the author's grouping of these beds, but by doing so in this case greater uniformity in the lithology and thickness of the different formations is attained. Peale himself has made equally wide departures in his summarized section published in the annual report for 1875, apparently with the object of bringing this section into a closer agreement with those of other areas. In this section he refers 500 feet at the base to the Eocarboniferous. This division is clearly that to which a thickness of 1,000 to 1,500 feet was earlier given, and which was doubtfully referred to the Devonian (beds 25 and 26). The Coal Measures division of the summarized section comprises without doubt beds 1 to 23 of his early Carboniferous section (section No. 2, page 115). To the Permian of the summary section a thickness of 2,000 feet is ascribed, while of the earlier Permian sections one has 1,500 feet and the other 1,276 feet. The upper portion of the summarized section evidently corresponds to the top of the Permian of the lower Eagle River section. The increase of 500 feet in the later reference must have been arbitrarily made, or else have been justified by adding to the base of the section on the lower Eagle River some portion of the Permian of the upper Eagle River section. This is the course which I have allowed myself in the foregoing discussion.

Proceeding in the manner already outlined, the combined Leadville and Weber formations, according to Peale's sections, would have an approximate thickness of from 1,200 to 1,700 feet. Assuming 300 feet for the Leadville limestone (this formation measures 350 feet at Aspen and 200 feet in the Tenmile district), and accepting about the mean of the measurements for the combined thickness of the two formations, in the neighborhood of 1,000 feet would then have to be assigned to the Weber formation. The Maroon, according to the above calculations, measures about 4,300 feet, and the Wyoming 1,500 to 1,800 feet.

Comparing the Carboniferous formations in the three sections discussed, it is found that their relative thickness is as follows: Leadville limestone, at Aspen 350 feet, on Eagle River 300 feet (assumed), in the Tenmile district 200 feet; Weber formation, at Aspen 1,000 feet, in Peale's section 1,000 to 1,200 feet, in the Tenmile district 300 feet; Maroon conglomerate and its equivalents, at Aspen 4,000 feet, in Peale's section 4,300 feet, in the Tenmile district 4,000 feet; Wyoming formation, at Aspen 2,600 feet, in Peale's section 1,500 to 1,800 feet, in the Tenmile district 1,500 feet; the upper limit of the Wyoming formation being an unconformity in each case. The total thickness of the Upper Carboniferous would then be, at Aspen, 7,600 feet; in Peale's section, about 7,500 feet, and in the Tenmile district 5,800 feet. The greatest variation in individual formations appears to be in the case of the Weber and Wyoming formations. The Maroon remains remarkably constant in thickness, though apparently very variable in lithologic detail. The Leadville also varies proportionately in thickness, being at Aspen nearly twice as much as in the Tenmile district. Variations in the thickness of the constituent formations and of the mass as a whole may be due to erosional unconformities, one of which followed the Leadville, while others possibly intervened between the Triassic and the Maroon and between the Weber and Maroon formations.

Stevenson's report for the One Hundredth Meridian Survey[a] upon his district in central Colorado covers much of the area which was worked by Marvine, Peale, and others. He describes several sections made in the Grand River, Elk Mountain, and South Park regions, one of which (that on the forks of Eagle River) must have been taken very near the outcrops which furnished Peale's section just discussed. Just what streams are intended to be indicated by the north and south forks of Eagle River I have not been able to ascertain, but the section must be located, as I have said, very near that which Peale worked out on Eagle River near the mouth of Roche Moutonnée Creek.

The exposures of the Silurian are said to be exceedingly fine on the South Fork of the Eagle River, and to differ little from those of Bald Peak. They appear to consist of massive, dark quartzite, which rests upon granite (page 360). No detailed

[a] U. S. Geog. Geol. Expl. Surv. W. 100th Mer., Rept., vol. 3, 1875, pp. 303–501.

section is given. Apparently here, as in the Elk Mountains, Stevenson did not see or did not record the light-colored Yule limestone which usually intervenes between the Sawatch quartzite and the Carboniferous.

The Carboniferous section, according to Stevenson, possesses characters which were uniformly observed over all the area examined. Referring to the section on the forks of Eagle River, he remarks: "As exhibited there and elsewhere, the succession seems to consist of, first, a group of sandstones resting on a thick limestone and holding beds of gypsum interstratified with thin limestones; second, resting on No. 1, a group of limestones and coarse sandstones; third, above all a great mass of coarse sandstone, in which no beds of limestone were seen." (Page 362.) Applying this to the detailed section of the rocks exposed on the forks of Eagle River (page 368), it appears that the upper division, bed 1 of the section, is about 2,500 feet in thickness; the middle division, beds 2 to 20, inclusive, 500 feet in thickness; and the lower, beds 21 and 22, about 2,000 feet in thichness. But it must not be supposed that with bed 22 the bottom of the section is reached, for he says (page 370): "With this stratum, which is not more than 200 feet above the bottom limestone, the measured section closes." The "bottom limestone" of this quotation is probably that described on page 362 as the thick limestone upon which the major portion of the section rests. This heavy limestone series must, I think, include the Leadville limestone as one of its members, with possibly the limestones of the Weber formation in its upper portion and the Yule limestone at its base. The three groups of strata overlying it appear to belong to the Maroon formation.

Stevenson apparently missed the Red Beds altogether in making this section, for (1) he does not recognize any Triassic series in this area, by which name he elsewhere distinguishes the Red Beds; (2) he remarks no discrepancy between this section and the Carboniferous sections of the Crested Butte region, where the Red Beds are apparently wanting; and (3) he compares the upper portion of the section of the Sangre de Cristo Range, in which no strata belonging to the Red Beds are included, with the upper portion of his section on the forks of Eagle River.[a] I therefore conclude that Stevenson saw no equivalent of the Wyoming formation in making this section; that if he had he would have referred it to the Triassic; and that the recognizable portions of his section can be referred to the Leadville limestone and the Maroon formation. He probably did not distinguish any beds equivalent to the Weber limestone.

The whole series of Stevenson's section above the basal limestone appears to belong to the Maroon formation, and is equivalent to the Carboniferous (bed 1 to the middle of bed 23) and Permian of Peale's upper Eagle River section, with probably the lower 700 feet of the Permian of the lower Eagle River section.

[a] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Suppl., p. 74.

Apparently the upper portion of Peale's series, including the gypsum beds, is not represented in Stevenson's section. Peale states[a] that the gypsiferous series on Eagle River which Stevenson refers to the Carboniferous is the same which he himself reported as Permian or Permo-Carboniferous. This can, however, hardly be the case, as Stevenson's gypsiferous series is at the bottom of his section, while Peale's is naturally at the top. The thickness given by Stevenson, which amounts to 5,000 feet, is greater than that of the corresponding beds in Peale's, Spurr's, or Emmons's sections,[b] and there is a more or less marked lack of agreement in detail between his section and the others mentioned, though this is to be expected in all save Peale's. Compared with the Aspen section, that given by Stevenson represents the Maroon formation, but at Aspen the Maroon is 4,000 feet thick and the calcareous beds are chiefly confined to the lower portion, while Stevenson found them in the middle portion and assigned to the whole a thickness of 5,000 feet. The series which Stevenson divides into two great sandstones with an intermediate calcareous group must apparently be correlated with the Weber grits and Maroon formation of the Tenmile folio. In the latter their combined thickness is given as 4,000 feet, while in Stevenson's section it is said to be 5,000 feet. Limestones appear to be much more abundant in the Tenmile district than in the section at the forks of Eagle River, and are especially characteristic of the upper portion, in which, in the latter, none were seen. This only proves, besides possibly a slight exaggeration in Stevenson's measurements, the great variability in lithologic details from point to point of this series of sediments. Stevenson has stated that the general description which I have quoted above holds good for the great area surveyed by him. It is true that the general features are very persistent and that the sequence almost everywhere consists of a heavy limestone below and a great series of sandstones, with shales and thin limestones, above. But the other points mentioned are not constant. Stevenson usually seems to find, it is true, gypsum beds in the lower part of the sandstone series, an occurrence not often mentioned by other geologists, but the abundance and position of the limestone beds, upon which the subdivisions made by the latter depend, appear to be features of great variability.

Stevenson remarks upon the conglomerate which forms the downward termination of his measured section on the forks of Eagle River that this bed is "somewhat altered, but in all other respects resembles the conglomerate seen at the head of Taylor River." This expression evidently refers to the section in the Elk Mountains described on page 365 of his report, where a conglomerate is recorded as

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[a] U. S. Geol. Geog. Surv. Terr., Ninth Ann. Rept., for 1875, 1877, p. 73.

[b] It is more in agreement with the Maroon of the Crested Butte quadrangle, which measures 4,500 feet, though here may be included probably inconsiderable portions of altered and unrecognizable Wyoming sandstone. Stevenson calls attention to the similarity of the upper division of his Eagle River section to the upper division of that in the Sangre de Cristo Range. The latter in its lithologic character strikingly resembles the upper Maroon of the Crested Butte district. All three have the same thickness, 2,500 feet. (U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Supplement, 1881.)

overlying 100 feet of shale and sandstone which rests upon 150 feet of limestone. The suggestion conveyed is that the "bottom limestone" which underlies the arenaceous series in the section on the forks of Eagle River, and which I have already inferred to be the basal calcareous member of the generalized Carboniferous section as recognized by Stevenson, corresponds to the limestone forming the base of the section on the West Fork of Taylor River. The character of these limestones is such as to support the belief that they belong to the Leadville limestone.

In 1876 Endlich was given the White River district for geologic examination and report.[a] "To us," he says, "had been assigned the region lying west of the [White River Indian] agency, bordered on the north by the White River, on the west by longitude 109° 30′ west, on the south by north latitude 40°, and joining on the east with the district of the late Mr. Marvine (1873) along a line of about 107° 45′ west."[b] This area includes only the western margin of the Grand River Paleozoic region.

The oldest beds exposed in this district are the Red Beds, or Juratrias. These are said to rest conformably upon the Carboniferous, which outcrops extensively in Marvine's district to the east. Endlich's account is very brief and may be condensed into few words. According to him the Trias consists of massive beds of red sandstone which have a thickness at one point of 2,000 feet and are overlain by a series of gray shales and marls interstratified with thin beds of sandstone. The latter apparently represent the Gunnison formation of the Crested Butte quadrangle, but the massive white sandstone at the base of the Gunnison is not differentiated here, or, at all events, is not distinguished by Endlich. The Triassic itself I am disposed to believe the same as the Lenado Red Beds and the Wyoming formation of the Tenmile district. The Lenado Triassic is reported as 2,600 feet in thickness, while the latter measures 1,500. On the other hand, Endlich states of the Red Beds that "In no manner were they observed to differ particularly from those observed on the eastern slope of the Front Range. Most likely their vertical development is somewhat larger here than there, but in all lithological and stratigraphical features they agree closely." The occurrences on the Front Range I have supposed to represent the Wyoming, and possibly, in local sections, part of the Maroon formations.

ELK MOUNTAIN REGION.

The only piece of detailed geologic work in the Elk Mountains in which a section is established suitable for use as a basis of comparison with the less complete observations of the several reconnaissance surveys which have visited this region is Folio 9 of the Geologic Atlas of the United States.[c]

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[a] U. S. Geol. Geog. Surv. Terr., Tenth Ann. Rept., for 1876, 1878, pp. 61–159.
[b] Ibid., p. 63.
[c] U. S. Geol. Surv., Geol. Atlas of the U. S., Anthracite-Crested Butte Folio, Colorado, folio 9, 1894.

The Paleozoic geologic section in the Crested Butte quadrangle, as given in the Anthracite-Crested Butte Folio, is as follows:

Paleozoic section in Crested Butte quadrangle.

	Feet.
JURATRIAS.	
Gunnison formation: The upper two-thirds drab, green, yellow, and pink clays, with thin limestone. The base is a heavy white quartzite	350–500
CARBONIFEROUS.	
Maroon conglomerate (upper portion): Conglomerate and sandstone in heavy beds. The material chiefly derived from the Archean and partly from the earlier Carboniferous beds. Occasional thin beds of fossiliferous limestone	2, 500
Maroon conglomerate (lower portion): Quartzose conglomerate, grit, and sandstone with varying amount of pebbles derived from the Carboniferous, which sometimes form the bulk of the deposits. Color yellowish gray. There are thin, interbedded limestone layers. These and the limestone pebbles are fossiliferous	2, 000
Weber limestone: Dark gray to black shale, with thin limestones carrying black chert	100–550
Leadville limestone: The upper third massive, blue, and cavernous. The lower two-thirds bedded, gray to brown. Dark cherts	400–525
SILURIAN.	
Yule limestone: At the top, 80 feet of green, pink, and yellow shale and thin limestone. The middle portion massive gray limestone with white chert. Lower portion white quartzite 75 to 100 feet thick	350–450
CAMBRIAN.	
Sawatch quartzite: The upper two-thirds red quartzite containing glauconite. The lower two-thirds quartzite with conglomerate at the base; pebbles of white quartz	50–350
ARCHEAN.	
Granite, gneiss and schist.	

An unconformity is indicated at the base of the Sawatch quartzite, another between the Weber and Leadville limestones, and a third at the top of the Maroon conglomerate.

The geologic sequence in the Crested Butte quadrangle appears to be in the main very similar to that at Aspen which I have discussed on the pages devoted to the Grand River region; and as the most probable correlation between the two is indicated by the nomenclature employed for the formations of the two sections, as well as in the text of the monograph, no discussion on my part is called for except in one or two instances. Spurr found that in his area the Cambrian and the Silurian beds became thicker toward the south, but, contrary to what one would expect from this, the Cambrian of the Crested Butte quadrangle is thinner than that of the Aspen region. The Silurian, however, is a trifle thicker. The combined thickness of these formations appears to be about the same in both areas.

The Parting quartzite was not recognized as a distinct formation in the Crested Butte quadrangle, but seems to be represented there in the upper part of the Yule formation. Spurr states:[a] "Mr. Eldridge has described what is also evidently the equivalent of these beds in the Crested Butte area thus: The upper division, 60 to 90 feet thick, consists mainly of green, yellow, red, and white shales, with more or less arenaceous and calcareous layers, the latter passing into thin limestones. The persistence of its general lithologic character renders this horizon easily recognizable."

The Leadville limestone is proportionally much thicker in the Crested Butte quadrangle than at Aspen, while the Weber formation is, on the other hand, much thinner. The Maroon formation is about the same in each, being a little thicker in the Crested Butte quadrangle. It is possible that the discrimination between the Weber and Maroon formations was not made at precisely the same horizon in the two areas, and at all events the combined thickness of these formations is in close agreement, being 5,000 feet near Aspen and from 4,600 to 5,050 feet in the Crested Butte quadrangle.

Spurr seems to feel satisfied that the beds which he calls Gunnison formation in the Aspen district are the equivalent of those bearing the same name in the Crested Butte quadrangle. The described character and occurrence of the two series tend to corroborate this view. A similar probability surrounds the correlation of the Maroon formation in the two areas. In the Crested Butte quadrangle the Maroon conglomerate is succeeded by the Gunnison formation with an unconformity between. In the Aspen region, however, beds having the character of the Maroon pass upward without apparent break into a series otherwise somewhat similar in character, but colored a brighter red. It is this formation which at Aspen is followed by the Gunnison preceded by its unconformity, as in the Crested Butte quadrangle. It seems from this that we have at Aspen a series of considerable thickness which is not represented in the Crested Butte region, a fact to which Spurr calls attention.[b] Its absence in the Crested Butte quadrangle can hardly be accounted for in any other way as satisfactorily as by ascribing the conditions there prevailing to the unconformity owing to which the Gunnison formation in that area, we are told, rests sometimes upon the Maroon conglomerate and in some cases upon older formations. It is possible, however, that this series may actually occur in the Crested Butte region, but so changed by metamorphism as to be unrecognizable. In the southern part of the region, however, where the upper portion of the Maroon is thinner and has not been altered, its absence is nearly certain.

Aside from the Anthracite-Crested Butte folio, but little has been written about the geology of the Elk Mountains which closely concerns the subject in hand.

Perhaps the earliest account of geologic exploration in this region was that pub-

[a] U. S. Geol. Surv., Mon., vol. 31, 1898, p. 20. [b] Ibid., p. 38.

lished by Ruffner in 1874[a], the geology being described by F. Hawn. One of the routes traversed by Ruffner's reconnaisance in the Ute country crosses the southern end of the Elk Mountains. The descriptive treatment, as one might expect from the rapidity with which the party must have traveled, consists of little more than mere notes, and I am unable to recognize with certainty the different rock groups distinguished in the Anthracite-Crested Butte folio except in one instance, where Coal Measure fossils are cited from an exposure of shale and sandstone some 200 feet thick, near the mouth of Spring Creek (p. 78). These probably belong to the Weber formation, and in that case the heavy limestone just below is the Leadville limestone. The Carboniferous age of all the beds both here and elsewhere in which Coal Measure fossils were obtained was recognized by Hawn, but in the Elk Mountains it seems from the context (p. 83) impossible to avoid the conclusion that he referred the anthracite coal seams, at the head of Anthracite Creek, to the same period.

The field of work assigned to Endlich for the season of 1873 was styled the San Luis region. His report for the year[b] deals chiefly with the line of Paleozoic outcrops along the Mosquito and Sangre de Cristo ranges, but he also discusses portions of the Front Range and Elk Mountain areas. Of the Paleozoics in the latter area coming under Endlich's survey I shall here briefly speak. The series in the Sangre de Cristo and Front ranges are considered elsewhere.

The Gunnison River, cutting through the Elk Mountains, dissevers their southern end, which, under the name of Fossil Ridge, forms an area of Paleozoic outcrop distinct from the larger body north of the river. The geologic sequence at Endlich's station 38, which is situated on Fossil Ridge, is described as follows:

"The lowest members that can well be distinguished are about 320 feet of light gray to bluish to almost white limestones, with quartzitic segregations characteristic to the strata of that horizon, and sparse remains of crinoids. Although the identification is necessarily not a very thorough one, these beds have been referred to the Silurian. Above that follow 80 feet of yellow and gray shales, regarded as Devonian; then 175 feet of variegated shales, partly sandy, with isolated banks of limestone, weathering smoothly, with a steep face; 260 feet of light-gray and yellowish limestones follow, interstratified with narrow bands of shale, and partly altered so as to appear like marble; the whole is covered by 40 feet of light shales, separated from 45 feet of the same material by a 20-foot stratum of dark-blue Carboniferous limestone full of fossils, etc. Upon this follow 150 feet of light-blue and yellow limestones, dolomitic in part, etc. Single bands of quartzite appear also, and almost all the strata contain a few fossils. Overlying these are 50 feet of yellow, reddish, and whitish shales without any fossils, etc."

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[a] Rep. Reconnaisance in the Ute Country in 1873, by Lieut. E. H. Ruffner. Washington, 1874. 43d Cong., 1st sess., House Ex. Doc., No. 193.

[b] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 305–357.

This series, which is reported as almost identically the same as that north of the canyon, both in thickness and in lithology, allows itself to be correlated with comparative ease with the formations recognized in the Crested Butte quadrangle. The Sawatch quartzite, it is clear, is wanting, or, more probably, occurs below the lowest strata described. These consist of 320 feet of light-colored limestone with chert concretions, and they, with little doubt, represent the Yule limestone. The yellow and gray shales next above, which have a thickness of 80 feet, are the equivalent of beds of a similar character which in the Crested Butte quadrangle occur at the top of the Yule limestone, and which, it will be remembered, Spurr correlates with the Parting quartzite. The variegated shales which follow also suggest the upper portion of the Yule limestone, but to so identify them would give this formation an almost excessive thickness. All the succeeding formations, except the last, probably belong to the Leadville limestone. The dark-blue limestone with Carboniferous (?) fossils at least almost certainly does. The age of the fauna is not clearly indicated by the faunal list given by Endlich. It is compared, perhaps upon the authority of Meek, with the fauna from Mystic Lake, which is of Mississippian age. On the other hand, the general make-up rather suggests the Devonian fauna of the Ouray limestone. The *Rhynchonella*, "which has a decidedly Devonian aspect," I suspect to be *Camarotœchia endlichi*. It is now known that both Devonian and Carboniferous faunas are found in the Ouray limestone, and it may be that the material collected in this case was a mixture from both horizons. At all events, in the limestone in the Elk Mountains identified with the Leadville limestone, Devonian and Carboniferous faunas occur similar to those from the Ouray limestone in the San Juan region, and the two formations can evidently be correlated. The occurrence in the limestone of Fossil Ridge of a fauna suggesting the same horizon, corroborating as it does the indications arising from geographic proximity and stratigraphic succession, makes it highly probable that we have a recurrence of that very persistent formation. There is, however, much more shale associated with the limestone than is known elsewhere, and the lithologic character of the series seems to be more like that of the Weber limestone.

The enormous area of Stevenson's survey in 1873[a] included portions of the Elk Mountains in Colorado. The Silurian he found to be well represented. I have quoted his description of these rocks at length, but while his remarks incite speculation they lend little aid toward arriving at a conclusion. He says (page 360):

"On Taylor River, at its head and along the west side of Taylor Park, as well as at its southeast corner, the Silurian rocks are well exposed, underlying the Carboniferous. So, also, at the head of Tumichi Creek. Throughout this region it seems to be almost entirely free from limestones, and the sandstones give no evidence

[a] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875, pp. 303-501.

of calcareous matter. At the head of Taylor River the following section, descending, was obtained:

	Feet.
1. Sandstone, very dark, somewhat vesicular in portions; contains much calcspar and some iron ore. It is not at all certain that this is Silurian. In many respects it is more nearly allied to the Carboniferous above	20
2. Sandstone, completely converted into quartzite; fine grained, light gray	20
3. Shale, arenaceous above, white on fresh fracture, bright buff on weathered surface; below quite argillaceous, with layers of cone in cone, and in parts quite micaceous	18
4. Sandstone, quartzite, coarse above, fine below; contains much chert, usually in lenticular nodules, but sometimes united so as to form continuous layers; this chert is mostly bluish-black, but occasionally light colored and dendritic; geodes of quartz are numerous, 1 to 3 inches in diameter. The stratum is very thick bedded	75
5. Sandstone, slightly altered, grayish yellow, fine grained, micaceous, shaly, with thin films of quartz along cleavage planes	45
6. Sandstone, on top completely altered, and for 20 feet has fracture like flint, is perfectly smooth, without grain, but shows clearly the lines of deposition; color, bluish white. Lower down is less altered, and the rock is a coarse-grained, compact sandstone. At the base is a conglomerate quartzite, the pebbles being usually as large as a pea. This stratum rests upon coarse granite	70

"At the head of Taylor Canyon No. 4 is quite light in color, and the chert is almost white, while at the head of Tumichi Creek it is as described in the section above. At the head of the canyon No. 5 is greatly increased in thickness, and is of Venetian-red or burnt-umber color, and has the same character where exposed along the headwaters of Tumichi Creek. Along the old miners' trail from Taylor to East River this section is occasionally seen, and differs from that given above only in that No. 3 becomes quite calcareous, being at one locality an argillaceous limestone. Nos. 3 and 5 are very characteristic and persistent throughout this region. In the southern portion of this area the Silurian has always been thin. On the lower portion of Tumichi Creek and at two localities west from the Indian agency isolated exposures are seen where erosion has removed the overlying eruptive rocks. The rocks here belong wholly to No. 6 of the section above, and have a total thickness of not more than 70 or 80 feet."

The thickness of this series, which aggregates only 248 feet, and its generally siliceous character, would lead one to believe at first that the whole section represents the Sawatch quartzite alone. On the other hand, it is peculiar that there appear to be no calcareous beds below the Carboniferous suitable to be referred to the Yule limestone. It is possible that Stevenson grouped the Yule limestone with the Carboniferous limestone, but this can not be ascertained from his descriptions. On the other hand, the lithologic sequence when closely compared with the section of the Crested Butte quadrangle is somewhat strikingly similar, though the measurements given by Stevenson are in every case considerably less. The lowest bed, No. 6, is lithologically quite like the basal member of the Sawatch quartzite. No. 5, which at the head of the canyon is reported as having a Venetian-red color, resembles the upper member of the Sawatch quartzite. No. 4 is similar to the basal portion of the

Yule limestone. No. 3, which is said to be calcareous at one point, may represent the middle division of the Yule, but the upper division, that which Eldridge mentions as being especially persistent, and which Spurr correlates with the Parting quartzite, appears to have no equivalent in Stevenson's section, unless No. 3 represents it, instead of the middle division. The surprising variability of these beds as described by Stevenson half leads one to doubt the accuracy with which they were identified at different points, in view of the rapidity with which the work must have been carried on. Stevenson's beds 1 and 2 seem to have no representatives in the Crested Butte section on the scale of the comparisons which have just been made. It seems more likely, therefore, that the varied series described by Stevenson is really only the Sawatch quartzite.[a] It is significant also that he in no instance describes beds which have the character and position of the Yule limestone.

The different beds mentioned by Stevenson suggest some of those described by Endlich in the San Luis district, but a detailed comparison would not be profitable. If the whole of Stevenson's section represents the Sawatch quartzite, a parallel to the calcareous and shaly portion (No. 3) seems to be cited by Endlich, who says (page 308) that sometimes the quartzites at the base of his section are represented by calcareous beds.

Stevenson gives two sections of the Carboniferous in the Elk Mountains, one near the head of Rock Creek (page 363), which I take to be the Rock Creek on the west side of the Elk Mountains, having its sources near Sopris Peak, and the other at the head of the West Fork of Taylor River. The relation of the Carboniferous beds at the latter locality to the Silurian section is not given, whether it follows directly or with an interval between.

The three beds of limestone at the base, aggregating 140 feet in thickness, are with little doubt the Leadville limestone, while the shale above it has the position and many of the characters of the Weber formation as described in the Anthracite-Crested Butte folio. With the conglomerate, just above, the Maroon formation probably begins. Above the 100 feet of conglomerate and sandstone which are supposed to form the base of the Maroon conglomerate there follows an interval of unknown extent, which is succeeded by the section near the head of Rock Creek previously mentioned. "This interval is occupied principally by coarse sandstones. . . ." The Rock Creek section consists of sandstones, thin limestones, and some shale. The thickness, aside from beds 16–25, which are Cretaceous (page 365), amounts to 1,475 feet, but as there is a repetition in the Cretaceous beds, there may be one, though it is not obvious, in the Carboniferous also. All these strata belong evidently to the Maroon formation.

[a] In this area the Maroon formation sometimes rests upon the Archean and occupies the position of the Sawatch quartzite. It is possible that an occurrence of this sort may have introduced a complication into this discussion.

Stevenson recognized no Triassic in this area, which is in accord with the mapping of the Crested Butte quadrangle.

The area of Peale's survey in 1873 embraced large areas of Paleozoic outcrop in central Colorado, and in chapter 4 of his report[a] a description of the geology of the Elk Mountains is given. Owing to the complicated geologic structure of this region and the absence of detailed geologic maps, of detailed sections of any length, or of a general section, it is difficult for the reader to gain an understanding of the extent, character, and thickness of the geologic sequence there shown. Bearing in mind, however, the sections given in the Anthracite-Crested Butte folio and the Aspen monograph, it is possible here and there to identify with the formations recognized in those works the strata described by Peale. Apparently the geologic sequence is maintained with reasonable constancy over all the area surveyed.

In the quartzite which he refers to the Silurian the Sawatch quartzite can be recognized, while the Yule and Leadville limestones can frequently be identified in his descriptions. His Jurassic is the Gunnison formation. I can not but think that for the most part his Triassic, Permo-Carboniferous, and Carboniferous, except such portion of the latter as may belong to the Weber and Leadville formations, are the Maroon formation of the Anthracite-Crested Butte folio. As pointed out by Emmons and Spurr, the bright-red sandstones which in the Aspen region are found to follow the Maroon formation and are referred to the Trias in the Aspen monograph have not been recognized in the Crested Butte quadrangle. Presumably they are wanting over the southern portion of the Elk Mountains. Wherever this formation is not present (and considerable of Peale's work lay in the southern portion of the range) his Permian and Triassic belong in the Maroon formation. It is possible that farther north his Triassic may be equivalent to the red sandstone previously mentioned, which I take to represent the Wyoming formation of the Tenmile folio. The fact is of interest, to which Spurr calls attention,[b] that the Triassic sandstones on Woody Creek were mapped by the Hayden survey as Carboniferous.

In narrating his observations during the field season of 1875[c] this author compares the section observed that year in the Dolores River region with other previous sections. In so doing he compiles a generalized section for the Elk Mountains, which is more readily intelligible than the fragmentary ones of the original report. This section I will quote as follows:[d]

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[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 193-273.
[b] U. S. Geol. Surv., Mon., vol. 31, 1898, p. 38.
[c] U. S. Geol. Geog. Surv. Terr., Ninth Ann. Rept., for 1875, 1877, pp. 29-101.
[d] U. S. Geol. Surv., Mon., vol. 31, 1898, p. 77.

Generalized section in the Elk Mountains district of 1873.[a] (*After Peale.*)

	Feet.
PERMIAN.	
Maroon-colored sandstones and shales, with conglomerate at base. No fossils. Thickness not estimated	
COAL MEASURES.	
Yellowish-gray and reddish sandstones and shales, with bands of limestone. Lower part of series is gray and greenish micaceous sandstones. Fossils. Third layer (top), *Loxonema,*[b] *Productus muricatus, Spirifer;* second layer, *Productus muricatus, Athyris subtilita, Rhynchonella osagensis, Hemipronites crassus, Terebratula bovidens, Retzia punctulifera;* first layer, *Productus muricatus*	1,300–2,000
SUBCARBONIFEROUS.	
Limestones and limestone shales. Beds so distorted that thickness not positively taken. Fossils of Subcarboniferous type not yet examined	
[Total]	4,000–4,500

The most appropriate sections with which to compare the foregoing are those of the Crested Butte quadrangle and of the Aspen district. It is clear that the lowest member of Peale's section represents in a general way the Leadville limestone, but it may also include the Weber formation, for the lowest beds of the "Upper Carboniferous," just above those from which the fossils are cited, probably belong to the Maroon conglomerate. This is the conclusion at which I have arrived from a study of the original detailed section given on page 251 of the Annual Report for 1873. Both the Carboniferous and Permian of Peale's generalized section of 1875 seem to belong in the Maroon formation, at least so it appears from the lithology of the upper beds and the thickness of the lower ones. The Permian, however, Peale correlates with the Permian of the Dolores River, the Eagle River, and the Park Range. Upon one hypothesis the Coal Measures and Permian combined of the Elk Mountains section are equivalent to the Coal Measures and the lower portion of the Permian of the Dolores River region, the boundary in one case passing above the Permian and in the other through it. Upon another hypothesis the Permian of the Elk Mountains, supposing it to have the same limits as the upper division of the Maroon, is missing in the Dolores River region, the Coal Measures and the lower part of the Permian of the latter being equivalent to the Coal Measures of the Elk Mountains.

The real equivalent of most of the Permian (and of most of the Triassic) in the Dolores section seems to be the bright-red sandstone described by Spurr from Lenado Canyon in the vicinity of Aspen. This formation is apparently not found at all in the Crested Butte quadrangle, and probably not at all in the southern portion of the

[a] See pp. 21, 225, 230, 232, 247–264, report of 1873.

[b] In modern terminology these forms are of course *Loxonema, Marginifera muricata, Spirifer, Marginifera muricata, Seminula subtilita, Pugnax utah, Derbya crassa, Dielasma bovidens,* and *Hustedia mormoni.*

Elk Mountains. Wherever Peale cites the Permian or the Triassic from this region, therefore, the beds probably form part of the Maroon formation. Farther north the beds so denominated may be equivalent to the "Lenado" sandstone on the one hand and in a more or less general way to this author's Permian and Triassic in other areas. Accordingly, thus qualified, the Permian of the Elk Mountains combined with the Carboniferous represents the Carboniferous and Permian of the Eagle River, with the exception of the upper 800 feet of the latter. This, together with the Triassic, would accordingly be equivalent to Spurr's Triassic about Aspen and to Peale's Permian and Triassic in the Elk Mountains wherever, if at all, these do not belong in the Maroon. Similarly, the Permian and Carboniferous combined of the Elk Mountains are equivalent to the Permian and Carboniferous of the Park Range, both representing the Maroon formation of the Crested Butte quadrangle. The Triassic of the Park Range, according to my view, is the same as Spurr's Triassic at Aspen, and probably has no equivalent in Peale's Elk Mountain section except, perhaps, sporadically.

The reports by Hayden and by Holmes[a] (chapters 5 and 6) upon explorations in the Elk Mountains during the year 1874 are descriptive in character and devoted to a discussion of the structural rather than of the historical geology of the area. One can recognize in their descriptions the Sawatch quartzite, the Maroon conglomerate, and the Wyoming sandstone, but the observations recorded are of a general character, and while agreeing with the section described in the Anthracite-Crested Butte folio add little or nothing to it except perhaps in the matter of distribution of the formations. Both authors speak of the gradation through the Red Beds into the well-established Carboniferous, and as a result of this circumstance and of the complicated geologic structure the Red Beds are united with the Carboniferous under a single color in the geological map accompanying their report. In the present instance the term Red Beds is employed for the bright-red "Triassic" series, the maroon-colored series being correctly referred to the Carboniferous (p. 62).

SOUTH PARK REGION.

Though situated at the extreme northern end of the Mosquito Range, the Leadville section would naturally be selected to compare with the less formal reports of earlier work dealing with the South Park region. Except for a few changes in the matter of formation names, the section described in the Leadville monograph[b] is practically the same as that of the Tenmile folio, which, though that area is almost contiguous with the Leadville district, has been considered in connection with the geology of the Grand River region. Both the Leadville monograph

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[a] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, pp. 54–58 and 59–71.
[b] U. S. Geol. Surv., Mon., vol. 12, 1886.

and the Tenmile folio, as is well known, are the work of the same geologist. The geologic section in the Leadville district may be condensed as follows (p. 58 et seq.):

Section in Leadville district.

	Feet.
CARBONIFEROUS.	
Upper Coal Measures: Base taken at the Robinson limestone. Consists of alternating calcareous and siliceous beds, which at the base are like those of the Weber grits and at the top like those of the Trias	
Weber grits: The typical rock a coarse white sandstone, passing into conglomerate, with which are mingled quartzose shale and mica-schists	2,500
Weber shale: Extremely variable. A transition series of argillaceous and calcareous shale, alternating with quartzitic sandstone	150–300
Blue limestone: Dolomitic, deep grayish-blue in color, often nearly black near the top, while some of the lower beds are lighter. Upper strata marked by chert concretions containing fossils	200
SILURIAN.	
Parting quartzite: White quartzite	40–70
White limestone: Light-colored, more or less siliceous dolomitic limestone	120–160
CAMBRIAN.	
Lower quartzite: Below, thin-bedded, white, saccharoidal quartzites, conglomeritic at the base. The upper 50 feet are shaly and calcareous, passing gradually into the siliceous limestone of the Silurian	150–200
ARCHEAN.	
Granite, gneisses, and schists.	

The section obtained from the Leadville monograph calls for but little comment, as it differs from that given in the Tenmile folio, whose relation with the other sections in central Colorado has already been discussed, chiefly in its nomenclature. From the different formations, and especially from those belonging to the Carboniferous, more or less extensive faunas are cited. The faunal evidence, which will be discussed more at length in the section devoted to paleontology, shows that the Leadville limestone is of Lower Carboniferous age and that the rest of the beds belong to the Upper Carboniferous. There is nothing to suggest the presence of Permian.

The Paleozoic section throughout the South Park area seems to be in the main uniform and similar to that of the Grand River area, and the section described in the Leadville monograph is in a general way representative of the entire region.

Aside from the Leadville monograph but little of importance has been written regarding the geology of this narrow strip of Paleozoic outcrop, and that little also deals chiefly with its northern portion. Peale described the geology and gave some sections, for the most part of the Leadville region, and Endlich described the geology of the southern portion in a way which it is difficult to understand and which does not inspire confidence as to his accuracy.

Peale's report for the year 1873, to which reference has already been made, has to do in part with the Elk Mountains, in part with the Front Range, which I shall consider later on, and with the Park Range.[a]

The sections given by Peale can be correlated more or less closely with the formations recognized in the Leadville monograph and the Tenmile folio. In fact, they are all located rather north than south of the central portion of the area. Those numbered 9 and 18 are the most complete and will best serve to compare with the Leadville section. Section 9, the description of which begins upon page 216 of the Hayden volume, was taken from the Platte River to Trout Creek, about 5 miles north of Fairplay. Beds 1 to 51, inclusive, Peale refers to the Carboniferous and Permian. They probably all belong to the two formations which are called Weber grits and Upper Coal Measures in the Leadville monograph and Weber grits and Maroon formation in the Tenmile folio. This series consists chiefly of sandstones, with some shaly beds and a considerable number of 2 and 3 foot limestones. Above these come the Red Beds, which attain here a thickness of 1,500 feet and have "all the characters of the same beds east of the foothills and on Trout Creek west of them." (Page 218.) This series Peale refers to the Triassic?, and it is followed without any observed unconformity by the Jurassic, and this by the Dakota Cretaceous. The Triassic, in its character and thickness, invites comparison with the formation which is described in the Tenmile folio as the Wyoming formation. It is also similar to the Permian (in part) and Triassic of Peale's section on the Eagle River. Indeed, Peale calls attention to the similarity of the lower portion of his Permian section on Eagle River[b] to the upper beds of the series called Permian and Carboniferous in the section under discussion. This naturally suggests that the Triassic of the latter corresponds to the Triassic and the upper portion of the Permian, combined, in the former.

Following Peale's suggestion, all the beds included in his sections Nos. 10, 11, and 12 would belong to the Weber grits and Maroon formation. In the section made from the mouth of Fourmile Creek westward to Horseshoe Mountain (No. 18, p. 229) beds 98 to 78 can with great probability be referred to the Sawatch quartzite. They aggregate 150 feet in thickness and consist of quartzites in the lower part and sandstone above. The four beds which come next in the section are limestones and dolomites and probably represent the Yule limestone. It is difficult to distinguish the Parting quartzite. Bed 72, representing 50 feet of blue limestone, and bed 68, representing 60 feet of bluish-black limestone, probably belong to the Leadville limestone. If this is so, the interval between beds 77 and 73, inclusive, though representing a thickness of only 100 feet, must stand for the Yule limestone and Parting

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 212–239.
[b] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 119.

quartzite combined. The thin, dark-colored limestones, interbedded with shales and sandstones, which overlie bed 68, apparently belong to the Weber shale, though possibly they should be referred to the Leadville limestone. At all events, bed 38, with its well-marked Upper Carboniferous fauna, must be higher than the Leadville, and perhaps represents the upper limit of the Weber shale, for immediately above occur some coarse sandstones, pretty well interstratified with limestones, it is true, which seem more characteristic of the Weber grits. Less than 2,000 feet of Weber grits then follow, after which there is a repetition of the basal portion of the section. Beds 11 to 19 are again the Potsdam, as pointed out by Peale, and belong to the Sawatch quartzite. This formation seems here to have a thickness of only 110 feet, while Peale points out that in Mosquito Gulch the thickness is 160 feet and in Buckskin Gulch over 200. The average thickness of the Potsdam group along this range he believes to be about 150 feet and the remainder of the Silurian about 200 feet. The rest of the section, consisting of about 230 feet, probably belongs in the Yule limestone, unless bed No. 2, consisting of 30 feet of blue limestone, belongs to the Leadville.

In describing his observations made during the field season of 1875 Peale devotes considerable space to comparisons and a summary,[a] in the course of which he gives a generalized section of the Carboniferous series of the Park Range for comparison with that made out for the region of the Dolores River. This generalized section, which seems to be in large measure made up from the early sections, No. 9 and No. 18, I will quote as follows:

Generalized section in the Park Range west of South Park on Fourmile Creek, district of 1873.[b] (*After Peale.*)

	Feet.
PERMIAN.	
Red, pink, and maroon-colored sandstones, gypsiferous and calcareous, with limestones in thin beds. No fossils	2,000–2,500
COAL MEASURES.	
Conglomeritic sandstones, green and gray micaceous sandstones and shales, bluish limestones, and interlaminated sandstones. Fossils, from below—Second layer: *Productus nebraskensis, Productus prattenianus, Productus semireticulatus, Spirifer opimus, Pleurotomaria taggarti.* First layer: *Productus, Spirifer, Trilobites*	2,000
SUBCARBONIFEROUS.	
Blue limestones and sandstone shales, limestones predominating; fossils are indistinct	300–400
Total	4,300–4,800

[a] U. S. Geol. Geog. Surv. Terr., Ninth Ann. Rept., for 1875, 1877, pp. 70–79.
[b] See section No. 18, p. 229, report 1873.

The most suitable standard sections with which to compare this of Peale's are those described in the Leadville monograph and in the Tenmile folio. There can be little doubt that in the Lower Carboniferous of Peale's section the Leadville limestone is included, and probably something more. He seems to have assigned to the Lower Carboniferous beds 40 to 72 of his detailed section No. 18. His Upper Carboniferous is probably the Weber grits of the Tenmile folio. The Weber shale of that folio I suspect to be equivalent to the upper part of his Lower and the lower part of his Upper Carboniferous. His Permian appears to correspond in the main to the Maroon formation of the folio, but it is possible that with it is included a part of the Wyoming sandstone, which in the main answers to his Triassic. This formation—i. e., the Permian—is in part described as being pink and containing gypsum, characters rather suggestive of the beds which in other sections he calls Permian and Triassic, and also of the Wyoming sandstone; but it is singular that none of the formations in either the Leadville monograph or the Tenmile folio is described as being gypsiferous, nor is this character mentioned in the original detailed sections from which the generalized one is supposed to be derived.

Just as the lower part of Peale's composite section for the Park Range is based mainly upon section No. 18 of 1873, the upper part is based upon section No. 9. In the latter all the higher beds up to 52 which he refers to the Triassic are "Permian." The Triassic, here 1,500 feet thick, probably represents the Wyoming formation, and the beds below, chiefly because of the abundance of limestone strata, would more naturally belong in the Maroon formation. If this is so, and if the upper part of the composite section is based upon this, or, consistently, upon several detailed sections, then the "Permian" of the general section would answer to the Maroon formation of the Tenmile folio without containing any of the Wyoming. Peale seeks to correlate the Permian beds of the Park Range with those in the Elk Mountains for which the same designation is employed. To this there would be no objection, as both probably represent the upper portion of the Maroon formation without extending up into the Wyoming sandstone. He also, however, assigns both these groups to the Permian of the Eagle River section. This does not seem to me altogether probable, as I suspect that the upper portion of the Eagle River Permian belongs to the Wyoming sandstone.

The relation to that of the Dolores River region of this Park Range section is open to two interpretations. In the one case the Coal Measures and Permian of the latter represent the Coal Measures and lower portion of the Permian in the former. In the other case only the Coal Measures division of the Park Range beds represents the Coal Measures and lower Permian in the Dolores River region, the Permian of the former being wanting in the latter. The Park Range "Triassic" would in any case answer to the upper part of his "Permian" combined with the lower part of his "Triassic" of the Dolores River section.

The so-called San Luis district which Endlich surveyed in 1873[a] included the southern portion of the South Park region and the northern portion of the Sangre de Cristo region. As these outcrops are practically continuous, and as Endlich did not divide his discussion geographically, it will be less confusing in abstracting his report to pursue the same course. Therefore his account of the geology of that portion of the South Park region included in the San Luis district will be discussed in connection with the Sangre de Cristo region. The same is true of Stevenson's account of the geology of the South Park and Sangre de Cristo[b] regions, which, as it is brief and more general in character, less readily yields to consideration in different sections.

SANGRE DE CRISTO REGION.

Endlich's report upon the geology of the San Luis district is one of the most unsatisfactory with which I have had to deal. The omission in the majority of cases of the thickness of the beds whose succession he describes greatly enhances the uncertainties involved in a comparison of different sections, while his failure to indicate upon the map many of the numbered stations with reference to which his observations are located is deserving of criticism. The presentation of his matter is obscure, so that with the defects already mentioned and other omissions and inconsistencies, it is a laborious task to effect a comprehension of what he has written. While some of the horizons of the Leadville and Crested Butte sections can be recognized with reasonable certainty in those described by Endlich, there is evidence of considerable change in constitution from their occurrence to the north and west. There is also ground for suspicion that Endlich has in some cases misinterpreted the mutual attitude of the beds and has possibly reversed their real succession.

There being in the Sangre de Cristo region no detailed section of the Paleozoic rocks similar to those of the several monographic works dealing with central Colorado, I have had to employ the latter as a basis of comparison in this region also.

The area included in the San Luis district is "bordered on the north by a line running east to west 6 miles south of Pike's Peak, on the west by the one hundred and seventh meridian, on the south by a line running east to west 12 miles south of Saguache, and on the east by the eastern slope of the Front Range." (Page 305.) Of the Carboniferous this area includes a strip along the Front Range (more correctly along the Colorado Range and the Wet Mountains) consisting chiefly of the series mapped as Triassic; of a somewhat branching body of outcrop, the northern portion of the Sangre de Cristo Range, the farthest extremity of which in the Park Range all but connects with the Carboniferous area reaching south from

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 305-351.
[b] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875, pp. 307-501.

Leadville; and of two small outlying patches to the west. In the western part are two local Carboniferous areas, one of them, Fossil Ridge, being an outlier to the south of the Elk Mountain area, and the other, called the Tomichi dome, a smaller and more isolated patch to the south of this.

Referring, it would seem, in a general way to the stratigraphic series in his district, rather than to any particular occurrence, Endlich says (page 308): "Resting immediately upon the granite, we find the Silurian characterized by but few fossils and the well-known quartzitic formation. At times the rock partakes more of the character of a limestone, but in that case segregations of siliceous matter, mostly in the shape of chalcedony and hornstone, afford a welcome lithologic character of distinction. Wherever the Silurian formation occurs in section *a*, it conformably underlies the Devonian and Carboniferous as far as could be ascertained." It would be natural to interpret the quartzite to which he refers as representing the Sawatch quartzite of the sections already discussed, his calcareous Silurian being the Yule limestone, which is also frequently characterized by cherty segregations; but in some of his sections the calcareous beds are reported as underlying the siliceous ones, and the quartzite in these cases can not be the Sawatch but must represent the Parting formation. Endlich's expression would appear to indicate a belief on his part that the calcareous and siliceous beds are only different aspects of the same series of strata. There is some evidence, however, that the Yule limestone rests in some cases immediately upon the granite, thus occupying a position similar to that of the Sawatch without, of course, being in any sense its equivalent.

While I believe that the Devonian is probably present in this area, the evidence so far except in one instance is quite inconclusive, and the beds to which I make reference seem not to be those which Endlich had in mind, if, indeed, he entertained precise views upon the subject. That his uncertainty in one case was considerable appears from the lines: "Whether any of the strata above the ones just spoken of should be referred to the Devonian, I am unable to say. The poorly preserved relics of paleontological testimony that could be obtained were so few and unsatisfactory that I am inclined to think the Devonian, if represented, is no formation of great extent, either vertically or horizontally." The same lack of evidence and apparently the same uncertainty seem to have existed in other instances where the Devonian is cited.

The Carboniferous recognized by Endlich consists of three divisions; a lower and an upper limestone, and a heavy series of red sandstone included between them. The lower limestone can probably be correlated with the Leadville limestone, or possibly the Leadville and Weber formations combined, and I expect that it will be found to contain in addition to its Lower Carboniferous fauna, a Devonian one, similar to that of the Ouray limestone, just as is the case in the regions to the north and west of this. Indeed, as the Devonian fauna of the Ouray limestone occurs very characteristically at Salida, its presence throughout the South Park and Sangre de Cristo regions wherever the Leadville limestone is present may be inferred with probability. The red sandstone would seem to be the representative of the Maroon formation, while the equivalence of the upper limestone, unless it is a localization of limestone beds elsewhere distributed through the Maroon, is uncertain.[a]

The Red Beds generally called Juratrias in the Hayden reports are recognized by Endlich, but their occurrence is apparently restricted to the eastern side of the Front Range, where they are accompanied by patchy outcrops of the Paleozoic series.

The main body of the Paleozoic outcrop described by Endlich lies in the long and narrow strip brought up by the elevation of the South Park and Sangre de Cristo ranges. The portion considered by Endlich is from where Trout Creek divides the Mosquito Range on the north, nearly to Sangre de Cristo Pass on the south. His work, therefore, comes partly in the artificial area which has been called the South Park region, and partly in that which has been designated the Sangre de Cristo region. For the sake of continuity, however, both areas will be considered in the same division of this résumé, and in that portion of it devoted to the Sangre de Cristo Range.

Turning now to Endlich's report, it seems that his station 53, though I have been unable to identify it with certainty upon the map, is located at the extreme northern end of that portion of the South Park region included within the San Luis district. A section running through station 53 is said to consist of the following elements. Resting upon the granite is a bluish quartzitic limestone in heavy beds, hard and compact, containing numerous crinoidal fragments resembling *Heterocrinus*, and a few indeterminable specimens of *Orthoceras*. Then follows a thin layer of dark-gray slaty shales. These are succeeded by hard gray limestone containing in its upper portion a number of corals and Spongidæ, above which follow thick beds of white, yellow, and pink quartzite, which turn higher up into a light-red sandstone.

What is with little doubt the continuation of this section is described on page 311 of Endlich's report, and from this I condense as follows: "Reclining upon the reddish Silurian sandstone and conformable with it is a thick stratum of yellowish and brown sandy shale, covered by light-yellow and gray shale. Upon these rests a limestone, grayish blue in color but weathering white, in which, apparently near the top, were found *Orthis*, *Productus*, and *Orthoceras*. Overlying the limestone are shales of gray and brown color, succeeded by others of a more sandy character, and these are brought to a close by a series of heavy strata of dark-blue limestone capped by brown sandstone."

[a] It perhaps represents the series of intermingled siliceous and calcareous beds called in the Leadville monograph Upper Coal Measures.

Comparison of the series thus briefly characterized with other known sections in areas adjacent is hampered by lack of measurements of thickness which Endlich fails to supply, and by the meagerness of paleontologic data. Nevertheless, if this series be closely compared with that of the Leadville monograph, though the result shows considerable changes in lithology between Leadville and the southern end of the Park Range, yet certain horizons seem to be recognizable as probably equivalent in the two sections. In view of its lithology and position, the siliceous limestone at the base of the section can be taken as representing the Yule limestone, and with it would probably go the overlying limestone containing corals and sponges. The Cambrian Sawatch quartzite appears from Endlich's statements to be entirely lacking. The light-colored limestone with *Orthis* and *Productus* is probably the Leadville limestone (or its more or less close equivalent, the Ouray limestone). The quartzite between these two calcareous formations should, from its character and position, be the Parting quartzite. The light-red sandstone and the heavy shale series above it, however, seem to have no lithologic equivalent in the Leadville section. Perhaps they should, in conjunction with the quartzites, be taken as representing the Parting formation. The shales above the supposed equivalent of the Leadville limestone present some claims of similarity to the Weber shales, but the succeeding beds certainly do not at all resemble the Weber grits series as it is described by Emmons. It seems rather more probable that the massive blue limestone above, as well as the lower fossiliferous one, belong in the horizon of the Leadville limestone, and, of course, with it would be carried the intermediate series of shales. The dark sandstones with which the section closes certainly are more similar to the Weber grits than any of the beds below.

Results not altogether satisfactory attend the comparison of this section with that described by the same author as occurring at Fossil Ridge in the Elk Mountain region. The series of Ordovician beds in the two sections are probably to be correlated with each other and with the Yule limestone. In the South Park region these consist of a blue quartzitic limestone with crinoids and *Orthoceras*, overlain by a hard gray limestone containing corals and sponges, with a thin interstitial shale. At Fossil Ridge this series comprises 320 feet of light-gray limestone, with quartzitic segregations and sparse remains of crinoids. The two limestone series which I correlate with the Leadville limestone are also probably equivalent. At Fossil Ridge these comprise 260 feet of light-gray and yellowish limestones, interstratified with narrow bands of shale; 40 feet of light shale; and 20 feet of dark-blue limestone carrying upper Devonian or lower Mississippian fossils. The bed last mentioned can be assigned with great probability to the Leadville or Ouray limestone. Above it come 45 feet of light shale, 150 feet of light-blue and yellow limestone, and 50 feet of yellow, reddish, and whitish shales, which may belong with the Leadville limestone or with the Weber limestone. In the other section the Leadville seems to consist of a lower series of gray limestone, an upper one of dark-blue limestone, and an intermediate one of shales. A certain resemblance to this series will be observed in the Fossil Ridge section, though the latter contains some overlying shale and limestone which appear to be without equivalent in the other.

Intermediate between the Yule and Leadville limestones at Fossil Ridge occur 80 feet of yellow and gray shale and 175 feet of variegated shale and limestone. The former especially seems to resemble in thickness and character the upper member of the original Yule limestone, which Spurr correlates with the Parting quartzite, but the other and heavier bed may possibly belong to the same series. In the South Park section Endlich describes a white, yellow, and pink quartzite and red sandstone as occurring just above the Yule, followed by yellow and brown shale and light-yellow and gray shale. The quartzite is not represented in the Fossil Ridge section, but is suggestive of the original Parting quartzite in character and position. The overlying shales have more the character of the Parting formation of the Elk Mountain region. The circumstances thus detailed suggest the possibility that the Parting beds, as identified at different localities, are of a dual character, consisting of quartzites below and variegated shales above, the shales alone being found in the Elk Mountain region, the quartzite alone at Leadville, both shale and quartzite in Endlich's section, and neither shale nor quartzite at Red Cliff. At all events, this formation apparently varies considerably from point to point both in character and thickness.

South of the point at which the preceding section occurs, according to Endlich, the Silurian retains its characters, the quartzitic limestone resting directly upon granite, and at a point designated by him as station 56 another section was taken across the same line of outcrop.

This station I have been unable to locate exactly, but it appears to be situated southeast of station 53 and not far to the west of the more northerly transsection by Badger Creek of the Paleozoic outcrop. The stratigraphic succession at station 56 consists of the following members: Resting upon porphyritic granite are found a series of yellow to light-brown, hard quartzites, followed by fine-grained white and pink quartzites, and covered by shales that can be referred to the Carboniferous. Endlich suggests that the blue limestone which formed the base of the other section underlies the quartzites, although it was not found at this point. The continuation of this section also appears to be found upon page 311 of Endlich's report. "Overlying," he says, "the yellowish shales, interstratified with quartzites, which have been referred to the Upper Silurian, are a series of blue limestones, irregularly alternating with gray shales containing *Orthis* and crinoids." On page 309 of his report, however, the yellowish shales are not referred to the Upper Silurian but to the Carboniferous, and no reference is made to their being interstratified with quartzites. The blue limestone and shales Endlich prefers to regard as oldest Carboniferous rather than Devonian. "Bluish shales that have been eroded considerably follow, forming the bottom of a narrow valley, and are covered in turn by a saccharoidal limestone rising steeply from them." Apparently following the limestone comes "the red sandstone, which has not appeared for 4 or 5 miles along the line of Carboniferous outcrop," nor, it might be added, has it appeared specifically mentioned before in Endlich's description, though it is probably the sandstone casually referred to on page 310–311 and the same as his Arkansas sandstone.

This section is so nearly a repetition of that made at station 53 that the correlation of the constituent members is obvious. A conspicuous feature is the absence of the basal limestone, which, however, appears to be only local, as Endlich states (page 310) that it reappears south of station 58 and remains entirely or partially exposed southward to beyond the Arkansas. This circumstance conspires with several others to render it probable that the granite in this case is not the Archean granite, but an intrusive body.

The Carboniferous formations are reported as following the Silurian to his station 58, at which point the sandstones, farther north of no great dimensions, are enormously developed, and the upper limestones make their appearance. Of the latter a spur branches off to the east and runs through a granitic country for a distance of about 7 miles, dipping northeast to east, and then comes to an end without connecting again (page 310).

This sandstone is said to be uniform in appearance and to be greatly developed, reaching a thickness of more than 5,000 feet, and even exceeding this in section *b* south of the Arkansas. To this formation Endlich gives the name "Arkansas sandstone." Running parallel with the Arkansas sandstone was found an outcrop of gray and bluish limestone already referred to, which, "for stratigraphical reasons, must be considered as properly belonging above the Arkansas sandstone." In this limestone were found *Favosites* and a few other fossils. As the range of *Favosites*, so far as known, does not extend above the lower Mississippian, the presence of this genus in this limestone, if the generic identification can be relied on, seriously contradicts other statements bearing evidence as to the geologic age of this bed. In the Hayden atlas, moreover, this spur is represented as consisting of Lower Carboniferous and Middle Carboniferous sediments. As there can be but little doubt that the Lower Carboniferous of this map is Endlich's lower limestone, and that his Arkansas sandstone is the Upper Carboniferous, it seems clear that the best information at the time the map was constructed indicated that the limestones of the spur were not a new series of limestones overlying the Arkansas sandstone, but a repetition of the series lying beneath it.

The Paleozoics south of the Arkansas (sections *b* and *c* of Endlich's district) come in the area which I have defined for my purposes and named the Sangre de Cristo region. Here the Silurian is again found, though in small quantities, but the Carboniferous occupies larger areas. The latter consists chiefly of the Arkansas sandstone, which forms the main bulk of the Sangre de Cristo Range. The typical Arkansas sandstone is here found to be more or less interstratified with dark shales and isolated limestones, the combined thickness of which is said in one instance probably to exceed a mile. The lower limestone, determined by its petrographic character and position, also occurs south of the river, and accompanies the Arkansas sandstone for some miles. No fossils were found in it (pages 326,327).

Farther west, along the southern end of the Arkansas Valley (in section *c* of Endlich's district), the Silurian is again reported. It consists of light-colored quartzites of yellowish, bluish, and reddish tints, which are conformably overlain by gray to bluish limestone with siliceous segregations. Lithologically they are said to be identical with those found north of the Arkansas River.

One can hardly doubt that in this instance the quartzite is the Sawatch quartzite, and that the limestone is the equivalent of a similar bed at Fossil Ridge, in the Elk Mountain region, of the basal limestone at station 53 in the South Park region, and of the Yule limestone of established sections. Endlich calls attention to the resemblance which these strata bear to those north of the river, but in the latter area the quartzite is represented as lying upon instead of under the limestone, so that its position is not that of the Sawatch but of the Parting quartzite. The Sawatch, indeed, appears to be wanting, but I can not altogether banish the suspicion that the sequence is wrong in Endlich's sections north of the Arkansas.

In the Hayden report for 1875[a] is found Endlich's account of the geology of the so-called Southeastern district. He described the boundaries of this district in the following terms (page 105): "The district assigned to our party during the field season for 1875 extended from longitude 104° 30′ west to longitude 108° west, was bordered on the south by north latitude 36° 45′ and on the north by north latitude 37° 50′. On the west side it connected with the work of 1874, and on the north with that of 1873." The geologic discussion is distributed into five divisions based upon geographic occurrence. These are the Sangre de Cristo Range and the Huerfano region, the San Luis Valley, the southern extension of the Sawatch Range, the Rio San Juan and its drainage, and the Post-Cretaceous formations of the Trinidad region. Only one of these chapters, that upon the Sangre de Cristo Range, contains anything of importance in our discussion.

Though present in the more northern portion of the Sangre de Cristo Range (see Endlich's report for 1873), the strata of Silurian and Mississippian age gradually

[a] U. S. Geol. Geog. Surv. Terr., Ninth Ann. Rept., for 1875, 1877, pp. 103-215.

disappear and are not found at all farther south, and the Arkansas sandstone generally rests directly upon the Archean. An exception to this statement seems to exist in the vicinity of Trinchera Peak, where a grayish-brown, compact shale, sandy in part, and interbedded with limestone, was seen conformably underlying the red Carboniferous sandstone. The position and character of these strata make it probable that they represent the Weber formation, or else, as suggested by Endlich, the horizon of the Ouray and Leadville limestones.

It was in the southern part of this area mapped by Endlich as "Lower Carboniferous" that Lee made a section and collected fossils as hereinafter described. The fauna obtained by Lee not far above the contact with the Archean is unquestionably of Pennsylvanian age, and is related to that of the Hermosa formation and of the Weber limestone and lower Maroon formation. Unless still lower rocks occur in other parts of the area, it is evident that the "Lower Carboniferous" color, so far as the "Lower Carboniferous" of the Hayden survey is understood to be equivalent to the Leadville limestone, is wrongly introduced in the vicinity of Trinchera Peak.

The remainder of the Paleozoic consists of the Arkansas sandstone, whose outcrop covers large areas on both sides of the Sangre de Cristo Range, extending as far south as Costillo Peak. This formation is made up chiefly of red sandstone, with which are interstratified red shales and blue limestones. In the vicinity of Costillo Peak Endlich reports some whitish sandstones and a quartzitic bed in association with the red sandstone (page 122). Although in his previous work the Arkansas sandstone had been placed in the Carboniferous, the first paleontologic evidence was not obtained until 1875. Hayden[a] had, however, collected Carboniferous fossils in this range in 1869 and Ruffner in 1873.[b] Endlich cites *Productus semireticulatus*, *Seminula subtilita*, and *Spirifer* at one station, *Calamites* and *Sigillaria* at another, while a third furnished *Productus*, *Orthis*, *Spirifer*, and crinoids. The latter fauna suggests those which he obtained in 1873 from rocks of supposed Mississippian age, but otherwise are diagnostic only of the Carboniferous as a whole. The thickness of the Arkansas sandstone is here given as 2,000 feet, while farther north it was reported by the same author as in one place not less than 5,000 feet. This great diminution in bulk, conjoined with the entire absence of the series which Endlich

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[a] Apparently the first adequate evidence as to the age of these beds was obtained by Hayden in 1869 (U. S. Geol Surv. Terr., Ann. Rept. for 1867, 1868, and 1869, 1873, p. 175), who observed near Sangre de Cristo Pass an extensive series of reddish sandstones, some of which contain impressions of *Calamites*, while from a bed of limestone, in a series of alternating limestones and sandstones, were obtained several species of *Productus*, "*Spirifer subtilita*, *Rhynchonella rockymontana*, *Spirifer lineatus*, and numerous corals and crinoidal stems." The names of species in this list are singularly mangled, but it is evidently an Upper Carboniferous fauna that is presented. These were found near the junction of the sedimentaries with the (Archean?) granite.

In his paleontologic report the year following Meek lists (U. S. Geol. Survey Wyoming, etc., Preliminary Rept. [Fourth Ann. Rept.], 1871, p. 295) *Productus punctatus*, *Productus semireticulatus*, and *Seminula subtilita* from Sangre de Cristo Pass.

[b] Ruffner's Rept Recon. Ute Country, 43d Cong., 1st sess., House Ex. Doc. No. 193, p. 61.

in 1873 distinguished by the name of Upper Carboniferous (if, indeed, the beds so designated really occupied the position ascribed to them), would indicate that the southern portion of the Sangre de Cristo Range had been the scene of severe post-Carboniferous erosion, though doubtless to the unconformity which preceded the deposition of the Arkansas sandstone may be ascribed an important share in the influences that produced this difference in bulk.

Endlich reports no Triassic in the Southeastern district, except at the southern end of the Wet Mountains. To these exposures I shall refer in connection with the Front Range region.

In 1874 was published Ruffner's report upon a reconnaissance in the Ute country[a] made the year previous. The map accompanying the report covers an extensive territory, extending from the thirty-seventh parallel on the south to north latitude 39° 30′, and from 105° 30′ west longitude on the east to 108° on the west. The primary object of the expedition was not geologic, but two geologists in the persons of F. and L. Hawn accompanied it, and their accounts form Appendix B (pp. 59 to 88) of the general report. The identification of the different outcrops described with the recognized Paleozoic formations of Colorado is in many cases difficult or impossible because of the brief mention made of them, but in several instances the citation of Carboniferous faunas removes all doubt with reference to formations of that period. The geologic observations so far as they concern this résumé fall into the San Juan, Elk, Sangre de Cristo, and Front ranges. These accounts add little to the subject, on account of the more detailed character of subsequent work in the same areas, and the interest which attaches to them is largely historical. In the earlier portion of the work, which is devoted to a general description of the route, not infrequent reference is made to the occurrence, character, and even thickness of the rocks observed, but with these I have not concerned myself, dealing only with the descriptions in the geologic reports.

In the Sangre de Cristo Range the chief line of observation was the road between Pueblo and Fort Garland by the way of Sangre de Cristo Pass. Mention is made of the Carboniferous limestones and brown sandstones (p. 61) of Sangre de Cristo Pass, and from the former are cited *Cyathophyllum* sp., *Productus equicostatus*, *Productus semireticulatus*, *Productus cora*, *Spirifer cameratus*, *Spiriferina kentuckyensis*, and *Seminula subtilita*. This is one of the earliest accounts[b] that I have found of this occurrence of fossiliferous strata, though authors have several times made subsequent mention of it.

Carboniferous rocks appear to have been found also at the extreme northern end of the range, and it is possible to recognize as the Leadville limestone a bed

[a] U. S. War Dept., Rept. Reconnaissance Ute Country in 1873, by Ruffner, Washington, 1874, pp. 1–101.

[b] Hayden found these fossiliferous beds as early as 1869 (see U. S. Geol. Survey Terr., Ann. Rept. for 1867, 1868, and 1869, 1873, p. 175). The fossiliferous Carboniferous beds of the Sangre de Cristo Range are also mentioned by Cope (p. 64, Ann. Rept. Wheeler Survey for 1875), but in a very cursory manner.

which is described[a] as a gray, cherty limestone containing small fragments of *Cyathophyllum.* This is succeeded by hard, ferruginous gray and blue sandstone, which in all probability belongs in Endlich's Arkansas sandstone. The point at which this observation was made is on the Arkansas River above its pass through the Sangre de Cristo Range and somewhat above the mouth of the Little Arkansas. This place can not be far from the locality, near Salida, at which were found the fossils in our collections representing the Devonian and Mississippian phases of the Leadville limestone.

As a portion of the extensive area embraced in Stevenson's report in Volume III of the Wheeler survey, the geology of the highlands on the west side of South Park, more or less directly connecting southward with the Sangre de Cristo Range, is briefly described.[b] What he says about the former should properly be considered in the section of this discussion devoted to the South Park region, but I believe that its relations will be easier appreciated in connection with the beds belonging to the Sangre de Cristo division.

To the Silurian Stevenson refers "all strata underlying the Carboniferous limestone;" (page 357) and, thus defined, it is exposed in numerous outcrops along the area mentioned. In his section of the Silurian made on Bald Peak in the canyon of Fourmile Creek (page 357), the five lowest beds (6 to 10) can safely be referred to the Sawatch quartzite. They consist of sandstones, and have a combined thickness of 162 feet. The 40-foot limestone represented as bed 5 is probably the Yule limestone, though it appears to be here of only half the usual thickness. The 170 feet of sandstone overlying can hardly be anything but the Parting quartzite, and possibly with it should be included the 20 feet of limestone of bed 1. The Sawatch quartzite is reported at numerous scattered localities. Its color varies from white to dark blue, and it ranges in thickness up to 200 feet. In the canyon of the Arkansas a very different section of these beds is given. I quote as follows (page 359):

Section in canyon of Arkansas River.

	Feet.
1. Sandstone, partially altered, with layers of quartzite; somewhat argillaceous; weathers to ochery color; contains many large fragments of jasper	75
2. Clay, calcareous, indurated, reddish, weathers into mud	20
3. Limestone, siliceous above, more argillaceous below, with thin layers of comparatively pure bluish limestone	27
4. Limestone, varying from dove color to black; several argillaceous layers; near the top vast numbers of crinoidal stems, with many sections of cyathophylloid corals and Brachiopoda. As these are not silicified they can not be separated. Near the base is a thin, argillaceous layer which contains many compressed individuals of *Rhynchospira* sp. and occasionally a bryozoan. From this layer was obtained also a fragment of a large trilobite	35

[a] Ruffner., op. cit., p. 80.

[b] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875, pp. 307-501.

	Feet.
5. Limestone, mostly quite siliceous and compact; varies from dove color to black; layers of the latter color very fetid when struck; weathers in lines and disintegrates readily; almost entirely nonfossiliferous, but near the top saw a few crinoidal plates and some very indistinct bryozoans	50
6. Sandstone, grayish blue in color, fine grained, and entirely converted into quartzite. Below this we find an exceedingly dark, hornblendic gneiss.	

The sandstone at the base (No. 6) presumably represents the Sawatch quartzite. Stevenson states that the limestones, Nos. 3, 4, and 5, are certainly the equivalent of No. 5 of the Bald Peak section, but the dark color of the limestone, together with the character of the meager fauna cited, might suggest that these do not belong to the Yule but to the Leadville limestone, which is known to be present in this region (e. g., at Salida). In the former case the sandstone and clay (1 and 2) would probably be the Parting quartzite; in the latter they would be the earliest beds of the Upper Carboniferous. The Arkansas Canyon is the most southern point along the range at which Silurian beds are cited by Stevenson.

Carboniferous strata appear to be exposed almost continuously along the line of the South Park and Sangre de Cristo ranges, and are mentioned at numerous localities from Quandary Peak to the divide between Wet Mountain Valley and Huerfano Park. The series seems to be twofold, consisting of limestones below and sandstones above. The lower member is a dark limestone of undesignated thickness, and it is usually referred to by Stevenson simply as "the limestone." Near the Arkansas Canyon the upper member is described as an enormous mass of reddish and gray sandstones and shales, not less than 2,500 feet thick, which forms the canyon's walls to its mouth at Pleasant Valley (page 371). At the northern end of the range, in the Leadville region, it is spoken of as "an enormous mass of red and gray sandstones, more or less finely conglomerate, capping the mountains on the main divide, and including several of these thin limestones, two of which are seen in Hamilton Pass." (Page 374.) Near its base the upper series is gypsiferous. "In Sangre de Cristo Pass the sandstones are finely exposed, and at one locality the limestone is seen with many imperfect fossils, of which *Productus semireticulatus* is most abundant." (Page 371.)

The limestone member of the Carboniferous is evidently the Leadville limestone, while the sandstone member represents wholly or in part the Weber shale, Weber grits, and Upper Coal Measures, or the Weber and Maroon formations of Emmons's work, and the Arkansas sandstone of Endlich's. In the north, because of the presence of interbedded limestones, and because both the divisions of the Upper Carboniferous which Emmons in the Tenmile folio distinguished as the Weber and Maroon formations, are known to be present, Stevenson probably saw nearly the whole series. Farther south, however, at Arkansas Canyon, he allows a thickness of but 2,500 feet and does not mention interbedded limestones. In both particulars this agrees especially with the Weber grits formation alone. Still farther south, on the other hand, fossiliferous limeststones are present, as we have just seen. Trustworthy and detailed information about the whole range south of the Leadville region is, unfortunately, sadly lacking, but I judge that the Upper Carboniferous sandstones and conglomerates, represented southward by the Arkansas sandstone, are thinner in the southern part, and suspect that this will prove to be due to erosion of the upper surface by one or several combined of the erosion periods that appear to have succeeded the deposition of the Maroon sediments. Stevenson found no Triassic in this region, and, in fact, the bright Red Beds appear to be in large measure wanting. They are, however, found in the Tenmile region, and their apparent absence farther south is possibly owing to the same cause by which the thickness of the Maroon sediments appears to have been seriously diminished.[a] Wherever any representation of the Wyoming formation occurs in the area examined by Stevenson it was evidently included by him in the Carboniferous.

In the supplement to volume 3 of the reports of the Wheeler survey[b] Stevenson described the geology of an extensive territory in New Mexico and southern Colorado. It probably included in the latter State all the mountainous portion south of north latitude 37° 20′. Two Carboniferous areas are described, one of which is situated entirely in Colorado and the other entirely in New Mexico. The Colorado area, which is described in less detail than the other, occurs on the eastern slopes of the chain of mountains called in the Hayden atlas the Sangre de Cristo Range, and extends from Spanish Peaks to Costillo Peak. The Carboniferous beds rest upon the Archean. The base of the series is a conglomerate sandstone not far from 800 feet thick which contains some beds of fine-grained red sandstone and red shale. Above this comes in the lowest limestone, which is 7 feet thick, blue, slaty, hard, and somewhat fossiliferous. Next occurs an interval of 700 feet filled with red shale and sandstone. This is succeeded by a blue, very compact limestone, of which 20 feet are exposed, showing some calcspar but no fossils. Above the limestone occur 300 feet of red sandstone and reddish shale. Next follows another limestone which is gray, not very hard, richly fossiliferous, and not far from 100 feet thick. Above the limestone are about 1,800 feet of reddish, thin-bedded, fine-grained sandstones, holding beds of red shales. The rocks thus far mentioned, which have a total thickness of 3,727 feet, seem to

[a] I have suggested the probability of an extensive time break and period of erosion between the brick-red or "Triassic" Red Beds and the Maroon formation. To this the reduction in the thickness of the upper Maroon from 2,500 feet in the Crested Butte quadrangle to 300 feet in the San Juan region (Rico formation) has been ascribed. Possibly the same influence was felt to the east and the Maroon reduced before the deposition of the "Triassic," which has been itself removed. The great thickness of the Maroon (Arkansas sandstone) farther south in the Sangre de Cristo would rather seem to indicate that the thinness of these beds in the region of the Arkansas was a local matter and probably the result of comparatively recent causes.

[b] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Suppl., 1881.

constitute a lower series and are overlain by an upper one of reddish-brown conglomerate sandstone not far from 2,500 feet thick. Large fragments of granite, gneiss, and quartzite prevail, but with them are some of sandstone and limestone. "This part of the section bears close resemblance to the upper division of the Carboniferous series seen on the Eagle River of central Colorado." No Triassic was found in this area, the Carboniferous underlying the Dakota throughout.

It may be added that neither has the "Triassic" series or "Red Beds" been reported by any of the geologists who have written of the Sangre de Cristo region, nor is it represented upon the Hayden maps. Its absence in this area is in agreement with its absence over the southern part of the South Park region, the southern part of the Elk Mountain region, and the southern part of the Front Range region, where the "Red Beds" apparently belong in the Fountain and not in the Wyoming formation. At the same time Hills remarks that a small thickness of brick-red sandstone occurs in the Sangre de Cristo Range above the Arkansas sandstone and in the Walsenburg quadrangle above the Badito formation. Yet, though the position and color of this bed rather suggests the "Triassic," it can probably be provisionally regarded as part of the Arkansas sandstone.

No fossils are cited from the Carboniferous, so that conclusive evidence is lacking as to the presence or absence of the Mississippian limestone in this section. The Hayden atlas, it is true, represents an area of Lower Carboniferous at and about Trinchera Peak, and this division frequently contains beds of Mississippian age, but I am disposed to think that the Mississippian is really wanting, if not at the Trinchera Peak locality, at least from Stevenson's section, first, because there is nothing in it comparable to the massive and persistent Leadville limestone, unless it be the highest limestone of the section, and, second, because the limestones of Sangre de Cristo Pass, which are probably the equivalents of those in Stevenson's section, appear from their fossils to be Upper Carboniferous. It would thus appear probable that the whole of the Carboniferous section is of Pennsylvanian age[a] and to be compared with the Maroon conglomerate of the Crested Butte section and with the Weber grit and Upper Coal Measures of the Leadville section. The two divisions of Stevenson's section are indeed comparable to the two divisions of the original Maroon. The resemblance in both lithology and thickness in the case of the upper divisions is rather striking. The lower one in Stevenson's section, however, though not unlike the other lithologically, is much thicker. But with indications of an unconformity at the base of the Maroon, and a possible time break between its two divisions, disparity in the thickness of the lower portion in different areas would not be surprising.

[a] This appears to be certainly the case in Lee's section west of Trinidad, but it is possible that here, as along the Front Range, the Mississippian limestone and earlier Palezoic formations may underlie the Arkansas sandstone in disconnected patches.

Very recently W. T. Lee[a] published a detailed section taken at the crest of the Sangre de Cristo Range directly west of Trinidad, Colo., between the sources of the Middle Fork and the North Fork of the Purgatory River. This point is near Culebra Peak, not far from the southern border of the State. Lee's section comprises about 400 feet of strata immediately overlying the Archean granite. Lithologically the series consists of coarse grits, conglomerate, and sandstones, with some shales and a number of thin limestones. Upper Carboniferous fossils were found in abundance about 150 feet above the base, and an extensive fauna is cited. Lee calls attention to the fact that Endlich had mapped Lower Carboniferous rocks at this point. Every test shows the inaccuracy of Endlich's work; but Stevenson, as long ago as 1881, described the section in such a manner as to leave no reasonable doubt that the Lower Carboniferous was generally absent from the Sangre de Cristo Range, at least from Spanish Peaks southward to Costillo Peak. The whole series is referred by him to the Carboniferous, apparently on paleontologic evidence, though no identified species are cited. Upper Carboniferous fossils had long been known from this series, however, having been obtained chiefly from the vicinity of the Sangre de Cristo Pass. The horizon of the earlier collections with relation to the granite was never, I believe, ascertained. The fauna cited by Lee is much more abundant than had ever been previously known from these rocks, and the stratigraphic position is far lower than any fossiliferous horizon mentioned by Stevenson. The combined evidence, both stratigraphic and paleontologic, tends to confirm Stevenson's early reference of the entire series to the Upper Carboniferous. The Lower Carboniferous and earlier Paleozoics must be either entirely missing or represented by local fragments, for I little doubt that they once extended over this region. Geologically the beds described by Lee doubtless belong at the base of Stevenson's lower series, which I am disposed to correlate with the lower portion of the Maroon formation.

The collections made at this point have recently come into my hands, though too late to be incorporated into the paleontologic discussion. The fauna, while not without individuality, is distinctly related to that of the Hermosa formation and of the Weber limestone and lower Maroon series, and quite distinct from that of the Rico formation.

In 1898 E. C. and P. H. Van Diest published a note on the geology of the western slope of the Sangre de Cristo Range in Costillo County.[b] The area of observation was along the Rito Seco, northeast of the town of San Luis. In this area Endlich had indicated (Hayden atlas) extensive areas of Upper Carboniferous. Apparently this series does not occur there, but instead Archean, Cambrian, and Silurian strata were found. The Sawatch here consists of white saccharoidal quartzites, with a thin basal conglomerate. These are succeeded by a thin bed of

[a] Jour. Geol., vol. 10, 1902, pp. 393–396.

[b] Colorado Sci. Soc., Proc., vol. 5, 1898, pp. 76–80.

argillaceous shale, "and the whole section is topped by layers of light-gray siliceous limestones for about 200 feet, where a quartzy parting separates them from others of somewhat darker color."[a] Though no fossils were found in these beds, their occurrence and lithology, as the authors point out, make it highly probable that the quartzite is the Cambrian and the limestone the Ordovician of the Paleozoic sections of central Colorado. Except that the wording seems to indicate an insignificant thickness for the siliceous bed above the light-colored limestone, one might see in it and in the darker limestone above, representatives of the Parting quartzite and the Leadville limestone. Neither Endlich nor Stevenson, nor, so far as I have ascertained, any other geologist, found the older Paleozoics in the Sangre de Cristo Range, except in its northern part, while Lee's section seems to afford positive evidence that they are in places actually absent.

FRONT RANGE REGION.

The character and correlation of the Paleozoics of the East as they reappear along the front of the Rocky Mountains after their long sequestration beneath the plains under deposits of later geologic ages is a subject of peculiar interest. In Colorado Paleozoic exposures (except for the Red Beds) are neither numerous nor extensive along the Front Range, and circumstances have combined to make their correlations, both with different outcrops of the same series and with the typical sections of the East, often a matter of difficulty.

The Pikes Peak quadrangle, which lies just west of Colorado Springs, contains part of one of the few areas of recognized Carboniferous in this region. Although much literature upon the geology of the Front Range had appeared before the Pikes Peak folio[b] was published, inasmuch as I shall use the nomenclature and definitions adopted in it for the different formations, it seems best to employ the logical rather than the historical order in this discussion.

The Pikes Peak quadrangle, therefore, includes portions of two more or less distinct Paleozoic areas, and as they seem to have passed through somewhat different geologic histories, or at least to show differences of note in the histories preserved to us, it will be more intelligible to consider the sequence in each separately. In the southern part is an area which extends southward and eastward beyond the limits of the quadrangle and reaches the well-known locality of Canyon. In the north is a somewhat smaller area, the southern extremity of the isolated Manitou Park Paleozoic tract. The basal formation in both areas resting upon granite and gneiss is called the Manitou limestone. A small thickness of quartzite and cherty limestone at the base is probably Cambrian, but the main body of the formation is Ordovician. "In Garden Park it consists of fine-grained pink or reddish dolomite less than 100

[a] Colorado Sci. Soc., Proc., vol. 5, p. 78.

[b] U. S. Geol. Surv., Geologic Atlas U. S., folio 7, Pikes Peak, 1894.

feet thick, and contains *Ophileta*, *Camarella*, and a few other invertebrate fossils characteristic of the Lower Silurian formation in the section at Manitou Springs and at Manitou Park, whence the name is derived." In the northern part of the quadrangle this limestone is not dolomitic, and is connected directly with the typical locality at the north end of Manitou Park. In the southern part of the quadrangle the Manitou limestone is immediately overlain by the Harding sandstone, which is predominantly a fine-grained, saccharoidal sandstone in alternating banks of light-gray and pinkish or variegated colors, and sometimes calcareous at the base. The maximum thickness is about 100 feet. This horizon is characterized by numerous remains of fishes of types not elsewhere found below the Devonian, and it carries also a rich invertebrate fauna of Trenton age. "The Harding sandstone is not found in Manitou Park, nor at Manitou Springs, and has not been identified at any other locality." In Garden Park the Harding sandstone rests with apparent conformity upon the Manitou limestone, but evidence elsewhere indicates that before its deposition the Manitou limestone was subjected to a period of erosion.

Succeeding the Harding sandstone with apparent conformity there occurs a bluish-gray or pinkish dolomite which has a thickness in Garden Park of about 100 feet, but increases southward, and near Canyon reaches a maximum of 270 feet. This is partly through the development of an upper and highly fossiliferous member not seen in Garden Park. The Fremont limestone in Garden Park is especially characterized by *Halysites catenulatus*, and it also contains a large invertebrate fauna like that of the upper Trenton of New York. This limestone horizon has not been recognized in other sections of Paleozoic strata along the east base of the mountains, nor has its equivalent been found in any other part of the West. Its present limitation eastward from Garden Park, on the slopes of the range, is by erosion, which took place after the deposition of the Millsap limestone.

The long period between the deposition of the Fremont and the Millsap seems to have been one of elevation and erosion, though there is seeming conformity between the two limestones in local exposures. Of the Millsap itself only remnants are found resting upon the Fremont limestone in Garden Park and along the western line toward Canyon. The formation is now represented by about 30 feet of thinly bedded, variegated, dolomitic limestone, with a few thin sandstone layers. Chert nodules in the upper part carry a limited fauna, elsewhere described.

The Fountain formation includes a series of red sandstones, grits, and conglomerates, a part of the so-called "Red Beds." The typical locality is in the northern part of the quadrangle, but it seems to have essentially the same lithologic characters in Garden Park. The thickness is estimated at nearly 1,000 feet. The Fountain beds rest unconformably upon the edges of the entire Silurian section in Red Ridge, at the upper end of Garden Park, and along the southern end of the Colorado Range they come in contact with the Harding sandstone. Beyond the eastern line of the quadrangle they are usually found to abut against granite or gneiss.

The Fountain formation is succeeded by the Morrison formation, and the Morrison by the Dakota. "The Morrison strata rest with apparent conformity upon the Fountain grits in the main foothill section, but in Twelvemile Park and in the higher plateau region to the north they lie directly upon granite. There is thus a great stratigraphic break between the Morrison and the Fountain formations. An extensive vertebrate fauna found in the Morrison formation shows that its age is post-Paleozoic."[a]

The Paleozoic series, then, in the southern part of the Pikes Peak quadrangle has at its base a slight development of Cambrian sediments, too thin to be mapped, upon which rest in succession the Manitou limestone, Harding sandstone, Fremont limestone, Millsap limestone, and Fountain formation. The Manitou, Harding, and Fremont formations represent Ordovician time, the Millsap and Fountain, Carboniferous. The age of the Fountain formation is determined only by analogy; that of the other formations rests upon paleontologic evidence. Unconformities occur between the Manitou limestone and the Harding sandstone, between the Fremont limestone and the Millsap limestone, and between the Millsap limestone and the Fountain formation, while still a fourth and very important one is found between the Fountain formation and the overlying Mesozoic.

The section in the northern, or Manitou Park, Paleozoic area is similar to that in the southern one, except that the Harding sandstone, the Fremont limestone, and the Millsap limestone are lacking in it.

In connection with the field work leading up to the Leadville monograph, Whitman Cross made a visit to the exposures in Manitou Park, on the eastern side of the Front Range.[b]

"Although only 50 to 75 miles distant from the Mosquito Range exposures, the beds were found to vary so much in lithological composition that it was impossible to obtain an exact correspondence of horizons. The purely siliceous beds at the base are much thinner than in the Mosquito Range, the greatest thickness found being 50 feet. They are succeeded by calcareous sandstones and shales of variegated colors, red prevailing, which pass up into white or drab limestones, sometimes containing chert secretions and alternating with shaly beds, with an aggregate thickness of about 200 feet. These beds may be considered as the equivalents of the Lower quartzite and White limestone of the Mosquito Range."

From the east bank of Trout Creek (Bergens Creek on the Hayden map), 2 miles below the hotel, Mr. Cross obtained fossils which have been identified by Mr. C. D. Walcott, as follows:

From reddish-brown sandstone, 45 feet above the Archean.

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[a] Much of the preceding digest is stated in the words of the original.
[b] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 62.

Lingulepis sp. ? An elongate form allied to *L. pinnæformis* of the Potsdam sandstone of Wisconsin.

From red calcareous sandstones, alternating with white limestone, 105 to 122 feet above the Archean.

Glytocistites (?). Single plates.	Cyrtolites.
Lingula sp. undet.; probably new.	Orthoceras sp. undet.; probably new.
Orthis desmopleura Meek.	Bathyurus simillimus Walcott (?).
Metoptoma new sp.	

These formations probably represent the Cambrian beds and Manitou limestone of the Pikes Peak folio.

For the same reason that the discussion of the geology of the Front Range area was introduced with the Pikes Peak folio, I will prefer the consideration of the Denver Basin monograph to accounts which preceded it in point of time.

In 1896 appeared Monograph XVII of the United States Geological Survey, by Emmons, Cross, and Eldridge, describing the geology of the Denver Basin. The map of areal geology shows what may be taken as the limits of this area. It is bounded on the south by parallel 39° 30′, its northern boundary being 3 or 4 miles north of the fortieth parallel. Its eastern boundary is about an equal distance east of longitude 104° 40′, and its western, the edge of the Archean mass of the Rocky Mountains, or approximately meridian 105° 20′ west. The oldest sedimentaries recognized are the Rocky Mountain Red Beds, which are described as the Wyoming formation. This consists of brilliant red conglomerates, sandstones, and shales, with thin limestones and gypsum in the upper part. The thickness exposed in the Denver Basin varies from 500 to 3,000 feet, but is generally somewhat under 1,500 feet. The variation, which relates chiefly to the lower beds, is accounted for as being due to the unevenness of the ancient floor upon which the formations were laid down.

"The formation is separable about midway into a lower division of soft, friable conglomerates and coarse sandstones with fine shale, and an upper one of shales, with some prominent sandstone bands, narrow beds of limestone, and small local deposits of gypsum." (Page 52.)

The lower Wyoming has below a mass, chiefly red sandstone and conglomerate, with a normal thickness of 1,200 feet, while the upper portion consists of the "creamy sandstone" 200 to 400 feet thick. The upper Wyoming contains in its lower half bright brick-red arenaceous shales and sandstone, with important intercalations of limestone. The strata above the limestone become more and more arenaceous, though still retaining in large degree their shaly nature.

"At 150 or 200 feet below the top of the Trias the strata become more clayey and take on a variety of irregularly distributed bright colors—gray, yellow, green, pink, and lilac. In this zone gypsum and brown earthy limestone are common." (Page 36.)

The Wyoming formation is succeeded by the Morrison, consisting essentially of fresh-water marls, and having an average thickness of about 300 feet. Its upper limit is sharply defined by the Dakota sandstone. Its Mesozoic age is positively determined by its contained saurian remains, and it is referred to the Jurassic. The age of the Wyoming formation is assigned, on somewhat indirect and conflicting evidence, to the Triassic.

The Wyoming formation is thought to overlie the Fountain formation described in the publication previously discussed, which is referred to the Carboniferous, and on this account a new name was given to the Wyoming beds. It is not improbable that the greatly varying thickness of the Wyoming formation in the Denver Basin may be due to the presence of local undifferentiated fragments of the Fountain series. The same suggestion is made by Emmons on page 19 of the monograph.

In 1901 Darton[a] read a paper before the Geological Society of America entitled "Comparisons of Stratigraphy of the Black Hills with that of the Front Range of the Rocky Mountains." This paper was never published except in abstract, in which form it appeared in the bulletins of the society and in Science. Speaking of the fine sections at Morrison, west of Denver, he says:

"There was found an extension of the Purple (Minnekahta) limestone of the Black Hills, having precisely similar stratigraphic relations in the Red Beds and containing some of the same Permian fossils, although these are scarce and not well preserved. The limestone was traced south for a considerable distance, and found to merge into a sandy bed, which was finally lost in the great mass of coarse, red deposits in the vicinity of the Garden of the Gods. Its very distinct occurrence at Morrison affords the means for a precise correlation with the Black Hills region. The underlying mass of coarse sandstones against the crystalline rocks represents portions, or perhaps all, of the Carboniferous formations of the Black Hills. The Red Beds overlying this Minnekahta limestone at Morrison are gypsiferous shales, similar to those of the red valley encircling the Black Hills."

The geologic position of the horizon containing Permian fossils mentioned by Darton is evidently in the Wyoming formation, and his characterization of the overlying beds as gypsiferous shales would indicate that it was in the upper division, from 200 to 300 feet below the top. Darton's correlation once accepted, the Paleozoic age of nearly the whole of the Red Beds of this area would be demonstrated, the Triassic being absent altogether or represented by a few hundred feet below the Morrison beds.

However, the character of the fossils upon which this correlation is based is not stated, so that it is impossible to pronounce upon the weight which should

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[a] Geol. Soc. America, Bull., vol. 12, 1901, pp. 478–479.

be given to it, and the fossils themselves can not be found. A small collection supposed to belong to the same horizon was obtained somewhat farther north, at Lyons, but it proves to be of little value in determining the questions at issue. It would be impossible to form from it a well-founded opinion as to whether the age is Mesozoic or Paleozoic. A minute gasteropod, resembling *Natica* or *Naticopsis*, was obtained, and some small pelecypods, suggesting by their shape several Paleozoic and Mesozoic genera. While on one hand the gasteropod is probably distinct from *Natica lelia*, with which one would first compare it, it is at the same time at present unknown in the Minnekahta fauna. The pelecypod also appears not to occur there. Though it may be the same as some indeterminable forms from the Black Hills, I believe, so far as the poor preservation justifies an opinion, that it is distinct. Paleontologic evidence, therefore, if given any weight at all in this instance, seems to be somewhat adverse to this correlation, which, based upon little but lithology and stratigraphic occurrence, can not under existing conditions be given unreserved acceptance.

Darton further says of the horizon from which he obtained fossils at Morrison that it was traced southward for some distance, until lost in the coarse sandstones of the Garden of the Gods. These sandstones, however, are supposed to represent the Fountain formation, and to occur stratigraphically entirely below the Wyoming, or to be equivalent to some of the lower beds included in it in certain sections.

One of the earliest reports which relate to the geology of Colorado, and perhaps the earliest whose scope and method give it real scientific value, was Hayden's account of the geology and natural history of the Upper Missouri.[a] This is the first of a number of papers from the pen of the same author in which the geology of this portion of Colorado is discussed, but the later ones mark but little advance, so far as the Paleozoics are concerned, over this earliest contribution. The map which accompanies this report, and the report itself, extend sufficiently far west to include the northern half of the Front Range in Colorado and its extension into Wyoming, though the chief field of observation was farther east. Hayden maps a continuous strip of Lower Silurian, Carboniferous, Permian, and Red Beds strata (which are here referred to the Jurassic) along the eastern flank of the Front Range from Laramie Peak southward to Pikes Peak. Of the existence of these series to the north and east Hayden had more or less satisfactory paleontologic evidence. Their identification along the Front Range was influenced by the idea that the sequence there was complete and unbroken, and was in most cases dependent upon similarity in lithologic characters or evidence still less appreciable.

The Lower Silurian of the Front Range is apparently the red sandstone and limestone underlying the fossiliferous Carboniferous limestones which play out just south of Colorado's northern line. King,[b] it will be remembered, later compared

[a] Am. Phil. Soc., Trans., vol. 12, n. s., 1863, pp. 1–219.
[b] U. S. Geol. Expl. 40th Par., Rept., vol. 1, 1878, p. 129.

these strata with the "Primordial" of the Black Hills, and tried to correlate them. Hayden's Carboniferous, a series of calcareous, areno-calcareous, and arenaceous beds said to occur on both sides of the Rocky Mountain Divide, probably includes the fossiliferous strata already mentioned. His Permian color, I think, must have been introduced on general principles without, it may be, his having any definite beds in mind, and certainly without any definite evidence of their Permian age.

Regarding this same area, Hayden writes in 1868:[a]

"At the head of Pole Creek on the eastern margin and in the Laramie Plains west, the Carboniferous rocks are mostly of a red arenaceous character, with a few layers 2 to 10 feet in thickness of whitish or yellowish limestone. From these limestones I collected *Productus prattenianus*, *Athyris subtilita*, and other well-known Carboniferous forms. Above these red beds which contain intercalated beds of limestone is a considerable thickness of purely red arenaceous beds, but in studying all these rocks with some care from Pole Creek nearly to Pikes Peak, I could not separate the red beds from the Carboniferous by any break in continuity, and I was rather inclined to the opinion that inasmuch as a large portion of the gypsiferous or variegated beds could be shown to be Carboniferous they might possibly all be included in that period."

In 1869 Hayden[b] made an extended and apparently a hasty trip chiefly along the eastern edges of the Rocky Mountains from Cheyenne, Wyo., as far south as central New Mexico. His observations deal in large measure with the eastern margin of the Front Range, but as they appear to be inaccurate in many particulars, and have been duplicated by the more detailed work of later geologists, I have made no serious attempt to compare or to harmonize them with known facts or present systems of classification. Hayden recognized the general absence of Paleozoic outcrops along the Front Range, and refers the Red Beds to the Triassic, with the reservation that they may in part be Jurassic.[c] But he is by no means consistent in maintaining this opinion, even in the course of the single paper under consideration, for, after citing a limestone with an undeniable Carboniferous fauna from the line of the Union Pacific Railroad just north of Granite Canyon,[d] he says that near Park station are some dull-purplish sandstones and pudding stones "which are probably of Carboniferous age,"[e] while to the same period he assigns a considerable thickness of limestone observed on Boxelder Creek in association with red Triassic sandstones.[f] The last two localities are in Colorado, but the first is in Wyoming. On the other hand, on page 126, the statement occurs:

"I do not know of any portion of the West where there is so much variety displayed in the geology as within a space of 10 miles square around Colorado City. Nearly all the elements of geological study revealed in the Rocky Mountains are

[a] Am. Jour. Sci. (2), vol. 45, 1868, p. 324.
[b] See U. S. Geol. Geog. Surv. Terr., First, Second, and Third Ann. Repts., 1873, Third Ann. Rept., pp. 103–251.
[c] Ibid., p. 113. [d] Ibid., p. 111. [e] Ibid., p. 118. [f] Ibid., p. 120.

shown on a unique scale in this locality. The same may be said, though in a less degree, of the valley of the Arkansas as it emerges from the mountains near Canon City. I am inclined to believe that it is only in these localities that rocks older than the Triassic or Red Beds are shown along the eastern flanks of the mountains south of Cheyenne. I have looked in vain for a single exposure of well-defined Paleozoic strata from Big Thompson to Colorado City, a distance of over 100 miles. I am now convinced that in the North the Paleozoic rocks are often concealed for long distances, although I have usually represented them by colors on a geological map by continuous bands along the mountains. That they exist continuously along the eastern margins in Colorado and New Mexico I can not doubt, but only at these specially favored localities do they appear from beneath the Triassic or Red Beds. They are, however, far more frequently exposed farther northward, and I think much more largely developed."[a]

Yet a little beyond, on page 133, he mentions the Jurassic Red Beds and the Paleozoic sandstone as occurring in Boulder Valley.

The actual presence of the older Paleozoics at several points along the Front Range was recognized by Hayden, as is seen in the passages above quoted. It is to one of these occurrences that he refers on page 144, without assigning any geologic age. On pages 145 and 148, however, he cites Carboniferous beds at Camp Creek Canyon and at Oil Creek. From the geographic position of these occurrences, and from the fact that practically all the Carboniferous along the Front Range, if Carboniferous at all, consists of Red Beds, which Hayden places in the Mesozoic, and from other associated circumstances, it is fairly certain that the rocks mentioned in all three instances are Ordovician.

In 1868,[b] referring to the Red Beds of Colorado and Wyoming, Hayden expresses the belief that their lower portion is of Carboniferous age, and that it is quite possible that a portion is Triassic, while the yellow, gray, and rusty sands and sandstone above are Jurassic. This was a preliminary statement prepared immediately after the field work which furnished the material for the report above quoted.

In his annual report for 1874 Hayden[c] again takes occasion to describe the geology of the Front Range. "Up to this time," he says, "we have determined the existence, in this belt in Colorado, of the Silurian, Carboniferous, Triassic (?), Jurassic, Cretaceous, and Tertiary groups; yet, while the more modern formations are very persistent throughout the entire distance from the north to the south line, some of the older beds are wanting in many places." From Fort Laramie to Colorado Springs, a distance of over 200 miles, no Silurian beds were recognized, with the possible exception of the variegated sandstones which lie next to the granite at Pleasant Park.

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[a] Essentially the same view is expressed in different language on page 139.
[b] Am. Phil. Soc., Proc., vol. 10, 1868, p. 474.
[c] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, pp. 19–58.

Hayden speaks in some detail of the sections at Colorado Springs and Canyon, referring to the Silurian, at the latter, the sandstones at the base of the section, and 600 to 800 feet of limestones lying above. The thickness in the latter case is probably erroneous, for in Peale's section at Glen Erie there are only 300 feet of beds which are, with any probability, Silurian. Hayden compares the sandstone at the base of the section at Canyon with "the Potsdam sandstone as seen in other localities farther to the north." But the sandstone at Canyon is Ordovician in age, and not Cambrian. "This sandstone passes up into a hard and rather massive limestone, evidently the same as that noted at Colorado Springs." This correlation is a very natural one, but at the same time is probably incorrect, for the limestone at Canyon, what part of it is not Carboniferous in age, is the Fremont limestone, of which Cross states that it has not been recognized in other sections along the east base of the mountains.

Of the Carboniferous he speaks in a general way, touching chiefly upon its distribution. He says:

"The Carboniferous group is a little more persistent, and yet this seems to be wanting over extended intervals unless a portion of what have been called the Red Beds is of this age. This group is extensively exposed along the flanks of the mountains 100 to 150 miles north of Cheyenne, as was shown in the annual report of 1870. It seems, however, to diminish somewhat in force and to contain comparatively few fossils in its southern extension until we reach Cañon City. From thence southward into New Mexico it increases again in thickness and importance, and yields an abundant supply of its characteristic fossils."

The Red Beds he refers to the Triassic, with some admitted uncertainty on account of the general lack of fossils. This group, he says, "is very persistent, and if absent at all, only at very short intervals." "Geographically, it is one of the most widely distributed formations in the West. From the northern boundary to the southern line and east of the Wasatch Range in Utah this red formation makes its appearance wherever a mountain range is elevated so as to expose the various sedimentary groups. The evidence indicates that it extends without any important interruption over the broad area as defined above." He states that this series varies in color from a pale, dull tint to a deep purple, in texture from a rather coarse conglomerate to a fine sandstone, and in thickness from 400 feet to 2,000 feet. He remarks (page 43) that he formerly held the view that the elevation of the Front Range was a single event and comparatively modern, and that the changes in the position of all the groups were brought about by the same cause and at the same time. "There could not be a strict conformity in the sedimentary groups, inasmuch as entire groups are wanting, and in some cases only fragments of others are remaining." "We now have the evidence, from the texture of these Red Beds and their position on the underlying granitic rocks, that the Front Range, during the supposed Triassic period, formed a vast shore line, and that the sediments of the Red Beds were deposited upon the base against the sides of the granitic range." It seems probable, indeed, that this condition has been one of periodic occurrence, and that the Front Range represents a line of permanent weakness which has been repeatedly elevated, denuded, and submerged.

Peale's district for 1873[a] includes, besides other territory west of this, the Front Range from the South Platte to Colorado Springs. Important detailed sections were made on the South Platte, through Pleasant Park, and at Glen Erie, and four others of almost equal interest were described from Trout Creek. The strata in the Front Range sections are classed as Silurian, Carboniferous, Triassic, Jurassic, and Cretaceous.

The southern part of the Trout Creek or Manitou Park Paleozoic area is included in the northern part of the Pikes Peak quadrangle, which in its southern portion embraces a larger area of the Paleozoics about Canyon. In the section given by Cross for that portion of the Manitou Park area included in the Pikes Peak quadrangle, the Ordovician, as we have just seen, is represented only by the Manitou limestone, and the Carboniferous by the Fountain formation. The four sections given by Peale deal only with the strata which underlie the Red Beds, or Fountain formation, which are mapped as Triassic, and therefore only with the Cambrian rocks and the Manitou limestone. The Millsap limestone apparently is entirely lacking, and the Hayden atlas shows no Carboniferous color in this area. The Cambrian is shown by Peale's sections to be considerably thicker here than in the Pikes Peak quadrangle. It consists of yellow, purplish, pink, and green sandstones, reaching a thickness in one case of 80 feet, from which Cambrian fossils (*Obolus* and *Lingulepis*) were obtained. The Manitou limestone contains red, white, and pink limestones, attaining in one instance a thickness of 130 feet. A well-characterized Ordovician fauna was obtained from them.

In the section made at Glen Erie, whose outcrops are all but connected with those of the Manitou Park area, the best-characterized bed is that numbered 13, which by reason of its fossils, its character, and its position clearly belongs to the Manitou limestone. With it can probably be associated the 26 feet of variegated calcareous beds next below, as indicated by Peale, while the sandstones forming the base of the whole section are probably Cambrian. Above bed 13 follows 279 feet of gray, purplish, and yellowish limestone, unfossiliferous and not otherwise differentiated. From the fact that there is no fossil evidence indicating that any portion is of Carboniferous age, and that the Millsap limestone, so far as is known, is absent from the Manitou Park area, this entire thickness may be regarded as belonging to the

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 193–273.

Manitou limestone. On the other hand, the horizon of the Millsap limestone is certainly present at Pleasant Park, and its occurrence in this region is too fickle to admit of a strong presumption based upon its presence or absence in neighboring areas.[a] The Trias belongs to the Fountain formation or to the Fountain and Wyoming combined, and the Jurassic has the characters of the Morrison formation.

Considering next the section through Pleasant Park and comparing it with that of the Pikes Peak quadrangle, a convenient point of departure is found in bed 8, which, with but little doubt, belongs in the Millsap limestone. It is impossible at this distance and without further information to reach a conclusion as to whether the beds below this horizon are all Carboniferous, as Peale has it, or in part earlier Paleozoic. The 80 feet of white sandstone at the base of the section, and the other sandstones above, in position and character are so like the Cambrian of the Glen Erie section as to suggest to my mind that perhaps they are equivalent beds. However, the fact that this correlation did not recommend itself to Peale, who was personally acquainted with the sections, is an impeachment of its correctness.[b] At all events in the fossiliferous, calcareous stratum (bed 8), and probably in the thin limestone just below, we are assured, all things considered, of an equivalent of the Millsap limestone and the presence of Lower Carboniferous sediments. The Triassic of the Pleasant Park section probably represents the Fountain formation in part and in part the Wyoming. The Jurassic corresponds to the Morrison formation, and the massive sandstone which overlies it, "No. 1 Cretaceous," as it is called, to the Dakota sandstone. The thickness of the Red Beds is here about 1,500 feet. This is about the average thickness of the Wyoming formation, which was described from the area of the Denver Basin, near by. But the Fountain beds also are known not far off, in the northeast corner of the Pikes Peak quadrangle. Lee refers part of this series to the Carboniferous and correlates it with the Fountain formation, while the portion which he calls "Trias," though not accepting this as its true geologic age, probably finds its equivalent in the Wyoming formation.

Section No. 1 of Peale's report, which was taken on the south side of the South Platte River, comprises about 4,000 feet of strata referred to the Triassic, Jurassic, and Cretaceous. The Triassic, which here rests immediately upon the granite, consists of from 1,500 to 2,000 feet, chiefly of red and red and white sandstones, and 600 feet of white sandstones overlying them. The locality where this section was made is probably just included in the southwestern corner of the Denver Basin. There can be little doubt that the Dakota sandstone of the Denver monograph is

[a] Mr. A. W. Grabau has recently informed me that he has collected a Carboniferous fauna from the upper portion of this limestone. It is not probable that this is an Upper Carboniferous limestone, and the conclusion seems safe that it represents the Millsap formation. Whether the entire thickness belongs to the Millsap or the lower part represents the Manitou limestone can not be ascertained.

[b] Hayden, however, suggests the same thing, for he writes, remarking upon the Calciferous group: "It is possible that in Pleasant Park, about 50 miles south of Denver, there are traces of this formation in the variegated sandstones that lie next to the granites, as shown in the section." (Ann. Rept. for 1874, p. 41.)

the basal member of Peale's Cretaceous (bed 7). Beneath this, in Peale's section, is a space estimated at 600 feet, a portion of which only is equivalent to the Morrison formation, as the latter has an average thickness of but 200 feet. The remainder and major portion of Peale's Jurassic, and his Triassic, having a maximum aggregate thickness of 3,100 feet, must be included in the Wyoming formation. The heavy bed of white sandstone (No. 14) forming the top of Peale's Triassic is probably the "creamy sandstone" which constitutes the upper member of the lower Wyoming. The Wyoming formation is referred to the Trias in the Denver Basin monograph, but, as already pointed out, in view of the great variation in thickness of the lower member, especially if the Fountain formation does occur as near as at Perry Park, it seems probable that the heavier sections of the Wyoming may include at their base portions of a distinct series, most likely the Fountain beds. This has been suggested also by Emmons, one of the joint authors of the Denver Basin monograph.

The beds here at the base of the section resemble those in Pleasant Park similarly situated. The latter, I suspect, may prove to be Cambrian, and the resemblance noted suggests the possibility that the base of the section here also may be of Cambrian age. The Millsap limestone, if the name may still be applied at Pleasant Park, had there thinned to complete insignificance, and if absent altogether the Red Beds of the Fountain formation would rest immediately upon the basal sandstones. It seems more probable, however, that the whole early Paleozoic section is here missing.

In a recently published paper W. T. Lee[a] describes the areal geology of the Castle Rock region. Except for the Red Beds, the only Paleozoics described occur in Perry Park. No detailed section is given and the characters of the geologic sequence described may be condensed as follows: The only Cambrian outcrop occurs 6 miles south of the area mapped, near Deadmans Creek. It is a deep-red quartzite 25 feet thick and corresponds in character and stratigraphic position with a similar quartzite in Manitou Park referred to the Cambrian in the Pikes Peak folio. Above the red quartzite appears a series of cherty limestone layers interstratified with red clay. Some obscure brachiopods, identified as *Dalmanella testudinaria*, indicate that the age of this bed is Ordovician.

The Carboniferous is thus described:

"At the base of the formation occur 40 feet of coarse-grained, crumbling sandstone, conglomeratic in places and mottled in varying shades of red and gray. Above this sandstone is a series, 10 to 15 feet thick, of deep red to white cherty limestone in layers, alternating with red shale. Near the top of this series is the fossiliferous seam. Above is a series of several hundred feet of coarse-grained

[a] Am. Geol., vol. 29, 1902, pp. 96–109.

sandstones and conglomerates, which appear to be perfectly conformable with the fossiliferous series. They are colored irregularly in various shades of red and gray to an extent which gives the series a conspicuous mottled appearance. The gray predominates near the base. From thence upward the red becomes prominent and the series passes gradually into the so-called 'Trias'—the Red Beds. No line of demarkation was found between this formation and the Trias."

The fossils mentioned, together with a series collected by Whitman Cross, are discussed in the paleontologic portion of the present paper. Of the Carboniferous age of this fauna there can be no doubt, and it can safely be referred to the Lower Carboniferous. The upper portion of Lee's Carboniferous section he correlates, by stratigraphy and lithology, with the Fountain beds of the Pikes Peak quadrangle, and the opinion seems to be entertained that by this series, together with the typical Red Beds into which it graduates, the Carboniferous and Permian, as well as the Triassic periods are represented. A nearly vertical series east of the park undoubtedly belongs to the Red Beds proper (Lee).

The relation of the beds in Lee's map is such as to indicate an unconformity by overlap of the Red Beds, which seem to be the Wyoming formation of the Denver Basin area, upon the supposed equivalent of Cross's Fountain formation.

Peale's section in Perry Park, or Pleasant Park, as it appears to have been called at that time, must include the same strata described by Lee. Peale refers all the lower part of the section down to the granite to the Carboniferous, as does Lee, but I inclined to identify as Cambrian the sandstones at the base of his section, founding the opinion upon the resemblance in lithology and position to strata in other near-by sections from which he reported Cambrian fossils. Hayden also suggests the possibility of the view held by me. All the lower part of Peale's section below the Red Beds seems to be equivalent to Lee's Carboniferous (except the part supposed to represent the Fountain formation). The fossiliferous limestone at the top in each case is the Millsap limestone. Of this, Peale cites 9 feet, and Lee 10 to 15 feet. As occurring beneath the limestone, Peale mentions 105 feet of red, white, and purplish sandstones, while Lee finds 40 feet of red and gray sandstones. The differences so far noted are not important, and doubtless result from the two sections not having been made at the same exposures. The sandstones in Peale's section, however, rest on granite, while in Lee's section one would infer that they were underlain by the Ordovician limestone already referred to. The Ordovician limestone, however, appears not to have been found in the Castle Rock quadrangle, but to have occurred with the red Cambrian (?) quartzite south of the area mapped by Lee.

Several interesting possibilities present themselves. The most probable is that the sandstones under the Millsap limestone are really not Carboniferous, but Cambrian, and that the place of the Ordovician limestone is not below but above them, the limestone itself having been cut out by the erosion by which the Millsap limestone is known to have been preceded. If Lee is correct in placing the Ordovician beneath the sandstone, the latter either belongs with the Millsap, as Lee and Peale have it, and is a new element introduced into the formation, or else it represents the Harding sandstone, the Ordovician limestone in all probability being the Manitou. This seems to me altogether improbable, as the Harding sandstone appears to be wanting north of Garden Park.

Peale's Trias, of course, is the more or less precise equivalent of Lee's Red Beds, including also the sandstones and conglomerates lying above the Millsap limestone, which he places in the Carboniferous. The raison d'être for the introduction into literature of the name Wyoming appears to have been that it was supposed to be Triassic and of later geologic age than the Fountain formation which Cross provisionally referred to the Carboniferous. Although in the Pikes Peak quadrangle the Fountain beds are followed by the Morrison formation, east of the Pikes Peak area the Wyoming formation is supposed to intervene. As Perry Park is intermediate between the Denver Basin and the Pikes Peak quadrangle, and as the Red Beds there seem to have the characters of the Fountain formation in the lower part and of the Wyoming formation in the upper part, it seems not improbable that the distinction made by Lee is correct. The Wyoming and Fountain formations and their supposed equivalents in other areas have the appearance of being continuously deposited, but the evidence of overlap here and in the Dolores River region seems to prove that this was not the case.

The area immediately north of that surveyed by Peale in 1873 was examined by Marvine[a] the same year. This, the Middle Park division, contains no beds referred by him to the Carboniferous or even to the Paleozoic, but as I regard the Red Beds which he maps as, Triassic as possibly Carboniferous in age, his remarks upon that division are germane to our study. The area embraced by the Middle Park division is included between parallels 39° 30′ and 40° 20′ north latitude and meridians 104° 45′ and 106° 30′ west longitude. It contains three topographic and geologic areas, the plains, the mountains, and the park, but it is only in the plains skirting the mountains that any of the so-called Triassic beds occur. They are there continuous with the series which Peale describes under the same name, and they extend without break to the northern limit of the Middle Park district. Their occurrence here differs both from the exposures to the north in Wyoming and those to the south in Peale's district in having no recognized Carboniferous beneath, resting directly upon the smoothed but uneven surface of the granite. The Red Beds vary in thickness in this area from over 1,600 to 2,000 feet down to 400 feet. The thinnest sections are found a few miles north of Golden, from which point the series thickens rapidly to the north and to the south. The color is for the most part a dark red, though in

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 83–192.

some places lighter colors predominate. In texture the rock is a sandstone with coarse grits and shaly layers. Though conglomerates may occur anywhere in the series, they are mostly confined to near the base, where they are often plainly derived from the subjacent rock. In this series, and in the Jurassic above, no fossils of any sort were found.

The area of Marvine's district completely embraces that of the Denver Basin monograph, and Marvine's Triassic and Jurassic in a general way correspond to the Wyoming and Morrison formations of the latter. Marvine's district also adjoins Peale's on the south, and from the uniformity in the thicknesses assigned to the Triassic and Jurassic by the two authors in their respective areas,[a] it seems that the same limits were adopted by both for these formations. As, in the case of Peale's Jurassic, it was found that only the upper portion belonged in the Morrison formation, as defined in the Denver monograph, so it seems necessary to assign to the Wyoming formation the lower part of Marvine's Jurassic, to which he gives a thickness of 770, 660, 870, and 400 to 500 feet in different sections, while the Morrison averages but 200 feet. As I have had occasion to remark in connection with Peale's report and the Denver monograph, the great variations in the thickness of the Wyoming formation as measured at different points may be due to the presence and inclusion of local undifferentiated remnants of the Carboniferous Fountain beds.

It is too well known to require repetition that the field of observation of the King survey was along and chiefly to the north of the fortieth parallel, and that it included a strip quite across the State of Colorado whose northern boundary is the forty-first parallel. Within this occur two areas of Paleozoic outcrop. One of these is found in the Uinta Mountains and their outliers; the other consists of two narrow strips—one on the east, the other on the west side of the Front Range. The report of this survey as it relates to the Uinta Mountains has been discussed elsewhere. I will here consider its discussion of the Paleozoics along the Front Range. It might be added, however, that, instead of the original descriptive account by Arnold Hague, I have considered especially the summary report by King,[b] in which much the same facts are presented in a more convenient arrangement.

The beds referred to the Paleozoic by King on the east side of the range begin just south of the forty-first parallel, but on the west side they do not come in until some distance north of it, and therefore are not strictly within the limits of my paper; but as their northern continuation bears somewhat upon the construction to be placed upon the succession farther south, I will summarize King's remarks upon them.

King's discussion, unfortunately, begins with a misstatement of fact, which, though unimportant, nevertheless stands open to correction. He says: "In Colorado

[a] In the South Platte section, as I have already had occasion to quote from Peale, the thickness of the Trias is from 1,500 to 2,000 feet.

[b] U. S. Geol. Expl. 40th Par., Rept., vol. 1, 1878, pp. 127–139, 249–259.

Range, between Colorado Springs and latitude 41°, the lowest sedimentary rocks found in contact with the metamorphic Archean series are sandstones of the Triassic age." In fact, however, the Hayden maps show Carboniferous rocks at the head of West Plum Creek, north of Colorado Springs, and there is reason to believe that some of the Paleozoics still exist in the canyon of the South Platte.

On the east side of the range, according to King, except for Tertiary overlaps, there is a continuous chain of Paleozoic outcrops from the headwaters of Boxelder Creek for 70 miles northward. Here the total Paleozoic series is limited to 850 feet. Of this the lower 150 feet consist of red limestones and a reddish sandstone of varying fineness. The upper portion consists of gray and blue arenaceous limestone and calcareous sandstone. At the base of the upper division Upper Carboniferous fossils occur. The species cited are *Productus cora*, *Productus semireticulatus*, and *Seminula subtilita*. King compares the rocks of this area, both as to lithology and to sequence, with those of the Black Hills, and comes to the conclusion that the lower series here is the same as the Primordial of that area. He believes, indeed, that into the 150 to 200 feet of beds below the horizon bearing Coal Measure fossils is condensed a complete and conformable series of all the sedimentation of Paleozoic time prior to the Upper Carboniferous. He says (p. 129): "Although we have actually found no fossils in this horizon [the lower division], we feel the greatest confidence in asserting that the whole Paleozoic series, from the Primordial to the Triassic, is here compressed within the 850 feet." And again (p. 132): "It may be predicted that sooner or later the missing horizons between the Trias and the Cambrian are likely to be in large part discovered, for in an ocean in which undisturbed deposition took place from the beginning of the Cambrian to the close of the Mesozoic age no great period of time would be likely to elapse without sedimentation, and it is to be predicted that one after another the now missing main horizons will be identified, even if reduced to extreme thinness." And also (page 138): "Although they are barren of fossils, from the downward sequence of beds, we have no doubt whatever that the red sandstones, conglomerates, and quartzites underlying the Carboniferous limestones belong, as we have correlated them, with the Primordial of the Black Hills and Colorado Range. On the east side of Laramie hills the Paleozoic series reaches its greatest compression, namely, 800 feet in thickness. There is absolutely no unconformity from the base to the summit. Therefore in this thin deposit is represented all the time from the Cambrian to the Trias, and yet organic life is only represented by types of the Coal Measure epoch and the Permian."

This hypothesis hardly deserves consideration at this day, but it is possible that the lower beds of the section may be, as claimed by King, pre-Carboniferous. Possibly the apparent nonconformity by overlap, cited by King, from the south branch of Crow Creek, by which the lower part of the section is missing and the upper is in contact with the Archean, should be regarded as evidence favorable to this view. But the strata at this point have a nearly vertical position, and this circumstance suggests that the thinning of the series here may be due to structural causes. The fact that King compares the compact conglomerate, which is the lowest bed exposed, with one "which is interstratified far up in the limestone, as seen at various points on the western slope," would seem to indicate that if an actual overlap the horizon of transgression does not coincide with the top of the lower of the divisions recognized by him, but took place at a higher level. On the whole, I am disposed to consider it more probable that the lower beds belong to the same series as the upper and that all are of Pennsylvanian age. The paleontologic evidence necessary to settle this point one way or the other is as yet unfortunately wanting.

"Along the west flank, as already mentioned, the series makes a continuous outcrop from the northern limit of the map to a point 2 miles north of the Pacific Railroad, where it is overlapped by the conformable red Trias." "Always next to the Archean series occur the red sandstones, which we correlate with the Black Hills Primordial, presenting toward the east a rather abrupt, but low, mural outcrop." Here, however, a greater thickness of the whole series is developed than on the eastern side of the range, for it contains beds amounting to 1,200 feet. "On the western side no fossils were obtained from the uppermost members, but distinct Coal Measure types were obtained within 200 feet of the base." The species, which are the same as found to the east, consist of *Productus semireticulatus*, *Productus costatus*, *Productus cora*, *Seminula subtilita*, *Bellerophon* sp., and *Orthoceras* sp. Much the same series, apparently, occurs at several points in the Medicine Bow Range, but at Rawlins Peak is one which rather suggests that in central Colorado. At the base is about 700 feet of gray and white quartzites and sandstones, the uppermost bed being a ferruginous sandstone 15 feet thick. These are suggestive of the Sawatch quartzite. The drab lithographic and white siliceous limestone next above may possibly represent the Yule limestone, while the dark blue, earthy limestone with *Pleurophorus oblongus* and *Productus*, both as to color, position, and fossil content, shows points of resemblance with the Leadville limestone, in which Whitfield identified *Pl. oblongus* at Leadville.[a] The gap of 500 feet not far above, which is supposed to be largely made up of calcareous and argillaceous beds, possibly represents the Weber formation. "Above this is another gap, without outcrop, of 400 feet, limited above by the distinct and characteristic Triassic beds."[b] Apparently in the Triassic near its base was found the species *Natica ? lelia*, which King believes to indicate the top of the Permian, but which is now generally placed in the Mesozoic. Considered by itself, this species can hardly be allowed much diagnostic force, and from this locality, at all events, no associated fauna is known.

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 66.

[b] U. S. Geol. Expl. 40th Par., Rept., vol. 1, 1878, p. 137.

King seems to take it for granted that the siliceous bed at the base of the Rawlings Peak section is the same as that occurring in a similar position on the flanks of the Laramie Mountains, but as the latter consists of red sandstones and red limestones, and the former of whitish quartzite without any limestone at all, there seems to be room for skepticism. If my conjectures prove at all true, the geologic ages of the two are entirely different.

As previously noted, south of the forty-first parallel, the strata bordering the Archean nucleus and resting upon it belong to the well-known Rocky Mountain Red Beds of supposed Triassic age. Locally, at several points south of this parallel, and more generally north of it, the Red Beds are underlain by strata of recognized Paleozoic age. King states that the relative position of the Red Beds and Paleozoics is one of conformity, but from the marked overlap of the Red Beds, it seems clear that the conformity can be only apparent.

"The beds along the southern limit of the map, bordering the Big Thompson and the Cache la Poudre, attain a thickness of 800 to 850 feet, thinning thence northward and reaching a minimum in the region of Horse and Lodgepole creeks, where they scarcely attain 300, but thickening again in the region of Chugwater and Bush creeks to nearly 700 feet.

"On the western borders of the range the conditions thus sketched are repeated. North of the Union Pacific Railroad the soft, easily eroded beds of the Trias, varying from 400 to 800 feet in thickness, rest directly upon the uppermost limestones of the Coal Measures. South of the railroad the Trias overlaps, and, as on the eastern side of the range, comes in contact with the Archean.

"Taken as a whole, and with the exception of the gypsum and limestone beds, which nowhere within our field of observation exceed 40 feet in thickness, it is essentially a sandstone series, for both clays and shales are exceedingly arenaceous, and the dominant color is a brick red for the lower half of the series, and variable lighter reds, pinks, and yellowish reds for the upper half. While this division of color holds good in general, it is often varied by extremely brick-red, almost vermilion-colored, beds appearing near the top, and light ones intercalated in the region of the heavy red lower strata.

"The Red Beds of Colorado Range have thus far yielded to our search no organic remains, saving obscure pieces of half-petrified, half-carbonized wood, which crumbles on exposure to the air, and displays no characteristic structure."

The distribution of the Triassic, so far as concerns the region discussed by King, consists chiefly of two strips, one on the eastern and the other on the western side of the Colorado Range, of an area of outcrops at Elk Mountain at the northern extremity of the Medicine Bow Mountains, of another at Rawlins Peak, of a bordering of outcrop on both sides of North Park near its northern end, and of one on both sides of the Uinta Mountains. In North Park the thickness is nearly 1,000 feet, and in the Uinta Mountains in the region of Vermilion Creek it is 2,000 feet.

It seems probable that this upper brick-red series is the Wyoming formation of the Denver Basin area, while all the series between it and the Archean, part of which contains Carboniferous fossils, may be the equivalent of the Fountain formation.

Because of their stratigraphic position and of the lack of fossil evidence as to the age of the Red Beds (by which term is here designated the upper or "Mesozoic" portion), King, as we have seen, refers them to the Trias.[a]

Quite recently W. C. Knight[b] reported the discovery of a Carboniferous fauna in the Red Beds of Wyoming. The locality is near Red Mountain, on the Colorado line, in the Laramie quadrangle, where the King atlas represents the Triassic as overlapping the Carboniferous and resting upon the granite. The horizon is about 725 feet above the base of the series, whose whole thickness is given as 1,578 feet. Knight states that the calcareous beds which King maps as Carboniferous a little farther north do not in reality underlie the Triassic series of Red Mountain, but, merging into it, are equivalent to its lower portion. He remarks on page 420:

"Just what proportion of the Red Beds will be equivalent to the limestones has not been determined, but probably not less than 500 feet of the strata near the Colorado line will correspond to limestones and light-colored sandstones some 15 or 20 miles to the northward, and possibly a greater thickness."

Of the Carboniferous age of the fauna found at Red Mountain it is impossible to entertain a doubt, but one may not draw from this occurrence any strong inference as to the age of the beds above, of the "Triassic" series farther north, or of the Wyoming formation of the eastern flank. A question may well be raised, however, as to the existence of the series consistently called "Triassic" by King and other authors; or, in other words, since the lithologic characters which locally distinguish the Carboniferous and "Triassic" beds break down within so short a distance as 20 miles, leaving the series uniform and indistinguishable, whether there is sufficient evidence to warrant separating 800 feet at the top and placing so important a division line as that between Paleozoic and Mesozoic in the midst of so thin and uniform a series. The consideration of this question is bewildered through the lack of paleontologic data or of refined stratigraphic evidence, of which we have some, but far too little. However, the Red Beds, including the so-called "Triassic," of this general area may prove to be Carboniferous, as suggested by Knight; but a closely similar case may be instanced in the Rico and Dolores formations of the San Juan region, where fossils seem to demand a division.

Probably the first account of the Paleozoics about Canyon is to be found in Ruffner's report on a reconnaissance in the Ute country, published in 1874.[c] Hawn's description contained therein amounts to little more than a mere mention of

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 1, 1878, p. 249

[b] Jour. Geol., vol. 10, 1902, pp. 413–422.

[c] Ruffner's Rept. Recon. in the Ute Country, 43d Cong., 1st sess., House Ex. Doc., No. 193, 1874.

the beds, without any attempt to determine their age. He says: "On descending again later in the day we met heavy formations of limestone dipping at nearly every angle and crowning some of the high foothills. These strata are hard, cherty, massive, and compact. They soon disappear with a general dip toward the east. We then pass on to thick beds of conglomerate ferruginous oxides, cementing rounded pebbles and water-worn bowlders." (Page 81.) The heavy limestones can probably be safely identified with the Ordovician and Mississippian limestones, which have subsequently been named the Manitou, Fremont, and Millsap formations. The conglomerates are possibly the Fountain beds. On page 81 fish remains are cited from Canyon, and it seems probable that they were derived from the horizon their occurrence in which has caused especial interest to attach to the Ordovician of this locality.

In 1876 S. G. Williams published a section along Oil Creek from the head of Oil Creek Park to the Arkansas River.[a] The essential portion of this section lies within the limits of the Pikes Peak quadrangle, and it is possible to identify Williams's formations with some accuracy. The whitish limestone at the base of his section (No. 1) is, with little doubt, the Fremont limestone. Fifty feet were measured and the bottom not seen. The mottled marble above (No. 2), 15 feet thick, is the Millsap limestone of Cross. The three red sandstones overlying (Nos. 3, 4, and 5), which have a combined thickness of 1,140 feet, can be no other than the Fountain formation. Williams says:

"Nos. 1 and 2 are probably Carboniferous; rocks holding the same relative position in the Arkansas Canyon, and from which I have fossils, are certainly of that age."[b]

If my correlations with Cross's section are correct Williams is of course mistaken as to the age of his lowest bed.

In 1892 C. D. Walcott described the geologic section at Harding's quarry, about 1 mile northwest of Canyon.[c] He distinguishes, describes, and names the Harding sandstone series and the Fremont limestone series. The former included beds 1(a to f); the latter, beds 2, 3, 4 (a–c), and apparently 5 of his section. Fossils of Ordovician age were found in 1c and a few in 1b, just below. The latter are indecisive, but probably indicate the same age. Bed 4c contains a large and varied fauna of the Trenton type. Bed 5 consists of impure variegated limestone with interbedded sandstones and argillaceous shales, and has a thickness of from 15 to 30 feet. It contains a few species of fossil Brachiopoda which are correctly assigned to the Carboniferous. It thus appears that probably the whole of this section except its upper

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[a] U. S. Geol. Geog. Surv. Terr., Bull., vol. 1, 2 ser., 1876, pp. 249–251.
[b] Ibid., p. 249.
[c] Geol. Soc. America, Bull., vol. 3, 1892, pp. 153–172.

bed is of Ordovician age. There seem to be no traces of the Silurian and Devonian groups.

Comparing this section with that in the Pikes Peak quadrangle near by, we find both the Harding sandstone and the Fremont limestone recognized as such, Cross having adopted the names from the Canyon exposures. Bed 1a of Walcott's section rests directly upon gneiss and schist, while in the Pikes Peak quadrangle, beneath the Harding sandstone, is found another limestone formation, named the Manitou limestone, and an inconsiderable thickness of Cambrian. The Cambrian and part of the Ordovician, therefore, seem to be missing in the Canyon section.

The propriety is somewhat doubtful of including in a single formation beds of geologic age as diverse as Ordovician and Carboniferous, and Cross has therefore distinguished the Carboniferous portion of the original Fremont under the name of the Millsap limestone.

In the third volume of the Wheeler Survey is a report by Stevenson, in which the geology of a large portion of Colorado is described.[a] Carboniferous is reported in a number of areas. Neither Silurian nor Carboniferous rocks are recognized along the Front Range, however, and the opinion is expressed that their western outcrop is far to the east of the base of the mountain, deeply buried under the more recent formations.[b] The series of red sandstones and conglomerates which was observed from Golden to the Greenhorn Mountains this author refers to the Triassic. At Beaver Creek, a few miles northeast from Canyon, a thickness of 2,700 feet is ascribed to it. At Manitou a bed of shale and another of limestone were observed at the base of the Triassic, and the suggestion was put forward that they might be Carboniferous. The Triassic is said to be unconformable with the overlying Jurassic, which is in turn conformable with the Cretaceous. The Jurassic on Oil Creek near Canyon consists of light-colored sandstones and shales, amounting in all to about 120 feet, overlying a limestone.

Stevenson's Jurassic corresponds in geologic position, lithologic character, and thickness with the Morrison formation. His Triassic appears to include in different sections now the Wyoming formation, now the Wyoming and Fountain, and again only the Fountain formation. Beaver Creek, the point at which he records an estimated thickness of 2,700 feet of Triassic strata, is in the extreme southeastern corner of the Pikes Peak quadrangle. His "Triassic" corresponds in this instance only to the Fountain beds, but as Cross gives this formation a thickness of but 1,000 feet, it seems that that assigned to it by Stevenson was overestimated.

While the "Triassic" of Stevenson embraced in the main only the Rocky Mountain Red Beds, in the limestones seen at Manitou it probably includes some Ordovician as well. However, the distribution along the Front Range of the older Paleozoics is

[a] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875, pp. 303–501.
[b] Ibid, p. 376.

so sporadic that with this exception it might easily be that none came under his observation.

The Pueblo quadrangle corners with the Pikes Peak quadrangle, which lies immediately to the northwest, and it is bounded upon the south by the Walsenburg quadrangle. Many of the formations occurring in the Pikes Peak are found also in the Pueblo quadrangle. The Paleozoic section consists of the Harding sandstone, Millsap limestone, and Fountain formation, above which follows the Morrison formation.

The Cambrian and the Manitou limestone of the Pikes Peak quadrangle appear to be wanting in the one under consideration, the earliest deposits preserved being a white sandstone which rests on the Archean, and which Gilbert correlates with the Harding sandstone. Above the Harding follows a series of gray and purple limestones 200 feet in thickness, with some shales in the lower part and with 30 feet of coarse gray and red sandstone on top. This series Gilbert calls the Millsap limestone, from which it would appear that the Fremont limestone of the Pikes Peak quadrangle is regarded as absent. His position upon this point is stated as follows:

"In a bed near the middle of the overlying limestone were found a few fossil shells of *Spirifera rockymontana*, a Carboniferous species found also in the Millsap limestone of the Pikes Peak quadrangle, but nothing was found to mark the presence of the Fremont limestone (Silurian), which in the Pikes Peak district separates the Harding and Millsap formations. The application of the name Millsap to the whole series of the Pueblo district is a somewhat arbitrary procedure, and is subject to correction when more facts are available."

As the Millsap limestone in the Pikes Peak quadrangle is only 30 feet in thickness, and as the Fremont is reported by Cross as 270 feet at Canyon, the natural expectation would be that the Millsap would be the one to die out in the Pueblo quadrangle. There can, however, be little doubt of the upper half at least of Gilbert's Millsap being correctly correlated. In any event, that formation shows a much increased thickness, and should it prove that the whole bed represents the Millsap, it will afford but one more instance of the sporadic and fragmentary representation of the Paleozoic horizons along the eastern line of the Front Range. It is not clear whether Gilbert includes in the Millsap the 30 feet of sandstone above the calcareous portion, but this would seem to be the case. One would think that these beds belonged to the Fountain formation. In view of the conditions observed in the Pikes Peak quadrangle I do not see how there could be conformity between the Millsap and Harding formations in the Pueblo quadrangle, especially if the Fremont limestone is absent, so that the Millsap rests on the Harding.

The Fountain formation in the Pueblo quadrangle has a thickness of 2,100+ feet, as against a maximum of 1,000 feet in the Pikes Peak quadrangle. The question might be raised whether a part of this does not represent the Wyoming formation. Gilbert refers the whole to the Juratrias. Only so far as any part of these strata belong to the series which farther north has been called the Wyoming formation do I believe this reference to be a correct one. The Fountain formation I have little doubt is Carboniferous. Of course, without fossils, opinions as to its age are largely matters of conjecture.

The Fountain formation is, according to Gilbert, conformably overlain by the Morrison formation; but Cross has shown the existence above the Fountain of an important erosion interval.

These Paleozoics, which Gilbert refers to the Harding and Millsap formations, form, by their outcrop, part of an area which is represented under the Lower Carboniferous color in the Hayden atlas. Endlich described these beds as grayish limestone and shale, from which it would appear that he missed the Harding beds.

The Walsenburg quadrangle is a 30-minute quadrangle whose northwest corner is formed by the intersection of the thirty-eighth parallel north latitude and the one hundred and fifth meridian. It lies immediately south of the Pueblo quadrangle and its northern border is not far south of the town of Pueblo, Colo. The geology of this quadrangle has been described and the formations mapped in the folio atlas of the same name.

According to the Hayden atlas, this quadrangle should contain a small area of Carboniferous in its southwestern corner (Arkansas sandstone), but this area proves to be occupied by Eocene (?) and Upper Cretaceous rocks.

The northwestern corner includes part of the southern end of the Wet Mountains, or of the Greenhorn Mountains, the area in which Endlich described Juratrias rocks as mentioned above.

The oldest sedimentary formations recognized by Hills in this quadrangle are the Badito and the Morrison formations, of which the former is referred questioningly to the Carboniferous, and the latter to the Juratrias. Of the Badito, Hills says:

"The upper half of this formation consists of brick-red sandstone, about 100 feet in thickness, generally massive or thick bedded, but sometimes shaly on the weathered surface. It apparently corresponds to part of the Fountain formation, but to what portion of it is uncertain. The lower half consists of about the same thickness of very coarse conglomerate of a brownish-red color. * * * No organic remains by which the age of these beds could be satisfactorily determined have been found within the limits of the quadrangle. In the Sangre de Cristo Range, to the westward, the stratigraphic section corresponds very nearly with that at the southern extremity of the Greenhorn Mountains, except in respect to the thickness of the conglomerate. Below the Cretaceous beds and the Morrison formation there is in each case about the same thickness of capping red sandstone, but the coarse conglomerate and sandstone on which it rests attain in the Sangre de Cristo a thickness of several thousand feet. In that locality the beds have afforded remains of an Upper Carboniferous fauna and flora. The evidence of a similar character from the

Fountain formation on the eastern slope of the Rocky Mountains is meager and contradictory, and it is still a question whether it should be classed as Permian or Triassic."

It would thus appear that the earlier Paleozoic is entirely unrepresented in this quadrangle, even the Harding and Millsap formations recognized in the Pueblo quadrangle having disappeared. A change of tint similar to that noted by Hills as occurring in the Badito formation has been described in many local sections of the red-colored beds of Colorado. The upper strata are often spoken of as brick red and the lower ones as being brownish red or maroon colored. Hills compares the lower part of his Badito formation with the Arkansas sandstone, thus suggesting a correlation with the Maroon formation and its equivalents in other parts of Colorado, while the upper, bright-red portion may represent the Lenado beds, the Wyoming formation in the Tenmile district, etc. Upon this hypothesis the Badito formation would contain the dividing line between the Wyoming and Fountain formations, and include about 100 feet of each series, the one above, the other below. This may be the case, and could be explained in its relation to the conditions existing in the Pueblo and Pikes Peak folios by considering the uncomformities which preceded the Fountain formation, the Wyoming formation(?), and the Morrison formation. But in view of the great thickness of the Fountain beds in the Pueblo quadrangle immediately north and of the apparent absence there and in the Pikes Peak quadrangle of the Wyoming formation it seems as if the color change in this case were being misinterpreted and as if the Badito formation represented the Maroon and Fountain horizon.

The Spanish Peaks quadrangle adjoins the Walsenburg quadrangle on the south. In its northwest corner this quadrangle should include, according to the Hayden atlas, an area of Carboniferous rock, probably part of Endlich's Arkansas sandstone; but the facts brought out in this folio show the Hayden mapping to have been incorrect. The oldest strata recognized in the Spanish Peaks folio is the Morrison formation, there being no Archean or Paleozoic in this area.

In his report upon the San Luis district[a] Endlich described the geologic succession along the Front Range from a point somewhat south of Colorado Springs to the thirty-eighth parallel.[b] South of Canyon an overlap of younger deposits conceals the beds of the Juratrias, which reappear, however, north of the limit above referred to. The northern area at least has been the subject of other reports, especially that of Cross upon the Pikes Peak quadrangle and Gilbert upon the Pueblo quadrangle; fortunately, since it seems impossible to make much out of Endlich's account. In this northern and more extensive area he gives three sections, to which, as usual with this author, measurements of thickness are lacking, and from these it would appear that he missed all of the admitted Paleozoics along this tract, though

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 275–361.
[b] Pages 312 to 316 and 328 to 329 of his report.

some of them are delineated as Silurian upon the Hayden Atlas. He states that the sedimentaries maintain a rather uniform character. The oldest of these he seems to refer to the Triassic and Jurassic, though adopting for them the name Mesozoic, which he employs in exclusion of the overlying Cretaceous formations. His Mesozoic beds, then, include the Fountain and Morrison formations recognized by Cross and by Gilbert, and his Cretaceous opens with what they call the Dakota formation.

But little space is devoted to the more southern exposures of the Triassic and Jurassic formations, which here, at least, seem to be discriminated, though it is not clear at what point the division is made. "South and southeast of station 78 * * * the shales of a dark red to a brown color seem to increase considerably in thickness, * * * while those beds referred to the Jurassic formation seem to decrease in thickness." Combined, their bulk probably exceeds 1,000 feet, though by how much is not told.

Near the southern limit of the tract grayish limestones and shales of Carboniferous age identified by fossils are reported, and they are mapped in the Hayden Atlas as Lower Carboniferous. Shortly south of this occurrence the beds which we have been following are concealed by the Cretaceous overlap.

This area which appears under the Lower Carboniferous color in the Hayden Atlas is partially included in the Pueblo quadrangle, and the beds which Endlich discriminated in the manner above described are identified by Gilbert as the Harding sandstone and Millsap limestone, though apparently Endlich saw only the latter.

In his Southeastern district Endlich reports upon the tract along the Front Range, immediately south of that included in the San Luis district. He describes the Trias as occurring on the southern end of the Wet Mountains, and it is so represented on the Hayden Atlas.

Endlich's remarks about these strata are somewhat obscure, but apparantly he recognizes two groups, the lower of which, consisting of bright red sandstones, shales, and marls, he calls the Red Beds or Triassic, and the upper consisting of light shales and marls, is called Jurassic. The lower strata have single beds of white or yellowish sandstone mingled with them, and are said to attain a considerable thickness.

Endlich states that these beds are identical with those further north, and expresses surprise that in his area they have not a more general distribution.

Part of the area which is colored Triassic in the Hayden Atlas falls within the Walsenburg quadrangle, and the beds grouped by Endlich under the title Juratrias are probably the exact equivalent of the Badito and Morrison formations of the Walsenburg Folio, though lithologically Endlich's beds resemble especially the Morrison formation as described and delimited by Hills.

SAN JUAN REGION.

In 1900 appeared a careful description by Cross and Spencer of the geology of the Rico Mountains,[a] the same group which in the Hayden atlas is set down as the Bear River Mountains. The strata described are classified as Devonian, Carboniferous, Juratrias, and Cretaceous. The Devonian is reported as consisting of three members. The lowest is a sandstone or quartzite, frequently conglomeratic in the lower part; the middle is a shale, and the upper a limestone, for which the name Ouray limestone is employed. It is said that the same series occurs in the Animas region, and apparently some points in the description are amplified from this wider knowledge. "In certain localities in the San Juan the quartzite was not deposited upon the Algonkian, and elsewhere both the quartzite and the shale are missing, in which case the limestone rests directly upon the pre-Paleozoic; but whenever the lowest member is present it is always followed in order by the other two in conformable sequence. It is possible that the shale and quartzite are pre-Devonian." There are thus indications of a species of unconformity between the several portions of the Devonian beds.

The quartzite is again described as massive, very dense, and highly indurated, in color dull yellow and white, with red and brown staining. Its thickness is given as about 200 feet. At the time this report was written no fossils were known from the quartzite, and its reference to the Devonian, as shown in the statement quoted above, was clearly made in a tentative manner. The character and geologic position of this bed are so similar to those of the Cambrian of other parts of Colorado as to suggest the Cambrian age of this series also. Furthermore, in some talus, with little doubt derived from this quartzitic formation, Mr. Cross has recently found a slab containing numerous specimens of a linguloid shell, probably belonging to the genus *Obolus* (*Lingulella*). This evidence, though imperfect in several ways, combined with the other, makes the Cambrian age of the quartzite member highly probable. This formation Cross now proposes to call the Ignacio quartzite.

The central shaly member of the Devonian series is not specifically described, but its thickness appears to be about 50 feet. If the quartzite does, as I suspect, represent the Sawatch quartzite, the Yule limestone, as such, has no equivalent in the Rico section. The relation of the shaly member to the series established for the Crested Butte quadrangle is of course altogether speculative, but the suggestion is made that it may correspond to the shale which in that section Spurr correlates with the Parting quartzite. This correlation is rendered somewhat the more probable because from this horizon Endlich[b] reports the occurrence of bones and scales of fishes of large size, a type of fossil that seems to characterize the Parting quartzite horizon.

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[a] U. S. Geol. Surv., Twenty-first Ann. Rept., pt. 2, 1900, pp. 7–165.
[b] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 212.

The Ouray limestone is made up of massive beds of limestone, separated by thin intercalations of marl or shale. Fossils are to be found in most sections, and show the geologic age to be upper Devonian. Only the Devonian fauna was known at the time this report was written, but at certain localities, at least, the top strata of the Ouray limestone contain fossils of a distinctly Mississippian aspect. The same Devonian fauna occurs in the Leadville limestone at Glenwood Springs, in the vicinity of Salida, and in the Crested Butte quadrangle, while a similar Mississippian fauna is found in the upper portion of the Leadville at Salida, in the Crested Butte quadrangle, and at Aspen. It can be regarded as established, therefore, that the Ouray limestone is the equivalent of the Leadville limestone of the Elk Mountains.

The Carboniferous of Cross and Spencer consists of the Hermosa and Rico formations, both of Upper Carboniferous age, for the Mississippian fauna of the Ouray limestone was not known at the time of their writing, and the Mississippian epoch accordingly was supposed to be unrepresented. On the evidence of the invertebrate faunas the Hermosa formation is referred to the Pennsylvanian period, and the Rico formation to the Permo-Carboniferous.

"Occurring between the Devonian limestone and the typical Red Beds, and sharply defined from each, there is a heterogeneous series of rocks which is generally distributed in the San Juan region, where it reaches a maximum thickness of about 2,000 feet * * * Lithologically the Hermosa is composed of limestones, shale, and sandstone, but all of these strata are more or less calcareous throughout. The limestones are of a blue-gray color, rather dense in texture, and usually very fossiliferous. They are frequently more or less bituminous, sometimes so much so as to afford a distinct odor of petroleum when struck with a hammer. The shales vary from black bituminous clay shales, rather fissile, to sandy shales and sandstones of an olive-green color. The sandstones are also of a greenish color * * * This formation has a considerable distribution in the western part of the San Juan region, but throughout the area of its occurrence it is not in general divisible, since individual beds and groups of strata change greatly in character from place to place, so that horizons can not be definitely recognized in localities separated from one another by more than short distances."

At Rico, still more than in the Animas section, are the limestones persistently segregated in the middle portion of the formation. It is therefore possible to divide the Hermosa at Rico into three approximately equal parts. The Hermosa formation corresponds in a general manner with the Middle Carboniferous mapped by the Hayden survey.

Between the Hermosa formation and the Ouray limestone in the Needle Mountains quadrangle occurs a bed of red shaly material whose character and occurrence are peculiar. It was not given particular description in the report by Cross and Spencer, but it is now proposed to discriminate it as the Molas formation. The following account of this horizon is abstracted from a description written by Mr. Cross:

The Molas formation is the lowest of the three Upper Carboniferous formations distinguished in the Animas Valley and adjacent region. It is distinguished on lithologic grounds, because it records a preceding interval of erosion, by which formations of Mississippian age were in large measure destroyed, and, in a subordinate degree, because of certain faunal peculiarities which further collections may or may not affect. The Molas beds were not included in the original definition of the Hermosa formation, although the Hermosa was said to rest on the Ouray limestone. In the localities examined before that definition was formulated there was, in fact, a hiatus in the observations, the thin Molas beds being nowhere well exposed. This formation is especially characterized by its deep-red, friable, sandy strata, which are variably calcareous and often shaly. They are seldom very distinctly bedded, and disintegrate so rapidly on weathering that good exposures are rare. In the lower part of the formation dark chert nodules abound, often making a large part, of flat lentils or discontinuous layers. The best section of the formation thus far observed is situated on the southwest slope of the Needle Mountains, on the south side of Tank Creek. At that locality there is a continuous section, about 75 feet in thickness, representing the whole formation as there developed between the Ouray limestone and the Hermosa complex. There is no distinct stratification in the section. At the base is a zone of gradation into the Ouray limestone, for the upper zone of the latter is much broken up with the red calcareous mud of the Molas filling the interstices. This filling of the formation is very common. For some feet above this transition zone there is a chaotic mixture of chert and limestone fragments, with not a few of bluish or white quartzite, but none of granite or schist. In all the lower part of the section much of the material is an impure limestone, reddish in color, but with the saccharoidal texture of the Ouray. It is probably a limestone sand rock. The matrix in which the fragments of chert, quartzite, and limestone are held is a red marl-like material. There are in places indications that a calcareous mud was broken up before consolidation, and was worked over with the fragments of foreign rocks. Gradually the section becomes more and more sandy, but chert fragments were found almost up to the fossiliferous limestone of the Hermosa.

The shale contains nodules of chert carrying a Mississippian fauna related to that in the upper portion of the Ouray limestone, and it is believed that they were derived from the Ouray. Otherwise the shale is almost unfossiliferous; but from some thin limestones in the uppermost part of the formation, in a single locality in the Needle Mountains quadrangle, a few species were obtained by Mr. Cross which, while not of themselves altogether diagnostic, are unlike the Mississippian fauna of the Ouray and similar to that which comes in at the base of the Hermosa, which is clearly Upper Carboniferous. On this account the beds down to the top of the Ouray are regarded as belonging in the Upper Carboniferous.

The Rico formation includes the lower portion of the Red Beds in this region, the upper portion being described as the Dolores formation. Lithologically the two formations are quite similar, and their discrimination is based chiefly upon the evidence of fossils. The fauna of the Rico formation is of Carboniferous age, while that of the Dolores is Triassic. The boundary between the Rico and the Hermosa formations is well marked, but that between the Rico and Dolores "is at present entirely artificial, being based upon the highest known occurrence of the Rico fossils. The former is made to include only strata characterized by the Rico fauna, while the latter comprises the apparently unfossiliferous medial portion of the Red Beds, together with the upper part, of known Triassic affinities. The actual age of the unfossiliferous Red Beds is thus left in doubt; they may eventually prove to be either Permo-Carboniferous, true Permian, or Trias. They correspond to what has been called Trias throughout the Rocky Mountain province." The thickness of the Rico formation thus determined is about 300 feet, and it is made up of "sandstone and conglomerates with intercalated shales and sandy fossiliferous limestones." The general characteristics of the Rico formation are again described as being, first, "its calcareous nature, in which it resembles the strata above and below; second, the very arkose character and the coarseness of the sandstones, in which respect it differs from the Hermosa and resembles the Dolores; and, third, its chocolate or dark-maroon color, which contrasts sharply with the gray or green of the Hermosa and which is more or less distinct from the bright vermilion of the Dolores."

With the Rico formation the portion of the section falling within the scope of my work is exhausted, but I will briefly recapitulate the important characters of the Juratrias groups. "All the Juratrias formations of the San Juan region," it is reported, "are represented in the Rico Mountains. Beginning at the base, they are the Dolores Red Beds, 1,600 feet in thickness; the La Plata sandstone, 250 feet or more; and the McElmo shales and sandstones, exposed to a thickness of 300 feet within the area represented on the map, but having a total thickness of nearly 900 feet in the region adjacent."

The La Plata sandstones and McElmo formations are said by Cross and Spencer to represent, respectively, the lower and upper portions of the Gunnison formation of the Crested Butte region. The Ouray limestone, as already shown, can be correlated with the Leadville limestone of that area, so that the Molas, Hermosa, Rico, and Dolores formations in one area and the Weber and Maroon formations in the other occupy similar positions in the section. The Weber formation appears to have no especially discriminated lithologic equivalent in the San Juan region. The Hermosa formation, in thickness, lithologic character, and position, is similar to the lower of the two divisions recognized in the Maroon conglomerate. The Rico formation in its color and lithology is similar to the upper division of the Maroon, and both are characterized by their arkose character, indicating that erosion having cut through the overlying sediments was playing upon the granitic basement rock. The Rico is, however, very much thinner, and its characteristic fauna has as yet not been found in the Maroon conglomerate, the fauna of the upper part of which is unknown. The bright-red Dolores beds appear to have no equivalent in the Crested Butte quadrangle, but they can be compared to the similar deposits described by Spurr at Lenado Canyon near Aspen. The time interval between the Rico fauna and that characterizing the top of the Dolores is so great that I believe that a period of erosion or of nondeposition must have intervened, even though it is not now recognizable in the mutual attitude of the sediments. With such a theory the great disparity in thickness between the Rico formation and the upper Maroon is in accord, and also the greatly reduced thickness of the upper Maroon in the southern part of the Crested Butte quadrangle reported by Eldridge. On the other hand, the Gunnison formation was preceded in the Crested Butte region by a recognized unconformity, and it is by pre-Gunnison erosion that the apparent absence of the Dolores formation in that region may be accounted for.

The paper which furnished the foregoing brief summary was one of the last dealing with the geology of this area, but because it establishes for the first time a section and a nomenclature, its consideration has been, as a matter of convenience, taken up before those of earlier date.

In the geologic reports which accompany Ruffner's report upon a reconnaissance in the Ute country[a] are accounts by F. Hawn and L. Hawn, of observations at Animas Park and Animas River in the San Juan Mountains. Most of the strata described along the Animas seem to belong to the Hermosa formation, and Carboniferous faunas are cited from them in a number of instances. At two localities in the vicinity of Engineer Mountain fossils are cited from a cherty limestone, which are said to be of Eocarboniferous age. The following species are reported (p. 68): *Cyathophyllum*, *Gorgonia*, *Crinoidea*, *Productus reticulatus*, and *Euomphalus latus*. As the character of the rock, the locality, and, to a certain extent, the fauna agree with our collections from the top of the Ouray limestone, it seems probable that Hawn was correct in the age determination of these beds. The red sandstone mentioned on page 68, and reported as 1,000 feet thick, possibly represents the Rico formation, unless the color is due to metamorphism as suggested by Hawn.

Stevenson's report in the third volume of the Wheeler survey[b] touches briefly upon the geology of the San Juan region.[c] The only beds which come within the purview of this discussion are referred to the Carboniferous and the Triassic. They were seen chiefly in the Animas Valley. The Carboniferous, distinguished by its

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[a] Ruffner's Rept. Recon. in the Ute Country, Forty-third Cong., 1st sess., House Ex. Doc. No. 193, 1874.
[b] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875, pp. 307-501.
[c] Ibid., p. 374 et seq.

characteristic fossils, comprises sandstones, limestones, and dark shales. Their thickness is reported as 1,200 feet, and the series is correlated with the lower sandstone measures in the Eagle River section. The Triassic beds, having a thickness of 1,500 feet, are said to abut against the lower sandstones of the Carboniferous.

There is nothing to indicate that the older Paleozoics recognized by Cross and Spencer in their Rico Mountains section were seen by Stevenson, and his Carboniferous, therefore, is more or less completely the equivalent of the Hermosa formation. The character of the Triassic beds is not described, but it is fair to assume that they are of the type of the Red Beds elsewhere in Colorado. With this interpretation the Triassic would be in a general way the same as the Rico, Dolores, and La Plata formations of the Rico section. Stevenson's measurements are in both cases, it may be mentioned, somewhat less than those more recently made by Cross and Spencer. Stevenson's correlation of the Hermosa with the lower portion of his Eagle River section is of interest, and that correlation I, too, am disposed to favor.

The area examined by Endlich in 1874, called the San Juan district,[a] lies between the one hundred and seventh and the one hundred and eighth degrees of west longitude, and between 37° 15′ and 38° 15′ north latitude. The Paleozoics in this area are largely confined to a more or less crescent-shaped outcrop on the southwest side of a subcircular Algonkian (?) nucleus, the northeastern half being concealed by eruptives. There are also a few small outlying bodies of outcrop, as that at Ouray.

The arrangement of this report is greatly improved over that of the preceding year, but we find employed the same objectionable method of indicating points of observation by numbered stations which are not systematically described or represented upon a map.

At only one point, the canyon of Lime Creek, did Endlich observe any beds which he refers to the Silurian, but in his Devonian are probably included the older horizons of the Paleozoic section. The Lime Creek exposures are said to consist of white, coarse-grained sandstones deposited in thick strata, and it was Endlich's now very quaint-seeming opinion that the pre-Devonian beds generally, and these sandstones in particular, furnished the material for, and by metamorphism were transformed into, the quartzites and other Algonkian(?) rocks of this area. Endlich implies that this sandstone underlies and is distinct from his Devonian, but it seems more probable that it is only a local phase of the siliceous lower portion of it (i. e., of the Ignacio quartzite).

His Devonian along Lime Creek is a light-blue to grayish limestone with abundant fossils, the entire series having a thickness of 1,200 to 1,500 feet. "Above the limestones the Carboniferous beds begin, while they are underlaid probably for

[a] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, pp. 181–240.

a considerable distance by the Silurian sandstone. This was observed, however, only at one point." (Page 211.)

The section at station 48, which appears to be located on the southern boundary of the metamorphic area, has at its base a white to red and brown quartzite resting immediately upon granite. Next follows a thin stratum of yellow siliceous shale containing narrow interstrata of softer shale. This formation is characterized by the presence of well-marked pseudomorphs after salt, together with scales and fragments of bone of large fishes. Above this the limestones set in. "The entire thickness of the sedimentaries at station 48 amounts to about 200 feet, while farther south the limestone alone reaches that figure." The limestone, which is presumably the same in both sections, is evidently the bed to which Cross subsequently has given the name, Ouray limestone. Endlich cites a list of the species found by him in the Ouray limestone. I described and illustrated this fauna characterized by the fine species, *Camarotœchia endlichi*, in some detail in 1900,[a] and although it was for a time set down as Carboniferous, later and more complete collections vindicate Meek's early determination of its age as Devonian. The Ouray limestone was succeeded by an interval of erosion, not of course observed by Endlich, and locally, at least, it contains in its upper portion another and quite distinct fauna of Mississippian age, whose presence was not known at the time I described the Devonian fauna. Whether the differences in thickness, to which attention is called by Endlich, are due to this post-Mississippian erosion, I am unable to say, but it seems probable that this was partially, at least, the case. If, as one would infer from Endlich's statements, the white limestone, called by him Silurian, underlies the so-called Devonian, the absence on Lime Creek between the Silurian sandstone and the Ouray limestone of the quartzite and siliceous shale observed at station 48, and of the Silurian sandstone at the latter between the granite and the Devonian, are equally inexplicable. It seems more reasonable to suppose that the white sandstone is a local phase of the siliceous beds at the base of the series exposed at station 48, or that it is a new group developed in the thicker section, probably at a higher horizon than the quartzite of the latter. The quartzite, both from its lithology and stratigraphic position when compared with other sections, and also from such scanty fossil evidence as it has yet furnished, is surmised to be of Cambrian age and equivalent to the Sawatch quartzite, while for similar reasons the siliceous shales can be compared with the Parting quartzite, or with that general horizon. The presence of fish remains in this formation rather enforces this hypothesis and brings to mind the fish-bearing Parting beds at Aspen.

Endlich divides the Carboniferous sediments into two divisions, which he calls the Lower Carboniferous and the Upper. As usual, these terms are to be divorced

[a] U. S. Geol. Surv., Twentieth Ann. Rept., pt. 2, 1900, pp. 31–63.

from their ordinary paleontologic associations. While the Lower Carboniferous consists of sandstones, shales, and limestones, the Upper is confined almost exclusively to massive beds of red sandstone. "In its lower strata the former shows mainly yellowish sandstones, interstratified with yellowish and gray shales, while higher up the blue limestone sets in, containing characteristic fossils. Immediately above that the red sandstones begin, and continue in an unbroken series until the white sandstones of the Lower Cretaceous are reached. Trias and Jura are missing or reduced to a minimum, and only exposed locally."

The "Lower Carboniferous" is reported by Endlich as entirely conformable with the Devonian. There is, indeed, an apparent conformity, but its earliest sediments were deposited upon the Ouray limestone only after the latter had undergone a protracted period of erosion. Endlich gives no total or average thickness for this formation, but he states the thickness of exposures at several points. Near station 49, apparently, 1,000 feet were observed (p. 216); at station 40 but 400 feet (p. 216); and in the Animas Valley it would appear to have a thickness of 1,400 to 1,800 feet, more or less (p. 219). Endlich found this series, which Cross has distinguished as the Hermosa formation, to be sparingly fossiliferous, but from it Cross and his associates have obtained extensive collections. Endlich cites *Productus semistriatus*, *Seminula subtilita*, and *Spirifer* sp. The species first mentioned was not found in the recent collections, and if its occurrence is authentic, as I doubt, it is of some interest, seeing that the species is a rare one. Apparently, however, the name is a blunder of Endlich's for the common *Productus semireticulatus*, for we seem to have his fossils among our present collections, and they belong to the type which I have discriminated as *P. semireticulatus* var. *hermosanus*.

The red sandstone or Upper Carboniferous of Endlich succeeds the beds which he calls Lower Carboniferous. This series consists principally of red sandstone, as already pointed out, but it seems to contain a certain amount of dark shale and to be sometimes strikingly interstratified with beds of white sandstone (p. 218). At one point a thin limestone occurs above the sandstone (p. 217). The thicknesses seen at several points are 2,000 feet on the east side of the Animas, 1,400 feet at station 40, and 1,800 feet on Bear Creek (p. 217). Fossils are reported as especially scanty, but *Seminula subtilita* is cited, and also *Productus semistriatus*, though the latter was not found in place, and some doubt seems to have been entertained as to the specimens really belonging to this horizon. Here also, if I judge correctly from the context, are reported crinoids and corals similar to those found in the red sandstone of the Sangre de Cristo Range. Indeed, that formation to which Endlich gave the name Arkansas sandstone he is disposed to regard as the stratigraphic equivalent of the Upper Carboniferous of the San Juan region (p. 240).

From the color of Endlich's Upper Carboniferous series, and the fact that it is followed by the Lower Cretaceous sandstone, and also because he in one place assigned to the Lower Carboniferous a thickness almost as great as that of Cross and Spencer's Hermosa formation, the inference might be made that his Upper Carboniferous represented their Rico, Dolores, and La Plata formations; but his faunal evidence seems to place this out of the question and make it necessary to consider that series part of the Hermosa formation, unless, what is not improbable, his Upper Carboniferous is represented by the Hermosa in one instance and by the Dolores in another.

The red sandstone is followed by the white sandstone of the Lower Cretaceous, which rests unconformably upon it, and Endlich points out that it was preceded by a deformation of the Paleozoic formations (p. 215). He says:

"Although the Cretaceous beds of the southern and western portion have the same general direction of dip as the older ones, several localities have furnished evidence that the disturbances affecting the Devonian and Carboniferous must have occurred before the deposition of the Cretaceous. It is possible that to this fact, to the higher relative position at the time, the absence of Triassic and Jurassic beds may be attributed" (p. 240).

In 1875 W. H. Holmes was given charge of the geologic survey of the San Juan division,[a] and his report is found on pages 237 to 276 of the Hayden Annual Report for that year. The San Juan division is defined as the area which is "bounded on the west by 109° 30′, on the south by 36° 45′, on the north by 37° 50′, and on the east by Mr. Wilson's work of 1874." Portions of this area lie in the States of Utah, Arizona, and New Mexico, but by far the greater part is in Colorado.

This territory is chiefly occupied by rocks of post-Paleozoic age, and it is to these, consequently, that most of the discussion is devoted. Carboniferous beds occur, however, overlaid by the Juratrias. To the latter are assigned beds 12, 13, 14, and 15 of the general section, with a combined thickness of 1,500 feet. "Group 12 consists of brownish and purplish laminated sandstones, generally less than 200 feet in thickness. This is the fossil-bone bed of Dr. Newberry, which is thought by him to be Triassic. Group 13 is the well-marked bed of massive white and pinkish sandstone. This is succeeded by a laminated series, and this by red sandstones."

I find it difficult to correlate these subdivisions exactly with the formations recognized by Cross and Spencer in the Rico Mountains, though the general equivalence is obvious. It seems a safe hypothesis to suppose that the Upper Dakota of Holmes is the same as the Dakota sandstone of Cross and Spencer. His Lower Dakota, therefore, would probably be the same as their McElmo formation. With this, however, the resemblance seems to end. Though the two sets of formations agree singularly in thickness when arranged in parallel columns according to this

[a] U. S. Geol. Geog. Surv. Terr., Ninth Ann. Rept., for 1875, 1877, pp. 237-276.

scheme, their lithologic and other characters do not agree. Bed 12, which Holmes believes to be the same as Newberry's bone bed, invites comparison with the Dolores formation, which also is bone-bearing, but the thickness is widely different. Similarly the white sandstone, which is Holmes's bed 13, resembles the La Plata sandstone, but they differ widely in thickness, and if correlated the bone bed would occur above the division in one case and below it in the other. Probably the Lower Dakota and the laminated bone bed combined are equivalent to the McElmo formation, the white and pink sandstone to the La Plata, and the red massive sandstone to the Dolores.

The distribution of these beds is described by Holmes as follows:

"The areas occupied by Juratrias and Carboniferous rocks call for nothing more than a mere mention, as they are quite limited in extent, incomplete in exposures, and totally without fossil remains. In the La Plata Mountains there are exposures both of Red Beds and of Carboniferous sandstones; but they are to a great extent metamorphosed beyond recognition. About the sources of Bear River there are also exposures of the rocks of these ages, but I was not able to examine them. In Dolores Canyon, in the McElmo at the north base of Ute Peak, in the Montezuma Canyon, and on the Lower San Juan, there are slight exposures of the purple laminated beds and of the pink and red sandstones. On three sides of the Carriso Mountains there are outcrops of the Red Beds, but these are mostly beyond our district. From the summits of the Carriso Mountains I obtained a comprehensive view of the tract of country about the valleys of Gothic Creek and the Rio de Chelly; nothing but red and white sandstones appear. A white or slightly pinkish sandstone is in this section peculiar to the upper part of the heavy sandstones of the Juratrias."

Under the title of "The geology and vein structure of southwestern Colorado," Comstock treats of an extensive area which includes the San Juan region.[a] The sandstones cropping out near the Animas Canyon this author refers to the Upper Silurian, and the Ouray limestone he makes Devonian. The Carboniferous is divided by him into an Eo- and a later Carboniferous series. The former, consisting of argillaceous, calcareous, and arenaceous beds with a thickness of 1,200 feet, is probably the exact equivalent of Cross's Hermosa formation. He remarks (page 227): "On Hayden's map they are marked Middle Carboniferous; but I can not find any good reason for this, and I suspect that we have here the representatives of both the Lower Carboniferous and Middle Carboniferous of other portions of the Rocky Mountains.". In this, of course, he is undoubtedly in error, as the Ouray limestone represents the Lower Carboniferous, as the term is used and the beds generally identified, by the Hayden survey. *Productus semistriatus*, *Athyris subtilita*, and *Spirifer* sp. are cited from this bed, the fauna apparently being borrowed from Endlich's account in the Hayden annual reports.[b] Under the term Later Carboniferous, he includes some 2,000 feet of red sandstone which probably is about

[a] Am. Inst. Min. Engrs., Trans., vol. 15, 1887, pp. 218-265.
[b] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 216.

equivalent to the Rico and Dolores formations of Cross and Spencer. Possibly part of their Hermosa formation is also included.

DOLORES RIVER REGION.

The district assigned to Peale for the year 1875[a] was designated as the Grand River district. It lies between the parallels of latitude 37° 52′ and 39° 15′. On the west it is limited by the meridian 109° 30′, and on the east by the western limit of the work of 1874, which is approximately the Gunnison and Uncompahgre rivers. In addition to this, there is a narrow strip of country south of the Gunnison River, from 10 to 20 miles in width, extending from meridian 107° to 107° 30′.

It was found that over a great part of this area the Red Beds (Triassic) rest immediately upon the Archean rocks. "In the extreme western limits of the district it is probable that older formations lie between," but "there are no exposures of rocks older than the upper part of the Lower Carboniferous. * * * Along the western edge of the Uncompahgre plateau we have Permo-Carboniferous, and west of the Dolores two places where beds of Upper Carboniferous age appear." In fact, the Hayden atlas shows that the Dolores and some of its tributaries are bordered with "Upper Carboniferous" rocks almost from the thirty-eighth parallel to the junction of the main stream with the Colorado, and that they accompany the Colorado from that point westward beyond the one hundred and ninth meridian. In Sinbads Valley rocks of "Middle Carboniferous" age are shown.

Peale's section made at the head of Salt Creek, which is about synonymous with saying in Sinbads Valley, is as follows (pp. 82 and 71):

Section at head of Salt Creek.

[TRIASSIC.]

	Feet.
1. Light-red sandstones, massive 2. Dark-red shales	600
3. Massive blood-red sandstones	700
4. Brown sandstones with interlaminated red shales	300
	1,600

[CARBONIFEROUS.]

	Feet.
1. Pink and red shales with conglomeritic sandstones becoming light-colored near the base and containing gypsum	700
2. Yellowish and black shales and sandstone with gypsum and salt. The creek, in passing the bluff where these beds are exposed, acquires a strong alkaline taste	300
3. Space filled with shaly sandstones and, perhaps, bands of limestone. Beds for most part entirely concealed	3,500
4. Light yellowish and greenish shaly sandstones 5. Blue limestone with *Productus*, crinoids, and corals	300
Total	4,800

[a] U. S. Geol. Geog. Surv. Terr., Ninth Ann. Rept., for 1875, 1877, pp. 31–101.

The section as here given is compiled from two parts of what appears to be a single continuous series divided into its Carboniferous and Triassic portions, and separately described on pages 71 and 82 of Peale's report. For comparison with sections similarly arranged of other areas examined by him, Peale has condensed the Carboniferous portion of this section and grouped its beds in the following form, which appears on page 77 of the same report:

General section in region of Dolores River—district of 1875.

	Feet.
PERMIAN.	
Pink conglomeritic sandstones and red gypsiferous shales	1,000
COAL MEASURES.	
Shales mostly arenaceous with calcareous and gypsiferous beds at the top. The beds are generally concealed; débris is light-yellow color	3,500
No fossils.	
SUBCARBONIFEROUS.	
Limestone, only upper part showing fossils, indistinct and not determined. *Productus*, corals, and crinoidal stems	300
Total	4,800–5,000

The correspondence of this section with that previously quoted is obvious and requires little comment save in the case of the Permian. In the original section the shales at the base of this division are described as yellowish and black, while in the later form their color is said to be red.

It is to be noted that the stratigraphic base of the section here is not given, and presumably was not observed. Peale is inclined to believe that the lowest bed is near the line separating the Mississippian from the Pennsylvanian. It may be provisionally regarded as representing the horizon of the Ouray and Leadville limestones. Beds 3 and 4 are referred by Peale to the Upper Carboniferous or Pennsylvanian, while 1 and 2 he calls Permian or Permo-Carboniferous. "Eastward the beds rapidly thin out and Nos. 2, 3, 4, and 5 disappear. No. 1 on West Creek rests on the granite and is made up of coarse conglomerates, especially at the base, showing the near proximity of land during their formation." "Along the Dolores River the pink conglomerates [upper Permian?] and sandstones appear beneath the blood red shales and sandstones that lie immediately below the massive red sandstones that cap the bluffs." These remarks describe the section quoted above, but appear to be less applicable to the Triassic exposures elsewhere.

"The general character of the Triassic beds is as follows: A massive yellow, white, or pink sandstone forms the top of the series. Toward the western part of our district this sandstone is calcareous. In many places the sandstones are markedly cross-stratified. The color is subject to much change locally, passing from white, through orange and pink, into deep red. Below the massive sandstone are blood-red shales, followed in most cases by massive brick-red sandstone. In Unaweep Canyon the sandstones are laminated, while northward and westward they seem to be consolidated into one massive bed. They are followed, as we descend in the series, by shales and blood-red sandstones, which, on the Dolores, change gradually into gypsiferous shales and sandstones." (P. 80.)

The beds last mentioned are probably those which form the upper division of the Permian of his Salt Creek section. This description can not be strictly fitted to the section of the Triassic series observed in Sinbads Valley, and other sections show similar deviations in detail. The Jurassic consists of variegated shales and marls, with thin bands of limestone near the base.

This series can most appropriately be compared with those of the San Juan district and of the Crested Butte quadrangle. The lowest bed seen can probably be correlated with that widespread calcareous horizon, the Leadville or Ouray limestone.

The shaly sandstone above, of which Peale cites a thickness of more than 3,500 feet, seems to correspond to the Hermosa formation of the San Juan region. The Red Beds are the probable equivalents of the Dolores and La Plata formations, while the Jurassic is almost certainly the McElmo formation.

The correlation of the Hermosa formation with Peale's Carboniferous beds has much to recommend it, yet the latter have a thickness of over 3,500 feet, while the Hermosa contains but 1,800 feet. However, the faunal break between the Hermosa formation and the Rico is sufficiently important to suggest an unrepresented time interval between those formations, to which the upper beds in Sinbads Valley may correspond. The only fossils we have from Sinbads Valley come from near the top of the supposed Hermosa. The fauna is quite distinct from the Rico fauna, and yet presents a different facies from the Hermosan fauna. So far the paleontologic evidence is favorable to this correlation and to the explanation suggested for the difficulties which arise from it.

Lithologically the 300 feet of yellowish and black shale which Peale includes with the Permian is unlike the Red Beds above and more similar to the Hermosa formation, with which it seems to me more appropriate to unite it. This course is also justified by the overlap of the Red Beds portion of the "Permian" upon the granite, as reported by Peale. The Rico fauna has not yet been found in the Sinbads Valley section, but it may occur there, as so little is known of the paleontology of that area. If the Rico does occur, however, it must have undergone a lithologic change, as there are no chocolate or dark maroon measures at the base of the Red Beds. The possible correlation of the Rico formation with the upper member of the Maroon has already been suggested, and the total absence of the series in Sinbads Valley would be quite in line with its great reduction in the San Juan region. Assuming that the Rico is absent in this area, that the base of the Red Beds begins with the upper half of Peale's Permian, and that the top ends with the base of his Jurassic, the intermediate beds would necessarily be the equivalent of the Dolores and La Plata formations combined. The massive, brick-red sandstone at the base of Peale's Triassic strongly suggests the Dolores formation, while the massive, light-colored upper portion is like the La Plata, but there is here an intermediate series, while below the beds similar to the Dolores 700 feet of Red Beds are found, which Peale places in the Permian. The total thickness of the Red Beds in the La Sal Mountain region, with the limits taken as above, is 2,300 feet. The Dolores and La Plata formations have a combined thickness of only 1,850 feet. The statement made by Cross and Spencer that the Dolores formation, which is almost 2,000 feet thick in the Animas region, is reduced to scarcely half that amount in the vicinity of the La Sal Mountains,[a] is in a measure offset by this fact, that the La Plata sandstone, which varies from 100 to 500 feet in the San Juan region, expands to the northwest, and in the Canyon and Plateau regions, to two or three times the maximum figure for the San Juan (loc. cit., p. 74). Furthermore, though the McElmo formation contains 300 feet in the Rico Mountains, and though Peale assigns to his Jurassic a thickness of 250 feet, yet 900 feet are said to be found in the region adjacent to the Rico section (loc. cit., p. 66), so that some of the upper beds of Peale's Triassic may go with his Jurassic to form the McElmo formation.

Peale relates that upon West Creek bed 1 (the upper division of his Permian series) rests upon the granite, and that over large areas his Triassic beds occupy a similar position. The interpretation of these facts which is to me the most probable is that they record two distinct episodes of submergence, if, indeed, it be granted that Peale has successfully performed the difficult task of correlating or tracing the variable members of his Red Beds sections. It may prove, however, that the conglomeratic beds on West Creek which he considers represent the upper member of his Permian are really identical with those producing the Triassic overlap; that there was a single submergence; and that parts of the section have been duplicated. In any event there appears to be a sort of unconformity between Peale's Permian, or at least the upper and larger portion of it, and the beds supposed to represent the Hermosa formation. As previously mentioned, there is evidence of this also in the fact that the Hermosa in Peale's area is so much thicker than farther east, and that the upper portion carries a somewhat different fauna. These speculations, however, are subject to such varying possibilities that in the absence of accurate stratigraphic tracing or the means for paleontologic correlation they seem almost futile.

Comparing next Peale's section with that exposed in the Crested Butte quadrangle, it appears that if the lowest limestone of the former is really of Mississippian age, it is the equivalent of the Leadville limestone. The shaly sandstone above the limestone would then represent the Weber combined with the lower member of the

[a] U. S. Geol. Surv., Twenty-first Ann. Rept., pt. 2, 1900, p. 67

Maroon formation, while the upper heavy sandstone of the Triassic, together with the overlying Jurassic, would represent the Gunnison formation. Peale's Permian and the lower part of his Triassic apparently have no equivalents in the Crested Butte quadrangle, where there is an important unconformity between the Maroon and Gunnison formations; but they probably do find expression in the Red Beds which overlie the Maroon at Aspen and other points farther north. The upper division of the Maroon has no lithologic equivalent in the Dolores River region.

Peale's district for the season of 1876[a] was again called the Grand River district, and the extent and character of the geologic section seems to be similar to that described in the report for 1875.

On the south side of Grand River there are a few isolated exposures of granitic rock, but neither Silurian nor Devonian was recognized. Upper Carboniferous beds were found in Paradox Valley and in the canyon of the Dolores, but "both the localities noted on the map were seen from a distance, and therefore no details respecting them can be presented. They are probably similar to the rocks of the same age showing farther north and west, which were described in the report for 1875 (p. 71). * * * The line separating them from the Trias has been arbitrarily fixed, as the soft sandstones and gypsiferous shales are much like the beds forming the base of the Trias." Another but unimportant outcrop is said to occur on the Grand River below the mouth of the Dolores.

Speaking of the Juratrias, he says: "The line separating the Triassic from the Jurassic is almost as obscure as that separating the Carboniferous from the Triassic. The line has been drawn lithologically, the massive red sandstone being considered the top of the Triassic." Of the latter, he remarks: "A massive red sandstone, becoming lighter colored toward the top, cross stratified at many places, is the prevailing characteristic rock. Its thickness is from 500 to 1,000 feet. The beds become laminated below, and gypsiferous, passing gradually into the Upper Carboniferous." The Jurassic is said to consist of "soft greenish and gray argillaceous and arenaceous shales and marls near the top, passing into the Lower Dakota sandstone, and dull, reddish, laminated sandstones and shales at the base."

Along Grand River the lithologic line separating the Trias and Jura is better defined. "The sandstones forming the upper part of the Red Beds are very massive, and the shaly beds just above contain thin beds of limestone. Below the massive sandstones come blood-red shales, followed by massive sandstones, generally of a deep-red color, although in many places the color fades to almost white. The thickness exposed is nearly 500 feet, which represents only a portion of the formation."

The correlation of the beds thus briefly described would apparently be the same

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[a] U. S. Geol. Geog. Surv. Terr., Tenth Ann. Rept., for 1876, 1878, pp. 161–185. Ibid., p. 178.

as that suggested for the similar section described in the report for 1875, and it is similarly uncertain. The Lower Dakota of Peale's report may be safely correlated with the Dakota of Cross's and Spencer's Rico Mountains section, and his Jurassic is, in a general way, equivalent to their McElmo formation. Peale gives a generalized section of his Jurassic beds, to which a thickness of 200 feet is assigned. At the base is a white sandstone, which may represent the whole or only a part of the La Plata sandstone. In either case Peale's Jurassic is considerably inferior in thickness to the McElmo formation.

By analogy with his Carboniferous series of the year previous, part of that for 1876 would represent the Hermosa formation and part would belong in the Red Beds. Indeed, in the passage quoted above, he calls attention to the similarity of the soft sandstones and gypsiferous shales forming the top of his Carboniferous to the beds forming the base of the Trias. Probably 700 feet of his Salt Creek section (which in 1875 he called Permian) should go with the Trias (?). The upper portion of his Carboniferous series, therefore, together with his Triassic, and possibly the white sandstone at the base of the Jurassic, probably represent the Dolores and La Plata formations. As the Triassic is said to measure 500 to 1,000 feet, possibly a maximum of about 1,700 feet would represent Peale's measurements, and this is not far from the combined thickness of the Dolores and La Plata given by Cross and Spencer, though all these formations appear to vary greatly from point to point.

Peale's measurements made the year previous are considerably larger. He had then 250 feet of Jurassic and in the Salt Creek section 1,600 feet of Triassic.

In 1901 Elmer S. Riggs described the Dinosaur beds of the Grand River Valley of Colorado.[a] The section treated by this author consists of so-called Mesozoic strata of this region, which is the vicinity of the Dolores, Grand, and Uncompahgre rivers. The lowest of these beds rest upon granitic rock and are referred to the Trias. The Trias is represented by a massive ledge of reddish sandstone, slightly cross bedded, and weathered in peculiar pinnacle and dome-like shapes. Below this is a softer stratum of vermilion-colored sandy shale, the entire thickness being about 400 feet. These are followed above by Jurassic strata, which range from 600 to 700 feet in thickness and admit of four subdivisions. The lower or marine Jura is from 100 to 120 feet in thickness, and consists of bluish and grayish gypsum-bearing clays in which thin layers of fine-grained sandstone and nodular ledges of limestone are interspersed. The latter are never more than 6 or 8 inches in thickness, and are usually from 3 to 5 in number. In no instance were fossils found in these measures. Above this lower member lies a stratum of greenish shale about 100 feet in thickness, and then a darker zone 40 or 50 feet thick, containing frequent ledges of cross-bedded sandstone, and at the top a series of variegated clays reaching a thickness of 300 or

[a] Field Columbian Museum, Publication 60, Geologic series, vol. 1, No. 9, 1901, pp. 267-274.

more feet. The Jurassic strata have no bearing upon the present discussion, though possibly the Triassic ones, which may be partially equivalent to the Wyoming sandstone, are germane to it. It is to be noted in this connection that Riggs conceives the granitic rock beneath the Triassic to be of intrusive origin (see pl. 39), but this formation has been regarded by the Hayden survey, and usually, I believe, as Archean.

It seems that the Jurassic beds of this paper, which have a thickness of 500 feet, are the same as the McElmo formation of the Telluride quadrangle, and they here have about the thickness as well as the character of that formation as it appears in the Rico region. It is also the Jurassic of Peale, though considerably thicker, and it does not contain the basal white sandstone which Peale in his report for 1876 includes in the Jurassic.

The Triassic is comparable in character and thickness to the beds discriminated by Peale under the same name in 1876. His Triassic of 1875 was much thicker. The character of Riggs's Triassic is similar to that of the Dolores formation, but it is thinner. It is difficult to understand the absence of the La Plata in Riggs's section.

RECAPITULATION OF PALEOZOIC FORMATIONS.

It is proposed in the following pages to give a brief summary of the historical geology of the Paleozoic strata of Colorado. My discussion will be limited geologically to data furnished by the literature, and paleontologically to the literature and to the Carboniferous faunas which have come into my hands. Perhaps a consideration of the Carboniferous strata is all that is strictly appropriate, but the distribution of the older Paleozoics is not without a bearing upon the mutual relations of land and water during Carboniferous time, and this in turn is prime in importance in the matter of the relations of the Carboniferous sediments and faunas.

The presence of Paleozoic sediments is demonstrated over extensive areas in Colorado. They are concealed over large areas by later deposits, and in places their absence is an established fact; but I believe that originally they may have existed almost continuously over the State. Even if preserved from post-Paleozoic erosion, however, it seems improbable that the different groups would have had the same distribution, owing to erosion and disturbances within Paleozoic time itself.

The only Paleozoic strata at present known in Colorado are those of the Cambrian, Ordovician, Devonian, Mississippian, and Pennsylvanian eras, which are represented in an imperfect and fragmentary manner. This condition is doubtless in part due to original deposition, but is, I believe, in larger measure than generally admitted, the effect of periods of Paleozoic erosion. The Cambrian, Ordovician, Devonian, and Mississippian beds are reduced to comparatively insignificant thickness, and though these strata underlie broad areas, their outcrop is chiefly linear, following that of the present Archean and Algonkian masses. In some cases Carboniferous or later deposits are brought by overlap into direct contact with the Archean.

Some of the areas where early Paleozoic sediments might be expected, but are apparently lacking, are very extensive. Much of the work done in Colorado so far has been of a reconnaissance character, greatly deficient in detailed measured sections, careful tracing of beds, and the accumulation of paleontologic evidence. Thus it seems probable that thin measures of Cambrian or other Paleozoic sediments may have been overlooked, but in some cases they are obviously lacking.

It is generally true that where one of these earlier Paleozoic groups is found the others also are present, but while this holds good in a general way, important exceptions occur.

The Upper Carboniferous formations, however, are much more important in the matter of thickness; their outcrop covers extensive areas, and their distribution conforms only partially to that of the earlier Paleozoics. The largest body of Paleozoic outcrop in Colorado is that in the central portion of the State, and as the Paleozoic section is rather surprisingly uniform over this area the most advantageous manner of approaching the subject will be to consider the sediments and faunas of this region first, and to compare with them those of surrounding districts.

CAMBRIAN.

The Cambrian of central Colorado has been named the Sawatch quartzite. In the Crested Butte quadrangle this formation, which is extremely variable in thickness, permits of being divided into two portions. The lower division, which is from 50 to 200 feet thick, is a white quartzite, and has a persistent conglomerate of pure white quartz at the base. The upper division, with a maximum thickness of 150 feet, is a red, ferruginous, and somewhat calcareous sandstone. In it a few fossils of the Potsdam type have been found. This division is in places entirely wanting, as at the head of Taylor Creek.

The Cambrian about Aspen bears the same name and is essentially identical in its physical characters with that of the Crested Butte quadrangle. It is thicker to the south, where it measures 350 or 400 feet, but gradually diminishes northward, where it is 200 feet or less. Spurr does not recognize two divisions, as does Eldridge, but describes it as consisting at the base of a thin bed of conglomerate, which soon passes upward into fine white quartzite. The upper third is not so compact and pure as the rest, and consists of dolomitic quartzite, glauconitic grit, and sandy dolomite. The glauconitic grit has a peculiar reddish color, and others of the upper beds are stained with iron.

In his Eagle River section Peale described 604 feet of siliceous rocks which I think must represent the Sawatch quartzite. At the base is 400 feet of white quartzite which he identifies as Primordial, the remainder of the section being referred to the Calciferous. This consists of 10 feet of glauconitic sandstone at the base, with quartzite and sandstone above. Both Eldridge and Spurr have described the Sawatch as being glauconitic, and Spurr regards this as a characteristic feature. Peale does not mention the reddish sandstones to which Eldridge and Spurr make reference, but if the glauconitic sandstone of his section can approximately be correlated with the similar bed in the Sawatch quartzite at Aspen, the horizon appears to be represented, even if that lithologic character is lost.

At Red Cliff, according to Tilden, the entire sedimentary series below the Leadville limestone has a thickness of only 250 feet, and consists throughout of quartzite and sandstone. A few feet at the top of this series are referred to the

Silurian, and are, I understand, supposed to represent the Parting quartzite. A simpler interpretation would be to refer the entire quartzitic series to the Cambrian, and to suppose the Yule and Parting formations to be absent, owing, possibly, to the unconformity noticed at Leadville between the Leadville limestone and the Parting quartzite. The Cambrian at Red Cliff would then be somewhat intermediate in thickness as well as in position between the Eagle River section, where it is at least 400 feet, and that of the Tenmile district, where it is from 160 to 200 feet.

In the Tenmile district and the area adjacent the Cambrian, which here also is called the Sawatch quartzite, has a thickness of from 160 to 200 feet. It consists of the typical white quartzite, with a conglomerate at its base, but seems to lack the red sandstone which distinguishes its upper portion at some points. However, it is said to pass upward into reddish and greenish argillaceous and calcareous shales, in which have been found fossils belonging to the *Dikellocephalus* fauna of the Upper Cambrian.

Of the Grand River area north of the Eagle and the Grand we have little or no precise knowledge. The indications are, however, that the Sawatch quartzite with all its distinguishing characters will be generally found there wherever the proper horizon is brought to view. Although, aside from the sections mentioned above, our information is of a reconnaissance character, in view of the frequent mention by geologists of beds of quartzite of the character of the Sawatch and at the right horizon, the wide distribution of this formation in central Colorado is certain.

The Sawatch quartzite at Leadville, called in the Leadville monograph the Lower quartzite, has an average thickness of about 150 to 200 feet. The lower 100 feet are composed of finely and thinly bedded white saccharoidal quartzite, with a fine-grained conglomerate at its base. The upper 50 feet are shaly in character and more or less argillaceous and calcareous, and transitional to the Silurian limestone above. On the east side of the Mosquito Range, however, the thickness is in some cases diminished to 40 feet. The upper division, which weathers brown or rusty, is extremely variable. On the east flank of Quandary Peak a species of *Dikellocephalus* near *D. minnesotensis* was found at an horizon apparently above the main body of quartzite and near the base of the transitional series.

We may infer from Stevenson's account that the Sawatch, as part of his Silurian group, is more or less continuously exposed from the Leadville district, where it was first distinguished, to the southern limit of the South Park region. His section, made at Arkansas Canyon, represents it as a grayish-blue fine-grained quartzite resting on hornblendic gneiss and overlain by limestones whose faunas show them to be post-Cambrian in age. The thickness is not given, and the red, sandy member, which elsewhere appears in the upper portion, seems to be missing.

Endlich's observations upon this area are confined to the southern portion, and are, I fear, not to be wholly relied on. In one case he describes at a certain "station 56" yellow and brown quartzites resting upon porphyritic granite and followed by white and pink quartzite, then by shales and yellow quartzite, and finally by blue limestone and gray shales, which are probably Carboniferous. The other section, made at station 53, shows a different series. Resting on granite is a heavy quartzitic limestone, which can hardly be older than the Ordovician, and this is followed by thin shales, gray limestone, white, yellow, and pink quartzite and red sandstone, yellow and brown sandy shale, gray limestone, gray shale, sandy shale, dark blue limestone, and brown sandstone. The gray limestone near the top of the section appears to belong to the Lower Carboniferous.

The section first mentioned can probably be best interpreted by taking the porphyritic granite as an intrusive, and considering the basal quartzite as the Parting formation and equivalent to the very similar quartzite of the other section made at station 53. Unless the granite of the latter is also an intrusive it would appear that through nondeposition or ancient erosion the Sawatch is wanting in places even in the South Park region, so that the Yule rests directly upon the Archean.

Endlich found the "Silurian," under which title the Sawatch quartzite is elsewhere included, in small quantities south of the Arkansas, and the Hayden Atlas shows the Silurian color in the northern end of the Sangre de Cristo region bordering the river. In section *c* of the San Luis district Endlich describes the Silurian as consisting of light-colored quartzites of yellowish, bluish, and reddish tints, conformably stratified with the superincumbent gray to bluish limestone with siliceous segregations (p. 338). These beds certainly suggest the Sawatch quartzite and Yule limestone of standard sections, and Endlich states that lithologically they are identical with the Silurian north of the Arkansas. As described by Endlich, the lithologic resemblance is in some cases striking, but an unexplained contradiction seems to exist in stratigraphic position. In Endlich's Fossil Ridge section (Elk Mountain region) only the limestone is cited, the quartzite, if present, probably lying unexposed beneath it. In the series described as occurring at station 53, north of the Arkansas, both quartzite and limestone are found, but with their relative position the reverse of that recorded in section *c*, for the quartzite there rests upon, not under, the limestone. In the section at station 56, also north of the Arkansas, only the quartzite is found, resting upon a porphyritic rock which probably can be best interpreted as an intrusive concealing the limestone which, as at station 53, near by, lies beneath the quartzite. From its reported position in the two sections north of the Arkansas, the quartzite must be regarded as the Parting formation, while in that cited from section *c* it must be the Sawatch. It seems, therefore, either that Endlich's correlation of the beds is faulty, or, what is not improbable, that his observations as to the position of the quartzite is in error in one case or the other.

South of the Arkansas border—that is, over almost the whole of the Sangre de Cristo region—the Sawatch, together with the other early Paleozoics, is lacking, perhaps through nondeposition, but more probably, I believe, through erosion prior to the deposition of the Arkansas sandstone which rests for the most part upon the granitic foundations of the range. However, on the west side of the Sangre de Cristo Range, in the vicinity of Culebra Peak, in an area mapped by Endlich as Arkansas sandstone, the Van Diests have recorded the occurrence of beds which probably represent both the Sawatch quartzite and the Yule limestone.

The identification in this case, though based only upon lithologic character and geologic position, is fairly conclusive, and this isolated occurrence makes it not improbable that similar disconnected areas of older Paleozoics may be discovered in this and other regions where they now seem to be wanting.

In the Uinta Mountain region the section is so different from that of central Colorado that a comparison of the lithologic sequence without further means of paleontologic correlation is hazardous. The great formation which Powell designates the Red Creek quartzite must belong to the series now called Algonkian. This is immediately overlain by the Uinta sandstone. If the recognition of this formation by geologists of the King survey as the equivalent of the Weber quartzite of the Wasatch Mountains be correct, since the latter is of Pennsylvanian age, the Cambrian would appear to be absent in the Uinta Mountains. Yet, as the Uinta sandstone is so much thicker than the Weber formation, it is possible that its base may comprise an undifferentiated series belonging to the Sawatch quartzite, and even that other pre-Carboniferous horizons may be represented there by siliceous equivalents. On the whole, however, it seems to me probable that the Uinta sandstone comprises Carboniferous strata above, with probably a considerable thicknesss of Cambrian beds in its lower part. Unfortunately, about the exposures north of Eagle River, whose conduct might afford a clue to their relation with the Uinta section, very little is known.

Along the Front Range the Paleozoic are largely concealed by the Red Beds, though I have no doubt that they are present somewhere to the east, under the plains. The Cambrian outcrops but scantily along the Front Range, and it is no longer the white quartzite which formed such a distinctive feature of the Sawatch, but is composed largely of reddish sandstones, resembling rather the upper beds of the Sawatch and the Cambrian of the Black Hills. In the Pikes Peak quadrangle Cross describes it as follows:

"No Cambrian formation is represented upon the map, although it is probable that a small thickness of quartzite and of cherty limestone below the Manitou Silurian limestone belongs to that period. In Manitou Park and near Manitou Springs brachiopod shells, *Lingulepis* and *Obolella*, have been found in quartzites beneath the Manitou limestone, and the cherty limestone at the base of the series in Garden Park has yielded a trilobite *Ptychoparia*."

Peale, in his report for 1873,[a] gives a number of sections near Trout Creek and in Manitou Park, or, as he calls it, Bergen Park. In the section across Trout Creek, just below the canyon (sections No. 4 and 5 on page 208), the series consists of (1) granite, (2) yellow sandstone, (3) pinkish sandstone, (4) dark, purplish-brown sandstone, (5) green sandstone, and (6) blood-red calcareous sandstone. Of these there are about 100 feet. From the upper bed *Lingulepis* and *Obolus* are cited. Above the fossiliferous horizon occur pink limestones (7) with an extensive Ordovician fauna. Peale refers 6 and 7 to the Quebec group, and the sandstones below to the Potsdam. The two genera cited from 6, however, are, if correctly identified, clearly indicative of Cambrian, while the fauna of 7, though not without contradictions, probably indicates Ordovician. On a small stream flowing into Trout Creek (section —, p. 207) he gives 40 feet of yellow, brown-purplish, and green sandstone resting on a granite, which, with little doubt, represents the Cambrian of the preceding section, and these are succeeded by 130 feet of Manitou ? limestone. Another small tributary of Trout Creek gives the following section: (1) Granite, (2) white and yellowish sandstone, (3) pink sandstone, (4) dark, purplish-brown sandstone, (5) green sandstone, (6) brick-red shaly limestone, (7) pale-pink and gray limestone, (8) pink limestone (sec. 7, p. 209). The sequence here is the same as in sections 4 and 5 preceding, and as the limestones are said to contain the same fossils it will be necessary to draw the Cambro-Silurian line at the top of bed 6, giving the Cambrian a thickness of 86 feet.

Passing now to the very margin of the Front Range, the early Paleozoics are represented by the Hayden atlas as absent over all the northern portion from the Wyoming line southward to Manitou Park. King, however, held the view that into an unfossiliferous series of red limestones and reddish sandstones only 150 feet thick, occurring below a thickness of Red Beds measures in which Upper Carboniferous fossils are found, the whole of earlier Paleozoic time is condensed. This series, which he correlates with the "Potsdam" of the Black Hills, he includes under the Carboniferous color in two bands which extend along both flanks of the Colorado Range, and on its eastern side reach a short distance into the State of Colorado, where a similar area is represented (as Carboniferous) on the Hayden maps. While it is possible that the series thus differentiated by King is of Cambrian age, the evidence so far adduced is very slight. It nevertheless resembles lithologically those beds farther south along the range whose fossils seem to demonstrate their Cambrian age, as well as the Cambrian of the Black Hills.

Although not represented upon the Hayden maps, Cambrian beds probably occur

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, pp. 193–273.

in Pleasant or Perry Park, the series to which I refer being apparently included by Hayden in the Carboniferous.

We have two sections of the Perry Park beds, one by Peale and the other by Lee. These have been discussed and a certain lack of agreement pointed out. Peale's series is as follows:

Section at Perry Park.

	Feet.
8. Fossiliferous limestone with chert pebbles	6
7. Irregular limestone, with pebbles of chert and limestone	3
6. Red calcareous sandstone	3
5. Compact red sandstone	15
4. Dark-purplish cherty limestone	3
3. Red calcareous sandstone	4
2. Very coarse white sandstone	80
1. Granite.	

This first is of Carboniferous age, the equivalent of Cross's Millsap limestone. It seems to me probable that the lower beds of this section, possibly even from 2 to 6, inclusive, may be Cambrian.

Lee found some quartzites overlaid by cherty limestones, not in Perry Park itself, but some distance to the south. The quartzite he believes to be of Cambrian age, and the same as the Cambrian quartzite of the Pikes Peak quadrangle. The 40 feet of coarse-grained crumbling sandstone at the base of his Carboniferous section in the park is evidently the same as the basal sandstones of Peale's section, which seem by analogy with other sections to be Cambrian.

In the vicinity of Colorado Springs, Peale gives a section, which is No. 3 on page 201 of the same report. The series here is as follows:

Section near Colorado Springs.

	Feet.
5. Brick-red sandstone, with green layers	20
4. Coarse gray sandstone	6
3. Coarse dark-green sandstone	4
2. Coarse grayish-white sandstone	20
1. Granite.	

Peale says (p. 202): "Beds Nos. 2 to 5 I have referred to the Potsdam group, while those just above are undoubtedly of the Quebec group, as in beds lithologically the same on the western side of the range I found characteristic fossils." This is not altogether conclusive, but certainly the correlation suggested appears the most satisfactory one. Yet it is possible (though not probable, since that formation is not found in Manitou Park) that these lower beds are the Harding sandstone, which Cross says on the southeast side of the range rests locally on the basal cherty limestone (Cambrian), or even on granite. The beds immediately above 5 are red limestones, from which no fossils are known, but which Peale refers to the

Quebec group. Cross also visited Manitou Park in connection with the work of the Leadville monograph. He found about 50 feet of reddish-brown sandstone resting upon the Archean and succeeded by about 200 feet of calcareous sandstones and shales of variegated colors, red prevailing, which pass up into white or drab limestones, sometimes containing chert secretions and alternating with shaly beds. The lower beds furnished a *Lingulepis* related to *L. pinniformis*, while from 60 to 77 feet above, an Ordovician fauna was obtained. The limestone is without doubt the Manitou limestone, and the Cambrian is correlated, by Emmons, with the Lower quartzite (Sawatch quartzite) of the Leadville area. In the Pikes Peak quadrangle the Cambrian is reported as present, but in measures too thin to be given separate representation upon the map. It consists of quartzite and cherty limestone.

In Walcott's Canyon section no paleontologic evidence has been found to indicate the presence of Cambrian, and there hardly seems room for it below the earliest Ordovician strata. It appears, therefore, best to regard the Cambrian as absent at this point. Walcott's section rests immediately upon the Algonkian, and Cross's remark regarding the Harding sandstone, which I have quoted above, was apparently made with reference to a case similar to this.

No Silurian, under which term the Hayden geologists included also Cambrian, is represented in the Hayden atlas along the mountain front south of the Canyon outcrop, and at some points it is almost certainly wanting, as in Lee's section in the Sangre de Cristo Range west of Trinidad, near the southern border of the State. Indeed it is probably wanting over much of the range except its northern portion, but E. C. and P. H. Van Diest have shown it and the Yule limestone to exist on the west side of the Sangre de Cristo Range near Culebra Peak, as I have already mentioned. The evidence is purely lithologic and stratigraphic, but the occurrence seems to be authentic. The formation here is a white quartzite with a basal conglomerate closely similar to the typical Sawatch quartzite.

In the San Juan region the Cambrian is probably represented by the 200 feet of yellow, white, red, and brown quartzites occurring below the Ouray limestone. These were tentatively placed as the lower member of the Devonian by Cross and Spencer, but their Cambrian age is suggested by their lithology and stratigraphic position when compared with other Colorado sections, and by the fact that Mr. Cross has found among some talus very probably belonging to this formation, a block of quartzite covered with linguloid shells which can apparently be referred to the genus *Lingulella*.

In the valleys of Grand and Dolores rivers and many of their tributaries the Cambrian appears to be unrepresented, the Carboniferous in some cases and in others sediments of later age resting immediately upon the Archean.

Two of the most marked peculiarities of this formation are its diminution in thickness eastward, and its change of character along the Front Range. Its thickness in the Crested Butte quadrangle is from 50 to 350 feet; near Aspen 350 to 400 feet in the south and 200 feet or less in the north. On Eagle River it is 604 feet (Peale); at Red Cliff 235 feet (Tilden); in the Tenmile district 160 to 200 feet; in the Leadville district 150 to 200 feet. On the east side of the Mosquito Range it is only 40 feet; in Manitou Park, at different points, 40, 86, and 100 feet (Peale); in Perry Park 105 feet (Peale); at Colorado Springs 50 feet (Peale); in the Pikes Peak quadrangle, too thin to be mapped; at Canyon (and all but a few places along the Colorado and Sangre de Cristo ranges) absent; near San Luis 160+ feet (Van Diest); in the San Juan region 0 to 200 feet. It seems to be generally present over the Grand River, Elk Mountain, and South Park, and in the northern end of the Sangre de Cristo areas.

The Cambrian of the Front Range for the most part seems to consist of reddish sandstones more or less comparable to the Black Hills Cambrian and to the upper part of the Sawatch quartzite which rests upon white quartzite in the Crested Butte district and elsewhere. If the red sandstones of the Front Range do prove to be the same as the reddish part of the Sawatch considerable evidence of an unconformity between its two members seems to be furnished by the fact that the red member is lacking in some areas (e. g., on Eagle River, at Red Cliff, and locally at Crested Butte), and the white quartzite is lacking in others (along the Front Range).

ORDOVICIAN.

There is no evidence of the presence of Upper Silurian strata in Colorado. The only Silurian known is that of the Ordovician, though many of the older surveys employed this term to include the Cambrian also. In central Colorado this is a limestone formation, and has received the name of the Yule limestone. The Silurian is not a formation of great thickness anywhere in the State. Its outcrop is linear and generally follows that of the Cambrian Sawatch quartzite.

In the Crested Butte quadrangle, its typical area, the Yule limestone is assigned an aggregate thickness of 350 to 450 feet. Three subdivisions are recognized, the lower of which consists of quartzite, the middle of limestone, and the upper of marly variegated beds. The quartzite, 75 to 100 feet thick, is generally white, often calcareous, and contains indistinct fossil remains. The limestones of the middle division are 250 to 280 feet thick, light colored, thin bedded, frequently siliceous, especially at the base, and carry grayish-white cherts. They contain characteristic fossils, among which may be mentioned the fish scales abundantly found at this horizon near Canyon. The upper division is 60 to 90 feet thick, and its horizon is said to be wonderfully persistent in retaining the same lithologic characters.

In the Aspen district, to the Silurian are referred some pure dolomites of light gray-blue color, hard and compact, with a fine frosty luster. They are also somewhat siliceous. Like the Cambrian, these beds are said to thicken toward the south and to range from 250 to 400 feet. It seems to me probable that Spurr's Silurian corresponds to only the middle division of the three which Eldridge makes in the Yule limestone, for the upper division of Eldridge's section Spurr correlates with the Parting quartzite. The lower division may not exist at Aspen or elsewhere, and is in fact very variable at Crested Butte, being even wanting in places. It is more like Spurr's Cambrian than his Silurian, and there seems a possibility that the line between Cambrian and Ordovician may have been variously taken in different areas. The occurrence of a glauconitic horizon, to which Spurr calls attention, in the upper part of the Sawatch in the Crested Butte and Aspen districts, and in Peale's Calciferous group on Eagle River, seems to warrant a provisional correlation. Above the glauconite at Aspen occur sandy dolomites of unrecorded thickness, while above the glauconitic sandstone in Peale's section are found about 175 feet of sandstone and quartzite that may represent the quartzite series at Crested Butte which Eldridge, apparently upon fossil evidence, separated from the Cambrian and placed in the Ordovician. The lower member of the original Yule limestone, therefore, probably represents the transitional beds elsewhere grouped with the Sawatch quartzite.

In Peale's Eagle River section the quartzite and sandstone of his Calciferous group are succeeded by 219 feet of light colored magnesian limestone. This is the Yule limestone. Spurr found this formation to be thinning toward the north. Its thickness in the northern portion of his area was 250 feet, and its reduction to 219 feet in Peale's section is quite in line with this observation.

Tilden describes the entire section below the Leadville limestone at Red Cliff as consisting wholly of quartzite and sandstone, with a total thickness of but 250 feet. He denominates a few feet at the top of this series as "Silurian quartzite," by which may be meant the Parting formation, and while it seems more probable that this, like the beds below, is Cambrian, there is evidently nothing in the sub-Leadville series which invites comparison with the Yule limestone.

In the Tenmile district the Yule limestone is represented by a series of light drab-colored limestones, which are often magnesian and always more or less siliceous, sometimes passing into calcareous sandstone. Their thickness averages 120 to 160 feet, and the scanty paleontologic evidence determines their age to be probably Ordovician.

In the Leadville district this formation was originally called the White limestone, and was said to consist in the main of light drab dolomite, with from 10 per cent upward of silica. It is characterized by concretions of white, semitransparent chalcedony or chert. The average thickness is 120 to 160 feet.

Farther south in the Mosquito Range our information is less satisfactory. Stevenson found the Silurian, under which title are included all the sedimentary formations below the Carboniferous limestone, to be practically continuous from Mount Lincoln to the Arkansas, and it is thus represented on the Hayden atlas. The Silurian appears upon the west but not upon the east side of South Park, apparently indicating an overlap of the Carboniferous at this point along a line having a north-south trend. In the canyon of Fourmile Creek the beds referred by Stevenson to the Silurian consist of two limestones separated by 170 feet of sandstone, with some Cambrian quartzites at the base. The lower limestone is 40 feet thick, siliceous, and contains fossils which probably indicate the Ordovician. The upper limestone is 20 feet thick, red, argillaceous, fissile, and without distinct fossils. The intermediate sandstones are converted into quartzites, and it seems to me probable that they represent the Parting quartzite. In this event of course the upper limestone would not belong to the Yule. On the other hand the succession at this point suggests the Manitou, Harding, and Fremont formations of the Front Range. In the Arkansas Canyon the Yule compromises 112 feet of limestone, varying from dove color to black, overlain by partially altered sandstone with layers of quartzite. The latter probably is the Parting member, and Stevenson is, without much doubt, correct in correlating the limestone with the Lower limestone of the former section.

Endlich also describes two sections in the South Park region, but without giving the thickness of the constituent beds. They are located in the southern portion of the region, but their exact situation can not now be ascertained. The beds observed at station 56 have at the base a porphyritic granite above which occur yellow and brown quartzite, white and pink quartzite, yellowish shales interstratified with quartzites, blue limestone alternating with gray shales, etc. It seems probable that the porphyritic granite is an intrusive rather than an Archean body, in which case the quartzite, because of its relation with the rest of the section, would better be taken as the Parting quartzite instead of the Sawatch, which would be the natural interpretation if the igneous basement rock were the Archean. The blue limestone with *Orthis*, crinoids, etc., would then be the Leadville limestone, while the red sandstone above is clearly the Arkansas sandstone. In the section made at station 53 the beds which appear to belong to the Yule are described as a blue quartzitic limestone with crinoids and *Orthoceras*, separated from a hard gray limestone with corals and sponges by a thin shale bed. The gray limestone is overlain by white, yellow, and pink quartzites, which I take to represent the Parting quartzite, and to be the same series that formed the base of the previous section. The blue siliceous limestone rests immediately upon coarse-grained red granite. It does not seem altogether probable that in this instance the granite is intrusive, and in the event of its belonging in the Archean this seems to be an instance of the overlap of the Yule over the Sawatch member.

The Silurian is accordingly mapped in the Hayden atlas almost continuously along the west side of South Park to the Arkansas River, and south of the river in the northern end of the Sangre de Cristo Range. Endlich describes it in section *c* of the San Luis district as a gray to bluish limestone with siliceous segregations, characters which apply equally to the typical Yule of the Crested Butte district or to the White limestone at Leadville. It rests upon a quartzite having the characters of the Sawatch quartzite. Except in the vicinity of the Arkansas River neither Endlich nor Stevenson found any Silurian in the Sangre de Cristo region, and in the Hayden atlas it is represented as missing, the Arkansas sandstone resting immediately upon the granitic axis of the range.

In a recent detailed section by Lee, made near Culebra Peak, the older Paleozoics certainly seem to be unrepresented. E. C. and P. H. Van Diest, however, on the west side of the range, at a point nearly opposite Lee's section, in an area in which the Carboniferous color appears on the Hayden map, found not the Arkansas sandstone, but beds which appear to belong to the Sawatch and Yule formations. The supposed Silurian rests upon the white Cambrian (?) quartzite separated only by a thin bed of argillaceous shale, and consists of light gray siliceous limestone about 200 feet thick, with others of darker color above.[a] Possibly other isolated occurrences similar to the foregoing will be discovered in the Sangre de Cristo region.

Of the Paleozoics of the central Colorado area which lies north of the Eagle and Grand rivers, we know next to nothing except that there seems to be a much greater development of the Cambrian and Ordovician.[b]

The section of the Uinta Mountains is lithologically unlike that of the rest of Colorado, and our paleontologic evidence is so incomplete and to a certain extent so contradictory that it will be useless to look there for the Yule limestone or a representative of it until better information is at hand. It appears, at least, to be absent in its character of a limestone, and should it prove to be represented there, it must be by some as yet undifferentiated portion of the Uinta sandstone. I am not unprepared, however, to find that the whole Uinta series is of Carboniferous age.

Turning now to the Front Range we find the Ordovician section, like the Cambrian, different from that of the interior of the State. The most complete section is that of the Pikes Peak quadrangle, and I will briefly recapitulate the formations there found and their characters, before touching upon the other sections. In the Pikes Peak folio,[c] Cross recognizes three Ordovician formations—the Manitou limestone, the Harding sandstone, and the Fremont limestone. The oldest of these, the Manitou limestone, is a fine-grained pink or reddish dolomite less than 100 feet thick, containing *Ophileta*, *Camarella*, and a few other Ordovician fossils. The Harding sandstone has a maximum thickness of 100 feet and is made up of fine-grained saccharoidal sandstone in alternating banks of light gray and pinkish or variegated colors

[a] Colorado Sci. Soc., Proc., vol. 5, 1898, pp. 76-80.
[b] Peale, U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 110.
[c] U. S. Geol. Surv., Geol. Atlas United States, folio 7. 1894.

with a few bands of dark-red or purplish sandy shale. It contains fish plates and scales, and a rich invertebrate fauna like that of the lower Trenton of New York. The Fremont limestone is a bluish-gray or pinkish dolomite of uneven grain. It is 100 feet thick in Garden Park, but increases southward, reaching a maximum of 270 feet near Canyon. It is characterized by *Halysites catenulatus*, and contains also a large invertebrate fauna like the upper Trenton of New York. The Harding is separated from the Manitou limestone by an unconformity, and the Fremont is similarly separated from the overlying Millsap limestone. As the distribution of these formations is far from uniform, and as the Pikes Peak quadrangle contains portions of two distinct and different areas of outcrop, I will depart from the artificial collocation of the folio and discuss the areas in their natural relations.

Ordovician strata are known along the Front Range in Colorado at Perry Park, at Manitou Park, near Colorado Springs, and about Canyon.

Between the outcrops in the vicinity of Colorado Springs and those to the north of Canyon a small area of Silurian is represented in the Hayden atlas. Of these beds no description has been found, but presumably they comprise some of the formations discriminated by Cross in the Pikes Peak quadrangle just to the west. In addition to the foregoing, King distinguishes in Wyoming a series at the base of the Red Beds which he correlates with the Black Hills Primordial, and regards as the representative of almost the whole of Paleozoic time. The beds immediately overlying contain Pennsylvanian fossils, and both series are included under the Carboniferous color in bands extending along both flanks of the Front Range, the more eastern of these reaching from Wyoming a short distance into Colorado. This correlation with the Black Hills beds is based upon lithology and position, and lies especially between the Cambrian of the Black Hills and of the Front Range. The presence of Ordovician beds in the series discriminated by King remains an open question.

The Pikes Peak quadrangle includes part of the Manitou Park tract. In this area only the Manitou limestone appears and it derives its name from this occurrence. Peale has given a number of sections in Manitou Park, and these show the following characters of this formation, its equivalents being ascertained as well as I am able. The section on page 207, made on a small stream flowing into Trout Creek, is as follows:

Section near Trout Creek.

	Feet.
3. White massive limestone	100
4. Shaly-white limestone	
5. Pink limestone	30
6. Green sandstone	4
7. Brown-purplish sandstone	6
8. Yellow sandstone	
9. Granite	

The lower part of the section should probably be referred to the Cambrian, the Manitou limestone embracing beds 3, 4, and 5, which are succeeded by the sandstones and conglomerates of the Red Beds. In sections 4 and 5, on page 208, probably only the pink limestone forming the highest bed of the section should be referred to the Manitou. In it were found an *Orthis* like *O. desmopleura*, *Euomphalus*, *Asaphus* (*Megalaspis*), *Conocoryphe*, *Lingula*, *Bathyurus*, and *Paradoxides*, or *Olenus*. Peale unites this with the bed 6, assigning them, with a combined thickness of about 60 feet, to the Quebec group, but as the blood-red calcareous sandstone (bed 6) is said to contain *Lingulepis* and *Obolus*, it seems that it should be united with the strata below which Peale calls the Potsdam. Another section (sec. 6, p. 208) was made on Trout Creek. The lower portion was concealed, the exposures consisting altogether of beds which probably belong to the Manitou. These are from below upward:

Section on Trout Creek.

	Feet.
6. Yellowish white limestone	20
5. Mottled limestone	3
4. Purplish sandstone	34
3. Red limestone	
2. Light shady limestone	20
1. Red limestone	26

These give a combined thickness of 100 feet. The lowest limestone is fossiliferous, the fauna cited indicating Ordovician. Section 7 (p. 209) was made on a small tributary of Trout Creek. Though no fossils were found in this section, by analogy with the sections 4 and 5, with which a close agreement exists, all the lower portion belongs in the Cambrian, and only the 16 feet of pale pink and gray limestone (bed 7) and the pink limestone above it belong in the Manitou limestone.

The beds in Manitou Park were examined in connection with the geologic work of the Leadville monograph. On page 62 of this work it is stated that Whitman Cross obtained from a reddish brown sandstone, 45 feet above the Archean, a species of "*Lingulepis* related to *L. pinnæformis* of the St. Croix sandstone of Wisconsin." From red calcareous sandstone alternating with white limestone 105 to 122 feet above the Archean, he obtained *Glyptocystites* (?) sp., *Lingula* sp., *Orthis desmopleura*, *Metoptoma* n. sp., *Cyrtolites* sp., *Orthoceras* sp., and *Bathyurus simillimus* (?). The Ordovician age of this fauna is not to be questioned. It is said to be essentially the same as that of the upper third of the Pogonip limestone of Nevada. Lithologically the beds in which these fossils occur do not exactly agree with any one of the varying sections described by Peale, but they are most similar to section 6.

The geologic section in Perry Park has been described by Peale and later by W. T. Lee. In Peale's section[a] there appears to be no equivalent of the Manitou

[a] U. S. Geol. Geog. Surv. Terr., [Second] Ann. Rept., for 1875, p. 197.

limestone, though the lower part resembles the Cambrian beds of Manitou Park. Lee found a series of cherty limestones interstratified with red clay, in which were found *Dalmanella testudinaria* and other fossils obscurely preserved, indicating Ordovician time. This occurrence is south of Perry Park and the Ordovician there rests upon a deep red quartzite supposed to be Cambrian. A similar bed exists in the southern part of Perry Park, where it is represented on the map as resting upon the pre-Cambrian and as being overlaid by Red Beds. No fossils were found at this point. These beds appear to be missing in the exposures on Plum Creek, according to both Peale and Lee. The horizon of this formation in the Plum Creek section should be below the Mississippian limestone and above the sandstones which underlie it, if the latter are, as I have suggested, Cambrian. To explain what now appear to be the facts of distribution of these formations requires an overlap of the Ordovician upon the Archean, and an erosion period followed by an overlap of the Mississippian upon the Cambrian.

Peale also made a section through Glen Erie, near Colorado Springs.[a] The sandstones at the base probably belong to the Cambrian. Peale refers them to the Potsdam, and the beds just above to the Quebec group. The latter, ascending, is as follows:

Section through Glen Erie.

	Feet.
13. Red shaly limestone with fragments of fossils (Silurian)	4
12. Limestone with interlaminated shale	7
11. Red limestone with flint nodules	7
10. Red limestone	2
9. Red shaly limestone	1
8. Red limestone	1
7. Irregularly laminated limestone	5
6. Red and greenish limestone	5

These, I believe, can all be safely referred to the Manitou limestone, together with part of the bed following, No. 14, consisting of 279 feet of gray, purplish, and yellow limestone. The upper portion at least represents the Millsap formation. The Ordovician beds here also appear to belong to the Manitou limestone.

The Paleozoic outcrops of Garden Park in the southern part of the Pikes Peak quadrangle connect with those about Canyon. The section in Garden Park contains both the Manitou limestone, the Harding sandstone, and the Fremont limestone, whose description, abbreviated from the Pikes Peak folio, has already been given. The geologic section at Harding's quarry near Canyon was described by C. D. Walcott, and it is from this series that the names Harding sandstone and Fremont limestone were adopted by Cross. The Cambrian is apparently lacking in this section, the Harding resting directly on the Algonkian. The Harding sandstone, with a thickness of 86 feet, consists of gray, reddish, and purplish-brown sandstones

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept,, for 1873, p. 201.

and shales, and from it an extensive fauna is listed, from which the conclusion is drawn that the formation is of lower Trenton or Black River and Birdseye age. The Fremont limestone series consists of red and purple fine-grained arenaceous shales, gray siliceous limestone, compact light-colored limestone, dark reddish brown sandstone, and compact light gray limestone, a total of 274 feet. Walcott apparently included here 15 to 30 feet of impure variegated banded limestone with interbedded sandstones and argillaceous beds containing Carboniferous fossils. This, Cross later differentiated and called the Millsap limestone. The fauna of the Fremont is large and varied and is compared with the middle and upper Trenton of America, or the Bala of Europe. The fauna of the Harding sandstone is remarkable for its fish remains, associated with a well-marked Ordovician fauna. With the outcrops near Canyon, at one of which the section quoted from Walcott was made, the Paleozoic area included in the southern portion of the Pikes Peak quadrangle is essentially continuous. The section in Garden Park, however, includes Cambrian beds, the Manitou limestone, the Harding sandstone, and the Fremont limestone, while only the Harding and Fremont are found at Harding's quarry. Furthermore, the thickness of the Fremont limestone in Garden Park is about 100 feet, but it increases southward, and near Canyon reaches a maximum of 270 feet. This is partly through the development of an upper and highly fossiliferous member not seen in Garden Park (Cross).

In the Pueblo quadrangle the Cambrian and the Manitou limestone appear to be wanting, and possibly also the Fremont limestone. The beds referred by Gilbert to the Harding consist of white sandstone and rest upon the Archean. They are followed in the section by a series of gray and purplish limestones, some 200 feet in thickness, with some shale in the lower part, which Gilbert calls the Millsap limestone. Near the middle of the formation was obtained *Spirifer rockymontanus*, which is cited also from the Millsap limestone of Garden Park, so that the upper part of the formation at least is Carboniferous. As the Millsap is only 30 feet thick in the Pikes Peak quadrangle, and as the Fremont is 270 feet at Canyon, it is unexpected to find the former increased to 200 feet at this point and the latter totally absent. Perhaps, therefore, the lower part of Gilbert's Millsap belongs in the Fremont, which otherwise, like the Manitou, has no representative in this area.

The outcrop of these beds is in the western part of the quadrangle, and includes part of the small area which in the Hayden atlas is represented as Lower Carboniferous. Endlich describes these beds as grayish limestone and shale with Carboniferous fossils.

This is, so far as known, the last outcrop of the pre-Carboniferous sedimentaries south of Canyon along the mountain front. None have yet been found on the eastern flank of the Sangre de Cristo Range, and one detailed section—that made by Lee west of Trinidad—leaves little room for doubt that they are absent at that locality. West of Canyon, in the northern end of the Sangre de Cristo Range, Silurian strata occur, and are so colored upon the Hayden maps, as has already been remarked.

On the western flank of the range, though no Silurian beds are mapped by the Hayden survey, they have been recognized at one locality, at least, though the identification rests upon stratigraphic and lithologic, and not upon paleontologic evidence. The locality is northeast of the town of San Luis, nearly opposite the point at which Lee's section shows its absence on the east side. Lithologically, the Silurian here appears to belong to the Yule limestone.

Attention has already been directed to the difference between the Silurian section of the Front Range and that of the interior of the State. The evidence is not at hand to determine the relationship existing between the two sets of beds. If any exact lithologic correlation is possible, it rests between the Yule limestone on the one hand and the Manitou or Fremont limestone on the other. I rather expect that the correlation will be made, if at all, between the Yule and Fremont. Emmons correlated the Cambrian sandstone and Manitou limestone of Manitou Park with the Sawatch quartzite and Yule limestone of the Leadville section (Leadville monograph, p. 64). There deserves to be considered in this connection the occurrence of the fish-bearing horizons in the Paleozoic rocks of Colorado, these vertebrate remains being in every case of the Devonian type. They constitute an important factor in the fauna of the Harding sandstone and are found also in the Parting quartzite at Aspen, in the middle or calcareous division of the Yule limestone at Crested Butte, and in the middle or shaly member of Cross and Spencer's Devonian in the San Juan region. The latter I believe can with great probability be placed in the Parting quartzite horizon, and the other occurrences carry the suggestion that possibly this formation is the equivalent of the Harding sandstone. The sequence of the Sawatch, Yule, and Parting formations is, therefore, suggestive of the Cambrian, Manitou, and Harding beds of the Front Range. In this case the Yule would be correlated with the Manitou, as Emmons has suggested, nor does the occurrence of these fish remains at Crested Butte in the formation underlying seem to me a serious objection to this correlation. On the other hand, Eldridge has suggested in the Anthracite-Crested Butte folio a correlation of the middle or calcareous member of the Yule formation in which fish scales occur, with the fish-bed in the Ordovician at Canyon. Cross relates that the Fremont limestone is especially characterized by the occurrence of *Halysites catenulatus*, a fossil which is not rare in the Yule limestone. It should further be borne in mind that the lowest division of the typical Yule is a quartzite formation apparently assigned to the Ordovician on paleontologic evidence, and that in the Front Range an unconformity intervenes between the Harding and Manitou beds. There is thus considerable evidence favorable to correlating the lower and middle divisions of the original Yule with the Harding sandstone and Fremont limestone. If future information proves the correlation thus suggested, it is evident that the Manitou formation must be missing from the section of central Colorado, while the Parting quartzite must be missing on the eastern side of the Front Range.

No lithologic equivalent of the Yule limestone and no strata of Ordovician age are known in the San Juan region. Cross and Spencer make a three-fold division of the beds which they refer to the Devonian, qualifying the reference by the opinion that the two lower members, a quartzite and a shale, may be pre-Devonian. The quartzite I have already suggested as a possible equivalent of the Sawatch quartzite. The shaly member may belong in the Ordovician, but shows a different phase of deposition from that which produced the calcareous division of the Yule limestone. It more probably represents the upper portion of the typical Yule, which Spurr correlates with the Parting quartzite and refers to the Devonian.

SILURIAN.

There is but little evidence of the existence of Upper Silurian strata in Colorado. Emmons states (Leadville monograph, p. 61): "Casts of a *Rhynchonella*, between *R. neglecta* and *R. indianensis* of the Niagara epoch, were found in the prospect shaft in California Gulch, not far below the White Limestone quarry, in such a position that they must have been derived from the beds of this horizon at least 50 feet above the base of the formation." The evidence of this one species is unimportant, nor is the deduction drawn from it by Mr. Emmons that any portion of the Yule limestone is of Upper Silurian age; and in view of the extreme rarity of Upper Silurian strata in the west, considering besides that none are known elsewhere in Colorado, and that the Yule limestone has in many places furnished an Ordovician fauna, it is only fair to reason that Upper Silurian time is not, so far as known, represented in the rocks of the State, and that the evidence for its existence near Leadville is due to the imperfect condition of the fossils or to ill-considered identifications.

DEVONIAN (?).

Above the Yule limestone over much of central Colorado occurs a second quartzite horizon, similar to the Cambrian at the base of the section. This formation was first discriminated by Emmons, at Leadville, where he called it the Parting quartzite, and it has since been recognized at a number of localities. At Leadville this formation is a white quartzite, of rather variable thickness but remarkable persistence, and it was regarded as constituting the upper limit of the Silurian. In thickness it varies from 40 to 70 feet. On the east fork of the Arkansas evidence of nonconformity by erosion was observed at its upper boundary, "which renders it possible that the Upper Silurian and Devonian formations may be entirely wanting in this region." (Leadville monograph, p. 61.) It will also be remembered that an unconformity occurs at this horizon in the Front Range region, between the Millsap limestone and the underlying beds.

Spurr identifies the Parting quartzite at Aspen. He gives a section (Aspen monograph, p. 13) in which it is seen to comprise 67 feet of dolomite, dolomitic shale, sandstone, and quartzite in thin alternations. At Castle Butte the series is said to consist of a basal impure quartzite, a shaly bed stained a deep maroon color, a heavy light-green lithographic dolomite, and at the top a heavy quartzite. Spurr correlates the beds at Aspen having the above characters and a stratigraphic position between the Yule limestone and the Leadville limestones with the Parting quartzite of Leadville and with the upper member of the Yule limestone as it was differentiated and described by Eldridge in the Crested Butte quadrangle. This portion of the Yule is from 60 to 90 feet in thickness and consists of green, yellow, and red and white shale, with more or less calcareous layers, the latter passing into thin limestone. The lithologic characters of the bed differ in some particulars from the Parting quartzite at Aspen, and both differ from the formation at its typical localities.

Emmons identifies the Parting quartzite in the Tenmile district. It there has a thickness of from 15 to 60 feet and consists of siliceous beds, generally quartzites. The possibility of its being of Devonian age is referred to, but it is still retained with the Silurian, chiefly because of the unconformity at its top.

I have not recognized the Parting quartzite in Peale's Eagle River section, but the strata are there largely concealed at the horizon at which it ought to occur.

At Red Cliff, also, the Parting quartzite is possibly missing. Emmons was not able definitely to recognize it, nor is its recognition clear in Tilden's section at Battle Mountain. He found beneath the Leadville limestone the following sedimentaries in ascending series: Cambrian white quartzite, 125 feet; fine-grained sandstone, 100 feet; Silurian white quartzite, 5 feet; and conglomerate quartzite, 8 feet. One might infer Tilden's opinion to be that the lowest bed of this series represented the Sawatch quartzite, the succeeding one the Yule limestone, and the third and fourth, probably the Parting quartzite. By this interpretation, however, the Yule is represented by a sandstone, while the Parting formation is reduced to but 13 feet in thickness. As the Sawatch measures 400 feet on Eagle River, not to mention a considerable transitional series above it, and 160 to 200 feet in the Tenmile district, all of the siliceous beds at Red Cliff, amounting to less than 240 feet, might, as to thickness, without impropriety be referred to the Sawatch quartzite. This, however, involves the local absence of both the Yule limestone and Parting quartzite, which is open to objection but might be explained through the unconformity by which the Leadville limestone was preceded in the Leadville district. While it seems to me more probable that at Red Cliff all the beds below the Leadville limestone belong to the Sawatch quartzite, it is quite possible that the Parting formation also is included, as indicated by Tilden.

Spurr, as we have already seen, correlates with the Parting quartzite the variegated shales which form the upper division of the typical Yule limestone in the Crested Butte district. What may be the same series is described by Endlich as occurring in the southern part of the Elk Mountain region, south of the Gunnison River, in an isolated area called upon the map Fossil Ridge. The series here seems to resemble that in the Crested Butte in position, but shows a remarkable increase in thickness. It apparently comprises 80 feet of yellow and gray shales overlaid by 175 feet of variegated shale, partly sandy, with isolated banks of limestone. These beds occur above a thickness of limestone that can with a high degree of probability be identified as the Yule limestone and below another series of limestones from which a Mississippian fauna is cited. The character, thickness, and position of the lower shale especially are such as to correlate it with the upper division of the Yule, which, according to Spurr, represents the Parting quartzite. Though to regard the upper shales as forming part of the same series gives the formation a thickness not known at any other point, this course seems more natural than to join them with the Leadville series.

In the Grand River region the Parting quartzite occurs at Aspen as identified by Spurr, and in the Tenmile district as identified by Emmons, but it seems to be absent at Red Cliff and may not be present on Grand River. At Fossil Ridge, at Crested Butte, and at Aspen this formation seems to lack some of the qualities that characterize it at Leadville, being composed, apparently, largely of shales, some of which are sandy and some calcareous. In the Tenmile district, however, the composition of the formation is more typical, and it consists for the most part of quartzite.

In the South Park district the Parting quartzite occurs at Leadville, which is indeed its typical area, and it is probably to be found more or less continuously southward to the Arkansas. As part of the Silurian of Stevenson it is described as having this distribution, and the Hayden atlas shows the Silurian color continuously along the west side of South Park. Stevenson gives two sections in which this formation can be recognized. In that made at Fourmile Creek there appear to belong to it 170 feet of quartzite the upper portion of which is a conglomerate. These beds occur above a limestone which can probably be correlated with the Yule, and below another upon which the Leadville limestone presumably rests. Though Stevenson includes the overlying limestone in the Silurian, it would seem more appropriate to close the Parting quartzite with the siliceous beds and refer the limestone provisionally to the Leadville.

A second section was made by Stevenson in the canyon of the Arkansas on the southern border of the South Park region. At that locality 75 feet of sandstone described as "partially altered, with layers of quartzite; somewhat argillaceous; weathers to ochery color; contains many large fragments of jasper," can be referred to the Parting formation. It here rests upon 112 feet of limestone which represent the Yule, about 20 feet of red calcareous clay intervening between the two formations. The overlying beds are not known, and Stevenson remarks (p. 359) that it is more than probable that the Arkansas exposures do not exhibit the complete section, being defective on top.

Endlich also gives two sections in this region which include beds belonging, it would appear, to the Parting quartzite. They are situated in the southern part of the South Park region, but their exact location can not be known. One of these, which was made at station 56, contains a series of yellow to light brown hard quartzites, followed by white and pink quartzites of very fine texture, covered by yellowish shales which are later said to be interstratified with quartzites. Above these occur shales and limestones which appear to belong to the Leadville series. The underlying rock is a porphyritic granite which is more probably an intrusive than a portion of the Archean complex. In the other section, that made at station 53, the series is of a similar character. It consists of thick beds of white, yellow, and pink quartzites passing into light red sandstone. To this must probably be added a thick stratum of yellow and brown sandy shale covered by light yellow and gray shales. Beneath the quartzite are limestones whose partially identified fossils are suggestive of the Ordovician faunas, and above the shale a blue limestone with a fauna which appears to be Carboniferous. It will be observed that in the two sections cited from Endlich the strata which occupy the position of the Parting quartzite consist of a series of quartzitic beds below and another of variegated shales which rest upon them. The quartzitic portion possess considerable resemblance to the typical Parting quartzite, while the shales resemble the beds which at Fossil Ridge, Crested Butte, and Aspen, have been referred to the same series. It is possible that these occurrences at the same time indicate a dual nature for the strata referred to the Parting formation and demonstrate the stratigraphic relations of the constituent members.

The Parting quartzite probably forms part of the Silurian of the Hayden reports, as it does in the case of Stevenson's. Endlich found Silurian strata along the northern edge of the Sangre de Cristo region in that portion of his San Luis district which he designates as sections *b* and *c*. Here it comprises the Sawatch and Yule beds, and he describes nothing which has the lithology and stratigraphic position of the Parting series. It may be recalled that at stations 53 and 56 north of the Arkansas this author describes two sections in which beds of light-colored quartzite are reported as overlying a limestone of probable Ordovician age. These quartzites, which hold the position of the Parting quartzite, resemble the Sawatch quartzite which lies beneath the Ordovician limestone in section *c* south of the Arkansas. Endlich apparently regards them as the same. This fact and the apparent absence of the Sawatch in Endlich's sections north of the river lead me to consider it possible that he may have mistaken the position of the beds, and that the quartzite really occurs beneath instead of upon the Yule. In that case the Parting formation as a quartzite would be wanting at stations 53 and 56, and the sections at Fossil Ridge and on the south side of the Arkansas would be in closer agreement with those made there. Along with the Sawatch and Yule, the Parting formation, probably as the result of Paleozoic erosion, seems to be wanting over the Sangre de Cristo region in all but its northernmost portion, though possibly it may be found in fragments associated with them in occurrences such as the Van Diests have made known in the vicinity of Trinchera Peak on the west side of the range.

In the San Juan region it seems to me probable that the Parting quartzite will prove to be represented by the middle or shaly member of the threefold Devonian series of Cross and Spencer, the two lower divisions of which are recognized by them as possibly pre-Devonian. This shale in the San Juan region, which has a thickness of about 50 feet, occupies a position with regard to the Ouray limestone similar to that which the upper or shaly member of the Yule limestone holds to the Leadville limestone in the Crested Butte district. This portion of the Yule, which measures 60 to 90 feet in thickness, Spurr believes to be the same as the Parting quartzite of the Aspen and Leadville sections. Spurr found fish remains of Devonian type in the Parting quartzite at Aspen. Somewhat similar ones occur in the middle or calcareous member of the Yule limestone at Crested Butte, while Endlich cites them from the middle or shaly division of Cross and Spencer's Devonian. While positive proof is lacking, it seems to me that a number of circumstances favor the correlation of these shales in the Crested Butte district and San Juan region. The absence of the calcareous and typical Yule limestone in the latter area shows an independence of distribution which would seem to justify the separation of the upper from the middle divisions of that series made by Spurr. Its correlation with the Aspen section and position in the time scale, however, are questions apart, and I am indisposed to accept the evidence for the Devonian age of this horizon as conclusive.

The Parting quartzite was included by Stevenson in the Silurian, to which he referred all the sedimentaries below the Carboniferous limestone, and the practice of the Hayden survey appears to have been the same. Emmons, as we have already seen, refers it to the Silurian in his Leadville work. Eldridge, in the Crested Butte district, includes what, according to Spurr, is an equivalent body, as the upper division of his Yule limestone. Spurr recognized the Parting quartzite at Aspen, but, on the strength of some fish remains of Devonian type, assigns the formation to that period.

In the Tenmile folio, however, Emmons, while recognizing the data upon which Spurr proceeded, in the lack of direct evidence as to the age of these beds, still retains them in the Silurian, influenced to a considerable extent by the unconformity which intervenes between it and the overlying Leadville limestone. Although Spurr found Devonian fishes in the Parting quartzite at Aspen, it should be borne in mind that similar fish remains of Devonian types occur in the Harding sandstone, whose Ordovician age seems to be secure, and in the calcareous division of the Yule limestone in the Crested Butte quadrangle, of whose Ordovician age there is also little doubt. In view of these facts the force of this evidence is largely destroyed. Considering that the only known Paleozoic horizon in Colorado distinguished for its fish remains is in the Ordovician, that the Parting quartzite is separated from the Leadville limestone, at Leadville at least, by an erosional unconformity, and that the lower portion of the Leadville limestone contains over large areas a Devonian fauna, it seems to me that the evidence preponderates in favor of the Ordovician rather than the Devonian age of the Parting quartzite. This, however, is only another of the departments in which further and thorough research is necessary before a satisfactory conclusion can be reached. If the Parting quartzite should prove to be Ordovician, it would bring out a certain correspondence between the early Paleozoics of the Front Range and those of central Colorado, for the Manitou limestone and Harding sandstone of the one show a certain resemblance to the Yule limestone and Parting quartzite of the other, which, while not extremely close, certainly gives the two sections more uniformity than if the Parting quartzite were Devonian. Both the Parting quartzite and the Harding sandstone are siliceous, they are variegated in color, have about the same thickness, and are characterized by containing fish remains. It is true, however, that the abundant Trenton fauna of the Harding is not yet known in the Parting quartzites, and that the Yule limestone in the Crested Butte quadrangle also contains fish remains, while none have been noted from its possible equivalent, the Manitou limestone.

DEVONIAN.

There is an undoubted Devonian horizon in Colorado. The fauna was originally discovered in the San Juan region and it has since been recognized at widely separated points through the State. These fossils were first listed and described by Meek[a], who identified the horizon as Devonian. Later, C. A. White[b] found some reason, which was never stated, for regarding it as Carboniferous. More recently extensive collections were made in the San Juan region by Whitman Cross and A. C. Spencer, who procured a large fauna, which I described in 1900.[c] The latter fauna is

[a] U. S. Geol. Geog. Surv. Terr., Bull., vol. 1, 2d ser., No. 1, p. 46, 1875, see also U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept. for 1874, 1876, pp. 212–214.
[b] Cont. Invert. Pal., No. 6, p. 133, 1880 (extracted from the Twelfth Ann. Rept. of the Hayden survey for 1878)
[c] U. S. Geol. Surv., Twentieth Ann. Rept., pt. 2, pp. 25–81.

extensive enough and critical enough to clearly demonstrate the Devonian age of this horizon and vindicate Meek's earlier judgment. This fauna occupies the major portion of the Ouray limestone of the San Juan region and the lower part of the Leadville limestone of central Colorado. It has been found in the Durango and Engineer mountain quadrangles of the San Juan region, at Ouray, in the Crested Butte quadrangle, at Salida, at Glenwood Springs, and on White River in northwestern Colorado. It seems probable that it will also be found, if sought for, in the lower part of the Leadville limestone at Leadville, and, in fact, wherever this formation is exposed in Colorado. Perhaps the only strict exception which need be made is along the Front Range, where the Millsap limestone, the probable equivalent of the Carboniferous portion of the Leadville limestone, appears to lack this Devonian horizon. There are areas also in which the Leadville limestone is probably missing, and there, doubtless, it may not be expected. Of the distribution of this formation, I will speak a little more specifically in connection with its Mississippian fauna.

The Ouray fauna, as I may continue to call it, is not closely similar to the faunas of eastern and central United States. It seems indeed to have a closer parallel in the Devonian of the Ural Mountains,[a] with which it shows some striking similarities. It also has points in common with and seems to be related to the interior Devonian of the Rocky Mountain region. The absence of this fauna in certain areas where the Mississippian fauna, which it often accompanies, is present, as on the eastern margin of the Front Range, and apparently over part of the Wasatch Range (e. g., Rock Canyon), leads me to think that probably deposition was not quite continuous even where both faunas occur, and both are found in limestones, and that a slight unconformity may exist between the strata characterized by the Devonian and Mississippian faunas in the midst of the Ouray and Leadville formations.

CARBONIFEROUS.

MISSISSIPPIAN.

The Lower Carboniferous strata of Colorado are geologically comparatively unimportant by reason of their thinness, but they are widely distributed and form one of the richest metalliferous horizons in the entire rock series. This horizon is everywhere a limestone or a dolomite, sometimes more or less interstratified with shale, but owing to minor differences of lithologic character and circumstances of distribution several local names have been received by it. In central Colorado this limestone is called the Leadville limestone. In the San Juan region it is called the Ouray limestone, and along the Front Range it has received the name of the Millsap limestone. The lower portion almost everywhere contains a distinctive and unmistakable Devonian fauna. At least this fauna has been found at so many and such

[a] Murchison, etc., Géologie de la Russie, Paléontologie, London.

widely separated points that it may safely be regarded as generally present over the central part of the State wherever the formation is brought to view. In the few fragments of it which are still visible along the Front Range, however, the Devonian fauna seems to be wanting. This individuality in the matter of distribution has led me to suspect that the Devonian and Carboniferous portions of the Leadville limestone may not have been deposited strictly consecutively.

Beginning with its typical locality at Leadville, this formation is described as a heavily bedded series of dolomitic limestone, in the upper part often coarsely crystalline, having an average thickness of 200 feet. The color is a deep grayish blue, frequently nearly black in the upper portion, while some of the lower beds are lighter in color, approaching a drab. The upper bed is marked by characteristic concretions of black chert, often containing casts of fossils. A list of species of fossils derived from this horizon is appended to the description in the Leadville monograph, and the conclusion drawn that "this horizon represents the Lower Carboniferous of this district." (Page 66.) This conclusion I believe to be correct, though it hardly seems to follow from the faunal list, which, with one exception, contains nothing but Upper Carboniferous species. In the Leadville monograph, from which I have quoted above, this limestone is called the Blue or Ore-bearing limestone, and it was not until later that it received the name by which it is now known.

Under the title of the Blue or Leadville limestone this formation is redescribed by the same author in the Tenmile folio. No new facts are brought out, and it will not be necessary to repeat the description.

It is easy to recognize this horizon in Peale's Eagle River section, in which bed 26, described as a black, flinty limestone, with pieces of pyrite and fragments of *Spirifer* or *Spiriferina*, clearly represents it. Possibly a part of No. 25, which indicates a space probably filled mainly by limestone, also belongs to the Leadville, but it is evident that little besides distribution is added in this instance.

At Red Cliff, according to Tilden, the Leadville limestone comprises 250 feet of blue, dolomitic limestone below, overlaid by black, siliceous limestone 300 feet thick.

In the Aspen district the Leadville limestone has an average thickness of about 350 feet. It consists of two members, the lower of which is a heavy dolomite from 200 to 250 feet in thickness, and the upper a massive blue limestone from 100 to 150 feet. Spurr states that there is abundant evidence of two periods of dolomitization, one of which occurred before the deposition of the Blue limestone, while the other was much later, and was closely connected with the ore deposition (page 22). This fact and the circumstance that these two divisions have a well-marked plane of separation (page 23) afford evidence in support of the hypothesis that an interruption in sedimentation occurred between the Devonian and the Carboniferous portions of the

Leadville and Ouray limestones. Some further evidence may possibly be found in the sandstone dikes occurring in the lower dolomitic member, to which Spurr has called attention. In this connection, however, it remains to be shown that the Devonian phase of Leadville deposition is represented in the Aspen beds, and that the stratigraphic plane noted by Spurr corresponds to the time boundaries between the Devonian and the Carboniferous. Regarding the former point, the wide distribution of the Devonian fauna and its recognition at points as near as Salida, Glenwood Springs, and the Crested Butte quadrangle, make its presence at Aspen a matter of great probability. Regarding the second particular, on the other hand, Spurr very naturally seeks to correlate the lower or dolomitic member at Aspen with the entire Leadville limestone at Leadville, which is only 200 feet thick and dolomitic throughout, and with the lower, dolomitic portion of the Leadville in the Crested Butte quadrangle. This inference would tend to indicate that the line between Devonian and Carboniferous is not coincident with that between the dolomitic and calcareous portions of the Leadville, since I refer fossils from this formation at Leadville to the Carboniferous. It is possible that the difference in facies between the Leadville faunas as we know them, from Leadville on the one hand and Aspen and the Crested Butte region on the other, may be due to a difference of horizon in agreement with the correlation suggested by Spurr. It is noteworthy that the Millsap limestone, whose fauna is similar to that at Leadville and different from those at Aspen and Crested Butte, is also dolomitic. From the dolomite in the Aspen region no fossils are known, but Spurr mentions a number of foraminiferal genera as having been identified by R. M. Bagg in thin sections of the Blue limestone.

In the Anthracite-Crested Butte folio, where I believe the name Leadville limestone is first mentioned, it is described somewhat as follows: Its thickness varies from 400 to 525 feet and it consists principally of beds of limestone from 5 to 30 feet thick, sometimes separated by bands of quartzite or calcareous shale. At the top of the formation is a massive bluish-black bed 75 to 150 feet thick, known to miners as the "Blue limestone." Below this the limestones are grayer, apparently somewhat dolomitic, and carry a few dark-gray or black cherts. The Leadville here seems to be much thicker than at Leadville itself, a condition which can be adequately explained by the erosional unconformity by which the formation is followed.

The character of the Leadville at some of the points where it is best known has been briefly outlined. In the Grand River region it has been studied in more or less detail at Aspen, at Red Cliff, on Grand River, and in the Tenmile district, and the statement seems justified that it is generally present in that area. In the Elk Mountain region also it may be said to be in all probability continuously present. Its occurrence in the Crested Butte district has already been described. Endlich gives a section made at Fossil Ridge south of the Gunnison, in which the Leadville probably includes 260 feet of light gray and yellowish limestone and shale, 40 feet of light shale, and 20 feet of dark-blue Carboniferous limestone. This 20-foot bed contains a fauna which is compared with that found near Mystic Lake in Montana, and is without much doubt a member of the Leadville limestone. It is followed by 45 feet of light shale, 150 feet of light limestone and quartzite, and 50 feet of yellow, red, and white shale. These may belong either to the Leadville or the Weber limestones so far as any information is at hand. The light-colored limestone which I have included with the Leadville is underlain by 80 feet of yellow and gray shale and 175 feet of variegated shale with isolated banks of limestone. Both of these beds probably belong to the Parting formation, though here again satisfactory evidence entirely fails.

In the South Park region the Leadville limestone, as it occurs at Leadville and its vicinity, has already been described. Information with regard to the region south depends chiefly upon the accounts of Stevenson and of Endlich, though Peale also has briefly touched upon it. Stevenson usually refers to this formation as the Carboniferous limestone, and he apparently found it at intervals on the west side of South Park all the way from Mount Lincoln to Hunts Peak. He gives no sections and no detailed description. Endlich publishes two sections which include the Leadville beds, but their exact location can not be determined. They occur in the northern portion of his San Luis district and the southern portion of my South Park region. In the section made at "station 53" the strata which probably belong to the Leadville consist of a grayish-blue limestone, from which were obtained *Orthis*, *Productus*, and *Orthoceras*, followed by shales of a gray and brown color, more sandy above, which are in turn overlain by a series of heavy strata of dark-blue limestones. The lower limestone rests upon quartzites and variegated shales, which I refer to the Parting quartzite. The fauna mentioned suggests the Devonian fauna of the Ouray limestone or the Mississippian fauna of the Leadville horizon. The upper limestone is followed by a brown sandstone, which is apparently the Maroon or Arkansas sandstone. In this case the Weber limestone or shale is wanting, unless the upper limestone represents it instead of the Leadville. In the section made at "station 56" the Leadville probably comprises a series of blue limestones irregularly alternating with gray shales containing *Orthis* and crinoids. Bluish shales follow, and are covered in turn by a gray saccharoidal limestone. Beneath the lower limestone are found the quartzites and shales of the Parting formation, while above the upper one comes in a series of red sandstones, which I take to be the Arkansas sandstone and equivalent to the brown sandstone of the previous section. In the two sections just discussed, as well as in that from Fossil Ridge quoted previously, the beds referred to the Leadville formation consist of two limestones separated by shales, but the corresponding members of each series do not agree especially well with each other in lithologic detail. At Fossil Ridge the upper limestone is overlain by shales and other limestones and contains a fauna which I have little doubt correlates it with the Leadville and Ouray limestones. In the two South Park sections no transitional or intermediate series is mentioned above the upper limestone, and the diagnostic fossils, so far as they are diagnostic at all, are reported only from the lower member, so that if the Weber formation is present it would probably embrace some of the beds tentatively placed with the Leadville formation. In the other case the change of the Leadville, which farther north appears to be a homogeneous limestone series, to two limestones with an interbedded shale is worthy of note.

Though the older Paleozoics whose distribution the Leadville limestone closely follows, are said by Endlich to occur for a short distance south of the Arkansas, and the "Lower Carboniferous" color appears in the Hayden atlas in the north end of the Sangre de Cristo Range, the Mississippian limestone is wanting over most of the region. We have, however, no description of its occurrence at its northern localities. The Hayden atlas also represents a small area of Lower Carboniferous at Trinchera Peak, and this Endlich describes as a grayish-brown, compact shale, sandy in part. and interbedded with limestone, and conformably underlying the red Carboniferous sandstone. He suggests that this may represent the Lower Carboniferous. There really seems to be no evidence sufficient to determine whether it is the Leadville series (though from the lithology this hardly seems likely), the Weber formation, or part of the Arkansas sandstone.[a] Lee has recently examined part of the area where Lower Carboniferous is represented on the map and found only the Arkansas sandstone, from which the inference may be drawn either that the limits of the area are incorrectly represented on the map, or that Endlich erred in separating these beds from the younger formation. Stevenson describes no formation older than the Arkansas sandstone south of the river, and if he met with any occurrences he presumably included them in the Pennsylvanian. While these formations pinch out and disappear south of the Arkansas it is possible that they may occur in local patches beneath the sandstone. The somewhat doubtful occurrence of the Leadville limestone at Trinchera Peak, and the appearance of the Sawatch quartzite and the Yule limestone northeast of San Luis, reported by the Van Diests, indicate that other similar instances may exist.

The equivalent of this formation in the Uinta Mountains is well-nigh as uncertain as that of the earlier Paleozoic beds. It can be correlated with the lower portion of the Wasatch limestone of Utah and with the Red Wall limestone of the Grand Canyon country, the lower portion of which belongs in the Mississippian, as Meek, Walcott, and Frech report. Though Meek's reference was made with hesitation, and

[a] The strata above the Archean in Lee's section have more the character of the Maroon than of the Weber limestone, which is absent or has lost its calcareous character.

several circumstances unite to cast suspicion upon the Mississippian determination for the Red Wall, collections of fossils more recently made demonstrate that the lower portion at least belongs to that epoch. The Pennsylvanian age of the upper portion, however, is unmistakably shown by the faunal list supplied by Meek, and since the upper Mississippian is usually missing in the western sections, owing to Pennsylvanian erosion (or possibly to nondeposition), it seems probable that the formation is divided by an unconformity otherwise undetected. Furthermore, Powell claims to have traced the Red Wall into the Uinta Mountains, where, both by its somewhat ambiguous fauna[a] and by its stratigraphic position above the Uinta sandstone, which Emmons correlates by tracing with the Weber quartzite, whose Pennsylvanian age throughout is satisfactorily known, it belongs, with little doubt, in the Upper Carboniferous. If the Leadville limestone occurs in the Uinta Mountains it must be as one of the siliceous beds of the Uinta sandstone and not as the Red Wall limestone as identified by Powell; but since this horizon is so persistently characterized by its calcareous nature it seems somewhat more probable that Mississippian time is unrepresented in the Uinta series of rocks.

Along the eastern margin of the Front Range the Mississippian limestones appear in several places. It is in this tract called the Millsap limestone. The Millsap limestone was first described in the Pikes Peak folio, from which I abstract the following: It consists only of local remnants resting upon the Fremont limestone in Garden Park and along the western line toward Canyon. It is represented by about 30 feet of thinly bedded, variegated, dolomitic limestone, with a few thin sandstone layers. Chert nodules in the upper limestone layers carry casts of *Spirifer rockymontanus* and *Seminula subtilita*. It is divided from both the formation which preceded and that which followed it by an erosional unconformity. This formation is found also at Perry Park, where both Peale and Lee have made sections including it. These sections have already been referred to, as the sandstones in the lower portion, though assigned by both authors to the Carboniferous,[b] may yet prove to be Cambrian. Peale's section includes the following beds: 1. Granite; 2. Very coarse white sandstone, 80 feet; 3. Red calcareous sandstone, 4 feet; 4. Dark purplish cherty limestone, 3 feet; 5. Compact red sandstone in layers of 1 foot thickness, with cross seams of calcite, 15 feet; 6. Red calcareous sandstone, very hard and with cross cleavage layers of 1 inch, 3 feet; 7. Irregular limestone, with pebbles of greenish chert and limestone, 3 feet; 8. Indistinct outcrop of limestone, with chert pebbles and fossiliferous—in the upper part of the space a purplish sandstone, above which is a gray sandstone passing into the next bed—6 feet. Peale says (p. 198): "The fossils found in No. 8 (*Terebratula* and *Spiriferina*) prove it to be Carboniferous beyond a doubt." This stratum, which probably belongs to the

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[a] Found not in the Uinta Mountains proper, but south of them, in eastern Utah.
[b] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, p. 197.

Millsap limestone, is overlain by the Red Beds. With No. 8 will probably go No. 7, and possibly also 6, 5, and 4, though it seems to me rather probable, by analogy with neighboring sections, that 2 and 3 at least are pre-Carboniferous and represent the Cambrian. No. 1 also suggests the Harding sandstone of the Pueblo quadrangle.

The beds which Lee refers to the Carboniferous have at the base 40 feet of coarse, green, crumbling sandstone, conglomeratic in places, and mottled in varying shades of red and gray. Above this sandstone appear 10 to 15 feet of deep-red to white cherty limestones alternating with red shales. Near the top of this series Carboniferous fossils were obtained. Above these occur several hundred feet of coarse-grained sandstones and conglomerates, which appear to be perfectly conformable with the fossiliferous series. It is clear that the siliceous series last referred to is not a part of the Millsap limestone, but probably represents a portion of the Fountain beds above. The sandstones at the base probably correspond to those mentioned by Peale, which I have referred, upon somewhat doubtful evidence, to the Cambrian. The Millsap limestone, then, would embrace merely the small thickness of cherty limestone in the middle of Lee's Carboniferous. It seems probable from these sections that the Millsap, small as is its thickness in Garden Park, in the Pikes Peak quadrangle, is still further reduced in Perry Park.

The Millsap is apparently absent in Manitou Park, the Fountain beds coming down upon the Ordovician; but at Glen Erie,[a] near Colorado Springs, the whole or part of a series of gray, purplish, and yellow limestones, 279 feet in thickness, may belong to it. Mr. A. W. Grabau informs me that he has collected a Carboniferous fauna from the upper portion. Beneath this bed occur red shaly limestones with Ordovician fossils (the Manitou limestone), and above it the Red Beds.

Some beds belonging to the Millsap limestone are apparently included by Walcott in a section which he describes from Harding's quarry, near Canyon. Here it is reported as 15 to 30 feet in thickness, and as consisting of impure, variegated, banded limestone, with interbedded argillaceous beds. *Spirifer rockymontanus* and *Seminula subtilita* are cited.

Gilbert recognized the Millsap limestone in the Pueblo quadrangle, where it consists of gray and purple limestone, with some shale, especially in the lower part. These strata are 200 feet thick, and are said to rest conformably upon the Harding sandstone. Near the middle was found *Spirifer rockymontanus*, a species which is cited from the typical exposures in Garden Park. It seems probable, therefore, that the upper part of Gilbert's Millsap is correctly correlated. As at the nearest outcrops of these formations, viz, those at Canyon, the Harding sandstone is followed by 270 feet of Fremont limestone and but 15 to 30 feet of Millsap, it is a little unexpected to find that the thick Fremont has vanished, and that the Millsap

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, p. 201.

has increased to ten times its bulk. It thus seems possible that the lower portion of this series in the Pueblo quadrangle may represent the Fremont, though satisfactory evidence upon this point is lacking, while Cross's remarks upon the restricted distribution of the Fremont should be borne in mind. In any event the Millsap is greatly increased in thickness from its Garden Park and Canyon outcrops.

Endlich also recognized the Paleozoic nature of these beds, and they are represented on the Hayden maps as an area of Lower Carboniferous, part of which is included in the Pueblo quadrangle. Endlich described them as consisting of grayish limestones and shales, and apparently his observation relates to the Millsap limestone alone, without including the Harding sandstone which lies beneath.

In the San Juan region Mississippian time is represented by the Ouray limestone, the major portion of the formation, however, containing a Devonian fauna.

The Ouray limestone is defined by Cross and Spencer somewhat as follows: It consists of massive beds of limestone separated by thin intercalations of marl or shale. Certain thin bands are frequently quite coarsely crystalline, but the large mass of the formation is a dense or semicrystalline limestone. The thickness is about 150 feet. The greater part of this formation appears to be of Devonian age, and it was only comparatively recently that a Mississippian fauna was obtained from its upper portion. The latter is intimately related to the Mississippian faunas at Leadville and Aspen, and also to the Waverly fauna of the Wasatch limestone of Utah, the Madison limestone of Wyoming and Montana, the typical Waverly of Ohio, and the Chouteau limestone of Missouri. The fauna of the Millsap limestone, as we know it from Perry Park and also from Garden Park and Canyon, and that of the Leadville limestone at Leadville, present a rather peculiar facies, but even this fauna seems to be related to those of the early Mississippian, and it is somewhat singular that the Leadville fauna is more nearly allied to that of Perry and Garden parks, while lithologically and stratigraphically the Leadville as a formation is especially to be compared with the Leadville of Aspen and of the Crested Butte region. I think we can safely regard these faunas as varying facies of a single widespread and contemporaneous fauna, the differences being due in part to varying environmental conditions and in part to quite a different cause. Our collections from these beds are extremely meager, and to this circumstance can be referred some of the differences at present existing.

The Lower Carboniferous of the Hayden survey geologists consists in the main of this bed, though it is doubtful if they were consistent throughout in recognizing its limits. With them also the term was used rather as meaning the lower portion of the local Carboniferous section than in its strict paleontological sense as the equivalent of Mississippian. In this sense apparently the term is used in the Leadville monograph, where the Leadville limestone is referred to the Lower

Carboniferous. Walcott in his Canyon section, Cross in the Pikes Peak folio, and Gilbert in the Pueblo folio refer the Millsap limestone to the Carboniferous merely, without being sure to what portion of the system it belonged. Lee, in discussing the Pikes Peak section, uses my determination of the age of the Millsap. Emmons in the Tenmile folio, Eldridge in the Anthracite-Crested Butte folio, and apparently Spurr in the Aspen monograph, refer the Leadville limestone to the Lower Carboniferous in its true sense as a division of the geologic time scale. Peale in his Eagle River section seems to be uncertain whether the corresponding beds were Carboniferous or Devonian. Cross and Spencer refer the Ouray limestone to the Devonian, because a Devonian and no Carboniferous fauna was known from it at the time of their writing. It is now fairly certain that the Carboniferous portion of the Leadville, Ouray, and Millsap limestones are of early Mississippian age.

This formation, or, as it has received several names, this horizon, is widely distributed in Colorado. It is known in the Grand River region (the Devonian portion has been recognized on the White River and at Glenwood Springs and the Carboniferous probably on Eagle River), in the Elk Mountain region, in the South Park region, in the northern part of the Sangre de Cristo Range, in the San Juan region, and along the Front Range. It is probably lacking over much of the Front Range and Sangre de Cristo areas, in the Uinta Mountains, and in the valleys of the Dolores and the Grand, and it is concealed over extensive areas by deposits of later geologic age; but it is perhaps the most widespread of all the Paleozoic formations except those belonging to the Pennsylvanian. The remarkable persistency of this horizon as a limestone formation, not only in Colorado but throughout the West, and the widespread distribution of essentially the same fauna, would argue extended and uniform marine conditions during Mississippian time. Whatever may have been the conditions prior to the formation of the Leadville limestone, I believe that there were no land areas in Colorado during the Leadville epoch. Aside from the persistency of the fauna and the lack of anything like shore deposits at this horizon, the fact that the Leadville nowhere, so far as I have read, lies upon the Archean is evidence in point. As the Leadville period was one of subsidence, had there been permanent Archean land areas deposits could hardly have failed to be laid down upon some of the submerged land. The possibility that the waters advanced only so as to fall short of at all points, or not to transgress, some former level does not need serious consideration. On the other hand, I do not see that the sedimentation of Leadville beds upon the Archean, even if it does occur, would necessarily be evidence in favor of permanent Archean land masses in Colorado.

PENNSYLVANIAN.

The Lower Carboniferous period was followed by an epoch of elevation and erosion. At all events none but the early portion of Mississippian time is apparently represented in the Colorado sediments. The chronological point at which this elevation took place is, except in a general way, unknown. It may have occurred soon after the formation of the Leadville limestone, the absence of the upper Mississippian horizons being due not so much to erosion as to nondeposition; but it seems to me rather more probable that this episode was nearly contemporaneous with the elevation in eastern North America at the close of Mississippian time. That the elevation is of wide extent is indicated by the absence over such large areas in our Western States of upper Mississippian faunas. To the erosion which resulted from this elevation the variation in thickness of the Leadville limestone in different sections can often be ascribed. When subsidence again permitted the formation of sediments, the earliest deposits were frequently of a less purely marine character, and shortly a great thickness of sands and conglomerates intermingled with non-persistent limestone bands began to form over great areas in the State.

The Paleozoic section of central Colorado, by which term I would include the Grand River, Elk Mountain, and South Park areas, is singularly uniform, and this is scarcely less true of the strata of Carboniferous age than of the earlier Paleozoics. Though these are fairly constant in lithologic characters, the nomenclature employed for them has varied somewhat. Thus in the Anthracite-Crested Butte folio the Carboniferous formations are called the Leadville limestone, Weber limestone, and Maroon conglomerate; in the Aspen monograph, the Leadville limestone, Weber formation, Maroon formation, and the Triassic;[a] in the Tenmile folio, the Leadville limestone, Weber shale, Weber grits, Maroon formation, and Wyoming formation;[a] and in the Leadville monograph, the Blue limestone, Weber shale, Weber grits, and Upper Coal Measures.

The distribution of the Leadville limestone has already been described. While the general equivalence of the Upper Carboniferous formations of this area is comparatively easy to ascertain, their relations to the different formations of the regions adjacent, of the Uinta Mountains, of the Front Range, of the Sangre de Cristo Range, and of the San Juan region are questions of more intricacy, and it will not be possible to consider each formation by itself, but in relation to the other Pennsylvanian formations of the same section.

In the Crested Butte quadrangle the beds immediately overlying the Leadville limestone are called the Weber formation, and they are succeeded by the Maroon formation. The Weber formation apparently derives its name from the Weber quartzite of the Wasatch Mountains of Utah. I shall refer to this point again, but it seems that the correctness of the correlation suggested by the nomenclature is very doubtful and that the employment of the term Weber for formations in Colorado can not with propriety be continued. The Weber formation consists principally of

[a] I do not of course mean to imply that the Triassic of the Aspen district and the Wyoming formation are Carboniferous formations, but I desire to consider them in connection with the Carboniferous and to compare their nomenclature.

dark carbonaceous and calcareous shales and thin limestones. The thickness varies from 100 to 550 feet, a range of measurement which is accounted for by Eldridge by the fact that it follows a marked unconformity. Its fossils are abundant, and of the Coal Measures type. The Maroon conglomerate is taken to begin with thin beds of calcareous grits different from the constituents of the Weber formation, and to end with "the unconformity overlying the Gunnison sandstone," though in this last statement "overlying" is clearly a misprint for *underlying*. The maximum thickness is thus 4,500 feet. A lower and an upper division of the formation are recognized. "The lower division is an alternating series of yellowish-gray grits, thin limestones, and shale beds, reaching 2,000 feet in thickness in their greatest development along lower Cement Creek. The grits consist of grains and pebbles of quartz and limestone, with a calcareous and somewhat ferruginous cement." The limestone pebbles vary in size up to 3 or 4 inches, and frequently contain Coal Measures fossils. This occurrence of Upper Carboniferous fossils in pebbles in the Maroon conglomerate is an important and well-established fact. Station 2306, near Cement Creek, in our collections, seems to be an instance of this association, and the fauna, it will be seen, is clearly a Pennsylvanian one. It is somewhat unexpected that the fauna of these pebbles is the native Maroon fauna and not that of the eroded Leadville limestone or of the Weber formation. The limestones of the lower division occur in beds from 1 to 15 feet thick, are of bluish-gray color, and are frequently fossiliferous. The upper division, which has a maximum thickness of about 2,500 feet, is composed of alternating beds of conglomerate and sandstone, with some shales and occasional limestone beds. The pebbles of the conglomerate consist largely of red granite and schist from the Archean areas, with representatives of quartzites and limestones of the older sediments. The upper division is of a peculiar red or chocolate color. It is found in greatest thickness in the northern part of the Crested Butte quadrangle, and is very greatly decreased in the southern portion.

In the Aspen district the Weber formation consists of a series of thin-bedded carbonaceous limestones and calcareous shales. The typical rock is a black limestone, thin bedded, and aphanitic. The maximum thickness is reported at not much less than 1,000 feet. "Above the Weber formation comes a great thickness of mixed arenaceous and calcareous sediments forming impure grits and thin-bedded shaly limestones. This formation is calcareous and thin bedded at first, but becomes more massive and arenaceous farther up. The general color is a peculiar dark red * * *."[a] "The purplish-red beds pass upward into more massive and fine-grained sandstones which are more purely siliceous in composition and of a bright brick-red color." "The change to these Red Beds, however, is not abrupt, and does not indicate any break in the sedimentation."[b] There is a basal gray bed of the Maroon

[a] U. S. Geol. Surv., Mon., vol. 31, p. 33.

[b] Ibid, p. 34.

formation (which in this district is not very conglomeratic) of about 200 feet in thickness, the remainder being a dark reddish-brown, impure, micaceous sandstone. The gray grits of this formation are made up almost wholly of granitic material, quartz, feldspar, and mica. The red sandstones are ferruginous and contain more calcareous and less granitic material. Spurr assigns to the Maroon formation a thickness of 4,000 feet, and to the brick-red sandstone overlying a thickness of 2,600 feet.

The relation between the sections described by Spurr from about Aspen and that of the Crested Butte quadrangle is not absolutely clear, although geographically the two areas are not widely separated. The Weber formation of the Aspen district appears to answer to the Weber formation of the Crested Butte quadrangle, though at Aspen its thickness is double what it seems to be in the Crested Butte quadrangle. The Maroon formation appears in the Aspen district with characters considerably changed. These seem to persist more uniformly throughout the series, in such a manner that it no longer can be divided into two members, as in the Crested Butte quadrangle. There it is conglomeratic, especially in the upper portion; but this character seems to be largely lost in the Aspen district. On the other hand, the dark-reddish color, which is one of the distinguishing characters of the upper member of the original Maroon, seems to pertain practically to the entire series about Aspen. The Maroon at Aspen graduates into a bright-red series, the Triassic of many authors, which appears to be unrepresented in the Crested Butte region. In the one case the Maroon formation, in the other the Trias, is overlain by the Gunnison formation, which was preceded by an erosional unconformity.

An argument might be constructed to show that the Maroon of Spurr represents only the upper member of the typical formation, but on the whole this seems too improbable to require serious discussion. Unfortunately, the paleontologic evidence is not at hand to put these matters beyond dispute.

While it is comparatively easy to see the general equivalence between Peale's Eagle River section and the groups of rocks distinguished in the later monographic and folio work, it is a little difficult to satisfactorily determine their corresponding boundaries.

In the Crested Butte quadrangle the Maroon formation is terminated above by an unconformity, and immediately followed by the Gunnison formation, of Mesozoic age. In the Aspen section Spurr distinguished above the beds correlated with the Maroon a series of bright-red sandstones referred to the Triassic. These are followed by an unconformity, and then by the supposed equivalent of the Gunnison formation. The beds which Peale counts as Jurassic appear to be same as the Gunnison formation of Spurr, and the latter's Leadville, Weber, and Triassic formations would be comprised in the series lying between Peale's Silurian and Jurassic. These Peale discriminates as possible Devonian, Carboniferous, Permo-Carboniferous or Permian, and Triassic. There are one Devonian, one Carboniferous, two Permian, and one Triassic section, which it will be desirable to consider. The Devonian, Carboniferous, and one of the Permian sections form, with the Silurian, a single continuous series. The other Permian section is probably continuous with the Triassic and with one of the Jurassic sections, and was made at a different locality from the first. Instead of being equivalent, I think Peale's two Permian sections are much more likely to be nearly consecutive, the second being above the first, but overlapping, it may be, to some extent. I have quoted Peale's sections in full in another place, and discussed their relations.

Above the beds which Peale refers to the Silurian occur black, flinty limestones with pieces of pyrite and fragments of *Spirifer* or *Spiriferina*. This is succeeded by a space probably filled mainly by limestones, the entire thickness being estimated at from 1,000 to 1,500 feet. The black, flinty limestone is without much doubt the Leadville limestone, but probably not the entire thickness can be assigned to that formation, which is only 350 feet thick at Aspen and 200 feet thick in the Tenmile district. After an interruption of 15 feet of trachytic rock, the section proceeds in an upward direction, with a space of 408 feet filled mainly with shale and sandstone, and having a limestone at the base, from which some fossils were obtained that seemed to indicate Pennsylvanian time. *Aviculopecten*, *Pleurophorus*, and an *Avicula* or *Bakewellia* are cited. The middle or upper portion of this series of poorly exposed beds probably belongs with the Maroon formation. The limestone at the base, together with those below, would then represent the Leadville and Weber formations, so that the dividing line between the Leadville and the Weber and between the Weber and the Maroon formations can not be ascertained. At all events, the calcareous beds of the Leadville and the Weber at this locality must aggregate about 1,500 feet, more or less. This is more like the Aspen section, where these two formations amount to 1,350 feet, than the Tenmile district, where they only measure 500 feet. In Tilden's section at Red Cliff also they have a combined thickness of 1,550 feet. The remainder of the Carboniferous section above the portion supposed to represent the Leadville and Weber limestones amounts to about 2,400 feet. The Permian section, which is continuous with it, is 1,276 feet thick. Together the two series comprise 3,676 feet, of about the same character of rock, and can safely be taken as part of the Maroon formation. The "Carboniferous" beds consist of greenish, brownish, white, gray, red, reddish-brown, and pink sandstones, which are sometimes conglomeratic and more or less intermingled with shaly beds. The Permian consists of gray sandstones and white conglomerate, with about 10 feet of blue limestone. The other Permian section consists of a lower portion 700 feet thick, which probably belongs in the Maroon conglomerate, and an upper portion 500 to 800 feet thick, which I think should be placed in the Red Beds. The lower division, which probably somewhat overlaps with the other Permian section but may follow it, with or without an interval, consists of pink, brown, and gray shaly standstone, with thin interlaminated beds of limestone below, followed by shales, sandstones, and limestones in alternating colors of pink, brown, gray, yellow, white, cream color, and blackish. With the addition of these strata the equivalent of the Maroon would have a thickness of 4,376 feet, approximately, and with the characters above designated. This thickness is greater than that of the Maroon in the Aspen district, which Spurr places at 4,000 feet, and less than the maximum thickness of the original Maroon, which measures 4,500 feet. It is possible, however, that in the latter measurement are included bodies of metamorphosed and no longer recognizable Triassic. The lithologic characters of Peale's series differ in detail from either the Aspen or the Crested Butte Maroon, and seem to be more like the Weber grits and Maroon series of the Tenmile and Leadville districts. The Maroon at Aspen seems to be nearly uniform throughout, to contain very little conglomerate, and to be of a dark brownish-red color. On Eagle River the conglomeratic bands appear to be more numerous, and while brownish and red beds occur, to consist mainly of grays. The original Maroon was divided into two approximately equal series, the upper of which was characterized by being a conglomerate and possessing a dark maroon color. On Eagle River beds of conglomerate and others of deep-red color occur, but instead of being segregated in the upper portion of the section, are distributed through it. The upper part of Peale's second Permian section, which I would unite with the "Triassic" as part of the Red Beds, is, as I have already said, from 500 to 800 feet in thickness, and consists of gypsiferous shale and sandstone having generally a pinkish or red color. The Triassic contains 978 feet, and consists of sandstone of red, pink, purplish, brown, white, and light colors, the red largely predominating. United these two series make up 1,478 to 1,778 feet of sediments, generally similar to Spurr's Triassic and to the Wyoming formation of the Tenmile district, the former of which measures 2,600 feet and the latter 1,500 feet. In Tilden's section at Battle Mountain, near Red Cliff, he found above the Leadville limestone 1,000 feet of Carboniferous limestone which would seem to be the equivalent of the Weber limestone and the Weber shales. In Peale's Eagle River section the Weber shale can hardly measure less than 1,000 feet, and at Aspen it measures 1,000. In the Crested Butte quadrangle, however, its thickness is from 100 to 550 feet, and in the Tenmile district it is only about 300 feet.

Peale found no distinctive invertebrate fossils, save a few species already mentioned. In the case of his Permian series, the age assigned rests upon a few plants which Lesquereux identified as *Calamites suckovii* Brogn., *Stigmaria ficoides*, and *Calamites gigas* Brogn. Before accepting the Permian age of these beds, in view of somewhat conflicting evidence upon this point, I should desire to see these identifications corroborated, and also the additional evidence of a larger flora or fauna.

Stevenson also describes a section, made on the forks of Eagle River, at nearly the same point at which that made by Peale was taken. At the base lies the Leadville limestone, some 200 feet above which is found a conglomerate 40 feet in thickness, followed immediately by 2,000 feet of sandstone, shale, and conglomerate, including gypsum beds. Reddish gray and yellow seem to be the prevailing colors. Then come in about 500 feet of sandstones interbedded with limestones, some of which contain Carboniferous fossils. The limestones are blue, and the sandstones reddish, gray, brown, etc. The upper member contains 2,500 feet of coarse sandstone, mostly of reddish-gray color and entirely without limestones and shales. It is this member of the section to which Stevenson later compares the upper portion of the Arkansas sandstone in the Sangre de Cristo Range. Stevenson apparently did not observe the series which is called by Peale Triassic, and for which the local name, Wyoming formation, is employed in the Tenmile district. No beds similar in position and lithology to the Weber shales or limestone can be discerned in this section unless the space of 200 feet at the base contains them. All these strata, therefore, would appear to belong to the Maroon formation of the Crested Butte district or the Weber grits and Maroon of the Tenmile district. The peculiarities of this section, among which may be mentioned the segregation of the limestones near the middle, the gypsiferous nature of the lower portion and the character and coarseness of its conglomerate beds, and the dark color of the upper portion which is compared with beds in the Sangre de Cristo having a reddish-brown tint, are probably not to be found together in any one of the described sections, and illustrate the great variability in detail of this series from point to point.

In the Tenmile district the Upper Carboniferous formations discriminated by Emmons are the Weber and Maroon; the Wyoming formation, above, is placed in the Trias. Of the Weber formation he recognizes two divisions, the Weber shales and the Weber grits. The Weber shales, which appear to be the equivalent of the Weber formation of the Anthracite-Crested Butte folio and the Aspen monograph, are described as consisting of argillaceous and calcareous shale alternating with quartzitic sandstones. Beds of impure limestone contain Coal Measure fossils. The thickness, which is very variable, is assumed to be about 300 feet. The Weber grits are part of the series elsewhere described under the name of Maroon conglomerate. The formation here distinguished by that name has an average thickness of about 2,500 feet. It consists mainly of coarse sandstones, or grits, often very micaceous, with a subordinate development of shales and a few thin and nonpersistent dolomitic limestones. The sandstones are generally light gray in color, and their prominent constituents are quartz and feldspar, evidently derived from the Archean. The Maroon formation consists predominantly of coarse gray and red sandstone, in some places passing into conglomerates, with many irregularly developed beds of limestone. The red color is more common than in the Weber grits, and results from iron oxide in the cement, and not from the presence of pink feldspar. The limestones of the Maroon differ from those of the Weber in physical characters, and are generally nonmagnesian. The Maroon as here defined is limited by the Robinson limestone below and the Jacque Mountain limestone above. The Wyoming formation has a maximum thickness of 1,500 feet, consisting principally of sandstones of an intensely brick-red color, with a moderate development of thin shales, and with limestones generally absent. The sandstones are often coarse, sometimes conglomeratic, and composed mainly of Archean débris. Archean bowlders 2 feet in diameter are cited.

The name "Wyoming formation" was first used in this connection in the Denver Basin monograph,[a] and by its employment in the Tenmile district a correlation is suggested with the bright colored Red Beds which occur on the eastern flank of the Colorado range. Emmons says that this name was used for these beds "not because of any fossil evidence of their age that could be found, but because by their position and petrological character they most nearly correspond to the beds of this formation which elsewhere in the Rocky Mountain region have, on fossil evidence, been determined to be Triassic. If the Permian is represented in Colorado, the evidence of which appears to the writer as yet very uncertain, it would be included in these beds, which have evidently been deposited in direct and unbroken succession over the Upper Carboniferous."

It can be admitted that the Weber shale of this section is the equivalent, in a general way at least, of the formation called by the same name at Aspen and in the Crested Butte region, and that the Weber grits and Maroon bear the same relation to the Maroon formation of the Crested Butte quadrangle and Aspen. The Wyoming formation appears to be the equivalent of the Triassic of the Aspen section.

While in a general way this seems to be the appropriate correlation of the different sections, there appear to be certain discrepancies in the lithologic character of the beds correlated. For instance, the origin of the material of the Weber grits of the Tenmile district seems to be the Archean, while the lower part of the Maroon at Crested Butte is derived from the older sedimentary series. Also it appears that the Maroon series at Aspen and the upper portion of the Maroon in the Crested Butte quadrangle are characterized by a dark-reddish color, more than is the case in the Tenmile district. The Wyoming formation of the Tenmile district appears to be more conglomeratic than the Trias of the Aspen section. Emmons states that

[a] U. S. Geol. Surv., Mon., vol. 27, 1896, p. 51.

the Weber formation "corresponds in a general way to the Weber quartzite of the Wasatch Mountain section and to the Lower Aubrey of the Colorado Canyon section" (Tenmile folio.) I have elsewhere stated more fully my own tentative correlation of these beds. The Weber grits, together with the Maroon formation, as defined by Emmons, which he seems to exclude from the correlations expressed above, I would assign to the Uinta sandstone, which Emmons at an earlier date correlated with the Weber quartzite. According to my view the Aubrey sandstone is stratigraphically above the horizon of the Weber quartzite and its equivalents.

The corresponding beds in the Leadville district bear the names of Weber shale, Weber grits, and Upper Coal Measures. The Weber grits are extremely variable in lithologic character and thickness, consisting of argillaceous and calcareous shales alternating with quartzitic sandstones. Impure limestones are sometimes developed, and they are abundantly fossiliferous. A large fauna of Upper Carboniferous species is cited in the Leadville monograph. The Weber grits, whose upper and lower limits are not sharply defined, have a thickness of 2,500 feet, and consist mainly of coarse sandstones, passing into conglomerates. The typical rock is a coarse white sandstone. A small Upper Carboniferous fauna is cited from a tolerably pure limestone occurring near the middle of the formation. The Upper Coal Measures are like the Weber grits, but in the Mosquito Range contain more calcareous and argillaceous beds (Tenmile folio). They consist of alternating calcareous and siliceous beds, the latter not being distinguishable from those of the Weber grits at the base, but passing upward into reddish sandstones, which in their turn are sometimes difficult to distinguish from the overlying red sandstones of the Trias. The lower limit is taken at the Robinson limestone. The calcareous beds below the Robinson are all more or less dolomitic, while the Robinson limestone itself is a pure limestone. The upper sandstones of this group are distinguished from the overlying Triassic beds by a deeper color, approaching a venetian red, whereas in the latter the color is rather of a light brick red. A large fauna of Coal Measure type is known from this horizon. The corresponding formations in the Tenmile folio, which have already been briefly described, are too obvious to require special citation. In lithology and thickness there is a close correspondence.

In the South Park region south of the Leadville district the Maroon formation seems to be continuously present, and still further to the south it forms the mass of the Sangre de Cristo Range in Colorado. Its occurrences in this area have been described in a cursory manner by Stevenson and also by Endlich and Peale, but no detailed sections are given. It was in this connection that Endlich used the name Arkansas sandstone.

While the persistence of the Leadville limestone has caused it to be often mentioned by those who have written of the geology of Colorado, the Maroon formation is that to which most frequent reference has been made. It has seldom been described in detail save in the sections mentioned above, and to cite and comment upon all the references would be fatiguing and unprofitable. It is, however, seldom possible to recognize in these reconnaissance reports either the Weber formation as a distinct unit or the two divisions of the original Maroon, for one of which the name Weber grits was subsequently used. From facts brought out by the literature, some of which have been repeated here, it seems safe to infer that the Maroon formation, though differing somewhat in character from point to point, is persistent over the Elk Mountain, Grand River, and South Park regions, being present wherever the horizon for it is brought to view. The Weber formation, however, much thinner than the Maroon and less prominent than the Leadville formation, can hardly be recognized outside of a few detailed sections. In Fossil Ridge 45 feet of light shale, followed by 150 feet of light blue and yellow limestone and quartzite and 50 feet of yellow, reddish, and whitish shales, may belong to this formation. They rest upon the Leadville. The occurrence of the Weber at Crested Butte, at Aspen, on Eagle River, at Red Cliff, and in the Tenmile and Leadvilie districts has already been described. South of Leadville I have not been able to identify it in the South Park region, though this is perhaps due to a lack of detailed information. If present, this series would probably contain the gypsum beds mentioned by Stevenson. In two sections described by Endlich it may be represented by part of the series which have been taken to belong to the Leadville limestone. This consists in the one case of gray and brown shale and dark-blue limestone, and in the other of bluish shale and gray saccharoidal limestone.

The great mass of the Upper Carboniferous sandstones and conglomerates appears to have been at one time continuous over most of central Colorado, and its distribution is still very wide. These strata seem to be generally present over the Grand River region, the Elk Mountains, and the South Park region, and they form the mass of the Sangre de Cristo Range southward to Costillo Peak, near the southern border of the State. Several geologists have described their occurrence in this range, but records of detailed study are rare. Endlich gave to them the name of the Arkansas sandstone, though but little satisfaction can be obtained from his reports. At one point in the San Luis district he describes the Arkansas sandstone as over a mile in thickness, consisting of heavy beds of red sandstone more or less interstratified with dark-brown shale and containing isolated beds of limestone. In his Southeastern district it appears to be made up chiefly of red sandstone interstratified with red shale and blue limestone. Stevenson says but little of these strata as they appear in the northern part of the range, but describes in more detail their occurrence in the southern part, where he recognizes two series, both of which are included in the Carboniferous. The lower one has a total thickness of 3,727 feet, and contains the following elements, beginning at the base: Conglomerate, with red sandstone and red shale, 800 feet; blue fossiliferous limestone, 7 feet; red shale and sandstone, 700 feet; blue unfossiliferous limestone, 20 feet exposed; red sandstone and reddish shale, 300 feet; gray limestone, richly fossiliferous, 100 feet; and reddish sandstone holding beds of red shale, 1,800 feet. The upper series is a reddish-brown conglomeratic sandstone not far from 2,500 feet thick. Large fragments of granite, gneiss, and quartzite prevail, but with these are some of sandstone and limestone. "This part of the section bears close resemblance to the upper division of the Carboniferous series seen on the Eagle River of central Colorádo."[a] The entire thickness of this series is 6,200 feet, distinctly greater than at any point at which measurements have elsewhere been made.

Stevenson's comparison of the upper beds in the Sangre de Cristo with the upper division of the Carboniferous on Eagle River (=the upper Maroon?) is suggestive, and the two divisions distinguished in the Sangre de Cristo can be compared with the two divisions of the Maroon formation in the Crested Butte district. This is especially true of the upper division, which measures the same in both areas, 2,500 feet. The lower division in the Sangre de Cristo is much thicker. In the San Juan the upper division is reduced to 300 feet (Rico formation) and the lower to 1,800 feet (Hermosa formation). In the Dolores River region, however, the upper division appears to be entirely absent, while the beds supposed to be equivalent to the lower division have about the same thickness as in the Sangre de Cristo, aggregating, according to Peale, 3,500 feet, to which possibly 300 more feet should be added from his Permian series. The fauna found by Lee near the base of Stevenson's lower division distinctly favors its correlation with the Hermosa and lower Maroon series.

W. T. Lee has recently published a very detailed section embracing about 400 feet at the bottom of the Arkansas sandstone. It was made on the east side of the range at a point directly west of Trinidad, near the southern end of a tract having its center at Trinchera Peak, which Endlich mapped as Lower Carboniferous. A horizon about 100 feet above the crystallines contains a well-marked Pennsylvanian fauna, and as no evidence of the Mississippian was found, nor any significant lithologic changes, there can be little doubt that the lowest beds at this point belong in the Upper Carboniferous. Lithologically the series described by Lee consists of numerous alternations of coarse red grits and sandstones, red and black shales, and limestones. The fauna collected by Lee presents points of individuality, but is distinctly that of the Hermosa formation in distinction from the Rico fauna.

The Arkansas sandstone for the most part rests directly upon the Archean, the earlier Paleozoics probably having been lost by erosion prior to its deposition.

[a] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Suppl. p. 74.

There can be no reasonable doubt of the absence of these strata in Lee's section, but as we have just seen, reputed Lower Carboniferous is mapped by Endlich about Trinchera Peak, while on the west side of the range, almost opposite where Lee's section was made, E. C. and P. H. Van Diest found the Sawatch quartzite and the Yule limestone in an area where the Arkansas sandstone is represented in the Hayden atlas. Lee cites Coal Measure fossils from several horizons near the base of the Arkansas sandstone, and fossils more or less diagnostic of the same age were reported by Hayden, Ruffner, Endlich, and Stevenson, the earliest as far back as 1869. The general resemblance to the Maroon formation, as it appears at other points in Colorado, of the series to which Endlich applied the name Arkansas sandstone in the Sangre de Cristo Mountains is apparent. It is to be remarked that in spite of the uniformity in general characteristics and the variability in details which this formation shows it seems generally divisible into two more or less equal portions. This has been done by Stevenson, as we have just seen, in the Crested Butte quadrangle and in the Tenmile and Leadville districts. Frequently the upper division seems to be characterized by a deeper red color than the lower, though when the lower has but little of a reddish tinge the upper does not show the same brownish red that appears where the lower is darker. The occurrence of coarse conglomerates derived from the Archean is somewhat variable. Stevenson cites conglomerates of this character and origin from the upper division in the Sangre de Cristo Range and from the top of the lower division on the forks of Eagle River. In the Crested Butte district sediments of this type appear in the upper half of the Maroon, while in the Tenmile section they occur in the Wyoming sandstone. This circumstance suggests a consideration of the possibility of the Wyoming sandstone and its correlates being only local variations of the same large series. The great variability in detail, especially in color, of this series at different points would lend probability to such a supposition, and the fact that where the thickest sections of the Maroon occur (Crested Butte quadrangle and Sangre de Cristo Range) sediments of the Wyoming type are not found. On the other hand, the very general change of tint to beds distinguished by distinctly brick-red color, the overlap of these beds upon the Archean (as along the Front Range and in the Dolores Valley), and the marked faunal break which sometimes occurs (as in the San Juan region) between the brick-red series and the underlying Carboniferous strata, seem to indicate that this is a distinct group. Stevenson's comparison of the upper series of the Sangre de Cristo Range with the upper portion of the Eagle River series is interesting, because the Eagle River beds appear to belong to the Maroon conglomerate and to occur below the horizon of the Wyoming sandstone.

Except for rare patches of older Paleozoic beds and the occasional overlapping of sediments of later deposition, the strata lying next to the granite and almost continuously exposed from the Wyoming line southward to the Greenhorn Mountains belong to the well-known Rocky Mountain Red Beds. These have usually been referred to the Triassic, but occasionally the lower portion has been called Carboniferous. The evidence in either case is for the most part indirect, remote, and unsatisfactory. It would hardly be worth while to quote every opinion which has been expressed as to the age of the Red Beds of the Front Range in Colorado or to recapitulate all the terms in which these strata have been described, but some of the more important evidence and some of the more significant sections will be repeated in the pages following.

Except for the Sangre de Cristo Range, which is composed largely of Carboniferous sandstones and conglomerates, the only areas of Carboniferous beds represented upon the Hayden atlas along the mountain front from the north to the south line of the State consist of five small disconnected areas. One of these is on the Wyoming line, another is in Pleasant or Perry Park, a third in Manitou Park, a fourth in the Garden of the Gods, and the last in the Wet Mountains southwest of Pueblo. That near the north line and that in Perry Park is Upper Carboniferous; in Manitou Park and southwest of Pueblo, Lower Carboniferous, while in the Garden of the Gods both Lower and Upper Carboniferous seem to occur.

King recognizes three series in the Red Beds as they appear upturned on the flanks of the Front Range in Wyoming and in northern Colorado. On the east side of the range the lower division is composed of red limestone and reddish sandstone, and has a thickness of about 150 feet. It contains no fossils, but is regarded by King as representing all of Paleozoic time prior to the Carboniferous, and he correlates it with the Primordial of the Black Hills, which it resembles lithologically and which has a similar stratigraphic position.

Above this series follows one composed chiefly of limestone and having a thickness of about 700 feet. The limestones are blue, gray, and red in color, siliceous and sandy, and more or less interstratified with sandstones and conglomerates. They contain fossil shells which show the geologic age to be Pennsylvanian. These strata in several ways suggest the Rico formation of the San Juan region.

Upon these rests the Triassic. Of this series King says: "Taken as a whole, and with the exception of the gypsum and limestone beds, which nowhere within our field of observation exceed 40 feet in thickness, it is essentially a sandstone series, for both clays and shales are exceedingly arenaceous, and the dominant color is a brick red for the lower half of the series and variable lighter reds, pinks, and yellowish reds for the upper half. While this division of color holds good in general, it is often varied by extremely brick-red, almost vermilion-colored beds appearing near the top, and light ones intercalated in the region of the heavy red lower strata." The thickness of this series is from 300 to 850 feet. It rests with apparent conformity upon the Carboniferous, but makes a striking overlap upon the Archean. No fossils occur in it except obscure and ill-preserved fragments of wood.

On the west side of the range these beds appear with somewhat increased thickness. The Paleozoic series measures 1,200 feet instead of 850, Carboniferous fossils occurring 200 feet above the base.

Too much importance need not attach, in the case of the lower division, to King's correlation with the Black Hills Primordial, and as there appears to be really no satisfactory evidence for distinguishing the lower series from that above, it seems best for the time being to assign both to the Upper Carboniferous. The striking overlap of the Triassic sediments, however, would seem to sanction their recognition as distinct from the Carboniferous. In the Laramie quadrangle an overlap of this sort occurs, which according to Knight is only apparent, the lower beds of the Triassic which lie next the granite being continuous with the Carboniferous farther north. It is possible that other supposed cases of overlap may find a similar explanation, but without doubt some are real.

The Paleozoic series does not, upon the west side of the range, extend into Colorado territory, but its outcrop upon the east side reaches a short distance into the State. It is with little doubt these beds that are represented in the Hayden atlas near the Wyoming line, and as they appear under the Carboniferous color without any Silurian intervening between them and the granite, it would seem that Hayden also did not recognize King's lower series as older than the Coal Measures.

Marvine examined the Red Beds in the northern part of the Front Range region, and describes them as varying in thickness from 1,600 or 2,000 to 400 feet, and consisting of red sandstones. The texture varies from coarse grits and moderately coarse sandstones, with fine examples of cross bedding, to quite fine-grained and shaly layers, which occasionally make up a considerable thickness. The conglomerates are mostly confined to near the base, where they are plainly derived from the subjacent rock. Dark red is the prevailing color, though light red, yellow, and cream-colored beds are frequent, and may in places predominate.

These rocks, which rest upon the granite, Marvine refers, as was customary, to the Triassic, and probably they are, for the most part at least, the equivalent of King's Triassic, the Paleozoic series being concealed by overlap. In some of the thicker sections, however, I suspect that Carboniferous beds are present.

Part of the area examined by Marvine forms the subject of the detailed work by Emmons, Cross, and Eldridge, the results of which appeared as the Denver Basin monograph.

To the Red Beds series as it occurs in the Denver Basin, Emmons, Cross, and Eldridge give the name Wyoming formation. They describe it as consisting of brilliant red conglomerates, sandstones, and shales, with thin limestones and gypsum in the upper part. The thickness varies from 500 to 3,000 feet, but is generally somewhat under 1,500 feet. The formation is separable about midway into a lower division of soft, friable conglomerates and coarse sandstones, with few shales, and an upper one of shales, with some prominent sandstone bands, narrow beds of limestone, and small local deposits of gypsum. The lower 5 to 20 feet of the Red Beds is nearly everywhere composed of coarse, subangular fragments of the adjacent granites, gneisses, and schists, with a small admixture of their derived sand, which shades in places to a red, arenaceous mud. Succeeding this formation is a series of heavily bedded sandstones and grits, with small local beds of arenaceous shale. The normal thickness is about 1,200 feet. The color varies from prevailing red to gray, according as the chief constituent of the rock is red feldspar or quartz. The lower 200 feet of sediments are generally coarser and less compact than those overlying. These pass, by a broad transitional zone of lighter red sandstones, to the upper member of the lower division, a bed of creamy white sandstone from 200 to 400 feet thick. It contains impure limestones and some conglomeratic layers. The lower half of the upper division consists of bright brick-red arenaceous shales and sandstones, with important intercalations of limestone. The strata above the limestone series become more and more arenaceous, though still retaining in large degree their shaly nature. At 150 or 200 feet below the top of the Trias the strata become more clayey, and take on a variety of irregularly distributed bright colors—gray, yellow, red, green, pink, and lilac. In this zone gypsum and brown earthy limestones are common. The Trias usually closes with a sandstone from 15 to 25 feet thick. The Wyoming formation is overlaid by the Morrison formation, the former being assigned to the Triassic and the latter to the Jurassic period. The Wyoming is supposed to overlie the Fountain formation, by which name Cross designates the lower portion of the Red Beds in the Pikes Peak quadrangle, but it has suggested itself to me that probably a part of the Wyoming formation may locally be equivalent to the Maroon. The great variability of the lower member, the lower half of which ranges from 270 feet to 2,000 feet, might be taken as evidence that at the points of greatest thickness the lowest beds belong to a different and older formation. The lithology of the lower division is not unlike that of the Maroon, while it is only the upper division which is described as being brick red. Emmons offers a similar suggestion on page 19 of the monograph. No fossils were found in the Wyoming formation and the evidence for assigning it to the Trias is more or less unsatisfactory. In the Morrison, however, remains of Jurassic dinosaurs occur.

In a paper read before the Geological Society of America, but never published, save by abstract, N. H. Darton recognizes in the fine section at Morrison a limestone which he identifies with the Minnekahta limestone of the Black Hills, "having," he says, "precisely similar stratigraphic relations in the Red Beds and containing some of the same Permian fossils, although these are scarce and not well preserved." Darton does not state more specifically the species found at Morrison, nor have the fossils themselves come to hand. He obtained from the same horizon at Lyons, farther north, however, a hand specimen containing more or less indistinct impressions of a gasteropod and a pelecypod. The former is very small and has the general appearance of a *Natica* or *Naticopsis*, but may be something quite different. The pelecypod is also small, oblong, and transverse, having somewhat the shape of a small *Pleurophorus*, but in this case also the generic position is indeterminable. Taken by itself this fauna is altogether negative as to the question under consideration, while a comparison with the fauna of the Minnekahta limestone of the Black Hills is almost equally inconclusive. It would be unsafe to say that neither of the species from Colorado occurs in the Black Hills, but the gasteropod has not yet been found there, and though I should be unwilling to state definitely that the pelecypod is different from some ill-preserved forms among the Black Hills fossils, I believe that it is not the same. For the present, therefore, it will probably be best to regard the paleontological evidence as nil. Reduced to a proposition of identification of horizon by means of tracing lithologic character and stratigraphic position, the correlation may be accepted with caution.

The area south of that examined by Marvine was the subject of Peale's report for 1873. Peale gives no general description of the Red Beds and attempts no classification, save by calling the lower portion Triassic, with a Jurassic series overlying. The Triassic beds, which are in a general way the equivalent of the typical Wyoming formation, especially with the upper portion of the thicker and all of the thinner sections, consist mainly of red, pink, and white sandstones, and are represented upon the Hayden atlas as continuous from the South Platte, where Peale's district begins, to Perry Park. Between Perry Park and Colorado Springs they are concealed by overlap of later sediments, while in the vicinity of Colorado Springs and in Manitou Park areas of greater or less extent are represented. The Triassic beds appear to be for the most part in direct contact with the Archean, but at Perry Park, Manitou Park, and Colorado Springs areas of Carboniferous and in some cases Silurian strata are represented as underlying them. While the Triassic apparently consists mainly of sandstones, the Jurassic comprises for the most part limestones and shales, and probably is the equivalent more or less precisely of the Morrison formation.

The Hayden atlas represents Upper Carboniferous sediments as intervening between the granite and Triassic in Perry Park. As I have already shown, the limestone described by both Peale and Lee as lying near the base of the sedimentary series in Perry Park carries Mississippian fossils and is to be correlated with the Millsap limestone. The sandstone beneath it I think may possibly be Cambrian. It is these beds which are represented under the Upper Carboniferous color in the atlas, and possibly some of the Red Beds above are included with them. Peale, in his Pleasant Park section, refers the overlying sandstone to the Triassic. Lee, however, is disposed to assign to the Carboniferous a series of undesignated thickness at the base of the Red Beds in Perry Park, which he correlates with the Fountain formation of the Pikes Peak quadrangle. He represents this series upon his map as occurring beneath the Triassic or Red Beds in Perry Park, but not farther north, on Platte Canyon. If this correlation with the Fountain formation is authentic, the appearance, at the base of some of the thicker sections of the typical Wyoming formation, of beds representing the Fountain series, is much more probable.

A considerable area of Triassic is represented by the Hayden atlas as occurring in Manitou Park, and beneath it beds of Lower Carboniferous and Silurian age are colored in. I can not see upon what evidence the Lower Carboniferous color is introduced into this area, however, as the Millsap limestone is apparently missing, while that portion of the "Triassic" coming in the southern part of the tract depicted on the map, which is included in the Pikes Peak quadrangle, is regarded by Cross as belonging to the Fountain formation, supposed by him to be of Carboniferous age. From the best evidence at hand, therefore, it would appear that the "Lower Carboniferous" is probably lacking in Manitou Park, that the "Triassic" of that area represents the Fountain and not the Wyoming formation, and that it is probably Carboniferous and not Triassic in age.

Near Colorado Springs the Triassic is represented as underlain by Upper Carboniferous, Lower Carboniferous, and Silurian beds. I have elsewhere suggested that in Peale's Glen Erie section part of a considerable thickness of limestone lying beneath the Red Beds is to be correlated with the Millsap limestone, and it is probably this bed which is represented as Lower Carboniferous on the Hayden atlas. In this section Peale gives as occurring above the Millsap limestone (?) and below the Jurassic about 1,200 feet of sandstone of red and white colors, which he calls Triassic. It seems probable, in fact, that all these beds belong to the Fountain formation, and that the Triassic, though represented on the map, is really absent, the Morrison coming down upon the Fountain formation exactly as in Garden Park, in the Pikes Peak quadrangle; and it is apparent from the following quotation that Hayden must have referred nearly if not quite all of Peale's Triassic beds to the Carboniferous. Hayden says, "On the small map of 'Colorado Springs and vicinity,' a light band will be seen between the Silurian on the west and the Red Beds or Triassic on the east, which represents a peculiar group of strata not observed elsewhere on the eastern slope, but resembling very closely a series of variegated beds, described by Dr. Peale in the annual report for 1873, in the valley of Eagle River, which yielded well-marked Carboniferous types. This group of strata is composed of variegated beds of sandstones of various textures alternately with layers of arenaceous clay. The entire thickness was estimated at about 1,000 feet. It is most probable that these beds are Carboniferous."[a] The beds on Eagle River with which Hayden compares this series (section 23, p. 244) form part of the Maroon formation.

South of Colorado Springs the Paleozoics and Red Beds are concealed for a short distance by Cretaceous overlap, but the Hayden atlas represents a considerable tract of Triassic and Silurian across the southern end of the Colorado Range, north and northeast of Canyon. Much of this area is included in the Pikes Peak quadrangle, where Cross recognizes two Carboniferous formations, the Millsap limestone and the Fountain formation, intervening between the Ordovician Fremont limestone and the Morrison formation of Jurassic age. The Millsap limestone is probably included under the "Silurian" color, the Fountain beds being the Triassic and the Morrison the Jurassic of the atlas. The conditions here would then be the same as I have supposed them near Colorado Springs, with the "Triassic" or Wyoming beds absent beneath the Morrison. Nevertheless, east of the Pikes Peak quadrangle this series is supposed to reappear above the Fountain formation.

The Millsap limestone is, of course, of Mississippian age and has been considered in the appropriate section. Cross's definition of the Fountain formation applies alike to the outcrop in Garden Park in the southern part of the quadrangle and to those in the northeastern part which connect with the exposures in Manitou Park north of the area. This consists of a series chiefly of coarse-grained, crumbling, arkose sandstones in heavy banks, locally conglomeratic and mottled with gray and various light shades of red. Near the base and at intervals throughout the series are very dark-red or purplish layers of arenaceous shale or fine-grained sandstones. The thickness is about 1,000 feet. No fossils were found by Cross, from whose description the facts noted above were derived, but the formation was referred by him to the Carboniferous, because of a similarity to the Arkansas sandstone, of known Carboniferous age. The beds overlying the Fountain formation are the Morrison formation, the same series by which the Wyoming formation is followed in the Denver Basin. East of the Pikes Peak quadrangle, however, another series resembling the Wyoming comes in above the Fountain formation, intervening between it and the Morrison formation. Because the Fountain formation seems to represent a distinct series underlying the Wyoming beds, the name "Wyoming" was introduced for the younger series in the Denver Basin monograph. At the same time I suspect that in local sections part of even the typical Wyoming is equivalent to the Fountain. Hayden also regarded this series as distinct from the Red Beds, as indicated in the passage quoted above, which, however, refers to the exposures west of Colorado Springs.

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[a] U. S. Geol. Geog. Surv. Terr., [Eighth] Ann. Rept., for 1874, 1876, p. 42.

Stevenson cites the following section from Beaver Creek a few miles northeast of Canyon:

Section on Beaver Creek.

	Feet.
1. Sandstone, soft, blood-red, shaly above, conglomerate below	100
2. Gypsum	100
3. Sandstone, soft, mostly deep-red, with layers of gray, somewhat micaceous, shows much cross bedding and is entirely unaltered. It is conglomerate throughout, but especially so at the base, where for several hundred feet it contains pebbles as large as a hen's egg and completely agatized. The coarseness of the material diminishes regularly to the top, where it is comparatively fine in grain. Estimated thickness	2,500

The locality of this section is within or just outside the area of the Pikes Peak quadrangle, and the strata which Stevenson refers to the Triassic probably belong in the Fountain and Morrison formations. The thickness of the lower series, 2,500 feet, which is only estimated, is much greater than Cross cites for the Fountain beds, and it is possible that in it are included some of the Wyoming series, which is supposed to intervene between the Fountain and the Morrison east of the quadrangle. At the same time Gilbert allows the Fountain formation a thickness of 2,100 feet in the Pueblo quadrangle near by.

South of Canyon the Red Beds and Paleozoics are again concealed for a short distance, but reappear on the eastern side of the Wet Mountains southwest of Pueblo in an area which is represented in the Hayden atlas under the Lower Carboniferous and Triassic colors. A portion of this area is included within the Pueblo quadrangle, where the beds designated as Lower Carboniferous and Triassic on the Hayden maps are called by Gilbert the Millsap limestone and the Fountain formation, these names being, of course, borrowed from the Pikes Peak quadrangle, which lies northwest of the Pueblo quadrangle and corners with it. As I have already suggested, the upper half at least of Gilbert's Millsap is without much doubt the equivalent of the original Millsap, but because there is a considerable thickness of the Ordovician Fremont limestone at Canyon it seems possible that the lower portion may be older.

Gilbert refers the Fountain formation to the Juratrias period and describes it as consisting of coarse, deep-red sandstone containing a considerable admixture of clay. In the upper half of the series are many beds of red and chocolate-brown shale, in the lower part are conglomerates. The lowest bed seen is a coarse conglomerate containing pebbles and bowlders of gneiss, schist, and granite similar to those of the adjacent Archean. The thickness near Beulah is 2,100 feet. The top of the series is not there seen, but the missing beds are probably thin. The Fountain formation here, as farther north, and like the Wyoming formation of the Denver Basin, is succeeded by the Morrison formation.

This is the last of the Paleozoics mapped in the Hayden atlas along the mountain front in Colorado (except the Sangre de Cristo Range) and all but the last of the Triassic, though a small area of the latter is represented at the southern extremity of the Greenhorn Mountains. Part of this tract is embraced by the Walsenburg quadrangle, where Hills has mapped the "Triassic" beds under the name of the Badito formation, which, however, he places somewhat doubtingly in the Carboniferous. The upper half of this formation consists of brick-red sandstones about 100 feet in thickness, generally massive, but sometimes shaly. It is supposed by Hills to correspond to part of the Fountain formation. The lower half consists of about the same thickness of very coarse conglomerate of a brownish-red color. In the Sangre de Cristo Range, according to Hills, the stratigraphic section corresponds very nearly with that at the southern extremity of the Greenhorn Mountains, except with respect to the thickness of the conglomerate. There is in each case about the same amount of capping red sandstone, but the coarse conglomerate and sandstone upon which it rests attains, in the Sangre de Cristo Range, a thickness of several thousand feet. Like the Fountain beds both in the Pueblo and in the Pikes Peak quadrangle, the Badito formation is succeeded by the Morrison formation, which here, as usual, probably is more or less closely the equivalent of the Jurassic of the Hayden atlas.

The sequence described by Hills in the Walsenburg folio and the comparisons made by him with the Sangre de Cristo Range make it almost appear as if in the 200 feet of strata exposed in that area the dividing line between the Wyoming and Fountain formations was contained, part of the Badito belonging to one and part to the other formation. If the upper or brick-red portion of the Badito formation be really the equivalent of the Wyoming formation, then the latter, greatly reduced in bulk, must be present in the Sangre de Cristo Range, a point of some interest in the distribution of that formation. Of course on this supposition it would be the lower and not the upper portion of the Badito which is equivalent to the Fountain. However, it seems to me a little more probable, from the fact that the Wyoming formation is apparently absent in the Pueblo quadrangle and over so much of the Sangre de Cristo Range, that the brick-red sandstone of the Walsenburg quadrangle does not really represent it, but is a local manifestation of the Maroon formation.

South of the Wet Mountains the line of outcrop is taken up by the Sangre de Cristo Range, composed largely of the Arkansas sandstone, whose age is Upper Carboniferous. The Triassic and even the Jurassic seem here to be absent, concealed, it is safe to say, beneath the overlapping Cretaceous. The Paleozoics of the Sangre de Cristo Range are discussed in a separate section.

The relation of these formations lying along the Front Range to one another and to the Red Beds in the interior mountain region, and also their geologic age, are questions in the highest degree perplexing.

In central Colorado the Maroon formation, variable in color and in the details of its lithology, but uniform as to its general character, is over considerable areas followed by what seems to be a distinct series, characterized by a persistent brick-red color. This is the Triassic series of most writers. The evidence derived from fossils is, unfortunately, lacking, as these beds have proved for the most part unfossiliferous in Colorado; but, basing their opinion upon whatever evidence was available, most geologists who have examined the strata on both sides of the Front Range agree in correlating the bright-red series of the eastern flank with the similar though quite differently associated beds of the western flank. This is true of Peale, Marvine, Hayden, Hague, Emmons, King, and others. Emmons, indeed, uses for a formation in the Tenmile district the same formational name which was employed for the Red Beds in the Denver Basin, viz, Wyoming formation. It seems necessary, therefore, to adopt as probably correct this correlation, in which all seem to concur, until the final paleontological test can be applied. If Cross and Hayden were correct in their statements relative to the Fountain beds, we have in that formation the equivalent of the Maroon conglomerate of the interior region.

Considering the Red Beds as I have traced them through the work of others from the north to the south line of Colorado, there appear to be two distinct series, showing a certain amount of system and regularity in their development and distribution. The lower of these, the Fountain formation of Cross, is probably of Carboniferous age. Its greatest development is southward. The other is the Wyoming formation, whose age still remains in dispute, but is probably Triassic, though Darton has brought evidence, which ought not to be disregarded, tending to show that it is equivalent to the "Permian" of the Mississippi Valley. If this is so the overlap of this series upon the Carboniferous assumes especial importance, but it would militate against the correlation with the "Triassic" of the west side of the Front Range, supposed to be the same as the Dolores formation of southwestern Colorado in which the remains of Triassic vertebrates have been found.

In the Sangre de Cristo Range the sandstones and conglomerates which carry Carboniferous fossils attain a thickness of 5,000 feet. Endlich has there given these strata the name "Arkansas sandstone," and they are without much doubt equivalent to the Maroon formation of central Colorado. It seems highly probable that the beds which Hills included in his Badito formation in the Wet Mountains only 20 miles to the east, though but 200 feet in thickness, belong to the same series. This area seems to be disconnected[a] to the north and to the south.

Another disconnected area of probably the same series occurs in the Pueblo quadrangle immediately north. Here it reaches a thickness of 2,100 feet, increased

[a] The word disconnected is employed in the sense of "without visible connection." Probably all these areas are continuous under cover except the Manitou Park basin, which in the true sense is disconnected.

from 1,000 feet in the Pikes Peak quadrangle, and speculation is permissible as to whether the Fountain formation of Gilbert may not include some portions of the Wyoming series, which appears to have no equivalent in Gilbert's section. His description, however, is more applicable to the Maroon than to the Wyoming formation. The apparent absence of the Wyoming formation in this area is in line with its apparent absence over the southern portion of the Elk Mountains and in the Sangre de Cristo Range. In the Pikes Peak quadrangle to the northwest a considerable amount of these beds exists. Cross refers the Fountain beds in this area to the Carboniferous, especially on account of their resemblance to fossiliferous strata on the Arkansas River, 50 miles to the west. These can be no other than the Arkansas sandstone of Endlich's reports. Cross measures 1,000 feet of these beds. Gilbert recognizes the Fountain formation in the Pueblo quadrangle, and assigns to it a thickness of 2,100 feet. Hills, in the Walsenburg quadrangle, finds a greatly reduced thickness, only 200 feet, the upper half a brick-red sandstone, which he compares to the Fountain formation, the lower half a brown conglomerate, which he compares to the sedimentaries of the Sangre de Cristo Range. Here, again, it must be the Arkansas sandstone which is meant. Thus the comparison made by Cross would indicate that the Fountain beds were the same as the Arkansas sandstone, while that of Hills would imply that it was a distinct series overlying the Arkansas sandstone.

The upper division of Hills's Badito formation by its character and position in the section suggests the Wyoming formation, but as that series appears to be absent both from the Sangre de Cristo Range and in the Pueblo and Pikes Peak quadrangles it seems more probable that this brick-red member is only a locally differentiated phase of Fountain sedimentation. The thickness of the Fountain in the Pueblo quadrangle is somewhat startlingly out of proportion to that in the Pikes Peak and Walsenburg districts, but the series with which it is supposed to be equivalent in the Sangre de Cristo Range and in central Colorado attains a thickness of 4,000 to 5,000 feet, and the difference here is probably due to an unconformity with the overlying Wyoming series, of which the marked overlap of the latter is additional evidence.

The area to the east and south of the Pikes Peak quadrangle is likewise disconnected, and the same is true of the series as it appears in the Manitou Park Basin. It occurs again in the Garden of the Gods, where Hayden reports about 1,000 feet, and it also exists in Perry Park, though Lee does not discriminate any definite thickness there. The great variation in thickness of the Wyoming formation in different sections in the Denver Basin is probably partly due to undifferentiated masses of Fountain beds included in their basal portions. The Carboniferous series of King, together with the one supposed to be Primordial, apparently is another recurrence of these beds. Taken together they measure 850 feet, and the Carboniferous beds carry fossils.

The "Triassic" or Wyoming formation seems to possess greater continuity, but apparently it does not extend much south of Colorado Springs, not being found in the Manitou Park Basin, in the Pikes Peak quadrangle, in the Wet Mountains, or in the Sangre de Cristo Range.

The distribution of these formations would indicate unconformities by overlap (and probably by erosion) between the Millsap and Fountain, between the Fountain and Wyoming, and between the Wyoming and Morrison formations.

In the San Juan region the sediments representing Upper Carboniferous or Pennsylvanian time are classed as the Molas, Hermosa, and Rico formations. The region from which the Hermosa and Rico formations were first described is the Rico Mountains, but a knowledge of its characters and variations over a much more extended area was drawn upon in framing the first description. The Hermosa formation, which has a thickness of 1,800 feet, is susceptible in the Rico region of a three-fold division. The lowest division consists chiefly of greenish-gray sandstones and shales, the latter being sometimes nearly black. The middle member is characterized by many bands of massive, dark-gray limestone, often highly fossiliferous and alternating with sandstones and conglomerates. The upper division is predominantly a complex of shales, with occasional limestones. The constituents of the Hermosa section vary largely from point to point, and the subdivisions which were there practicable can not be distinguished over large areas. The lower division at Rico contains about 800 feet. The beds resting on the Ouray limestone are shales and impure limestones. Above this are gray grits or sandstones alternating with gray shales and several beds of black shale and thin, impure limestone. The middle division is made up very largely of blue, bituminous limestone carrying many fossils and occurring in massive beds from 5 to 100 feet in thickness, separated by shales and sandy shales. This division has a thickness somewhat in excess of 600 feet. The upper division contains some bands of limestone similar to those of the middle division, but they are thin and unimportant in comparison. Its strata are mainly black and gray shale alternating with green grits and sandstones. Occasionally reddish sandstones are observed, and two black shales are present in the lower third. The top of the upper division and of the Hermosa as a whole is well defined from the base of the next higher formation. The topmost member consists of about 30 feet of fine-grained, mica-bearing green shales, immediately above which comes a red, sandy, fossiliferous limestone of the Rico formation.

The Rico formation is a part of the Red Beds series of southwestern Colorado. This series is rather a uniform one lithologically, and somewhat sharply defined from the Hermosa formation below, but the upper portion has been found to contain Triassic fossils, while at the base a well-marked Carboniferous fauna occurs. The upper limit of the Rico formation is arbitrarily taken about 300 feet above its base, for within these limits the Carboniferous fauna is known to occur. Thus defined it is made up of sandstones and conglomerates, with intercalated shales and sandy, fossiliferous limestones. Lithologically the Rico formation resembles the Dolores formation, which immediately overlies it, and which contains the median unfossiliferous portion of the Red Beds, as well as the upper portion, which carries Triassic fossils. "The general characters of the Rico formation in the vicinity of Rico are, first, its calcareous nature, in which it resembles the strata above and below; second, the very arkose character and the coarseness of its sandstones, in which respect it differs from the Hermosa and resembles the Dolores; and, third, its chocolate or dark-maroon color, which contrasts sharply with the gray or green of the Hermosa, and which is more or less distinct from the bright vermilion of the Dolores. "The bulk of the formation is made up of sandstones and sandy shales, composed of such materials as are derived from the disintegration of granite. The sandstones are mostly coarse or conglomeratic." Intercalated with the sandstones and shales, which are for the most part very calcareous throughout, there are several beds of impure limestone, some an earthy gray and others sandy and red in color.

In the Engineer Mountain quadrangle the Hermosa formation is underlain by beds of no considerable thickness but of rather marked lithology which Cross has differentiated and named the Molas formation. His description of this series can be condensed as follows:

The Molas beds were not included in the original definition of the Hermosa formation, although the Hermosa was said to rest on the Ouray limestone. In the localities examined before that definition was formulated there was, in fact, a hiatus in the observations, the thin Molas beds being nowhere well exposed. The best section of the formation thus far observed is situated on the southwest slope of the Needle Mountains, on the south side of Tank Creek. At that locality there is a continuous section about 75 feet in thickness, representing the whole formation as there developed between the Ouray limestone and the Hermosa complex. There is no distinct stratification in the section. At the base is a zone of gradation into the Ouray limestone, for the upper zone of the latter is much broken up with the red calcareous mud of the Molas filling the interstices. This filling of the formation is very common. For some feet above this transition zone there is a chaotic mixture of chert and limestone fragments, with not a few of bluish or white quartzite, but none of granite or schist. In all the lower part of the formation much of the material is an impure limestone, reddish in color, but with the saccharoidal texture of the Ouray. It is probably a limestone sand-rock. The matrix in which the fragments of chert, quartzite, and limestone are held is a red, marl-like material. There are in places indications that a calcareous mud was broken up before consolidation, and was worked over with the fragments of foreign rocks. Gradually the section becomes more and more sandy, but chert fragments were found almost up to the fossiliferous limestone of the Hermosa.

This formation is especially characterized by its deep-red, friable, sandy strata. which are variably calcareous and often shaly. They are seldom very distinctly bedded, and disintegrate so rapidly on weathering that good exposures are rare. In the lower part of the formation dark chert nodules abound, often making a large part of flat lentils or discontinuous layers. Many of the cherts carry a Lower Carboniferous invertebrate fauna, like that at the top of the Ouray limestone. In a single locality in the Needle Mountains quadrangle some thin limestones contain a fauna of Upper Carboniferous age, which is elsewhere discussed.

The Molas formation is distinguished on lithologic grounds because it records a preceding interval of erosion, by which formations of Mississippian age were in large measure destroyed, and in a subordinate degree because of certain faunal peculiarities which further collections may or may not affect.

Above the Rico formation come the Juratrias formations, which are the Dolores Red Beds, 1,600 feet in thickness, the La Plata sandstones, 250 feet or more, and the McElmo shales and sandstones, having a total thickness of nearly 900 feet.

Comparing this series with that in the Elk Mountains, where, in the Crested Butte quadrangle, the geographically nearest detailed section occurs, we do not find the same patent equivalence, either in the rock groups themselves or in the formation names employed for them, which was a feature of the central Colorado sections. However, the Hermosa formation bears comparison in many ways with the lower portion of the Maroon conglomerate, though it evidently consists of finer materials and contains a larger proportion of shales and limestone. The lower member of the Maroon measures 2,000 feet, and the Hermosa 1,800 feet, with a maximum of 2,000 feet. The Weber formation of the Crested Butte has no distinctly marked equivalence in the San Juan, unless it be the Molas formation, which is somewhat different lithologically. There is, however, a certain resemblance between the fauna of the Weber and the rather distinctive faunas at the base of the Hermosa formation, which would indicate that the Weber formation had a correlate in the San Juan region, if not a very distinct one lithologically.

The lithologic and color changes from the lower to the upper division of the Maroon formation have a counterpart in the change from the Hermosa formation to the maroon-colored Rico formation. While the Maroon of the typical area has a maximum thickness of 2,500 feet, this character is qualified by the fact that the thickness in the southern part of the Crested Butte area is very much decreased. The Dolores formation has apparently no lithologic equivalence in the Crested Butte region, but it greatly resembles the bright-red Triassic sandstone which overlies the Maroon at Lenado Canyon, near Aspen, and the Wyoming sandstone, which overlies the Maroon in the Tenmile and Leadville districts. It is not clear, however, that this bright-red series may not after all be present in the Crested Butte quadrangle, for in the northern portion, where the greatest thickness of the Maroon occurs, the rocks of this formation are bleached and greatly metamorphosed (Crested Butte folio). Nevertheless, one would expect some equivalent of the Dolores formation to appear, with its characteristic color character, in the southern portion of the Crested Butte area, unless it were cut out, owing to the pre-Gunnison unconformity.

In the Dolores River region the Upper Carboniferous, according to Peale, in whose accounts almost the only descriptions of the Paleozoic strata of this region are found, consists of light-yellowish and greenish shaly sandstones and a space filled with shaly sandstones and perhaps bands of limestone, the whole amounting to 3,500 feet. This series rests upon a blue limestone about 300 feet in thickness, referred to the Subcarboniferous, and is overlain by the "Permian." This has at its base 300 feet of yellowish and black shales and sandstones, with gypsum and salt, and 700 feet of pink and red shales, with conglomerate, the sandstones becoming light colored near the base and containing gypsum. The upper bed of the Permian is unlike the lower and unlike the rest of the Carboniferous, and as it seems to partake of the character of the Red Beds above, it appears more appropriate to unite it with Peale's Triassic, the lower portion possibly being joined with the Carboniferous, which would then have a thickness of 3,800 feet.

Lithologically this series appears to be the equivalent of the Hermosa formation of the San Juan region, while by the Red Beds above, the Dolores and La Plata formations are represented. The Rico formation, which forms a part of the San Juan Red Beds, appears to be missing, or to have lost somewhat its distinctive color, for Peale describes no brownish or maroon-colored beds in his Permian or Triassic series. The nearest instance is the blood-red sandstone and shale of his Trias, which are over 700 feet up in the Red Beds. This point is interesting, and it is to be regretted that the evidence by which a satisfactory conclusion can be reached is lacking. If, however, my correlation of the Rico with the upper part of the Maroon is justified, by which the thickness is reduced from 2,500 feet in the Crested Butte to 300 feet in the San Juan region, its complete disappearance in the Dolores region is not surprising. The fact mentioned by Eldridge, that the upper Maroon is greatly diminished in thickness in the southern part of the Crested Butte quadrangle, is distinctly favorable to its correlation with the Rico. The upper portion of Peale's Permian, taken with his Triassic, and possibly in places with a portion of his Jurassic, are the probable equivalent of the Dolores and La Plata formations, as the Jurassic is of the McElmo; but these formations appear to be of reduced thickness in Peale's area.

The Carboniferous of Peale, even without the 300 feet of "Permian" which I have united with it, is very much thicker than the Hermosa formation. This may be due to the recognized unconformity by which the Hermosa (or the Hermosa plus the Molas formation) was preceded, but it may result from an unconformity by which I suspect it was followed. The sharp faunal break between the Hermosa and the Rico formations suggests an unrepresented time interval between them. This fact, the greatly increased thickness in the Dolores River region, and the fauna from the upper beds there, which is unlike that of the Rico and still different from that of the Hermosa, all favor the hypothesis, if not of an unconformity between the authentic Hermosa and Rico formations, at least of a period of nondeposition during which, in areas adjacent, as in the Dolores River region, sedimentation was going on. The possibility of the Rico being represented by the series referred by Peale to the Carboniferous is so remote, from the evidence at hand, as to need no discussion.

The fact that the upper portion of the "Permian" is described by Peale as overlapping upon the Archean serves as a warrant at the same time for subdividing the beds grouped by him and for correlating the upper portion with the "Triassic" Red Beds overlapping elsewhere in Colorado.

Compared with the Crested Butte section, Peale's Upper Carboniferous seems to equal the lower member of the Maroon conglomerate, the upper member of which may have no equivalent in the Dolores River region. Almost the same difficulties here arise as in the suggested correlation with the San Juan Carboniferous, and the same facts must be used to meet them, though their application rests upon the correctness of my correlation of the upper and lower Maroon with the Rico and Hermosa formations, respectively. If the Dolores Carboniferous equals both the lower and upper Maroon, wholly or in part, my correlation of the Maroon with the Rico and Hermosa formations will probably be in error, the slender evidence at hand for the correlation of the Dolores and Crested Butte areas will have been misinterpreted, and the lithologic character of the Maroon will have proved very variable, but its general thickness more constant.

In addition it must be pointed out that while the upper Maroon seems to be absent in the Dolores River region, the Red Beds of the latter (including most of Peale's Permian and most of his Trias) are wanting in the Crested Butte region. Peale's Jurassic, with probably the upper members of his Triassic, are the equivalent of the Gunnison formation, and while they show somewhat reduced dimensions in Peale's area, the discrepancy is not so great as when compared with the equivalent formations in the San Juan region.

The geology of the Uinta Mountains is described chiefly in two reports, one by Emmons, the other by Powell. King also recapitulated and rearranged Emmons's account in his general geologic discussion of the area covered by the survey under his charge. Powell's survey was conducted along the Green and Colorado rivers;

his correlations are with the Grand Canyon section, and his nomenclature in large part that employed by Gilbert for strata in northern Arizona. Similarly, Emmons's survey was westward, along the fortieth parallel, through the Uinta Range and into the Wasatch Range. His comparisons are, therefore, with the Wasatch section, and the same nomenclature is employed. I have elsewhere considered at some length the three sections thus bound together in the literature, and need only repeat the outlines of the previous discussion.

Powell's section, which was made in the eastern end of the Uinta Range, is more detailed than that of King and Emmons. The basal member of the sedimentary series is the Red Creek quartzite, a formation of very great thickness, which will doubtless prove to be of Algonkian or pre-Cambrian age.

Above the Red Creek quartzite, and separated from it, according to Powell, by an important unconformity, is another great siliceous formation, the Uinta sandstone, which has a thickness of over 12,000 feet. The Uinta sandstone is followed by the Lodore, Red Wall, lower and upper Aubrey, and Shinarump groups, whose characters may be summarized somewhat as follows:

The Uinta group consists of sandstones and sandy shales, and is very ferruginous throughout, the general color being red and brown. Conglomeratic horizons are occasionally found in the series, and at its junction with the Red Creek quartzite there is a basal conglomerate. The thickness is 12,500 feet.

The Lodore group is said to rest unconformably upon the Uinta sandstone. It is 460 feet thick, and composed of soft sandstones and shales, with conglomerates at the base. Carboniferous fossils have been found in these beds (Powell).

The Red Wall group consists of cherty limestone on the north flank of the Uinta Mountains, while on the south flank many sandstones are intercalated with the calcareous beds. A measured section in the Uinta Mountains gives the entire thickness as 2,400 feet, but it is elsewhere stated as 2,000 feet.[a]

The lower Aubrey group consists of soft sandstones and intercalated limestones. The thickness found in a detailed section in the Uinta Mountains is 800 feet. It is elsewhere stated as 1,000 feet.

The upper Aubrey in the Uinta Mountains is composed of two members, a massive, homogeneous, gray sandstone called the Yampa sandstone, and above it a cherty limestone for which the name Bellerophon limestone is employed. The Yampa sandstone has a thickness of a thousand feet or more. The Bellerophon limestone is 150 to 200 feet in thickness. The thickness of the upper Aubrey is also given as 1,000 feet, and in a detailed section 1,575 feet was measured.

The Shinarump group is given a thickness of 1,800 feet in the Plateau province section, and consists in the Uinta Mountains of shales and soft sandstones. In the

[a] Powell's Rept. Geol. Uinta Mountains, p. 76.

section made at Flaming Gorge, in the Uinta Mountains, the series comprises 1,095 feet of shales and sandstones containing much gypsum and weathering in many colors, but with prevalent tints of brown and chocolate. It is succeeded by the Red Beds series, consisting of the Vermilion Cliff, White Cliff, and Flaming Gorge groups, which, together with the Shinarump, Powell places in the Juratrias.

The Uinta series of Powell is usually called by King the Weber quartzite. The Lodore, Red Wall, Lower Aubrey, and Upper Aubrey groups are collectively cited by King as the Upper Coal Measures. The upper limit of King's Upper Coal Measure series is evidently precisely that of Powell's Upper Aubrey group, both being determined by the Bellerophon limestone; but it can not be said with equal certainty that both drew the line between the Uinta sandstone and the overlying beds at exactly the same point. From 200 to 500 feet of Powell's Shinarump group are subtracted by King under the name of the Permo-Carboniferous series. The rest of the Shinarump, together with the White Cliff and Vermilion Cliff groups of Powell, are King's Triassic; the Flaming Gorge group his Jurassic, etc.

Several disagreements are found between Powell's and King's accounts of the geology of this area, the chief of which are as follows: Powell describes a great unconformity between the Uinta sandstone and the Lodore group, which was not observed by the geologists of the Fortieth Parallel Survey. The combined thickness of the four groups, which taken together form the Upper Coal Measure series of King, is over 5,000 feet,[a] while King assigns to that series a thickness of but from 2,000 to 2,500 feet. Finally, Powell refers the Uinta sandstone to the Devonian, while by King's correlation it would be Pennsylvanian. Powell's correlation implied in the use of the name Red Wall, would make the Uinta sandstone probably pre-Carboniferous in age, since the base of the true Red Wall is Lower Mississippian.[b] I am forced to conclude, therefore, that Powell's correlation is erroneous, that of Emmons and King being probably correct, and that the upper part of the Uinta sandstone at least is of Pennsylvanian age, the overlying beds being, of course, still younger. This conclusion seems to be demanded by the following facts:

1. Because Emmons traced the Uinta sandstone westward into the Wasatch Range, finding its equivalent to be the Weber quartzite, the age of which, as determined by fossils, is Pennsylvanian.

2. Because the supposed Red Wall limestone at Gypsum and Cataract canyons furnished a few fossils probably indicating Upper Carboniferous.

3. Because a Pennsylvanian fauna was found at the very base of the Upper Coal Measures of King.

[a] As determined by Powell's detailed section, which would naturally be supposed to be more exact than the statement in round numbers made elsewhere.

[b] In the Grand Canyon region both Meek, Walcott, and Frech agree in a general way in referring the lower portion of the Red Wall to the Mississippian series, and our collection also contains Mississippian fossils from it.

4. Because very fragmentary evidence from the Uinta sandstone itself indicates that its upper portion is also of Pennsylvanian age.

Powell obtained a few species from the Red Wall at Cataract and Gypsum canyons in eastern Utah which while apparently indicating Upper Carboniferous are not very diagnostic. They are *Chætetes milleporaceus*, *Syringopora multattenuata*, and *Campophyllum* sp. King also cites *Syringopora* as occurring west of Ute Peak, at a horizon somewhat higher than the fauna referred to below. Powell says that Carboniferous fossils were found in the Lodore group, but does not specify what they were. Apparently none were collected. King cites *Spiriferina kentuckyensis*, *Seminula subtilita*, and *Meekella striaticostata*, adding: "These are the lowest forms obtained from the Upper Coal Measures system in the Uinta, and are collected within 60 feet of heavy beds of the Weber."[a] The locality is west of the canyon of Lodore at Ute Peak, and the stratigraphic horizon should be in the Lodore group if the limits of King's Weber and Powell's Uinta series are taken at the same level. Though some doubts might remain in spite of the corals found by Powell, the evidence of the *Spiriferina*, *Seminula*, and especially the *Meekella*, is unmistakable, and shows that the Lodore group, or in any event the Red Wall group, belongs in the Upper Carboniferous.

The Uinta sandstone has been said to be essentially unfossiliferous. Only three instances of the occurrence of fossils are known; all were from débris, but their occurrence and lithology seem to render the assignment to the Uinta sandstone as the original horizon probable. Half of a *Spirifer* of the *imbrex* type found near Mount Agassiz, the impression of a crinoid column at the head of Bear River, and a specimen of *Spirifer cameratus* from the Bench region, near Geode Canyon, comprise the entire paleontologic evidence. *Spirifer cameratus* is distinctly an Upper Carboniferous type. The *Spirifer imbrex* could hardly be lower than the Carboniferous, while, in view of local conditions, even the crinoid column may be taken as probably indicating the same period. The paleontologic evidence, therefore, is confirmatory of the correlation by stratigraphy of the Uinta sandstone, at least in its upper part, with the Weber quartzite of the Wasatch Range, which is known to be of Upper Carboniferous age.

Another matter of disagreement between King and Powell is that the latter refers his Shinarump group to the Juratrias, the lower portion of which constitutes King's Permo-Carboniferous series. Powell's Shinarump measures 1,800 feet. King's Permo-Carboniferous is reported as from 200 to 500 feet. Near the top of the Permo-Carboniferous the geologists of the Fortieth Parallel Survey obtained some fossils which were identified as *Myalina* (resembling *subquadrata*), *Myalina* n. sp., *Bakewellia parva*, *Pleurophorus* sp., and *Macrodon* sp. If correctly identified,

[a] U. S. Geol. Expl. 40th Par., Rept., vol. 1, p. 145.

this fauna would indicate the Carboniferous period without question; but recent collections from the Permo-Carboniferous of the Wasatch Mountains have raised a doubt as to whether the age is really Paleozoic or Mesozoic.

The Paleozoic section of central Colorado has a maximum thickness of 7,120 feet, made up as follows: Sawatch quartzite (Cambrian), 604 feet at Eagle River; Yule limestone (Ordovician), 400 feet at Aspen; Parting quartzite (Devonian?), 90 feet at Crested Butte; Leadville limestone (Devonian and Mississippian), 525 feet at Crested Butte; Weber shale (Pennsylvanian), 1,000 feet at Aspen; and Maroon formation (Pennsylvanian), 4,500 feet at Crested Butte. In addition to this we have the brick-red series of Red Beds, commonly referred to the Trias, which measures 2,600 feet at Aspen. There are in this series, however, a number of time breaks and some erosional unconformities. The most important instance of the latter is at the top of the Leadville limestone.

An interesting parallel can be drawn between the Paleozoic section of central Colorado and that of the Wasatch Mountains of Utah, one also which will aid in determining the relation of the former with the Uinta Mountain section. Except in thickness, the Cambrian series of the Wasatch Range is not unlike the Cambrian of Colorado. The Cambrian in each case is followed by a limestone of Ordovician age—the Ute limestone in Utah and the Yule limestone in Colorado. This again is succeeded by a quartzite series—the Ogden quartzite in Utah and the Parting quartzite in Colorado, the age of which is suspected to be Devonian. Then also, in both areas, follows a limestone of Mississippian age—the Wasatch limestone of the Wasatch section and the Leadville limestone of Colorado. In Colorado a Devonian series is included with the Leadville limestone, which I believe to have no equivalent in the Wasatch section. The geologists of the Fortieth Parallel Survey found Upper Carboniferous fossils down to 5,400 feet below the top of the Wasatch limestone. We may consider, therefore, that the lower 1,600 feet are of Mississippian age and the upper 5,400 feet of Pennsylvanian age. The Mississippian portion of the Leadville limestone can be correlated, not only by its lithology and position in the section, but also almost conclusively by its fauna, with the Mississippian portion of the Wasatch limestone. If the sedimentation which produced the Wasatch limestone was not entirely uninterrupted, the series is at least more complete than that in Colorado, for above the beds whose fauna warrants a correlation with the Leadville limestone succeeded others with an upper Mississippian fauna, which were either never deposited upon the Leadville, or, as I believe more probable, have been lost by erosion.

The Leadville limestone is succeeded by shales and limestones, unfortunately called the Weber limestone, or Weber shales, which occupy the same position in the section as the upper portion of the Wasatch limestone. Above the Weber in Colorado follows the Maroon formation, and above the Wasatch limestone the Weber quartzite, both siliceous series of like geologic position and thickness. The Upper Coal Measures and Permo-Carboniferous of the Wasatch section have no obvious equivalents in Colorado, while the equivalence of the Wyoming formation in the Wasatch Mountains is similarly obscure.

The geologic section of the Wasatch Mountains and that of central Colorado are thus seen to be very similar. They also show this striking difference—that nearly all the formations are thinner, and many of them much thinner, in Colorado. As a marked exception to this prevalent rule, the Maroon formation of Colorado and the Weber quartzite of Utah have essentially the same mass, namely, 4,000 or 5,000 feet in each case.

There is another possibility, however, which may not be entirely passed over. If the Weber limestone and Weber shale of Colorado stand for the Pennsylvanian portion of the Wasatch limestone, this series is reduced from 5,400 feet in Utah to a maximum of about 1,000 feet in Colorado, while in the Uinta Mountains it does not occur at all or has lost its calcareous nature. That it does change character to a considerable extent seems probable. The upper Mississippian fauna, whose presence would indicate less extensive erosion if not uninterrupted sedimentation in Utah during the transition from Lower to Upper Carboniferous time, was found not in the Wasatch but in the Oquirrh Mountains, where the lithologic series is somewhat different. This fauna is conjectured to correspond in the Wasatch limestone to an indefinite horizon not far below that assumed to mark the division between the Mississippian and Pennsylvanian. In the Oquirrh Mountains, however, the beds immediately following are not limestone, but alternations of limestone containing Coal Measure fossils and quartzite, in which the siliceous beds predominate. Either these must be the upper Wasatch of the Wasatch Range, or else the upper Wasatch is missing.[a] King also instances changes from a calcareous to a siliceous phase in certain beds of the upper Wasatch. The variations in thickness of the lower member of the Maroon formation in several sections in which I have correlated it have suggested to me that a period of erosion or nondeposition may have intervened between it and the upper Maroon. This fact, taken with the tendency of the upper Wasatch to pass over into siliceous phases, would seem to justify entertaining the suggestion that the upper Wasatch may be equivalent to the Weber limestone and shale combined with the lower Maroon, and the Weber quartzite itself equivalent to the upper Maroon only. This, however, seems less likely than that the Maroon and Weber quartzite and the upper Wasatch and Weber limestone are equivalent.

While there is little direct evidence supporting this view, I believe that the

[a] Provided, of course, that the upper portion of the Wasatch is of Pennsylvanian age.

diminution in thickness of these strata as they pass eastward is due to the absence of increasing amounts of sediment, probably the effect of erosion. That this agency had a dominant share in reducing the Mississippian (Leadville) limestone to its present dimensions I have no doubt; while the fact that the series along the Front Range, which the earlier geologists thought to be unbroken and complete, has been shown, as work increased in detail and refinement, to be most incomplete and interrupted, lends color to such an explanation for the whole.

It is indeed possible that another interruption or unconformity occurs within the Upper Carboniferous. The thinning of the upper Wasatch from 5,400 feet in the Wasatch Mountains to 100 feet (Weber limestone), for instance, in the Crested Butte quadrangle, would indicate, if not actual erosion, at least somewhat exceptionally unequal deposition, while the overlap of the Maroon beds upon the granite is not without significance. Variation in the lower Maroon, as elsewhere discussed, has led to a somewhat similar suspicion relative to the division between it and the upper member. It also appears to me highly probable that an interruption in sedimentation, if not actual erosion, intervened between the Maroon series and the Triassic above it.

From the evidence at hand it seems impossible not to accept the correlation by Emmons and King of the Uinta sandstone and the Weber quartzite. The correlation of the Weber quartzite of Utah and the Maroon formation of Colorado, thus suggested by a comparison of the geologic sections of the two areas, seems to be partially expressed by Emmons in employing the term Weber formation for the lower half of the series which, in the Tenmile and Leadville districts, represents the original Maroon formation. It is the Weber quartzite of Utah and the Maroon formation of Colorado that in approaching each other are supposed to pass into the Uinta sandstone. One point of difference is the red color of the typical Maroon and the general whitish tint of the Weber quartzite. However, the Maroon seems to lose most of its color in the Leadville and Tenmile districts, while the eastern exposures of the Uinta sandstone have the brownish tint which is supposed to characterize it.

Since the Weber and Maroon formations maintain so uniform a thickness (from 4,000 to 5,000 feet) both in Utah and Colorado, it is a matter of surprise that the Uinta sandstone should reach a thickness of 12,000 feet and more, and the first inference would be that the Uinta sandstone represents something more than these formations. It can, however, hardly represent the whole Paleozoic series of Colorado.

The differences existing between the Uinta sandstone and the varied sediments of the different Paleozoic horizons of Colorado are differences both of character and of thickness. If the supposition be entertained that the Uinta sandstone represents the entire Paleozoic series of Colorado, the differences of character become more pronounced; if only the Maroon formation, differences of thickness. The former hypothesis, on the whole, seems to me altogether untenable. The Paleozoic series in Colorado as it now stands is so incomplete that the column in its entirety would probably far exceed even the great thickness of the Uinta sandstone. This becomes obvious from the consideration that the Maroon formation represents only a moiety of Carboniferous time, yet it alone is half as thick as the Uinta. Again, the supposition is incredible that all Paleozoic time could be represented by a uniform series of sediments like the Uinta sandstone. Much more incredible is it that the Uinta represents a frequently interrupted and eroded series.

The Cambrian quartzites, though at most but 600 feet in thickness in Colorado, are expanded to 12,000 feet in the Wasatch. It would seem likely that this series is represented in the Uinta Mountains by considerable thicknesses[a] proportional to its intermediate position, and it is admissible that the Parting quartzite, or even the siliceous Yule limestone, may be represented there by modified and less important measures; but the persistence of the Leadville as a limestone horizon is so striking that I should hesitate to adopt any mere hypothesis which demanded its local mutation into sandstones and conglomerates. It seems to me more probable, however, that a period of uplift and erosion during Carboniferous time destroyed in the Uinta area the older sediments, perhaps already thinned by previous erosion, down into the Cambrian beds; and that upon the base thus formed was spread the waste so similar in character to the much older sediments that it now has the casual aspect of a single continuous series. Which of the two erosion epochs whose occurrence during Carboniferous time I have tentatively hypothecated performed this work, it is impossible to say. If the one which intervened between Leadville sedimentation and that of the Weber limestone, whose existence seems to be established, it is evident that the Uinta sandstone must include, besides the Weber quartzite and Maroon formation, thicknesses of shales and sandstones representing the Pennsylvanian portion of the Wasatch limestone, unless the latter is conceived to be entirely lacking in the Uinta Mountains of Colorado. The absence of the Pennsylvanian Wasatch might, however, be accounted for by the suppositious unconformity between the Maroon and Weber formations of Colorado, owing to which also the 5,400 feet of upper Wasatch wedge out to a few hundred in that State. If this erosion were performed or consummated by the still more hypothetical occurrence which has been suggested between the two divisions of the Maroon itself, these calcareous beds of the upper Wasatch, as well as the Mississippian ones and even part of the Maroon-Weber series itself, would appear to be equally unrepresented. On the other hand, it is possible that the whole of the Uinta sandstone may be of Pennsylvanian age.

[a] Peale remarks, under the caption "Silurian Age:" "There was a much greater development in Mr Marvine's district and further details will be found in his report." (Hayden's U. S. Geol. Geogr. Surv. Terr., [8th] Ann. Rept., for 1874, 1876, p. 110.) It is not clear whether this refers to the Silurian as a whole or to one or several of the divisions which Peale recognizes. Most of his Silurian series (probably 600 feet) is Cambrian (Sawatch quartzite) and his statement is somewhat favorable to the hypothesis adopted above. Marvine's district lay to the north and northwest of that of Peale. Unfortunately his report never came to publication.

In this case the unconformity between the Red Creek and Uinta formations would correspond to that which follows the Leadville limestone in central Colorado.[a]

This supposition would be most favorably entertained in connection with the hypothesis that the Pennsylvanian portion of the Wasatch limestone becomes transformed in the Uintas into sands and clays, while the several hypothetical unconformities within the Pennsylvanian series of Colorado, and especially that above the Maroon beds, might be appealed to as the cause of the diminished representation in that region. That the Wasatch limestone of Utah or the Weber limestone of Colorado is represented in the Uinta Mountains seems to me rather doubtful, the probability being that the Maroon-Weber series rests directly upon the pre-Carboniferous, chiefly Cambrian, quartzites, with the Wasatch limestone on one hand and the Leadville and Weber limestones on the other wedging out convergingly in the direction of the Uinta Mountains. The overlap of the Maroon-Weber series upon the Cambrian in the Uinta Mountains would then be but another expression of the same readjustments by which in the Crested Butte quadrangle it came in contact with the Archean.

While it is true that no unconformities are known within the Uinta sandstone, they may have escaped detection because of the uniform composition of the series and the difficulty of tracing individual beds.

Accepting provisionally the correlation of the Maroon-Weber series of Colorado with the upper portion of the Uinta sandstones, the correlation of the Wyoming formation (the so-called "Triassic") in the Uinta section and the determination of its geologic age are beset with still greater uncertainties.

Powell's Jurassic of the Uinta Mountains is clearly the same as that of King, and King expresses absolute certainty of the Jurassic of the Front Range being the same as that of the Uinta Mountains. Between the Jurassic and Maroon formations in central Colorado is found the Wyoming formation, whose average thickness seems to be 1,500 feet (it is possibly 2,600 feet at Aspen). Within equivalent limits in the eastern end of the Uinta Range, according to Powell's section, are his Carboniferous and part of his Mesozoic groups, comprising the Lodore group, with a thickness of 465 feet; the Red Wall group, with a thickness of 2,460 feet; the Lower Aubrey group, with a thickness of 805 feet; the Upper Aubrey, with a thickness of 1,575 feet; the Shinarump, with a thickness of 1,095 feet; the Vermilion Cliff, with a thickness of 615 feet; and the White Cliff, with a thickness of 1,025 feet. The whole comes to a total of 8,090 feet.

It has elsewhere been remarked that though Powell gives a combined thickness of over 5,000 feet to his Carboniferous groups in the Uinta Mountains, King allows

[a] This unconformity would have to be invoked to account for the absence of the Ogden quartzite and of the Wasatch and Ute limestones. In default of evidence as to the age of the Red Creek quartzite it might be taken as equivalent to the Cambrian series of the Wasatch Mountains.

but 2,000 or 2,500 feet to the same series, together with an additional 200 to 500 feet taken from Powell's Mesozoic. King's Triassic is fixed at 2,000 feet, while Powell's Shinarump, Vermilion Cliff, and White Cliff groups aggregate 2,785 feet, from which, however, must be deducted 200 to 500 feet to represent the lower portion of the Shinarump, assigned by King to the Carboniferous.

Two possibilities, in default of decisive evidence, present claims for consideration. The hypotheses that the Wyoming formation represents either the Carboniferous or the Triassic can be supported by evidence. If the Wyoming beds be placed as the equivalent of the "Upper Coal Measures" of the Uinta Mountains, it must needs follow that its age would be Carboniferous and that the Triassic of the Uinta Mountains would be absent from central Colorado. Regarding the former deduction, it will be recalled that Knight found Carboniferous fossils in King's Triassic near the Colorado-Wyoming line, and Darton reports a similar occurrence in the Wyoming formation of the Front Range. To be sure, in Knight's case only the lower half of beds mapped Triassic by King are proved to be Carboniferous, but it might have the appearance of forcing the correlation to cut off the upper 800 feet as Triassic, especially since the upper beds are similar lithologically and appear to have been deposited in unbroken succession. Further, some of the faunal assemblages found by Knight are strongly suggestive, in the abundance of *Bellerophon* and *Dentalium*, of the fauna of the Bellerophon limestone, and of one which occupies a similar position at the top of the Aubrey series in the Grand Canyon region. Powell describes this formation as being an indurated calcareous sandstone on the south side of the Uinta Range (p. 55), so that the lithologic as well as the faunal facies of the beds in Wyoming are suggestive of the Bellerophon limestone. Darton's evidence is less complete, but tends in the same direction. He identified at Morrison, near the top (?) of the Wyoming formation, strata having the same lithologic character and similar invertebrate fossils to the Carboniferous Red Beds of the Black Hills. Over much of the State the Red Beds (Wyoming formation) are without determinable fossils, except for the two occurrences just mentioned. Unconformably above them rests the Jurassic (Morrison and Gunnison formations). Though commonly referred to the Triassic, these strata, therefore, might really be Carboniferous, so far as intrinsic evidence is concerned, and equivalent to the Upper Coal Measures of the Uinta Mountains. Indeed, Emmons states of the Wyoming formation that if any Permian exists in Colorado that series probably represents it. The absence of the Shinarump, Vermilion Cliff, and White Cliff groups of Powell's Uinta Mountain section (the Triassic of King) might readily be accounted for by the erosion which preceded Jurassic sedimentation. In southwestern Colorado the Carboniferous is followed by a formation (the Dolores) which has the characteristics and position of the Triassic in other parts of the State, which Cross and Spencer affirm to be the same as the Triassic of the Rocky Mountain province, and which carries Triassic vertebrates. If, however, the paleontologic evidence produced by Knight and by Darton, which is by no means unassailable, be admitted, it is evident that the two series are not the same. However, it has already been remarked that the Wyoming beds appear to be absent in the Crested Butte quadrangle and generally over the southern end of the Elk Mountains, the Mosquito Range, and the Sangre de Cristo Range, so that its absence in the San Juan is not unanticipated; while that area is geographically so related to the Colorado Canyon and Uinta Mountains, where Triassic beds are found, that the presence there of the Triassic need not be an objection, even if the series is absent over the rest of the State, as it must be if the Wyoming beds are really Carboniferous.

On the whole, however, the evidence seems to me stronger that the "Red Beds" of Colorado are really Triassic, and represent the Shinarump, Vermilion, and White Cliff groups of the Uinta section, or parts of them. The apparent absence elsewhere in Colorado of the "Upper Coal Measures" of the latter area can be accounted for in another way.

If the Maroon formation represents the upper portion of the Uinta sandstone and the Wyoming formation the Triassic of the Uinta Mountain section, where the Wyoming beds rests upon the Maroon, as in the Leadville and Tenmile districts, or when the Jurassic occupies a similar position, as it does in the Crested Butte district, it is evident that the Upper Coal Measure series of King must be absent. Many observers agree that the Wyoming formation succeeds the Maroon in apparently a perfectly continuous manner, and the same with their supposed correlates in different parts of the State. Yet along the Front Range and in southwestern Colorado the supposed Triassic series overlaps upon the Archean and indicates important isostatic readjustments in which the conduct of the strata in northwestern Colorado may find a rational explanation. Furthermore, the faunal break in the San Juan region between the Rico and Dolores, in which Permian and probably portions of Carboniferous and Triassic time are apparently missing, together with the variability seeming to exist, such that the upper division of the Maroon formation, 2,500 feet thick in the Crested Butte quadrangle, is reduced to 300 feet (Rico formation) in the San Juan region and is entirely absent in the Dolores River region, are indications of an uncomformity, or at least of very abnormal conditions of deposition. There is some evidence, however, that the Upper Coal Measure series is represented in Colorado. Both the fauna itself, while no correlation can be based upon it, and the lithologic association with reddish sandy limestones and white sandstone of the fossils cited by King from Ute Peak, in the eastern end of the Uinta Mountains, are suggestive of the fossiliferous horizons in the Red Beds as they occur on the flanks of the Front Range, just north of the Colorado line. The similarity in a general way of the fauna recently found by Knight in the Triassic of this area to that of the Bellerophon limestone has already been remarked. The Jurassic comes only 800 feet above these Carboniferous horizons in Knight's section, and it is necessary to conclude either that the Triassic is wanting at this point, and erroneously represented there by King, that it is represented by these upper 800 feet, even though they are lithologically like the Carboniferous beneath and apparently continuous with it, or that the Triassic, nowhere in this area determined by fossils, is really Carboniferous, the series being in fact a unit determined as to age by the Carboniferous faunas occurring invariably in the lower portion. Probability, in my judgment, as already remarked, weighs more heavily in favor of regarding the Carboniferous and "Triassic" of this region as two separate series, the upper one correlated with the Triassic of more distant areas where Triassic fossils are found.

The interesting discovery by Knight, above referred to, I believe to represent the Carboniferous which King describes as comprising 1,500 feet on the west side of the Front Range, the same thickness as all of Knight's Red Beds below the Jurassic. The absence of the Triassic at this point, if, as seems rather more probable, it is not represented by the upper unfossiliferous series, is by no means without precedent, and is easily to be accounted for by the erosion period which preceded the Jurassic sediments. It appears not improbable that some of the sediments now supposed to represent the Maroon formation should really be assigned to this division (i. e. King's Upper Coal Measures). The Weber grits and Maroon formation of the Tenmile district, for example, lack at least the distinctive color of the original Maroon, as does the corresponding series on Eagle River.

As regards the general similarity of the two formations in Colorado, a similarity which is not obvious when only the section given by Powell is considered, reference may be made to White's remark that his Lower Carboniferous so resembles the underlying Uinta sandstone, and his Middle Carboniferous the Lower, that in some cases it was difficult to distinguish them.

Emmons states in the Tenmile folio that the Weber formation of that area represents in a general way the Weber quartzite of Utah and the Lower Aubrey group of Arizona. This implies that the Aubrey sandstone, the Weber quartzite, and the Weber grits or lower Maroon, are of the same age. As a corollary they would probably represent the upper portion of the Uinta sandstone. There seems to be no reason why the upper and lower Maroon should not be made two distinct, possibly as to age two rather different, series. That the Weber grits and Maroon beds of the Tenmile district represent a higher horizon than the Maroon series of the Crested Butte district, seems to me altogether out of the question, because, for one reason, the fauna of the Weber grits is so similar to that of the lower Maroon that a correlation of them can probably be made on this evidence alone. That the Maroon series alone of the Tenmile district overlies the Maroon of the Crested Butte district seems also improbable and is contradicted by the nomenclature which Emmons employs. They are much rather to be considered equivalent. It would, therefore, furthermore result from Emmons's correlation that the Maroon of the Tenmile district (the upper Maroon of the Crested Butte district) occupies in this section the position of the Aubrey limestone of the Grand Canyon section and the Upper Coal Measures of the Uinta Mountain and Wasatch Mountain sections. I have elsewhere discussed the evidence which, while not conclusive, indicates that the Upper Coal Measure limestone of the Wasatch Mountains, the series called by the same name in the Uinta Mountains, and the Aubrey limestone, if not the Aubrey sandstone, of the Grand Canyon, should be correlated. Whether this series is represented by the upper Maroon beds of Colorado, or is represented in the State at all, are points upon which there is, so far, little direct evidence. The fauna found by Knight just over the line in Wyoming, as already remarked, suggests the Bellerophon limestone of the Uinta section. It is probable that these beds extend into Colorado. From the upper division of the Maroon in the Crested Butte quadrangle, and from the Maroon of the Tenmile quadrangle, scarcely any fauna deserving the name is known. The species that have been found, however, do not greatly disagree with the fauna of the Rico formation, which is supposed to represent the horizon of the upper Maroon. The Rico fauna is superficially somewhat similar to that obtained by Knight, but it is doubtful if a complete study of the latter will result in many instances of perfect specific identity. The Rico fauna is also very different from that of the upper Aubrey group of the Grand Canyon. Though the opinion is expressed with hesitation, it seems probable to me that the upper Maroon is not equivalent to the Upper Coal Measures of the Wasatch and Uinta sections (the Aubrey limestone of the Grand Canyon section), but joined with the lower Maroon (the Weber grits) is equivalent to the upper part of the Uinta sandstone and to the Weber quartzite. As to whether the Aubrey sandstone should be correlated with the Weber quartzite and lower Maroon series, as Emmons suggests, and with them be merged in the Uinta sandstone, or overlies the horizon of the Uinta sandstone, I am in doubt. The opinion has elsewhere been expressed that its horizon was above the Uinta, but there is very little evidence upon this point. In any event it is not to the Weber grits, but to the Maroon series of the Tenmile section, or to both combined, that the Aubrey sandstone is probably equivalent.

It is necessary, however, to give some further consideration to the tentative correlation of the Weber quartzite and the Maroon series of Colorado implied in the nomenclature employed by Emmons in the Leadville monograph and elsewhere and strongly enforced by a comparison of the Paleozoic series of Colorado and of the Wasatch Mountains. The fauna of the Weber quartzite is not well known. It has a brachiopod facies and is quite different from the fauna of the upper Maroon as exemplified by the Rico formation. It is, in fact, more like the fauna of the lower Maroon, but at the same time contains many novelties. No satisfactory estimate of this evidence can be made pending a careful study of the Weber fauna, which I hope to make at some future time. If the differences prove to be as important as they at first appear, the paleontologic correlation of the Maroon and Weber series would hardly be justified. It is possible to suppose that the Maroon series is absent in Utah, or that it, combined with the Weber limestone, is represented by the upper portion of the Wasatch limestone and that its horizon is below the Weber quartzite. In that event the simultaneous occurrence of these two series in the Uinta Mountains would adequately account for the Uinta sandstone, even if it became necessary to refer to the Carboniferous the whole of that great series. On the other hand, a provincial influence may possibly be cited to account for the faunal peculiarities noted above and others corresponding to them. It is necessary to consider that the waters of the Mississippian sea extended into Utah and possibly as far west as the Sierra Nevada, but in the elevation which preceded the first Pennsylvanian sediments this area must have been analyzed into a more composite geography. The Pennsylvanian faunas of Colorado have every appearance of being provincially related to those of the Mississippi Valley. The faunas of Pennsylvanian age found to the west and southwest, however, are sufficiently different and novel to suggest that the post-Mississippian elevation, if it did not establish a barrier between the Colorado and Utah seas, at least aroused influences sufficiently potent to modify the faunas of the two areas.

I shall permit myself, before closing, a few words upon the nomenclature of the Carboniferous formations of Colorado, deprecating not so much that many names have been employed, but that some have been used in several senses and some have been imported from such a distance that the correlation intimated must have been originally doubtful and is now perhaps more than doubtful.

Of Mississippian age we have the Leadville limestone of central Colorado, the Millsap limestone of the Front Range, and the Ouray limestone of southwestern Colorado. While I believe that the Leadville, Millsap, and Ouray limestones, so far as their Mississippian faunas are concerned, and for that matter the Red Wall, Wasatch,[a] and Madison limestones, can be correlated, the employment for them of distinct formational names seems to be a field matter of geologic propriety and to be judged only from that point of view. I think, however, that it would have been better, in view of the fact that the Leadville and Ouray limestones contain a fauna of Devonian as well as one of Mississippian age, if two formations, instead of one,

[a] I mean only the lower or Mississippian portion of the Red Wall and Wasatch limestones and only the Red Wall limestone of the Grand Canyon.

had been discriminated. Indeed, had this fact been known when these formation names were first proposed it is possible that this course would have been adopted.

For the Upper Carboniferous formations in the Uinta Mountains we have the Uinta sandstone, the Lodore group, the Red Wall limestone, and the Upper and Lower Aubrey groups. The names Red Wall and Aubrey are adopted from the Grand Canyon region, and, as the correlation of the Red Wall group is certainly erroneous and that of the Aubrey still doubtful, it appears to me that these names should be abandoned for this area.

In central Colorado we have the Weber formation, the Maroon formation, and possibly the Wyoming formation. I take it that the use of the name Weber records the attempted correlation with the Weber quartzite of the Wasatch Range, by which formation the name was long preoccupied. It is doubtful if the Weber formation of Colorado[a] can be correlated with the Weber quartzite of Utah, and certainly the two formations can not be considered the same geologic unit. Indeed, the Maroon formation is much more probably to be correlated with the Weber quartzite, a fact which perhaps finds partial expression in the later expansion of the term "Weber formation" in Colorado so as to include the lower half of the Maroon formation (vide the section of the Tenmile folio). This step has made the free use of the term "Weber" impossible in discussions of Colorado geology, and it seems to me that the name can not be too quickly laid aside in this connection. Endlich's term, "Arkansas sandstone," which was given to the more or less exact continuation into the Sangre de Cristo Range of the Maroon conglomerate of the Elk Mountains, seems to have been generally overlooked. We have now the Weber quartzite (of the Wasatch Mountains), the Uinta sandstone, the Maroon conglomerate, the Arkansas sandstone, the Fountain formation, the Badito formation, and the Hermosa formation in use for parts or variations of the whole of about the same series of strata. All these names, and especially the Maroon and Arkansas,[b] will need careful consideration whenever a recension of this nomenclature or further detailed work involving this series is attempted. The variability of the Maroon beds is such, however, especially in view of the disconnected character of the areas of outcrops, as to justify, if not to demand, numerous local appellations.

The opinion that in the Rocky Mountain region the Archean mountains of to-day represent island masses which have never been completely submerged has had the support of eminent geologists from the time that the Rocky Mountains first became the subject of geologic study, and probably no one has given the matter more thoughtful investigation than S. F. Emmons, or more frequently and ably advocated this view. The conception, I think, has its origin in the very obvious overlap of many

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[a] As the term was first used in the Anthracite-Crested Butte folio.

[b] The proposal of the Badito formation might have been avoided by more fully ascertaining the relations of the beds, so called, with the Fountain formation or the Arkansas sandstone.

of the sedimentaries, especially of the Red Beds, upon the Archean, and their failure to cross the summits of the ranges, and was developed from the theory that the existing Paleozoic series (for it is only to Paleozoic time that these remarks refer) represents more or less uninterrupted sedimentation. Similarly, in discussions of the subject, Paleozoic time has been for the most part lightly touched upon and treated in general terms as if the conditions which prevailed were in the main uniform. Writing in 1893 of the Rocky Mountains of Colorado,[a] Emmons recognized five great marine transgressions, the post-Archean, the post-Algonkian, the late Paleozoic, the late Jurassic, and the post-Cretaceous. The first disturbance recognized subsequent to the Algonkian therefore is placed in the late Paleozoic, and probably this conclusion is connected with the occurrence in the conglomerates of the Maroon formation in the Elk Mountains of pebbles containing Carboniferous fossils. Again, in the Tenmile folio, published in 1898,[b] he remarks that deposition was more or less continuous from the Upper Cambrian to the Trias, without evidence of any change in the relations of the sea bottom to the successive sediments, and that the first orogenic disturbance probably occurred in the Jurassic.

Much evidence has now accumulated, however, tending to show that the Paleozoic series is anything but continuous and complete. This is indicated by the frequency of unconformities, sometimes by erosion, sometimes by overlap, by the thinness of the remaining beds, and by their unequal distribution. That some of the intervals were of protracted duration is shown by the extent of the time break between apparently consecutive formations. The often much greater gaps indicated where different Paleozoic formations rest directly upon the granite is probably not so much the product of a single erosion period or a single transgression as the sum of a number of briefer ones and the resultant of a complicated series of movements. The permanence of these Archean islands seems to me to involve an a priori improbability, from the fact that they must have been reduced almost to sea level long before the immeasurable stretch of Paleozoic time had elapsed, so that even slight oscillations, which during so long a period could hardly have failed to occur, would have sufficed to submerge them.

That the Paleozoic series in Colorado is really an extremely disconnected one is shown by the number and extent of the gaps that are known to occur in it, and an intimation of this is to be fouud in the greatly reduced thickness of the pre-Carboniferous series, considered as a whole and in relation to areas farther east and farther west. The Cambrian so far as it is known is represented by only a few hundred feet, all of which belongs to the Upper Cambrian. All Lower and Middle Cambrian time appears to be unrepresented. The Ordovician must be approached with

[a] Int. Geol. Cong., Comt. Rend., 5th sess. (1891), 1893, p. 404.
[b] U. S. Geol. Surv., Geol. Atlas United States, folio 48, 1898.

caution, because enough is known to raise many questions in regard to it, but too little to answer them.

In the interior there is only the inconsiderable thickness of the Yule limestone, with perhaps the Parting quartzite, by which it seems possible that only a small portion of Ordovician time can be represented. In the Pikes Peak quadrangle Cross has discriminated the Manitou limestone, the Harding sandstone, and the Fremont limestone, all of Ordovician age. The faunas of the Harding and Fremont are those of the upper Ordovician (Trenton), and I doubt if the lowest Ordovician is represented. Another gap would then exist between the highest Cambrian and the lowest Ordovician bed. Cross notes an unconformity of overlap between the Harding sandstone, and I can not believe that this unconformity, or the movements which caused it, were restricted to the immediate region of the Pikes Peak quadrangle. It can probably safely be said of the Ordovician that it is now represented by fragments, and that deposition was affected (and possibly the present existence governed) by contemporaneous movements. The Upper Silurian appears to be entirely wanting in Colorado, and most of the Devonian as well. The latter period is very doubtfully represented by the Parting quartzite, whose age is not definitely known, and certainly by the lower part of the Ouray and Leadville limestones, whose fauna belongs to the upper Devonian. No rocks were formed, then, from the end of Ordovician to toward the end of Devonian time, or if formed they were also swept away again. The upper portion of the Ouray and Leadville limestones carries a Mississippian fauna, and while the faunal break is what one might almost call absolute, the lithological indications are that sedimentation was continuous from the Devonian. But the sharp faunal break and the fact that apparently in places, as along the Front Range the upper limestone with the Mississippian fauna exists without the lower, would seem here again to indicate an overlap and possibly an interval of erosion or nondeposition. The upper portion of the Ouray and Leadville limestones is of Mississippian age. Its upper limit is marked by an erosional unconformity, and the paleontological evidence indicates that only lower Mississippian time is represented. The middle (?) and upper Mississippian, and probably part of the Pennsylvanian, are wanting through erosion or nondeposition. The lower part of the Hermosa (and the Molas formation where present), which succeeds the Ouray, I am disposed to correlate with the Weber shale and the Weber limestone, which follow the Leadville limestone. Their deposition appears to have been consecutive with that of the rest of the Hermosa and with the lower Maroon and the Weber grits, which I also correlate. At the same time the Maroon sediments transgress the Weber series, and in fact all the earlier Paleozoics, and in the Crested Butte quadrangle and elsewhere lap over upon the Archean. There is also a certain individuality about the lower Hermosa and the Weber faunas, while the conglomerates of the lower Maroon contain pebbles of limestone with Upper Carboniferous fossils. The fauna of the pebbles, however, is not that of the Weber limestone (and of course not that of the Leadville), but of the Maroon itself. Between the Hermosa (= the lower Maroon) and the Rico (supposed to equal the upper Maroon) another interval may exist. This is indicated by the faunal change between the Hermosa and Rico formations, by the much greater thickness of the Hermosa in Sinbads Valley, and the presence in its upper portion of a fauna different from that of the typical Hermosa. Evidence favorable to this, however, may exist in the color change to the dark-red Maroon beds, and in the great number and size of the Archean bowlders which their conglomerates contain. Between the Rico and the upper Maroon formation on one hand, and the brick-red Dolores of the San Juan, the Triassic of Aspen and elsewhere in Colorado, and the Wyoming formation of the Tenmile district on the other, another important interval, probably accompanied by erosion, seems to have occurred. This is indicated by the probable absence of the Permian and possibly of portions of the Pennsylvanian series between the Rico and Dolores beds, and by the overlap of the "Triassic" upon the Archean at a number of points, and is implied in the suggested correlation of the section in the Uinta Mountains with that of central Colorado. Owing to it the whole Carboniferous series in the Uinta Mountains above the Uinta sandstone is missing elsewhere in Colorado,[a] and the upper Maroon from a thickness of 2,500 feet in the northern part of the Crested Butte quadrangle is greatly reduced in the southern, becomes only 300 feet in the San Juan (Rico formation), and is apparently missing altogether in the Dolores River region. I may have misread the paleontologic and other evidence in some cases, and have erred in correlating the Colorado sections with one another and with those of the Uinta and Wasatch mountains (though the latter correlation is certainly borne out by numerous collateral circumstances), but the existence of an unconformity and time break following the Leadville horizon can hardly be questioned. Now, it seems to me that the conditions under which neither erosion was carried forward nor sedimentation going on (except for abyssal tracts which can probably be left out of the discussion) must have been rather exceptional, and that their existence over large areas and permanence through protracted periods of time must have been of rare occurrence. The apparent conformity in Colorado in local sections of Paleozoic formations showing important differences of geological age would then indicate either protracted erosion and complete baseleveling or slight elevation and shorter periods of exposure to atmospheric forces. Somewhat as it is true that the oldest mountains are the lowest, may it almost be said that the greatest unconformities, those involving the most extensive territory and the longest periods, are least apparent. Where the areas which have been tilted are extensive, the angular unconformity between the existing and the succeeding sediments is often imperceptible. Where

[a] Unless they are represented in the northern part of the State by sediments now supposed to belong to the Maroon-Weber series.

the elevated surface has been reduced by protracted erosion to a base-level, erosional unconformity in local exposures is largely obscured.

I shall venture to say but little about Paleozoic time earlier than the Carboniferous. It seems to me, however, that the evidence, briefly and partially submitted, indicates that conditions were not uniform in successive epochs, and that sedimentation was not continuous during Paleozoic time; that it was not only interrupted, but one might almost say was reversed. Indeed, the evidence coming before me seems to indicate uniform contemporaneous conditions, sediments, and faunas over remarkably extensive areas in the West, with changes to other contemporaneous conditions equally widespread. It is possible that some of the present Archean areas were islands during Cambrian time, yet too much weight should not attach itself to the siliceous character and basal conglomerate, for the wide distribution of moderately coarse conglomeratic material not linearly along a coast but apparently in an areal sheet is a common geologic occurrence. On the other hand, the different calcareous beds I conceive, accepting the common interpretation, to represent moderately deep clear waters. I can not believe in the formation of reasonably pure calcareous sediments close to an Archean land mass save as an exceptional occurrence. The overlap of a limestone series upon the Archean or Algonkian, as noted in the case of the Ouray limestone of the San Juan region, is significant in indicating important hypsometric changes.

I would conclude, from the foregoing considerations, not that there were no land masses during Paleozoic time, but that they were independent, and not necessarily continuous from period to period; and that the consideration of geographic conditions should be epochal, while to speak of them in connection with Paleozoic time as a whole is fallacious. But the accumulation of many more facts, both in stratigraphy and in paleontology, is necessary to complete the evidence. While perhaps an opinion has been expressed regarding early Paleozoic conditions stronger and in more general terms than the facts really warrant, it is my belief that during Leadville time at least the questionable Archean islands were submerged beneath a widespread Mississippian sea. This opinion rests chiefly upon the persistent lithologic and paleontologic characters displayed by the rocks of this period. The Waverly horizon occurs in a large number of our Western States. It is nearly everywhere a limestone formation, and everywhere characterized by essentially the same fauna. This is quite true of the Waverly horizon of Colorado—the Leadville limestone. It seems likely that the proximity to land, if such existed, would be indicated by a change in the sedimentation if not in the fauna. Nowhere does this seem to be the case in Colorado. The small isolated area of Paleozoic outcrop in Manitou Park and the long strip in the Mosquito Range are frequently accounted for as having been bays and inlets, but the character of the fauna seems to be essentially the same as that of open water, with similar calcareous sediments. For my own part, these and similar phenomena, such as the fragmentary occurrence of the Sawatch quartzite and the Yule limestone described by the Van Diests, near San Luis, are more naturally explained as remnants of strata that once were continuous over the Archean. In the matter of faunal characters the Leadville limestone at Leadville and the Millsap limestone of the Front Range possess characters in common which distinguish them in some degree from the other Mississippian faunas of Colorado; but since they occur on opposite sides of the long Archean tract of the Colorado range, it seems to me very doubtful whether this fact can be taken as indicating local conditions due to adjacence to land masses. On the other hand, the difference of the Ordovician section along the Front Range and in the interior may afford ground for argument in favor of the existence of a barrier between them during Ordovician time. Yet it would little surprise me, if a careful study of the faunas of both areas were made, to find that the difference is not so great as now appears, and that it is due rather more to lack of uniformity in what has been removed than to lack of uniformity in what was originally deposited.

Attention has several times been called in geologic works to the thinning visible throughout the Paleozoic series in passing eastward from central Utah to the Front Range. This is noticeable even in following the different Paleozoic formations in the State of Colorado. I would attribute this not to a normal thinning or compression of the larger series, but to the removal or nondeposition of sediments at many horizons. An instance in point seems to be the absence in Colorado of the upper part of the Mississippian portion and part of the Pennsylvanian portion of the Wasatch limestone of Utah.[a]

It is a rather significant fact that so many of the formations thin toward the east, and seems to indicate that about the present position of the Front Range, or possibly east of it, exists a permanent line of weakness which has been repeatedly elevated, eroded, and submerged. This has a certain bearing upon a question which has often recurred to me as needing explanation. If, as many believe, mountain or land masses and marine basins have in their general outlines always existed, and if, as seems little doubtful, the clastic rocks which form masses of the continental bodies have as their ultimate source the original Archean basement, together with such additional supply as is afforded by volcanic extrusions, or obtained from the atmosphere in the formation of carbonates, it must follow that the original Archean continents were of as large size as the existing ones, unless the land masses were then much higher or the marine basins shallower. The latter proposition seems, indeed, a probable one. If, however, the Archean masses represent permanent

[a] The reality of this instance depends of course upon the correctness of my correlation of the Colorado rocks with those of Utah.

areas of weakness, which were continually being pushed up and eroded, a constant source of material would be afforded by comparatively limited tracts. There certainly seems to be evidence to favor such a hypothesis with regard to the Archean area represented by the Rocky Mountains of Colorado, and possibly similar conditions existed with regard to the other notable Archean areas. Somewhat as a corollary to this would be the supposition that these areas were not permanently above water, and though repeatedly elevated were sometimes depressed. In the Rocky Mountains these movements seem to have involved such large surfaces that their effect upon the strata is often not apparent, except as indicated by overlap or by the comparison of sections widely separated from one another. The great amount of disturbance which the strata in Colorado have undergone would also aid in concealing local evidence of unconformity.

FAUNAL EVIDENCE AND CORRELATION.

MISSISSIPPIAN.

In Colorado, and generally throughout the West, the Upper and Lower Carboniferous faunas are well differentiated. In Colorado the only Mississippian horizon is that of the Leadville limestone and its equivalents, the Ouray and Millsap limestones. This formation contains at many points a characteristic Upper Devonian fauna in its lower part, and at the top a fauna equally distinctive of Carboniferous time. This is true of the Crested Butte region, the San Juan region, and the beds at Salida. At some points only the Devonian fauna is known, and at others only the Mississippian; but in view of the scanty character of our collections from many of the areas, the expectation is reasonable that if careful search be made both faunas will be found at some of the points at which only one is now known.

The Mississippian fauna of the Leadville limestone represents the early portion of Mississippian time, and is related to the fauna which occurs with such wonderful persistency throughout the West. It is closely similar to the fauna of the Cuyahoga shale of Ohio and the Chouteau limestone of Missouri, and this relationship has been generally recognized. Of this further proof need hardly be offered than the faunal lists themselves. The evidence both of species and of genera is quite clear in indicating the early Mississippian.

In Colorado we have no upper Mississippian faunas. This is true of a large part of the western country, even where early Mississippian rocks are known. On the other hand, at a few points, unmistakable faunas of the Genevieve period have been found, so that there is no reason to believe that these rocks and faunas have never been deposited in the West. In Colorado there is satisfactory evidence that the Leadville limestone was followed, though probably not directly, by a period of elevation and erosion; and I believe that the absence of Genevieve faunas, both in Colorado and elsewhere in the West, is in large measure accounted for through the same circumstance. In the Leadville limestone, therefore, so far as its fossils have come into my hands, I believe that Genevieve time is not represented, nor probably Keokuk or upper Burlington. The Leadville fauna, according to my interpretation, represents, in the Carboniferous, Kinderhook, and possibly lower Burlington time.

I have spoken of the Leadville fauna as a unit. In fact, collections from different disconnected areas show rather strong local groups of species. This is no doubt in part due to local differences in the condition of environment. It is in part the result of the scantiness of many of our collections. Mississippian faunas have been found in Colorado, in the San Juan region, in the Crested Butte quadrangle, in the Aspen district, in the Leadville district, at Salida, at Canyon, in the Pikes Peak quadrangle, at Perry Park, and in the Upper Carboniferous (?) conglomerate of Larimer County. I shall proceed to speak separately of each local group of faunas.

SAN JUAN REGION.

Collections were made in the San Juan region at nine localities (stations 2379, 2380, 2381, 2382, 2384, 2385, 2386, 2387, 2388), and contain 32 species. The material was obtained, part of it in place (from the top of the Ouray limestone), part from cherts and cherty limestones lying loose upon areas of Ouray outcrop, and part from chert bowlders included in the unconformably overlying red shale of the Hermosa formation. The fauna is in every case essentially the same. The local faunas of this region represented in our collections are exhibited in the following table:

TABLE I.[a]—*Table showing distribution of Mississippian species in the Ouray limestone of the San Juan region.*

	2379.	2380.	2381.	2382.	2384.	2385.	2386.	2387.	2388.	Total.
CŒLENTERATA.										
Zaphrentis tantilla	×				×					2
Zaphrentis? sp. a	×		×							2
Menophyllum ulrichanum	×			×	×		×		×	6
Syringopora surcularia			×							1
ECHINODERMATA.										
Rhodocrinus sp				×						1
Platycrinus sp				×		×				2
BRYOZOA.										
Fenestella serratula?				×		×				2
Fenestella cf. filistriata				×						1
Fenestella sp				×			×			2
Batostomella sp				×						1
Fistulipora? sp				×						1
BRACHIOPODA.										
Rhipidomella pulchella	×			×	×	×				4
Orthothetes inæqualis	×		×	×	×	×				5
Chonetes illinoisensis	×		×							2
Productella concentrica	×									1
Productus semireticulatus var	×		×	×	×					4
Productus parviformis			×							1
Productus lævicostus	×			×						2
Spirifer centronatus	×		×	×	×					4
Spirifer peculiaris?				×	(?)					2
Spiriferina solidirostris?	×		×	×		×				4
Seminula sp			×							1
Eumetria marcyi?			×	×						2
Camarotœchia metallica				×						1
PELECYPODA.										
Crenipecten hallanus				×						1
Myalina arkansasana?		×				×		×		3
Myalina keokuk				×						1
GASTEROPODA.										
Platyceras paralium?			×	×		×				3
Orthonychia formosa?				×						1
Straparollus utahensis			×							1
Bellerophon sp			×							1
TRILOBITA.										
Phillipsia peroccidens				×						1

[a] For a description of the localities indicated by number in this table see locality register, pp. 519–532.

This fauna is so closely similar to that from the Wasatch limestone of Utah and the Madison limestone of the Yellowstone National Park that detailed comparisons can well be omitted. A somewhat alien feature is the presence of *Myalina arkansasana?*. The identification is not certain, but the association of this form, thus imperfectly identified, with an early Mississippian fauna is reasonably sure. Though the age of the fossils from station 2385 is not entirely unassailable, yet the stratigraphic, together with the direct and indirect paleontologic evidence, raises it almost above suspicion. This form, to which it will be necessary to refer later, while possibly belonging to a somewhat distinct horizon, nevertheless forms a part of and is of the same geological age as the regular Ouray Mississippian fauna.

CRESTED BUTTE QUADRANGLE.

The fossils here considered were collected in connection with the areal work for the Anthracite-Crested Butte folio.[a] Ten local collections (stations 2350 to 2359) and 15 species constitute the available data. The local representation and distribution of species can be seen in the accompanying table.

TABLE II.[b]—*Table showing distribution of Mississippian species in the Leadville limestone of the Crested Butte district.*

	2350.	2351.	2352.	2353.	2354.	2355.	2356.	2357.	2358.	2359.	Total.
CŒLENTERATA.											
Zaphrentis tantilla	......	×	×	×	......	×	......	......	×	......	5
Zaphrentis ? sp. a	......	......	×	×	......	......	......	......	......	......	2
Syringopora aculeata	......	......	......	......	......	......	......	......	......	×	1
Syringopora surcularia	......	......	......	......	......	......	......	......	×	......	1
BRACHIOPODA.											
Rhipidomella pulchella	......	......	......	......	......	......	......	......	×	......	1
Orthothetes inæqualis	......	......	......	......	......	......	×	......	......	......	1
Productus semireticulatus var	......	......	......	......	×	......	......	......	......	......	1
Spirifer centronatus	×	......	×	......	×	×	×	×	......	......	6
Spirifer centronatus var	......	......	......	......	......	×	......	......	......	......	1
Spirifer peculiaris ?	......	......	......	......	......	......	......	......	×	......	1
Syringothyris carteri	......	......	......	......	......	......	......	......	×	......	1
GASTEROPODA.											
Straparollus luxus	......	......	×	......	......	×	......	×	......	......	3
Straparollus ophirensis	......	......	×	......	......	......	......	......	......	......	1
Loxonema ? sp	×	......	......	......	......	......	......	......	×	......	2
Bellerophon sp	×	......	......	......	......	......	......	......	......	......	1

The most diagnostic assemblage of species occurs at station 2358. The assignment of this fauna to a period in the Mississippian older than the Genevieve will hardly, I think, excite objection. The other local collections are less extensive and in general less diagnostic, but so far as they are significant indicate essentially the

[a] U. S. Geol. Surv., Geol. Atlas U. S., folio 9, 1894.

[b] For a description of the localities indicated by number in this table see locality register, pp. 519–532.

same geologic age and agree with the stratigraphic evidence which assigns them to the same formation. Taken as a whole, this fauna is closely related to that of the San Juan region, and like it is allied to the Waverly fauna of the Wasatch limestone and the Madison limestone. Nine of its fifteen species occur in the San Juan region, while the others are found associated with the San Juan species in other areas.

ASPEN DISTRICT.

The Aspen collections are very scanty. They were obtained from the Leadville limestone in that vicinity by Mr. Manuel and A. Lakes, and were originally examined by C. D. Walcott, whose identifications, quoted from Lakes's paper,[a] are as follows:

1. Syringopora sp. Turtleout Park, Aspen Mountain.
2. Zaphrentis sp. Turtleout Park, Aspen Mountain.
3. Sponges in oolitic limestone. Head of Keno Gulch, Aspen Mountain, above the "Grand Pacific" mine.
4. Pleurotomaria sp. Turtleout Park, Aspen.
5. Straparollus sp. Turtleout Park and Frying Pan.
6. Euomphalus sp. Frying Pan Creek, near Aspen.

The following table, based upon my own determinations, shows the local faunas and the specific distribution:

TABLE III[b].—*Table showing distribution of Mississippian species in the Leadville limestone of the Aspen district.*

	2362.	2363.	Total.
CŒLENTERATA.			
Zaphrentis ? sp. a	×	×	2
Syringopora aculeata		×	1
BRACHIOPODA.			
Productus cf. pustulosus	×		1
GASTEROPODA.			
Straparollus ophirensis		(?)	2
Straparollus utahensis	(?)		(?)
Loxonema ? sp			1

The geologic age of this fauna is not entirely apparent independently, though it contains suggestions of the Waverly faunas of the Wasatch Mountains and the Yellowstone National Park. As it occurs at the same horizon (in the Leadville limestone) as the more extensive faunas of the Crested Butte and San Juan areas, their evidence can safely be employed to supplement that which is intrinsic.

[a] Colorado State School of Mines, Bienn. Rept. for 1886, 1887, p. 60.

[b] For a description of the localities indicated by number in this table see locality register, pp. 519–532.

LEADVILLE REGION.

The material studied by me is that collected in the early eighties in the course of the areal work for the Leadville monograph.[a] Since that time no new collections have been made, though it is possible that the old ones have suffered in some slight degree from loss. The fossils under immediate consideration came from the Blue or Leadville limestone, which is eponymous of this region. It comprises ten species, from seven localities, a meager and unsatisfactory fauna. The fauna and its different local facies can be seen from the accompanying table:

TABLE IV.[b]—*Table showing distribution of Mississippian species in the Leadville limestone of the Leadville district.*

	2372.	2373.	2374.	2375.	2376.	2377.	2378.	Total.
CŒLENTERATA.								
Zaphrentis ? sp. b			×					1
BRACHIOPODA.								
Orthothetes inæqualis						?		(?)
Spirifer sp. a						×		1
Spirifer sp. b	×	×		×		×	×	5
Seminula subquadrata ?				×		×	×	3
Eumetria woosteri				(?)				(?)
PELECYPODA.								
Myalina arkansasana ?	×					×		2
Conocardium sp				×				1
GASTEROPODA.								
Straparollus cf. spergenensis			×		×			2

All of these collections are recorded as from the Blue or, as it has since been called, the Leadville limestone; and with slight exceptions the physical character of the matrix and the fossil faunas which they carry are correspondingly similar. "The only fossils obtained from this horizon were found in the extreme upper part of the formation, either in the limestone itself or in chert nodules, which are found scattered over its weathered surface."[c] This statement occurs in the Leadville monograph, and the following specific list, drawn up by R. P. Whitfield, is appended (page 66):

Euomphalus sp. cf. Eu. spergenensis.
Spiriferina sp., probably new, resembling Sp. kentuckyensis.
Athyris subtilita.
Pleurophorus oblongus.
Productus costatus.
Spirifera (Martinia) lineata.
Spirifera rockymontana.
Streptorhynchus crassus (crenistria).
Cyathophylloid corals, resembling Zaphrentis, or Cyathaxonia cynodon.

[a] Geology and mining industry of Leadville, Colo., by S. F. Emmons: U. S. Geol. Surv., Mon., vol. 12, 1886.
[b] For a description of the localities indicated by number in this table see locality register, pp. 519–532.
[c] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 66.

The differences between my list and that in the Leadville monograph must in part be charged to the element of personal equation in the matter of identification, in which the unfortunate condition of preservation in the present case allows unusual latitude, and in part probably to losses from the collection since the publication of the report. My table shows the present condition of the collection.

In a previous statement I had reference to the species *Productus costatus*, *Spirifera lineata*, and possibly also *Spirifera rockymontana*, which occur in the earlier list but not in mine, for of these species nothing has come to hand which would in any likelihood receive these identifications. My reasons for differing from the published identifications are in most cases given in the description of the species.

From the faunal list above quoted the conclusion was drawn that the Blue limestone is of Mississippian age. "While most of the forms are common to the Coal Measures of the East, the first mentioned is there found in the Lower Carboniferous. For this reason, and because this form and the *Spiriferina* do not occur in any of the higher beds, it seems justifiable to assume that this horizon represents the Lower Carboniferous of this district."[a] Although this conclusion is, I believe, a correct one, it hardly seems justified by the faunal list, which is composed chiefly of Upper Carboniferous species, even though there are present a form of *Euomphalus* like *Eu. spergenensis* and a new species of *Spiriferina* (which is said to resemble the Coal Measure *Sp. kentuckyensis*) not found in the beds below, unless, indeed, the term Lower Carboniferous is not employed as a division of the time scale equivalent to Mississippian, but simply indicates the lower part of the Carboniferous, an equivocal and altogether objectionable usage.

Of the general age of the Blue limestone as belonging to the Lower rather than to the Upper Carboniferous I have little doubt. The fact hinted at in the monograph, that there is a distinct faunal break (brought out more strongly in my lists than in the earlier ones) between the Blue limestone and the formation next above, is certainly significant. The presence of a retzioid of the type of *Eumetria verneuiliana* would, if the determination were based upon adequate material, be almost conclusive; but as it is, the value of this evidence is somewhat diminished. This occurrence, however, the absence of characteristic and common Upper Carboniferous species, the affinity and sometimes identity with Mississippian forms of such as are present, together with the stratigraphic and zoological relations of this fauna with other Mississippian faunas of Colorado, seem to me to be satisfactory evidence of its Mississippian age at least.

I will proceed to consider the fauna, species by species, in its bearing upon the age of the Blue limestone as Lower rather than Upper Carboniferous. *Orthothetes*? sp. more nearly resembles forms occurring in the lower portion of the Mississippian

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 66.

series than the familiar Pennsylvanian *Derbya crassa* or even the Neo-Mississippian forms. The *Seminula* present resembles the Chester form *S. subquadrata* more than *S. subtilita*, common in the Upper Carboniferous, but the evidence of the present material in its relation to both these species can only be regarded as slight. *Spirifer* sp. is of a type which is unknown in our Upper Carboniferous faunas, and one so rare that I am acquainted with but two others similar to it—*Spiriferina aciculifera* Rowley, which was found at the very base of the Mississippian series, viz, in the Louisiana limestone of the Chouteau group of Missouri, and *Spirifer schucherti* Rowley, found in the Lower Burlington limestone at Louisiana, Mo. Regarding *Eumetria?* sp., as previously stated, if this fossil could be definitely identified as *Eu. marcyi* or *Eu. altirostris*, the evidence thus afforded would be of considerable moment. As I personally regard the identity of this shell with one or other of the species mentioned as highly probable, I still attach importance to its presence in this fauna. *Myalina arkansasana?* seems to be more nearly allied to the Chester form than to any occurring in the Upper Carboniferous, not even excepting *Naiadites elongatus*. *Euomphalus* cf. *spergenensis* has its closest and indeed its only close allies in the Mississippian series, and I can recall no form in the Upper Carboniferous, and especially no common form, to which it could be referred. The other species of the Leadville have essentially no weight in the present discussion. The intrinsic evidence, therefore, is almost invariably in favor of referring the Leadville limestone to the Lower Carboniferous, and its cumulative force is considerable. But the age of the Leadville limestone at Leadville need not be, and indeed should not be, determined independently of the Carboniferous faunas of other areas.

Geographically and in the correspondence of geologic section the Paleozoic deposits at Leadville are closely related to those of Aspen. The fauna from the Leadville limestone at Leadville, however, is less similar to that of the Leadville limestone at Aspen or in the Crested Butte quadrangle than to that of the Paleozoic exposures of the Front Range. Indeed, only a single species, doubtfully identified, of those at Leadville occurs either at Aspen or in the Crested Butte quadrangle, and but two are found to be common to the Leadville and the San Juan, Crested Butte, and Aspen faunas. As I shall subsequently point out in detail, a much closer relation exists between the Leadville fauna and that of the Front Range Mississippian, and the faunas of this group are rather markedly different from those of central Colorado.[a] Neither can the age in the Mississippian of this typical Leadville fauna be considered apart from the evidence of the related faunas which I have yet to consider. Therefore the discussion of this point will be deferred to a somewhat later and more advantageous place.

[a] While these statements are true for the collections in hand, the latter are so scanty and presumably so imperfectly represent the whole fauna that they may not accurately express the real faunal relations.

SALIDA.

Only two Mississippian collections are present from Salida, and only four species are represented. The correlative force of this fauna, therefore, is very slight indeed. As, however, it was derived from the horizon of the Leadville limestone, and as all the species save one occur in the Crested Butte quadrangle, and that one, a *Seminula*, is similar to a species occurring in the Madison limestone, it will be safe to unite these localities with the Leadville limestone fauna. It should be remarked, however, that its affinities appear to be with the group of faunas obtained at Aspen and in the San Juan and Crested Butte areas rather than with the faunas of the typical Leadville limestone at Leadville, or those of the Front Range.

TABLE V.[a]—*Table showing distribution of Mississippian species in the Leadville limestone of Salida and the Monarch district.*

	2360.	2361.	Total.
CŒLENTERATA.			
Syringopora aculeata	×		1
Syringopora surcularia	×		1
BRACHIOPODA.			
Spirifer centronatus	×	×	2
Seminula claytoni		×	1

CANYON.

The fossils in this group are from the vicinity of Canyon, and were collected by T. W. Stanton. Part of the material came from the Harding's quarry locality, and were mentioned by C. D. Walcott,[b] being identified as *Spirifera rockymontana* and *Athyris subtilita*. In view of the geologic proximity of the localities and the identity of the faunas, these collections might appropriately have been considered with those collected by Whitman Cross from the Pikes Peak quadrangle. I have, however, kept them separate. The fauna, which is preserved in chert, comprises only six species, and was derived from two localities. The following table shows its distribution and local representation:

[a] For a description of the localities indicated by number in this table see locality register, pp. 519–532.
[b] Geol. Soc. Am., Bull., vol. 3, 1892, p. 157.

TABLE VI.[a]—*Table showing distribution of Mississippian species in the Millsap limestone in the vicinity of Canyon.*

	2366.	2370.	Total.
BRACHIOPODA.			
Orthothetes inæqualis	(?)		(?)
Spirifer centronatus	×	×	2
Spiriferina solidirostris ?	×		1
Cranæna subelliptica var. hardingensis	×	×	2
PELECYPODA.			
Myalina arkansasana ?	×		1
GASTEROPODA.			
Pleurotomaria ? sp. a	×		1

Considered by itself the age of this fauna is not very clear from the species collected, but so far as they go the indications are for the Mississippian epoch, and the lower part of it. This fauna is related to that of the Millsap limestone of the Pikes Peak quadrangle, to the Mississippian limestone of Perry Park, and also to the Leadville limestone of Leadville. It will be more satisfactory to consider the combined evidence from the faunas of all these areas than to review each separately.

PIKES PEAK QUADRANGLE.

The collections considered in this group were made by Whitman Cross in the course of stratigraphic work for the Pikes Peak folio. They came from the Millsap limestone at its exposures in Garden Park in the southern part of the quadrangle. The fauna, which consists of but four species from as many localities, is shown in the following table:

TABLE VII.[a]—*Table showing distribution of Mississippian species in the Millsap limestone in Garden Park in the Pikes Peak quadrangle.*

	2365.	2368.	2369.	2371.	Total.
BRACHIOPODA.					
Spirifer centronatus				×	1
Spiriferina solidirostris ?				×	1
Cranæna subelliptica var. hardingensis	×	×		×	3
PELECYPODA.					
Myalina arkansasana ?				×	1

In its geographic and faunal relations the localities in the Pikes Peak quadrangle are essentially the same as those from near Canyon, and the same comments that were offered there apply here also.

[a] For a description of the localities indicated by number in this table see locality register, pp. 519–532.

PERRY PARK.

Only two collections from Perry Park have come to hand. One of these was made by Whitman Cross, the other was examined through the courtesy of W. T. Lee. The following table shows the distribution and faunas by localities:

TABLE VIII.[a]—*Table showing distribution of Mississippian species in the Millsap limestone in Perry Park.*

	2367.	2389.	Total.
BRACHIOPODA.			
Orthothetes inæqualis	(?)		(?)
Spirifer centronatus	×		1
Spirifer sp. b	×		1
Spiriferina solidirostris?	×	×	2
Seminula subquadrata?	(?)		(?)
Cranæna subelliptica var. hardingensis	×	×	2
PELECYPODA.			
Myalina arkansasana?	×		1
Streblopteria media		×	1
CRUSTACEA.			
Leperditia sp		×	1
Beyrichia sp		×	1

Though all too scanty, the faunal evidence indicates the closest relation as existing between the Perry Park outcrops and those about Garden Park and Canyon. Every species but one of those found at the latter locality appears also at the former. The relation of these faunas with those found at Leadville and the other Colorado areas will be discussed after considering the last somewhat peculiar collection of Mississippian forms.

LARIMER COUNTY.

This fauna is based upon impressions made from casts of shells contained in some pebbles in the conglomerate[b] occurring 32 miles west and 18 miles north of Greeley, Colo. The collection was made by Prof. L. C. Wooster some time prior to July, 1880. The locality (station 2364) is in Larimer County, east of the Front Range, apparently near the point at which the Cache la Poudre River debouches from the mountains, or possibly somewhat north of that stream. The horizon is probably that of the Red Beds. Among the impressions obtained in the manner described is that upon which White based the species *Eumetria woosteri*. Associ-

[a] For a description of the localities indicated by number in this table see locality register, pp. 519–532.

[b] Cannon, writing in 1892 (Colorado Sci. Soc., Proc., vol. 4, pp. 224–234), describes the occurrence of Carboniferous fossils in loose chert bowlders widely distributed along the Front Range. The character of the rock and the circumstance that no fossiliferous Carboniferous strata, except the Millsap limestone, are known along the eastern flank of the range, save in the Sangre de Cristo Mountains and near the Wyoming line, make it probable that this formation was their source. The occurrence in this case is similar to that which furnished the fossils described by White, except that the latter were found in an ancient conglomerate and these in recent gravels, which, however, may possibly be partially formed from the destruction of the conglomerate.

ated with this species White cited *Spirifer rockymontanus* Marcou, *Spiriferina octoplicata* Sow., *Spirigera subtilita* Hall, *Hemipronites crenistria* Phillips, and *Axophyllum rudis* White and St. John, and he refers the whole to the age of the Coal Measures.[b] The list of species identified by me is as follows:

COELENTERATA.

Zaphrentis? sp. c.

BRACHIOPODA.

Orthothetes inæqualis.
Spirifer centronatus.
Spirifer sp. b.
Seminula humilis?
Eumetria woosteri.

GASTEROPODA.

Pleurotomaria? sp. b.

With material which is not only scanty but preserved in the fashion that this is, the same precision is not attainable as in more abundant normal examples, and it will be noticed that I have departed from White's identifications in many instances. My reasons for doing so are stated in the description of species in each case. Considered apart from the form described as *Eumetria woosteri*, the evidence is not conclusive; but the absence of characteristic Coal Measure forms and the presence of such as *Spirifer centronatus* and *Seminula humilis* directs a decision favorable to the Lower Carboniferous age of the fauna.

Eumetria woosteri, although its generic position on internal and strictly generic characters can not be ascertained, is a form to which nothing similar has yet been recorded from Upper Carboniferous strata, but which is very closely allied to several species occurring some in the Kinderhook and others in the St. Louis and Chester divisions of the Lower Carboniferous, and forming together a group of shells peculiarly Mississippian in expression. It may be that subsequent discoveries will enlarge the range of *Eumetria* and the other types involved, but at present at least the evidence, coincident in every species, indicates the Lower Carboniferous age of this fauna. I think, too, that the age indicated is basal Lower Carboniferous. *Eumetria woosteri* appears to be on the whole more closely related to the Kinderhook than to the Chester species of *Eumetria*, and I am disposed to believe that it will prove a synonym of *Eumetria altirostris*. Strands of evidence more or less tenuous proceeding from the species *Orthothetes inæqualis?*, *Spirifer centronatus*, and *Seminula humilis* all tend to the same conclusion, and justify the provisional reference of this fauna to a position somewhere in the Kinderhook or the Osage division of the Mississippian. Most of the species which I have identified are found also in the Millsap limestone farther south or in the Leadville limestone at Leadville. It seems very likely, therefore, that the rock from which these impressions were made was derived from the same horizon that furnished the fossils from those localities. The sharpness of the detail of the impressions and their nature as such even suggests

[b] U. S. Geol. Geog. Surv. Terr., Cont. to Pal., Nos. 2-8, author's edition, July, 1880, p. 134.

that the original bowlders were siliceous or cherty, in which material all our fossils belonging to the faunas mentioned are preserved.

SUMMARY.

The Lower Carboniferous faunas of Colorado can be separated on intrinsic evidence into two groups, the first of which embraces those from the Ouray limestone of the San Juan region and the Leadville limestone of the Crested Butte, Aspen, and Salida localities; the other embraces those from the Leadville limestone at Leadville, the Millsap limestone of Canyon, Garden Park, and Perry Park, and the Red Beds conglomerates near the northern border of the State. Where small collections are made at different points from a large and varied fauna it would follow that comparatively few species would be common to any two of them. This seems true, both as to condition and result, of our Mississippian collections from Colorado. On the whole, however, both groups of faunas show considerable homogeneity. The chief question is how far they are distinct from each other. The fauna of the San Juan and Crested Butte collections is clearly that which has several times been described from the Wasatch limestone of Utah and the Madison limestone of the Yellowstone Park and Montana. It occurs also in the Chouteau limestone of Missouri and the Waverly group (Cuyahoga shale) of Ohio, and its geological age is probably chiefly upper Kinderhook and lower Burlington. It may at least safely be asserted that it is older than the Genevieve period. The fauna of the other group of localities has a more unusual facies. Considering the meager character of the collections, this fauna is rather unusually homogeneous. The faunas from Garden Park and Canyon are practically identical. Five of the eleven species found at Perry Park occur also in Garden Park, and these five include the abundant species. Four of the seven species from the Red Beds conglomerate occur at Perry Park or at Garden Park. Five of the nine species found at Leadville were obtained in the Front Range beds, and only two occur in the far more abundant faunas of the San Juan and Crested Butte regions. At the same time, though the Leadville fauna is much more similar to those of the Front Range than to those of central and southwestern Colorado, there are certain well-marked peculiarities, as, for instance, the abundance along the Front Range of *Cranæna subelliptica* var. *hardingensis*, which is not known at Leadville. The Front Range group of faunas, therefore (including Leadville), is rather peculiar—to what extent may be gathered from the fact that from a total of nineteen species but four occur in the San Juan and Crested Butte group, the resemblance being especially with the faunas of the San Juan region. The fossils at Canyon, Garden Park, and Perry Park occur in cherty bands or nodules, bright red on the outer surface, but whitish, purplish, or buff within. From their occurrence and preservation there is reason to believe that the impressions from Larimer County were made from cherty bowlders. Most of the Leadville fossils occur in siliceous segregations of nearly black color, while many of those from the San Juan region are inclosed in cherts of a nearly white tint. Thus the collections having this rather puzzling facies are characterized by their cherty matrix. While the fauna of the San Juan, Crested Butte, and other areas occurs at a number of points both north, east, south, and west of central Colorado, I do not recall the Front Range association of species from any other point. It is the grouping of these species rather than the species themselves that is novel. Considered individually, each member of this fauna is found elsewhere or has close allies, especially in the early Mississippian. *Orthothetes inequalis*, *Spirifer centronatus*, *Spiriferina solidirostris*, *Seminula humilis*, and *Streblopteria media* are found in the Waverly faunas. The nearest allies of *Spirifer* sp. *b* occur the one at the very base of the Kinderhook, the other at the base of the Burlington in the Mississippi Valley. *Cranæna subelliptica* var. *hardingensis* is allied to upper Devonian and Waverly forms. *Eumetria woosteri* might be either lower or upper Mississippian. *Straparollus* cf. *spergenensis* and *Seminula subquadrata?* are Genevieve species, but have allied forms in the early Mississippian. On the whole, I should estimate the horizon of this fauna as in the Eo- or Meso-Mississippian, not far, in fact, from that of the other group. The geologic evidence tends unmistakably to the same conclusion. The identity of the Leadville limestone of Leadville with beds at Aspen and in the Crested Butte quadrangle has been rather generally asserted by geologists than doubted by anyone, yet the fauna of the typical Leadville limestone is distinctly unlike that of the Crested Butte quadrangle. Its fauna allies it closely with that of the Millsap limestone. The faunas of the Millsap limestone along the Front Range are correlated with that of the Leadville limestone at Leadville by paleontologic evidence. The latter is correlated with those of the Leadville limestone at Aspen and in the Crested Butte quadrangle by stratigraphic evidence, and these again with the Ouray limestone of Colorado by paleontologic evidence. The two groups of Mississippian faunas of Colorado, both by stratigraphy and paleontology, are placed at about the same horizon. Their difference in facies is partly due to the incompleteness of our collections, but partly to the selection of local environment, which was possibly somehow connected with cherty segregation. Most authors have considered central Colorado to have been the site of a number of large islands occupying the position of the present Archean mountain masses. One asks the question whether the peculiarities of the faunas at Leadville and the Front Range are connected with these conditions. This is possibly the case. But it should be borne in mind that this fauna is a marine one, so that its habitat could hardly have been a landlocked basin. Besides which, all the species found occur elsewhere themselves or have closely allied forms. The physical condition could not have been in the nature of a barrier, for the faunas of the Elk and San Juan Mountains are found to the north, south, and east of this area. So far as

I can see, the peculiarities of the Leadville and Front Range facies indicate merely contemporaneous variation in local marine conditions, or slight difference in geologic age. They have absolutely no necessary bearing upon the question of land and water areas in Colorado during their deposition, but from the persistent lithologic character of this horizon as a nearly pure limestone we may infer that land areas of any size could not have been near at hand.

TABLE IX.—*Summary table for comparing the distribution of Mississippian species in the San Juan, Salida, Crested Butte, Aspen, Leadville, Perry Park, Pikes Peak, Canyon, and Larimer County areas.*

	San Juan.	Salida.	Crested Butte.	Aspen.	Leadville.	Perry Park.	Pikes Peak.	Canyon.	Larimer County.
CŒLENTERATA.									
Zaphrentis tantilla	2		5						
Zaphrentis ? sp. a	2		2	2					
Zaphrentis ? sp. b					1				
Zaphrentis ? sp. c									1
Menophyllum ulrichanum	5								
Syringopora aculeata			1	1					
Syringopora surcularia	1		1						
ECHINODERMATA.									
Rhodocrinus sp	1								
Platycrinus sp	2								
BRYOZOA.									
Fenestella serratula ?	2								
Fenestella cf. filistriata	1								
Fenestella sp	2								
Batostomella sp	1								
Fistulipora ? sp	1								
BRACHIOPODA.									
Rhipidomella pulchella	4		1						
Orthothetes inæqualis	4		1		(?)	1		(?)	(?)
Chonetes illinoisensis	2								
Productella concentrica	1								
Productus semireticulatus var	4		1						
Productus parviformis	1								
Productus cf. pustulosus				1					
Productus lævicostus	2								
Spirifer centronatus	4		6			1	4	2	1
Spirifer centronatus var			1						
Spirifer peculiaris ?	2		1						
Spirifer sp a					1				
Spirifer sp b					5	1			1
Syringothyris carteri			1						
Spiriferina solidirostris ?	4					2	1	1	
Seminula claytoni									
Seminula subquadrata ?					3	(?)			
Seminula humilis ?									1
Seminula sp	1								
Cranæna subelliptica var. hardingensis						2	3	2	
Eumetria woosteri					(?)				1
Eumetria marcyi ?	2								
Camarotœchia metallica	1								

TABLE IX.—*Summary table for comparing the distribution of Mississippian species in the San Juan, Salida, Crested Butte, Aspen, Leadville, Perry Park, Pikes Peak, Canyon, and Larimer County areas*—Cont'd.

	San Juan.	Salida.	Crested Butte.	Aspen.	Lead-ville.	Perry Park.	Pikes Peak.	Can-yon.	Larimer County.
PELECYPODA.									
Crenipecten hallanus	1								
Streblopteria media						1			
Myalina arkansasana ?	3				2	1	1	1	
Myalina keokuk	1								
Conocardium sp					1				
GASTEROPODA.									
Platyceras paralium ?	3								
Orthonychia formosa ?	1								
Straparollus luxus			3						
Straparollus ophirensis			2	2					
Straparollus utahensis	1			(?)					
Straparollus cf. spergenensis					2				
Loxonema ? sp			2	1					
Pleurotomaria ? sp. a						1			
Pleurotomaria ? sp. b								1	1
Bellerophon sp	1		1						
CRUSTACEA.									
Phillipsia peroccidens	1								
Leperditia sp						1			
Beyrichia sp						1			

PENNSYLVANIAN.

Very far the larger portion of our collections from Colorado belong to the Upper Carboniferous. They come mainly from three distinct and separate areas—from the San Juan area, from the Crested Butte quadrangle and its vicinity, and from Leadville and its adjoining district—but we have a few fossils from all the Upper Carboniferous areas of Colorado except the Front and Sangre de Cristo ranges.

UINTA MOUNTAIN REGION.

About the paleontology of the Uinta Mountains in Colorado very little can be said. The large faunas cited in Powell's Geology of the Uinta Mountains [a] came from beyond the borders of the State, in Utah, though the same horizons, characterized by the same faunas, doubtless extend to the eastern end of the range. The faunas identified by White, however, are different from any of the formational faunas known in Colorado. We have collections from but three stations in the Uinta Mountain area in Colorado, and the faunas in each case are so scanty as to be without weight in the matter of correlation. The species collected are as follows:

Euphemus subpapillosus is from near the South Fork of the Vermilion and near the east base of Diamond Peak, Colorado (station 2189). These fossils were not found

[a] U. S. Geol. Geog. Surv. Terr., Powell's Rept. Geology Uinta Mountains, 1876.

in place, and occur in the form of internal casts. Their probable horizon is the Bellerophon limestone, at the top of the Upper Aubrey group. The identification is by C. A. White, who refers to the specimens on page 92 of Powell's Uinta Mountains volume.

Lophophyllum profundum and *Rhombopora lepidodendroides* are from station 2191, overlooking Yampa River. The locality of this collection is not very definite, and the horizon is unknown, but without much doubt is lower than the Bellerophon limestone, almost certainly somewhere in King's Upper Coal Measure series. I can not find that these fossils have ever been referred to in literature.

Prismopora triangulata and *Spiriferina kentuckyensis* are from Yampa Plateau, northwestern Colorado (station 2330). The identification of *Prismopora triangulata* is that of C. A. White, who figured this specimen in 1880.[a] I can not find that this occurrence has been elsewhere mentioned. His figures, somewhat enlarged, are reproduced on Pl. I of the present volume. He states that the horizon is the middle division of the Carboniferous series, which he correlates with the Lower Aubrey group. Unless I am mistaken in supposing the Uinta sandstone to represent the Maroon formation, this horizon is not that called Middle-Carboniferous by the other Hayden geologists, but is considerably higher. These fossils are inadequate not only to indicate more than the Upper Carboniferous age of the rocks furnishing them, but also to supply a means of correlation with other sections in Colorado.

GRAND RIVER REGION.

We have Carboniferous collections from a number of points in the Grand River region of Colorado, but they are in most cases quite scanty. The most complete collections are those made at Glenwood Springs, but, unfortunately, few of these can be satisfactorily located in the standard geologic section. It is probable that they came from the Weber limestone or its equivalent. Our collections are 7 in number, and contain a fauna of 25 species. The distribution of this fauna by localities can be seen in the accompanying table:

[a] U. S. Geol. Geog. Surv. Terr., Cont. to Pal. (author's edition), 1880, p. 131, pl. 33, figs. 3a–3e.

TABLE X.[a]—*Table showing distribution of Pennsylvanian species in the vicinity of Glenwood Springs.*

	2193.	2193a.	2326.	2329.	2329a.	2329b.	Total.
CŒLENTERATA.							
Lophophyllum profundum						(?)	(?)
HELMINTHA.							
Spirorbis sp	×						1
BRYOZOA.							
Rhombopora lepidodendroides						×	1
BRACHIOPODA.							
Lingula sp		×					1
Orbiculoidea sp		×					1
Rhipidomella pecosi						×	1
Orthotichia schuchertensis		×					1
Derbya crassa		×					1
Chonetes flemingi		×	×			×	3
Chonetes geinitzianus						×	1
Productus inflatus		×					1
Marginifera ingrata		×					1
Marginifera muricata			×				1
Spirifer cameratus					×	×	2
Spiriferina kentuckyensis						×	1
Seminula subtilita		×		×			2
Cleiothyris orbicularis		×					1
GASTEROPODA.							
Aclisina stevensiana?	×						1
Loxonema parvum?	×						1
Strophostylus cf. nanus	×						1
Soleniscus cf. paludiniformis	×						1
Pleurotomaria? cf. carbonaria	×						1
Worthenia? sp. b	×						1
Phanerotrema sp	×						1
CRUSTACEA.							
Beyrichia sp	×						1

Stations 2326, 2329, and 2329a can safely be referred to the Weber formation,[b] since they occur from 100 to 200 feet above the Leadville limestone. Unluckily, these are the most restricted in the number of species of the entire collection, but they show the Pennsylvanian age of this horizon, and, as far as they go, agree with the fauna of the Weber formation found elsewhere. The faunas of 2193a and 2329b also agree fairly well with the Weber fauna, and perhaps represent that horizon. The collection from 2193a is of interest in that it supplied the specimens of *Orthotichia schuchertensis*, the first instance of the occurrence of *Orthotichia* in North America, unless *Orthis resupinoides* Cox is incorrectly referred to *Schizophoria*. The fauna from 2193 is also an interesting one. It consists chiefly of very small gasteropods not found in the other collections at this locality, or indeed elsewhere in

[a] For a description of the localities indicated by number in this table, see locality register, pp. 519-532.

[b] As the Weber is defined in the Crested Butte folio; this is the Weber shale or base of the Weber formation of the Tenmile and Leadville districts.

Colorado. However, possibly the same species occur in the unidentifiable forms preserved as internal casts in chert, which I have cited simply as minute gastropods in the lists from the Leadville, San Juan, and Crested Butte areas. These shells are all of extremely small dimensions, a circumstance which, taken with their not very perfect preservation, has made their specific identification difficult and uncertain.

Into this geographic division also probably fall four collections made near the junction of the Grand and Eagle rivers. Station 2190 is on Grand River, 1 mile below Eagle River. Here was obtained only *Conularia crustula ?*. I can find no reference to this collection in published reports, and its horizon is not known. Probably this material was collected by Marvine, whose report upon the Grand River region, owing to his death, was never published.

From station 2192 we have only *Pleurophorus angulatus ?*. This locality, which could not have been far from station 2190, is described on pages 242 and 243 of the Hayden annual report for 1873,[a] and the fossils were collected from bed No. 12 of the section. The horizon seems to be near the top of the Weber shales, or just at the base of the Maroon formation. The other fossils mentioned besides the *Pleurophorus* have not come to hand.

Of station 2325 all that is known is that it is located on Grand River in northwestern Colorado. The description of station 2324 is still less exact, the label reading "Ranch west of Camp 59." The latter collection appears to have been made by Marvine, and the fossils probably were not included in any published report.

From station 2324 we have *Chonetes mesolobus*, *Chonetes flemingi*, *Marginifera haydenensis*, *Marginifera muricata*, *Spirifer cameratus*, and *Seminula subtilita*. From station 2325 appears only *Marginifera haydenensis*. The latter species is not found elsewhere in Colorado, save only at station 2324, and the preservation is so exactly alike in the two lots as to arouse the suspicion that they are really parts of the same original collection. In point of preservation these fossils, which are weathered free and more or less covered with a reddish coating, are different from any of our Colorado material, and I suspect that the labels may be wrong, and that they may not have come from Colorado at all.

Really the scanty collections from stations 2288 and 2289, together with the few collections made in connection with the stratigraphic work of the Leadville monograph and the Tenmile folio, should be considered here; but I find it more advantageous to include them in the discussion of the Leadville fossils. From station 2288 we have only *Spirifer rockymontanus*, and from station 2289 only *Spirifer rockymontanus* and *Spirifer boonensis ?*. With this scanty and unsatisfactory collection the paleontologic evidence from the Grand River region concludes.

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[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874.

ELK MOUNTAIN REGION.

The Crested Butte quadrangle is that whose northwestern corner is made by the intersection of the one hundred and seventh meridian and the thirty-ninth parallel. It is a 15-minute quadrangle. The areal geology, which forms part of the subject-matter of the Anthracite-Crested Butte folio,[a] was surveyed by G. H. Eldridge, by whom most of the collections studied were made. Two Upper Carboniferous formations are recognized in the Anthracite-Crested Butte folio. The lower one is called the Weber formation and the other the Maroon conglomerate. The Weber formation consists of shales and thin limestones, and varies in thickness from 100 to 550 feet. The Maroon conglomerate measures 4,500 feet, and is subdivided into two portions. The lower division, which is 2,000 feet thick, is derived from the waste of older sedimentary deposits; the upper, which contains 2,500 feet, is largely derived from the waste of granites. Both series contain thin limestone beds.

Thirty-three collections in all were obtained from the Upper Carboniferous beds of the Elk Mountain region, and thirty of these were made in connection with the areal work of the Anthracite-Crested Butte folio. These are from stations 2290–2300, 2302–2308, 2310–2321. The following stations occur in the Weber limestone: 2307, 2308, 2312–2316, and 2320. The remainder occur in the lower portion of the Maroon conglomerate, though the position of 2302 and 2303 is not quite certain. No fauna is at present known from the upper Maroon. The fossils from 2306, however, can not properly be included with the Maroon fauna, since they were derived from pebbles in one of the Maroon conglomerates where their presence is only secondary. In the accompanying table the local faunas are set down, and in the two final columns the composite faunas of the Weber formation and of the lower portion of the Maroon conglomerate.

[a] U. S. Geol. Surv., Geol. Atlas U. S., folio 9, 1894.

TABLE XI.[a]—*Table showing the distribution of Pennsylvanian species in the Crested Butte district, and their range, so far as known, in the Weber limestone and lower portion of the Maroon formation.*

	2244	2245	2280	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2302	2303	2304	2305	2306
PROTOZOA.																			
Fusulina cylindrica																			
CŒLENTERATA.																			
Lophophyllum profundum													(?)						
Campophyllum torquium					×							×							
Chætetes milleporaceus				×															
Cladopora sp																			
Monilipora prosseri				×												×			
BRYOZOA.																			
Prismopora serrata		×																	
BRACHIOPODA.																			
Derbya crassa																			
Chonetes flemingi																			
Chonetes mesolobus																			
Productus semireticulatus var. hermosanus																			
Productus gallatinensis																			
Productus cora																			
Marginifera muricata																			
Marginifera wabashensis var																			
Spirifer boonensis ?		?																	
Spirifer rockymontanus																			
Spirifer cameratus																			
Squamularia perplexa																			
Spiriferina kentuckyensis																			
Seminula subtilita																			
Hustedia mormoni																			
Pugnax utah																			
Dielasma bovidens																			
PELECYPODA.																			
Aviculopecten ? interlineatus																			
SCAPHAPODA.																			
Dentalium sublæve																			
GASTEROPODA.																			
Euomphalus catilloides																			
Bellerophon crassus																			
Minute gasteropods																			
CRUSTACEA.																			
Phillipsia trinucleata											(?)								

[a] For a description of the localities indicated by number in this table see locality register, pp. 519–532.

TABLE XI.—*Table showing the distribution of Pennsylvanian species in the Crested Butte district, and their range, so far as known, in the Weber limestone and lower portion of the Maroon formation*—Continued.

	2307	2308	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	Weber limestone.	Maroon formation.
PROTOZOA.																
Fusulina cylindrica														×	1	4
Fusulina cylindrica var. ventricosa?					×										1	
CŒLENTERATA.																
Lophophyllum profundum												×				3
Zaphrentis gibsoni					×										1	
Campophyllum torquium					×										1	2
Amplexus sp									×						1	
Chætetes milleporaceus																1
Cladopora sp																1
Monilipora prosseri																2
ECHINODERMATA.																
Archæocidaris cratis															1	
Eocidaris halliana?													×		1	
HELMINTHA.																
Spirorbis arietina																2
Enchostoma sp															1	
BRYOZOA.																
Stenopora tuberculata					×										1	
BRACHIOPODA.																
Derbya crassa	×												×		2	3
Chonetes flemingi						×		×							2	1
Chonetes mesolobus																2
Productus semireticulatus var. hermosanus																5
Productus inflatus															1	
Productus cora						×				×					1	3
Marginifera lasallensis?									(?)						1	
Marginifera muricata									×		×				1	5
Marginifera wabashensis var									×						1	2
Marginifera ingrata					×			×							2	
Spirifer rockymontanus															2	
Spirifer cameratus																3
Squamularia perplexa															1	9
Spiriferina campestris															1	
Spiriferina kentuckyensis																1
Seminula subtilita																10
Hustedia mormoni																3
Pugnax utah																2
Dielasma bovidens																1
PELECYPODA.																
Aviculopecten occidentalis										(?)						(?)
Aviculopecten? interlineatus																1
Myalina cuneiformis															1	
SCAPHAPODA.																
Dentalium sublæve																1
GASTEROPODA.																
Euomphalus catilloides																1
Bellerophon crassus																1
Minute gasteropods																2
CRUSTACEA.																
Phillipsia trinucleata																(?)

The fauna of the Weber formation, with its Fusulinas and other species, is clearly of Upper Carboniferous age. Without a sharp break between the upper and lower faunas there is yet a certain distinct lack of agreement. The Weber formation has a total of 21 species and the Maroon a total of 28 species, yet they have only 8 species in common. The same facts can be expressed in a different and somewhat less relative manner. The two formations have a combined fauna of 41 different species. Of these, 8 are common, and 33 peculiar to one formation or the other. The fraction $\frac{8}{41}$, or the percentage 19.51, may be taken as expressing in a general way the degree of affinity of the two faunas. This, however, fails in accuracy, for in the case of species common to both formations no account is taken of instances of 8 and 5 occurrences in one, balanced by only 1 in the other. Such faunal peculiarities as exist are brought out so clearly by the table that it seems hardly necessary to indicate them here. It may be remarked, however, that the echinoids are not present in the Maroon conglomerate, nor any of the Mollusca, save only 1 species, in the Weber limestone, and that *Productus inflatus*, *Marginifera lasallensis?*, *M. ingrata*, *Spirifer rockymontanus*, and *Spiriferina campestris* are nearly or quite peculiar to the Weber, and *Chonetes mesolobus*, *Productus semireticulatus* var. *hermosanus*, *P. cora*, *Marginifera muricata*, *Spirifer cameratus*, *Squamularia perplexa*, *Spiriferina kentuckyensis*, *Seminula subtilita*, *Hustedia mormoni*, and *Pugnax utah* to the Maroon.

In working over these collections my attention was attracted to the circumstance that the large *Producti* and the smaller species, chiefly belonging to the genus *Marginifera*, seldom appeared in the same local assemblage. In some instances, however, the *Marginiferae* and the large *Producti* do so occur, and in the case of stations 2312 and 2313 the two types were found stratigraphically within 10 feet of each other. The selective agency, therefore, whether stratigraphic or environmental, was not unvarying in its action.

Mention is made in the Anthracite-Crested Butte folio of the occurrence of Upper Carboniferous fossils in pebbles of the Maroon conglomerates. The collection from station 2306 seems to be an instance of this. The fauna consists of *Chætetes milleporaceus*, *Productus cora*, *Marginifera wabashensis* var., *Squamularia perplexa*, *Seminula subtilita*, and *Hustedia mormoni*, and it is surprising to note that its affinities are distinctly with the other indigenous faunas of the Maroon, and not with those of the Weber formation or of the Leadville limestone.

Collections from three stations not made in connection with the areal work of the Crested Butte quadrangle are included in the table. These are stations 2244, 2245, and 2280. The collection from station 2244, which is on Rock Creek, was made by J. J. Stevenson, and probably is from the horizon of bed No. 1 in his Rock Creek section.[a] A considerable fauna is cited by Stevenson as occurring in this bed,

[a] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., Vol. III, p. 362.

only two species of which, however, remain. The stratigraphic horizon appears to be in the Maroon conglomerate, and the fauna mentioned by Stevenson agrees rather with that of the lower member of the Maroon than with the Weber. But, as I have already pointed out in the stratigraphic division of my report, the occurrence in the middle of Stevenson's section of duplicated Cretaceous beds inspires a doubt as to the mutual relations of the rest of the section.

The material from station 2245 appears to have been collected by W. H. Holmes, but there is evidently a mistake in the locality given in the National Museum Register, and I can find no published section with which it is connected. The locality, though uncertain, is with great probability in the Elk Mountains. The evidence of the fauna would tend to place the horizon of this collection in the Maroon conglomerate.

Station 2280 is in the section made by Peale at a point southeast of Italian Peak, described on page 251 of the [Seventh] Annual Report of the United States Geological and Geographical Survey of Territories for 1873, 1874. The collection, which includes six species, comes from bed No. 11 of the section, and Peale cites the same forms under different but synonymous names. The stratigraphic horizon is clearly in the Maroon series, and the fauna also agrees with that of the lower Maroon. In the final columns of the table, which show the composite faunas of the Weber and Maroon formations, stations 2244 and 2280 but not 2245 are included.

SOUTH PARK AREA.

Just as in the Elk Mountain region practically all the collections studied came from a limited area, that of the Crested Butte quadrangle, so in the South Park region all the fossils examined were obtained in its northern portion, the Leadville district.

The localities represented in the accompanying table are 31 in number, and are chiefly in the Tenmile and Leadville districts. The Tenmile district lies between meridians 106° 8′ and 106° 16′ 8″ W., and parallels 39° 22′ 57″ and 39° 30′ 25″ N. It does not strictly form a part of the South Park region. The area of the Leadville district is somewhat less precise, but includes the mineral-bearing tract near Leadville, in the northern part of the Mosquito Range.

The geology of the Tenmile district is described in the Tenmile folio[a] and that of the Leadville district in the Leadville monograph.[b] The areas of the Tenmile and Leadville districts are geographically almost continuous. The same rocks occur in both, and the geology of both was described by S. F. Emmons. It has therefore seemed to me best to consider the faunas of both areas in the same place.

[a] U. S. Geol. Surv., Geol. Atlas U. S., folio 48, 1898.
[b] U. S. Geol. Surv., Mon., vol. 12, 1886.

The same formations occur in both areas, as I have already said, but the nomenclature adopted in the Tenmile folio differs from that of the Leadville monograph, which preceded it by twelve years. The Upper Carboniferous formations of the Leadville monograph are called the Weber shales, the Weber grits, and the Upper Coal Measures. In the Tenmile folio these are called the Weber shales, the Weber grits, and the Maroon formation. In fact, the Weber shales and Weber grits are united as the Weber formation. Above the Weber grits a third formation is discriminated as the Wyoming formation, whose age may be Carboniferous, but is not definitely known. In addition to this, two of the limestones included in the sandstones and conglomerates of the Weber and Maroon formations proved of sufficient local importance to receive distinct names. The Robinson limestone below and the Jacque Mountain limestone above are assigned as the bounding beds of the Maroon formation. It will be noticed that the geologic sequence here is similar to that in the Crested Butte quadrangle, but though the same names have been employed in some cases, and apparently the same formations differentiated, the names are used in a somewhat different sense, a course which is to be deprecated as very confusing.

For the lowest Pennsylvanian horizon in the Leadville and Tenmile districts the name Weber shale has been adopted, as I have already said. The formation in this area has a thickness of about 300 feet, and consists of calcareous and argillaceous shales alternating with quartzitic sandstone. The Weber grits have an average thickness of 2,500 feet, and consist of sandstones and conglomerates, with a few thin shales and dolomitic limestones. The source of this material is said to be the Archean. The Maroon formation is similar to the Weber grits in constitution, but contains a larger proportion of shales and limestones. The latter are nonmagnesian. Its limits are taken as the Robinson limestone below and the Jacque Mountain limestone above, and its thickness 1,500 feet. The Wyoming formation consists of brick-red sandstones 1,500 feet in thickness. No fossils are known from it.

Twenty-eight collections were obtained in the Leadville and Tenmile districts in connection with the work for the Tenmile folio and Leadville monograph. These are stations 2250–2277, inclusive, of which 2260, 2261, 2272, 2273, 2274, 2275, and 2276 are from the Tenmile district, the rest from the Leadville district. Stratigraphically these have been distinguished as lower, middle, and upper Weber, Robinson limestone, and Maroon formation. The lower Weber corresponds to the Weber shale of the two reports above mentioned, the middle and upper Weber to the Weber grits formation. The Robinson limestone forms the division between the Weber grits and the Maroon formation. The Maroon is, in a general way, the same as the Upper Coal Measures of the Leadville monograph and the upper division of the Maroon of the Crested Butte folio, the lower division of the Maroon finding its equivalent in the Weber grits of the Leadville and Tenmile districts. To the Weber shales belong collections from stations 2250, 2251, 2252, 2253, 2257?, 2258, 2264, 2267, and 2277; to the middle Weber those from stations 2262, 2263; to the upper Weber stations 2269, 2272, 2275, and 2276; to the Robinson limestone stations 2260, 2261, 2273, and 2274; and to the base of the Maroon formation station 2270. Stations 2254, 2255?, 2259?, 2265, 2266, and 2268 are referred merely to the Weber, and the horizon of 2256 and 2271 was not definitely determined. Of these, all the collections from the Robinson limestone and all but one from the upper Weber are derived from the Tenmile district, from which we have no collections representing either the lower or the middle Weber.

Most of this material was studied by R. P. Whitfield, who made the paleontological determinations for the Leadville monograph. It has all been reworked and the identifications brought into harmony with those of the other Colorado collections. I have agreed with the identifications recorded in the Leadville monograph in some cases, but in others have ventured to depart from them. It would hardly be profitable, especially since I am in accord with Whitfield's determinations of the ages of the different formations, to make a comparison of the two series of faunal lists further than this, adding that some of the material appears to have been lost since it was originally studied. In addition to what appear to be losses from the collection, many of the local lots have been thrown together, so that frequently a number of different locality labels were found accompanying a single set of specimens. It was of course impossible to separate these into their original groups, and no attempt was made to do so. In the following table are included not only the species collected during the field work for the Leadville monograph and Tenmile folio, but also those from two other stations in the same neighborhood, 2281 and 2288, both of which are believed to belong in the Weber shale:

TABLE XII.[a]—*Table showing distribution of Pennsylvanian species in the Leadville and Tenmile districts, and their range in the lower, middle, and upper Weber formation, Robinson limestone, and Maroon formation.*

	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269
ECHINODERMATA.																				
Archæocidaris cratis																				
Archæocidaris ornata																				
Archæocidaris trudifer?																				
Eocidaris halliana?																				
BRYOZOA.																				
Rhombopora lepidodendroides																				
Fenestella sp																				
Polypora cf. distincta																				
Polypora whitei var. insculpta																				
Polypora n. sp.																				
Septopora delicatula																				
Stenopora cestriensis																				
BRACHIOPODA.																				
Lingula carbonaria															(?)					
Lingula? sp. (indeterminable)									×											
Orbiculoidea manhattanensis																				
Rhipidomella pecosi										(?)										
Derbya crassa	×		×													×				
Meekella striaticostata					×															
Chonetes geinitzianus								(?)							(?)	(?)				
Productus semireticulatus var. hermosanus			×							×			×		×	×	×			
Productus inflatus	×			×	×			×		(?)						×		×	×	
Productus cora																				
Productus nebraskensis					(?)															
Productus sp. b										(?)										
Marginifera ingrata		(?)																		
Spirifer rockymontanus																				
Spirifer sp. (indeterminable)																				
Squamularia perplexa																				
Seminula subtilita			×		×					×		×	×	×	(?)					
PELECYPODA.																				
Aviculopecten rectilaterarius																				
Acanthopecten carboniferus																				
Myalina wyomingensis								(?)												
Aviculopinna? peracuta								(?)												
Nucula ventricosa?																				
Nucula sp. (indeterminable)																				
GASTEROPODA.																				
Minute gasteropods																				
CRUSTACEA.																				
Beyrichia sp																				
Leperditia sp																				
Bairdia cf. cestriensis																				
Kirkbya sp																				
Phillipsia trinucleata																				
Phillipsia major																				

[a] For a description of the localities indicated by number in this table, see locality register, pp. 519-532.

TABLE XII.—*Table showing distribution of Pennsylvanian species in the Leadville and Tenmile districts, and their range in the lower, middle, and upper Weber formation, Robinson limestone, and Maroon formation*—Continued.

	2270	2271	2272	2273	2274	2275	2276	2277	2281	2288	2289	Weber lower.	Weber middle.	Weber upper.	Robinson limestone.	Maroon base.
ECHINODERMATA.																
Archæocidaris ornata												1				
BRYOZOA.																
Rhombopora lepidodendroides									×			1				
BRACHIOPODA.																
Lingula carbonaria												1				
Lingula tighti								×				1				
Lingula ? sp. (indeterminable)												1				
Orbiculoidea manhattanensis												2				
Rhipidomella pecosi												1				
Derbya crassa												2		1		
Chonetes geinitzianus												3				
Productus semireticulatus var. hermosanus						×						2	1	1		
Productus inflatus		×				×			×			5		1		
Productus cora	(?)	×				×			×			2		1		1
Productus nebraskensis		×							×			2				
Marginifera ingrata												2				
Spirifer boonensis?																
Spirifer rockymontanus		×							×			4			1	
Squamularia perplexa			(?)											1	1	
Seminula subtilita												3	2	1	3	
PELECYPODA.																
Aviculopecten rectilaterarius												1				
Entolium ? sp														1		
Myalina wyomingensis												1				
Aviculopinna ? peracuta												1				
Macrodon obsoletus														1		
Macrodon tenuistriatus ?														1		
Pleurophorus occidentalis ?						(?)								1		
GASTEROPODA.																
Euconispira taggarti												1				
Phanerotrema cf. grayvillense						×								1		
Worthenia ? marcouiana ?														1		
Worthenia ? sp. a														1		
Loxonema sp														1		
Strophostylus remex				×											1	
Bulimorpha chrysalis		(?)														
Minute gasteropods														1		
Bellerophon crassus				×										1	1	
Bellerophon percarinatus ?														1		
Bellerophon sp. (indeterminable)	×															1
Patellostium montfortianum						(?)								1		
CEPHALOPODA.																
Domatoceras sp						×	×							2		
CRUSTACEA.																
Phillipsia major												1				

The preceding table shows the local distribution of species of the Upper Carboniferous strata of the Leadville region. The last five columns show their range in the five stratigraphic divisions which have been recognized. They indicate two somewhat different and contrasting, though both Upper Carboniferous, faunas. One of these is exemplified by the fossils of the Weber shales. To the other those of the upper division of the Weber belong. The fauna now known from the Robinson limestone is a meager one. Thus far the evidence does not indicate that the Robinson fauna differs essentially from that of the upper Weber. The middle division of the Weber also has furnished a very limited fauna. All of its species are common to the contiguous formations, both above and below, and there is no evidence for uniting it with one rather than another, or for retaining it as coordinate with either. The upper fauna is especially characterized by the number of its pelecypod and gasteropod species, which were obtained, however, in large part at a single locality.

The difference in facies between the Weber shales and the middle and upper Weber is as marked in this case as in the corresponding formations of the Crested Butte region. While only 4 species of the true Mollusca have been found in the Weber shales in this area, almost the entire brachiopod representation is centered there, only 7 species being found in the four upper stratigraphic divisions. Even among these the most numerous representation is in the Weber shale, the only instance where the range is nearly uniform being in the species *Seminula subtilita*. However, while the Weber shale has perhaps been sufficiently collected to warrant the belief that its main features are known, this is far less true of the upper beds of the section.

Comparing the formational faunas of the Leadville area after the same method that was employed with those of the Crested Butte region, the following facts appear: In the case of the lower and upper Weber, these two formations have a joint fauna of 35 species, of which only 5 are contained in common. The relation of these faunas will then be expressed by the fraction $\frac{5}{35}$ or by the percentage 14.3. If, however, the lower Weber is contrasted with all the series above, the percentage is raised to 16.2, for the total fauna is 37 and the common species 6.

The Leadville area is related to the Crested Butte region geologically and geographically, and a general faunal agreement can be traced. In both areas the fauna characteristic of the Rico formation of the Animas region is wanting, as will appear later. When the faunas of the different divisions of the Carboniferous in the Leadville region are tabulated with those of the Crested Butte region a certain correspondence in the abundance and range of species is disclosed. The evidence thus obtained indicates that the Weber shale of the Leadville region is the representative of the Weber formation of the Crested Butte region, and that the upper member of the Weber grits formation, carrying with it probably the Robinson limestone and possibly the middle Weber, corresponds to the Maroon conglomerate. This correspondence is not so close as to be striking, and many departures can easily be pointed out; but I feel that we have data very far from full as to the faunas of these formations. A comparison of the faunas of all the formations from which we have any adequate collections can be made by consulting the summary tables at the end of this chapter.

Station 2281 probably is bed 38 in Peale's section No. 18, which was made from the mouth of the canyon of Fourmile Creek westward to Horseshoe Mountain.[a] This locality is in the Leadville district, and the horizon can safely be put at the Weber shales. The fauna also agrees with this identification.

Station 2288 appears to be that mentioned by Peale on page 242 of the same report. The locality is probably near the Tenmile district. The horizon is rather uncertain, but appears to be the Weber shales, from the stratigraphic evidence, while the fauna itself is too limited to afford a clue.

The collection from station 2289 is that cited on page 369 of the third volume of the reports of the Wheeler survey.[b] The section was made on the forks of Eagle River, a locality which I have been unable to identify exactly, but which appears to be not far northwest of the Tenmile district. The horizon is bed 19 of the local section, whose relations with the standard one are as difficult to ascertain as the position of the locality upon the map. As it occurs in the middle of a great sandstone series, I suppose that it comes about on the horizon of the Robinson limestone, just above or just below the division between the Weber grits and the Maroon formation. The fauna is too scanty to afford evidence on this point.

As our collections contain no fossils from the Front Range and Sangre de Cristo regions, I will proceed to give the faunal evidence from the San Juan region.

SAN JUAN REGION.

A wholly disproportionate amount of material in our Colorado collections was obtained from the small area of Carboniferous strata exposed in the Rico Mountains and in the valley of the Animas River in the southwestern part of the State. This area is partly covered by the Durango, Rico, Engineer Mountain, Needle Mountains, and Silverton quadrangles, and is shown on sheets 4 and 15 of the Hayden atlas of Colorado.[c] Most of the material obtained was collected by Whitman Cross, A. C. Spencer, and others associated with them.

The geologic section in the Rico Mountains has been described by Cross and Spencer,[d] but generally, it may be said, with reference to the larger area in which

[a] U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, p. 227.
[b] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875.
[c] U. S. Geol. Geog. Surv. Terr., Geol. Geog. Atlas Colorado, 1877.
[d] Geology of the Rico Mountains, Colorado: U. S. Geol. Surv., Twenty-first Ann. Rept., pt. 2, pp. 7–165.

previous studies had been made and over which the same formations extend with only local variations. They recognized two formations of Upper Carboniferous age, the Hermosa and the Rico formations; but Cross has recently discriminated a third, the Molas formation, which is a thin stratum of red shale intermediate between the Hermosa formation and the Ouray limestone.

The Molas formation is best known in the Needle Mountains quadrangle, where it has a thickness of only about 75 feet. It is a series of shales, but contains bands of diverse texture and material, among them being some of impure limestone and some sandy. The color is an intense red, often strongly mottled with lighter tints, which occasionally are nearly white. It contains pebbles and small bowlders of chert, some of them fossiliferous. The fossils are the same species which occur in the Mississippian fauna of the upper part of the Ouray limestone, where the cherts without doubt had their origin. The base of the Molas often contains bowlders of Ouray limestone of considerable size. The upper surface of the Ouray is more or less stained with the Molas, whose material and color appear to have worked down into cracks and crevices between partly loosened blocks of the older formation. Some of the impure limestone beds of the Molas are fossiliferous. The collections so far obtained from the formation are but 3 in number, with a total of 6 species. The stations are 2186, 2187, and 2188.

The Hermosa formation consists of limestones, shales, and sandstones, and has a maximum thickness of 2,000 feet. Its characters are very inconstant, and while a threefold division was made in the Rico region, by reason of the segregation of the limestones into the middle portion, this could not be effected satisfactorily elsewhere. The lower division, composed mainly of shales, is, roughly speaking, 700 feet in thickness. The central division, or heavy limestone series, is 500 feet thick, while the upper or transition member, of sandy and limy shales, is about 800 feet thick. In all, 71 collections were obtained from the Hermosa formation, and most of them have been located in one or another of the three stratigraphic subdivisions. The following stations are located in the lower series: 2197, 2198, 2209, 2213, 2214, 2247, 2279, and 2284. In the middle series are the following stations: 2202, 2211, 2212, 2217, 2220, 2222, 2223, 2224, 2225, 2228, 2229, 2235, 2236, 2237, 2246, 2249, 2282, 2286, 2287, 2301, 2332, 2333, 2334, and 2335; and in the upper series are the following: 2200, 2201, 2203, 2204, 2205, 2207, 2208, 2210, 2216, 2218, 2219, 2221, 2226, 2231, 2232, 2238, 2239, 2240, 2241, and 2283.

Upon these stratigraphic subdivisions and upon the collections designated is based the following tabular statement, which shows the distribution of the Molas and Hermosa species by localities and in the final three columns their vertical range. Details of local representation, distribution, and range can, therefore, be secured from this source and from the register of localities appended.

TABLE XIII. [a]—*Table showing distribution of Pennsylvanian species in the San Juan region, and their range in the Molas and lower, middle, and upper Hermosa formations.*

	2186	2187	2188	2196	2196*a*	2196*b*	2196*c*	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209
PROTOZOA.																				
Fusulina cylindrica																				
CŒLENTERATA.																				
Lophophyllum profundum																				
Campophyllum torquium																				
Chætetes milleporaceus																				
Monilipora prosseri																				
ECHINODERMATA.																				
Archæocidaris triplex ?			×																	
BRYOZOA.																				
Fistulipora carbonaria																				
Rhombopora lepidodendroides	×																			
Polypora sp. b																				
Septopora sp																				
BRACHIOPODA.																				
Rhipidomella pecosi	(?)																			
Derbya crassa																				
Productus semireticulatus var. hermosanus																		×		
Productus inflatus																				
Productus gallatinensis																				
Productus cora*																			×	
Productus punctatus																				
Productus nebraskensis*																				
Productus sp. a																				
Marginifera muricata																				
Marginifera wabashensis var																				
Spirifer boonensis?													(?)							
Spirifer rockymontanus																				
Spirifer cameratus																				
Squamularia perplexa																				
Seminula subtilita*				×																
Dielasma bovidens							?													
PELECYPODA.																				
Acanthopecten carboniferus*																				
Myalina subquadrata ?*											?					?				
Myalina perniformis?																				
Pseudomonotis hawni*																?				
Aviculopinna ? peracuta																				
Chænomya leavenworthensis																				
Allerisma terminale																				
Schizodus sp																				
Edmondia subtruncata																				
GASTEROPODA.																				
Euconispira bicarinata																				
Patellostium montfortianum																				
CEPHALOPODA.																				
Tainoceras sp																				

[a] For a description of the localities indicated by number in this table see locality register, pp 519–532.

* Also found in Rico formation.

TABLE XIII.—*Table showing distribution of Pennsylvanian species in the San Juan region, and their range in the Molas and lower, middle, and upper Hermosa formations*—Continued.

	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229
PROTOZOA.																				
Fusulina cylindrica	×	×		×								×						×		
CŒLENTERATA.																				
Lophophyllum profundum													×							
Zaphrentis gibsoni							×													
Amplexus sp													×							
Chætetes milleporaceus																			×	
ECHINODERMATA.																				
Eupachycrinus? sp												×								
BRYOZOA.																				
Fistulipora carbonaria				×																
Rhombopora lepidodendroides																				
Fenestella sp												×								
Stenopora carbonaria				×																
Stenopora? sp												×								
Leioclema? sp												×								
BRACHIOPODA.																				
Derbya crassa										×	×									
Meekella striaticostata																				×
Chonetes flemingi var. verneuilianus				×																
Chonetes mesolobus*																	×			
Productus semireticulatus var. hermosanus	×																(?)			
Productus inflatus				×																
Productus gallatinensis				×			(?)													
Productus pertenuis?															(?)					
Productus cora*	×			×			×			×		(?)	×							
Productus nebraskensis*				×		×														
Productus sp. b					×															
Marginifera wabashensis var											×									
Marginifera ingrata																×				
Spirifer boonensis?				×	×					×										
Spirifer rockymontanus													×	×						×
Spirifer cameratus	×			×			×													
Squamularia perplexa				×							×	×	×	×	×	×				
Ambocœlia planiconvexa											×									
Spiriferina campestris										×										
Spiriferina kentuckyensis											×									
Seminula subtilita*		×		×	×		×			×	×		×	×	×					×
PELECYPODA.																				
Aviculopecten occidentalis*										×										
Aviculopecten pellucidus												×								
Aviculopecten rectilaterarius																	×			
Acanthopecten carboniferus*																	×			
Streblopteria tenuilineata							×					×								
Modiola? subelliptica																				
Chænomya leavenworthensis										?										
Leda bellistriata?										×										
Edmondia? sp										×										
Cypricardinia carbonaria										×										

* Also found in Rico formation.

TABLE XIII.—*Table showing distribution of Pennsylvanian species in the San Juan region, and their range in the Molas and lower, middle, and upper Hermosa formations*—Continued.

	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229
SCAPHOPODA.																				
Dentalium sublæve										×										
GASTEROPODA.																				
Worthenia? lasallensis?								×												
Naticopsis altonensis*														×						
Strophostylus subovatus?								?												
Platyceras parvum									×											
Minute gasteropods																				
Bellerophon crassus*							×	×												
Bellerophon percarinatus?								×												
Patellostium montfortianum												?								
Patellostium bellum*								×												
Euphemus nodocarinatus								?												
CRUSTACEA.																				
Phillipsia trinucleata	?																			
Leperditia sp																				

	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2246	2247	2249	2279	2282	2283	2284
PROTOZOA.																				
Fusulina cylindrica					×		×													
SPONGIA.																				
Hyalostelia sp																	×			
Hystriospongia? sp																	×			
CŒLENTERATA.																				
Lophophyllum profundum			×								×									
Amplexus sp											×									
Leptopora winchelli																	×			
ECHINODERMATA.																				
Archæocidaris ornata					×															
HELMINTHA.																				
Conularia crustula									(?)											
BRYOZOA.																				
Rhombopora lepidodendroides					×															
Prismopora sp																				
Polypora sp. b																				
BRACHIOPODA.																				
Derbya crassa			×																	
Chonetes mesolobus*			×					×												
Productus semireticulatus var. hermosanus						×					×									
Productus inflatus															×					
Productus gallatinensis															×					×
Productus cora*									×											
Productus punctatus											×									
Productus nebraskensis*									×	×										
Spirifer boonensis?															×					(?)
Spirifer cameratus									×					×						×
Squamularia perplexa								×											×	
Ambocœlia planiconvexa																				
Seminula subtilita*	×		×				×		×	×		×								×

*Also found in Rico formation.

TABLE XIII.—*Table showing distribution of Pennsylvanian species in the San Juan region, and their range in the Molas and lower, middle, and upper Hermosa formations*—Continued.

	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2246	2247	2249	2279	2282	2283	2284
PELECYPODA.																				
Aviculopecten occidentalis*																				
Acanthopecten carboniferus*																				
Modiola? subelliptica																				
SCAPHOPODA.																				
Dentalium sublaeve																				
GASTEROPODA.																				
Naticopsis monilifera*																				
Platyceras parvum																				
Bellerophon crassus*				?																

	2286	2287	2301	2309	2322	2323	2327	2328	2331	2332	2333	2334	2335	2339	Molas.	Hermosa. Lower	Middle	Upper
PROTOZOA.																		
Fusulina cylindrica																1	1	1
SPONGIA.																		
Hyalostelia sp																1		
Hystriospongia ? sp																1		
CŒLENTERATA.																		
Lophophyllum profundum																	2	2
Campophyllum torquium																		1
Zaphrentis gibsoni																	1	1
Amplexus sp																	1	1
Chætetes milleporaceus																	1	
Leptopora winchelli																1		
ECHINODERMATA.																		
Archæocidaris triplex ?															1			
Archæocidaris ornata																	1	
Eupachycrinus ? sp																		1
HELMINTHA.																		
Conularia crustula ?																		(?)
BRYOZOA.																		
Fistulipora carbonaria																1		1
Rhombopora lepidodendroides															1		1	
Prismopora serrata																	1	
Prismopora sp																	1	
Fenestella cf. tenax																		
Fenestella sp																		1
Polypora cf. cestriensis																		
Polypora whitei var. insculpta																		
Polypora n. sp									(?)								1	
Polypora sp. a																		
Polypora sp. b																	1	1
Septopora sp																		1
Chainodictyon laxum																	1	
Stenopora carbonaria																1		
Stenopora ? sp																		1
Leioclema ? sp																		1

* Also found in Rico formation.

Table XIII.—*Table showing distribution of Pennsylvanian species in the San Juan region, and their range in the Molas and lower, middle, and upper Hermosa formations*—Continued.

	2286	2287	2301	2309	2322	2323	2327	2328	2331	2332	2333	2334	2335	2339	Molas.	Hermosa.		
																Lower	Middle	Upper
BRACHIOPODA.																		
Rhipidomella pecosi															1			
Derbya crassa										×						3	3	2
Meekella striaticostata				(?)													1	
Chonetes flemingi var. verneuilianus																1		
Chonetes mesolobus*																		2
Productus semireticulatus var. hermosanus											×	×	×				4	6
Productus inflatus																3		
Productus gallatinensis																4		(?)
Productus pertenuis?																	1	
Productus cora*										×		×	×			2	4	9
Productus punctatus												×	×				2	2
Productus nebraskensis*											×					2	1	7
Productus sp. a								×					×				1	1
Productus sp. b																1		
Marginifera wabashensis var						×										2	1	
Marginifera ingrata																	1	
Spirifer boonensis?									(?)	×		×			1	6	4	3
Spirifer rockymontanus						×											4	
Spirifer cameratus									×	×						3	2	6
Squamularia perplexa	×		×							×						2	9	4
Ambocœlia planiconvexa																	2	
Spiriferina campestris																		1
Spiriferina kentuckyensis					×												1	
Seminula subtilita*				×		×			×						2	5	13	8
PELECYPODA.																		
Aviculopecten occidentalis*																		2
Aviculopecten pellucidus																		1
Aviculopecten rectilaterarius																		1
Acanthopecten carboniferus*																		4
Streblopteria tenuilineata																		2
Modiola? subelliptica																		1
Myalina subquadrata?*																		2
Myalina perniformis?															1			
Pseudomonotis hawni*																		?
Aviculopinna? peracuta																		1
Chænomya leavenworthensis																		2
Allerisma terminale																		1
Schizodus sp																		1
Leda bellistriata?																		1
Edmondia subtruncata																		2
Edmondia? sp																		1
Cypricardinia carbonaria																		1
SCAPHOPODA.																		
Dentalium sublæve																		2
Dentalium sp																	1	
GASTEROPODA.																		
Worthenia? lasallensis?																	1	
Naticopsis altonensis*																	1	
Naticopsis monilifera*																		1

* Also found in Rico formation.

TABLE XIII.—*Table showing distribution of Pennsylvanian species in the San Juan region, and their range in the Molas and lower, middle, and upper Hermosa formations*—Continued.

	2286	2287	2301	2309	2322	2323	2327	2328	2331	2332	2333	2334	2335	2339	Molas.	Hermosa		
																Lower	Middle	Upper
GASTEROPODA—continued.																		
Strophostylus subovatus?																	1	
Platyceras parvum																1		1
Euomphalus catilloides																	1	
Minute gasteropods																1	1	
Bellerophon crassus*																	1	1
Bellerophon giganteus?																	1	
Bellerophon percarinatus?																	1	
Patellostium montfortianum																		2
Patellostium bellum*																	1	
Euphemus nodocarinatus																	2	
CEPHALOPODA.																		
Tainoceras sp																		1
CRUSTACEA.																		
Phillipsia major																	1	
Phillipsia trinucleata																		?
Leperditia sp																	1	

* Also found in Rico formation.

The Rico formation is part of the regular Red Beds. Its thickness is assumed to be 300 feet, because this portion of the Red Beds contains Carboniferous fossils. For a distance above this horizon no fossils are found, while at the top Triassic vertibrates occur. The Rico formation is made up of sandstone and conglomerate, with included shales and sandy, fossiliferous limestones. Our collections from the Rico formation are 12 in number, and the total fauna known consists of 39 species. The stations at which Rico fossils have been obtained are 2248, 2337, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, and 2349. The Rico fauna is so different from that of the Hermosa formation that it has been deemed best to represent it on a separate table, from which the local distribution of the species can readily be ascertained. A comparison of the Rico with the Hermosa fauna can be made by means of the asterisks, which are attached in both tables to species common to the two formations.

TABLE XIV.[a]—*Showing distribution of Pennsylvanian species in the Rico formation of the San Juan region.*

	2248.	2337.	2340.	2341.	2342.	2343.	2344.	2345.	2346.	2347.	2348.	2349.	Total.
BRACHIOPODA.													
Chonetes mesolobus*						×							1
Chonetes geinitzianus													1
Productus cora*				×									5
Productus nebraskensis*	(?)												(?)
Seminula subtilita*	×	×	×	×	×							×	6
PELECYPODA.													
Aviculopecten occidentalis*		×	×	×	×					×			5
Acanthopecten carboniferus*					×								1
Myalina wyomingensis			×	×	×			×				×	5
Myalina subquadrata?*			×	×	×		×	×					5
Myalina perattenuata?		×	×										2
Posidoniella pertenuis?				×									1
Pseudomonotis hawni*													1
Pseudomonotis equistriata					×								1
Pseudomonotis kansasensis													1
Pseudomonotis sp													3
Monopteria polita					×								1
Monopteria alata													1
Monopteria longispina				×									1
Aviculopinna nebraskensis				×	×								2
Allerisma terminale					×								1
Sedgwickia topekensis?								×					1
Schizodus cuneatus?													3
Schizodus meekanus		×											1
Schizodus pandatus?											×		4
Pleurophorus subcostatus			×	×	×			×	×				5
Pleurophorus occidentalis?													1
Edmondia gibbosa			×	×	(?)								3
Astartella? gurleyi													1
GASTEROPODA.													
Euconispira sp. a													1
Euconispira sp. b													1
Worthenia? marcouiana?													2
Loxonema plicatum					×		×						2
Loxonema? peoriense					×			×					2
Naticopsis altonensis*			(?)										(?)
Naticopsis monilifera*													2
Strophostylus remex			×					×					2
Bulimorpha chrysalis					×			×		×			3
Bellerophon crassus*			×	×	×								3
Patellostium bellum*													2
Euphemus nodocarinatus			×				×	×				×	4

[a] For a description of the localities indicated by number in this table, see locality register, pp. 519–532.
* Species marked by an asterisk occur also in the Hermosa formation.

The fauna of the Molas formation known is very limited, and will be found represented in the first of the final columns of Table XIII. Isolated from other facts there might exist some doubt from the present faunal evidence whether the Molas formation belonged in the Lower or in the Upper Carboniferous, though I think that even so it would be placed by most paleontologists in the higher series. Comparing its fauna with that of the basal Hermosa I find that three of its six species do not appear there. The most abundant species in the Molas, however—*Spirifer boonensis* and *Seminula subtilita*—are also especially abundant in the base of the Hermosa, and the somewhat peculiar variations are the same in each case. Not enough is yet known of the Molas fauna to assure a safe opinion, but I expect that it will prove to be closely related to that of the basal Hermosa. Lithologically, however, the Molas is a distinct thing, and it may be that the fauna will show corresponding modifications. This is, indeed, already indicated to a certain extent.

On the other hand, while the Molas fauna shows a distinct relationship with that of the Hermosa formation, it is completely disconnected with the Mississippian fauna of the Ouray limestone, not a single species apparently passing into it from below. In view of this fact, of the unconformity which preceded it, of the independent significance of its fauna, and of its affinity with that of the Hermosa, the Pennsylvanian age of which is clear, it seems that the Molas formation also can safely be placed in the Upper Carboniferous.

The fauna of the lower Hermosa is less numerous than that of either of the upper divisions or of the Rico formation. Only 20 species have been obtained from it, while the middle has furnished 42, the upper 49, and the Rico 40. It is also less varied, and is predominantly a brachiopod fauna. In the middle division a number of gasteropod species appear, while the upper, in addition to brachiopods and gasteropods, has a considerable force of pelecypods. The number of brachiopod species remains in a general way nearly constant, there being 12 in the lower Hermosa, 17 in the middle, and 13 in the upper; but by reason of the accession of other types, especially of the true Mollusca, they hold a regularly diminishing ratio to the entire fauna. Thus they rate at 60 per cent in the lower Hermosa, 40.5 per cent in the middle, and 26.5 per cent in the upper. In the Rico formation only 5 species have been found, and they represent only 12.5 per cent of the entire fauna. The Mollusca are at the same time increasing in proportion, passing from 10 to 26.2 and 46.9 per cent of the entire fauna in the different divisions of the Hermosa and to 87.5 in the Rico formation.

The collections from the lower member of the Hermosa formation were all obtained from its basal portion. In areas where the Molas formation appears their occurrence is just above its upper boundary, and where the Molas has not been distinguished they were found within about 50 feet or less of the Ouray limestone, whose upper beds contain, as I have already shown, a fauna of Mississippian age. The fauna exhibited by these collections is of Upper Carboniferous age. There is, therefore, a great faunal break between the base of the Hermosa formation and the Ouray limestone, corresponding to the unconformity by which they are known to be separated. The time interval indicated by this faunal break is a long one, representing much of Mississippian time and probably encroaching upon the ensuing Pennsylvanian. The general age of the base of the Hermosa formation is, fortunately, quite without the range of speculation. The presence of such characteristic forms as *Fusulina cylindrica*, *Derbya crassa*, *Chonetes flemingi* var. *verneuilianus*, *Productus nebraskensis*, *Marginifera wabashensis* var., *Spirifer cameratus*, *Squamularia perplexa*, and *Seminula subtilita* stamps this fauna as Upper Carboniferous.

The lower Hermosa fauna is probably closely related to that of the Molas formation, though the latter is too imperfectly known to permit much to be said of it with safety. It is also related to the fauna of the middle Hermosa, yet retains a certain individuality of facies which renders its recognition in the San Juan region easier than that of either of the overlying divisions. The table shows that *Ch. flemingi* var. *verneuilianus*, *Productus inflatus*, *Productus gallatinensis*, and *Productus* sp. b. do not range into the middle and upper Hermosa, and that *Productus semireticulatus* var. *hermosanus*, *Productus punctatus*, *Spirifer rockymontanus*, and a number of other species found above do not occur in the lower. In working through the collection, however, I was more impressed by the abundance, persistence, and distinctive form of *Spirifer boonensis ?*, though the latter sometimes occurs abundantly at higher levels, and of the small *Productus gallatinensis*. Aside from the brachiopods the fauna of the lower Hermosa has little in common with the division above. Such species belonging to other groups as are found there appear as a rule to be peculiar to it.

Expressing the relation between the three divisions of the Hermosa formation and the Rico formation numerically, as has been done in other cases, by taking the ratio of the combined fauna of two adjacent divisions to the species common to both, the relation between the lower and middle beds is expressed by the number 19.2, between the middle and upper by 21.3, and between the upper Hermosa and the Rico by 12.8. Similarly, the relation between the Rico formation and the Hermosa[a] taken as a whole is 9.9, somewhat less, as one would expect, than that existing between it and the upper division alone. While this form of comparison is not without significance it is doubtful whether a numerical expression ever adequately represents the relation between two faunas in stratigraphic paleontology, while sometimes it is evidently misleading. One defect, which might perhaps be remedied, is that it overlooks the element of abundance in individual local occurrences or persistent repetition of local occurrence. The most serious defect is that it expresses in regard to faunas their total similarity or difference resulting from the two factors of evolutionary development and of the selective action of environmental conditions, while it is for one of these chiefly that the paleontologist would find expression. The other in most cases could be safely overlooked. At all events, to correctly understand the geologic relations of faunas, as well as the geographic, it is necessary

[a] Two of the species common to the Rico and Hermosa formations have not been recognized in the upper Hermosa. If they are regarded as having a continuous range and are counted in with the other upper Hermosa species, this relation would be expressed by the number 15.4.

that these two independent interacting factors be as far as practicable differentiated. A method which would give mathematical expression to both these forces separately, instead of to their resultant, would be very useful. Qualified as must be their acceptation, the figures just given indicate a less intimate relation between the Hermosa and Rico formations than between the several members of the Hermosa. In whatever way the two faunas be viewed a marked difference in facies must be granted. As in the Dolores River region at Sinbads Valley the supposed equivalent of the Hermosa greatly exceeds in thickness the typical sections, and as its upper beds contain a fauna at once different from that of the Rico formation, and only in a less degree from that of the Hermosa, it would appear as if the faunal break between the Hermosa and Rico formations, and to a certain extent the marked lithologic change which it accompanies, were the expression of a period of nondeposition or erosion represented in other areas by sediments and faunas not found in the San Juan.

It has been noted that the fauna of the lower division of the Hermosa also has a certain individuality of facies; but it appears from the consideration of corresponding horizons in other regions adjacent that the species which our collections indicate might serve to distinguish the lower from the middle division are not as sharply limited in range as in the San Juan. Possibly the reason that a faunal break seems to exist in the San Juan region is that there the collections from the lower Hermosa were all made at the very base, some 600 or 700 feet of strata intervening between them and the middle division.

Ouray.—It would be difficult to say whether the small, isolated Carboniferous area about Ouray would more appropriately be included with the San Juan or with the Dolores River region. I have, however, decided to discuss the few collections from Ouray in connection with the former.

The Ouray limestone is not exposed at Ouray in such a manner that its stratigraphic relation to the Upper Carboniferous formations could be satisfactorily made out. I was not sufficiently acquainted with the upper part of the Paleozoic section in the San Juan to determine on lithologic evidence (for the Rico fauna was not found at Ouray) the position there of the Rico horizon. Therefore, while it is safe to say that the Ouray collections came from the equivalent of the Hermosa formation, their position relative to either the top or the base of the section was not determined. I am of the opinion, however, that the collection made on the west side of the valley represents a higher horizon than those made on the east side. The latter, while containing some of the forms supposed to characterize the lower Hermosa—as, for instance, *Productus inflatus* and *Productus gallatinensis*—contain certain others, such as *Spirifer rockymontanus*, rather distinctive of the upper divisions. The same is true of the collection from the west side of the valley, from which it appears that the differences distinctive of the lower and middle divisions of the Hermosa formation in the San Juan region are less strongly marked in other areas. I believe, however, that the collections on the east side of the valley probably belong to the horizon of the lower Hermosa of the San Juan region and the Weber formation of the Crested Butte region. The accompanying table shows the local distribution of the species found near Ouray.

TABLE XV.[a]—*Table showing distribution of Pennsylvanian species in the Hermosa formation at Ouray.*

	2194.	2195.	2195a.	2195b.	2195c.	Total.
PROTOZOA.						
Fusulina cylindrica	×			×	×	3
CŒLENTERATA.						
Campophyllum torquium	×					1
ECHINODERMATA.						
Archæocidaris ourayensis	[illegible]					1
Archæocidaris cratis			[illegible]			1
BRACHIOPODA.						
Derbya crassa			×			1
Chonetes flemingi	×					1
Productus gallatinensis			[illegible]			1
Productus inflatus		[illegible]		[illegible]		3
Productus semireticulatus var. hermosanus	×					1
Productus cora	[illegible]		[illegible]			2
Productus nebraskensis				×		1
Marginifera ingrata		×				1
Spirifer boonensis?	×					1
Spirifer rockymontanus			[illegible]	[illegible]		3
Spirifer cameratus	[illegible]					1
Squamularia perplexa	×					1
Seminula subtilita		[illegible]	[illegible]	[illegible]		3
PELECYPODA.						
Aviculopecten sp. b	×					1
Streblopteria tenuilineata				×		1
CRUSTACEA.						
Phillipsia major		[illegible]				1

[a] For a description of the localities indicated by number in this table see locality register, pp. 519–532.

DOLORES RIVER REGION.

A single collection from Sinbads Valley (station 2285) is all we have to represent the Carboniferous strata of the Dolores River region. Its horizon is in the stratigraphic equivalent of the Hermosa formation, about 100 feet below the Red Beds. The following species have been identified:

Lophophyllum profundum.
Orthotichia schuchertensis.
Enteletes hemiplicatus.
Chonetes granulifer.
Productus portlockianus.
Productus semireticulatus, var. hermosanus?
Spirifer cameratus.
Chænomya leavenworthensis.
Edmondia mortonensis?
?Naticopsis altonensis.
Euomphalus catilloides.
Worthenia tabulata?
Bellerophon percarinatus.

This is clearly not the Rico fauna, and its affinities are rather with those of the middle and upper portions of the Hermosa formation. It presents, however, a distinctly different facies from any portion of the Hermosa, as will be seen from the fact that *Enteletes hemiplicatus*, *Chonetes granulifer*, *Productus portlockianus*, *Edmondia mortonensis?*, and *Worthenia tabulata?* are not known to occur in that formation. In Sinbads Valley the Hermosa, or what is supposed to be that formation, has a much greater thickness than in the San Juan region. This collection, therefore, which comes from near the top of the formation in Sinbads Valley, presumably represents a higher horizon than any portion of the Hermosa in the San Juan region and also a lower horizon than the Rico formation. These facts, taken in connection with the rather marked faunal break and lithologic change between the typical Rico and Hermosa, are all favorable to the supposition that in the San Juan a period of erosion or nondeposition intervened between those two series of sediments, represented by the upper beds in Sinbads Valley and indicated by the different facies of their faunas.

SUMMARY.

Probably of greater interest than the relation to one another of the faunas of the different formations of the same section are the relations of the faunas of formations in the different sections which have been studied in different portions of the State. The only sections represented by collections adequate to make such a comparison are those of the San Juan region, Crested Butte district, and Leadville and Tenmile districts, the last two being considered together. To this end I have prepared a summary table, giving the composite faunas of the several formations recognized in these three regions. The character of the local faunas from which the composite list is made up is shown in the tables dealing individually with the different regions.

Table XVI.—*Summary table for comparing the Upper Carboniferous formational faunas of the San Juan, Crested Butte, and Leadville and Tenmile districts.*

	San Juan.				Crested Butte.		Leadville and Tenmile.				
	Molas.	Hermosa.			Weber.	Maroon.	Weber.			Robinson.	Maroon.
		Lower.	Middle.	Upper.			Lower.	Middle.	Upper.		
PROTOZOA.											
Fusulina cylindrica	....	1	4	4	1	4	....	....	....	....	....
Fusulina cylindrica var. ventricosa ?	....	....	....	....	1	....	....	....	....	....	....
SPONGIA.											
Hyalostelia sp	....	1	....	....	....	....	....	....	....	....	....
Hystriospongia ? sp	....	1	....	....	....	....	....	....	....	....	....
CŒLENTERATA.											
Lophophyllum profundum	....	....	2	2	....	3	....	....	....	....	....
Campophyllum torquium	....	....	....	1	1	2	....	....	....	....	....

TABLE XVI.—*Summary table for comparing the Upper Carboniferous formational faunas of the San Juan, Crested Butte, and Leadville and Tenmile districts*—Continued.

	San Juan.				Crested Butte.		Leadville.				
	Molas.	Hermosa.			Weber.	Maroon.	Weber.			Robinson.	Maroon.
		Lower.	Middle.	Upper.			Lower.	Middle.	Upper.		
CŒLENTERATA—continued.											
Amplexus sp			1	1	1						
Zaphrentis gibsoni			1	1	1						
Cladopora sp						1					
Leptopora winchelli		1									
Monilipora prosseri						2					
Chætetes milleporaceus			1			1					
ECHINODERMATA.											
Eupachycrinus ? sp				1							
Archæocidaris ornata			1				1				
Archæocidaris cratis					1						
Archæocidaris trudifer ?											
Archæocidaris triplex ?	1										
Eocidaris halliana ?					1						
HELMINTHA.											
Spirorbis arietina						2					
Conularia crustula ?				(?)							
Enchostoma sp					1						
BRYOZOA.											
Fistulipora carbonaria		1		1							
Rhombopora lepidodendroides		1	1				1				
Prismopora serrata			1								
Prismopora sp			1								
Fenestella cf. tenax											
Fenestella sp				1							
Polypora cf. distincta											
Polypora cf. cestriensis											
Polypora whitei var. insculpta											
Polypora n. sp			1								
Polypora sp. a											
Polypora sp. b			1	1							
Septopora delicatula											
Septopora sp				1							
Chainodictyon laxum			1								
Stenopora carbonaria		1									
Stenopora cestriensis											
Stenopora tuberculata					1						
Stenopora ? sp				1							
Leioclema ? sp				1							
BRACHIOPODA.											
Lingula carbonaria							1				
Lingula tighti							1				
Orbiculoidea manhattanensis							2				
Rhipidomella pecosi	1						1				
Derbya crassa		3	3	2	2	3	2		1		
Meekella striaticostata			1								
Chonetes flemingi					2	1					
Chonetes flemingi var. verneuilianus		1									
Chonetes geinitzianus							3				

TABLE XVI.—*Summary table for comparing the Upper Carboniferous formational faunas of the San Juan, Crested Butte, and Leadville and Tenmile districts*—Continued.

	San Juan.				Crested Butte.		Leadville.				
		Hermosa.					Weber.				
	Molas.	Lower.	Middle.	Upper.	Weber.	Maroon.	Lower.	Middle.	Upper.	Robinson.	Maroon.
BRACHIOPODA—continued.											
Chonetes mesolobus				2		2					
Productus semireticulatus var. hermosanus			4	6		5	2	1	1		
Productus inflatus		3			1		5		1		
Productus gallatinensis		1		5							
Productus cora		2	4	9	1	3	2		1		1
Productus pertenuis ?			1								
Productus nebraskensis		2	1	7			2				
Productus punctatus			2	2							
Productus sp. a			1	1							
Productus sp. b		1									
Marginifera lasallensis ?					1						
Marginifera muricata					1	5					
Marginifera wabashensis var		2	1		1	2					
Marginifera ingrata			1		2		2				
Spirifer boonensis ?	1	6	4	3							
Spirifer rockymontanus			4		2		4			1	
Spirifer cameratus		3	2	6		3					
Squamularia perplexa		2	9	4	1	9			1	1	
Spiriferina campestris				1	1						
Spiriferina kentuckyensis			1			1					
Ambocœlia planiconvexa			2								
Seminula subtilita		5	13	8		10	3	2	1	3	
Hustedia mormoni						3					
Pugnax utah						2					
Dielasma bovidens						1					
PELECYPODA.											
Aviculopecten occidentalis				2		(?)					
Aviculopecten rectilaterarius				1			1				
Aviculopecten ? interlineatus						1					
Aviculopecten pellucidus				1							
Acanthopecten carboniferus				4							
Streblopteria tenuilineata				2							
Entolium ? sp									1		
Modiola ? subelliptica				1							
Myalina wyomingensis									1		
Myalina subquadrata ?				2							
Myalina cuneiformis					1						
Myalina perniformis ?	1										
Pseudomonotis hawni				1							
Aviculopinna ? peracuta				1			1				
Leda bellistriata ?				1							
Nucula ventricosa ?											
Nucula sp											
Edmondia subtruncata				2							
Edmondia ? sp				1							
Schizodus sp				1							
Cypricardinia carbonaria				1							
Macrodon tenuistriatus?									1		
Macrodon obsoletus									1		
Pleurophorus occidentalis?									1		

TABLE XVI.—*Summary table for comparing the Upper Carboniferous formational faunas of the San Juan, Crested Butte, and Leadville and Tenmile districts*—Continued.

	San Juan.				Crested Butte.		Leadville				
	Molas.	Hermosa.			Weber.	Maroon.	Weber.			Robinson.	Maroon.
		Lower.	Middle.	Upper.			Lower.	Middle.	Upper.		
PELECYPODA—continued.											
Allerisma terminale				1							
Chænomya leavenworthensis				2							
SCAPHOPODA.											
Dentalium sublæve				2		1					
Dentalium sp			1								
GASTEROPODA.											
Platyceras parvum		1		1							
Strophostylus remex										1	
Strophostylus subovatus?			1								
Naticopsis altonensis			1								
Naticopsis monilifera				1							
Worthenia? lasallensis?			1								
Worthenia? marcouiana?									1		
Worthenia? sp. a									1		
Phanerotrema cf. grayvillense									1		
Euconispira taggarti							1				
Euconispira bicarinata											
Loxonema sp									1		
Bulimorpha chrysalis											
Euomphalus catilloides			1			1					
Minute gasteropods		1	1			2				1	
Bellerophon crassus			1	1		1			1	1	
Bellerophon giganteus?			1								
Bellerophon percarinatus?			1						1		
Patellostium montfortianum				2					1		
Patellostium bellum			1								
Euphemus nodocarinatus			?								
CEPHALOPODA.											
Tainoceras sp			1								
Domatoceras sp									2		
CRUSTACEA.											
Phillipsia major			1				1				
Phillipsia trinucleata				?							
Leperditia sp			1								
Kirkbya sp											
Bairdia cf. cestriensis											
Beyrichia sp											

In the above table are given the composite faunas of the Molas and of the lower, middle, and upper Hermosa formations in the San Juan region, of the Weber formation and of the lower member of the Maroon in the Crested Butte district, and of the lower, middle, and upper Weber, of the Robinson limestone, and of the Maroon formation in the Leadville and Tenmile districts. The fauna of the Rico formation of the San Juan region has not been found elsewhere in Colorado, and it did not seem necessary to introduce it for comparison. The fauna of the upper Maroon of the Crested Butte district is not known, and those of the middle Weber, Robinson limestone, and Maroon formation of the Leadville and Tenmile districts are very imperfectly known.

A comparison of the sections of these three areas without the aid of paleontologic evidence would indicate that the Hermosa formation, and possibly the Molas of the San Juan and the Weber and Maroon formations of the Crested Butte and Leadville districts, are in a general way equivalent. The correctness of this correlation is borne out by the distribution and range of species shown in the table. The species which characterize the lower Hermosa are present in the Crested Butte and Leadville districts, in the Weber formation of the one and the lower Weber or Weber shale of the other. The agreement in range of individual species with that in the San Juan is, as might be anticipated, somewhat greater in the case of the Crested Butte district than in the Leadville district. This may be entirely due to geographic separation, or it may be partly owing to a possible mixing in the Leadville collections of specimens from different geologic horizons. The evidence for suspecting that this may have occurred consists in the fact that several, and in some cases a large number, of different locality labels were found with single lots of fossils.

There seems to be evidence for believing that the lowest Pennsylvanian deposits in the San Juan, Crested Butte, and Leadville areas were essentially synchronous. It also seems to be true that essentially the same fauna occurs in the Hermosa formation of the San Juan region, the Weber and lower Maroon formations of the Crested Butte, and the Weber shale and Weber grits of the Leadville district. Of the fauna of the upper Maroon in the Crested Butte district and of the Maroon in the Leadville district we know nothing in one case and very little in the other. I have entertained the hypothesis that the Rico formation of the San Juan region is equivalent to the upper Maroon formation of the Crested Butte, but unfortunately no paleontologic evidence exists to prove or disprove this conjecture, as has just been said. The Maroon formation of the Leadville district corresponds in its position in the section to the upper division of the Maroon in the Crested Butte. Only one determined species, *Productus cora*, is known from the Maroon formation of the Leadville area, and it occurs in both the Hermosa and Rico formations. In the Robinson limestone, which is taken as the base of the Maroon formation, or as the dividing line between the Maroon and Weber grits, five species are known: *Spirifer rockymontanus*, *Squamularia perplexa*, *Seminula subtilita*, *Strophostylus remex*, and *Bellerophon crassus*. Of these, *Strophostylus remex* is found in the Rico but not in the Hermosa, *Seminula subtilita* and *Bellerophon crassus* in both Rico and Hermosa, and *Spirifer rockymontanus* and *Squamularia perplexa* only in the Hermosa formation. The case stands then somewhat against my hypothesis, but the evidence can not be regarded as conclusive, especially in view of the variation in the matter of range of species exhibited in the Leadville and San Juan regions in the case of the earlier formations.

A general comparison of the geologic column as shown in sections in Colorado, Utah, and Arizona has led me to consider the existence of nonsequence of sediments and life at several horizons in the Carboniferous of these areas. As indicated by variations in geologic sections, one of these occurs at the top of the Leadville and the Ouray limestone, another between the Weber limestone and the Maroon formation, a third between the two divisions of the Maroon, and a fourth between the Maroon and Wyoming formations. The unconformity and erosion found between the Leadville limestone and the overlying Pennsylvanian sediments find faunal expression in Colorado in a complete change of invertebrate life and in the absence of faunas of late Mississippian age. Another striking though not equally strong faunal break is found between the Hermosa and Rico formations, and is further borne out by the existence in Sinbads Valley of a greatly thickened series resembling the Hermosa, which has at its top a fauna more like the Hermosa than the Rico fauna, yet not entirely the same as either. As the Rico formation is supposed to represent the upper Maroon and the Hermosa the lower Maroon, there is some substantial faunal evidence favorable to the third hypothetical interruption. No invertebrate fauna is known from the Trias of Colorado, whose age is determined by vertebrate remains found in the San Juan. As I believe that the Rico fauna is not so young as the Permian, it is probable that a long interval occurred between the Maroon and Wyoming sediments. The reduction in thickness of the Pennsylvanian portion of the Wasatch limestone from 5,400 feet in Utah to 1,000 feet and less in its supposed equivalent in Colorado, the Weber limestone, suggests that in Utah beds are contained in the Wasatch which are absent in Colorado. Part of this thinning might be ascribed to the ascertained unconformity which preceded the Weber limestone of Colorado and which can probably safely be said to be more extensive there than in Utah. On the other hand, it is necessary to consider the possibility of an interruption between the Weber limestone and the Maroon series, the supposed representative in Colorado of the Weber quartzite which succeeds the Wasatch limestone of Utah. It is not possible to consider here the faunas of the Wasatch limestone and Weber quartzite. The faunas of the Weber limestone of the Crested Butte and of the Weber shale of the Leadville district have an expression sufficiently distinctive and are sufficiently different from those above to lend some color to such a hypothesis, though doubtless not to prove it. But the faunal evidence tends to correlate the Molas and basal Hermosa formation on one hand with the Weber limestone and the Weber shale, and also the persistence over most of the San Juan of the limestones which occur at the base of the Hermosa affords a feature of lithologic correspondence. Many of the distinctive forms of the lower Hermosa are found lower in the beds of the other areas, and a faunal change of about the same value separates it from the fauna of the middle Hermosa. This last is, however, partly due to the fact that the fauna of the lower Hermosa was in almost every case found at the base of the series, with a considerable thickness intervening between it and the fossiliferous horizons of the middle Hermosa. If the Weber limestone and the Maroon formation were not deposited consecutively, it is probable that a similar interruption intervened between the lower and the middle Hermosa. This does not, however, seem to find support from observations in the field, and it is important to mark that in a numerical expression the fauna of the lower Hermosa is but little more different from that of the middle than is the middle from the upper division, though certain features of the brachiopod representation give it a more distinct facies.

With regard to the age of the Pennsylvanian formations of Colorado compared with the better-known sections of the Mississippi Valley, I believe that the Hermosa formation, the Weber and the lower Maroon formations, and the Weber shale and Weber grits come very early in Pennsylvanian time and are probably older than any beds of the Kansas and Nebraska sections. The opinion that these formations represent very early Pennsylvanian time is supported by the fact that a number of species, as, for example, *Productus gallatinensis*, and especially the Bryozoa, are either identical with Mississippian forms or closely related to them. The belief that these formations are older than the oldest beds of the Kansas section, or at least are to be correlated with them, finds support not only in the same facts, joined to this other, that apparently a long period of early Pennsylvanian time is unrepresented in the Kansas section, but also from the following considerations, many others similar to which could probably be mentioned. The genus *Meekella* occurs in the Fort Scott limestone (2)[a] almost at the base of the Kansas section, while in Colorado it is known at but two localities and is not very characteristic. *Enteletes*, which is abundant well down in the Kansas section in the Iola limestone (16), is not known in Colorado, except at one locality, Sinbads Valley, whose horizon is supposed to be in the Hermosa formation, but higher than any of the Hermosa beds of the San Juan region. *Chonetes mesolobus* is abundant in Colorado, but is restricted to the early portion of the section in Kansas, extending no higher than the Parsons limestone (6). The same is true of *Chonetes flemingi*, which is abundant in Colorado, and though having a long range in Kansas seems to be the antecedent type of *Ch. granulifer*, which does not make its appearance until about the Lecompton limestone (22). This species is not known in Colorado except at Sinbads Valley, where its horizon appears to be considerably above the top of the Hermosa formation in the San Juan. *Productus semireticulatus* var. *hermosanus*, which distinguishes the upper divisions of the Hermosa formation, is found only in the lower portion of the

[a] The numerals refer to the beds in the general section of Upper Carboniferous rocks of Kansas.

Kansas section, while the variety of *Productus semireticulatus* common in the Kansas section is not found in Colorado at all except possibly at Sinbads Valley. *Productus inflatus*, on the other hand, which is rather characteristic of the lower division of the Hermosa formation, is extremely rare in the Kansas section. The same is true of *Productus gallatinensis*. *Spirifer rockymontanus* and *Spirifer boonensis*(?), which, being of the Keokuk group of spirifers, may be considered rather Mississippian than Pennsylvanian types, though found abundantly in the Mississippi Valley at horizons I believe to be older than the Kansas section, do not occur in the latter at all. They are abundant in Colorado, and generally throughout the Rocky Mountains. *Spiriferina campestris* also, which is all but identical with the Mississippian *Spiriferina spinosa*, is not known in the Kansas section. Considerable other evidence might be adduced, but enough has been given to be significant. The evidence of the gasteropods and pelecypods is less clear, but in the main it bears out that of the brachiopods and Bryozoa, which have just been hastily referred to. However, as these types are less common than the brachiopods, their range is less completely known, and as they are more often poorly preserved and more difficult to identify they are not as a rule as practicable for evidence. A possible contradiction to the tendency of the foregoing evidence may exist in *Pseudomonotis hawni*, a single doubtful instance of which is found in the Hermosa formation, while in Kansas it seems not to come in until toward the close of the section. Other species of *Pseudomonotis*, however, appear earlier, as, for instance, *Pseudomonotis equistriata*, which is present in the Iola limestone (16). It seems to me, however, that there is abundant evidence to prove that the Hermosa formation and its correlates (except the upper portion exposed in Sinbads Valley) are not younger than the lower portion of the Kansas section, and that they probably are somewhat older. I might add that I believe this to be true of a large part of the Upper Carboniferous of the West, and that its more or less unfamiliar facies is often due to its being older than the well-known faunas of the Upper Coal Measures of the Mississippi Valley.

Owing to the faunal break between the Hermosa and Rico formations, and to other evidence already several times referred to, I believe that sedimentation was not continuous in the San Juan region from one period to the other. It will be necessary, therefore, to discuss the age of the Rico fauna independently. Several years ago, when I think it may be said that less was known of the sequence in Kansas and Nebraska, I had occasion to consider this same question, and reached the conclusion that the Rico period occurred late in the Kansas section, not so late as the Marion formation, but about at the time of Prosser's Neosho and Chase, the Permo-Carboniferous of Meek and Hayden, which he includes with the Marion to constitute the "Permian" of the Mississippi Valley. My conclusions at that time were in a measure expressed by Cross and Spencer in their report upon the geology of the Rico Mountains.[a] Considering the Rico fauna in the light of later evidence and further studies, I am disposed to think that I placed its age distinctly too late in the Kansas section.

In my early effort to correlate the Rico formation, which resulted in assigning it to about the horizon of the Neosho and Chase formations of the Kansas section, the lines of evidence chiefly considered were the relative abundance of the brachiopods to the true Mollusca, and the range in the formations discussed by Prosser of such genera and species as seemed to have special significance. Prosser, as is well known, treated only the upper portion of the Kansas section,[b] and the evidence of individual genera and species in the matter of correlation proved rather conflicting. Considerable weight was given the relative representation of the brachiopods, because their gradual disappearance seemed an important feature in the changes which marked the progression from the Wabaunsee to the Marion fauna. I held the opinion at the time, however, that this circumstance would be of only local significance unless it proved to be a part of the far-reaching vital changes that resulted in the extinction of nearly all the Paleozoic types of brachiopods.

Later publications upon the earlier faunas of the Kansas section and further studies of my own have made it possible to reconsider the faunal evidence of the Rico upon a somewhat different basis, but with a result nearly as unsatisfactory.

Except for *Chonetes mesolobus* the brachiopods of the Rico afford no evidence in point, for *Seminula subtilita*, *Productus nebraskensis*, *Productus cora*, and *Chonetes glaber* range from bottom to top of the Kansas series. *Chonetes mesolobus*, however, there appears not to pass beyond the Parsons limestone (No. 6). On the other hand, in the Sinbads Valley collection, the horizon of which is supposed to be below the Rico, we have characteristic *Enteletes hemiplicatus*, which does not appear in Kansas until the Iola limestone (No. 16), and *Chonetes granulifer*, which is first seen in the Lecompton limestone (No. 22)

Among the Rico pelecypods are a few forms whose evidence may be considered. *Pseudomonotis equistriata* first appears in Kansas in the Iola limestone (No. 16), *Pseudomonotis hawni* in the Eskridge shales (No. 37), and *Pseudomonotis kansasensis* in the Garrison formation (No. 39). *Myalina subquadrata*, like *Pseudomonotis equistriata*, is introduced in the Iola (No. 16), and *Bulimorpha chrysalis*, like *Pseudomonotis hawni*, in the Eskridge shales (No. 37).[c]

The absence of *Bakewellia* is to be noted in the Rico fauna, which should hardly be correlated with the top of the Kansas section (Marion formation), nor yet with its

[a] U. S. Geol. Surv., Twenty-first Ann. Rept., pt. 2, 1900, pp. 15–165.

[b] Jour. Geol., vol. 3, 1895, pp. 682–705 and 764–800. Geol. Soc. Am., Bull., vol. 6, 1895, pp. 29–54. Jour. Geol., vol. 5, 1897, pp. 1–16, 148–172. Kansas Univ. Quart., vol. 6, pp. 149–175, 1897.

[c] The range of species in the Kansas section can not be regarded as completely known, and the statements above are only approximations.

very base. I feel little disposed to defer the evidence of other species to *Chonetes mesolobus*, though the range of the latter in Kansas is confirmed by many observations. Compromising the somewhat conflicting evidence of the Rico genera and species and holding in view that of the Hermosa fauna, I think that the age of the Rico can hardly be earlier than the Iola limestone (No. 16) nor older than the Eskridge shales (No. 37). I am disposed to think that its age is somewhat intermediate between these two limits, or about the horizon of the Deer Creek, Hartford, and Howard formations, though this opinion is set down with diffidence and with a realization of the very slender evidence upon which it rests.

Comparison between the faunas of Colorado and those of the Mississippi Valley with a view to correlation presupposes that both areas were connected with the same zoological basin, so that the same faunas had access to each simultaneously. The occurrence in Colorado of so many species identical with those in the Mississippi Valley leaves little doubt that this was the case. If land existed in Colorado during Upper Carboniferous time, or between Colorado and the Mississippi Valley, it could hardly have been sufficiently extensive to form a barrier to the migration of species from one to the other, or to shut off either area so that it was subjected to peculiar conditions checking or diverting the course of faunal evolution.

DESCRIPTIONS OF SPECIES.

Many works dealing with the geology of Colorado contain lists of fossils varying in extent and in the degree of care with which they appear to have been prepared, and the evidence thus conveyed I have used as far as it seemed safe and as far as it bore upon my subject.

Believing, however, that contradictions result from compilations of lists of species made by different individuals at different times, I shall employ in this portion of my discussion only such evidence in the way of collections of fossils as has come under my own observation. Deserving somewhat different consideration are those works of paleontologic rather than geologic character which carry authority for the identifications made in them in the shape of descriptions and illustrations of species. In works of this sort the following species have been cited from Colorado: *Euphemus subpapillosus*,[a] *Prismopora triangulata*,[b] *Lophophyllum profundum* var. *sauridens*,[c] *Marginifera muricata*,[d] *Cleiothyris orbicularis*,[e] *Euconispira taggarti*,[f] *Patellostium ourayense*,[g] *Myalina cuneiformis*,[h] *Seminula subtilita*,[i] and *Eumetria woosteri*.[j]

Of these citations the original material in most cases has come under my observation and is included in the discussion of species and of faunal evidence. The originals of *Lophophyllum profundum* var. *sauridens*, *Cleiothyris orbicularis*, and *Seminula subtilita*, however, have not come to hand. The two latter I have recognized in Colorado, though not from the locality of original citation. *Lophophyllum profundum* also I have cited from the State, though not the variety *sauridens*, which may, however, be included in the material referred to the central form.

[a] As *Bellerophon subpapillosus* from northwestern Colorado. White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, 1880, p. 138, pl. 34, fig. 3a.

[b] As *Ptilodictya triangulata* from Yampa Plateau, northwestern Colorado. White, op. cit., p. 131, pl. 33, figs. 3a–e.

[c] As *Lophophyllum proliferum* var. *sauridens* from Rock Creek, Lake County, Colo. White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, 1877, p. 101, pl. 6, figs. 4a–d.

[d] As *Productus muricatus* from Rock Creek, Lake County, Colo. White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, 1877, p. 120, pl. 8, figs. 4a–c.

[e] As *Spirigera planosulcata* from Rush (probably misprint for Rock) Creek, Lake County, Colo. White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, 1877, p. 143, pl. 10, figs. 5a–d.

[f] As *Pleurotomaria taggarti* from near Horseshoe Mountain, South Park, Colorado. Meek, U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, 1874, p. 231.

[g] As *Bellerophon ourayensis* from Ouray, Colo. Gurley, New Carb. Foss., Bull. No. 2, 1884, p. 8.

[h] From Ouray, Colo. Gurley, New Carb. Foss., Bull. No. 1, 1884, p. 4.

[i] As *Athyris subtilita* from the Sierra la Plata. Newberry, U. S. Expl. Exped. from Santa Fe to Grand and Green rivers, 1876, p. 138.

[j] As *Retzia woosteri* from 18 miles north of Greeley. White, U. S. Geol. Geog. Surv Terr., Bull., vol. 5, 1879, p. 215

MISSISSIPPIAN SPECIES.

PROTOZOA.

In the Aspen monograph Spurr cites[a] a number of foraminiferal genera from the upper portion of the Leadville limestone of that region. These as determined by Mr. Bagg include *Endothyra* sp., *Nodosinella* sp. near *N. priscilla* Dawson, *Textularia* sp. similar to *T. gibbosa*, *Bigenerina* sp., *Valvulina* sp., and *Lagena* sp. near *L. parkerina*.

It is of interest to find so large and varied a fauna of this character in the Mississippian, and it may be mentioned in this connection that in 1899 I cited a small variety of *Endothyra* in a similar faunal association from the Madison limestone of Yellowstone National Park.

None of the fossils mentioned by Spurr have come under my observation.

Locality and horizon.—Leadville limestone; Aspen, Colo.

CŒLENTERATA.

ZAPHRENTIS Rafinesque, 1820.

ZAPHRENTIS TANTILLA Miller.

1891. *Zaphrentis tantilla.* Miller, Adv. Sheets Geol. Surv. Indiana, 17th Rept., p. 11, pl. 1, figs. 23, 24.
Chouteau limestone: Near Sedalia, Mo.

1892. *Zaphrentis tantilla.* Miller, Geol. Surv. Indiana, 17th Rept., p. 621, pl. 1, figs. 23, 24.
Chouteau limestone: Near Sedalia, Mo.

1895. *Zaphrentis tantilla.* Keyes, Missouri Geol. Surv., vol. 4, p. 111. (Date of imprint, 1894.)
Kinderhook limestone: Sedalia, Mo.
Burlington limestone: Louisiana and Hannibal, Mo.

These pretty little corals seem to be nearer to a form from the Chouteau limestone to which Miller gave the name *Zaphrentis tantilla* than to any other of our American species.

In shape they are conical, elongate, moderately curved. A few constrictions of growth can sometimes be observed, but usually the form is smooth and tapering. Externally this species is distinguished by its small size and its regular and slender shape. It scarcely ever attains a diameter of over 10 mm., and more often it is only 5 or 6 mm. The greatest observed length is 17 mm., and in this instance the diameter was only about 7 mm. In an example of 10 mm. diameter there are about 32 primary septa whose expanded inner ends unite to form a thick wall about the rather large fossula. The latter is centrally situated, but extends to the corallum wall and contains at least one septum. The septa are thickened at their outer ends also and cemented into a massive stereoplasmic wall. The thickened ends and the free inter-

[a] U. S. Geol. Surv., Mon., vol. 31, 1898, p. 29.

mediate portion divide each septum into three nearly equal parts. Embedded in the thick outer wall appear to be small secondary septa, but these do not project into the central cavity. There are a few dissepimental plates developed.

It will be recalled that *Z. tantilla* has 24 septa at a diameter of 0.1 inch, but in a larger specimen there are said to be 30. In this respect, therefore, the Colorado form is fairly representative, but it may show some difference in the character of the fossula and in the matter of the secondary septa.

Locality and horizon.—San Juan region (stations 2379, 2384); Ouray limestone. Crested Butte district (stations 2351, 2352, 2353, 2355, 2358); Leadville limestone.

ZAPHRENTIS? sp. *a*.

I am prevented by the fragmentary character and small amount of the material representing this species from identifying or giving a full description of it. The shape is elongate conical and the curvature slight. It is sometimes marked by strong concentric furrows. The largest fragment seen measures over 30 mm. in diameter. There are from 40 to 50 septa, which are of equal length and reach nearly, though probably not quite, to the center. Their inner portions are thick, but near the periphery they suddenly become more slender. At this point also they are usually united by sheets of massive dissepimental tissue which, appearing nearly simultaneously, form a more or less continuous circular wall. Between this and the epitheca, which is thin and delicate, the septa and dissepiments are also thin. Dissepimental tissue is fairly abundant. The fossula is strongly marked, though not large. In one instance at least it seems to be completely surrounded by the bent ends of the adjacent septa, and it usually contains one or two of the septa within it. The effect of the structures above described is to produce two zones, the inner one characterized by the massive nature of its structures; the other by their delicacy. As a result, the outer zone is often more or less broken away. Specimens occur in three conditions, some being entire, some retaining only the massive central portion, about which in others a more or less incomplete zone of the finer tissue without its outer wall is preserved. In fact, in one specimen all three states can be observed. Where only the inner zone remains (a condition in which it might easily be mistaken for a complete coral), a free specimen is seen to be covered with numerous saucer-shaped facets or, as it were, inverted blisters.

I can hardly think that this coral is a proper representative of *Zaphrentis*, but am uncertain where to refer it. It has points in common with *Campophyllum* and is possibly related to that genus.

Locality and horizon.—San Juan region (stations 2379, 2381); Ouray limestone. Crested Butte district (stations 2352, 2353); Leadville limestone. Aspen district (stations 2362, 2363); Leadville limestone.

Zaphrentis? sp. *b*.

At Leadville (station 2374) occurs a form which is certainly a zaphrentoid coral, but regarding whose affinities it is impossible to affirm anything definite, so little in the way of structure, beyond the mere presence of septa, being discernible. In general form these corals are nearly straight and exhibit extreme inequalities of growth. The greatest diameter found in our material is 12 mm., and the length must have been 30 mm. or more. The number of septa I have not been able to ascertain.

Locality and horizon.—Leadville district (station 2374); Leadville limestone.

Zaphrentis? sp. *c*.

This is the *Axophyllum rudis* of White.[a] As the impression is that of the outside of the corallum, preserving only the shape, neither the genus nor the species can be ascertained.

Locality and horizon.—Pebbles of Millsap limestone (?) in the Red Beds conglomerate, Larimer County (station 2364).

MENOPHYLLUM Milne Edwards and Haime, 1850.

Menophyllum ulrichanum n. sp.

Pl. I, figs. 1, 2.

1900. *Streptelasma* sp. (pars) Girty, U. S. Geol. Surv., Twentieth Ann. Rept., pt. 2, p. 38.
Ouray limestone: Durango quadrangle (not Crested Butte region), Colorado.

At several localities in the Mississippian strata of southwestern Colorado a well-characterized zaphrentoid coral occurs in considerable abundance. A somewhat careful search amongst our series of American forms has only led to the conviction that the species is as yet an undescribed one. Its generic affinities seem to be clearly with the genus *Menophyllum*. Several years ago I described from Yellowstone National Park a species of *Menophyllum* whose horizon can not be far different from that to which the Colorado specimens belong. *Menophyllum excavatum* is, up to the present, the only member of the genus known from American strata; nevertheless, the descriptions of some of the forms referred to *Zaphrentis* are such as to warrant the suspicion that they really belong to the less common type. *Menophyllum ulrichanum* differs from *M. excavatum*, as it differs from most of the American species of *Zaphrentis*, in the large number of its septa. With due consideration to its smaller size, it may be said to rival in this regard *Zaphrentis multilamella*, *Z. stansburyi*, and *Z. excentrica*, all which forms, it will be remembered, are peculiar to our Rocky Mountain faunas.

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[a] U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, 1879, p. 215.

Menophyllum ulrichanum may be described as follows: Corallum simple, turbinate, small, rapidly expanding, and rather strongly curved. Marked by numerous irregularities of growth, resulting in concentric expansions and constrictions. The principal septa are thin and about 48 in number. There are smaller secondary septa alternating with them, which are, however, not to be observed below the calice. The septa below the calyce are so thickened with stereoplasma as to form a nearly solid mass, and the constituent rays on this account can there scarcely be counted. Dissepimental tissue and tabulæ appear to be entirely wanting. The principal fossette is large and joins the convex side of the corallum. The secondary fossulæ are much smaller, but the tripartite arrangement of the septa is a distinctly marked character. There are 13 principal septa in the divisions on either side of the principal fossette and 22 in the division directly opposite it. The numbers here given, as well as the total number cited above, are derived from the calycinal cast figured on Plate I. In other examples of no greater size the number of septa developed, both primary and secondary, is fully one-fourth greater than in this example. There seems to have been a solid (?), elevated, concentric platform in the center of the calice into which the principal fossula was deeply and strongly excavated. The corallum walls on the inside between the septa seem to have had a finely and regularly pitted surface, as is seen from the pustulose edges of a siliceous internal cast (fig. 2) of the calice of a specimen belonging to this species.

M. ulrichanum is smaller than *M. excavatum*, more rapidly expanding and more strongly curved. It also differs in the much greater number of its principal septa.

Simpson has recently described two genera of Zaphrentoid corals which appear to be closely allied to *Menophyllum*. I refer to *Meniscophyllum* and *Triplophyllum*. The resemblance is so strong, in fact, as to suggest that the latter, if not the former, is a synonym for Edwards and Haime's genus.

I avail myself of this opportunity to rectify an error into which I fell in the course of describing the Devonian fauna of the Ouray limestone, the only one which it was at that time known to contain.

Corals were obtained from the Ouray limestone at two stations. At one of these in the Crested Butte quadrangle (Gunnison 145a) they were found associated with the characteristic Ouray fauna. The other station was in the Durango quadrangle and the horizon occurred at the top of the Ouray limestone. In this case these fossils were found by themselves, unassociated with other species. Not knowing at that time that the upper portion of the Ouray limestone, locally at least, represented Mississippian time and contained a characteristic fauna of that age, I included these fossils in the Ouray fauna. I furthermore included those from both localities under a single heading as *Streptelasma* sp., failing to observe differences which are clearly seen on reexamination. The specimens from the top of the Ouray from the locality on the east side of the Animas River, then called Durango 286, but now cited as station 2388, can be referred with little doubt to the species just described as *Menophyllum ulrichanum*.

The brief description accompanying the title *Streptelasma* sp., while based mainly upon the coral belonging to *Menophyllum ulrichanum*, unfortunately includes characters possessed by both species, and as a whole it will apply to neither. The only feature recorded from the Devonian form is that of the septa meeting in the center and being twisted. The other form possesses the characters of *M. ulrichanum* as cited above. The number of septa is greater than in the specimen figured on Pl. I, but it is not greater than in other characteristic examples. The number cited in the earlier reference is from 60 to 64, and there is an almost equal number of secondary septa.

The Devonian species is a larger and more slender form with perhaps 34 septa which are differently arranged from those of *M. ulrichanum*. Dissepimental tissue and tabulæ are developed in moderate degree. This form would, I believe, better be placed with *Zaphrentis*.

Locality and horizon.—San Juan region (stations 2379, 2382, 2384, 2386, 2388); Ouray limestone.

SYRINGOPORA Goldfuss, 1826.

Syringopora aculeata Girty.

1899. *Syringopora aculeata*. Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 509, pl. 67, figs. 5*a*, 5*b*. Madison limestone: Yellowstone National Park.

The material presented does not retain its structures for satisfactory study, but in the size of the corallities, mode of growth, and such few characters as are available, the fossils from Colorado agree with the types.

Locality and horizon.—Crested Butte district (station 2359); Leadville limestone. Aspen district (station 2363); Leadville limestone. Salida region (station 2260); Leadville limestone.

Syringopora surcularia Girty.

1899. *Syringopora surcularia*. Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 510, pl. 67, figs. 4*a*, 4*b*. Madison limestone: Yellowstone National Park.

Several large fragments of this form were collected at Salida (station 2358) and a small one at Crested Butte (station 2360). The structures in both cases are poorly preserved, but the specimens probably belong to the species cited above.

A specimen from the Rico region (station 2381) referred to *S. surcularia* occurs as external casts in chert. The corallites have a diameter of about 2.5 mm., and much resemble those of *S. surcularia*, but of course, strictly speaking, they are indeterminable. The surface is shown to be prettily marked with delicate growth lines.

Possibly the fossil referred to among the Upper Carboniferous forms as *Syringopora* sp. belongs to *S. surcularia.*

Locality and horizon.—San Juan region (station 2381); Ouray limestone. Crested Butte district (station 2358); Leadville limestone. Salida region (station 2260); Leadville limestone.

ECHINODERMATA.

RHODOCRINUS Miller, 1821.

Rhodocrinus sp.

Although the stems and plates of crinoids are by no means rare in the Lower Carboniferous limestones and cherts of the San Juan region, only a single complete specimen has come to hand. This was obtained from a locality in the Engineer Mountain quadrangle and probably belongs to the genus *Rhodocrinus.* It is preserved as a cast (external and internal), but the definition of the plates is poorly shown, and their number and arrangement has not been made out. I have been unable to ascertain the exact specific relationship of this crinoid, but it appears to belong in the same group as *Rh. kirbyi.* The height is about 14 mm. and the diameter 11 mm. The general shape was cylindrical, the base and top being nearly flat, and the lateral surfaces normal to them. The lateral and upper surfaces were ornamented with knobs and prominent protuberances.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

PLATYCRINUS Miller, 1821.

Platycrinus sp.

In the Engineer Mountain quadrangle (stations 2382 and 2385) occur several convex subpyramidal plates, the largest having a diameter of 10 mm., which are probably the basal plates of some unidentified species of *Platycrinus.*

Locality and horizon.—San Juan region (stations 2382 and 2384); Ouray limestone.

BRYOZOA.

FENESTELLA Lonsdale, 1839.

Fenestella sp.

Portions of fronds of fenestelloid bryozoa are not uncommon in the material collected in the San Juan region. They are, however, fragmentary and poorly preserved. At least three forms have been discriminated, and though I have not ventured to identify them definitely, the species are mentioned with which they seem to be nearly related.

One of these, which occurs at station 2382 and probably also at station 2385, is allied to *F. serratula* Ulrich. It is characterized by its regular, fine mesh, and in this regard has about the proportions of the latter species, but seems to differ in having the dissepiments nearly as large as the branches, and not depressed, as they are represented in the figures of the type specimens. The fenestrules are subrectangular and somewhat longer than wide. The reverse side is covered with strongly elevated pustules on both branches and dissepiments. There are from 5 to 6 zoœcia opposite two fenestrules.

Another form, one whose closest allies I am unable to point out, is found at station 2382, and probably also at station 2386, where it is abundant. The branches divide frequently so that the fenestrules are of unequal size. Their shape is elliptical, with length about twice the breadth, to nearly circular. There are about 11 in the space of 10 mm. The dissepiments are nearly as wide as the branches themselves, and both seem to lack ornamentation of any kind. The zoœcia are small and numerous, about 4 occurring opposite each fenestrule. When compared with the species last described, this one is larger and coarser, without the pustules with which the surface of the other is covered, and with comparatively smaller and more numerous zoœcia.

There is also a third species which seems to be intermediate between *F. limitaris* and *F. filistriata*. It is represented by an external cast of the reverse side, which shows the surface to be ornamented with delicate but sharp striæ. The fenestrules are rectangular in shape, three or four times as long as wide, and with some 8 or 9 in a space of 10 mm. The dissepiments are much more slender than the branches. This species also occurs at station 2382.

Locality and horizon.—San Juan region; Ouray limestone.

BATOSTOMELLA Ulrich, 1890.

Batostomella sp.

In the San Juan region a few imperfect specimens were obtained which probably can be referred to the genus *Batostomella*. The material is so poor that no specific identification is suggested.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

FISTULIPORA McCoy, 1849.

Fistulipora? sp.

From the cherts at station 2382 in the San Juan region a specimen was obtained showing, as an external cast, a large ramose zoarium of what was probably a fistuliporoid bryozoan. It is of course indeterminable.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

BRACHIOPODA.

RHIPIDOMELLA Oehlert, 1891.

RHIPIDOMELLA PULCHELLA Herrick.

1888. *Orthis vanuxemi* var. *pulchellus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 38, pl. 5, fig. 9.
Waverly group: Licking County, Ohio.

1895. *Orthis vanuxemi* var. *gracilis.* Herrick, Geol. Surv. Ohio, Rept., vol. 7, pl. 21, fig. 9.
Kinderhook: Granville, Ohio.

1899. *Rhipidomella michelini.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 521.
Madison limestone: Yellowstone National Park.

This is a small, poorly characterized form, not materially different from several other representatives of the genus, and it may perhaps include what are only small or immature examples of some of the larger species such as *Rh. oweni.* All of my specimens, however, are small, rarely exceeding 15 mm. in greatest diameter. They are often somewhat transverse. The striation is very fine (about 20 striæ in the space of 5 mm.) and appears to be tubulose and spinose. A form which is believed to be the same occurs in the Madison limestone of Yellowstone National Park, and I at one time identified it as *Rh. michelini.* A similar and probably identical species is found in the Cuyahoga shale of northern Ohio, and to a closely related, if not identical form, occurring at a somewhat higher horizon in central Ohio, Herrick has given the name *Orthis vanuxemi* var. *pulchella*, which I have adopted for the Colorado form under discussion.

Locality and horizon.—San Juan region (stations 2379, 2382, 2384, 2385); Ouray limestone. Crested Butte district (station 2358); Leadville limestone.

ORTHOTHETES Fischer de Waldheim, 1829.

ORTHOTHETES INÆQUALIS Hall.

1858. *Orthis inequalis.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 490, pl. 2, figs. 6*a–c*.
Chemung group: Burlington, Iowa.

1865. *Streptorhynchus inequalis.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 117.
Marshall group: Weymouth, Medina County, Ohio, 80 feet below conglomerate.

1870. *Hemipronites inequalis.* Winchell, Am. Phil. Soc., Proc., vol. 11, p. 251.
Waverly group: Newark and Granville, Ohio; near Shafers, Pa.

1877. *Streptorhynchus equivalvis.* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 252, pl. 4, figs. 1, 2.
Waverly group: Ogden and Logan canyons, Utah.

1883. *Streptorhynchus æquivalvis.* Hall, Rept. New York State Geol. for 1882, pl. (11A) 42, figs. 20–23.
Waverly group: Burlington, Iowa.

1892. *Orthothetes inæqualis.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 9A, figs. 20–23.
Kinderhook group: Burlington, Iowa.

1899. *Orthothetes inæqualis*. Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 522, pl. 68, fig. 3a.
Madison limestone: Yellowstone National Park.

1900. *Orthothetes inæqualis*. Weller, Acad. Sci. St. Louis, Trans., vol. 10, p. 66, pl. 1, fig. 18.
Chonopectus sandstone: Burlington, Iowa.

1901. *Orthothetes inæqualis*. Weller, Acad. Sci. St. Louis, Trans., vol. 11, p. 159, pl. 14, figs. 16–18.
Kinderhook: Bed 4, Burlington, Iowa.

1901. *Orthothetes inæqualis?*. Weller, Acad. Sci. St. Louis, Trans., vol. 11, p. 195, pl. 19, fig. 9.
Kinderhook: Bed 7, Burlington, Iowa.

The material representing *Orthothetes* in the San Juan region, recently added to our collections, far exceeds in quantity all that had been previously obtained from other portions of the State, and of course, though often fragmentary, offers a much more complete presentation of the specific characters. I believe that I am safe in referring all of this material to the same species. Nevertheless, because of its scanty representation in all the areas but one, each set of specimens will be considered separately.

In the San Juan region, as just intimated, the form seems to be rather plentiful at a number of localities. I feel little hesitation in expressing the opinion that it is the same species which, in studying the fauna of the Madison limestone (of Yellowstone Park) I referred to *Orthothetes inæqualis*. The form is of medium size, transversely semicircular, with subquadrate cardinal angles. The dorsal valve is moderately inflated, the ventral slightly concave or nearly plane. The ventral area, which is not very high, makes a more or less acute angle with the general surface of the valve. The ventral beak is small and ill defined, but produces in the cardinal outline a broadly obtuse-angular shape. The surface is crossed by numerous, very slender radiating striæ, the spaces between which, considerably wider than the elevations themselves, are traversed by delicate concentric striæ. The radiating striæ vary considerably in coarseness, but usually show a pretty regular alternating inequality, especially on the lower areas of the shell. The number of striæ varies in different individuals from 9 to 14 in 5 mm., depending somewhat upon the part of the shell in which the measurement is taken. The same range of variation occurs in Yellowstone Park, and as it can frequently be found at one locality with the intermediate conditions abundantly represented, this character does not, in my judgment, furnish a satisfactory basis for subdivision into species or even varieties in this case. In the matter of size a transverse diameter of 40 mm., though not infrequent, is above the average.

From the Crested Butte region there is only a single specimen, an imperfect external cast of a ventral valve. It differs from characteristic specimens of *Derbya crassa* in being much larger and having the striation finer and somewhat less alternating. It agrees in all the characters preserved with *Orthothetes inæqualis* as seen in specimens from the Madison limestone.

The only specimen observed in the Leadville region consists of an imperfect external cast of a ventral valve. The generic position of this shell can not of course be exactly determined. Comparing the surface ornamentation with that of *Derbya crassa*, it is seen to be more finely striate; the striæ are not so strikingly alternating, and seem not to be crossed by strong concentric crenulations. So far as these characters are exhibited, it agrees with the shell from the Crested Butte region (station 2356) identified as *Orthothetes inæqualis*, and it may readily belong to the same species.

The conformation of the valve is similar to that of *Derbya kaskaskiensis*, but the striation is finer and less alternating than in the prevailing form of the Chester species. I can discover no intrinsic reason for holding it separate from the other forms referred to *Orthothetes inæqualis*.

The only specimen representing this species from the Larimer County locality (station 2364) is an impression of an internal cast of the dorsal valve. It can not, of course, be determined whether this form is an *Orthothetes* or a *Derbya*. As far as the material permits one to judge, it might be referred with almost equal propriety to either *Orthothetes inæqualis* or *Derbya kaskaskiensis*. *Derbya crassa*, with which White[a] identifies it, is distinguished from the Mississippian species just mentioned, among other differences, by the character of the concentric crenulations, which are stronger and more crowded. This feature, however, is not preserved in the impression before me, but there is a marked difference between the internal structural characters shown by this impression and those possessed by the specimens of *D. crassa*, which are illustrated by Meek[b] and by White.[c] It seems improbable, therefore, that this impression is that of a specimen of *Derbya crassa*, and as it does not differ materially from characteristic representatives of *Orthothetes inæqualis* from the Rico region and from Yellowstone National Park, I have referred it provisionally to that species.

Our material from Canyon consists of two small internal casts, both probably of dorsal valves. If a *Derbya*, they would probably be nearest related to the common *D. crassa*, but the hinge plate, the impression of which is retained in the better specimen, is less powerful and somewhat differently formed. In this particular it is similar to the impression from Larimer County (station 2364), but it is more finely striated and much smaller. In its size, which is but 18 mm. in transverse diameter, shape, and surface characters, though imperfectly shown, this form rather strongly recalls *Orthothetes lens*, but here again the cardinal structures are in disagreement, chiefly in the matter of the socket plates, which are nearly parallel to the cardinal line in one case, but which in typical *O. lens* are directed to it at an angle of about 45°. On the whole it seems less likely that this form is a *Derbya* and related to *D.*

[a] U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, 1879, p. 215.
[b] U. S. Geol. Surv. Nebraska, etc., 1872, pl. 5, fig. 10*b*.
[c] Indiana, Dept. Geol. Nat. Hist., Thirteenth Rept., 1884, pl. 26, figs. 9, 11.

crassa and *D. kaskaskiensis* than that it is allied to *Orthothetes inæqualis*, and I am prepared to believe that it is probably conspecific with the strophomenoids from the Rico, Crested Butte, and other areas.

Locality and horizon.—San Juan region (stations 2379, 2381, 2382, 2384, 2385); Ouray limestone. Crested Butte district (station 2356); Leadville limestone. Leadville district (station 2377?); Leadville limestone. Canyon (station 2366?); Millsap limestone. Castle Rock quadrangle (station 2367?); Millsap limestone. Pebbles of Millsap limestone (?) in the Red Beds conglomerate, Larimer County (station 2364).

CHONETES Fischer de Waldheim, 1830.

CHONETES ILLINOISENSIS Worthen.

1858. *Chonetes logani.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 598, pl. 12, figs. 1*a–e*, 2. (Not *C. logani* N. and P., 1855.)
Burlington limestone: Burlington, Iowa; Quincy, Ill.

1860. *Chonetes illinoisensis.* Worthen, Acad. Sci. St. Louis, Trans., vol. 1, p. 571.
Crinoidal Mountain limestone: Quincy, Ill.

1863. *Chonetes illinoisensis.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 5.
Yellow sandstone and Burlington limestone: Burlington, Iowa.

1865. *Chonetes illinoisensis.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 116.
Marshall group: Rockford, Ind.; Licking County, Ohio.
Burlington limestone: Burlington, Iowa.

1868. *Chonetes illinoisensis.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 3, p. 505, pl. 15, figs. 8*a*, *b*.
Burlington limestone: Jersey County, Ill.; Burlington, Iowa.
Kinderhook group: Wassonville, Iowa.

1870. *Chonetes illinoisensis.* Winchell, Am. Phil. Soc., Proc., vol. 11, p. 251.
Waverly group: Rockville, Ohio.

1877. *Chonetes loganensis.* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 253, pl. 4, fig. 9.
Waverly group: Logan Canyon, Wasatch Range, Utah.

1888. *Chonetes illinoisensis.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 35, pl. 3, fig. 21.
Waverly group: Licking County, Ohio.

1890. *Chonetes illinoisensis.* Herrick, Geol. Soc. Am., Bull., vol. 2, p. 48, pl. 1, fig. 16.
Keokuk: Scioto County, Ohio.

1895. *Chonetes illinoisensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 53. (Date of imprint, 1894.)
Lower Burlington limestone: Louisiana and Ash Grove, Mo.

1899. *Chonetes illinoisensis.* Weller, Acad. Sci. St. Louis, Trans., vol. 9, p. 15, pl. 4, fig. 10.
Vermicular sandstone: Northview, Webster County, Mo.

1899. *Chonetes loganensis.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 525, pl. 68, figs. 5*a* to 5*c*.
Madison limestone: Yellowstone National Park.

1900. *Chonetes illinoisensis.* Weller, Acad. Sci. St. Louis, Trans., vol. 10, p. 67, pl. 1, fig. 14.
Chonopectus sandstone: Burlington, Iowa.

1901. *Chonetes* sp. cf. *C. illinoisensis.* Weller, Acad. Sci. St. Louis, Trans., vol. 11, p. 151.
Kinderhook: Bed 3, Burlington, Iowa.

In a discussion of *Ch. loganensis* based upon specimens from the Madison limestone of Yellowstone Park, I called attention to the almost exact correspondence between that species and one which had previously been described under the name of *Ch. illinoisensis*, but nevertheless retained Hall and Whitfield's name. I had not, nor have I now, any doubt of the identity of these two species, and have here definitely thrown into synonymy the name proposed for the Utah representatives.

The material from Colorado, though not very plentiful or well preserved, is referred to this species with considerable confidence.

Locality and horizon.—San Juan region (stations 2379, 2381); Ouray limestone.

PRODUCTELLA Hall, 1867.

Productella concentrica Hall.

1857. *Productus concentricus.* Hall, New York State Cab. Nat. Hist., 10th Rept., p. 180.
Chemung sandstone: Burlington, Iowa.

1858. *Productus shumardianus* (pars). Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 499, pl. 7, fig. 1 (not pl. 3, fig. 9).
Chemung group: Burlington, Iowa.

1858. *Productus concentricus.* Hall, Geol. Surv., Iowa, vol. 1, pt. 2, p. 517, pl. 7, fig. 3.
Chemung group: Burlington, Iowa.

1860. *Productus cooperensis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 640.
Chouteau limestone: Cooper County, Mo.

1862. *Producta concentrica.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 411.
Marshall group: Pointe Aux Barques, Mich.

1865. *Producta concentrica.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 114.
Marshall group: Northern and southern Michigan; Burlington, Iowa; Rockford, Ind.

1865. *Producta cooperensis.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 115 (not Winchell, 1870).
Bed No. 1: Burlington, Iowa.

1869. *Producta concentrica.* Winchell, Safford's Geol. Tennessee, p. 443.
Shales just above Black Shale: Hickman and Maury counties, Tennessee.

1870. *Producta concentrica.* Winchell, Am. Phil. Soc., Proc., vol. 11, p. 249.
Waverly group: Tennessee; Sciotoville, Ohio.

1883. *Productella shumardiana.* Hall, Rept. New York State Geol. for 1882, pl. (17) 48, fig. 7.
Sandstone: Burlington, Iowa.

1888. *Productus concentricus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 33, pl. 6, fig. 16.
Waverly group: Licking County, Ohio.

1888. *Productus (Productella) shumardianus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 32, pl. 7, fig. 18; pl. 12, figs. 6, 43.
Waverly group: Licking County, Ohio.

1892. *Productella shumardiana.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 17, fig. 7.
Yellow sandstone: Burlington, Iowa.

1899. *Productella concentrica* ? Weller, Acad. Sci. St. Louis, Trans., vol. 9, p. 17.
Vermicular sandstone: Northview, Webster County, Mo.

1899. *Productella cooperensis.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 528, pl. 68, figs. 8*a*–8*c*, 9*a*, 9*b*.
Madison limestone: Yellowstone National Park.

1901. *Productella concentrica.* Weller, Acad. Sci. St. Louis, Trans., vol. 11, p. 184, pl. 16, figs. 12–14.
Kinderhook: Bed 6, Burlington, Iowa.

There are but two specimens in our collections from Colorado which represent this species, both of them small and imperfect. They are not referred without reservation to *Productella concentrica*, for lack of conclusive evidence, but at the same time I know of no reason for mistrusting the identification.

In discussing the synonymy of this species in 1896 I expressed the opinion that *Productella shumardiana* and *P. concentrica* are distinct, but that the former is probably identical with *P. pyxidata.* Some ambiguity is probably introduced into this utterance, and into those of Winchell and Herrick as well, from the fact that under the name *Productus shumardianus* two species were probably included by Hall. One of these is represented by figure 9 of plate 3 among the Hamilton fossils and the other by figure 2 of plate 7 among those of Chemung age. The former was obtained from Clarksville, Mo., and the latter from Burlington, Iowa. It matters not that Hall was in error in regard to the age of these fossils. They came from very different localities and from somewhat different horizons. In the case that these two forms thus differently derived are, as an inspection of the figures would lead one to believe, specifically different, I propose to restrict the name *P. shumardiana* to the Clarksville form, which is the first figured in the plates and the first mentioned in the text. With the disposition of *P. shumardiana*, whether it is retained as a distinct form or is placed in the synonymy of *P. pyxidata* or of *P. subalata*, I am not now concerned. I believe, however, that the Burlington form of *P. shumardiana* is only a dorsal valve of a species which is described from the same place under the name of *P. concentrica.* This conclusion is one which can be absolutely vindicated only by a comparison of the types themselves. The collateral evidence, however, seems to me all but convincing, since in one case we have specimens from different localities and different horizons which excellent figures show to be different and in the other specimens from the same locality and the same horizon which excellent figures show to be the same.

The opinion is still entertained that *P. cooperensis* is a synonym for *P. concentrica* and that Winchell's identification of it from Sciotoville is based upon a distinct though related species.

Locality and horizon.—San Juan region (station 2379); Ouray limestone.

PRODUCTUS Sowerby, 1814.

PRODUCTUS SEMIRETICULATUS var.

1847. *Productus semireticulatus* (pars). De Koninck, Monog. du Gen. Prod. et Chon., p. 83, pl. 8, figs. 1*a-h*; pl. 9, figs. 1*a-m*; pl. 10, figs. 1*a-d*.

Carboniferous: Harrisville, Bagdad, Cuyahoga, Zanesville, Flint Ridge, Greensburg, and Antrim, Ohio; near Louisville, Ky.; near St. Louis and St. Charles, Mo.; Leavenworth, on the Missouri River; Long Creek, Crawfordsville, and near New Harmony, Ind.; Sparta, Ill.; Bolivia, South America.

1858. *Productus semireticulatus*. Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 637.

1863. *Productus semireticulatus*. Davidson, Geol. Soc. London, Quart. Jour., vol. 19, p. 174, pl. 9, figs. 20, 21.

Lower Carboniferous limestone: Windsor, Brookfield, Shubenacadie, East River, Debert River, Minudie, Pugwash, near Amherst, Boulardarie, Cape Breton, Horton Bluff, Grays River, etc., Nova Scotia.

1865. *Producta semireticulata*. Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 115.

Marshall group: Weymouth, Medina County, Ohio; Orange, Cuyahoga County, Ohio.

1868. *Productus semireticulatus*. Dawson, Acadian Geology, p. 296, pl. 97*a*, *b*.

Carboniferous limestone: Windsor, Brookfield, Shubenacadie, East River, Debert River, Minudie, Pugwash, near Amherst, Boulardarie, Cape Breton, Horton Bluff, Grays River, etc., Nova Scotia.

1869. *Producta semireticulata*. Winchell, Safford's Geol. Tennessee, p. 442.

Immediately above black shale: Manchester, Cannon County, Tenn.

1870. *Producta semireticulata*. Winchell, Am. Phil. Soc., Proc., vol. 11, p. 249.

Waverly group: Newark, Sciotoville, Rockville, and Vinton County, Ohio; near Shafers, Venango County, Pa.

1877. *Productus semireticulatus*. Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 267, pl. 5, figs. 5, 6.

Lower Carboniferous limestone: North of Snowstorm Hill, Dry Canyon, Oquirrh Mountains, Utah.

1878. *Productus semireticulatus*. Dawson, Acadian Geology, 3d ed., p. 296, figs. 97*a*, 97*b*.

1888. *Productus semireticulatus*. Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 31, pl. 1, fig. 26; pl. 6, fig. 11; pl. 10, figs. 6, 6*a*.

Waverly group: Licking County, Ohio.

1897. *Productus semireticulatus*. Smith, Am. Phil. Soc., Proc., vol. 35, p. 30.

Lower Coal Measures: White County, Ark.
Marshall shale: Stone County, Ark.
Fayetteville shale: Searcy County, Ark.
Boone chert: Searcy County, Ark.

1899. *Productus semireticulatus*. Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 535, pl. 69, figs. 8*a-d*.

Madison limestone: Yellowstone National Park.

1900. *Productus semireticulatus*. Weller, Acad. Sci. St. Louis, Trans., vol. 10, p. 70, pl. 1, figs. 5, 6.

Chonopectus sandstone: Burlington, Iowa.

In a report published in 1899 dealing with some Carboniferous fossils from Yellowstone National Park I recognized the cosmopolitan species *Productus semireticulatus*, several individuals of which were figured. Mention was made that the material thus identified showed a wide range of variation, some of it departing considerably from the type represented by the figures. These same varieties occur, for the most part, in the limestones of Burlington and Keokuk age in the Mississippi Valley, and have there been distinguished by different specific names. The material from the Park, being both scattered, scanty, and often fragmentary, did not lend itself to nice specific discriminations. Nevertheless, I believe that subdivisions should then have been made.

The Colorado material is still more imperfect than that from Yellowstone Park, but does not embrace as widely divergent types. At the same time, I am not confident that two species or varieties may not be present. The same form or forms are found in Yellowstone Park and in the lower Mississippian faunas of the Mississippi Valley. It is doubtful if any of these Mississippian forms, commonly identified with *P. semireticulatus*, show precise specific identity with the dominant type of the Upper Carboniferous, and at least there is nothing in the fauna of the Hermosa formation, so far as it has been brought to light, with which a critical comparison would justify identifying the fossils which form the subject of these notes.

In the matter of synonymy I have brought together all, or at least the most important citations of American Mississippian forms, not so much to imply that they are all one species, or the same as my Colorado material, but to indicate that, as I believe to be the case, these Mississippian forms are distinct from the Pennsylvanian ones.

Locality and horizon.—San Juan region (stations 2379, 2381, 2382, 2384); Ouray limestone. Crested Butte district (station 2354); Leadville limestone.

Productus parviformis Girty.

1899. *Productus parviformis.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 536, pl. 68, figs. 6*a*–6*d*. Madison limestone: Yellowstone National Park.

At one locality in the San Juan region (station 2381) occurs a form in some abundance which I believe can be safely identified with *Productus parviformis.* The only difference which I am able to point out consists in the fact that the individuals from Colorado are apt to be a trifle undersized.

Locality and horizon.—San Juan region (station 2381); Ouray limestone.

Productus cf. pustulosus Phillips.

1836. *Producta pustulosa.* Phillips, Geol. Yorkshire, vol. 2, p. 216, pl. 7, fig. 15. Mountain limestone: Bolland; Florence Court.

1857. *Productus pustulosus.* Davidson, Pal. Soc., British Carb. Brach., pt. 5, p. 168, pl. 41, figs. 1–6; pl. 42, figs. 1–4.

1857. Carboniferous limestone: In England at Bolland, Settle, Kendal, Isle of Man, Derbyshire, etc.; in Scotland at Cat Craig, near Dunbar.

Calciferous slate and Carboniferous limestone: In Ireland, Bundoran, Ballyduff, Carrigaline, Lisnapaste, Millecent, Tankardstown, Florence Court, Little Island, shores of Lough Gill, valley of the Maine, Hook, St. Doolas, near Dublin, etc.

On the Continent at Visé and Tournay, etc., in Belgium; Ratingen, in Prussia; and also in America.

Of this species there is but a single specimen, somewhat fragmentary and poorly preserved. It had previously been identified as *P. nevadensis*, but can hardly be a true representative of Meek's species. It is almost certainly of the *pustulosus* type, but strictly speaking may not belong to that species. It much resembles the form figured by Davidson on plate 42, fig. 4, of his monograph (loc. cit.). It is a rather large shell, with a distinct though not deep median sinus, crossed transversely by closely arranged, concentric corrugations, and roughened by numerous fine pustules or spine bases (?).

This species is evidently related to the species from the Madison limestone which I identified as *P. scabriculus* Martin, but seems to be specifically distinct. It is unlike any form known to occur in the Ouray limestone (Devonian) or in the Hermosa formation (Pennsylvanian).

Locality and horizon.—Aspen district (station 2362); Leadville limestone.

Productus lævicosta White.

1860. *Productus lævicostus.* White, Boston Soc. Nat. Hist., Jour., vol. 7, p. 230.

Burlington limestone: Burlington, Iowa.

1874. *Productus prattenianus* (= ? *P. lævicostus*). White, U. S. Geog. Geol. Surv. W. 100th Mer., Prelim. Rept. Invert. Foss, p. 17.

1875. *Productus prattenianus* (pars.). White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 113. (Entire volume published in 1877.)

Subcarboniferous: Mountain Spring, Lincoln County, Nev., and below Ophir City, Utah.

1877. *Productus lævicostus?* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 266, pl. 5, figs. 7, 8.

Lower Carboniferous limestone: North of Snowstorm Hill, Dry Canyon, Oquirrh Mountains, Utah.

(?) 1887. *Productus* sp.? compare *prattenianus.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 18, fig. 4.

Waverly sandstone: Newark, Ohio.

1895. *Productus lævicostus.* Keyes, Missouri Geol. Surv., vol. 5, p. 41, pl. 38, fig. 1. (Date of imprint 1894.)

Kinderhook group: Louisiana, Mo.

Burlington group: Louisiana, Mo.

1899. *Productus lævicosta.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 534, pl. 69, figs. 9*a*–9*c*.

Madison limestone: Yellowstone National Park.

1900. *Productus lævicosta.* Weller, Acad. Sci. St. Louis, Trans., vol. 10, p. 71, pl. 1, figs. 1, 2

Chonopectus sandstone: Burlington, Iowa.

In the San Juan region (at stations 2379 and 2382) occurs somewhat scantily a little *Productus* of the *cora* type which, because of its associations, I have referred to *P. lævicosta.* It resembles in every essential specimens from Yellowstone Park belonging to White's species, and is chiefly peculiar for its rarity and its small size. Twelve millimeters is the transverse diameter of the largest specimen seen, and only three or four have come to hand. Into the synonymy of this species I have introduced several references withdrawn from the Pennsylvanian species, *P. cora.* Probably several other citations of *P. cora* (or *P. pratteniamus*) from Mississippian horizons should be removed to the synonymy of this species. It is possible, however, that *Productus lævicosta* is a synonym of *P. cora.*

Locality and horizon.—San Juan region (stations 2379, 2382); Ouray limestone.

SPIRIFER Sowerby, 1815.

SPIRIFER CENTRONATUS Winchell.

1865. *Spirifera centronata.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 118.
Marshall group: Cuyahoga Falls and Akron, Ohio.

1874. *Spirifer centronata.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Prelim. Rept. Invert. Foss., p. 17.
Subcarboniferous: Mountain Spring, Old Morman road, Nevada.

1875. *Spirifer centronatus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 86, pl. 5, figs. 8*a*–8*c*. (Whole volume published in 1875.)
Subcarboniferous: Mountain Spring, Old Morman road, Nevada.

1875. *Spirifera* (*Trigonotreta*) *biplicata.* (Hall?) Meek, Pal. Ohio, vol. 2, p. 290, pl. 14, fig. 5.
Waverly group: Richfield, Ohio; Iowa.

1877. *Spirifera centronata.* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 254, pl. 4, figs. 5, 6.
Near base of Wasatch limestone (Waverly?): Dry Canyon, Oquirrh Mountáins; Logan and Ogden Canyons, Wasatch Range, Utah.

1899. *Spirifer centronatus.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 547, pl. 70, figs. 3*a*–3*d*.
Madison limestone: Yellowstone National Park.

1901. *Spirifer centronatus.* Weller, Acad. Sci. St. Louis, Trans., vol. 11, p. 163, pl. 14, figs. 3–4.
Kinderhook: Bed 4, Burlington, Iowa.

This species is more abundant than any other in the faunas from Colorado, which I regard as of Mississippian age. It occurs in abundance in the San Juan, Crested Butte, and Canyon regions, and amongst the impressions from Larimer County, but it has not yet been identified at Leadville or at Perry Park. With some exceptions the Colorado material possesses somewhat coarser ribs than that from Yellowstone Park or the specimens from Utah figured by White and by Hall and Whitfield, but it agrees with perhaps the majority of typical representatives of the species from the Cuyahoga shale of northern Ohio. The latter show a certain amount of range in this particular, quite sufficient to embrace both forms.

The variety with coarse striæ might pass without challenge for a form from the Hermosa formation which I have identified as *Sp. boonensis.*

Among the impressions from Larimer County both a coarsely and a finely striated variety can be distinguished. These specimens were identified by White[a] as *Sp. rockymontanus.* Marcou's name certainly represents a very variable type, to judge by his figures, even if it does not include more than a single species. These specimens, however, have unusually fine ribs, even for the Waverly species, and I know no *Spirifer* in the Upper Carboniferous resembling them in other respects which equals them in this. A similar form occurs in the Hermosa formation, but those shells have coarser ribs and are comparable rather to *Sp. keokuk*, *Sp. increbescens*, and the coarse variety of *Sp. centronatus.* The fine-ribbed specimens, however, are not unlike *Sp. subæqualis*, but they differ in having the sinus more sharply outlined, as well as in other particulars.

In the Crested Butte region this species occurs in relative abundance. The coarsely ribbed type predominates, and one specimen is so large and coarsely plicated that I have separated it as a distinct variety.

In the whitish cherts from near Canyon, Garden Park, and the vicinity, this species has been collected at nearly every locality and frequently occurs in great abundance. The shape varies from subquadrate to subtriangular. The hinge line is as long as the width of the shell and usually somewhat longer. There are 3 to 7 plications in the sinus, according to size, and from 12 to 17 lateral ones. The latter frequently manifest a tendency to be broad and flattened instead of sharply rounded, as is characteristic of *Sp. centronatus*, and occasionally those nearest the fold or sinus are distinctly bifurcated. Bifurcation of the lateral plications of typical *Sp. centronatus* itself is not unknown, though it is not common. The surface is marked by a system of minute radiating and concentric striæ. In most cases the concentric striæ alone can be seen, but on well-preserved specimens the radiating ones appear and they then seem to be nearly as strongly marked as the others.

The material from the San Juan region is so similar to that from the Madison limestone of Yellowstone Park, and associated with a fauna so manifestly allied to that which accompanies the latter, that I feel no doubt of their specific identity with one another or with typical *Sp. centronatus* from Ohio.

Locality and horizon.—San Juan region (stations 2379, 2381, 2382, 2384); Ouray limestone. Crested Butte district (stations 2350, 2352, 2354, 2355, 2356, 2357); Leadville limestone. Salida region (stations 2360, 2361); Leadville limestone. Canyon (stations 2366, 2370); Millsap limestone. Pikes Peak quadrangle (stations 2365, 2368, 2369, 2371); Millsap limestone. Castle Rock quadrangle (station 2367); Millsap limestone. Pebbles of Millsap limestone (?) in the Red Beds conglomerate, Larimer County (station 2364).

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[a] U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, 1879, p. 215.

SPIRIFER sp. *a*.

The only material at present in the collection which could have served as evidence for the appearance of *Spirifer rockymontanus* in the faunal list of the Blue limestone given in the Leadville monograph,[a] consists of two imperfect specimens from station 2377. They are mere fragments of external casts, consisting of a group of radiating striæ, none of the finer ornamentation having been preserved. From the curvature of the surface and the character of the plications I judge that these impressions were made by a *Spirifer*. The species is most likely of the *imbrex* type, as the latter is defined by Hall and Clarke. The sinus was very faintly bounded and elevated, and contained, if its limits are correctly ascertained, four or five plications. These are too fine and too numerous to afford much probability that this form is identical with *Sp. rockymontanus*, *Sp. keokuk*, or *Sp. increbescens*, and an exact identification is clearly impossible. The plications are no finer than in a fine example of *Sp. centronatus*, such, for instance, as one of the impressions from Larimer County, but if really belonging to the Waverly species they are particularly large specimens with plications unusually slender for the size of the shells.

Locality and horizon.—Leadville district (station 2377); Leadville limestone.

SPIRIFER sp. *b*.

In the "Blue limestone" of the Leadville region, a small *Spirifer* is found, frequently in considerable abundance. It is this form which appears in the faunal list of the Leadville monograph as *Spiriferina* sp. probably new, cf. *Sp. kentuckiensis*.[a]

The unfortunate preservation of this form renders it difficult of study, and its generic position is still somewhat uncertain. It occurs in a matrix of chert and therefore but little can be done in the way of manipulation. The shell substance has been completely removed or is otherwise so altered that it can not be told whether the structure was punctate or merely fibrous. The cavity thus left has in many cases been coated with a rusty or siliceous deposit, which often entirely obscures the superficial markings.

The shape is that of *Spiriferina* and of the *Delthyris* group of Spirifers. The shell is transverse, semicircular. The cardinal angles seem to be rounded and the hinge line is thus a little shorter than the width of the shell below. The area of the ventral valve is rather high and incurved. The fold and sinus are moderately broad and high, and are marked respectively by a median groove and ridge which can be clearly seen in most specimens. The fold and sinus are otherwise simple. The sides are marked by 5 or 6 simple strong plications. Large representatives of this species have a transverse diameter of at least 24 mm.

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 66.

In neither valve is a septum developed, and the dorsal as well as the ventral shell is furnished with dental plates. In most ventrals, though the dental plates are moderately strong, there is no trace, even, of a septum. In others, a shallow groove, which can sometimes be made out, proves that this structure was sometimes present, although insignificant. Several specimens agree in showing that the dorsal valve possessed dental plates developed to almost as great a degree as in the ventral one. No apical callosity can be seen.

The surface is practically free from radiating or concentric striæ. Sometimes varices of growth occur, and often a marginal band of varying width is marked by concentric lamellosities, but most of the surface is essentially smooth in this regard. It is, however, shown to be finely pustulose or spinose. This is clearly seen in casts of the exterior. In one specimen the holes which the spines have left in the matrix are closed by tiny plugs of rock, the shelly matter being represented by rings of white about them. This would seem to indicate that the spine was hollow. Another example, equally favorable, shows only rows of perforations. Several other specimens, while disclosing the spinose character of the surface in an unmistakable manner, do not give clear evidence as to whether the spines were solid or hollow, but the opinion resulting from a careful study of all the material is that they were hollow. In the specimen first mentioned they are arranged in alternating concentric rows, the lateral distance between any two adjacent elements in the same row being distinctly less than the diagonal distance between those in adjacent rows. Along the anterior margin, where overlapping lamellæ occur, they are more crowded and irregular. In other shells they are sometimes closely arranged and irregular, but usually a quincunx assemblage can be made out. The shape of the spines is oval or elliptical for the most part, with often a linear projection at one end or the other, and in less distinct preservation the surface of the cast looks to be traversed by very fine interrupted striæ.

The affinities of this shell are puzzling. The absence of a septum and the presence of well-developed dental lamellæ in the dorsal valve would seem to forbid its being referred to *Spiriferina* in spite of the superficial resemblance to members of that genus. If admitted into the *Spiriferina* group, however, it would, by reason of its surface, be more closely allied to *Sp. spinosa* than to the *kentuckyensis* section, but as to its specific distinctness from *Sp. spinosa* itself there can be no question. The spines are finer and more numerous, and the fold and sinus show a median groove and ridge, not to mention differences in shape and others of a like nature. But besides these superficial differences its structural ones, already pointed out, are of a sufficiently fundamental character to bar it from the genus *Spiriferina* altogether. It seems, therefore, that its place should be sought among the true spirifers. It does not, however, agree satisfactorily with any of the six divisions of *Spirifer* recognized by Hall and Clarke. It can evidently not be grouped with the *radiati* nor with the *lamellosi*, nor yet with the great group of the *aperturati*, while the *glabrati* are too unlike in every way to require consideration. However, this shell seems to show a certain parallel development in internal structure with *Martiniopsis* of the *glabrati*, as in that genus both valves possess dental lamellæ. With the *ostiolati* many points of similarity exist. "Many of the middle Devonian representatives," say Hall and Clarke,[a] "bear a low, median sulcus on the fold, which may be accompanied by a broad, very faint, indistinct plication apparent only near the anterior of the sinus." Some species have the plications covered with elongate pustules (*Sp. granulosus* and *Sp. marcyi*) or erect granules (*Sp. asper*), and in *Sp. parryanus* the minute elongate pustules are arranged upon the summits of distinct, fine, radial striæ (Hall and Clarke). Another character, which is frequently met with in this group, is the callosity developed in the apex of the delthyrium.

In general configuration the form under discussion agrees with the *ostiolati* even to the extent of showing a median groove on the fold and a corresponding elevation in the sinus, but the *ostiolati* are characteristically large and stout shells, while this is a very small one.

The surface ornamentation may be conceived to be the same, but after examining the surface of a number of the ostiolate spirifers, I am led to believe that the granules or pustules are related to the superficial layers of the shell and are solid, while in the form under comparison they are believed to be hollow. In this form the callosity characteristic of the *ostiolati* is not known to occur, nor, I believe, are there found in the *ostiolati* the dental lamellæ which seem to be a constant feature of its internal structure. The evidence, therefore, seems on the whole to separate this form from the *ostiolati*. Its affinities are, indeed, possibly closer with the *fimbriati* than with any other group. If my conclusions regarding the character of its surface tally with fact, namely, that the spines are simple and hollow, it would fall by reason of this and other characters within the *unicispinei* division of that group. It agrees in its short hinge line, spinose surface, and simple plications with the *unicispinei*, among which certain forms, as for instance *Sp. vanuxemi*, exhibit a tendency to division in the fold and sinus. Of the two subsections recognized by Hall and Clarke this species belongs undoubtedly to type *a*, or the *crispus* type, because of its strong plications. However, the surface of the *unicispinei* is closely lamellate, the lamellæ bearing fimbriæ of crowded spines, while the surface of *Spirifer* sp. *b* shows no regular concentric lamellæ, and, though the spines are in concentric rows, they are inclined to be distributed at regular and comparatively distant intervals. A structural difference of some importance consists in the dental lamellæ of the dorsal valve

[a] Pal. New York, vol. 8, pt. 2, 1894, p. 29.

of *Spirifer* sp. *b*, structures which do not occur in *Sp. crispus*, *Sp. vanuxemi*, and their allies.

On the whole it seems more probable that this form is a true *Spirifer*, a survivor, possibly, of the earlier type abundant in Silurian and early Devonian time, one which departs so far from its nearest allies, the *unicispinei*, that it can hardly with propriety be referred to the same subordinate group. Indeed, if the appearances described are real characters of the shell, and of this I have little doubt, it can only be regarded as an aberrant member of any of the groups recognized by Hall and Clarke, and should other species possessing similar characters be brought to light, I believe they would better be recognized as an independent section. The salient characters of this form which would probably apply in large measure to the whole subsection are its small size, primitive shape (like that of *Delthyris*), short hinge line, spinose surface (the spines not being mounted upon the edges of concentric lamellæ, which are in fact practically absent),[a] the absence of a septum in the ventral valve, and the presence of dental lamellæ in both valves.

The stratigraphic significance of this species depends chiefly upon which spiriferoid group it is conceived to be closest allied to. In my own view its affinities with any of the known groups of American spirifers is so remote that its bearing in that relation can not yet be estimated. In this connection attention may be called to *Sp. agelaius* Meek, which may possibly be based upon small or immature shells of this species. The similarity is not so great as to be impressive, but our lack of knowledge regarding the minutiæ of Meek's species does not permit a decision in the negative. The most closely allied species which I have been able to find, however, is a little shell from the Louisiana limestone of Missouri, described by Rowley under the name *Spirifer* or *Spiriferina aciculifera*.[b] This species also is a spine-bearer, but as its internal structures are not known no comparison with the Colorado form can be made in this direction. It is improbable that Rowley's species is a true *Spiriferina*. Rowley has recently described another little shell which is externally similar to the form from the Leadville limestone. I refer to *Spirifer schucherti*[c] which was found in the Lower Burlington limestone at Louisiana, Mo. Though a somewhat smaller form, the essential superficial resemblance is marked, but it is uncertain whether the internal characters would show an equal agreement.

In configuration this species simulates the form referred to *Spiriferina solidirostris*, though it differs from the latter in every essential particular. The two forms can usually be discriminated even superficially, however, as *Spirifer* sp. *b* has rounded cardinal angles and a more distinct median plication on the fold and sinus,

[a] The surface ornamentation evidently varies somewhat in different individuals in regard to the shape of the spines, their abundance, and arrangement, but all specimens agree in showing the essential absence of lamellose striæ as a normal system of surface ornamentation and the abundance of minute, simple, hollow spines.

[b] Am. Geologist, vol. 12, 1893, p. 307, pl. 14, figs. 13, 14.

[c] Am. Geologist, vol. 25, 1900, p. 261, pl. 5, figs. 15, 16, 17, 59.

which are also proportionately a trifle broader. In surface ornamentation, shell structure, and internal characters the two forms are widely different.

The preceding remarks are based upon abundant but unsatisfactory material from the Leadville region. There has lately come into my hands a block of chert from Perry Park, Colo., upon whose surface numerous specimens of this species occur. They are all internal casts, but present the characters superficial and structural of the Leadville form, although ranging considerably smaller in size. The lithologic appearance of these fossils from Perry Park is identically that of the the Canyon material, and at first sight the little *Spiriferina* of the latter locality might be mistaken for the small *Spirifer* of the former. Closer examination, however, shows them to be entirely distinct. Even the punctation, traces of which are distinctly preserved upon the cherty casts from Canyon, are lacking upon those from Perry Park.

Among the impressions taken at the Larimer County locality are those of two small spiriferoid shells which are believed to belong to this species, although I originally placed them with *Spiriferina solidirostris?*. As the impressions were made from external casts, their generic position is a matter of conjecture. They are of moderate size, with a transverse diameter of about 14 mm. The ventral valve is gibbous and the area appears to be high and incurved. There are six ribs each side of the median sinus, which is somewhat broad and shallow, with a small median plication. In one specimen the surface appears to be smooth, but in the other it is marked by a number of lamellose varices of growth.

Neither *Spiriferina spinosa* nor *Sp. campestris* shows a half-developed rib within the sinus, and, if the impressions belong to *Spiriferina* at all, this character would seem to ally them rather with the lamellose section of the genus. There, however, inequalities of growth in the nature of varices are comparatively rare, and these impressions also seem to show a shell without lamellose surface ornamentation. They much resemble the form from the San Juan and Crested Butte regions which I identified as *Spiriferina solidirostris*, but the median rib of the sinus is distinctly stronger, and the surface seems not to have been marked with concentric lamellæ. They are also similar to *Sp. kentuckyensis*, but are distinguished by being less sharply plicated, while the sinus is shallower and the median rib more strongly expressed, perhaps, than in that common Coal Measure species. White refers these specimens to *Spiriferina octoplicata*, which, as identified by him, I believe to be the same as *Sp. campestris* White. From that species[a] the impressions differ considerably, being less sharply plicated and having a very distinct rib in the middle of a shallower, broader sinus.

It is much more likely that the delicate spinose ornamentation of *Spirifer* sp. *b* should not have been retained upon the casts or received upon the impressions, than

[a] As identified by White at Santa Fe, etc.

that the delicate but relatively stronger ornamentation of *Spiriferina solidirostris* should have been lost. As the impressions agree with the shells referred to *Spirifer* sp. *b* in other characters, I regard their specific identity, though not certain, as still rather probable.

Locality and horizon.—Leadville district (stations 2372, 2373, 2375, 2377, 2378); Leadville limestone. Castle Rock quadrangle (station 2367); Millsap limestone. Pebbles of Millsap limestone (?) in the Red Beds conglomerate, Larimer County (station 2364).

SPIRIFER PECULIARIS Shumard?

1855. *Spirifer? peculiaris.* Shumard, Geol. Rept. Missouri, p. 202, pl. C, figs. 7*a*, *b*.
Cheming group: Chouteau Springs, Cooper County, Mo.

1874. *Spirifer* (*Martinia*) *peculiaris.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Prelim. Rept. Invert. Foss., p. 17.
Subcarboniferous: Mountain Spring, Old Mormon road, Nevada.

1875. *Spirifer* (*Martinia*) *peculiaris.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 90, pl. 5, figs. 7*a*, *b*. (Whole volume published in 1877.)
Subcarboniferous: Mountain Spring, Old Mormon road, Nevada.

1895. *Spirifera peculiaris.* Keyes, Missouri Geol. Surv., vol. 5, p. 79. (Date of imprint 1894.)
Kinderhook limestone: Chouteau Springs, Missouri.

1899. *Reticularia* (*?*) *peculiaris.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 557, pl. 70, figs. 8*a*, 8*b*.
Madison limestone: Yellowstone National Park.

1901. *Spirifer peculiaris?* Weller, Acad. Sci. St. Louis, Trans., vol. 11, p. 165, pl. 14, figs. 6–9; p. 198, pl. 20, fig. 1.
Kinderhook: Beds 4 and 7, Burlington, Iowa.

This species was described by Shumard from the Chouteau limestone of Missouri. Later it was identified by White at Mountain Spring, Old Mormon road, Nevada. I recognized it in the Madison limestone of the Yellowstone National Park region, and it also reappears in the fauna under discussion. Shumard evidently regarded his reference of this form to *Spirifer* as doubtful, and White placed it in the *Martinia* section of the genus. I referred it with a query to *Reticularia*, but in typical material from the Chouteau limestone the presence of neither septa nor dental lamellæ is indicated in either valve, in which it differs widely from our Lower Carboniferous *Reticulariae*. It certainly differs considerably from the dominant Carboniferous types of *Spirifer*, and seems to be most closely allied to *Sp. subcardiformis* and *Sp. suborbicularis*, which constitute what Hall and Clarke designate the *suborbicularis* type.

While all probably belong to the *subcardiformis* section and are with little doubt specifically identical with one another, that the forms from Nevada, Colorado, and Yellowstone Park are correctly referred to *Sp. peculiaris* I now believe to be doubtful.

At all the localities in the West at which this form has been collected it seems to be comparatively rare, and the fossils which have thus far come into my hands are few in number and not in good condition. One important distinction resides in the fact that *Sp. peculiaris* is marked as to its surface by regular, closely arranged, concentric lamellæ, while the Western specimens appear to be quite smooth. They probably constitute an undescribed species, but it seems wiser to await more abundant material before making detailed comparisons or assigning a new name. So far as the available specimens, which are very variable, are characteristic, this form can scarcely belong to *Sp. suborbicularis* or to *Sp. subcardiformis*, and in general configuration, at least, it most closely resembles *Sp. peculiaris.*

In the above remarks, wherever the Colorado material is involved, I have had in mind especially that from the Crested Butte region. From the San Juan region but two very imperfect examples have so far come to hand. One of these is so poor as to render its relation to *Sp. peculiaris* no more than a probability, while the other, though probably of the *suborbicularis* type, shows a distinct median rib in the ventral sinus, a character which I have yet observed neither in typical *Sp. peculiaris* nor in the material provisionally allowed to remain under the same name.

Locality and horizon.—San Juan region (stations 2382, 2384?); Ouray limestone. Crested Butte district (station 2358); Leadville limestone.

SYRINGOTHYRIS Winchell, 1863.

SYRINGOTHYRIS CARTERI Hall.

1857. *Spirifer carteri.* Hall, New York State Cab. Nat. Hist., 10th Rept., p. 170.
Waverly sandstone: Licking County, Ohio.

1860. *Spirifer* (*Cyrtia?*) *hannibalensis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 647.
Lithographic limestone: Marion County, Mo.

1863. *Syringothyris typa.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 7.
Base of Burlington limestone: Burlington, Iowa.

1865. *Syringothyris cuspidatus.* Meek, Acad. Nat. Sci. Philadelphia, Proc., p. 275.

1867. *Syringothyris cuspidatus.* Meek, Am. Jour. Sci., (2), vol. 43, p. 407.

1870. *Spirifera carteri.* Winchell, Am. Phil. Soc., Proc., vol. 11, p. 252.
Waverly group: Sciotoville and Rockville, Ohio; near Shafers, Pa.

1870. *Syringothyris typa.* Winchell, Am. Phil. Soc., Proc., vol. 11, p. 252.
Waverly group: Newark and Sciotoville, Ohio; near Shafers, Pa.

1875. *Spirifer carteri.* Meek (partim), Pal. Ohio, vol. 2, p. 285 (not his figures—*S. texta* Hall).
Waverly group: Ohio.

1877. *Spirifer cuspidatus?* Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 87, pl. 3, figs. 11, 11a.
Carboniferous or Devonian limestone: White Pine Mountains, Treasure Hill, Nevada.

1884. *Syringothyris cuspidata.* Walcott (not Martin), U. S. Geol. Surv., Mon., vol. 8, p. 219, pl. 3, fig. 11.
Lower Carboniferous: Eureka district, Nevada; near Clendenin, Mont.

1888. *Syringothyris cuspidatus.* Herrick (partim), Sci. Lab. Denison Univ., Bull., vol. 3, p. 41, pl. 1, fig. 7; pl. 2, fig. 17 (not pl. 5, figs. 4–7—*S. herricki*).
Waverly group: Licking County, Ohio.

1890. *Syringothyris carteri.* Schuchert, 9th Ann. Rept. New York State Geol., p. 30.
Bedford shale: Bedford, Ohio.
Waverly sandstone: Licking County, Ohio.
Chouteau limestone: Marion and Pike counties, Mo.
Kinderhook group: Burlington, Iowa.
Burlington group: Burlington, Iowa.
Lower Carboniferous: White Pine Mountains, Richmond Mountain, Eureka district, Nevada; near Clendenin, Mont.

1893. *Syringothyris typa.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 8, 48, 50; fig. 40 on p. 48; pl. 26, figs. 6, 7, 10; pl. 27, figs. 1–3. (Advance distribution in fascicles.)
Burlington limestone: Burlington, Iowa.

1894. *Syringothyris typa.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 30, figs. 1, 2.
Burlington limestone: Burlington, Iowa.

1895. *Syringothyris carteri.* Keyes, Missouri Geol. Surv., vol. 5, p. 87, pl. 40, fig. 10. (Date of imprint, 1894.)
Burlington limestone: Springfield, Mo.

1895. *Syringothyris hannibalensis.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pl. 25, figs. 33–35.
Chouteau limestone: Pike County, Mo.

1895. *Syringothyris typa.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 8, 48, 50; pl. 26, figs. 6, 7, 10; pl. 27, figs. 1–3.
Burlington limestone: Burlington, Iowa.

1899. *Syringothyris carteri.* Weller, Acad. Sci. St. Louis, Trans., vol. 9, p. 20, pl. 4, figs. 5, 6.
Vermicular sandstone: Northview, Webster County, Mo.

1899. *Syringothyris carteri.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 558, pl. 71, figs. 1*a*–1*c*.
Madison limestone: Yellowstone National Park.

So far as the characters of each can be made out, the dorsal valve of this shell agrees with what may be regarded as typical specimens of *S. carteri*, but the ventral valve seems to be more erect than the corresponding one of that species. The same is true when comparison is made with the specimen from the White Pine mining region which was figured by Meek (1877, loc. cit.), but the latter is somewhat distorted by crushing. Other specimens from the White Pine district show a similar erect habit.

Locality and horizon.—Crested Butte district (station 2358); Leadville limestone.

SPIRIFERINA d'Orbigny, 1847.

Spiriferina solidirostris White?

Pl. I, figs. 3, 4.

1860. *Spirifer solidirostris.* White, Boston Soc. Nat. Hist., Jour., vol. 7, p. 232.
Carboniferous: Burlington, Iowa.

1865. *Spiriferina solidirostris.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 120.
Base of Burlington limestone: Burlington, Iowa; Hamburg, Ill.

1870. *Spiriferina solidirostris.* Winchell, Am. Phil. Soc., Proc., vol. 11, p. 252.
Waverly group: Newark, Sciotoville, and Rockville, Ohio.

1888. *Spiriferina solidirostris.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 47, pl. 1, fig. 8 (?); pl. 2, figs. 9–11; pl. 5, fig. 13.
Waverly group: Licking County, Ohio.

1895. *Spiriferina solidirostris.* Herrick, Geol. Surv. Ohio, Rept., vol. 7, pl. 21, fig. 13.
Burlington: Ohio.

1899. *Spiriferina solidirostris.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 71, fig. 10*a*.
Madison limestone: Yellowstone National Park.

1901. *Spiriferina solidirostris.* Weller, Acad. Sci. St. Louis, Trans., vol. 11, p. 198, pl. 20, figs. 2–4.
Kinderhook: Bed 7, Burlington, Iowa.

This species is found in the San Juan and the Canyon areas and in each it is rather an abundant form. It is rather constant in the characters shown and can be briefly described as follows:

Shell of medium size, transverse. The width of a large specimen is about 20 mm. and the length 11 mm., but the average size is considerably less. The fold and sinus are rather narrow and deep but usually show a tendency toward division. Accordingly, the fold is centrally flattened or even slightly grooved, and the sinus shows a corresponding condition. The lateral plications are simple and strong. In large specimens six of these are found on each side of the sinus and five on the fold, but in smaller examples these numbers are diminished by one. The area of the ventral valve is high, but it is sometimes nearly flat, and at others more strongly incurved. The surface is marked by numerous regularly disposed concentric lamellæ, which become stronger and more crowded near the margin. Their edges appear delicately fluted, a circumstance which can doubtless be interpreted as indicating that they bore spinous fimbriæ. The punctation is rather coarse and very abundant. The ventral valve is provided with a strong median septum and also with strong dental lamellæ.

This form is probably identical with part of the material from Yellowstone Park which I identified in 1896 as *Sp. solidirostris.* The fossils then in hand were few and poor and I now suspect that more than a single species was involved. The specimen figured at that time has more numerous and more slender ribs than the Colorado type, but some of the other specimens approach it closely.

Spiriferina solidirostris ? would much resemble *Sp. subelliptica* at the same size in general configuration and in the character of its surface ornamentation, but McChesney's species does not show a faint median plication on fold and sinus. A common form in the Waverly group at Sciotoville, Ohio, which can probably be identified with *Sp. depressa* Herrick, also resembles the Colorado form in general appearance, but it is without a median plication, and the lamellose concentric striæ are considerably coarser. Another related form is *Sp. subtexta* White, but the latter is too little known for comparisons to be of value. It seems to have a simple fold and sinus, which should distinguish it from the Colorado form, but it must be borne in mind that this character is often very obscure in the latter as well. A similar resemblance seems to exist also with *Sp. clarksvillensis*, but that species, too, has never been figured and is little known. *Spiriferina kentuckyensis* approaches this Colorado form in many ways. It differs in being usually smaller and much more mucronate. The plications and intervening grooves are slightly sharper and the concentric lamellæ a trifle finer. But the most marked and constant character is the extended and often mucronate hinge line.

This form seems at first to be the same as that from the Leadville region described as *Spirifer* sp. b, but a closer examination removes any question of their identity. In their internal structure as well as in the details of their surface ornamentation they are quite distinct.

Locality and horizon.—San Juan region (stations 2379, 2381, 2382, 2385); Ouray limestone. Canyon (station 2366); Millsap limestone. Pikes Peak quadrangle (station 2371); Millsap limestone. Castle Rock quadrangle (stations 2367, 2389); Millsap limestone.

SEMINULA McCoy, 1844, emend. Hall and Clarke, 1893.

SEMINULA CLAYTONI Hall and Whitfield.

1877. *Athyris claytoni.* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 256, pl. 4, figs. 15–17.

Lower Carboniferous limestone (Waverly?): Little Cottonwood, 800 feet east of Reed and Benson's minê, Wasatch Range, Utah.

1897. *Seminula claytoni.* Schuchert, U. S. Geol. Surv., Bull. No. 87, p. 378.

From the vicinity of Salida (loc. 2361) several specimens of *Seminula* have been collected. They seem to have been abundant, and, so far as their crushed condition admits the forming of a conclusion, can be referred to *S. claytoni* White. They appear to represent one of the large oval forms with little or no fold and sinus, and resemble also the species which I described from the Madison limestone as *Seminula immatura*. *S. claytoni* is larger than *S. immatura* and with a less distinct sinus. In these particulars the Colorado material is nearer the former than the latter species.

S. claytoni occurs associated with *Sp. centronatus* and probably belongs to the same fauna of which *S. immatura* is a member. I rather look to see the two species proved synonymous, but it seems better to await more conclusive evidence before abandoning the latter name.

Locality and horizon.—Salida region (station 2361); Leadville limestone.

SEMINULA SUBQUADRATA Hall?.

Pl. I, fig. 5.

1858. *Athyris subquadrata.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 703, pl. 27, figs. 2a–d; p. 708, fig. 118.
Kaskaskia limestone: Chester, Ill.; Crittenden County, Ky.

1877. *Athyris subquadrata?* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 271, pl. 5, figs. 19, 20.

Wasatch limestone: Snowstorm Hill, near Dry Canyon, Oquirrh Mountains, Utah.

1886. *Athyris subquadrata.* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 453, p. 440, fig. 2.

Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pa.

1886. *Athyris subquadrata.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 269, fig. 2.

Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pa.

1891. *Athyris subquadrata.* Whitfield, New York Acad. Nat. Sci., Ann., vol. 5, p. 585, pl. 14, figs. 1–3.

Maxville limestone: Newtonville and Maxville, Ohio.

1893. *Seminula subquadrata.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 95, pl. 47, figs. 7–9, 15, 16; pl. 84, figs. 30, 31. (Advance distribution in fascicles.)

Chester limestone: Crittenden County, Ky.

St. Louis limestone: Spergen Hill, Ind.; Pella, Iowa.

Kaskaskia limestone: Chester, Ill.

1894. *Seminula subquadrata.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 35, figs. 13, 15.

Chester limestone: Crittenden County, Ky.

St. Louis limestone: Pella, Iowa.

1895. *Athyris subquadrata.* Keyes, Missouri Geol. Surv., vol. 5, p. 92. (Date of imprint, 1894.)

Kaskaskia limestone: St. Mary, Mo.

1895. *Seminula subquadrata.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 95, pl. 47, figs. 7–9, 15, 16; pl. 84, figs. 30, 31.

Kaskaskia limestone: Chester, Ill.; Crittenden County, Ky.

St. Louis limestone: Pella, Iowa; Spergen Hill, Ind.

1895. *Athyris subquadrata.* Whitfield, Geol. Surv. Ohio, Rept., vol. 7, p. 472, pl. 10, figs. 1–3.

Maxville limestone: Newtonville and Maxville, Ohio.

1897. *Athyris subquadrata.* Weller, New York Acad. Sci., Trans., vol. 16, p. 258, pl. 18, fig. 16. (Date of volume, 1898.)

Batesville sandstone: Batesville, Ark.

Near the top of the Blue limestone, at several localities in the Leadville region, a species of *Seminula* occurs in some abundance (especially at station 2375). None of the fossils of this formation are well preserved or in a condition favorable for study, and the seminulas have suffered equally with the rest. Suspending for the moment the discussion of the generic position of this form, it will be desirable to comment upon its specific characters and its relation to the species to which I have referred it.

My specimens show considerable variety in size, the largest observed having a length of probably 20 mm., the others ranging to half that or less. These inequalities in size evidently correspond to differences in age. The shape is subquadrate to subcircular, the width being about the same as the length, or usually a trifle greater. The upper portion of the contour is made by approximate right lines, extending perhaps halfway down the figure. The inferior outline is either regularly curved or subrectilinear, depending somewhat on the degree of development of the fold and sinus. The feature last mentioned is faint, but can usually be ascertained. It is apt to be narrow and shallow, a linear median depression. None of the shell sexamined attain either the size or the development of fold and sinus of mature examples of *S. subquadrata*, but they follow, with agreement singularly exact, the young and adolescent stages of that species. Comparison has been made with specimens characteristic of *Seminula subquadrata* from Pope County and from Chester, Ill., and the closest agreement was found.

This form somewhat resembles the rounder specimens of *Cranæna subelliptica* var. *hardingensis*, and suggests a doubt of the generic reference, which probably would not otherwise be questioned. No specimen perfect enough to retain such characters which is at the same time certainly a dorsal valve has been observed, but this valve seems to have had no internal structures of a septal nature. The ventral valve shows two rather weak dental plates.

Compared with less elongate specimens of *Cranæna subelliptica* var. *hardingensis* this shell is smaller and more quadrate, and it possesses a faint though distinctly discernible fold and sinus. In the ventral valve the plates are less strong as a rule and farther apart, and the umbonal portion has not, seemingly, the peculiar and characteristic conformation of the terebratuloids.

At Perry Park (station 2367) there occurs in considerable abundance a small species of *Seminula* that I believe can be referred only to the species to which the material from Leadville belongs. None of the examples from Perry Park are as large as the larger ones from Leadville, but with such as are of their own size they agree completely. This identification is in a measure confirmed by the circumstance that these shells at both localities occur associated with a peculiar and probably new species of *Spirifer*. These specimens might be placed with *Seminula humilis* or with *S. wasatchensis*, but probably with less precision. The ventral beak of *S. humilis* is larger and more tumid, and where the thick shell is removed the internal cast shows the presence of a deep rostral cavity, imparting to these molds a different shape from those from Perry Park, for the specimens from that locality occur in this condition.

Seminula humilis and *S. wasatchensis*, of which mention is made above, are closely similar, and were it not that the latter is founded upon a solitary specimen whose horizon is still in doubt and may be very different from that of *S. humilis* I would not hesitate to throw them together.

Although *Seminula subquadrata* was described from rocks of Genevieve age, and although it was especially abundant during that period, the identification of it in the upper beds of the Leadville limestone can not be considered as entirely diagnostic of their geologic age, since a very similar shell occurs in the Cuyahoga shale of Ohio, which probably belongs to the Osage period.

Locality and horizon.—Leadville district (stations 2375, 2377, 2378); Leadville limestone. Castle Rock quadrangle (station 2367?); Millsap limestone.

SEMINULA HUMILIS Girty?.

1899. *Seminula humilis.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 565, pl. 71, figs. 6a–6c. Madison limestone: Yellowstone National Park.

The impression upon which White based his determination of *Seminula subtilita*[a] in the fauna from Larimer County is a small, nearly circular shell, having a diameter of 11 mm., which probably represents a dorsal valve of a specimen belonging to the genus *Seminula.* The beak is small, depressed, and incurved, and neither fold nor sinus is developed. This impression agrees very closely with dorsal valves of the little shell which I described under the name of *S. humilis.* At the same time it can not be distinguished from dorsal valves of the same dimensions of the type which, in the Perry Park and Leadville regions, I have referred to *Seminula subquadrata.* While it shows no evidence of a fold, in them also that feature of the dorsal valve is less noticeable than the corresponding one of the ventral, and it is proportionally obscure in young specimens; and doubtless immature shells of some of the numerous varieties of *Seminula subtilita* assume the same form, but certainly it is very different from the common mature type of *S. subtilita.*

Locality and horizon.—Pebbles of Millsap limestone (?) in the Red Beds conglomerate, Larimer County (station 2364).

SEMINULA sp.

In the San Juan region a single tiny *Seminula* has been collected. Its entire length is but 6 mm., and because of its probable immaturity and its solitary occurrence it has scarcely seemed worthy of more than mention, without an attempt to refer it to any described species.

Locality and horizon.—San Juan region (station 2381); Ouray limestone.

CRANÆNA Hall and Clarke, 1893.

CRANÆNA SUBELLIPTICA var. HARDINGENSIS n. var.

Pl. I, figs. 8–10.

As Hall and Clarke figure but do not describe *Cranæna subelliptica*, the following description, based upon a series of upward of 50 specimens from the type locality, Sciotoville, Ohio, may not be without value:

Shell large, ovate. Outline regular. Curvature evenly rotund, without fold or sinus. Shell substance thick, abundantly punctate. Surface marked by numerous, more or less distinct growth lines.

Cranæna subelliptica is difficult to describe effectually because it is largely lacking in distinctive characters. While in shape it is always longer than wide,

[a] U. S. Geol. Geog. Surv Terr., Bull., vol 5, 1879, p. 215.

the specimen figured by Hall and Clarke has these dimensions unusually unequal; nor are the sides, as a rule, straightened, as in the type specimen. Older examples are proportionately more elongate than young ones. The ventral valve does not project as far beyond the dorsal as in many species of *Dielasma*, and the beak is not attenuate nor strongly incurved. The recurved pedicle sheath is often well developed.

The common shape of this species is more like that of *Cryptonella eudora*. Indeed, as the fossils from Licking County, Ohio, which have been identified with the latter, come from almost the same horizon in the Waverly as the Sciotoville beds, I feel some confidence that they belong to this species. Should this prove to be the case, it would be well to restrict the name *eudora* to the Devonian species and place *Cryptonella eudora* (pars) in the synonymy of *Cranæna subelliptica*.

Cranæna subelliptica resembles *Cr. iowensis* in the closest manner, and I am not sure that, if similarly preserved, it would be easy to distinguish them. *Cr. iowensis* is apt to be more highly arched, with the beaks of both valves more attenuate and produced. The surface is smoother and less interrupted by appreciable lines of growth. The blunt, clumsy form of the beaks in *Cr. subelliptica* is rather noticeable and characteristic.

In both *Cr. subelliptica* and *Cr. iowensis* the hinge plate is large and similarly formed. It connects posteriorly with the end of the valve and is supported by the strong socket walls with which it is united. In *Cr. subelliptica* at least its posterior extremity is adnate to the floor of the valve for a short distance or even seems to be mounted upon a short, low septum. It is deeply concave, and often with an incomplete heart-shaped section. Usually it is divided by two radiating carinæ into three portions, only the central one having a homologue in *Dielasma*. The shape is pentagonal, the two anterior angles being formed by the two carinæ just mentioned, which run out at the margin and project in the form of crura. The hinge plate converges with the bottom of the valve posteriorly, the anterior extremity being often a considerable distance away. The hinge plate is not divided in either *Cr. iowensis* or *Cr. subelliptica*, as illustrated by Hall and Clarke's figures.[a] I have not been able to ascertain the characters of the loop in this species with satisfaction. It seems to be short, with short diverging crura and short ascending lamellæ.

If we may rely upon *Cr. iowensis* and *Cr. subelliptica* as criteria, it seems to be rather characteristic of this genus that the brachial valve is marked by rather strong muscular impressions situated near together and anterior to the end of the hinge plate. On internal casts three grooves, diverging anteriorly, are usually clearly visible, inclosing the scars between their anterior ends. The central groove evidently represents an incipient median septum, which in *Cr. subelliptica* at least is

[a] Pal. New York, vol. 8, pt. 2, 1894, p. 297, fig. 215.

developed posteriorly and supports the hinge plate. Its anterior extremity divides the median pair of muscles. The inner surface of the hinge plate of *Dielasma* is often marked by transverse flutings, and this structure has, therefore, naturally been interpreted as a surface of muscular attachment, beneath which it has sometimes been considered the viscera were lodged. The analogy between *Cranæna* and *Dielasma* is so strong throughout that the conclusion seems warranted that a pair of muscles, leaving scars too faint to be often preserved, was attached to the bottom of the shell anterior to the hinge plate in *Dielasma*, just as in *Cranæna*, and that the hinge plate in *Cranæna*, which is also fluted, bore other muscles, as is supposed to be the case in *Dielasma*.

Hall and Clarke[a] correctly describe the hinge plate of these dielasmatoid forms, but their figures are misleading in that the most enlarged and elaborate ones fail to show this structure at all, while in the smaller ones it is inconspicuous and somewhat slurred over. For example, in the figure of *Eunella sullivanti*, the type species of *Eunella* (fig. 23 of pl. 80), the crura spring almost immediately from the posterior wall of the valve, and one would infer that the hinge plate was either absent or an inconsiderable structure. The same feature is shown in *Eunella lincklæni* (fig. 30 of same plate), where nothing resembling the cardinal plate seems to be present. That a similar condition obtained in *Cranæna* one would be led to infer from the figure of the type species, *Cr. romingeri* (fig. 16 on same plate).

I have referred to *Cranæna*, *Cranæna subelliptica*, which Hall and Clarke described as a *Cryptonella*, because it seems to have the characteristic brachidium of *Cranæna* and because it seems to be so closely allied to *Cranæna iowensis*. It resembles the latter not only in the general physiognomy of the shell, but in the structure of the hinge plate and the shape, strength, and arrangement of the muscle scars of the dorsal valve. In fact, there seems to be the closest agreement throughout between these two forms. For my own part, I incline to lay greater stress upon the structure of the hinge plate than upon minor crural characters and to rank *Cranæna* with *Eunella* as a subgenus of *Cryptonella*, rather than allow it to occupy that position with regard to *Dielasma*.

The specimens from Colorado, while often abundant, are so imperfect as to preclude a satisfactory determination. The generic characters, so far as I have been able to ascertain them, agree with those of *Cranæna iowensis* and *Cr. subelliptica*. I feel considerable assurance that the shell is not a *Dielasma*. For all I am able to determine, however, it might be a representative of either *Cryptonella*, *Cranæna*, or *Eunella*. In specific character it approaches *Cr. subelliptica*. Some examples have the same broadly oval form which characterizes that species,

[a] Pal. New York, vol. 8, pt. 2, 1894, p. 297.

but others are more elongate than even the type specimen of *Cr. subelliptica*, which, as has been said, is somewhat unusual in that regard. For the present, therefore, I refer the Colorado species as a variety of *Cranæna subelliptica*, though better preserved and more perfect specimens may show that it should be removed to another species or even another genus. However, its generic affinities can be limited to three closely allied subgeneric groups, a circumstance which, with its specific affinities, does not deprive it of stratigraphic significance. In fact, in connection with the associated species, I attach some importance to its presence, as it indicates an age certainly not so late as the Coal Measures and probably earlier than the Genevieve period. Its associated fauna can scarcely be Devonian, and on the whole the evidence of this species points to the earlier half of the Mississippian era.

Locality and horizon.—Canyon (stations 2366, 2370); Millsap limestone. Pikes Peak quadrangle (stations 2365, 2368, 2371); Millsap limestone. Castle Rock quadrangle (stations 2367, 2389); Millsap limestone.

EUMETRIA Hall, 1863.

Eumetria woosteri White.

Pl. I, figs. 11, 11*a*.

1879. *Retzia woosteri.* White, U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, p. 215. (Some copies dated 1880.)

Carboniferous: 18 miles north of Greeley, Colo.

1880. *Retzia woosteri.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 134, pl. 34, figs. 8*a*, *b*.

Coal Measures: 32 miles west and 18 miles north of Greeley, Colo.

1883. *Retzia woosteri.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 134, pl. 34, figs. 8*a*, *b*.

Coal Measures: 32 miles west and 18 miles north of Greeley, Colo.

1898. *Eumetria woosteri.* Weller, U. S. Geol. Surv., Bull. No. 153, p. 263.

Founded upon an impression taken from a mould in a bowlder in a conglomerate in Larimer County, some 50 miles from Greeley, Colo., it is unfortunate that this species was ever the recipient of a distinctive name. The type and only authentic specimen occurs with a fauna which White referred to the Coal Measures, but which I feel satisfied is of Mississippian age, and *Eu. woosteri* itself is of a distinctly Mississippian type. Nothing comparable to it is known from the Upper Carboniferous, while it is so similar to *Eu. marcyi* and *Eu. altirostris* that it is almost certainly a synonym of one or other of these species. Weller[a] states that *Eu. altirostris* is distinguished from *Eu. marcyi* by having a more acute and more erect beak, coarser plications, and the slight sinus with its stronger median furrow. These characters,

[a] Acad. Sci. St. Louis, Trans., vol. 10, 1900, p. 75.

if constant, would satisfactorily differentiate the Kinderhook from the Genevieve species, but at the same time *Eu. altirostris* is so rare a form that the limits of its variation can scarcely be said to be known.

Eu. woosteri closely resembles *Eu. marcyi*, but it is in even more close agreement with *Eu. altirostris*. Its general shape is more elongate than in Shumard's rotund species; the ventral beak is more slender, though it can not be described as more erect; the ribs are somewhat coarser than is common in *Eu. marcyi*, but they are not without parallel in fossils referable to that species. There is present a sinus, a character which I have as yet not observed in the Genevieve form.

Comparing it with *Eu. altirostris* as represented by Weller's figures and discription, *Eu. woosteri* is found to agree very closely in size, though the shape is somewhat more broadly ovate. The beak seems to be almost equally acute, but is probably more strongly incurved. The ribs are a little finer and slightly greater in number. There is a sinus but no strong median furrow. It seems highly probable that *Eu. woosteri* is a synonym of *Eu. altirostris*, but I retain both names awaiting further evidence.

White compares this species with *Retzia utah*, evidently a slip for *Retzia* (*Hustedia*) *mormoni*. There can be no doubt that *Eu. woosteri* is distinct from the latter species.

The form from the San Juan region of Colorado and from the Yellowstone National Park, which I have identified with *Eu. verneuiliana*, differs from *Eu. woosteri* in being smaller, with finer striæ, and, so far as is known, in lacking a sinus.

In the Leadville district (at station 2375) was found a fossil which seems to be a retzioid brachiopod. It is an imperfect external cast of one valve, in which only the impressions of rigid striæ are presented to view, the finer ornamentation, if any existed, having been lost. It is larger and more numerously striated than *Hustedia mormoni*, and seems to be rather of the *Eumetria* type. It appears to present the general characters of *Eu. woosteri*, and though slightly smaller than the type specimen, and with ribs somewhat coarser and more broadly rounded, it appears, like it, to have had a sinus, faint indications of which are still retained.

On the whole, it is probable that this shell is an *Eumetria* and closely related to *Eumetria woosteri*, to which I have provisionally referred it, but its relations with *Eu. marcyi* and *Eu. altirostris* are also close.

Locality and horizon.—Leadville district (station 2375); Leadville limestone. Pebbles of Millsap limestone in the Red Beds conglomerate, Larimer County (station 2364).

EUMETRIA MARCYI Shumard?

1852. *Terebratula serpentina.* Owen (not de Koninck), Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 3A, fig. 13. (See specimens in U. S. Nat. Mus. Cat. Invert. Foss., 17955.)
Carboniferous: Skunk River, Iowa.

1854. *Terebratula marcyi.* Shumard, Marcy's Expl. Red River of Louisiana, p. 177, pl. 1, figs. 4*a*, *b*.
Carboniferous. Washington and Crawford counties, Ark.

1858. *Retzia verneuilana.* Hall, Albany Inst., Trans., vol. 4, p. 9.
St. Louis limestone: Bloomington and Spergen Hill, Ind.

1858. *Retzia verneuliana.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 657, pl. 23, figs. 1*a–d*.
Warsaw limestone: Spergen Hill and Bloomington, Ind.

1858. *Retzia vera.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 704, pl. 27, figs. 3*a*, *b*.
Kaskaskia limestone: Chester, Ill.

1858. *Retzia vera* var. *costata.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 704, pl. 27, figs. 3*a*, *b*.
Kaskaskia limestone: Chester, Ill.

1863. *Eumetria vera.* Hall, New York State Cab. Nat. Hist., 16th Rept., p. 55, pl., figs. 1–3, and p. 59.

1863. *Eumetria verneuili.* Hall, New York State Cab. Nat. Hist., 16th Rept., p. 55, fig. 2.

1882. *Eumetria verneuilana.* Whitfield, Am. Mus. Nat. Hist., Bull., vol. 1, p. 50, pl. 6, figs. 28–30.
St. Louis group: Spergen Hill, Paynters Hill, and Bloomington, Ind.; Alton, Ill.

1883. *Eumetria verneuiliana.* Hall, Geol. Surv. Indiana, 12th Rept., p. 335, p. 29, figs. 28–30.
St. Louis group: Spergen Hill, Lanesville, and Bloomington, Ind.

1884. *Retzia radialis.* Walcott (non Phillips) (pars), U. S. Geol. Surv., Mon., vol. 8, p. 220, pl. 7, figs. 5–5*e*. (?)
Upper Devonian: Eureka district, Nevada.
Lower Carboniferous: Eureka district, Nevada; Little Belt Mountains, near Clendenin, Mont.

1889. *Retzia marcyi.* Miller, North Amer. Geol. and Pal., p. 366.
Kaskaskia group.

1893. *Eumetria vera.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 117, pl. 51, figs. 36, 37. (Advance distribution in fascicles.)
Chester group: Crittenden County, Ky.

1893. *Eumetria verneuiliana.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 117, pl. 51, figs. 13–26, 34, 35; pl. 83, figs. 26, 27. (Advance distribution in fascicles.)
St. Louis group: Spergen Hill, Ind.; Greene County, Mo.

1894. *Eumetria verneuiliana.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 37, figs. 1–4, 6, 10.
St. Louis group: Spergen Hill, Ind.

1894. *Eumetria vera* var. *costata.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 37, figs. 5, 11.
Chester limestone: Chester, Ill.; Crittenden County, Ky.

1894. *Eumetria vera.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 37, figs. 8, 12.
Chester limestone: Crittenden County, Ky.

1895. *Retzia vera.* Keyes, Missouri Geol. Surv., vol. 5, p. 95. (Date of imprint, 1894.)
Kaskaskia limestone: St. Marys, Mo.

1895. *Retzia verneuiliana.* Keyes, Missouri Geol. Surv., vol. 5, p. 95. (Date of imprint, 1894.)
St Louis limestone: St. Louis, Mo.

1895. *Eumetria vera* var. *costata.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pl. 51, figs. 27–33.
Chester limestone: Crittenden County, Ky.; Chester, Ill.

1895. *Eumetria vera.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 117, pl. 51, figs. 36, 37.
Chester group: Crittenden County, Ky.

1895. *Eumetria verneuiliana.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 117, pl. 51, figs. 13–26. 34, 35; pl. 83, figs. 26, 27.
St. Louis group: Spergen Hill, Indiana; Greene County, Mo.

1897. *Eumetria verneuilana.* Weller, New York Acad. Sci., Trans., vol. 16, p. 259. (Date of volume 1898.)

Batesville sandstone: Batesville, Ark.

1899. *Eumetria verneuiliana.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 560, pl. 68, figs. 12*a*–12*b*. Madison limestone: Yellowstone National Park.

Just as in the higher beds of the Mississippian series in the Mississippi Valley two species of *Eumetria* were early recognized, one a large form with coarse striæ, the other smaller and with finer ornamentation, so in the material from Colorado a similar condition is found to exist, and although it has been general of late to unite *Eu. vera* and *Eu. verneuiliana* into one species, I feel indisposed to follow a similar course in treating the specimens under discussion.

The coarsely striated form from Colorado has been accordingly referred to *Eumetria woosteri.* The finely striated one I have distinguished from it under the name *Eumetria marcyi.* In so doing and in adopting here the common synonymy of that species which includes the names *Eumetria verneuiliana* (which my specimens especially resemble) and *Eumetria vera* (to which *Eu. woosteri* is closely allied), I am aware that my course is not altogether consistent, but I am hopeful at least that the distinctions which originally led to the proposal of these specific names will be found significant of differences of geologic age or geographic occurrence. I have not at hand, however, the fossils and stratigraphic data upon which to establish an opinion or rest a proof of the validity and relationship of *Eumetria altirostris*, *Eumetria vera*, *Eumetria verneuiliana*, *Eumetria marcyi*, and *Eumetria woosteri*, and their synonymy, and hardly venture to disturb the status quo by an invalid attempt at betterment.

The smaller variety has so far been found in Colorado only in the San Juan region. It is a comparatively rare form, and the specimens collected are so fragmentary that only general comparisons are possible.

The largest specimen has a length, probably, of not more than 12 mm.; and has at the margin 8 or 9 striæ in the space of 5 mm. These fossils, as far as I am able to judge, agree very closely with examples of the same size from Spergen Hill, Indiana, representing *Eu. verneuiliana*, although a larger series of more perfect specimens may show that the Colorado form should not be referred to Hall's species.

As the fauna with which this form occurs in Colorado is with little doubt of Osage age, the range of *Eu. verneuiliana* is somewhat increased in a downward direction by this identification. Yet since at least one representative of the genus (*Eu. altirostris*) is known in the Kinderhook, it is much more a matter for surprise that the line of descent should have been interrupted by the apparent absence of *Eumetria* from the Osage of the Mississippi Valley, than that it should have come to light in the Osage faunas of the Rocky Mountain region.

This seems to be the form which in the Madison limestone of Yellowstone Park I cited under the same specific name, *Eumetria verneuiliana.* It differs considerably from the Kinderhook species, *Eu. altirostris*, being smaller, more finely striated, and apparently without a sinus or strong median furrow therein.

Locality and horizon.—San Juan region (stations 2381, 2382); Ouray limestone.

CAMAROTŒCHIA Hall and Clarke, 1893.

Camarotœchia metallica White.

1874. *Rhynchonella metallica.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Prelim. Rept. Invert. Foss., p. 20.

Carboniferous (Coal Measures): Old Potosi mine, Lincoln County, Nev.

1875. *Rhynchonella metallica.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 129, pl. 10, figs. 10*a*–*d*. (Whole volume published in 1877.)

Carboniferous: Old Potosi mine, Lincoln County, Nev.

1877. *Rhynchonella pustulosa?* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 257, pl. 4, figs. 12–14.

Waverly group: Logan Canyon, Wasatch Range, Utah.

1899. *Camarotœchia metallica.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 540, pl. 69, figs. 3*a*–3*e*.

Madison limestone: Yellowstone National Park.

In the San Juan region (at station 2382) occurs a form which, though it is represented by scanty and rather imperfect material, is referred with some confidence to *Camarotœchia metallica.* At all events, with but little doubt it is the same form which I identified with that species in the Madison limestone of Yellowstone Park. I believe, too, that the type specimen of *C. metallica* is not of Upper Carboniferous age, as stated in the original description, but belongs really to the Madison fauna.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

PELECYPODA.

CRENIPECTEN Hall, 1883.

Crenipecten hallanus Walcott.

1884. *Crenipecten hallanus.* Walcott, U. S. Geol. Surv. Mon., vol. 8, p. 231, pl. 8, figs 7–7*c*.

Lower Carboniferous: Eureka district, Nevada.

At locality 2382 in the San Juan region were found two specimens, imperfect internal and external casts, of a rather large pectinoid shell which probably belongs to the species *Crenipecten hallanus* Walcott. The striæ are rather coarse, much more so, for instance, than in the related *Cr. winchelli.* They are somewhat irregularly alternating, and are crossed by numerous delicate, somewhat flexuous, imbricating lamellose striæ.

Cr. hallanus was described from strata in the Eureka district, Nevada, which I believe to be of Osage age, and so can not be far from the horizon at which the material from Colorado was obtained.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

STREBLOPTERIA McCoy, 1851.

Streblopteria media.

Pl. I, fig. 13.

1888. *Streblopteria media.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 56, pl. 3, figs. 4, 8, 9; pl. 1, figs. 13, 19; pl. 7, figs. 2, 6.
Waverly group: Licking County, Ohio.

1895. *Streblopteria media.* Herrick, Geol. Surv. Ohio, Rept., vol. 7, pl. 24, figs. 16, 17.
Cuyahoga shale: Moots Run, Ohio.

From the Millsap limestone of Perry Park was obtained a single specimen of a pectinoid shell which so closely resembles Herrick's description and figures of *St. media* that the identification with that species is made with some confidence. The shape, which is well shown by the illustration, agrees very closely with the right valve figured by Herrick as fig. 8 of pl. 3. The chief points of difference which I have been able to detect are not important. Possibly the posterior wing of my specimen is a trifle larger, and the outline under the anterior wing does not project as it is seen to do in Herrick's figure, but more nearly approaches a straight line. The surface appears to be almost smooth, being interrupted only by obscure concentric lines and corrugations. The anterior wing, however, has a few coarse, indistinct, radiating striæ.

Locality and horizon.—Castle Rock quadrangle (station 2389); Millsap limestone.

MYALINA de Koninck, 1844.

Myalina arkansasana Weller?.

1897. *Myalina arkansana.* Weller, New York Acad. Sci., Trans., vol. 16, p. 262, pl. 19, figs. 16, 17. (Date of volume, 1898.)
Batesville sandstone: Batesville, Ark.

This species has been identified in the San Juan, Canyon, and Leadville districts, in Colorado, and a form believed to be the same occurs in the limestones of St. Louis age at Pella, Marion County, Iowa. The Colorado material upon which the following brief description is based is in every case preserved in a cherty matrix; it is often obscure and unfavorable for study.

The shape is modioliform. The axis is oblique, and there is a distinct anterior lobe. The posterior outline is entire and subrectilinear. The anterior extremity is rounded; the posterior-superior angle obtuse and not projecting in an alate or mucronate extension. The surface appears for the most part nearly smooth, though obscure, ill-defined, concentric markings can be made out. Toward the anterior end, however, these gradually become stronger and develop into sharp, regularly spaced ridges.

The specimens from the San Juan region, though abundant, are indistinct. They appear to belong to the same species as those from Leadville and Canyon. Certain differences in their occurrence and lithology have led me to suspect that *M. arkansasana* occupies a horizon different and somewhat higher than that at which the majority of Mississippian species were found in this (San Juan) area. It need not necessarily, however, represent more than a different facies of the same fauna.

Although the Leadville material is very imperfect, its characters lend themselves to a similar identification. This species appears in the faunal list of the Leadville monograph as *Pleurophorus oblongus*.[a] With this identification I can in no wise agree. The latter shell has a subquadrate, this a subtriangular, shape. The one is abruptly truncated behind, while in this species the posterior slope is strongly inclined to the cardinal line. The surface, too, is marked by rather prominent and regularly disposed lamellæ of growth, while in *Pl. oblongus* the striæ seem to be finer and more crowded. The preservation of the types of *Pl. oblongus*, however, is not such as to faithfully portray the surface characters of that species.

I was at one time disposed to refer my Colorado material to *Modiola? nevadensis* Walcott, but it can be distinguished from that species by the greater prominence of its umbonal ridge and by the presence of a faint though distinct sinus just in front of the latter in the anterior third of the shell. The shape of the two forms, however, is closely similar. The same characters will serve to distinguish my specimens from *Modiola? subelliptica*, which so closely resembles *M.? nevadensis* that the possibility is entertained that they will subsequently prove to be identical.

M. arkansasana very closely resembles certain shells from the Pottsville series and Lower Coal Measures of the Appalachian region which I have been accustomed to refer to *Naiadites elongatus* Dawson. The latter can sometimes be distinguished by having the posterior cardinal angle more nearly quadrate and by having the surface marked by finer, sharper striæ, but these characters may not hold good in every case. The general resemblance is certainly very marked.

The fossils from Pella mentioned above can probably be safely identified with *M. arkansasana*, and afford a satisfactory basis for comparison. From these and from Weller's figures the Colorado form differs in having the axis slightly less oblique and the anterior lobe larger and better defined, producing a gentle emargination in front of the umbonal ridge. These differences are slight in degree, and I am not sure that the two forms should be separated by more than a varietal distinction, if so much.

The characters which Weller points out as distinguishing his species from *Myalina swallowi* hold good when the latter is compared with the specimens from

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 66.

Colorado which I have identified with *M. arkansasana*, with this exception—that the sinus above referred to does produce a slight emargination, giving the inferior border a somewhat sinuate outline, which is, however, much less strongly marked than in *M. swallowi*.

While I have identified these Colorado shells with a certain degree of confidence with a form occurring in the Genevieve division of the Mississippian Carboniferous, the evidence thus afforded for correlation should not be overestimated. Modioloid and aviculoid shells of this general type are common throughout upper Devonian and Carboniferous time and are distinguished for their variability. Herrick figures several closely similar shells from the Waverly group of Ohio, identified as *Myalina michiganensis* (pl. 4, fig. 6) and *Modiola waverlyensis* (pl. 4, fig. 10),[a] and others, described or undescribed, doubtless occur.[b] The evidence of this species, therefore, must be accepted with caution.

Locality and horizon.—San Juan region (stations 2380, 2385, 2387); Ouray limestone. Leadville district (stations 2372, 2377); Leadville limestone. Canyon (station 2366); Millsap limestone. Pikes Peak quadrangle (station 2371); Millsap limestone. Castle Rock quadrangle (station 2367); Millsap limestone.

MYALINA KEOKUK Worthen.

Pl. I, fig. 12.

1875. *Myalina keokuk.* Worthen, Geol. Surv. Illinois, Rept., vol. 6, p. 524, pl. 30, fig. 5.
Keokuk limestone: Keokuk, Iowa; Warsaw, Nauvoo, and Hamilton, Ill.

1895. *Myalina keokuk.* Keyes, Missouri Geol. Surv., vol. 5, p. 117. (Date of imprint, 1894.)
Keokuk limestone: Bonaparte, Iowa; St. Francisville, Mo.

My material consists of a single specimen from the San Juan region (station 2382). It has something the shape of a parallelogram, having the anterolateral and posterolateral margins nearly straight and parallel, and the superior margin, also rectilinear, cutting them at an acute angle. The inferior margin is rounded. The axis is strongly inclined to the cardinal line. The anterolateral margin is recurved so that it is concealed beneath the shell when the latter is viewed from above. The umbonal portion, though enlarging below, is thin, much elevated, and projecting.

This species resembles *M. congeneris*, *M. sanctiludovici*, and *M. keokuk*, but especially the latter, by reason of its elevated and projecting umbo. In size, however, it is in accord rather with *M. sanctiludovici*, and as the three species mentioned above are very similar to one another, I am not altogether satisfied that my identification is the best one.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

[a] Sci. Lab. Denison Univ., Bull., vol. 3, 1888.

[b] A distinct but evidently related species has recently been described by Weller under the name of *Lithophaga minuta* (Acad. Sci. St. Louis, Trans., vol. 11, No. 9, p. 168, pl. 15, fig. 19).

CONOCARDIUM Bronn, 1835.

CONOCARDIUM sp.

One specimen of *Conocardium* has come to hand, but it is too poor for identification. It is one of the forms with an elongated posterior portion like *C. catastomum*, but it is fully three or four times larger than that species. It is so far known only in the Leadville region.

Locality and horizon.—Leadville district (station 2375); Leadville limestone.

GASTEROPODA.

PLATYCERAS Conrad, 1840.

Keyes, following European usage, advocates[a] the employment for this group of Paleozoic shells of the name given by Montfort to a closely similar type of living ones. He states,[b] "the two genera last mentioned [*Capulus* and *Platyceras*] are practically coextensive, and, since the first has precedence of more than thirty years, it should be used instead of the second." It is admitted on all hands that the recent *Capuli* are closely related to the *Platycerata*, but it seems to me improbable that the same type has survived without change in its generic characters from middle or possibly early Paleozoic to recent time. The circumstance that the *Capuli* are fairly abundant at the present day, and that the *Platycerata* enjoyed their maximum development during the middle Paleozoic, declining rapidly in the Mississippian,[c] and being comparatively rare during most of the Carboniferous and Mesozoic, at least lends color to this view. I therefore propose to retain the Paleozoic *Capuli* under a name distinct from their living representatives. Regarding the eligibility of the name *Platyceras*, Keyes further states:[d] "Even if the group to which Conrad gave the name *Platyceras* were a valid one, it is very questionable whether the term could stand, inasmuch as it has been pre-occupied for three-quarters of a century. It has long been known that Geoffrey in 1764 proposed for a genus of Coleoptera the name *Platyceras*, a term which was later employed by Latreille, and which continues to the present day in good usage as originally proposed." I find, however, that the spelling given by both Bronn[e] and Scudder[f] for the Coleopterous genus is not *Platyceras*, as Keyes cites it, but *Platycerus*. The objection to the employment of Conrad's *Platyceras* being thus removed, I shall retain it in the force and significance in which it has long been known.

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[a] Missouri Geol. Surv., vol. 5, 1894, p. 164 et seq., and in other publications.
[b] Ibid.
[c] Ibid., p. 172.
[d] Ibid., p. 164.
[e] Index Palæontologicus, pt. 1, Stuttgart, 1848, p. 992.
[f] U. S. Nat. Museum, Bull. 19, 1882, p. 251.

Platyceras paralium White and Whitfield?

1862. *Platyceras paralium.* White and Whitfield, Boston Soc. Nat. Hist., Proc., vol. 8, p. 302.
Chemung group: Burlington, Iowa.

1865. *Platyceras paralium.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 131.
Lithographic limestone: Clarksville, Mo.

1888. *Platyceras* sp. (cf. *P. paralium*). Herrick, Sci. Lab. Denison Univ., Bull., vol. 3, p. 92, pl. 1, fig. 23 (fig. 22?).
Waverly group: Licking County, Ohio.

1889. *Platyceras paralium.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 294.
Kinderhook group: Burlington, Iowa.

1890. *Capulus paralius.* Keyes, Am. Geol., vol. 6, p. 9.

1890. *Capulus paralius.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 166, pl. 2, figs. 1*a*, *b*.
Kinderhook beds: Des Moines and Marshall counties, Iowa; Lodi, Ohio.

1895. *Capulus paralius.* Keyes, Missouri Geol. Surv., vol. 5, p. 174, pl. 53, figs. 1*a*–*d*. (Date of imprint, 1894.)
Chouteau limestone: Sedalia, Mo.
Burlington limestone: Louisiana, Mo.

The material from Colorado consists of three specimens from as many localities in the San Juan region, and it occurs entirely in the form of internal casts. These show a loosely coiled, laterally compressed shell, without any traces of longitudinal plications. It is the form which, occurring in the Madison limestone of Yellowstone Park, was briefly described in my report upon the Madison fauna, as *Platyceras* form *d*. As pointed out in that place, a shell of this type has been figured by Keyes under the name of *Capulus paralius*,[a] although it seems to differ rather widely from the type specimen of that species represented by fig. 1*a* of the same plate. The Colorado material, while attaining a size considerably greater than that from Yellowstone Park, is still not quite as large as shown in fig. 1*d*.

Locality and horizon.—San Juan region (stations 2381, 2382, 2385); Ouray limestone.

ORTHONYCHIA Hall, 1843.

Orthonychia formosa Keyes?

1888. *Platyceras formosum.* Keyes, Am. Phil. Soc., Proc., vol. 25, p. 242, pl. —, figs. 8, 9.
Kinderhook group: Marshall County, Iowa.

1890. *Capulus formosus.* Keyes, Am. Geol., vol. 6, p. 9.

1890. *Capulus formosus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 164, pl. 2, fig. 8.
Kinderhook beds: Marshall County, Iowa.

1892. *Orthonychia formosum.* Keyes, Am. Geol., vol. 10, p. 276.

1895. *Orthonychia formosum.* Keyes, Missouri Geol. Surv., vol. 5, p. 189, pl. 53, fig. 2. (Date of imprint 1894.)
Kinderhook group: Marshall County, Iowa.
Burlington limestone: Louisiana, Mo.

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[a] Missouri Geol. Surv., vol. 5, 1894, pl. 53, fig 1*d*.

The only specimen in the collection is an internal cast which shows a rapidly expanding, slightly curved, conical shell, the apex of which has been broken away. Though somewhat larger, it resembles in general shape Keyes's figure of *Orthonychia formosa*, but the lobation is considerably more indistinct than in his type, and I am unable to state definitely whether, as in it, there are exactly five lobes or not.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

STRAPAROLLUS Montfort, 1810.

STRAPAROLLUS LUXUS White.

1875. *Euomphalus luxus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 94, pl. 5, figs. 13a, b. (Whole volume published in 1877.)

Subcarboniferous: Ophir City, Utah.

1877. *Euomphalus laxus.* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 260, pl. 4, figs. 24, 25.

Near base of Wasatch limestone (Waverly): Dry Canyon, Oquirrh Mountains, and Logan Canyon, Wasatch Range, Utah.

My material represents for the most part only internal casts, but, fortunately, some specimens show clearly that the peritreme was carinated and had a section comparable to that of *Straparollus luxus.* The rise of the spire is also about the same, and a comparison with the type and other typical specimens leaves little doubt that the Colorado form is conspecific. The latter attains a greater size than has yet been observed in *St. luxus* from the typical area. Some specimens show a major radius of 35 mm., and one has been observed still larger.

A direct comparison of the types of the two species leads me to believe that *Straparollus luxus* is probably a synonym of *Straparollus subplanus* Hall (Weller incorrectly refers the latter to *Phanerotinus*),[a] and *Straparollus latus* should also be examined in the same connection. This species is abundant in the Crested Butte region, where alone it has so far been brought to light.

Locality and horizon.—Crested Butte district (stations 2352, 2355, 2357); Leadville limestone.

STRAPAROLLUS OPHIRENSIS Hall and Whitfield.

1877. *Euomphalus* (*Straparollus*) *ophirensis.* Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 261, pl. 4, figs. 26, 27.

Waverly group: Dry Canyon, Oquirrh Mountains, Utah.

This species has been identified at three localities, two of them (stations 2362 and 2363) being in the Aspen region, the other (station 2352) in the Crested Butte region. The specimens from Frying Pan Creek (station 2362) are identified with some confidence. A less degree of assurance is felt regarding two small imperfect examples from station 2352 and some very fragmentary specimens from station 2363.

[a] U. S. Geol. Surv., Bull. No. 153, p. 420.

Locality and horizon.—Crested Butte district (station 2352); Leadville limestone. Aspen district (stations 2362, 2363?); Leadville limestone.

STRAPAROLLUS UTAHENSIS Hall and Whitfield.

1877. *Euomphalus* (*Straparollus*) *utahensis*. Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 259, pl. 4, figs. 20–23.
Near base of Wasatch limestone (Waverly): Dry Canyon, Oquirrh Mountains, Ogden, and Logan canyons, Wasatch Range, Utah.

1899. *Straparollus utahensis*. Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 573, pl. 66, figs. 10a–10c.
Madison limestone: Yellowstone National Park.

This species is represented in the Aspen region by a single specimen. It is mostly exfoliated, but there is evidence of a carination centrally located on the upper surface of the peritreme. This specimen also differs from similar casts of *St. luxus* by reason of its depressed spire, which is lower than the outer volution. These characters ally it to *St. utahensis*, though it attains a much greater size than has yet been observed in that species. It shows a major axis of 60 mm., and the outer volution is 32 mm. thick. *Straparollus utahensis* should be compared with *St. roberti*, to which it is closely related.

Two specimens from the San Juan region (station 2381), though not well preserved, can be referred with considerable certainty to this species.

Locality and horizon.—San Juan region (station 2381); Ouray limestone. Aspen district (station 2362?); Leadville limestone.

STRAPAROLLUS cf. SPERGENENSIS Hall.

1856. *Euomphalus spergenensis*. Hall, Albany Inst., Trans., vol. 4, p. 19.
St. Louis limestone: Spergen Hill and Bloomington, Ind.

1882. *Euomphalus spergenensis*. Whitfield, Am. Mus. Nat. Hist., Bull., vol. 1, p. 69, pl. 8, figs. 16–19.
St. Louis group: Spergen Hill, Paynters Hill, Bloomington, and Ellettsville, Ind.

1883. *Euomphalus spergenensis*. Hall, Geol. Surv. Indiana, 12th Rept., p. 350, pl. 31, figs. 16–19.
St. Louis group: Spergen Hill, Lanesville, and Bloomington, Ind.

1895. *Straparollus spergenensis*. Keyes, Missouri Geol. Surv., vol. 5, p. 159. (Date of imprint 1894.)
St. Louis limestone: St. Louis, Mo.

This form has been found only in the Leadville region and the identification adopted is that suggested in the list of Blue limestone species given on page 66 of the Leadville monograph.[a] A few specimens obtained from the Leadville limestone show indeed a close resemblance to *St. spergenensis*. They vary considerably among themselves in the rise of the spire, but the limits ascribed to Hall's species in this particular are not exceeded. The more elevated ones are like the specimen figured by Whitfield (loc. cit., pl. 8, figs. 16, 17, 18), but there are others which, if not deformed by compression, have the spire nearly flat, closely corresponding to the types of the species (fig. 19) and to the dominant form at Spergen Hill.

[a] U. S. Geol. Surv., Mon., vol. 12, 1886

While these shells are similar to the Genevieve species, *St. spergenensis*, they show fully as close resemblance to *St. ammon* of the Kinderhook and lower Burlington periods, or they might be regarded as a slightly undersized variety of *St. macromphalus* Win., also of the Kinderhook; and it is quite possible that they are only immature specimens of some such species as *St. luxus*, the younger stages of which they closely imitate.

Locality and horizon.—Leadville district (stations 2374, 2376); Leadville limestone.

LOXONEMA Phillips, 1841.

Loxonema? sp.

This rather striking form has been observed at three localities. Two of these (stations 2350 and 2358) are in the Crested Butte region; the other (station 2363) in the Aspen region. Though the material obtained is so poor as to render even its generic reference uncertain, there is considerable probability that in each occurrence the species is the same. It is a large, elongate, spiral shell, with a diameter below of perhaps 35 mm. or more and an altitude of certainly not less than 60 mm. There must have been seven or eight whorls. The surface appears to have been smooth. A similar and perhaps identical form occurs in the Chouteau limestone of Pettis County, Mo.

Locality and horizon.—Crested Butte district (stations 2350, 2358); Leadville limestone. Aspen district (station 2363); Leadville limestone.

PLEUROTOMARIA Defrance, 1824.

Pleurotomaria? sp. *a*.

Shell small; greatest diameter, 10 mm. Spire low, probably not exceeding 7 mm. from the middle of the inferior portion to the apex. Whorls, probably three or four. Umbilicus, probably closed. Peritreme, flattened above (for about 2.5 mm. near the aperture) and gently sloping downward. There is a strong angulation where the return contour begins, the remainder of the outline being formed by a rather full curve. A short distance below the angulation, where the surface is still nearly vertical, two ridges, probably representing a comparatively broad band, are seen. The upper, which is the stronger, is about 1.5 mm. below the angulation.

A single specimen, an internal cast, is all that has yet been discovered of this species. No serious effort has been made to determine its specific affinities, and it is probably indeterminable. It is certainly distinct from the *Pleurotomaria* represented by an impression from Larimer County.

Locality and horizon.—Canyon (station 2366); Millsap limestone.

Pleurotomaria? sp. *b*.

As mentioned by White,[a] among the impressions from Larimer County is one of a small gasteropod shell. It consists of about four volutions which are flattened above and angulated. The spire is high. This shell may be a pleurotomarioid, but in general configuration it presents many features in common with a form described by White as *Macrocheilina angulifera*. It is much smaller than that species, however, and more slender, and probably was derived from a much earlier geologic period.

Locality and horizon.—Pebbles of Millsap limestone (?) in the Red Beds conglomerate, Larimer County (station 2364).

BELLEROPHON Montfort, 1808.

Bellerophon sp.

At station 2350 in the Crested Butte district and station 2381 in the San Juan region single specimens of *Bellerophon* have come to hand, representing, not improbably, the same species. As one specimen is an internal cast and the other is completely embedded in chert, but few characters of importance can be ascertained. The species seems to be a large one and the axial diameter of the larger specimen (at the aperture) is about 40 mm.; the longitudinal, 45 mm. It somewhat resembles *Bellerophon crassus* and probably can be referred to the genus *Bellerophon* sensu stricto.

Locality and horizon.—San Juan region (station 2381); Ouray limestone. Crested Butte district (station 2350); Leadville limestone.

CRUSTACEA.

PHILLIPSIA Portlock, 1843.

Phillipsia peroccidens Hall and Whitfield.

1877. *Proetus peroccidens* (pars). Hall and Whitfield, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 262, pl. 4, figs. 31, 32, 30 (?), (non figs. 28, 29=*Phillipsia loganensis*).

Waverly group: Ogden and Logan canyons, Wasatch Range, and Dry Canyon, Oquirrh Mountains, Utah.

1887. *Proetus peroccidens* (pars). Vogdes, New York Acad. Sci., Ann., vol. 4, p. 79.

Waverly group: Ogden, Logan Canyon, Wasatch Range, and Dry Canyon, Oquirrh Mountains, Utah.

In discussing *Proetus loganensis* in 1899[b] I expressed a doubt as to the propriety of referring to *P. peroccidens* certain cephalic shields which, though associated with the pygidia characteristic of that species, are yet very different in the character of their surface ornamentation. The pygidium of *P. peroccidens*, it may be remarked, is highly ornamented with rows of nodes or pustules, while the surface of *P. logan-*

[a] U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, 1879, p. 215.

[b] U. S. Geol. Surv., Mon., vol. 32, pt. 2, 1899, p. 578.

ensis is smooth. The cephala referred by Hall and Whitfield to *P. peroccidens*, however, while correspondingly larger than the pygidium upon which *P. loganensis* is based, and though occurring on the same slab as the types of *P. peroccidens*, are yet entirely without the ornamentation of the latter species.

During the past few years I have handled more or less material containing this fauna, and in it have noticed on several occasions a large cephalic shield ornamented with numerous prominent nodes. At station 2382, in the San Juan region, one of these ornamented cephala is associated with an ornamented pygidium clearly belonging to the species *P. peroccidens*, while in Yellowstone Park the smooth heads and pygidia occur together. It seems quite conclusive, therefore, that part of *P. peroccidens* as defined by Hall and Whitfield, and all of that species as defined by myself, must go with *P. loganensis*. These changes in synonymy have been made in the list preceding this discussion.

This species, in view of the large number of segments in the axis of the pygidium, the distinctness of the lateral lobes of the glabella, and the strong circular basal lobes, should, it seems, be properly referred to the genus *Phillipsia*.

Locality and horizon.—San Juan region (station 2382); Ouray limestone.

LEPERDITIA Rouault, 1851.

Leperditia sp.

Two specimens of ostracodes, one a *Leperditia*, the other a *Beyrichia*, were found in the Millsap limestone at Perry Park (station 2389). The material is both scanty and imperfect, but since these were the only ostracodes obtained from this horizon it has seemed worth while to make some record of their presence.

The single *Leperditia* is preserved as an internal cast. It is a small left valve having a width of about 2 mm. and a height of 1¼ mm. The convexity is moderate. The anterior end is somewhat narrower than the posterior. The posterior outline appears to have little or nothing of a backward swing, but is rather regularly rounded, meeting the ventral outline possibly somewhat abruptly. There are indications of a large, round, subcentral, muscular imprint, but I am not sure that what appears to be such is not an accidental character of the rock. The ocular tubercle I have been unable to distinguish.

Locality and horizon.—Castle Rock quadrangle (station 2389); Millsap limestone.

BEYRICHIA McCoy, 1844.

Beyrichia sp.

Like the preceding, this species, of which a single specimen has been found, is represented as an internal cast in white chert, in which the fossils of this horizon chiefly are found. The shell, which is a right valve, is quite a small one, having a width of only about 1 mm. and a height of one-half mm. The shape is transversely elliptical, there being very little difference in height apparent between the two ends. The median lobe is small, circular, strongly marked, and has about three-fifths of the shell anterior to it. A deep furrow bounds it centrally, giving off a branch which extends a short distance toward the anterior end and disappears, thus marking off, but imperfectly, an anterior lobe considerably larger than the small circular one. The dorsal portion of the cast is flattened, the anterior abruptly elevated and ridge-like.

Locality and horizon.—Castle Rock quadrangle (station 2389); Millsap limestone.

PENNSYLVANIAN SPECIES.

PROTOZOA.

FUSULINA Fischer de Waldheim, 1830.

FUSULINA CYLINDRICA Fischer de Waldheim.

1830. *Fusulina cylindrica.* Fischer de Waldheim, Oryct. du Gouv. Moscou, pl. 13, figs. 1–5. (Another edition of this work which I have not seen appeared in 1837. Probably to this edition the usual references, p. 126, pl. 18, apply, as they do not to the early one.

1858. *Fusulina cylindrica.* Meek and Hayden, Acad. Nat. Sci. Philadelpia, Proc., p. 260.
Carboniferous: Valley of the Kansas River, Kansas.

1859. *Fusulina cylindrica.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 24.
Coal Measures: Kansas.

1861. *Fusulina cylindrica.* Newberry, Ives's Colorado River Expl. Exped., p. 129.
Coal Measures: Kansas.

1864. *Fusulina cylindrica.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 14, pl. 1, figs. 6*a–i*.
Coal Measures: Ohio to Kansas and Southwestern Nebraska, and South to Texas.

1864. *Fusulina cylindrica?* Meek, Pal. California, vol. 1, p. 4, pl. 2, figs. 2, 2*a*.
Carboniferous: Bass's ranch, Shasta County, Cal.

1866. *Fusulina cylindrica.* Geinitz, Carb. und Dyas in Nebraska, p. 71, tab. 5, fig. 5.
Upper Coal Measures: Plattsmouth, Nebr.

1872. *Fusulina cylindrica.* Meek, U. S. Geol. Surv. Nebraska, p. 140, pl. 1, fig. 2; pl. 2, fig. 1; pl. 5, figs. 3*a*, *b*; pl. 7, figs. 8*a*, *b*.
Upper Coal Measures: 2½ miles west and 1 mile southeast of Nebraska City; Bennett's Mill, Wyo.; Rock Bluff, Plattsmouth, Bellevue, and Omaha City, Nebr.

1877. *Fusulina cylindrica.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 96, pl. 6, figs. 6*a*, *b*.
Carboniferous: Wasatch Range, south of Spanish Fork; Uiyabu Pass, Gosute Range; near Beckwith Spring, Cedar Range; near the mouth of Spanish Fork Canyon; southeast of Mount Nebo; all in Utah.

1877. *Fusulina cylindrica.* Whiteaves, Geol. Surv. Canada, Rept. Prog., 1875–76, p. 97.
Carboniferous or Permian: Rear of Fort St. James, Stewarts Lake, British Columbia.

1884. *Fusulina cylindrica.* White, Geol. Surv. Indiana, 13th Rept., p. 116, pl. 23, figs. 1–3.
Coal Measures: Ohio to California; limestone roof of coal K, Lodi, Fountain County, Ind.

1887. *Fusulina cylindrica.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 50, pl. 3, fig. 20. Coal Measures: Flint Ridge, Ohio.

1891. *Fusulina cylindrica.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 245. Lower Coal Measures: Des Moines, Iowa.

1894. *Fusulina cylindrica.* Keyes, Missouri Geol. Surv., vol, 4, p. 102, pl. 12, figs. 1 *a–c*. Coal Measures: Kansas City and Lexington, Mo.

1899. *Fusulina cylindrica.* Smith, Kansas Acad. Sci., Trans., vol. 16, p. 64, figs. 1–4.

1900. *Fusulina secalica.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 10, pl. 1, figs. 1, 1*b*. Upper Coal Measures: Kansas.

The genus *Fusulina* experienced a long range in the Carboniferous strata of Colorado, although it is possibly less abundant at the lower horizons than at the upper.

The lowest ascertained occurrence of the genus is at Ouray, where it is plentiful at an horizon about 100 feet above some beds with fossil plants, the evidence of which, though not conclusive, would favor correlating them with the lower portion of the Lower Coal Measures as developed in the Pennsylvania section. In the San Juan region also *Fusulina* is found toward the base, as well as near the top, of the Carboniferous section, and a range probably of 2,000 feet must be assigned to it in this area. A similar range is indicated by its occurrence at Leadville.

It is difficult to correctly estimate the shape and size of these small bodies, as they lie promiscuously diffused through the rock in which they are embedded, but examples from the same locality seem to be in essential agreement with each other in the particulars named, while, with the exception of a station in the Crested Butte region (2312), all the occurrences noted appear to belong to the same species. This opinion, however, is based upon their agreement in external characters and lacks the corroboration of microscopic study.[a]

The prevailing form in the Colorado collections is rather small and spindle shaped, with an axial diameter of from 3 to 4 mm. and a radial diameter of from 1.5 to 2 mm. While there seems to be but little variation in *F. cylindrica* as it appears at different localities, specimens from the San Juan region often attain a larger size than elsewhere.

It is doubtless true that wherever this species has been found it is abundant, but this circumstance probably proceeds from the fact that owing to its minute size it attracts attention only when present in large numbers. But if its rarer occurrences were known it would perhaps be found to be rather continuously represented in the rocks than, as seems now, at remote but prolific intervals.

Beede employs the name *Fusulina secalica* instead of the more familiar one proposed by Fischer, the specific portion of the combination being due to Say. The latter originally referred his types, which were obtained on the Missouri River near the Platte, to *Miliolites*, but it is clear that he had a species of *Fusulina*. In view

[a] Microscopic study of these shells, as far as it has been carried by me, tends to confirm the opinion that they belong to one species.

of our inadequate knowledge of the fossils which Say called *Miliolites secalicus*, it seems to me inadvisable at present to substitute it for the name in current use. Furthermore, since Say states that *M. secalicus* has a length of three-tenths of an inch and a diameter of one-sixteenth, it appears that his species is larger and differently proportioned from the one under discussion.

It may not be out of place to mention at this point that evidence exists of the presence of foraminifers other than *Fusulina* in the Colorado Carboniferous. Near Ouray (station 2195b) minute shells whose foraminiferal nature is very probable occur in considerable numbers. As they are known only in thin sections, and as identification in this condition is very difficult, it seemed unprofitable to continue their investigation.

Locality and horizon.—San Juan region (stations 2199, 2208, 2210, 2211, 2213, 2221, 2227, 2232, 2233, 2235, 2237, 2286, 2339); lower, middle, and upper portions of the Hermosa formation. Ouray (stations 2194, 2195b, 2195c); Hermosa formation. Crested Butte district (stations 2290, 2293, 2305, 2308, 2321); Weber limestone and Maroon formation.

FUSULINA CYLINDRICA var. VENTRICOSA Meek and Hayden?

1858. *Fusulina cylindrica* var. *ventricosa*. Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 261. Carboniferous: Juniata and Manhattan, Kans.

1859. *Fusulina cylindrica* var. *ventricosa*. Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 24. Coal Measures: Manhattan and Juniata, Kans.

1873. *Fusulina ventricosa*. Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 560, pl. 24, fig. 8. Coal Measures: Fulton and Peoria counties, Ill.

1874. *Fusulina ventricosa*. Meek. Am. Jour. Sci. (3), vol. 7, p. 484.

In the Crested Butte region (station 2312) occurs a form of *Fusulina* in moderate abundance which differs considerably from the type common in the rest of the collection. It is smaller and in shape nearly spherical. Its axial diameter is under 1 mm. and its radial diameter is somewhat less.

This form seems rather closely related to that figured by Meek and Worthen under the name of *Fusulina ventricosa*, although it is very much smaller. I mistrust that the *F. ventricosa* of their reference may not be the same as that to which the name *F. cylindrica* var. *ventricosa* was originally applied.

Locality and horizon.—Crested Butte district (station 2312); Weber limestone.

SPONGIA.

HYALOSTELIA Zittel, 1878.

HYALOSTELIA sp.

Crossing the surface of a slab of limestone from near Molas Lake in the Silverton quadrangle (station 2279) are large numbers of an unusual fossil which I at first took to be *Productus* spines, but which, it seems, can be properly referred only to a sponge of the genus *Hyalostelia*. These bodies consist of nearly straight, smooth, slender, cylindrical rods of several sizes, all, or nearly all, lying in the same direction, contiguous and superimposed. Some of the largest have a diameter of but little less than 0.5 mm., and one of them has been traced to a length of 82 mm. In this distance the taper is almost imperceptible. Besides the large rods there are others of almost hair-like proportions, and altogether of both sorts there must be many hundred. No anchoring hooks or other peculiar terminal formations have been observed. While most of the spicules have a nearly or exactly identical direction, a few fine and fragmentary ones are directed more or less transversely to them. There can be little doubt that these bodies are the basal tuft of a sponge of a type for which the name *Hyalostelia* was proposed. No spicules of different type have been observed, the shorter ones being cylindrical like the larger and doubtless but fragments of them.

Locality and horizon.—San Juan region, Silverton quadrangle (station 2279); lower portion of the Hermosa formation.

HYSTRIOSPONGIA Ulrich, 1890.

Hystriospongia ? sp.

From the same station which furnished the specimen of *Hyalostelia* just mentioned another quite different sponge was obtained. It occurs in a calcareous black shale, on the surface of which it appears as a superficial entanglement of spicules, with a circular shape and a diameter of about 20 mm. The spicules are so meshed together that it is impossible to make out their characters as completely as desirable. They seem to consist of fine, slender, rod-like elements, having a radial direction. No trifid spicules have been observed, but such might readily escape notice.

Locality and horizon.—San Juan region, Silverton quadrangle (station 2279); lower portion of the Hermosa formation.

CŒLENTERATA.

LOPHOPHYLLUM Milne-Edwards and Haime, 1850.

Lophophyllum profundum Milne-Edwards and Haime.

1851. *Cyathaxonia profunda.* Milne-Edwards and Haime, Monog. des Polyp. Foss., p. 323. Carboniferous: Flint Ridge, Ohio.

1860. *Cyathaxonia profunda.* Milne-Edwards, Hist. Nat. Corr., vol. 3, p. 331. Carboniferous: Ohio.

1860. *Cyathaxonia prolifera.* McChesney, Desc. New Spec. Pal. Foss., p. 75. Coal Measures: Widely distributed in the Western States.

1865. *Cyathaxonia prolifera.* McChesney, Illustrations New Spec. Foss., pl. 2, figs. 1–3.

1866. *Cyathaxonia* (?) sp. Geinitz, Carb. und Dyas in Nebraska, pp. 65, 66, tab. 5, figs. 3, 4.
Upper Coal Measures: Plattsmouth, Nebr.

1868. *Cyathaxonia prolifera.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 1, pl. 2, figs. 1–3.
Coal Measures: Springfield, Ill.

1872. *Lophophyllum proliferum.* Meek, U. S. Geol. Surv. Nebraska, p. 149, pl. 5, figs. 4*a*, *b*.
Upper Coal Measures: Nebraska City and Rock Bluff, Nebr.; Springfield and Lasalle, Ill.; Texas.

1873. *Lophophyllum proliferum.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 560, pl. 24, fig. 1.
Upper Coal Measures: Springfield, Ill.

1876. *Lophophyllum proliferum.* White, Powell's Rept. Geol. Uinta Mountains, p. 88.
Lower Aubrey group: Confluence of Grand and Green rivers, Utah.

1884. *Lophophyllum proliferum.* White, Geol. Surv. Indiana, 13th Rept., p. 118, pl. 23, figs. 6, 7.
Coal Measures: Indiana; Illinois; Iowa.

1887. *Cyathaxonia prolifera.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 2, p. 86, pl. 7, figs. 15*a*–*c*.
Coal Measures: Flint Ridge and Bald Hill, Ohio.

1888. *Lophophyllum profunda.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 3, p. 136.
Coal Measures: Flint Ridge, Ohio.

1888. *Lophophyllum proliferum.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 225.
Lower Coal Measures: Des Moines, Iowa.

1890. *Lophophyllum profundum.* Worthen, Geol. Surv. Illinois, Rept., vol. 8, p. 79, pl. 10, figs. 14, 14*a*.
Coal Measures: Lasalle, Ill.

1894. *Lophophyllum proliferum.* Keyes, Missouri Geol. Surv., vol. 4, p. 115, pl. 13, figs. 8*a*, *b*.
Upper Coal Measures: Kansas City, Mo.

1897. *Lophophyllum proliferum.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 25.
Upper Coal Measures: Poteau Mountain, Indian Territory.

1900. *Lophophyllum profundum.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 17.
Upper and Lower Coal Measures: Fort Scott, Marmaton, Bourbon County, Thayer, Olathe, Kansas City, Lawrence, Lecompton, Topeka, McFarland, Grand Summit, Kans.

This species has been identified at nine localities, but it is represented for the most part by only one or two specimens at each. The material is not only scanty but it is frequently fragmentary. It shows a high degree of variation in essential points, such that in some examples, especially in the younger stages, it is not even clear whether a pseudo-columella has been developed or not. In some specimens many interseptal plates are present, in others none at all—at least in the sections examined. Sometimes the septa are almost diagrammatic in their regularity and arrangement; at other times they are contorted and their extremities connate into varying groups. Occasionally the latter irregularity is carried to an extreme. Perhaps the most diagnostic character consists in the number of the septa, and upon this basis it is possible to distinguish two groups among the specimens examined. In one of these there are about 21 primary septa, in the other from 24 to 30. Alternating with these, especially in the calicinal portion of the corallum, can sometimes be seen an equal number of shorter secondary septa. Specimens from stations 2222, 2302, and possibly 2329b belong to the group with 21 septa. To the other belong specimens furnished by stations 2202, 2204, 2233, 2241, 2285, and 2299. I am in doubt about the bearing which more extensive collections would have in the matter of the validity of the two groups which my material indicates, whether it would establish them as distinct species or varieties, or demonstrate that they are only mutations of a single radical. I have placed all with the well-known *L. profundum*, but it is with a feeling of dissatisfaction at this disposition.

Locality and horizon.—San Juan region (stations 2202, 2204, 2222, 2233, 2241); middle and upper portions of the Hermosa formation. Dolores River region, Sinbads Valley (station 2285); Hermosa formation. Crested Butte district (stations 2299?, 2302, 2319); Maroon formation. Grand River region, Glenwood Springs (station 2329b?). Uinta Mountain region, overlooking Yampa River (station 2191).

AMPLEXUS Sowerby, 1814.

Amplexus sp.

Only two specimens of this species have yet been found, both from the San Juan region, but each from a different locality. One, from the mouth of Hermosa Creek (station 2242), is nearly indeterminable, but it probably belongs to the same species as the other, which was found near Deadwood Gulch in the Rico quadrangle (station 2222).

The latter is small, conical, and wnere the diameter measures 7 mm. has 18 septa which reach about halfway to the center. There is no dissepimental tissue, the remaining cavity being dissected by tabulæ.

The characters shown by this material indicate that it belongs with the genus *Amplexus* rather than with *Zaphrentis* or *Campophyllum*. The only known species of *Amplexus* from the Upper Carboniferous of America is *A. zaphrentiformis* White, young specimens of which, when sectioned at the same stage, differ materially from the form under consideration. The septa are somewhat more numerous, reaeh quite to the center, and inclose a large, well-marked fossula. I would scarcely be justified, therefore, in regarding these fossils as representatives of White's species.

This coral quite strikingly resembles, in some particulars, the species which Beede described as *Amplexus westi*,[a] but that form, as Beede has since shown,[b] is clearly a member of the genus *Lophophyllum*.

Locality and horizon.—San Juan region (stations 2222, 2241); middle and upper portions of the Hermosa formation. Crested Butt district (station 2316); Weber limestone.

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[a] Kansas Univ. Quart., vol. 7, 1898, p. 17.
[b] Univ. Geol. Surv. Kansas, Rept., vol. 6, 1900, p. 18.

CAMPOPHYLLUM Milne-Edwards and Haime, 1850.

Campophyllum torquium Owen.

1852. *Cyathophyllum* (*vermiculare?*). Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 4, fig. 2.
Carboniferous limestone: Near mouth of Keg Creek.
1852. *Cyathophyllum torquium*. Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 4, fig. 2.
Carboniferous limestone: Near mouth of Keg Creek.
1852. *Cyathophyllum flexuosum* (?). Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 4, figs. 3*a*, *b*.
Carboniferous limestone: Near mouth of Keg Creek.
1872. *Campophyllum torquium*. Meek, U. S. Geol. Surv. Nebraska, p. 145, pl. 1, figs. 1*a–d*.
Upper Coal Measures: Rock Bluff and Cedar Bluff, Nebraska; Iowa.
Coal Measures: Illinois.
1884. *Campophyllum torquium*. White, Geol. Surv. Indiana, 13th Rept., p. 119, pl. 23, figs. 10–13.
Upper Coal Measures: Iowa; Missouri; Nebraska; Illinois; Indiana.
1894. *Campophyllum torquium*. Keyes, Missouri Geol. Surv., vol. 4, p. 107, pl. 12, figs. 7*a–c*; pl. 13, fig. 7.
Coal Measures: Kansas City, Mo.
1900. *Campophyllum torquium*. Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 19, pl. 4, fig. 1; pl. 5, figs. 1–4.
Coal Measures: Kansas City, Jefferson, Douglas, and Chautauqua counties, Kans.

The fossils representing this species are in no instance abundant, and they are usually in a poor condition of preservation. They can probably safely be referred, however, to the common *C. torquium*.

Locality and horizon.—San Juan region (stations 2206, 2208); upper portion of Hermosa formation. Ouray (station 2194); Hermosa formation. Crested Butte district (stations 2291, 2298, 2312); Weber limestone and Maroon conglomerate.

ZAPHRENTIS Rafinesque, 1820.

Zaphrentis gibsoni White.

1884. *Zaphrentis gibsoni*. White, Geol. Surv. Indiana, 13th Rept., p. 117, pl. 23, figs. 4, 5.
Coal Measures: Vermilion County, Ind.

White calls attention to the fact that the genus *Zaphrentis*, which occurs so abundantly in the earlier Carboniferous and throughout the Devonian, is very rare in strata of Upper Carboniferous age. Only three specimens in our collections from Colorado can be referred to *Zaphrentis*, and each was found at a separate locality. They are in mutual agreement in having 35 somewhat alternating septa, but present minor differences in regard to rate of enlargement, prominence of the fossula, amount of interseptal tissue, etc. As these points are susceptible of considerable variation within the limits of a single species, they do not in this instance, it seems to me, call for a subdivision of the small group of forms presented for study. As these agree, in all the points mentioned by White in his description, with *Z. gibsoni*, I have referred them to that species without much hesitation.

Locality and horizon.—San Juan region (stations 2216, 2332); middle and upper Hermosa. Crested Butte district (station 2312); Weber limestone.

MONILIPORA Nicholson and Etheridge, 1879.

MONILIPORA PROSSERI Beede.

1898. *Aulopora prosseri.* Beede, Kansas Univ. Quart., vol. 7, No. 1, p. 18.
Upper Coal Measures: Lyndon, Osage County, Kans.

1900. *Aulopora? prosseri.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 23, pl. 3, fig. 2; pl. 4, fig. 2.
Upper Coal Measures: Lyndon, Osage County; Lecompton and near Twin Mounds, Douglas County, Kans.

This form occurs in large masses in some thin limestones outcropping along the Silverton road in the Engineer Mountain quadrangle (station 2199). It agrees in so many particulars with *Aulopora? prosseri*, as the latter is represented in Beede's illustrations and descriptions, that it probably belongs to the same species.

Beede calls attention to the large size to which coralla of this species sometimes attain, citing one colony which, though incomplete, measured 22 inches across. At the Colorado locality a growth, belonging apparently to a single colony, formed a bed from 3 to 6 inches high, which covered an area of 9 square feet and probably considerably more. While the size of the colony in these instances is suggestive rather of the genus *Syringopora*, the manner of growth is different, for instead of consisting of long, nearly parallel corallites connected by stolonal arms, the individuals are short and variously directed. They bud persistently, and I judge, although the imperfect manner in which the specimen is seen embedded in matrix may be misleading, that with few exception each corallite gave off two buds at a time, and perhaps more than once. There results a thick entanglement of corallites pointed in various directions; and though the component units are short and not connected and supported by stolonal growths, as in *Syringopora*, they contrive to build up a colony, as has been said, of several inches in height and very great spread. They are no doubt enabled to do this through the circumstance that the cell walls are excessively thickened, so that the lower portion of the corallites are nearly, possibly entirely, closed in this manner. It is naturally by concentric deposition that the walls are thickened; and as all the layers are not of quite the same consistency, weathered specimens sometimes present an appearance which simulates the well-known internal structure of *Syringopora*, but here the lines which might be mistaken for infundibuliform tabulæ are invariably completely circular, which is rarely the case in *Syringopora*, and they are parallel to the walls instead of converging to the center. The real structure, as unmistakably shown in thin sections, is with the inner space, though much diminished through the thickening of the walls, uninterrupted by partitions. The average diameter is 2 mm. or less, as in typical *Aulopora? prosseri*, the shape is tubular rather than campanulate, and, indeed, the agreement in many particulars is close. On the other hand, there are important differences, among which may be mentioned the apparent absence from my material of tabulæ and pseudosepta, and the fact that the corallum of typical *Aulopora? prosseri* is described as prostrate and bifurcating, while in that before me the corallum is certainly not prostrate; for instead of having a thickness of from 3 to 7 mm., as I judge to be the case in the eastern form, it is ten times that, or 6 cm., and more; nor is the growth, so far as I have made out, so much bifurcating as that the corallites put forth simultaneously two lateral buds, each of these two others, and so on.

In the Coal Measures of Kansas occurs a form which is probably congeneric with this one, although the species is different. The mode of growth is more regular than in the Colorado form, and the general appearance is much like that of *Syringopora*. The corallites are long, erect, and approximately parallel. The mode of increase is by budding, and two offshoots are as a rule developed simultaneously. The corallites are not generally connected by stolons, but occasionally root-like processes are put out somewhat as in *Eridophyllum*. These seem to be invariably solid and are of a different character from the stolonoid process which connects the incipient bud with its parent. The cell walls are extensively thickened. In the aperture of weathered specimens, where the wall is thinner than in the older portions, there can frequently be made out a number of indistinct septa or pseudosepta. The interior is otherwise entirely without structures in most cases, but in a few instances, for a limited space, the cavity is intersected by numerous closely arranged, slightly concave tabulæ.

It seems to me that the three forms here mentioned belong to the same generic group. The mode of growth is rather different in the original *Aulopora? prosseri* and the form last mentioned, which I have no doubt has often been identified as *Syringopora multattennuata* McChesney, but the Colorado form, which may not be specifically identical with Beede's species, is intermediate in this regard. The syringoporoid colony must also have had a similar creeping growth in its earlier stages. I have not observed pseudosepta or tabulæ in the Colorado specimens, but the former are, as a rule, to be seen only in weathered examples, while a large number of syringoporoid specimens from Kansas were examined before the tabulation was observed.

The generic relations of all three forms is, I believe, with *Monilipora*. This is particularly evident in the case of *Aulopora? prosseri*, though the tabulation, rare in the latter, seems to be unknown in that genus. The growth of the syringoporoid colonies is also unlike that of *Monilipora*, but may be a development of it. All these species need to be thoroughly studied and revised, but it is my belief at present that it would be departing from their obvious relationships to discriminate them by more than specific rank.

Several years ago I described under *Syringopora*[a] two species that present certain close resemblance to some forms for which Grabau about the same time proposed the generic name *Ceratopora*. Structurally my species seem to belong to Grabau's genus, but they differ in their mode of growth in the same manner that *Syringopora* does from *Aulopora* and the erect forms tentatively referred to *Monilipora* do from the typical ones. The parallelism in growth shown by these species is significant, and seems to me to indicate that this character should be given only secondary importance. I am not sure but that my original reference of those species was correct. Strangely enough, Grabau does not discuss the relationship of his *Ceratopora* with either *Aulopora* or *Syringopora*. Yet this relationship seems to me very real. Nicholson placed *Monilipora* in the Auloporidæ, but Grabau erected for it and *Ceratopora* a new family which he called the Moniliporidæ. This seems to me altogether superfluous.

On a slide from the Crested Butte region (station 2290) prepared for the microscopic study of the form referred to *Chætetes milleporaceus*, two young *Aulopora*-like colonies are shown which probably belong to the form described above from more abundant material. In one case the youthful colony had been completely covered over and probably inclosed by the *Chætetes* upon whose massive corallum it had started to grow. The other was a later and apparently more prosperous attempt to colonize upon the same *Chætetes.* Both incidents are transcribed upon the same thin section. The individual corallites in this instance are about 2 mm. in diameter and appear to be without septa, septal spines, or tabulæ. The walls are so much thickened as to leave an insignificant aperture in the center, the wall substance being radially fibrous.

Associated with the auloporoid at both localities are numerous minute bodies, some of which resemble spicules so closely as to suggest that they may be of organic origin. They may, however, be only segregations of calcite (of which substance they now consist) without organic beginnings. The largest probably does not exceed 1 mm. in length. The shape is irregularly elongate with one end usually larger than the other, and with the length some four or five times the greatest breadth. In other words, the outline is straight and tapering, with one end bluntly and irregularly rounded, and the other more or less pointed, but it is interrupted by spinous projections of considerable size, so that these bodies present an almost endless variety of shapes, and it is extremely difficult to frame a generalized description of them. They can scarcely be considered echinoid spines even if they are organic at all, and the general appearance is rather that of *Gorgonia* spicules. If the organic nature of

[a] U. S. Geol. Surv., Mon., vol. 32, pt. 2, 1899, pp. 507, 510.

these objects could be demonstrated, their evidence might be of value in its bearing upon the disputed point as to whether *Aulopora* really does belong, as has been claimed, to the Alcyonarian corals. At least the evidence would be in force to the extent that these forms are related to *Aulopora*.

Another specimen from the Crested Butte region (station 2303) which probably belongs to the same species, though consisting of but a few corallites, yet seems to shed light upon the means by which extensive coralla are built up by these more or less disconnected tubes. In this specimen, in which the growth is more clearly shown through combined silicification and weathering than in the others, some of the corallites are closely proximate and, where in contact, develop strong concentric rugæ, which alternate in the two individuals adjacent to one another, and so in a measure interlock. These projections appear to be somewhat radiciform, and to a certain extent resemble the structures which form a distinguishing character of the genus *Eridophyllum*.

In this specimen, as in those previously described, the corallites have a diameter of about 2 mm.; the walls are thickened, and tabulæ and septa appear to be absent.

Locality and horizon.—San Juan region (station 2199); Hermosa formation. Crested Butte district (stations 2290, 2303); Maroon conglomerate.

LEPTOPORA Winchell, 1863.

Leptopora winchelli White.

1879. *Leptopora winchelli.* White, U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, p. 211.

Carboniferous: Near the forks of Logan River, in Bear River Range, northern Utah.

1880. *Leptopora winchelli.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 121, pl. 34, fig. 11*a*.

Carboniferous: Near the forks of Logan River, in Bear River Range, northern Utah.

If the single specimen obtained were in a more perfect condition it is possible that it would prove distinct from the species described by White. It has a somewhat irregular semicircular shape, with a diameter of about 45 mm., and seems to have been attached to a large specimen of *Platyceras nebraskense*. The constituent cells vary greatly in size. Some of the larger ones have a diameter of almost 5 mm., rather larger than anything in the material described by White. The height of the corallum seems to be insignificant compared with its lateral expansion, but some of the corallites must have had a length of at least 5 mm. There appear to have been no tabulæ, and no septa have been observed on the thin cell walls.

Locality and horizon.—San Juan region (station 2279); lower portion of Hermosa formation.

CLADOPORA Hall, 1852.

CLADOPORA sp.

The specimens referred to under this name consist of two hemispherical masses having a diameter of about 5 mm., composed of numerous cells, the larger of which are about 1 mm. in diameter. The cell walls are thin, perforate, and appear to be faintly fluted longitudinally. No tabulæ have been noticed. Except for the latter character these growths might pass for a small globular species of *Favosites*, but they more probably represent either the terminal or the initial portions of a rare and undescribed form, of which we have specimens from Graham, Young County, Tex., and also from the Trans-Pecos region, Texas. The latter has a dendritic shape, the larger branches attaining a diameter of 20 mm. These Texas specimens in general appearance resemble coralla in the Devonian which have been commonly referred[a] to the genus *Striatopora*, but they show more points of affinity with the type species of *Cladopora* than with that of *Striatopora*. They lack the projecting lip of *Cladopora*, which is easily lost by attrition, but they also lack the thickened apertures of *Striatopora*, which would most likely be preserved. In their present condition the cells open slightly upward and outward without the inferior projection or lip of *Cladopora* or the stereoplasmic (?) apertural deposit of *Striatopora*.

The figures of many American species of *Striatopora* strongly suggest that they properly belong rather to *Cladopora*.

Locality and horizon.—Crested Butte district (station 2305); Maroon conglomerate.

CHÆTETES Fischer de Waldheim, 1830.

CHÆTETES MILLEPORACEUS Milne-Edwards and Haime.

1851. *Chætetes milleporaceus*. Milne-Edwards and Haime, Monog. des Polyp. Foss., p. 272.
Carboniferous: Cumberland Mountains, Tennessee; Newburg, near Evansville, on the Ohio.

1860. *Chætetes milleporaceus*. Milne-Edwards, Hist. Nat. des Corr., vol. 3, p. 271.
Carboniferous: United States.

1876. *Chætetes milleporaceus*. White, Powell's Rept. Geol. Uinta Mountains, p. 88.
Red Wall group: Gypsum Canyon, Colorado River, Utah.
Lower Aubrey group: Split Mountain Canyon, Green River, Utah.

1877. *Chætetes milleporaceus*. White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 98, pl. 6, fig. 2*a*.
Carboniferous: Virgin Range, southwest of St. George, Utah.

1894. *Chætetes milleporaceus*. Keyes, Missouri Geol. Surv., vol. 4, p. 123, pl. 14, figs. 12*a*, *b*.
Upper Coal Measures: Glasgow, Mo.

1900. *Chætetes milleporaceus*. Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 25, pl. 2, figs. 11, 11*b*.
Coal Measures: Girard; very abundant in the Oswego limestone, Kansas.

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[a] Proctor's Kentucky Geol. Surv.; Kentucky Fossil Corals, Davis, 1885, Pt. II. Rominger's Geol. Surv. Michigan; Lower Peninsula, vol. 3, pt. 2, 1876.

This species is very abundant at several localities in the Crested Butte region and it has also been found in the San Juan region. It is massive in its growth, and my specimens indicate that the corallum attained a large size. The cells are small, seldom reaching 0.5 mm. in any diameter. They are usually considerably less. They present an almost infinite variety in the matter of shape, often having reentrant sides, but with the angles almost always rounded. Tabulæ are present, but great variation has been remarked in the intervals at which they occur. In some specimens they are regularly distributed and about 0.25 mm. apart. Such examples seem to represent the normal type of *Ch. milleporaceus*. In others they are at one place close together, at another quite distant, varying largely in the interval of occurrence, and in still others they can not be detected at all. Part at least of this variation can, I think, be ascribed to obliteration through mineralizing agencies, for the tabulæ are thinner than the walls, which are regularly preserved, but it is possible that there is considerable real structural variation as well. Periods of alternate growth and inactivity seem to have been an occasional feature in the life history of these colonies, which gives the corallum a banded appearance, and near the plane of inanition tabulation seems to be most frequent. The walls are thick and fibrous, the fibers being directed at right angles to the cell axes.

It would seem that our collections show the presence of true *Chætetes milleporaceus* in Colorado, with variations from the normal type, which may be deemed sufficient, provided they are not due to the agencies of fossilization, to constitute a definite variety or possibly even a distinct species.

Locality and horizon.—San Juan region (stations 2196, 2228); middle portion of the Hermosa formation. Crested Butte district (stations 2290, 2306); Maroon conglomerate.

ECHINODERMATA.

ARCHÆOCIDARIS Meek, 1872.

ARCHÆOCIDARIS OURAYENSIS n. sp.

Pl. I, fig. 14.

The character of this species is well shown by the accompanying figure. It consists of a slender axis, slightly over 1 mm. in diameter, upon which are thickly clustered rather short, large spines which have a diameter almost as great as the axis itself. They are subcylindrical, bluntly pointed, inclined upward, and sometimes gently curved.

The basal and distal portions of the style are unknown.

This species is so unlike any other American form that comparisons with them are scarcely necessary. Its characteristic features so far as known are, of course, the very large size and close arrangement of the lateral spines.

Locality and horizon.—Ouray (station 2194); Hermosa formation.

ARCHÆOCIDARIS TRIPLEX White?

1881. *Archæocidaris triplex.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Supp., Appendix, p. xxii, pl. 4, figs. 3*a–c*.
Carboniferous: New Mexico.

1895. *Archæocidaris triplex.* Keyes, Iowa Acad. Sci., Proc., vol. 2, p. 191.
Upper Coal Measures: New Mexico.

This species has been found at only one locality, and the identification is unsatisfactory because of the fragmentary character of the material. This consists entirely of spines of unusually large proportions. The diameter is 4½ mm. just above the ring and is still greater distally. When complete the length could hardly have been less than 12 mm., and it may have been greater. Comparatively small spinules project from the principal style at intervals of about 8 mm. On one important feature I have been unable to assure myself—the character of the cross section. Of course near its base the style is cylindrical. Some small weathered fragments appear to be three-cornered, but in sections brought to view on the broken faces of the matrix this feature is less distinct. Here they usually show one or two flattened sides, with the rest of the outline circular. In the largest and most perfect specimen the spinules appear to be arranged in rows, which are sufficiently far apart to admit of but about three in the circumference. This would seem to indicate that the style was originally three-sided. The spines in the two rows in view are nearly but not quite opposite. Those in the same row are about 8 mm. apart, somewhat less than in the typical specimen of *A. triplex*, and the articulating ring is transverse, instead of, as in it, oblique. The nearest described species, next to *A. triplex*, is *A. megastylus*, but my specimens show many more spinules than are exhibited in Keyes's figures, and the articulating ring is much more projecting. The species also closely resembles *A. cratis*, but it is very much more robust, and the spinules appear to be considerably finer.

Locality and horizon.—San Juan region, Needle Mountains quadrangle (station 2188); Molas formation.

ARCHÆOCIDARIS TRUDIFER White?

1874. *Archæocidaris trudifer.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Prelim. Rept. Invert. Foss., p. 17.
Carboniferous (Coal Measures): Camp Apache, Arizona.

1876. *Archæocidaris trudifer.* White, Powell's Rept. Geol. Uinta Mountains, p. 89.
Lower Aubrey group: Confluence of Grand and Green rivers, Utah.

1877. *Archæocidaris trudifer.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 104, pl. 6, figs 8*a*, *b*.
Carboniferous (Red Wall limestone): Camp Apache, Arizona.

1895. *Archæocidaris trudifer.* Keyes, Iowa Acad. Sci., Proc., vol. 2, p. 191.
Lower Carboniferous: "Camp Apache," Arizona.

1900. *Archæocidaris trudifer.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 47, pl. 8, fig. 10.
Upper Coal Measures (Topeka limestone): Topeka, Kans.

A single specimen, not very perfect, which resembles *A. trudifer* closer than any described species except, perhaps, *A. edgarensis*. The figures of these two species are so similar as to suggest that both names were proposed for the same specific type.

Locality.—Leadville district (station 2265).

ARCHÆOCIDARIS ORNATA Newberry.

1861. *Archæocidaris ornatus.* Newberry, Ives's Colorado River Expl. Exped., p. 116, pl. 1, figs. 2, 3, 3*a*.
Upper Carboniferous limestone: Banks of Colorado River.

1877. *Archæocidaris ornatus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 104, pl. 6, fig. 7.
Carboniferous: Ojo del Oso, near Fort Wingate, N. Mex.

1895. *Archæocidaris ornatus.* Keyes, Iowa Acad. Sci., Proc., vol. 2, p. 191.
Carboniferous: Ojo del Oso, N. Mex.

One good specimen from the San Juan region (station 2235) is clearly the form which White identified with Newberry's species. At the two other localities the material is too imperfect to admit of a conclusive identification.

Locality and horizon.—San Juan region (station 2235); middle portion of Hermosa formation. Leadville district (stations 2265, 2267); base of the Weber formation.

ARCHÆOCIDARIS CRATIS White.

1876. *Archæocidaris cratis.* White, Powell's Rept. Geol. Uinta Mountains, p. 109.
Lower Aubrey group: Confluence of Grand and Green rivers, Utah.

1880. *Archæocidaris cratis.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 130, pl. 33, fig. 2*a*.
Middle Carboniferous: Confluence of Grand and Green rivers, Utah.

1895. *Archæocidaris cratis.* Keyes, Iowa Acad. Sci., Proc., vol. 2, p. 188.
Coal Measures (Lower Aubrey): Utah.

This species is abundant near Ouray (station 2195b) and in fair preservation. Fragments of what is doubtless the same form were collected in the Leadville region (station 2265) and in the Crested Butte region (station 2307). This species is related to one described and figured by Keyes[a] as *A. megastylus* Shumard, and it would be little surprising if the one form should be traced into the other. The interambulacral plates have almost precisely the same characters in both, but the spines of *A. megastylus* are much larger and less spinose than the type known as *A. cratis*. It should be noted, however, that in the latter species the large spines or portions of spines have fewer subsidiary spinules than the smaller ones or portions.

Locality and horizon.—Crested Butte district (station 2307); Weber limestone. Leadville district (station 2265). Ouray (station 2195a); Hermosa formation.

[a] Missouri Geol. Surv., vol. 4, 1894, p. 129, pl. 15, figs. 2*a*, 2*b*.

EOCIDARIS Desor, 1858.

EOCIDARIS HALLIANA Geinitz?

1866. *Eocidaris hallianus.* Geinitz, Carb. und Dyas in Nebraska, p. 61, tab. 5, figs. 1 *a*, *b*, 2 *a*, *b*.
Upper Coal Measures: Nebraska City, Nebr.

1872. *Eocidaris hallianus.* Meek, U. S. Geol. Surv. Nebraska, p. 152, pl. 7, figs. 9 *a–d*.
Upper Coal Measures: Nebraska City, Nebr.

1894. *Archæocidaris hallianus.* Keyes, Missouri Geol. Surv., vol. 4, p. 129.
Upper Coal Measures: Kansas City, Mo.

1895. *Archæocidaris hallianus.* Keyes, Iowa Acad. Sci., Proc., vol. 2, p. 190.
Upper Coal Measures: Kansas City, Mo.; Nebraska City, Nebr.

The material collected has suffered so much from weathering that a satisfactory identification is not possible. The fossils have been referred to Geinitz's species largely on account of their minute size.

Locality and horizon.—Leadville district (station 2265). Crested Butte district (station 2320); Weber limestone.

EUPACHYCRINUS Meek and Worthen, 1865.

EUPACHYCRINUS? sp.

This identification rests upon a single imperfect specimen. Its generic position can not be determined with certainty, but it is of interest as being the only crinoid in the collections examined.

Locality and horizon.—San Juan region (station 2221); upper portion of the Hermosa formation.

HELMINTHA.

CONULARIA Miller, 1821.

CONULARIA CRUSTULA White?

1880. *Conularia crustula.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 170, pl. 42, fig. 4*a*.
Coal Measures: Kansas City, Mo.; near Taos, N. Mex.

1881. *Conularia crustula.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Supp., Appendix p. xxviii, pl. 3, figs. 4*a*, *b*.
Carboniferous: Near Taos, N. Mex.

1894. *Conularia crustula.* Keyes, Missouri Geol. Surv., vol. 5, p. 219, pl. 35, fig. 2.
Upper Coal Measures: Kansas City, Mo.

1897. *Conularia* conf. *crustula.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 41.
Coal Measures: Scott County, Ark.

Crushed and imperfect specimens of *Conularia* appear in our collections from two localities. In their present condition it would be difficult to reach a trustworthy conclusion as to their relations to each other and to other forms; they seem to belong to a single species, namely, that to which White gave the name *Conularia crustula*.

Both specimens attain a size unusual for *C. crustula* and must have had a diameter of 25 mm. and a length proportional. The striæ seem to be without ornamentation and are about 1 mm. apart on one specimen and 0.8 mm. on the other.

Except for being of somewhat larger proportions these specimens are quite similar to *C. crustula.* In comparison with *C. roeperi*, however, the only other member of the genus known from the Upper Carboniferous, they are much smaller, more tapering, and with striæ which are at the same time more distant and are sigmoidally curved instead of nearly straight.

Locality and horizon.—San Juan region (station 2239?); upper part of the Hermosa formation. Grand River region, Grand River, 1 mile below Eagle River (station 2190).

ENCHOSTOMA Miller, 1896.

Enchostoma sp.

At a station in the Crested Butte region (station 2313) occurs in considerable abundance an organism which I feel little hesitancy in referring to Miller's genus. Specimens have the bluish color and shining phosphatic surface which are both striking and distinctive. In occurrence they are much flattened, and cross the surface of the limestone blocks in ribbon-like strips whose edges are parallel. No tendency to taper is apparent in the specimens studied, but at the same time no specimens of any considerable length have come under my observation. The breadth rarely exceeds 3.5 mm., and sometimes measures but 2 mm.

Miller believes these organisms to be the remains of mollusks and allied to the Conulariidæ. Whatever be the affinities of *Conularia*, I am convinced that those of *Enchostoma* are with the polychætous annelids. The tube, which is the only portion of the organism yet discovered, affords but a slender support for a conclusion upon this point, but a suggestive resemblance, if no more, can be pointed out between the Paleozoic shells under discussion and the living genus *Hyalinacea.* The latter inhabits a smooth, gently tapering, incomplete, cylindrical tube, composed of chitinous material, from which that of *Enchostoma* differs chiefly in being more massive and made up of phosphate of lime (?) in concentric laminæ.

Locality and horizon.—Crested Butte district (station 2313); Weber limestone.

SPIRORBIS Lamarck, 1801.

Spirorbis arietina Dawson.

1871. *Spirorbis arietina.* Dawson, Geol. Surv. Canada, Rept. Prog., 1866–1869, p. 14, fig. —.
Carboniferous: Near New Glasgow, Nova Scotia.

The Colorado shells referred to *Spirorbis arietina* attain a rather large size for the genus. They are sinistral, and composed of four or five turns, the first two or three of which are in contact, forming a rather high spire with a broad, deep umbilicus, and the last one or two free and irregularly bent. The cross section is circular. The surface seems to be marked with regular, very fine, transverse striæ, and toward the aperture by a few irregular, transverse wrinkles. Well-preserved surfaces are also seen to be minutely papillose, or occasionally appear as if the crests of the striæ were minutely crenulate.

The data thus briefly set down are derived largely from the material from station 2311. Though specimens occur more abundantly at station 2310, the preservation is much less satisfactory. Nevertheless the species is believed to be the same at both.

My material, while attaining a somewhat greater size than that shown by Dawson's figure of *Spirorbis arietina*, agrees with that species in so many particulars as to lead me to believe that if not actually identical with it, it is at least very closely related.

This form differs from that occurring at Glenwood Springs in being larger and in appearing to lack the longitudinal striæ of that species. The latter is also close-coiled throughout and the final portion is not free as in *Sp. arietina*. At the same time I am not sure that an abundance of good material would show that they are distinct.

Locality and horizon.—Crested Butte district (stations 2310, 2311); Maroon formation.

Spirorbis sp.

This form occurs in abundance at Glenwood Springs, and in an excellent state of preservation. It forms small, rather regularly conical sinistral shells, consisting of two or three volutions and having a moderately high spire. The larger specimens have a diameter of 2 mm. The surface is crossed by numerous delicate transverse striæ, and also by fine, wavy, probably inosculating, revolving ones. The tube shows additional irregularities, chiefly of a concentric kind, due to growth. The surface ornamentation, though minute, is very pretty and very well shown.

This form is probably distinct from that referred to *Sp. arietina*. It is as a rule considerably smaller, and specimens of the latter seem to lack the surface markings of this one, though not being so well preserved that character may have been obscured in them.

Locality.—Grand River region, Glenwood Springs (station 2193).

BRYOZOA.

FISTULIPORA McCoy, 1849.

Fistulipora carbonaria Ulrich.

1884. *Fistulipora carbonaria*. Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 7, p. 45, pl. 3, figs. 1, 1a. Upper Coal Measures: Kansas City, Mo.

1895. *Fistulipora carbonaria*. Keyes, Missouri Geol. Surv., vol. 5, p. 16. (Date of imprint 1894.) Upper Coal Measures: Kansas City, Mo.

This species is represented by a zoarium which had an irregular shape and a submassive growth. The thickness is about 12 mm. and the greatest diameter 26 mm. Ulrich's description and figures, which I will not quote here, so closely represent the characters of my specimen as I have made them out, that the identification is offered with some confidence.

Locality and horizon.—San Juan region (stations 2207, 2213); upper and lower portions of the Hermosa formation.

STENOPORA Lonsdale, 1844.

Stenopora carbonaria Worthen.

1875. *Chætetes? carbonaria.* Worthen, Geol. Surv. Illinois, Rept., vol. 6, p. 526, pl. 32, fig. 5.
Coal Measures: St. Clair County, Ill.

1887. *Stenopora carbonaria.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 2, p. 85, pl. 7, figs. 13a–c.
Coal Measures: Bald Hill and Flint Ridge, Ohio.

1888. *Stenopora carbonaria.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 3, pl. 8, figs. 13a–c.

1890. *Stenopora carbonaria.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 445, pl. 73, figs. 8, 8a.
Coal Measures: Caseyville, Ill.; Lawrence, Kans.; Ohio.

Two specimens of this form have come to hand. They seem to belong to the well known *Stenopora carbonaria.*

Locality and horizon.—San Juan region (station 2213); lower portion of the Hermosa formation.

Stenopora cestriensis Ulrich.

1890. *Stenopora censtriensis.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 442, pl. 74, figs. 7, 7a.
Chester group: Chester, Ill.

1895. *Stenopora cestriensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 16. (Date of imprint 1894.)
Kaskaskia limestone: Chester, Ill.

This species is represented by two specimens in a fairly good state of preservation. They agree with Ulrich's description of *St. cestriensis* and differ from the related form, *St. tuberculatus*, in the characters pointed out by him, viz, "the cells are smaller, their individual walls more clearly defined, the acanthopores more conspicuous, and the zooecial layers at least twice as thick."

Locality.—Leadville district (station 2265).

Stenopora tuberculata Prout.

1859. *Flustra tuberculata.* Prout, Acad. Sci. St. Louis, Trans., vol. 1, p. 447, pl. 17, figs. 3–3f.
Second Archimedes limestone: Barrett Station, St. Louis County, Mo.

1860. *Cyclopora polymorpha.* Prout, Acad. Sci. St. Louis, Trans., vol. 1, p. 578.
Chester limestone: Pope County, Ill.

1866. *Cyclopora polymorpha.* Prout, Geol. Surv. Illinois, Rept., vol. 2, p. 421, pl. 21, figs. 5–5b.
Chester group: Pope County, Ill.

1890. *Stenopora tuberculata.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 441, fig. 17.
Chester group: Chester, Ill.
St. Louis limestone and Warsaw beds.

1895. *Stenopora tuberculata.* Keyes, Missouri Geol. Surv., vol. 5, p. 15. (Date of imprint 1894.)
St. Louis limestone: Barrett Station, Mo.
Kaskaskia limestone: Chester, Ill.

This form is represented by two excellent specimens. They agree very closely with Ulrich's description of Prout's species, and although the latter is especially abundant in and characteristic of rocks of the Genevieve epoch, and the present material seems to be of Upper Carboniferous age, they probably can safely be referred to the same species.

Locality and horizon.—Crested Butte district (station 2312); Weber limestone.

Stenopora ? sp.

Associated with the form which I have distinguished under the title of *Leioclema ?* sp. occur two other zoaria of a general appearance closely similar, but which are probably at least generically distinct.

The shape of the zoarium is discoid, almost flat, more or less flexuous. Diameter about 10 mm., thickness inconsiderable. Mesopores practically absent. Autopores small, angular, 6 or 8 in a space of 2 mm. Walls thin. Acanthopores probably present. Diaphragms probably absent.

Though in general appearance similar to *Leioclema ?* sp. with which this form is associated, it can be distinguished without difficulty by reason of its much smaller cells and practical absence of mesopores.

Locality and horizon.—San Juan region (station 2221); upper portion of the Hermosa formation.

LEIOCLEMA Ulrich, 1882.

Leioclema ? sp.

At station 2221 in the San Juan region occurs in considerable abundance a form of whose generic position I am much in doubt, but which I have placed provisionally with *Leioclema.* The zoaria are small and extremely thin. The shape is that of a disk, slightly depressed in the center and more or less flexuous. The diameter is usually under 12 mm. and the thickness inappreciable. The cells are minute, subcircular or petaloid in shape, and separated by abundant mesopores, which have an angular outline. They radiate in an almost horizontal position from the center of the colony. Acanthopores seem to be absent, and the height of the zoœcia is so slight as to suggest that diaphragms also are lacking. Certainly none have been seen.

Locality and horizon.—San Juan region (station 2221); upper portion of the Hermosa formation.

CHAINODICTYON Foerste, 1887.

CHAINODICTYON LAXUM Foerste.

1887. *Chainodictyon laxum.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 2, pp. 81 and 87, pl. 7, figs. 8a–c.
Coal Measures: Flint Ridge, Ohio; Seville, Ill.

1888. *Chainodictyon laxum.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 3, p. 135.

A poorly preserved fragment is all that we have of this strongly characterized species, but its affinities are probably as stated above.

Locality and horizon.—San Juan region (station 2332); middle portion of the Hermosa formation.

SEPTOPORA Prout, 1859.

SEPTOPORA DELICATULA Ulrich.

1890. *Septopora delicatula.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 634, pl. 64, figs. 5, 5a.
Lower Coal Measures: Seville, Ill.

This species is represented by very fragmentary and scanty material, but the identification is probably correct.

Locality.—Leadville district (station 2265).

SEPTOPORA sp.

A single very imperfect specimen of this species has come to hand. It is specifically distinct from the form noticed above, and is possibly related to *S. cestriensis* Prout.

Locality and horizon.—San Juan region (station 2207); upper portion of the Hermosa formation.

POLYPORA McCoy, 1845.

POLYPORA WHITEI var. INSCULPTA Ulrich.

1889. *Polypora whitei* var. *eximia* (in error for insculpta). Miller's North American Geol. and Pal., p. 317.

1890. *Polypora whitei* var. *insculpta.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 600, pl. 62, fig. 1.
Upper Coal Measures: Springfield, Ill.

At station 2331 on the Animas River in the San Juan region, a prolific locality for Bryozoa, was obtained a small fragment of a *Polypora* whose characters, so far as they are shown, ally it closely to *P. whitei* var. *insculpta.* A form which is possibly identical with that from the San Juan occurs in the Leadville region at station 2265.

Locality and horizon.—San Juan region (station 2331); Hermosa formation. Leadville district (station 2265).

POLYPORA cf. DISTINCTA Ulrich.

1890. *Polypora distincta.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 603, pl. 61, figs. 7, 7a.
Upper Coal Measures: Springfield, Ill.

This is a rather coarse form, characterized by somewhat lax and irregular growth. The branches are strong, and connected by dissepiments which are slender, short, and situated at distant intervals. The zoœcia are arranged in four, possibly in five, longitudinal rows. Their apertures have elevated margins and they manifest a certain tendency toward, or appearance of, dimorphism, for, scattered among the regular zoœcia, are a number of others which are often of smaller size, or, when equal, seem by their proximity to them to be arranged in groups of two. The nonporiferous side has not been seen.

This form is not identical with *P. distincta* but is probably no more than a variety. It is also allied to *P. gracilis* Ulrich.

Locality.—Leadville district (station 2265).

POLYPORA cf. CESTRIENSIS Ulrich.

1890. *Polypora cestriensis.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 594, pl. 55, figs. 4–4*b*; pl. 60, figs. 7–7*c*.
Chester group: Chester, Kaskaskia, and near Anna, Ill.; Litchfield and Sloans Valley, Kentucky.

1895. *Polypora cestriensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 29. (Date of imprint, 1894.)
Kaskaskia limestone: Ste. Genevieve, Mo.

This is a coarsely reticulated form with elongate elliptical fenestrules. The zoœcia are in four rows. The nonporiferous side is ornamented with sharp but rather fine longitudinal striæ. The poriferous side also is marked by ridges which pass between the zoœcia and in some degree define them.

Locality and horizon.—San Juan region (station 2331); Hermosa formation.

POLYPORA n. sp.

This form is represented by a fragment of a frond from the Leadville region, and by two fragments, each from a different locality in the San Juan region, which probably belong to the same species. My material is too fragmentary and ill preserved to permit a detailed description of what is probably a new species.

The frond is rather coarsely reticulate with thick branches and short, thin dissepiments. The fenestrules are elongate elliptical. The branches are carinated on the nonporiferous side and marked by moderately fine, sharp striæ. The zoœcia are in three or four rows and their apertures have elevated margins.

Locality and horizon.—San Juan region (stations 2331?, 2332); middle portion of the Hermosa formation. Leadville district (station 2268).

Polypora sp. *a*.

This species occurs associated with that provisionally identified as *P. cestriensis* Ulrich. It resembles the latter in many particulars, the chief difference which the scanty and imperfect material exhibits being that the unidentified form is distinctly more finely reticulated. As in *P. cestriensis*, there are four rows of zoœcia, and the nonporiferous side is marked with sharp, fine striæ.

Locality and horizon.—San Juan region (station 2331); Hermosa formation.

Polypora sp. *b*.

Another undetermined species of *Polypora* is found at station 2235 in the San Juan region. The frond is rather rapidly enlarging, the branches thick, the dissepiments thin and long. The fenestrules are nearly square or subcircular. The only specimen observed shows the poriferous side, where the zoœcia are seen to be arranged in about four rows.

Locality and horizon.—San Juan region (stations 2205, 2235); middle portion of the Hermosa formation.

FENESTELLA Lonsdale, 1839.

Fenestella cf. tenax Ulrich.

1888. *Fenestella tenax.* Ulrich, Sci. Lab. Denison Univ., Bull., vol. 4, p. 71.
Waverly group: Cuyahoga County, Ohio.

1890. *Fenestella tenax.* Ulrich, Geol. Surv. Illinois, Rept., vol. 8, p. 546, pl. 51, figs. 2–2e.
Warsaw beds: Monroe County and Warsaw, Ill.
Chester group: Chester and Kaskaskia, Ill.; Sloans Valley, Ky.

1895. *Fenestella tenax.* Keyes, Missouri Geol. Surv., vol. 5, p. 24. (Date of imprint, 1894.)
Kaskaskia limestone: Chester, Ill.

This species is already credited with a long range, since it is found from the Waverly group into the Chester, and this will be considerably increased if the present identification proves correct, as is not unlikely. This form presents a very fine, regular network, in which the dissepiments are more slender than the branches. The latter are marked by comparatively strong, sharp, flexuous, longitudinal striæ. There are about five zoœcia opposite two fenestrules, which are subrectangular upon the nonporiferous side and elliptical upon the other.

Locality and horizon.—San Juan region (station 2331); Hermosa formation.

Fenestella sp.

This form, which is probably the same in the San Juan and Leadville regions (stations 2221 and 2265, respectively), is indeterminable from the material in hand. It differs from that briefly described as *F. tenax* in having the fenestrules nearly square or subcircular, the dissepiments thicker, and the nonporiferous face granulose instead of striated. These observations are based entirely upon the Leadville specimen.

Locality and horizon.—San Juan region (station 2221); upper portion of the Hermosa formation. Leadville district (station 2265).

PRISMOPORA Hall, 1881.

PRISMOPORA TRIANGULATA White.

Pl. I, fig. 5.

1878. *Ptilodictia triangulata.* White, Acad. Nat. Sci. Philadelphia, Proc., p. 35.
Coal Measures: Danville, Ill.

1879. *Ptilodictia triangulata.* White, U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, p. 214.
Carboniferous: Yampa Plateau, northwestern Colorado.

1880. *Ptilodictia triangulata.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 131, pl. 33, figs. 3a–c.
Coal Measures: Danville, Ill.; Yampa Plateau, northwestern Colorado; and region southward from Yellowstone National Park.

1881. *Ptilodictia triangulata.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Supp., Appendix, p. xxiv, pl. 4, figs. 2a–c.
Carboniferous: Cebolla Creek and Coyote Creek, New Mexico.

White described this species from Danville, Ill., in 1878, and the year following published an identification, with comments and figures, from the Yampa Plateau, in northwestern Colorado. Although specimens belonging to the genus *Prismopora* appear in our collections from several stations, those identified by White are the only ones which I have placed with *Pr. triangulata*, and his figures, drawn from a Colorado specimen, have been used to illustrate the species.

The illustration on Pl. I represents the specimen as somewhat enlarged. The real size of the branches between the nodes varies from 2 to 1.5 mm.

Locality and horizon.—Uinta Mountain region, Yampa Plateau (station 2330); middle division of the Carboniferous.

PRISMOPORA SERRATA Meek.

1875. *Ptilodictya (Stictopora) serrata.* Meek, Pal. Ohio, vol. 2, p. 327, pl. 20, fig. 4.
Lower Coal Measures: Flint Ridge, Ohio.

1887. *Prismopora serrata.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 2, p. 75, pl. 7, figs. 6a–c.
Coal Measures: Bald Hill and Flint Ridge, Ohio.

This species occurs in some abundance near Rock Creek (station 2245) and in the San Juan region (station 2331), and a single fragmentary specimen has also been collected at Rico (station 2301). The edges are often flexuous, but sometimes nearly straight. The branches are of larger size than the specimen by which *Pr. triangulata* is represented. The zoœcia are small and evenly distributed.

Locality and horizon.—San Juan region (stations 2301, 2331); middle part of the Hermosa formation. Crested Butte district (station 2245).

Prismopora sp.

This form probably belongs to a yet undescribed species, but it is represented, unfortunately, by only extremely imperfect material. The branches are larger than in *Pr. triangulata*, the zoœcia larger and more closely arranged. It resembles *Pr. serrata* in the size of its branches, but has the zoœcia a little larger and considerably more closely arranged.

Locality and horizon.—San Juan region (station 2236); middle portion of the Hermosa formation.

RHOMBOPORA Meek, 1872.

Rhombopora lepidodendroides Meek.

1866. *Stenopora columnaris* (pars). Geinitz, Carb. und Dyas in Nebraska, p. 66. (Not Schlotheim, 1813.)
Upper Coal Measures: Nebraska City, Bennetts, and Wyoming, Nebr.

1872. *Rhombopora lepidodendroides.* Meek, U. S. Geol. Surv. Nebraska, p. 141, pl. 7, figs. 2a–f.
Upper Coal Measures: Nebraska City, Bennetts, Wyoming, Rock Bluff, and Plattsmouth, Nebr.; Kansas; Iowa; Missouri; Illinois.

1875. *Rhombopora lepidodendroides.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 99, pl. 6, figs. 5a–d. (Whole volume published in 1877.)
Carboniferous: West face of Oquirrh Range, near "E. T. City," Utah, and at confluence of White Mountain and Black rivers, Arizona.

1884. *Rhombopora lepidodendroidea.* Ulrich, Jour. Cincinnati Soc. Nat. Hist., vol. 7, p. 27, pl. 1, figs. 1–1b.
Upper Coal Measures: Kansas City, Mo.; Nebraska City and Wyoming, Nebr.

1887. *Rhombopora lepidodendroidea.* Foerste, Sci. Lab. Denison Univ., Bull., vol. 2, p. 73, pl. 7, figs. 3a, b.
Coal Measures: Flint Ridge and Bald Hill, Ohio.

1887. *Rhombopora* ———. Foerste, Sci. Lab. Denison Univ., Bull., vol. 2, p. 74, pl. 7, figs. 5a–c.
Coal Measures: Flint Ridge, Ohio.

1888. *Rhombopora lepidodendroides.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 225.
Lower Coal Measures: Des Moines, Iowa.

1895. *Rhombopora lepidodendroidea.* Keyes, Missouri Geol. Surv., vol. 5, p. 35, pl. 33, figs. 4a, b. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1896. *Rhombopora lepidodendroides.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 237.
Upper Coal Measures: Poteau Mountain, Indian Territory.

1896. *Rhombopora lepidodendroides.* Smith, Leland Stanford Junior Univ., Pub.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 27.
Upper Coal Measures: Poteau Mountain, Indian Territory.

This name, as I have used it here and as it has often been employed in literature, probably stands rather for a group of forms than for a single consistent species. To reduce to proper scientific status the collections from Colorado, and much more the citations in literature, would be a task of difficulty even if it could be accomplished at all in an acceptable manner without more abundant and better preserved material than most of that which has come into my hands.

Rhombopora lepidodendroides is very abundant at station 2215 in the San Juan region, and it seems to be common also at 2281 in the Leadville region.

Locality and horizon.—San Juan region (stations 2186, 2215, 2235); Molas formation and middle portion of the Hermosa formation. Leadville district (stations 2265, 2281); base of the Weber formation. Grand River region (station 2329b). Uinta Mountain Region, overlooking Yampa River (station 2191).

BRACHIOPODA.

LINGULA Bruguière, 1792.

Lingula carbonaria Shumard.

1858. *Lingula carbonaria.* Shumard, Acad. Sci. St. Louis, Trans., vol.1, p. 215.
Coal Measures: Clark County, Mo.

1873. *Lingula mytiloides?* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 572, pl. 25, fig. 2.
Coal Measures: Illinois.

1887. *Lingula umbonata?* Herrick (non Cox), Sci. Lab. Denison Univ., Bull., vol. 2, p. 144, pl. 14, fig. 2.
Coal Measures: Flint Ridge, Ohio.

1899. *Lingula mytiloides?* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 575.
Upper Coal Measures: Atoka quadrangle, Hartshorne, Ind. Ter.; roof shale of the Grady or Hartshorne coal.

I have only one specimen of this form, and it is too imperfect to be identified with certainty. It seems to belong to the type of shell often referred in this country to *Lingula mytiloides* Sowerby. This type differs from Sowerby's figures in being smaller and as a rule more quadrate before and behind. It is probable that Shumard's *Lingula carbonaria* was founded upon a shell belonging to this group, for his description answers to it quite closely. It might be well, therefore, to employ *Lingula carbonaria* for American shells of the *mytiloides* type.

Lingula umbonata? Herrick (non Cox) is probably another example of the species for which *L. carbonaria* was proposed. Indeed, if one may depend upon the accuracy of published figures, none of the identifications of Cox's species are correct. White,[a] Keyes,[b] and Beede[c] appear to have had in hand a slender elongate form of a shape differing materially from that depicted by Cox's figure. Judging from the literature, therefore, I would look to find four species involved—the slender form figured by White et al. as *L. umbonata*, *L. umbonata* as figured by Cox, *L. carbon-*

[a] Geol. Surv. Indiana, Thirteenth Rept., 1884, p. 120, pl. 25, fig. 14.

[b] Missouri Geol. Surv., vol. 5, 1894, p. 38, pl. 35, fig 4.

[c] Univ. Geol. Surv. Kansas, Rept., vol. 6, 1900, p. 54, pl. 8, fig. 5.

aria figured by Meek as *L. mytiloides*, and *L. tighti* Herrick. But the study of these forms is most difficult and but little profitable.

Locality and horizon.—Leadville district (station 2264?); base of the Weber formation.

Lingula tighti Herrick.

1887. *Lingula tighti.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 43, pl. 4, fig. 5
Coal Measures: Flint Ridge, Ohio.

This species is found at but one locality. It is there very abundant, though not well preserved. The material studied is as a rule much smaller than *L. carbonaria*, which has been identified at another locality in the Leadville area, but the essential difference resides in the fact that it is a more slender and elongate form, with a shape which is rather subelliptical than subquadrate. Most of the material referred to this species is also smaller than the specimen figured by Herrick, but one or two examples from the same locality and apparently belonging to the same specific type, are nearly of normal size. It is possible, however, that we have here only young shells of *L. carbonaria*.

This species is very abundant in the *Lingula* bed of station 2227. One peculiarity of the occurrence at this locality is that in most instances both valves are found in conjunction.

In addition to the material belonging to the genus *Lingula*, whose specific identification has been attempted as above, several occurrences of indeterminable specimens may be noted, e. g., Glenwood Springs, station 2193a.

Locality and horizon.—Leadville district (station 2277); base of the Weber formation.

ORBICULOIDEA d'Orbigny, 1850.

Orbiculoidea manhattanensis Meek and Hayden.

1859. *Discina manhattanensis.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 25.
Upper Coal Measures: Kansas River, opposite Manhattan, Kans.

1892. *Orbiculoidea manhattanensis.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 5, fig. 12.
Coal Measures: Riley County, Kans.

1892. *Orbiculoidea manhattanensis.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 4E, fig. 20.
Coal Measures: Riley County, Kans.

1900. *Orbiculoidea manhattanensis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 56, pl. 8, figs. 2–2b.
Upper Coal Measures: Wabaunsee formation, black shale in wagon-road cut east side of Blue Mount, Manhattan, Kans.

Of this species but few specimens have come to hand, and they are crushed and fragmentary. The best preserved example, a dorsal valve, affords the following data:

The shape is of course nearly circular, with a diameter of about 15 millimeters.

The apex is one-half a diameter or a little more from the margin and the height is about 2 millimeters. The surface is marked by sharply elevated, thread-like striæ, 3 or 4 in a distance of 1 millimeter, with flat interspaces. The latter when exfoliated show faint, fine, radiating lines. Other specimens show that this species attained a diameter considerably exceeding that stated.

The measurements and other characters mentioned above, though necessarily somewhat lacking in accuracy by reason of the imperfect nature of my material, indicate that this form is probably that described by Meek and Hayden as *Discina manhattanensis*.

Locality and horizon.—Leadville district (stations 2252, 2264); base of the Weber formation.

ORBICULOIDEA sp.

Near Glenwood Springs (station 2193a) a small species of *Orbiculoidea* occurs in considerable abundance. Without intermediate forms I do not feel justified in referring it to the same species as the shells which I have identified as *O. manhattanensis*, nor have I been able to satisfy myself that it can properly be referred to any other known species. It may be briefly described as follows:

The nearly circular outline has a diameter which rarely exceeds 5 millimeters. The apex is one-third of a diameter, or a little less, from the margin, and the height is sometimes as great as 2 millimeters. In the ventral valve the slit is strongly marked and reaches from near the center to halfway to the circumference.

The surface is marked by comparatively strong, somewhat irregular, closely arranged, concentric striæ.

Locality.—Grand River region, Glenwood Springs (station 2193a).

RHIPIDOMELLA Oehlert, 1887.

RHIPIDOMELLA PECOSI Marcou.

1858. February. *Orthis pecosii.* Marcou, Geol. North America, p. 48, pl. 6, figs. 14–14b.
Mountain Limestone: Pecos Village, N. Mex.

1858. June. *Orthis carbonaria.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 218.
Middle Coal Measures: Lexington, Mo.

1864. *Orthis* (sp. undet.). Meek, Pal. California, vol. 1, p. 10, pl. 2, figs. 5–5c.
Carboniferous: Bass's Ranch, Shasta County, Cal.

1872. *Orthis carbonaria.* Meek, U. S. Geol. Surv. Nebraska, p. 173, pl. 1, figs. 8a–8c.
Upper Coal Measures: Rock Bluff and Nebraska City, Nebr.; Iowa; Kansas; Illinois.
Middle Coal Measures: Lexington, Mo.

1873. *Orthis carbonaria.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 571, pl. 25, fig. 4.
Upper Coal Measures: Lasalle, Ill.

1875. *Orthis pecosii.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 125, pl. 9, figs. 5a–5e. (Volume appeared as a whole in 1877.)
Carboniferous: Santa Fe, N. Mex.

1883. *Orthis carbonaria.* Hall, Rept. New York State Geol. for 1882, pl. (7) 37, figs. 1–4.
Coal Measures: Springfield, Ill.

1883. *Orthis pecosi.* Kayser, Richtofen's China, vol. 4, p. 177, pl. 24, fig. 1.
Upper Carboniferous: Lo-Ping, China.

1884. *Orthis pecosii.* Waagen, Paleontologica Indica, ser. 13, vol. 1, p. 573, pl. 56, figs. 13a–13e.
Lower Productus limestone: Salt Range, Amb., India.

1884. *Orthis pecosi.* White, Geol. Surv. Indiana, 13th Rept., p. 129, pl. 32, figs. 20–22.
Coal Measures: Horse Shoe of Little Vermilion and Garret's Mill, Vermilion County, Ind.; Vermilion County, Ill.

1892. *Rhipidomella pecosi.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pp. 210, 226, pl. 7, figs. 1–4.
Coal Measures: Near Springfield, Ill.

1895. *Orthis pecosii.* Keyes, Missouri Geol. Surv., vol. 5, p. 64. (Date of imprint, 1894.)
Coal Measures: Kansas City, Mo.

1896. *Orthis pecosii.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 237.
Upper Coal Measures: Poteau Mountain, Ind. T.

1900. *Rhipidomella pecosi.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 90.
Upper and Lower Coal Measures: Fort Scott, Kansas City, Eudora, Lawrence, Lecompton, Kans.

My material is, as a rule, rare and not well preserved, but the species has been obtained from near Glenwood Springs (station 2329b) in fair abundance and preservation. Specimens attain a size greater, somewhat, than that figured by Marcou, and a length of 14 millimeters seems to be about normal for the specimens seen by me, which agree in this and other particulars, so far as I have been able to ascertain, with the species as it is represented in the Mississippi Valley.

A very poor specimen from Leadville (station 2259), which seems to have been originally identified as *Derbya crassa*, probably belongs to this species.

Locality and horizon.—Leadville district (stations 2259, 2264); base of the Weber formation. Grand River region, Glenwood Springs (station 2329b). San Juan region (2186?); Molas formation.

ORTHOTICHIA Hall and Clarke, 1892.

ORTHOTICHIA SCHUCHERTENSIS n. sp.

Pl. I, figs. 16 to 16b.

Shell of medium size, transverse. Dorsal valve strongly convex; beak large and incurved; area small (?); fold broad and scarcely appreciable; anterior outline emarginate.

Ventral valve smaller and shallower than the dorsal; beak probably incurved and not quite as projecting as the other; sinus broad and strong, especially toward the front. This valve is provided with a rather thick, but not very high, median septum reaching about one-third the distance toward the anterior margin, and by a pair of strong dental lamellæ.

The surface is marked by very slender, equal, radiating striæ and by much stronger ones regularly distributed among them. The latter are discontinuous and outlined by such deep grooves that they appear to be depressed below the general surface. This peculiarity is stronger upon the ventral valve than on the dorsal, where it appears upon the lateral areas, but scarcely at all over the median portion.

There is but one other species of this genus known from the Western Hemisphere, the South American form, *Orthotichia morganiana.* To this my species is related, but I feel no doubt as to their being specifically distinct. The fold and sinus of *O. morganiana* I take to be less strongly marked, and the surface, as shown by specimens in my possession, is distinctly different. It shows a feature common to many species of Orthoids, consisting of individual striæ somewhat more prominent than the rest, terminating abruptly and running out into a small spine, but does not possess the heavy, short, depressed striæ which probably are to be associated with a similar origin, but which form such an unusual character of my shell.

The species described by Cox as *Orthis resupinoides* has much the same configuration as the Colorado form, but seems to lack the peculiarities of its surface ornamentation, besides which Hall and Clarke refer Cox's species to the genus *Schizophoria*, so that further comparisons of course are unnecessary.

I know of no other species with which this is likely to be confused.

A single small specimen from Sinbads Valley has been referred to the same species as that from Glenwood Springs (though it may be merely a young example of *Enteletes*), and it discloses characters of the area which were concealed in the material from the type locality. In this example, which has a length of but 14 millimeters (the type is 26 millimeters long), the beaks of the two valves are about on a level when the shell is looked at from the side. The area of the dorsal valve in this position is nearly vertical; that of the ventral starts out in a nearly horizontal direction. The areas of both valves are small, slightly curved, and contain large, open, triangular foramina. That of the ventral valve is higher and more strongly curved than is that of the dorsal.

Locality and horizon.—Grand River region, Glenwood Springs (station 2193a). Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

ENTELETES Fischer de Waldheim, 1830.

ENTELETES HEMIPLICATUS Hall.

1852. *Spirifer hemiplicata.* Hall, Stansbury's Exped. to Great Salt Lake, p. 409, pl. 4, figs. 3a, b.
Carboniferous: Missouri River, near Weston.

1859. *Spirifer hemiplicata.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 28.
Upper Coal Measures: Near Leavenworth, Kans.

1866. *Rhynchonella angulata.* Geinitz (non Linné), Carb. und Dyas in Nebraska, p. 37, tab. 3, figs. 1–4.
Upper Coal Measures: Bennett's Mill and Nebraska City, Nebr.

1866. *Syntrielasmà hemiplicata.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 323, fig. 36; p. 324, fig. 37.
Upper Coal Measures: 12 miles north of Vandalia, Ill.; eastern Kansas, northern Missouri, western Iowa.

1872. *Syntrielasma hemiplicata.* Meek, U. S. Geol. Surv. Nebraska, p. 177, pl. 6, figs. 1a, b; pl. 8, figs. 12*a*, *b*.
Upper Coal Measures: Nebraska City, Wyo., and Bennett's Mill, Nebr.
Coal Measures: Illinois, Iowa, Missouri, Kansas.

1873. *Syntrielasma hemiplicata.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 571, pl. 26, fig. 20.
Upper Coal Measures: 12 miles north of Vandalia, Ill.

1882. *Camerophoria giffordi.* Worthen, Illinois State Mus. Nat. Hist., Bull. No. 1, p. 39.
Middle Coal Measures: Near Alta, Peoria County, Ill.

1883. *Camerophoria giffordi.* Worthen, Geol. Surv. Illinois, Rept., vol. 7, p. 318, figs. a–c.
Middle Coal Measures: Near Alta, Peoria County, Ill.

1883. *Syntrielasma hemiplicata.* Kayser, Richtofen's China, vol. 4, p. 179, pl. 24, figs. 2, 3.
Upper Carboniferous: Lo-Ping, China.

1884. *Syntrielasma hemiplicata.* White, Geol. Surv. Indiana, 13th Rept., p. 131, pl. 26, figs. 15–18.
Coal Measures: Indiana.

1892. *Enteletes hemiplicata.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 12, figs. 18–21.
Coal Measures: Winterset, Iowa; Kansas City, Mo.

1892. *Enteletes hemiplicata.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pp. 215, 226, pl. 7A, figs. 44–52.
Upper Coal Measures: Kansas City, Mo.; Winterset, Iowa.

1895. *Syntrielasma hemiplicata.* Keyes, Missouri Geol. Surv., vol. 5, p. 76, pl. 39, figs. 8a–d. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Enteletes hemiplicata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 91, pl. 12, figs. 6, 6b.
Upper Coal Measures: Kansas City, Independence, Iola, Edwardsville, Eudora, Lawrence, Lecompton, Topeka, Kans.

Though not occurring elsewhere in our Colorado collections, this species is found in considerable abundance at Sinbads Valley (station 2285). The specimens are badly crushed, but appear to be typical in every way.

Locality and horizon.—Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

DERBYA Waagen, 1884.

Derbya crassa Meek and Hayden.

1852. *Orthis umbraculum?* Hall, Stansb. Exped. Great Salt Lake, p. 412, pl. 3, fig. 6.
Carboniferous: Missouri River, above Fort Leavenworth.

1852. *Orthis umbraculum?* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 5, fig. 11.
Carboniferous: Missouri River, near mouth of Keg Creek, and at Council Bluffs.

1852. *Orthis arachnoidea.* Roemer (non Phillips), Kreid. von Texas, p. 89, pl. 11, figs. 9a, b.
Carboniferous: San Saba Valley, Tex.

1857. *Orthis arachnoidea.* Hall, Mexican Boundary Survey, pl. 20, fig. 3.

1858. *Orthisina crassa.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 261.
Coal Measures: Leavenworth, Kans.

1858. *Orthis crenistria.* Marcou, Geol. North America, p. 49.
Mountain limestone: Pecos Village, New Mexico.

1859. *Orthisina crassa.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Coal Measures: Leavenworth, Kans.

1859. *Orthisina umbraculum?* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Upper Coal Measures: Fort Riley and Cottonwood Creek, Kans.

1860. *Orthis lasallensis.* McChesney, Desc. New Pal. Foss., p. 32.
Upper Coal Measures: Lasalle, Ill.

1860. *Orthis richmonda.* McChesney, Desc. New Spec. Pal. Foss., p. 32.
Coal Measures: Twelve miles northwest of Richmond, Mo.

1860. *Orthis pratteni.* McChesney, Desc. New Spec. Pal. Foss., p. 32.
Coal Measures: Charboniere, Mo.

1861. *Streptorhynchus umbraculum.* Newberry, Ives's Colorado River Expl. Exped., p. 125.
Upper Carboniferous (Cherty limestone): Canyon of Cascade River near the junction of the Colorado Chiquito with the Colorado; at Agua Azul; east of Fort Defiance; at Santa Fe; at Ojo Vernal, and on Cottonwood Creek, Kansas.

1864. *Hemipronites crassus.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 26, pl. 1, figs. 7a–d.
Coa Measures: Leavenworth, Kans.

1865. *Orthis richmondi.* McChesney, Illustrations New Spec. Foss., pl. 1, figs. 5a–c.

1865. *Orthis lasallensis.* McChesney, Illustrations New Spec. Foss., pl. 1, figs. 6a, b.

1866. *Orthis crenistria.* Geinitz (non Phillips), Carb. und Dyas in Nebraska, p. 46, pl. 3, figs. 20, 21.
Upper Coal Measures: Bellevue and Plattsmouth, Nebr.; Stage Bb, at Bennett's mill, southwest of Nebraska City; Stages Bb^{iv}, Cc^{ii}, Cc^{v}, at Nebraska City.

1868. *Hemipronites crassus.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 28, pl. 1, figs. 5a–c.
Coal Measures: 12 miles northeast of Richmond, Mo.

1868. *Hemipronites lasallensis.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 28, pl. 1, figs. 6a, b.
Upper Coal Measures: Lasalle, Ill.

1872. *Hemipronites crassus.* Meek, U. S. Geol. Surv. Nebraska, p. 174, pl. 5, figs. 10a–c; pl. 8, fig. 1.
Upper Coal Measures: Nebraska City, Bennett's Mill, Wyo.; Cedar Bluff, Rock Bluff, Plattsmouth, Bellevue, Omaha, Peru, Rulo, and Brownsville, Nebr.
Coal Measures: Kansas; Iowa; Missouri; Illinois.
Chester limestone: West Virginia.

1873. *Hemipronites crassus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 570, pl. 25, fig. 12.
Upper Coal Measures: Lasalle, Ill.

1875. *Hemipronites crenistria.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 124, pl. 10, fig. 9*a*. (Whole volume published in 1879.)
Carboniferous: Meadow Creek, south of Fillmore; Star District, Picacho Range; North Fork of Lewiston Canyon, Oquirrh Range; below Ophir City, Kanab Canyon, Wasatch Range; pass between Rush and Cedar valleys; and east side of Mount Nebo, Utah; top of Grass Mountain, Ely Range; Fossil Hill; Camp Apache; Old Potosi Mine; Tenney's ranch; Kaibab Plateau; and at confluence of White Mountain and Black rivers, Nevada.

1876. *Hemipronites crenistria.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey Group: Near Echo Park, and at confluence of Grand and Green Rivers, Utah.
Upper Aubrey Group: Beehive Point, near Horseshoe Canyon, Utah.

1883. *Streptorhynchus richmondi.* Hall, Rept. New York State Geol. for 1882, pl. (10) 40, figs. 10, 11.
Coal Measures: Iowa.

1884. *Hemipronites crassus.* White, Geol. Surv. Indiana, 13th Rept., p. 129, pl. 26, figs. 4–11.
Coal Measures: Lodi, Eugene, Perrysville, Merom, Big Creek, and New Harmony, Ind.

1884. *Derbyia crassa.* Waagen, Palæontologia Indica, ser. 13, vol. 1, p. 592.

1887. *Hemipronites crassus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 50, pl. 2, fig. 19.
Coal Measures: Flint Ridge, Ohio.

1888. *Streptorhynchus crenistria.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 229.
Lower Coal Measures: Des Moines, Iowa.

1891. *Streptorhynchus crassum.* Whitfield, New York Acad. Sci., Ann., vol. 5, p. 580, pl. 13, figs. 11, 12.
Maxville limestone: Ohio.

1892. *Derbya crassa.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 17, figs. 1–4, 9.
Upper Coal Measures: Kansas City, Mo.; Winterset, Iowa.

1892. *Derbya crassa.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 10, figs. 10, 11; pl. 11A, figs. 28–33; pl. 11B, figs. 23, 24; pl. 20, figs. 12, 13.
Upper Coal Measures: Near Kansas City, Mo., and Winterset, Iowa.

1893. *Streptorhynchus crassum.* Whitfield, Geol. Surv. Ohio, Rept., vol. 7, p. 468, pl. 9, figs. 11, 12.
Maxville limestone: Ohio.

1895. *Streptorhynchus crenistria.* Keyes, Missouri Geol. Surv., vol. 5, p. 67, pl. 38, figs. 8a–h. (Date of imprint 1894.)
Coal Measures: Kansas City, Clinton, and Lexington, Mo.

1896. *Derbya crassa.* Smith, Leland Stanford Junior Univ. Pub.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 28.
Upper Coal Measures: Poteau Mountain, Indian Territory.
Lower Coal Measures: Conway County, Ark.

1896. *Derbya crassa.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 238.
Upper Coal Measures: Poteau Mountain, Indian Territory.
Lower Coal Measures: Conway County, Ark.

1900. *Derbya crassa.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 62, pl. 8, figs. 11, 11b.
Upper and Lower Coal Measures: Fort Scott, Kansas City, Lawrence, Topeka, Kans.

This species appears in our collections at many localities, but it is usually rather rare. Though abundant in the Crested Butte region (stations 2307 and 2320), at Glenwood Springs (2193a), and at Ouray (2195a), it is somewhat crushed and poorly preserved. Specifically it agrees with the Mississippi Valley variety in every essential.

The material from Leadville is both scanty and poor, and the identification in one or two cases may not be correct.

Locality and horizon.—San Juan region (stations 2197, 2203, 2219, 2220, 2233, 2246, 2247, 2284, 2332); throughout the Hermosa formation. Crested Butte district (stations 2280, 2293, 2303, 2307, 2320); Weber limestone and Maroon formation. Leadville district (stations 2250, 2252, 2265, 2275); upper and lower portions of the Weber formation. Ouray (station 2195a); Hermosa formation. Grand River region, Glenwood Springs (station 2193a).

MEEKELLA White and St. John, 1868.

Meekella striaticostata Cox.

1857. *Plicatula striato-costata.* Cox, Owen's Geol. Surv. Kentucky, Rept., vol. 3, p. 568, pl. 8, fig. 7.
Coal Measures: Providence, Hopkins County, Ky.

? 1858. *Orthisina shumardiana.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 183.
Lower Permian: Valley of Cottonwood, Kans.

1858. *Orthisina missouriensis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 219.
Upper Coal Measures: Dallas, Mo.; Kansas.

? 1859. *Orthisina shumardiana.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Upper Coal Measures: Fort Riley, Kans.

1859. *Orthisina missouriensis.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Upper Coal Measures: Leavenworth, Kans.

? 1859. *Streptorhynchus* (*Orthisina*) *shumardianus.* Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 395.
Permian sandstone: Guadalupe Mountains.

? 1863. *Orthisina occidentalis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 2, p. 82.
Upper Coal Measures: Caldwell County, Mo.

1866. *Orthis striato-costata.* Geinitz, Carb. und Dyas in Nebraska, p. 48, Tab. 3, figs. 22–24.
Upper Coal Measures: Crescent City, Iowa.

1868. *Meekella striato-costata.* White and St. John, Chicago Acad. Sci., Trans., vol. 1, pp. 120, 122, figs. 4–6.
Coal Measures: Iowa.

1872. *Meekella striato-costata.* Meek, U. S. Geol. Surv. Nebraska, p. 175, pl. 5, figs. 12a–c.
Upper Coal Measures: Nebraska City, Bellevue, Plattsmouth, Otoe City, and Aspinwall, Nebr.; Kentucky; Iowa; Missouri; Illinois.

1873. *Meekella striato-costata.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 571, pl. 26, fig. 21.
Upper and Lower Coal Measures: Caseyville and various localities in Illinois.

1875. *Meekella striato-costata.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 126, pl. 9, figs. 4a–e. (Volume published as a whole in 1877.)
Carboniferous: Camp Cottonwood, Lincoln County, Nev.; Tenney's ranch, Kaibab Plateau, Arizona; Kanab Canyon; Meadow Creek, south of Fillmore; Le Verkins Creek, and at cliff east of Belleview, Utah.

1876. *Meekella striatocostata.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey Group: Confluence of Grand and Green rivers, Utah.

1883. *Streptorhynchus* (*Meekella*) *striatocostata.* Hall, Rept. New York State Geol. for 1882, pl. (10) 40, figs. 18–23.

1883. *Meekella striatocostata.* Kayser, Richtofen's China, vol. 4, p. 178, pl. 23, fig. 8.
Upper Carboniferous: Lo-Ping, China.

1884. *Meekella striatocostata.* White, Geol. Surv. Indiana, 13th Rept., p. 130, pl. 26, figs. 12–14.
Coal Measures: Western part of Vigo County, Ind.

1892. *Meekella striatocostata.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 17, figs. 10–13.
Upper Coal Measures: Winterset, Iowa; Lawrence County, Kans.

1892. *Meekella striatocostata.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, p. 265, pl. 10, figs. 18–23; pl. 11B, figs. 20–22.

Upper Coal Measures: Winterset, Iowa; Lawrence County, Kans.

1895. *Meekella striatocostata.* Keyes, Missouri Geol. Surv., vol. 5, p. 68, pl. 39, figs. 1a–c. (Date of imprint 1894.)

Upper Coal Measures: Kansas City, Mo.

1900. *Meekella striatocostata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 65, pl. 12, figs. 9–9c.

Upper and Lower Coal Measures: Fort Scott, Olathe, Kansas City, Eudora, Lawrence, Lecompton, Topeka, Beaumont, Grand Summit, Kans. Widely distributed but moderately rare throughout the Coal Measures and base of the Permian. Abundant near base of Permian.

Shells referable to the genus *Meekella* have been collected at three localities, but I am dissatisfied, I confess, with the specific disposition which their unfavorable condition has led me to make of them. At Deadwood Gulch in the San Juan region (station 2229), specimens are abundant but fragmentary. At the two other points they are rare and also fragmentary. At the former occur specimens which can without impropriety, so far as their imperfect condition permits judgment, be placed with Cox's *Meekella striaticostata.* From this type there is deviation in several directions, a very noticeable phase of which consists in a varying obsolescence of the longitudinal plications, and accompanying it of a manifestation by the striæ of a strong tendency to grow straight and parallel, instead of being arranged in a somewhat pinnate manner as in the typical variety. In some of these specimens, also, the striation is much finer than in typical examples.

At Silver Creek (station 2309), also in the San Juan, the only specimen obtained shows a form with high area whose surface lacks all but the faintest traces of plications and is covered with fine, straight striæ which are more or less regularly unequal.

A still different type is found in a dorsal valve from Leadville (station 2254). Here the striæ are coarse when compared with the last, but, like them, are rigid and parallel. Plications, provided they have not been obliterated by crushing, are almost obsolete. Where the crest of each would probably be situated, one of the striæ is exaggerated, the intermediate ones numbering six or eight.

I judge that there are two species or varieties involved in this collection, or possibly three, but the small amount and wretched condition of my material prevents ascertaining their respective limits or their mutual relations. It was apparently for a form similar to those with faint plications and straight, parallel striæ that Swallow proposed the name *Orthisina shumardiana*, and this name, it seems to me, it would be well to retain, at least in a varietal sense.

Locality and horizon.—San Juan region (stations 2229, 2309?); middle portion of the Hermosa formation. Leadville district (station 2254).

CHONETES Fischer de Waldheim, 1830.

CHONETES FLEMINGI Norwood and Pratten.

Pl. I, figs. 17, 18, 18a.

1854. *Chonetes flemingii.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2 S.), vol. 3, p 26, pl. 2, figs. 5a–c. (Imprint of whole volume, 1855.)
[Coal Measures]: Ten miles northwest of Richmond, Mo.

1859. *Chonetes flemingi* (*?*). Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 390.
White Permian limestone: Guadalupe Mountains.

1891. *Chonetes flemingi.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 247.
Lower Coal Measures: Des Moines, Iowa.

1892. *Chonetes flemingi.* Hall and Clarke, Pal. New York, vol. 5, pt. 1, pl. 15B, fig. 1.
Coal Measures: Illinois.

1895. *Chonetes flemingi.* Keyes, Missouri Geol. Surv., vol. 5, p. 54, pl. ~~26~~ 27, figs. 6a, b. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

In identifying this species, comparison has been made with a rather extensive series from the Mississippi Valley. I feel little hesitation in referring both sets of specimens to the same species, which I take to be *Chonetes flemingi* Norwood and Pratten. The latter has been regarded by Schuchert and Weller as a synonym for *Ch. variolatus* d'Orbigny.

My study of this material aroused the suspicion that *Ch. flemingi* and *Ch. verneuilianus* were proposed for divergent variations of the same type. One would be led by Norwood and Pratten's work to conclude that *Ch. flemingi* could be distinguished from *Ch. verneuilianus* by being larger, less strongly marked by fold and sinus, by having seven instead of four spines on either side of the beak, by having more numerous striæ (150 instead of 100), and by the pitted character of the surface lying between them. The difference in number of striæ might be largely offset by size, so that this factor would probably have to be disregarded in discriminating the two species.

In the collections examined, although they had been for the most part identified with *Ch. verneuilianus*, I find that almost all the material can be correctly referred only to *Ch. flemingi*. In regard to size, of course the greatest diversity occurs, but in almost every instance specimens were found which attained a much larger size than that cited by the authors of *Ch. verneuilianus.* Exception must, however, be made in favor of a small collection of about a dozen specimens from Caseyville, Ill., to which reference will be made later on. These specimens are all small, very few attaining a greater transverse diameter than 7 mm.

It was not in every case possible to ascertain the number of spines possessed by each specimen, but almost always more than four could be counted on even the smaller examples. As many as nine have been observed, but the most common number is six or seven. Even in specimens of the same size and apparently the same age, differences occurred in the number and arrangement of the spines developed, at least in the number which could be ascertained. There was also great variation in the plicated or sinuate condition of the shell. The dominant type had a strong sinus of about the degree of development shown in Norwood and Pratten's figures of *Ch. flemingi*, but variation extended on the one hand to an incipient obsolescence of plication and on the other to a condition as strongly folded, in some instances, as *Ch. verneuilianus*, where figured in the original description. Another point of variation which may be mentioned here is in the proportions of the shell, which ranges from distinctly transverse to subquadrate, and in the prolongation of the cardinal extremities. A transverse shape, produced cardinal line, and a deep fold and sinus usually go together in this species, so far as my observations extend.

The number of striæ developed depends, of course, in large measure upon the size of the shell, but in the size of the striæ and the number occurring in a given space no considerable variation was observed. They do vary appreciably, however, in the strength with which they are developed, in some cases being raised and strong and in others obsolescent. This difference can not be ascribed to erosion, as in many cases the delicate concentric growth lines could be detected. These are unlike the even, threadlike, concentric striæ covering the coarser radiating ornamentation on many Lower Carboniferous members of the genus, but are rather irregular and minutely lamellose.

The pittings between the striæ mentioned by the authors in connection with *Ch. flemingi* could be seen in most of the specimens examined, though, of course, preservation plays an important part in concealing and revealing such minute characters.

Much the greater part of the material examined, therefore, seems to belong rather to *Ch. flemingi* than to *Ch. verneuilianus*. In several instances a few individuals, especially by reason of increased gibbosity and an exaggerated development of fold and sinus, approach the limits occupied by the species *Ch. verneuilianus*. Whether they are true representatives of that species is still a matter of doubt in my mind, but if they can be correctly so identified, I think one name might well be reduced to varietal import, as every gradation seems to occur between the two types. In view of these observations *Ch. flemingi* would more properly be retained as the specific appellation, not only because it has priority among the species described by Norwood and Pratten, but because it seems to be the abundant and dominant type of which the other is but a variant.

The small variety from Caseyville mentioned above is transverse, with well developed sinus, hinge line much longer than the width of the shell below, and with slightly obsolescent striæ.

The Colorado collection consists for the most part of large shells, with strong striæ and slight development of sinus. The shape is generally subquadrate. The width is greater, though not very much so, than the length, and the hinge line is but slightly extended. Exception must be made, however, of a few poorly preserved specimens from station 2213 in the San Juan region, which are smaller and more gibbous than the others and have a strongly impressed ventral sinus. These latter have been referred to *Ch. flemingi* var. *verneuilianus.* *Ch. flemingi* is rather abundant at Glenwood Springs, the form being small and with indistinct sinus.

Locality and horizon.—Crested Butte district (stations 2293, 2313, 2315); Weber limestone and Maroon formation. Grand River region (station 2324), Glenwood Springs (stations 2193a, 2326, 2329b). Ouray (station 2194); Hermosa formation.

CHONETES FLEMINGI var. VERNEUILIANUS.

1854. *Chonetes verneuilana.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 26, pl. 2, figs. 6a–c. (Imprint of whole volume 1855).
Coal Measures: Charboniere, Mo.

1859. *Chonetes verneuiliana.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Upper Coal Measures: Manhattan, Kans.

1861. *Chonetes verneuiliana.* Newberry, Ives's Colorado River Expl. Exped., p. 128.
Upper Carboniferous: Cherty limestones on banks of the Colorado River, 100 miles northwest of San Francisco Mountain.

1872. *Chonetes verneuilana.* Meek, U. S. Geol. Surv. Nebraska, p. 170, pl. 1, figs. 10a, b.
Upper Coal Measures: Plattsmouth, Nebr.; Kansas; Iowa; Missouri; Illinois.

1883. *Chonetes verneuili.* Hall, Rept. New York State Geol. for 1882, pl. (16) 47, figs. 20–21.
Coal Measures: Western States.

1884. *Chonetes verneuiliana.* White, Geol. Surv. Indiana, 13th Rept., p. 128, pl. 25, figs. 7, 8.
Coal Measures: Every county in the Coal Measures of Indiana.

1892. *Chonetes verneuiliana.* Hall and Clark, Int. Study of Brach., pt. 1, pl. 20, figs. 5, 6.
Coal Measures: Illinois.

1892. *Chonetes verneuiliana.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 6, figs. 20, 21.
Coal Measures: Illinois.

1900. *Chonetes verneuilianus.* Beede, Geol. Surv. Kansas, Rept., vol. 6, p. 72, pl. 9, figs. 4–4c.
Lower and Upper Coal Measures: Bronson, Bourbon County, Kansas City, Buffalo Mound, Wabaunsee County, Kans.

A few poorly preserved specimens from station 2213 in the San Juan region have been provisionally placed with *Ch. flemingi* var. *verneuilianus.* They differ from the form identified as *Ch. flemingi* in being smaller, more transverse, and furnished with a deeper sinus.

Locality and horizon.—San Juan region (station 2213); lower portion of Hermosa formation.

CHONETES GEINITZIANUS Waagen.

Pl. I, figs. 19, 19a.

1866. *Chonetes glabra.* Geinitz, Carb. und Dyas in Nebraska, p. 60, tab. 4, figs. 15–18 (not *C. glaber* Hall, 1857.)
Dyas: Nebraska City, Nebr.

1869. *Chonetes glabra.* Toula, Sitzb. der Kais. Akad. der Wissench. Wien, 1. Abth., vol. 59, p. 442.
Carboniferous limestone: 10 miles from Cochabamba, Bolivia.

1872. *Chonetes glabra.* Meek, U. S. Geol. Surv. Nebraska, p. 171, pl. 4, fig. 10; pl. 8, figs. 8a, b.
Upper Coal Measures: Nebraska City, Nebr.; Atchison, Kans.

1874. *Chonetes glabra.* Derby, Cornell Univ. (Science), Bull., vol. 1, No. 2, p. 43, pl. 8, figs. 11, 14, 15, 19.
Coal Measures: Bomjardim and Itaituba, Brazil, and Cochabamba, Bolivia.

1876. *Chonetes glabra.* Derby, Mus. Comp. Zool., Bull., vol. 3, p. 280.
Coal Measures: Yampopata, Brazil.

1884. *Chonetes geinitziana.* Waagen, Paleontologica Indica, ser. 13, vol. 1, pp. 616, 621.

1888. *Chonetes lævis.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 229, pl. 12, figs. 3a, b.
Lower Coal Measures: Des Moines, Iowa.

1889. *Chonetes geinitzanus.* Miller, North American Geol. and Pal., p. 339.

1891. *Chonetes lævis.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 246.
Lower Coal Measures: Des Moines, Iowa.

1892. *Chonetes lævis.* Keyes, Iowa Acad. Sci., Proc., vol. 1, pt. 2, p. 22.
Lower Coal Measures: Near Des Moines, Iowa.

1894. *Chonetes lævis.* Keyes, Missouri Geol. Surv., vol. 5, p. 55, pl. 37, figs. 5a, b.
Upper Coal Measures: Kansas City, Mo.

1900. *Chonetes glaber.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 68, pl. 9, fig. 2.
Upper Coal Measures: Topeka.

When Waagen proposed *Chonetes geinitzianus* for this species to replace the older name first given it by Geinitz, he pointed out that *Chonetes glaber*, used by the latter, had long been preoccupied by *Chonetes glaber* Hall.[a] While *Chonetes geinitzianus* has not yet come into use among American paleontologists, there can be no question about the propriety of adopting the name.

The representation of *Chonetes geinitzianus* in our collections is often scanty and the preservation poor. About the only identifications which are believed to be unquestionable are at two localities in the Leadville district (stations 2267 and 2268). The form at Empire Gulch in the Leadville district (station 2264) is extremely abundant, but so poorly preserved as to make a certain identification impossible. A single specimen of small size from near Glenwood Springs can probably be referred here.

In the San Juan region (at station 2243, which is believed to be in the Rico formation) *Chonetes geinitzianus* is found in moderate abundance. The specimens, however, are rather undersized.

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[a] New York State Cab. Nat. Hist., 10th Rept., 1857, p. 117, figs. 1–8.

It is, perhaps, deserving of notice that this species is largely restricted, so far as our collections indicate, to the Leadville region.

Locality and horizon.—San Juan region (station 2343); Rico formation. Leadville district (stations 2257?, 2264?, 2265?, 2267, 2268); base of the Weber formation. Grand River region, Glenwood Springs (station 2329b).

CHONETES GRANULIFER Owen.

1852. *Chonetes granulifera.* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, p. 583, pl. 5, fig. 12.
Carboniferous limestone: Near mouth of Keg Creek.

1854. *Chonetes smithii.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 24, pl. 2, figs. 2a–c. (Entire volume bears imprint of 1855.)
Coal Measures: Belleville, Ill.

1854. *Chonetes granulifera.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 24., (Entire volume bears imprint of 1855.)
Coal Measures: Belleville, Ill.; Keg Creek, Missouri.

1858. *Chonetes mucronata.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 262. (Not *C. mucronatus* Hall, 1843.)
Upper Coal Measures: Near Fort Riley, Kans.

1859. *Chonetes mucronata.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Upper Coal Measures: Fort Riley and Cottonwood Creek, Kansas.

1864. *Chonetes mucronata.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172; p. 22, pl. 1, fig. 5a–c.
Coal Measures: Near Fort Riley, Kans.

1866. *Chonetes mucronata.* Geinitz, Carb. und Dyas in Nebraska, p. 58, tab. 4, figs. 12–14.
Upper Coal Measures: Bennett's Mill and Nebraska City, Nebr.

1869. *Chonetes mucronata.* Toula, Sitzb. der Kais. Akad. der Wissensch. Wien, 1 Abth., vol. 59, p. 442.
Carboniferous limestone: Ten miles from Cochabamba, Bolivia.

1872. *Chonetes granulifera.* Meek, U. S. Geol. Surv. Nebraska, p. 170, pl. 4, fig. 9, pl. 6, fig. 10; pl. 8, fig. 7.
Upper Coal Measures: Nebraska City, Wyoming, Bennetts Mill, Plattsmouth, Bellevue, and Omaha, Nebr.; Kansas; Missouri; Iowa.
Coal Measures: Illinois.

1873. *Chonetes smithii.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 570, pl. 25, fig. 11.
Coal Measures: St. Clair County, Ill.

1875. *Chonetes granulifera.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, pt. 1, p. 122, pl. 9, figs. 8a–c. (Entire volume bears imprint 1877.)
Carboniferous (Upper Aubrey limestone): Kanab Canyon, Arizona.

1876. *Chonetes granulifera.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey Group: Confluence of Grand and Green rivers, Utah.

1891. *Chonetes granuliferus.* Beecher, Am. Jour. Sci., (3), vol. 41, p. 357, pl. 17, fig. 15.
Coal Measures: Manhattan, Kans.

1892. *Chonetes smithi.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 15B, fig. 12.
Coal Measures: Illinois.

1894. *Chonetes granulifera.* Keyes, Missouri Geol. Surv., vol. 5, p. 56.
Upper Coal Measures: Kansas City, Mo.

1900. *Chonetes granulifer.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 69, pl. 9, figs. 1–1c.
Coal Measures: Common throughout Coal Measures; from Kansas City to Topeka and Manhattan, Grand Summit, etc., Kans.

1900. *Chonetes granulifera.* Knight., Univ. Wyoming, Wyoming Exp. Sta., Bull. No. 45, pl. 3, fig. 2.

In all the collections examined but a single specimen of this form, so common at certain horizons in the Mississippi Valley, has come to hand. It seems, however, to be a characteristic example of Owen's well-known species.

Locality and horizon.—Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

Chonetes mesolobus Norwood and Pratten.

Pl. I, figs. 20, 21, 22, 23.

1855. *Chonetes mesoloba.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour. (2), vol. 3, p. 27, pl. 2, figs. 7a–c.
Coal Measures: Belleville, Ill.; Charboniere, Mo.

1875. *Chonetes mesoloba.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, pt. 1, p. 123, pl. 9, fig. 7a. (Entire volume published in 1877.)
Carboniferous: Confluence of White Mountain and Black rivers, Arizona.

1883. *Chonetes mesoloba.* Hall, Rept. New York State Geol. for 1882, pl. (16) 47, fig. 22.
Coal Measures.

1887. *Chonetes mesoloba.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 49.
Coal Measures: Flint Ridge, Ohio.

1888. *Chonetes mesoloba.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 228.
Lower Coal Measures: Des Moines, Iowa.

1892. *Chonetes mesoloba.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 20, fig. 7.
Coal Measures: Illinois.

1892. *Chonetes mesoloba.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 16, fig. 22.
Coal Measures: Illinois.

1894. *Chonetes mesoloba.* Keyes, Missouri Geol. Surv., vol. 5, p. 53.
Upper Coal Measures: Kansas City, Mo.

1899. *Chonetes mesolobus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 576.
Upper Coal Measures: Atoka quadrangle.

1900. *Chonetes mesolobus.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 71, pl. 9, figs. 3, 3b.
Lower Coal Measures: Fort Scott and Bronson, Bourbon County, Kans.

The Colorado representatives of this well-characterized species are quite typical in every way. It is not found at many localities, nor usually in great numbers, but at station 2343, which is on Dolores River, in the Rico formation, it occurs in abundance. Two different types of shell can be distinguished, one small in size and with strong lobation, the other large, with the two sulci of the ventral valve tending toward evanescence. Specimens from station 2238 in the San Juan region represent the latter variety. I am disposed to advocate the distinction by a varietal name of this large faintly lobate type, especially if, as I believe to be the case, it can be correlated with circumstances of range or distribution.

Locality and horizon.—San Juan region (stations 2226, 2233, 2238, 2343); upper part of the Hermosa formation, Rico formation. Crested Butte district (stations 2293, 2303); Maroon formation. Grand River region (station 2324).

PRODUCTUS Sowerby, 1814.

Productus semireticulatus var. hermosanus n. var.

Pl. II, figs. 1 to 1c, 2 to 2b, 3 to 3b, 4 to 4b.

Although representing a type which has sometimes probably been referred to *Productus costatus* Sowerby, I believe the material in hand to be more closely related to *Productus semireticulatus* Martin. Meek[a] seems to doubt the existence of typical *P. costatus* in this country, and cites an opinion of Davidson to the effect that some, at least, of the American shells referred to it are more nearly allied to Martin's species. Although the material from Colorado is probably not identical with the form which called forth the remarks just quoted, they tend to corroborate the opinion with which the discussion of this species here opens.

The striæ usually number from 8 to 10 in the space of 10 mm. over the median portion of the shell, and are equal and regular, but anteriorly they are apt to be unequal and irregular. In this region they are often coarser owing in large measure, I believe, to the increased size of the shell, their number remaining about the same and their size proportionally augmented. It is not rare, however, to find two or more striæ coalescing anteriorly into a single larger one, nor, on the other hand, is the bifurcation of striæ toward the anterior margin of rare occurrence. The former process is sometimes regarded as characteristic of *Productus costatus*, but in the present form it takes place only in a limited degree, and a much greater number of striæ are found around its margin than is the case in *P. costatus*. Sowerby[b] cites only 18 in the original description, while in this form 50 or more is a common number. In point of fact however, neither Sowerby's description nor figures indicate that the large size and small number of the striæ of *P. costatus* is due to coalescence, and the reverse seems to be the case. The spines developed in this species, except upon the ears, though of large size, are comparatively few in number.

On the other hand, though certainly resembling it in many ways, this is not the common form in the Pennsylvanian rocks of the Mississippi Valley which passes under the name of *Productus semireticulatus*. It is in general somewhat smaller, more inflated and incurved, with fewer and larger spines, and ears which are at the same time more extended and inrolled. These differences seem to me sufficiently constant and well marked to have at least varietal value, and I have distinguished, by the term *hermosanus*, the western form possessing them. This species is related to

[a] U. S. Geol. Surv. Nebraska, 1872, p. 159.

[b] Min. Conch., vol. 6, 1829, p. 115, pl. 560, fig. 1.

Productus spiralis Waagen, from India, and to *Productus boliviensis* d'Orbigny, but is clearly distinct from either. It is also very closely allied to the form I have designated as *P. inflatus* McChesney, which is little more than a variety, and the two apparently intergrade completely. This statement, however, might have to be modified if all the material were in perfect preservation.

In its typical condition *Productus semireticulatus* var. *hermosanus* is largely confined in Colorado to the San Juan region. The stations at which well characterized material has been obtained are, in the San Juan region, 2204, 2207, 2210, 2236, 2241, 2243, 2302, 2331, 2333, 2335, in the Leadville region, 2262, and in the Crested Butte, 2245 and 2293. Most of the other identifications rest upon intermediate gradations between it and *P. inflatus*, or upon imperfect and scanty material. In the San Juan region the two forms seem to be well distinguished and it is in other areas where *P. inflatus* is the prevailing form that intermediates mostly occur. *P. inflatus* displays more of a tendency to graduate into *P. semireticulatus* var. *hermosanus*, than into *P. inflatus*, and in some cases the coarser forms of *P. inflatus* when associated with the finely striated variety have been placed with *P. semireticulatus* var. *hermosanus* when, had they been found alone, they might have been referred to the other.

This species also occurs in the Mississippi Valley, where its horizon seems to be at the base of and just below the Upper Coal Measures of the Kansas section. It thus is an earlier form than the typical, or at all events the best-known, variety of *P. semireticulatus*, and is probably its progenitor. The latter is as yet not known to occur in Colorado.

The identification of this form in the fauna from Sinbads Valley is doubtful.

Locality and horizon.—San Juan region (stations 2200, 2204, 2207, 2210, 2226?, 2236, 2241, 2243, 2331, 2333, 2334, 2335); middle and upper portions of the Hermosa formation. Crested Butte district (stations 2245, 2291, 2293, 2300, 2302, 2304); Maroon formation. Leadville district (stations 2252, 2259, 2262, 2264, 2265, 2266, 2275); lower, middle, and upper portions of the Weber formation. Ouray (station 2194); Hermosa formation. Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

Productus inflatus McChesney.

Pl. III, figs. 1 to 1b, 2, 2a, 3.

1860. *Productus inflatus.* McChesney, Desc. New Spec. Pal. Foss., p. 40.
Carboniferous limestone: Leavenworth, Ind.

1865. *Productus inflatus.* McChesney, Illustrations New Spec. Foss., pl. 6, figs. 1a–c.

1868. *Productus inflatus.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 27, pl. 6, figs. 1a–c.
Carboniferous limestone: Leavenworth, Ind.

Shell of medium size, very gibbous, transversely subquadrate. Ventral valve highly inflated, the posterior portion being more strongly flexed than the anterior.

Beak small, incurved, projecting but slightly beyond the hinge line. Ears rather large, extended, vaulted. Sinus broad and shallow, distinct though not strong.

Dorsal valve slightly concave over the visceral portion. After attaining a length of about 20 mm. the curvature is strong and sudden, and subsequent growth follows that of the other valve. The visceral cavity is of considerable height, sometimes as much as 15 mm., but usually a little less.

The surface is marked by numerous fine, even, wire-like, radiating striæ, and posteriorly, over about one-third its length, by concentric wrinkles. The spines are few and distant, though large. They are scattered over the surface, sometimes in more or less regular quincunx arrangement. Often one or two of the striæ are interrupted by each spine as it develops, to reappear in a bifurcated condition, three or four originating at each spine base.

This form closely resembles the one which I have designated as *Productus semireticulatus* var. *hermosanus*. I am unable to point out any differences of significance in the conformation of the shell, and the chief distinction concerns the surface ornamentation. In the more typical examples of *Productus inflatus* the concentric wrinkles and radiating striæ are much finer and the spines smaller and more numerous. As many as 15 or 16 striæ occur in the space of 10 mm., while in *Productus semireticulatus* var. *hermosanus* only 9 or 10 are found in the same distance. Variation from this proportion in *P. inflatus*, however, is rather toward coarseness than fineness, and the two forms intergrade so that, while well-characterized examples can be readily distinguished, others are found which it is difficult to discriminate, identification with one species seeming to present equal claims with the other.

Productus inflatus is certainly a good variety of *P. semireticulatus* var. *hermosanus*, but I doubt if it should be accorded higher recognition unless on account of the difference in range which our Colorado collections indicate.

This form occurs also in the Mississippi Valley, and I have identified it at Rock Bluff, Nebr., Bellevue, Nebr., and at Sumner, Kans. A form which is probably the same is found also at Sneedville, Tenn., and 14 miles east of Cumberland Gap, Tenn. The fossils from Colorado are somewhat larger than those from Kansas and Nebraska, while the Tennessee collection shows a still smaller and somewhat more coarsely striated variety.

I am uncertain as to the correct identification of this species. The form from Colorado and that from the localities in Kansas and Nebraska just mentioned are, I have little doubt, the same. Except for being a trifle larger, this type answers closely to McChesney's description of *Productus inflatus*, but this author fails to give exact data regarding the size of the striæ in the form he was describing. The shell from Sneedville is possibly more typical than that from beyond the Mississippi. As I have already stated, it is smaller and somewhat more coarsely striate, and I am not satisfied that it is conspecific with the latter.

The affinities of the Colorado form with Derby's Brazilian species, *Productus chandlessi*, are very close. I have compared my specimens with a small collection from Itaituba, Brazil, and except for one particular the two types seem to be identical, and perhaps the form under discussion would better have been referred, as a variety, to *P. chandlessi* than to McChesney's species. The difference referred to is that the Brazilian form has the anterior areas of the shell nearly or quite smooth, the striæ becoming obsolete over the additions of later growth. *P. inflatus* also closely resembles *P. boliviensis* of d'Orbigny. The prolongation of the hinge line into projecting, enrolled ears is not as marked as in that species. Another closely allied form is *P. cora* var. *mogoyoni* of Marcou, and I look to see all three appear some day in synonymy. There can be no doubt that they are at least intimately related.

Locality and horizon.—San Juan region (stations 2209, 2213, 2233, 2247); lower portion of the Hermosa formation. Crested Butte district (station 2313); Weber limestone. Leadville district (stations 2250, 2253, 2254, 2257, 2259?, 2265, 2267, 2268, 2271, 2275, 2281); abundant in the lower portion of the Weber formation, rare in the upper portion. Ouray (stations 2195, 2195a, 2195b); Hermosa formation Grand River region, Glenwood Springs (station 2193a).

Productus gallatinensis Girty.

Pl. III, figs. 4, 4a, 5, 6 to 6b, 7, 8, 8a.

1899. *Productus gallatinensis.* Girty, U. S. Geol. Surv., Mon., vol. 32, pt. 2, p. 533, pl. 68, figs. 11*a*–11*d*, 7*a*–7*c*.

Madison limestone: Yellowstone National Park.

Ventral valve very convex, strongly enrolled longitudinally, especially toward the beak, which is sometimes placed anterior to the posterior outline of the shell. Anterior portion nearly vertical, and but slightly curved. The sides also are nearly vertical, slightly converging toward the vault, which is broad and flattened, sometimes with even a shallow, slightly perceptible sinus. The anterior view would thus be subquadrate in outline. Hinge line as long as the shell in front, the ears being small and quadrate.

The shape of the dorsal valve is semicircular or subquadrate. It is nearly flat over the visceral region, strongly geniculate peripherally, the margin being normal to the flattened portion of the shell. Ears small, quadrate, marked off by grooves near the hinge line converging to the beak. Visceral area crossed by strong, fine, concentric wrinkles.

The surface is ornamented with fine, strong, rigid, radiating striæ, which number 8 to 10 in the space of 5 mm. The visceral region of both valves is crossed for some distance by fine, strong, concentric wrinkles, and in the ventral valve the outer portions of the shell are furnished with a small number of spines which are proportionately rather large, and sometimes assume, when sufficiently numerous, a more or less regular quincunx arrangement.

Transverse diameter at the hinge line of a moderate-sized individual, 19 mm. Length from hinge line to anterior margin, 15 mm.

In its shape and proportions this shell belongs to a series of forms among which I have distinguished five varieties or species besides the one in question. These six species are naturally assembled into two groups, one with fine striæ, the other with coarse. Each group in turn separates into three minor units, chiefly by reason of difference in size, and this is very readily accomplished because the differences are strong and not bridged over by intermediate examples. Size, however, is not the only particular, though it is the most obvious one, in which differences can be found. Correspondence in size in the two series of forms is striking, so that, assuming this feature as the basis of division, three units would result, each having a coarse and a fine variety. I am not satisfied what importance should attach to the differences marking these six types, but feel that they are sufficiently strong to deserve notice of some sort. I have, therefore, severally referred these forms or phases to species already in the literature which they either resemble or with which they are identical, thus admitting them to a rank which subsequent investigation may considerably diminish.

It surprised me to find this form, which I originally described from strata of Mississippian age in Yellowstone National Park, reappearing in association with an unmistakable Coal Measure fauna, but after a careful comparison of two rather extensive suites of specimens I am unable to point out characters of even varietal value by which they can be distinguished. Only inconsiderable differences, chiefly between individuals, can be discovered, and their identity is practically complete so far as shown by my material, which is both abundant and well preserved.

This form answers very closely to Swallow's description of *Productus boonensis*, and I suspect, now that its range seems to extend up into the Coal Measures, that my name will prove a synonym. It is impossible, however, to decide this point without authentic specimens of *P. boonensis* with which to make comparisons.

Occasionally, among the material examined, one specimen or two will take on almost the proportions of *P. parviformis*, which differs from *P. gallatinensis* in little but size.

Locality and horizon.—San Juan region (stations 2197, 2213, 2216?, 2233, 2247, 2284); lower portion of the Hermosa formation. Ouray (station 2195a); Hermosa formation. Crested Butte district (station 2245).

PRODUCTUS PORTLOCKIANUS Norwood and Pratten.

1854. *Productus portlockianus.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 15, pl. 1, figs. 9*a–c*. (Whole volume published in 1855.)

Coal Measures: Grayville, White County, Ill.; Charboniere, Mo.

In Sinbads Valley, at station 2285, occurs a form which is identified with some confidence with Norwood and Pratten's *Productus portlockianus*. This species has generally been considered a synonym of *Productus costatus* Sowerby. The identification of American forms with Sowerby's species has often been made with protests and reservations on the part of authors, and in most cases can be justified only by allowing very broad specific limits to the European form. Meek[a] clearly doubts the correctness of his identification of Nebraska specimens, and quotes Davidson to the effect that the American forms referred to *P. costatus* are in fact more closely allied to *P. semireticulatus*. With this I am ready to concur, and the widely distributed shell identified with that species as a variety in Colorado is perhaps more nearly in agreement with *P. costatus*, as identified by American paleontologists, than with the form commonly referred to *P. semireticulatus*. *P. portlockianus* comes closer to true *P. costatus* than the form which gave rise to the comments of Meek just mentioned, but I think it can not be strictly referred to Sowerby's species. I therefore propose to revive Norwood and Pratten's name for the form.

Locality and horizon.—Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

Productus sp. *b*.

Pl. III, figs. 9–9b, 10, 11.

This form has been found at but two localities. Eight specimens from a station in the San Juan region, and a few poorly preserved and doubtfully determined examples from another in the Leadville region, constitute all the available material, which is insufficient to disclose completely the specific characters of the type to which it belongs. For this reason and because in shape and other general characters it resembles a group of *Producti* already sufficiently described, viz, *P. semireticulatus* var *hermosanus*, *P. inflatus*, *P. gallatinensis*, and *Marginifera*, no formal description will here be given.

Productus sp. *b* most resembles, perhaps, the Colorado form of *P. inflatus*. It is distinguished by its smaller size, being only about 30 mm. across the hinge line, and by the fact that the ventral valve is narrower and more rounded, and without the mesial sinus which marks the larger shell. The surface ornamentation seems to be about the same. *Productus* sp. *b* resembles the form from Sneedville, Tenn., which has also been referred to *P. inflatus*. The latter, as already noticed, is smaller than the Nebraska type of McChesney's species and much smaller than the Colorado representative. *Productus* sp. *b*, however, has considerably finer striæ and is without a mesial sinus so far as observed.

In size and shape dorsal valves are closely similar to the dorsal valve which I have identified as *Marginifera lasallensis*, but the striation is much finer. It also resembles *P. gallatinensis*, but is larger and stands midway between that species and *P. inflatus*.

[a] U. S. Geol. Surv. Nebraska, 1872, pp. 159, 160.

The dorsal valve, of which a figure is given on Pl. III, fig. 9, in the nodulose surface ornamentation presents a character not found in the species above mentioned, but this example shows mainly the inner surface of the shell.

Locality and horizon.—San Juan region (station 2214); base of Hermosa formation. Leadville district (station 2259).

PRODUCTUS CORA d'Orbigny.

Pl. IV, figs. 1–1b, 2–2a, 3–3a, 4–4b.

1842. *Productus cora.* D'Orbigny, Voyage dans l'Amérique Méridionale, Pal., p. 55, pl. 5, figs. 8–10.
Carboniferous: Above Patapatani, on an island in Lake Titicaca; Yarbichambi.

1845. *Productus lyelli.* De Verneuil, Lyell's Travels in North America, vol. 2, p. 221.
Mountain limestone: Windsor, Horton Bluff, Shubenacadie, Gays River, Debert River, Minudie, and Cape Breton.

1847. *Productus cora.* De Koninck, Soc. Roy. d. Sci. Liége, Mém., vol. 4, p. 148, pl. 4, fig. 4, a, b; pl. 5, fig. 2, a, b, c, d.
Lower Carboniferous limestone of Visé, of Chokier, and of Ratingen; in the shales of the median étage near Tournay, and in the Upper Carboniferous slates of Epinoy near Binche (Hainaut); banks of the Missouri; Kendal, Westmoreland; Lowick; Yorkshire; Derbyshire; Ireland; banks of the Wilji, an affluent of the Taroussa; on the banks of the Louja in the district of Medynsk, province of Kalouga; beyond Cosatchi-Datchi on the eastern side of the Urals, near Sterlitamack, between Perm and Serebriansk; on the west side of the same chain from Kachira on the Oka, and from Unja near Kosimof; Flint Ridge, Zanesville, Guernsey County (Ohio); between New Harmony and Mount Vernon (Indiana); Windsor (Nova Scotia); Leavenworth, Ind.; on the Bolivian plateau, above Patapatani; in one of the islands of Lake Titicaca, and at Yarbichambi, South America.

1847. *Producta cora.* De Koninck, Recherches sur les Animaux Fossiles, pt. 1, p. 50, pl. 4, figs. 4a, b; pl. 5, figs. 2a–d.
Carboniferous: Guernsey County, Flint Ridge, and Zanesville, Ohio; between New Harmony and Mount Vernon, Ind.; Leavenworth, Ind.; Windsor, Nova Scotia; Bolivia, etc., South America.

1848. *Productus martini.* Christy, Letters on Geology, pl. 5, figs. 6, 8, 9.
[Carboniferous]: Pinckneyville, Ill.

1848. *Productus* sp. Christy, Letters on Geology, pl. 5, fig. 1.
Sandstone above the Black shale, Elk River, Tennessee.

1852. *Productus semireticulatus.* Hall, Stansbury's Exped. Great Salt Lake, p. 411, pl. 3, figs. 3, 5a, b.
Carboniferous: Near Fort Laramie; and Flat Rock Point and other places in the neighborhood of Great Salt Lake.

1852. *Productus cora.* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pp. 103, 136, pl. 5, fig. 1.
Carboniferous: Missouri River, below mouth of Little Platte River.

1852. *Productus cora.* Roemer, Kreid. von Texas, p. 90.
Carboniferous: San Saba Valley, Texas.

1854. *Productus cora.* Marcy's Expl. Red River of Louisiana, p. 176.
Carboniferous: Washington and Crawford counties, Ark.

1854. *Productus cora.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 6. (Entire volume appeared in 1855.)
Mountain limestone: Chester, Rosiclare, and Warsaw, Ill.; near Richmond, Mo.; Carrsville, Ky.

1854. *Productus prattenianus.* Norwood, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 17, pl. 1, figs. 10a–d. (Entire volume appeared in 1855.)
Coal Measures: Crossing of Big Nemahaw River, about 85 miles northwest of St. Joseph, Mo.

1855. *Productus cora.* Salter, Belcher's "Last of the Arctic Voyages," p. 387, pl. 36, fig. 12.
Carboniferous: Top of Exmouth Island.

1855. *Productus lyelli.* Dawson, Acadian Geology, p. 219, fig. g.
Lower Carboniferous limestone: Nova Scotia.

1858. *Productus cora.* Marcou, Geol. North America, p. 45, pl. 6, figs. 4, 4a.
Mountain limestone: Tigeras Canyon of San Antonio; Pecos Village; summit of Sierra de Sandia, New Mexico.

1859. *Productus prattenianus.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Coal Measures: Indian Creek and Leavenworth, Kans.

1863. *Productus cora.* Davidson, Geol. Soc. London, Quart. Jour., vol. 19, p. 174, pl. 9, figs. 22, 23.
Lower Carboniferous limestone: Windsor, Horton Bluff, Shubenacadie, Gays River, Cape Breton, Pugwash, eastward of Cumberland, Lennox Passage, McKenzie's Mill, at eastern extremity of Wallace Harbor, etc., Nova Scotia.

1866. *Productus flemingi.* Geinitz, Carb. und Dyas in Nebraska, p. 52, tab. 4, figs. 1–4. (Not *P. flemingi* de Koninck.)
Upper Coal Measures: Bellevue, Plattsmouth, and Nebraska City, Nebr.

1866. *Productus koninckianus*? Geinitz, Carb. und Dyas in Nebraska, p. 53, tab. 4, fig. 5. (Not *P. koninckianus* de Verneuil.
Upper Coal Measures: Nebraska City, Bennett's Mill, Nebr.

1866. *Productus calhounianus.* Geinitz, Carb. und Dyas in Nebraska, p. 53. (Not *P. calhounianus* Swallow).
Upper Coal Measures: Diamond Spring, Santa Fe, in Kansas.

1866. *Productus cora.* Geinitz, Carb. und Dyas in Nebraska, p. 50.
Carboniferous limestone and shales: Germany, Belgium, England, Ireland, Spain, Russia, North America, Bolivia, etc. Belleview, Plattsmouth, Nebr.

1868. *Productus cora.* Dawson, Acadian Geology, p. 297, figs. 98a, b.
Carboniferous limestone: Windsor, Horton Bluff, Shubenacadie, Gays River, Minudie, Cape Breton, Pugwash, east coast of Cumberland, Lennox Passage, McKenzie's Mill, Wallace Harbor, etc., Nova Scotia.

1869. *Productus* cf. *cora.* Toula, Sitzb. der Kais. Akad. der Wissensch, Wien, 1 Abth., vol. 59, p. 441.
Carboniferous limestone: 10 miles from Cochabamba, Bolivia.

1872. *Productus prattenianus.* Meek, U. S. Geol. Surv. Nebraska, p. 163, pl. 2, figs. 5a–c; pl. 5, fig. 13; pl. 8, figs. 10a, b.
Upper Coal Measures: Nebraska City, Bennetts Mill, Cedar Bluff, Plattsmouth, Bellevue, and Omaha, Nebr.; Kansas, Iowa, Illinois.
Lower Coal Measures: Illinois.

1874. *Productus cora* (?). Derby, Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 49, pl. 2, fig. 17; pl. 6, fig. 17.
Coal Measures: Itaituba and Barreirinha, Brazil.

1875. *Productus pratteniauus* (pars). White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 113, pl. 7, figs. 1a–c. (Entire volume published in 1877.)

Carboniferous: Near Sante Fe and Zandia Mountains, New Mexico; Piloncillo Range near Gavilan Peak, and at the confluence of White Mountain and Black rivers, Arizona; Egan Range, 35 miles south of Egan Pass; Fossil Hill, White Pine County; Robert's Creek Range, Lander County, and top of Grass Mountain, Ely Range, 35 miles north of Pioche, Nev.; near Beckwith Spring, Cedar Range; near top of Mount Nebo, and west face of Oquirrh Range, Utah.

1876. *Productus pratteniauus*. White, Powell's Rept. Geol. Uinta Mountains, p. 90.

Lower Aubrey group: Confluence of Grand and Green rivers, Utah.

1876. *Productus cora*. Derby, Mus. Comp. Zool., Bull., vol. 3, p. 281.

Coal Measures: Yampopata.

1877. *Productus prattenianvs*. Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 72, pl. 7, fig. 7.

Carboniferous: Fossil Hill, White Pine district; Railroad Canyon, Diamond Mountains, Nevada.

1878. *Productus cora*. Dawson, Acadian Geology, 3d edition, p. 297, fig. 98.

Carboniferous limestone: Windsor, Horton Bluff, Shubenacadie, Gays River, Minudie, and Cape Breton, Nova Scotia; Pugwash, on the eastern coast of Cumberland; Lennox Passage; M'Kenzie's Mill, at eastern extremity of Wallace Harbor, etc.

1884. *Productus cora*. White, Geol. Surv. Indiana, 13th Rept., p. 126, pl. 26, figs. 1–3.

Coal Measures: Fountain, Vermilion, Parke, Montgomery, Clay, Owen, Pike, Dubois, and Warrick counties, Ind.

1884. *Productus cora*. Waagen, Palæontologia Indica, ser. 13, vol. 1, p. 677, pl. 66, fig. 3; pl. 67, figs. 1, 2.

Productus limestone: Katta, Omarkheyl, Shekh Budin, and Jabi, India.

1886. *Productus cora*. Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. 1885, p. 452; p. 440, figs. 1, 1a. Mill Creek limestone.

Upper Coal Measures: Wilkesbarre, Pa.

1886. *Productus cora*. Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, p. 268, figs. 1, 1a. Mill Creek limestone.

Upper Coal Measures: Wilkesbarre, Pa.

1887. *Productus cora*. Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 47, pl. 2, fig. 26.

Coal Measures: Flint Ridge, Ohio.

1888. *Productus cora*. Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 227.

Lower Coal Measures: Des Moines, Iowa.

1895. *Productus cora*. Keyes, Missouri Geol. Surv., vol. 5, p. 47, pl. 37, figs. 2a–c. (Date of imprint 1894.)

Coal Measures: Calhoun and Kansas City, Mo.

1896. *Productus cora*. Smith, Am. Phil. Soc., Proc., vol. 35, p. 238.

Upper Coal Measures: Poteau Mountain, Indian Territory.

? Archimedes limestone: Independence County, Ark.

? Marshall shale: Independence and Stone counties, Ark.

? Fayetteville shale: Independence County, Ark.

1896. ? *Productus cora*. Smith, Leland Stanford Junior University Pub., Cont. Biol. Hopkins Seaside Lab., No. 9, p. 28.

Upper Coal Measures: Poteau Mountain, Indian Territory.

? Archimedes limestone: Independence County, Ark.

? Marshall shale: Independence and Stone counties, Ark.

? Fayetteville shale: Independence County, Ark.

1900. *Productus cora.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 75, pl. 11, figs. 1–1f.

Upper Coal Measures: Kansas City, Eudora, Lawrence, Lecompton, Topeka, Geary County, Melvern, Osage County.

The shells which I have referred to this species vary much in size, but agree in being finely, often flexuously, striate, with occasional large spines projecting at right angles from the surface. There are from 15 to 18 or more striæ in the space of 10 millimeters. The hinge line is nearly as wide as any portion of the shell in front, the ears large, quadrate, and marked by coarse wrinkles, which are sometimes continued more or less strongly over the visceral portion of the valves. This is especially the case in the dorsal valve.

The largest example noted must have had a transverse diameter of nearly 65 millimeters with a length of nearly 80 millimeters. An average specimen of the larger sort would measure about 45 millimeters across.

This is the form to which Norwood in 1854 gave the name *Productus prattenianus.* These shells differ materially from d'Orbigny's figures of *Productus cora*, but it is almost certain that his figures are altogether misleading, and the résumé of the matter given by Waagen is a very plausible argument for considering that the South American form is the same as that for which *Productus prattenianus* was proposed. It has therefore been found necessary to employ the earlier published but less perfectly defined term.

Productus cora is rare in the Rico formation. Four localities have furnished each a specimen. So far as the collections at hand indicate, the form which is found in the Rico does not differ materially from that occurring in the lower formation.

Locality and horizon.—San Juan region (stations 2196, 2196a, 2200, 2204, 2205, 2208, 2209, 2210, 2213, 2216, 2219, 2221?, 2222, 2233, 2239, 2248, 2331, 2332, 2334, 2335, 2340, 2341, 2342, 2344); abundant in the lower, middle, and upper portions of the Hermosa formation, rarer in the Rico formation. Crested Butte district (stations 2300, 2302, 2306, 2313, 2317); Weber limestone and Maroon formation. Leadville district (stations 2254, 2257, 2259, 2268, 2270?, 2271, 2275, 2281); lower and upper portion of the Weber formation, and base of the Maroon formation (?). Ouray (stations 2194, 2195a); Hermosa formation.

PRODUCTUS PERTENUIS Meek?

1866. *Productus cancrini.* Geinitz, Carb. und Dyas in Nebraska, p. 54, tab. 4, fig. 6. (Not *P. cancrini* de Verneuil, 1843.)

Upper Coal Measures: Nebraska City, Nebr.

1872. *Productus pertenuis.* Meek, U. S. Geol. Surv. Nebraska, p. 164, pl. 1, figs. 14a–c; pl. 8, figs. 9a–d.

Upper Coal Measures: Nebraska City and Brownville, Nebr.; Grasshopper Creek, 12 miles west of Leavenworth and Atchison, Kans.

1898. *Productus pertenuis.* Drake, Am. Phil. Soc., Proc., vol. 36, p. 404, pl. 9, figs. 8–10. Reprinted without change of date, page, etc., in Leland Stanford Junior Univ. Pub.; Cont. Biol. Hopkins Seaside Lab., No. 14.
Lower Coal Measures: 4 miles north of Vinita.
Upper Coal Measures: Cavinol group: McClellan ford on the Verdigris River. Poteau Group: 6 miles west of South Canadian.
Permian division: Upper bed of sandstone, 4 miles west of McDermitt; Pawhuska sandstone, 5 miles west of Cushing.
Lower Carboniferous limestone (Boston group) (St. Louis-Chester): 5 miles southeast of Adair.
1900. *Productus pertenuis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 83, pl. 9, figs. 5–5c.
Upper Coal Measures: Kansas City, Eudora, Lawrence, Lecompton, Topeka, Kans.

This species is very rare in the collections examined. Comparison has been made with the type, and the identification here noted is probably correct, so far as can be determined from a single not too perfect specimen.

Locality and horizon.—San Juan region (station 2224?); middle portion of the Hermosa formation.

PRODUCTUS PUNCTATUS Martin.

1809. *Anomites punctatus.* Martin, Petrf. Derb., p. 8, pl. 37, fig. 6.
1836. *Productus punctatus?* Morton, Am. Jour. Sci., (1), vol. 29, p. 153, pl. 26, fig. 38.
Coal Measures: Ohio Valley.
1838. *Productus semipunctata.* Shepard, Am. Jour. Sci., (1), vol. 34, p. 153, fig. 9.
Limestone: Peru, Ill.
1847. *Productus punctatus.* De Koninck, Monog. du Gen. Prod. et Chon., p. 123, pl. 12, figs. 2a–k.
Carboniferous: Zanesville, Ohio; Eddyville and Louisville, Ky.
1854. *Productus punctatus.* Shumard, Marcy's Expl. Red River of Louisiana, p. 175, pl. 1, fig. 5; pl. 2, fig. 1.
Carboniferous: Washington County, Ark.
1854. *Productus punctatus.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 19. (Entire volume published in 1855.)
Mountain limestone: Warsaw, Ill.
Coal Measures: 12 miles northwest of Richmond, Mo.; near Caseyville, Ill.
1858. *Productus punctatus.* Marcou, Geol. North America, p. 48, pl. 6, fig. 2.
Mountain limestone: Tigeras, Pecos Village, and in the Sierra de Mogoyon, New Mexico.
1860. *Productus tubulospinus.* McChesney, Desc. New Spec. Pal. Foss., p. 37.
Coal Measures: Western States.
1865. *Productus tubulospinus.* McChesney, Illustrations New Spec. Foss., pl. 1, figs. 10, 11.
1866. *Productus punctatus.* Geinitz, Carb. und Dyas in Nebraska, p. 55.
Carboniferous limestone: Bellevue and Plattsmouth, Nebr.
1868. *Productus punctatus.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 27, pl. 1, figs. 10, 11.
Upper and Lower Coal Measures: Throughout the Western States.
1872. *Productus punctatus.* Meek, U. S. Geol. Surv. Nebraska, p. 169, pl. 2, fig. 6; pl. 4, fig. 5.
Upper Coal Measures: Nebraska City, Bennetts Mill, Wyoming, Rock Bluff, Plattsmouth, and Bellevue, Nebr.; Illinois; Iowa; Missouri.
Lower Coal Measures: Missouri; Iowa; Illinois.
Lower Carboniferous: Missouri; Iowa; Illinois.

1873. *Productus punctatus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 569, pl. 25, fig. 13.
Upper and Lower Coal Measures: Illinois.

1875. *Productus punctatus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 114, pl. 7, figs. 2a–c. (Entire volume published in 1877.)
Carboniferous: At and near top of Grass Mountain, Ely Range, 35 miles north of Pioche, Nev.

1876. *Productus punctatus.* White, Powell's Rept. Geol. Uinta Mountains, p. 89.
Lower Aubrey Group: Confluence of Grand and Green rivers, Utah.

1878. *Productus* sp. allied to *P. punctatus.* Etheridge, Geol. Soc. London, Quart. Jour., vol. 34, p. 630.
Carboniferous: Feilden Isthmus, latitude 82° 43′.

1882. *Productus punctatus.* White, Geol. Surv. Indiana, 11th Rept., p. 373, pl. 42, figs. 1–3.
Coal Measures: Newport, Ind.

1883. *Productus punctatus.* Hall, Rept. New York State Geol. for 1882, pl. (19) 50, figs. 14–16.

1883. *Productus rogersi.* Hall, Rept. New York State Geol. for 1882, pl. (19) 50, figs. 17, 18.
Coal Measures.

1884. *Productus punctatus.* White, Geol. Surv. Indiana, 13th Rept., p. 124, pl. 27, figs. 1–3.
Coal Measures: Vermilion, Vigo, Sullivan, Vanderberg, Dubois, Warrick, and Pike counties, Ind.

1887. *Productus punctatus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 48, pl. 2, fig. 29.
Coal Measures: Flint Ridge, Ohio.

1892. *Productus punctatus.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 22, figs. 9, 10.
Coal Measures: Mississippi Valley.

1892. *Productus punctatus.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 17A, fig. 21; pl. 19, figs. 14–18.
Upper Coal Measures: Near Kansas City, Mo.; Missouri.

1895. *Productus punctatus.* Keyes, Missouri Geol. Surv., vol. 5, p. 51. pl. 37, figs. 1a–c. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1896. *Productus punctatus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 239, pl. 22, fig. 7.
Lower Coal Measures: Conway County, Ark.
Lower Carboniferous: Several localities in Arkansas.

1900. *Productus punctatus.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 87, pl. 10, figs. 3–3c; pl. 11, fig. 3.
Upper Coal Measures: Kansas City, Turner, Lawrence, Lecompton, Topeka, Moline.

1896. *Productus punctatus.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 29, pl. 22, fig. 7.
Lower Coal Measures: Conway County, Ark.
Lower Carboniferous: Several localities in Arkansas.

The collections examined indicate that this is a rather rare fossil in the Colorado Carboniferous. The identification at station 2221 in the San Juan region is doubtful on account of the poor character of the material, a single very small, exfoliated specimen.

Locality and horizon.—San Juan region (stations 2204, 2241, 2334, 2335); middle and upper portion of the Hermosa formation.

PRODUCTUS NEBRASKENSIS Owen.

Pl. V, figs. 1, 2, 2*a*.

1852. *Productus nebrascensis.* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, p. 584, pl. 5, fig. 3.
Carboniferous limestone: Bellevue, Missouri River, Nebr.

1854. *Productus rogersi.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 9, pl. 1, figs. 3*a–c*. (Whole volume appeared in 1855.)
Coal Measures: Near Huntsville, Mo.

1854. *Productus nebrascensis.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 21. (Whole volume appeared in 1855.)
Coal Measures: Crossing of Big Nemaha, Nebraska Territory.

1856. *Productus rogersi.* Hall, Pacific Railroad Rept., vol. 3, p. 104, pl. 2, figs. 14, 15.
Carboniferous limestone: Pecos Village, N. Mex.

1859. *Productus rogersi.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Upper Coal Measures: Kansas River Valley, below mouth of Blue River, Kansas.

1860. *Productus asperus.* McChesney, Desc. New Spec. Pal. Foss., p. 34.
Coal Measures: Lasalle and Springfield, Ill.

1861. *Productus rogersi.* Newberry, Ives's Colorado River Expl. Exped., p. 121.
Coal Measures: Pecos Village and Kansas.

1865. *Productus asper.* McChesney, Illustrations New Spec. Foss., pl. 1, figs. 7 a–b.

1866. *Strophalosia horrescens.* Geinitz, Carb. und Dyas in Nebraska, p. 49. (Not *S. horrescens* of Murchison, Verneuil, and Kayser.)
Coal Measures: Bellevue, Plattsmouth, Nebraska City, and Bennett's Mill, Nebr.

1868. *Productus nebrascensis.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 24, pl. 1, figs. 7a–b.
Coal Measures: Lasalle and Springfield, Ill.

1872. *Productus nebrascensis.* Meek, U. S. Geol. Surv. Nebraska, p. 165, pl. 2, fig. 2; pl. 4, fig. 6; pl. 5, figs. 11a–c.
Upper Coal Measures: Nebraska City, Wyoming, Bennett's Mill, Rock Bluff, Plattsmouth, Bellevue, and Omaha, Nebr.

1873. *Productus nebrascensis.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 569, pl. 25, fig. 8.
Coal Measures: Sangamon and Lasalle counties, Ill.

1875. *Productus nebrascensis.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 116, pl. 8, figs. 3a–d. (Whole volume published in 1877.)
Carboniferous: Camp Apache and Carrizo Creek, Maricopa County, Ariz.; Rubyville, Schell Creek Range, and top of Grass Mountain, Ely Range, Nevada; Meadow Creek, south of Fillmore, Utah.

1876. *Productus nebrascensis.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey group: Confluence of Grand and Green rivers.

1877. *Productus nebrascensis.* Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 65.

1883. *Productus aspersus.* Hall, Rept. New York State Geol. for 1882, pl. (19) 50, figs. 5–7.
Coal Measures: Lasalle, Ill.

1884. *Productus nebrascensis.* White, Geol. Surv. Indiana, 13th Rept., p. 122, pl. 24, figs. 7–9.
Coal Measures: Fountain, Vermilion, Parke, and Vigo counties, Ind.

1886. *Productus nebrascensis?* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 453, fig. 4c; p. 440, figs. 4–4b.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Productus nebrascensis?* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 268, figs. 4, 4b.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1887. *Productus nebrascensis.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 49, pl. 2, fig. 30.
Coal Measures: Flint Ridge, Ohio.

1892. *Productus nebrascensis.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 22, fig. 7.
Coal Measures: Lasalle, Ill.

1892. *Productus nebrascensis.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 19, figs. 5–7.
Coal Measures: Lasalle, Ill.

1895. *Productus nebrascensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 48, pl. 37, figs. 3a–c. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Productus nebrascensis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 84, pl. 9, figs. 7–7f.
Upper Coal Measures: Kansas City, Turner, Eudora, Lawrence, Lecompton, Topeka, Manhattan, and Grand Summit, Kans.

In our collections the representation of this species is practically confined to the Durango quadrangle and to the Leadville district. In these two areas it has been found at a number of localities, and seems to be fairly abundant, though it is not often well preserved, owing to the character of its surface ornamentation. Because of the circumstance last mentioned, some of the identifications may possibly represent specific affinity, rather than strict specific identify.

Herrick identifies with *Productus nebraskensis* certain shells from the Waverly group in Licking County, Ohio.[a] His figures represent at least two and possibly three species, none of which is closely related to *P. nebraskensis.* The large form shown on his pl. 1 is, I believe, a species which is rather abundant at Sciotoville, Ohio. Meek described and figured it as *Productus* sp.[b] Winchell probably referred to it as *Productus cooperensis?*.[c] It is related to *Productus blairi*, but is probably new. The name *Productus winchelli* is here proposed for it.

The small form figured by Herrick on pl. 3 as *Productus nebraskensis* seems to belong to the *semireticulatus* type, and is possibly related to *P. wortheni.*

Locality and horizon.—San Juan region (stations 2200, 2204, 2205, 2207, 2209, 2210, 2213, 2215, 2239, 2240, 2248?, 2333); lower, middle, and upper portions of the Hermosa formation, and in the Rico formation. Leadville district (stations 2254?, 2267, 2268, 2271, 2281); base of the Weber formation. Ouray (station 2195b); Hermosa formation.

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[a] Sci. Lab. Denison Univ., Bull., vol. 3, 1888, p. 31, pl. 1, fig. 24; pl. 3, figs. 25 (?), 25a.

[b] Geol. Surv. Ohio, Rept., vol. 2, pt. 2, 1875, p. 282, pl. 10, figs. 4a–4c.

[c] Am. Phil. Soc., Proc., vol. 12, 1870, p. 249.

PRODUCTUS sp. *a*.

Pl. V, fig. 3.

This species has a very scanty representation among our collections, four fragmentary specimens from three localities in the San Juan region, being all the material that has so far come to hand. The shape of the ventral valve appears to be not unlike that of *P. semireticulatus* var. *hermosanus*, but the beak is as a rule more tapering. There is a more or less distinct sinus. The posterior portion is crossed by rather faint, irregular wrinkles. The striæ are sharp but nodulose, and somewhat discontinuous, especially about the ears. They thus present a wavy, irregular appearance. The nodules formed in many cases the bases of small spines.

The dorsal valve is more regular and finely reticulated, the spaces between the striæ and wrinkles forming little pits.

At one time I was disposed to place this form with that which Marcou identified as *P. pyxidatus* de Koninck, but this course seems hardly prudent in view of his rather meager, poor, and conflicting figures and description.

There can be no doubt that his identification with de Koninck's species, if his figures even approach accuracy, is altogether incorrect.

Locality and horizon.—San Juan region (stations 2208, 2328, 2335); middle and upper portions of the Hermosa formation.

MARGINIFERA Waagen, 1884.

MARGINIFERA LASALLENSIS Worthen?.

Pl. V, figs. 4–4a.

1873. *Productus lasallensis.* Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 569, pl. 25, fig. 9.
Upper Coal Measures: Lasalle, Ill.

1892. *Productus* (*Marginifera*) *lasallensis.* Hall and Clarke, Int. Study of Brach., pt. 1, pl. 22, fig. 15.
Upper Carboniferous: Lasalle, Ill.

1892. *Productus* (*Marginifera*) *lasallensis.* Hall and Clarke, Pal. New York, vol. 8, pt. 1, pl. 17A, fig. 13.
Upper Carboniferous: Lasalle, Ill.

The form which I have referred to Worthen's species is represented by one good dorsal valve and by fragments of three ventrals. The latter are almost too poor to serve for description or as a guide in identifying the species, but the dorsal seems to be identical in its diagnostic characters with the corresponding valve of *P. lasallensis.*

Viewed from its convex or inner side this specimen may be described as follows: In shape it is transversely semielliptical, hinge line about 28 mm. long, ears quadrate, defined by two shallow radiating grooves. There is a distinct, though not very strong, mesial depression. The visceral area is but slightly convex. After attaining a length of about 15 mm. the shell assumed a strong downward growth, so that the peripheral portion lies almost perpendicular to the plane of the visceral area. The surface is crossed by rather coarse radiating striæ, 10 or 12 in the space of 10 mm., and the entire visceral portion is traversed by fine concentric wrinkles.

In size the shell corresponds to *Productus* sp. *b*, but is much more coarsely striate. It resembles in striation as well as shape both *P. semireticulatus* var. *hermosanus* and *Marginifera muricata*, but is much smaller than the one and much larger than the other.

We have two authentic specimens of *M. lasallensis* from Lasalle, Ill., with which collections from Pawnee City, Nebr., Fort Scott, Kans., and Graham, Young County, Tex., agree in every way. The collections from Kansas, Nebraska, and Texas I do not hesitate to refer to the same species as the shell from Illinois which Worthen has identified as *M. lasallensis.* These specimens, however, do not agree with Worthen's figures and description in several particulars. He states that *M. lasallensis* is without concentric wrinkles over the posterior portion of the shell, a character which all these specimens possess in some degree, and which is usually well marked. Furthermore, he has restored his fragmentary specimen in such a manner as to make a larger shell than any seen by me, and to give it a very alate shape, while the hinge line of the specimens I have studied is but little extended.

The Colorado examples present a close superficial agreement with this, as I regard it, characteristic material, but the true *Productus lasallensis* clearly belongs to Waagen's genus *Marginifera*, while I doubt if my material does. Still, the latter is too imperfect to permit me to satisfy myself upon this point. Were it not for this important difference I would refer the Colorado specimens without hesitation to Worthen's species, so close is their general agreement.

Locality and horizon.—Crested Butte district (station 2316?); Weber limestone.

MARGINIFERA MURICATA Norwood and Pratten.

Pl. V, figs. 5, 5b, 6, 6b, 7.

? 1852. *Productus flemingii.* Roemer (non de Koninck), Kried. von Texas, p. 89, pl. 11, figs. 8a, b. Carboniferous: San Saba Valley, Texas.

1855. *Productus muricatus.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 14, pl. 1, figs. 8a–e. (Not *P. muricatus* Phillips.)

Coal Measures: Fishhook Creek, Pike County, Ill.; 6 miles northwest of Richmond, Mo.

1857. *Productus muricatus.* Cox, Geol. Surv. Kentucky, Rept., vol. 3, p. 573, pl. 9, fig. 6.

Coal Measures: Union County, Ill.; Lewisport, Hancock County, Ky.; Gallatin County, Ill.

1876. *Productus muricatus.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.

Lower Aubrey group: Near Echo Park, Utah.

1877. *Productus muricatus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 120, pl. 8, figs. 4a–c.

Carboniferous. Rock Creek, Lake County, Colo.

1887. *Productus muricatus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 49.
Coal Measures: Flint Ridge, Ohio.

1888. *Productus muricatus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 228.
Lower Coal Measures: Des Moines, Iowa.

1900. *Productus longispinus.* Knight, Univ. Wyoming, Wyoming Exp. Sta., Bull. No. 45, pl. 3, fig. 10.

The form which, in Colorado, I have identified with *Marginifera muricata*, may be described as follows:

Shell rather small, semicircular. Ears small, quadrate, and not prolonged. Hinge line about equal to the greatest width. Curvature moderate, not so great as in *M. splendens.* Surface marked by concentric nodose wrinkles, strongest on the ears, and by coarse, somewhat nodose striæ, which number about 25 on a medium-sized shell. It is entirely covered at short intervals by small spines springing from the ribs. The transverse diameter is usually from 16 to 19 mm.

The dorsal valve is semicircular in shape with quadrate ears. The latter are upturned, when looking at the interior of the valve, and defined by two ascending and diverging ridges. The shell is nearly flat over the visceral portion, but a geniculation occurs about 10 mm. from the beak.

The shells agree closely with what I consider typical *M. muricata* from the Mississippi Valley, but with this exception, that while specimens of the latter are (so far as my experience goes) nearly uniform as regards the size of the striæ, those from Colorado vary from a degree of fineness comparable with the latter to considerably coarser. The Colorado form is also somewhat more strongly arched. I have considered the advisability of distinguishing these coarse occidental shells by a varietal name, but as they occur in immediate association with the typical form into which they merge by insensible gradations, it seemed sufficient merely to call attention to the circumstance in an informal manner.

In addition to variation in the matter of striation, which has already been referred to as occurring among these shells, variation, often of local occurrence and appearing in most of the specimens from a station, has been noticed in size, abundance of spines, and other matters.

It is possible that imperfectly preserved material may have given rise to misapprehension as to the degree of variation in some particulars, as, for example, the abundance of spines, but, on the other hand, it may be that with more perfect material I would have felt justified in discriminating subdivisions among the fossils here assembled into a single group.

Schuchert[a] retains Norwood and Pratten's name for this species, because *Productus muricatus* Phillips, which has priority, is regarded by many as a synonym for *P. costatus* Sowerby. This course violates the rule, once a synonym always a synonym, and can scarcely be allowed, but Norwood and Pratten's name will still hold if Waagen's genus *Marginifera*, of which it is a representative, be accorded generic

[a] U. S. Geol. Surv., Bull. No. 87, 1897, p. 327 (*P. muricatus*).

standing. Hall and Clarke[a] rather discredit the significance of the characters upon which *Marginifera* is founded, and if their view is correct, a new name will have to be sought for this species.

I have tentatively added to the usual synonomy Roemer's identification with *P. flemingi* of a shell from Texas. The figures of the Texan form are certainly suggestive of Norwood and Pratten's species.

Locality and horizon.—San Juan region (station 2196a); Hermosa formation. Crested Butte district (stations 2244, 2245, 2280, 2292, 2297, 2316, 2318); Weber limestone and Maroon formation. Grand River region (station 2324), Glenwood Springs (station 2326).

MARGINIFERA WABASHENSIS Norwood and Pratten var.

Pl. V, figs. 8, 8*a*.

1854. *Productus wabashensis.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 13, pl. 1, figs. 6a–d. (Imprint of whole volume, 1855.)
Coal Measures: Near New Harmony, Ind.

I have experienced great difficulty in reaching a decision satisfactory to myself in regard to the forms belonging to the group for which Waagen proposed the name *Marginifera*, not only in the matter of discriminating species, but in determining the name which should be employed for them.

In 1854 Norwood and Pratten described three species of *Productus* belonging to this group whose mutual specific relations are very close. They were given the names *P. muricatus*, *P. splendens*, and *P. wabashensis.*

Meek[b] places all three species in the synonymy of *P. longispinus* Sowerby, following Davidson's judgment in this, though, it is apparent, doing violence to his own, at least in the case of *P. muricatus.* Waagen[c] recognizes *P. wabashensis* and *P. splendens* as independent species, each of them valid and distinct from *P. longispinus.* Frech[d] regards *P. wabashensis* and *P. splendens* as identical, but as certainly distinct from Sowerby's species.

There can, I think, be no doubt but that *P. muricatus* is distinct not only from *P. splendens* and *P. wabashensis*, but from *P. longispinus. P. splendens* and *P. wabashensis* are much more closely akin to each other than is either of them to *P. muricatus;* nor can there be much doubt that they also are distinct from *P. longispinus.* Although Sowerby[e] described his species as "indented in the middle," and though Davidson[f] included under *P. longispinus* shells which are both evenly convex

[a] Pal. New York, vol. 8, pt. 1, 1892, p. 331.
[b] U. S. Geol. Surv., Nebraska, 1872, p. 161.
[c] Geol. Surv. India, Mem. Pal. Ind., 13th series, vol. 1, 1887, p. 715.
[d] Lethæa Geognostica, 1. theil, 2. band, 2. lieferung, 1899, desc. pl. 47c, fig. 14.
[e] Min. Conch., vol. 1, 1814, p. 154.
[f] Pal. Soc., Mon. British Carb. Brach., pt. 5, 1857, p. 145, pl. 35, figs. 5–17.

and divided by a sinus, neither Sowerby's nor Davidson's figures of the type specimen show a sinus. Their figures as well as their descriptions indicate that the hinge line is no wider than the body of the shell. The ventral valve seems not to have been very highly arched, to judge by the figures, though Sowerby says that the "reflexed margin is entirely lost, etc." The ribs are not mentioned in the original description nor represented in the figures, but Davidson's figure shows them to be as prominent as in the average specimen. They vary from 30 to 50 in number, according to this author. Norwood and Pratten mention 30 as occurring in *P. splendens.* They are usually more or less obsolete, however, and the sinus is typically deep and the ears are produced. Frech states that though related to *P. longispinus*, *P. splendens* can easily be distinguished by reason of its fainter striation and more strongly expressed muscular and visceral markings. Waagen finds that typical specimens of *P. longispinus* are practically entirely without the internal ridges characteristic of *Marginifera*, and according to his view, therefore, *P. longispinus* and *P. splendens* would be found in different genera even. At all events it will be safe to conclude that they are specifically distinct.

Another species whose relationship with *P. splendens* is certainly close, and whose name, in case of identity proved, would supersede that proposed by Norwood and Pratten, is *P. capacii* d'Orbigny. Waagen expresses the opinion that this species is distinct from *P. splendens*, and with this I am content to agree, although, being without specimens with which to make comparisons, a conclusive judgment can not be formed. One difference manifest at first sight from the figures is the inflation of the posterior portion of d'Orbigny's shell by which it is brought to project far beyond the hinge line. In this particular *P. capacii* is close to *Marginifera haydenensis* described below, which is certainly distinct from *P. splendens.*

Turning now to the relationship of *P. splendens* and *P. wabashensis*, one would not long hesitate to conclude from Norwood and Pratten's figures that the two species are clearly distinct. Meek, however, after examining good specimens of *P. wabashensis* from the original locality, concludes (loc. cit.) that the figures of that species are quite defective in representing the costæ, and if one considers the difference in proportion shown by the figures of the original reference between the dorsal and ventral views of the same specimen, it seems clear that the outline, too, is not to be trusted.

I have before me some specimens "from below the coal" at Wabash cut-off, New Harmony, Ind., which I suppose can be considered as coming from the original locality and as representing the typical phase of *P. wabashensis.* They show a broad, highly arched form, with strong median sinus and slightly extended ears. The beak is small and transgresses the hinge line but little. Concentric wrinkles are almost wanting; the striæ are fine and obsolescent, and the surface supports a few comparatively large scattering spines. This form has a wide distribution in the Mississippi Valley, and I have remarked it in Indiana, Illinois, Iowa, Missouri, and Kansas. It undergoes many variations in minor particulars, but seems everywhere to retain the same general expression. Many specimens occur in which the shape is not alate and the hinge line is no longer than the shell below. It is usually difficult to determine whether this is due to breakage or is the natural shape, but in some cases it can hardly be accidental. Oftentimes the curvature, instead of being regularly arcuate, is angulated, the flattened visceral portions giving onto the lateral parts by a sort of geniculation. The two forms occur together at the New Harmony locality mentioned above, and are associated at most of the points from which collections have been obtained. The striæ, which are never very strong, sometimes become so faint that the shell looks almost smooth. In many cases they are apparent over the posterior portion of the shell and become obsolete toward the margin. More rarely they are obsolete over the visceral portions of the shell. The sinus is often strong, but its variation is considerable. The peculiar submarginal ridges of *Marginifera* are distinct in some specimens, but apparently lacking in others. I have not been able to find them in my material from the type locality. Although the shells examined are thus variable, the variation is so inconstant that I would not feel satisfied to distinguish any of them as separate species. In most cases, however, it is possible without much difficulty to discriminate between individuals with regular curvature and those which are geniculate. I will provisionally make a division of these shells upon this basis, distinguishing the geniculate ones as a variety without, however, giving it a name. The other group is of course the typical one.

In Colorado only the geniculate variety has as yet been found, and it seems to be, as a rule, rather rare. My specimens, which are for the most part in not very good condition, agree closely with those from the Mississippi Valley. They add nothing to the facts shown by the latter, and deviate only so far as that they are generally a little undersized.

Another feature of these shells which may be worthy of mention is that I have observed many ventral valves to be covered externally, sometimes nearly all over, but especially on the posterior portion, by a rough superficial deposit, which gives them a peculiar scaly appearance. This has been noticed at several localities in the Mississippi Valley. I believe that it is not of mineral origin, but it may be parasitic.

Of *Productus splendens* also I have specimens from a number of localities in Kansas. They are of a nearly uniform type, one whose characters correspond faithfully with those ascribed to *P. splendens* by Norwood and Pratten. The shell is broad, strongly arched, often with the visceral area nearly flat and merging with a geniculation into the lateral portions, this character being well shown by Norwood and Pratten's figures.[a] The sinus is deep, the ears well extended, concentric wrinkles

[a] Loc. cit., pl. 1. figs. 5c, 5d.

faint, striæ almost obsolete, spines few and scattering, development of submarginal ridges strong.

From this it will be seen that *P. wabashensis*, especially that variety of it which is characterized by a geniculate curvature, is very similar indeed to *P. splendens*, for *P. splendens* was founded upon a geniculate shell, just as *P. wabashensis* was founded upon an arcuate one. But in the case of *P. splendens* the variation to an arcuate type appears to be less frequent and less pronounced than that in *P. wabashensis* to a geniculate one.

On the whole, I believe that *P. wabashensis*, together with its geniculate variety, can be recognized as a distinct species, because of its smaller size, its generally more distinct striation, and its less persistent disposition to develop the *Marginifera* type of structure. To many, doubtless, it will seem that the geniculate variety of *P. wabashensis* should not be separated from *P. splendens*, and to others, recognizing the near relationship of the former with the type to which the name strictly pertains, that the species should lapse to *P. splendens* as a full synonym. For my own part, as far as my experience extends, it would justify the recognition of these small shells, with their evanescent marginiferoid characters, as at least a variety distinct from *P. splendens*. The distinction between the arcuate and geniculate phases of *P. wabashensis* is a minor one and probably not worthy of varietal recognition.

The peculiar beveled condition of the dorsal valve which is present in all these forms, but especially in *M. splendens*, was noticed by Norwood and Pratten and shown in their figures.[a] The formation of this truncated rim is correlated with the development of the internal submarginal ridges upon which, chiefly, Waagen founds his genus *Marginifera*. These occur largely on the dorsal valve and on the sides of the ventral valve. Where specimens possessing this structure are found weathered free, the outer or peripheral portions of the shell are usually broken away, so that they have the appearance of being abruptly terminated at this point. A specimen of this sort is illustrated by Norwood and Pratten (fig. 5a). Their figure, representing a section through the shell, seems to be a constructive one, based upon the abbreviated condition just mentioned. The dorsal valve, when complete, instead of terminating with the beveled portion and leaving the ventral valve to project beyond, is, as one would expect, prolonged from the inner margin of the bevel, the prolongation conforming with that of the opposite valve and being almost in contact with it.

In Colorado a certain tendency toward localization seems to characterize the distribution of shells of this group, a feature which, though it may be somewhat influenced by doubtful identifications of poor material, without doubt possesses some

[a] Loc. cit., pl. 1, figs. 5b and 5c.

reality. It is unusual for two species to be associated in the collection from a single station, and even a certain amount of individuality is manifested in the different areas represented in our collections.

The discussion of this species opens with the citation of the original reference of *Marginifera wabashensis*, which is a sort of contradiction, since I do not consider the form in hand quite the same as Norwood and Pratten's species. The uncertainty I am under regarding their true relations must explain this action.

Locality and horizon.—San Juan region (stations 2196, 2197, 2198, 2220, 2323); lower and middle portions of the Hermosa formation. Crested Butte district (stations 2302, 2303, 2306, 2316); Weber limestone and Maroon formation.

Marginifera ingrata n. sp.

Pl. V, figs. 12, 12a, 13, 13b.

? 1875. *Productus longispinus.* White (non Sowerby), (pars) U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 118, pl. 8, figs. 5c, d (not figs. 5a, b), (imprint of entire volume 1877).
Carboniferous: East of Minersville and at Meadow Creek, south of Fillmore, Utah; Camp Cottonwood, Old Mormon road, Lincoln County, Nev.; near Santa Fe, N. Mex.

? 1877. *Productus longispinus.* Meek (non Sowerby), U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 78, pl. 8, figs. 4, 4a.
Carboniferous limestone: Fossil Hill, White Pine district, Nevada.

I am uncertain of the specific relationships of this little shell and of the importance which should be attached to the characters which I am about to recount. Because of the former consideration, I have decided to describe it as a new species, and because of the latter I do so with some misgivings. The form which I shall take as my type is found in great abundance at station 2259 in the Leadville region; but it occurs there only in the condition of casts. It is small, transverse, subrectangular. A transverse diameter of 15 mm. and a longitudinal of 11 mm. is somewhat above the average. The curvature is strong, the ears distinct, large, quadrate, and somewhat upturned. The surface is marked by strong, moderately fine striæ, about 7 in the space of 5 mm., and by fine, regular concentric wrinkles over the posterior half of the shell. The spines are small and rather numerous. Mesial sinus absent. Submarginal ridges persistently well developed.

This species can be distinguished from *M. wabashensis* var. by reason of the strength of its striæ and concentric wrinkles, its lack of a mesial sinus, and its regular instead of geniculate curvature.

From *M. muricata* it can be distinguished by being smaller, with larger, more distinct ears, finer striae, and much fewer spines.

The features mentioned in the description, especially the strong wrinkles and striæ conjoined with the absence of a sinus are relied on to distinguish this form from the other American species.

A form from Little Ella Hill (station 2253) in the Leadville region, which is illustrated by figs. 12 and 12a of Pl. V has been placed somewhat doubtfully with *M. ingrata*. It has a faint sinus and is less strongly arched than in the typical variety. Of the latter, the figured specimen shows an indistinct mesial depression, due in part, at least, to compression and fracture, and the concentric wrinkles and radial striæ are unnaturally faint, because they appear upon an internal cast. It is very probable that the shell from Sante Fe, N. Mex., identified by White as *P. longispinus* Sow., belongs to the species above described; rather less so the similar form from Nevada identified by Meek in the same manner.

Locality and horizon.—San Juan region (station 2225); middle portion of the Hermosa formation. Ouray (station 2195); Hermosa formation. Leadville district (stations 2251?, 2253, 2259); base of the Weber formation. Crested Butte district (stations 2312, 2315); Weber limestone. Grand River region, Glenwood Springs (station 2193a).

Marginifera haydenensis n. sp.

Pl. V, figs. 9 to 9c, 10 to 10b, 11 to 11a.

Shell small. Ventral valve strongly curved and inclined backward, so that the posterior portion overhangs the hinge line, which is in some examples half way between the posterior outline and the front edge of the shell. The posterior portion is usually flattened, and the curvature geniculate. The width varies from about equal to the length to somewhat greater. The vault of the shell is large. The ears are usually small, but sometimes are large; quadrate, upturned. A more or less distinct mesial sinus is a persistent feature. Surface marked by longitudinal striæ, which vary from strong to almost obsolete, and are very irregular. They are wavy, sometimes bifurcate or fasciculate, often nearly obsolete over the anterior half of the shell. Posterior portion marked by rather regular, faint, concentric wrinkles. Spines comparatively large and moderately numerous.

Dorsal valve much smaller than the ventral, transverse, with flattened, recurved ears defined by ridges. Surface almost without ornamentation, concentric wrinkles being sometimes present, striæ rarely. Submarginal ridges developed often to an exaggerated degree.

Some examples of this shell are almost unique in the extent to which the posterior portion overhangs the hinge line, but others are far from displaying this peculiarity as well as the specimens figured. This peculiarity seems to arise from the condition of strong fore and aft curvature combined with the late period at which the submarginal ridges are initiated. The character above noted allies *M. haydenensis* with *M. capacii* d'Orbigny, and indeed, its affinities with that species generally are especially close. The striæ of the South American shell are said to be coarse, while in this they are certainly fine.

M. haydenensis in some of its phases resembles *M. wabashensis*, especially the geniculate variety. One, the least characteristic specimen seen, can not be distinguished, except for size, from geniculate shells belonging to *M. wabashensis*, but average, and certainly well characterized, examples are smaller, less transverse, much more inflated, and with stronger submarginal ridges. The Colorado specimens referred to *M. wabashensis* are all, as I have taken occasion to remark, of the geniculate type, and somewhat smaller than is common in the Mississippi Valley. They are extremely similar to *M. haydenensis* when the latter is in its least typical expression, but they do not assume the characters of typical *M. haydenensis*, and probably as a rule—certainly in many cases—begin the development of submarginal ridges at a much earlier period of their growth. Since the shell preserved in the average specimen is terminated by the submarginal ridges, the form referred to *M. wabashensis* would be less highly arched and would very much less transgress the hinge line than typical *M. haydenensis*.

Locality.—Grand River region (station 2324), Grand River (station 2325).

SPIRIFER Sowerby, 1815.

Spirifer boonensis Swallow ?.

Pl. VI, figs. 1–1b, 2, 2a, 3.

1860. *Spirifer boonensis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 646.
Lower Coal Measures: Boone, Randolph, and Monroe counties, Mo.

The Upper Carboniferous spirifers in our collection from Colorado can be assembled into three specific groups. One of these belongs to the type usually referred to *Sp. cameratus* Morton. Another is the form for which Marcou proposed the name *Spirifer rockymontanus*, and which Hall almost simultaneously described as *Sp. opimus.* The third I have referred rather doubtfully to *Sp. boonensis* Swallow. It is distinguished from *Sp. rockymontanus* by being larger and by having an extended hinge line. The largest specimen of *Sp. rockymontanus* observed by me has a transverse diameter of 26 mm., and the average individual has dimensions considerably less. A large specimen of *Sp. boonensis* measures 40 mm., though this, too, is somewhat above the average.

Sp. boonensis, or the form which I have referred to that species, is of the *imbrex* type, transverse, with more or less extended cardinal extremities. Growth in older specimens is often by anterior and anterolateral additions, which gives the shell a subquadrate shape, but the hinge line remains characteristically its longest diameter. There are 4 to 6 plications on the fold and 3 to 5 on the sinus, with 12 or 13 lateral ones. These are crossed by a system of very fine imbricating concentric and radiating striæ, the latter being frequently the more prominent.

Sp. boonensis is known only from the original description, and it has not been figured. My identification can not, therefore, be considered conclusive. The Colorado shell agrees with Swallow's description in many particulars, but also presents divergencies from it. For instance, the hinge line in *Sp. boonensis* is said to be longer, shorter, or equal to the greatest width of the shell, but in the specimens from Colorado this dimension is, I believe, always greater than any other. Swallow also finds no signs of longitudinal striæ, but these are always minute and faint, and might easily have been obliterated in his material. *Sp. boonensis*, furthermore, is described as being below the medium size, which is not true of the Colorado type, and as *Sp. boonensis* is compared by its author to *Sp. opimus* without any discrepancy in this regard being referred to, I judge that the typical material was considerably smaller than that now in my hands.

In the comparison alluded to, *Sp. boonensis* is said to differ from *Sp. opimus* "in the form of the area, the greater number and arrangement of the plications on the mesial fold and sinus, and the much greater number on the sides, and I find no signs of longitudinal striæ." It is probable that the absence of longitudinal striæ noted is due to individual peculiarities or to imperfect preservation. Hall describes *Sp. opimus* as having 8 to 10 simple plications, a statement which, as shown by his figures, should be modified so as to mean on either side of the fold or sinus. Swallow, however, could scarcely have understood it thus and written the words quoted above. Discounted in this way the differences pointed out by Swallow largely disappear, and one is almost ready to believe with Keyes that *Sp. boonensis* belongs in the synonymy of *Sp. opimus* Hall=*Sp. rockymontanus* Marcou. In this case the form under discussion probably represents an unrecorded species, for I believe that it should be distinguished from *Sp. rockymontanus*, and am acquainted with but one other Coal-Measure species which invites comparison. I refer to *Sp. organensis*, to which it seems closely allied. The latter, however, is larger, with more numerous plications both on fold and sinus and on the sides, the lateral ones, moreover, being disposed in fascicles of three or four. The last statement, quoted from Shumard, taken in connection with the rest of the description, would lead to the suspicion that *Sp. organensis* was a synonym of *Sp. cameratus* Morton, were it not for the somewhat obscure remark to be met with just beyond, that the striæ are not arranged in fascicles as in the latter species.

The affinities of the form which I have provisionally referred to *Sp. boonensis*, with the Waverly species *Sp. centronatus*, are very close. This is so true that it would not be easy on intrinsic characters to distinguish typical examples of the latter species from the Cuyahoga shale of Ohio, from the fossils occurring in Colorado. *Sp. centronatus* is usually a little smaller, a little more alate and mucronate, with two or three more lateral plications, while the minute surface ornamentation, though of the same character, seem to be somewhat coarser and stronger. On the surface of *Sp. centronatus* the fine concentric striæ dominate the radiating ones, but in *Sp. boonensis* the radiating striæ seem to be dominant. However, these differences are by no means marked, and although exhibited by the few more perfect examples which have come before me, it is doubtful if they would be maintained in even the limited measure in which they there obtain, in a more extended series.

Our collections show that this species is found at a number of localities, and the evidence seems to indicate that it is seldom associated with *Sp. rockymontanus.* My material is not satisfactory, as often but a single individual is known from a locality, and the preservation poor. Yet I believe that in most cases the determinations made would be substantiated if more abundant and better preserved specimens could be obtained. This species is especially abundant in the San Juan region, and its most typical representatives are found at the base of the Hermosa formation and in the Molas formation. Two examples from the base of the Hermosa are figured on Pl. VI.

Locality and horizon.—San Juan region (stations 2187, 2197, 2201, 2202?, 2205, 2209, 2213, 2214, 2219, 2243, 2246, 2247, 2284?, 2331?, 2332, 2334); Molas formation, lower, middle and upper portions of the Hermosa formation. Ouray (station 2194); Hermosa formation. Crested Butte district (station 2245). Grand River region, North Fork of Eagle River (station 2289); base of the Maroon formation.

Spirifer rockymontanus Marcou.

Pl. XVI, figs. 4, 4a, 5, 5a, 6, 6a, 7, 7c.

1858. (March.) *Spirifer rockymontani* (pars). Marcou, Geol. North America, p. 50, pl. 7, figs. 4c–4e, (non 4–4b?).
Mountain limestone: Tigeras, N. Mex.

1858. (December.) *Spirifer opimus.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 711, pl. 28, figs. 1a, b.
Coal Measures: Ohio, Maryland, Iowa, etc.

1860. *Spirifer subventricosa.* McChesney, Desc. New Spec. Pal. Foss., p. 44.
Coal Measures: Big Creek, Indiana, near New Harmony.

1861. *Spirifer rockymontani.* Newberry, Ives's Colorado River Expl. Exped., p. 127.
Upper Carboniferous limestone: New Mexico.

1865. *Spirifer subventricosa.* McChesney, Illustrations New Spec. Foss., pl. 1, figs. 4a, b.

1868. *Spirifera opimus.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 35, pl. 1, figs. 4a, b.
Coal Measures: Big Creek, near New Harmony, Ind.

1874. *Spirifera opima.* Derby, Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 15, pl. 1, fig. 4; pl. 2, fig. 7; pl. 4, fig. 12.
Coal Measures: Bomjardim, Paredao, and Itaituba, Brazil.

1875. *Spirifer* (*Trigonotreta*) *opimus?* Meek, Pal. Ohio, vol. 2, p. 329, pl. 19, figs. 14a, b, c, d, (e?).
Coal Measures: Ohio, Illinois, Iowa, Missouri, West Virginia, and Rocky Mountains.

1875. *Spirifer rockymontanus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 134, pl. 11, figs. 9a–d. (Whole volume published in 1877.)
Carboniferous: North Fork of Lewiston Canyon, Oquirrh Range, and on west face of Oquirrh Range, Utah; near Santa Fe, N. Mex.

1876. *Spirifer rockymontanus.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey group: Split Mountain Canyon and near Echo Park, Utah.
Upper Aubrey group: Beehive Point, near Horseshoe Canyon, Utah.

1877. *Spirifer (Trigonotreta) opimus?* Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 88, pl. 9, fig. 6.
Carboniferous limestone: Six miles south of Promontory Station, Promontory Mountains, Railroad Canyon, Moleen Peak; Mount Nebo in Utah; Fossil Hill, White Pine district.

1879. *Spirifer rockymontanus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 32.
Lower Coal Measures: White County and Crawford County, Ark.
See also *Spirifer keokuk.*

1883. *Spirifera opima.* Hall, Rept. New York State Geol. for 1882, pl. (31) 56, figs. 4–7.
Coal Measures: Iowa; Brazil, South America,

1887. *Spirifera opima.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 44, pl. 2, fig. 23.
Coal Measures: Flint Ridge, Ohio.

1888. *Spirifera rockymontana.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 231.
Lower Coal Measures: Des Moines, Iowa.

1891. *Spirifera rockymontana?* Whitfield, New York Acad. Sci., Ann., vol. 5, p. 584, pl. 13, fig. 20.
Maxville limestone (Chester): Newtonville, Ohio.

1893. *Spirifer opimus.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 27, 39, pl. 31, figs. 4–7. (Advance distribution in fascicles.)
Coal Measures: Bomjardim, Brazil.

1894. *Spirifer opimus.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 27, figs. 12, 13.
Coal Measures: Iowa.

1895. *Spirifera rockymontana.* Keyes, Missouri Geol. Surv., vol. 5, p. 84. (Date of imprint 1894.)
Upper Coal Measures: Kansas City, Mo.

1895. *Spirifer opimus.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 27, 39, pl. 31, figs. 4–7.
Coal Measures: Iowa; Bomjardim, Brazil.

1895. *Spirifera rockymontana?* Whitfield, Geol. Surv. Ohio, Rept., vol. 7, p. 471, pl. 9, fig. 20.
Maxville limestone (Chester): Newtonville, Ohio.

1899. *Spirifer rockymontanus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 578.
Upper Coal Measures: McAlester quadrangle; Atoka quadrangle.

From a study of Marcou's figures, I am inclined to believe that he had in hand two distinct species when *Spirifer rockymontanus* was described. Figs. 4c, 4d, and 4e clearly represent a shell of the type which commonly passes under the name proposed by Marcou, and which Hall described as *Sp. opimus.* But the larger specimen figured by Marcou represents a different sort of shell. It has many bifurcating ribs, and is perhaps one of the short-hinged varieties of *Sp. cameratus* or its allies, such as sometimes occur. I propose to restrict the name *Spirifer rockymontanus* to shells of the type of Marcou's figures 4c, 4d, and 4e, thus retaining the name in its customary significance.

Spirifer rockymontanus has a wide distribution, both in the Mississippi Valley and the Rocky Mountains. It has been found at many stations in Colorado, but seems to be especially abundant in the Leadville region. Specimens having all the characters of mature *Sp. rockymontanus* vary much in size. There are usually five or six plications on the fold and about ten lateral ones. The cardinal extremities are characteristically rounded.

Locality and horizon—San Juan region (stations 2196, 2196b, 2196c, 2202, 2222, 2223, 2229, 2323); middle portion of the Hermosa formation. Ouray (station 2195, 2195a, 2195b); Hermosa formation. Crested Butte district (stations 2245, 2308, 2315); Weber limestone. Leadville district (stations 2253, 2254, 2259, 2261, 2267, 2268, 2271, 2281, 2288, 2289?); base of the Weber formation and in the Robinson limestone. Grand River region (station 2288, 2289); base of Weber formation and base of the Maroon formation (?).

SPIRIFER CAMERATUS Morton.

1836. *Spirifer cameratus.* Morton, Am. Jour. Sci., (1), vol. 29, p. 150, pl. 2, fig. 3.
Coal Measures: Ohio Valley.

1852. *Spirifer triplicata.* Hall, Stansbury's Exped. Great Salt Lake, p. 410, pl. 4, figs. 5a–e.
Carboniferous: Missouri River above Weston.

1852. *Spirifer fasciger?* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 5, fig. 4. (Not. *Sp. fasciger* Keyserling.)
Carboniferous: Missouri River, near mouth of Keg Creek, and Plattsburg, Mo.

1852. *Spirifer meusebachanus.* Roemer, Kreid. von Texas, p. 88, tab. 11, figs. 7a–c.
Carboniferous: San Saba Valley, about 20 miles below the old Spanish forts, Texas.

1852. *Spirifer inequicostatus?* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, p. 586, pl. 5, fig. 6. (See specimens in U. S. Nat. Mus., Cat. Invert. Foss., 17954.)
Carboniferous limestone of Iowa: Skunk River,? Iowa.

1856. *Spirifer cameratus.* Hall, Pacific Railroad Rept., vol. 3, p. 102, pl. 2, figs. 9, 12, 13.
Carboniferous: Pecos Village, N. Mex.

1858. *Spirifer striatus* var. *triplicatus.* Marcou, Geol. North America, p. 49, pl. 7, fig. 3.
[Mountain limestone]: Abundant in the Rocky Mountains, especially at Pecos Village, at Tigeras, on the summit of the Sierra de Sandia, at Great Salt Lake, and at Vancouver Island.

? 1858. *Spirifer rockymontani* (pars). Marcou, Geol. North America, p. 50, pl. 7, figs. 4–4b.
Mountain limestone: Tigeras, N. Mex.

1858. *Spirifer cameratus.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 709, pl. 28, figs. 2a, b.
Coal Measures: Ohio; Illinois; Iowa; Missouri; Nebraska; Santa Fe and Pimas Village, N. Mex.

? 1859. *Spirifer cameratus.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 27.
Upper Coal Measures: Kansas.

1859. *Spirifer cameratus.* Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 391.
Permian sandstone and White limestone: Guadalupe Mountains.

1861. *Spirifer cameratus.* Newberry, Ives's Colorado River Expl. Exped., p. 127.
Upper Carboniferous limestone: Santa Fe and Pecos Village, N. Mex.

1866. *Spirifer cameratus.* Geinitz, Carb. und Dyas in Nebraska, p. 44.
Carboniferous limestone: Bellevue and Plattsmouth, Nebr.; stage B, b^1, Nebraska City, and stage B *b*, b. Bennetts Mill, northwest of Nebraska City.

1868. *Spirifer.* Rogers, Geol. Rept. Pennsylvania, vol. 2, pt. 2, p. 833, fig. 694.
Western Coal Measures.

1872. *Spirifer cameratus.* Meek, U. S. Geol. Surv. Nebraska, p. 183, pl. 6, fig. 12; pl. 8, fig. 15.
Upper Coal Measures: Nebraska City, Nebr.
Coal Measures: Eastern Ohio; West Virginia; Pennsylvania; Iowa; Kansas; Texas; New Mexico.

1873. *Spirifer cameratus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 573, pl. 25, fig. 7.
Coal Measures: Illinois.

1873. *Spirifer*, young of *S. cameratus?* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, pl. 25, figs. 6a–c.
Coal Measures.

1874. *Spirifer camerata.* Derby, Cornell Univ., (Science.) Bull., vol. 1, No. 2, p. 12, pl. 1, figs. 1, 3, 6, 9, 14; pl. 4, figs. 2, 15; pl. 4, fig. 5; pl. 5, fig. 11.
Coal Measures: Bomjardim and Itaituba, Brazil.

1875. *Spirifer cameratus.* Toula, Neues Jahrbuch Mineral., p. 240, pl. 7, fig. 3.
Permo-Carboniferous: West coast of Spitzbergen.

1875. *Spirifer cameratus.* Toula, Sitzb. der Kais. Akad. der Wissen. Wien, p. 543, pl. 2, figs. 2a, b.
Carboniferous limestone: Nova Zembla.

1875. *Spirifer cameratus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 132, pl. 10, figs. 1a–d. (Whole volume published in 1877.)
Carboniferous: Fossil Hill, White Pine County; Ely Range; Old Potosi mine, Lincoln County, and Egan Range, 35 miles south of Egan Pass, Nevada; Camp Apache, Maricopa County; Salt River; confluence of White Mountain and Black rivers; and Canyon Butte, Arizona; Oquirrh Range, near Camp Floyd; Lake Range on Fairfield road; west face of Oquirrh Range; North Fork of Lewiston Canyon, Oquirrh Range; cliff east of Bellevue; Meadow Creek, south of Fillmore; North Star district; Picacho Range; near Beckwith Spring, Cedar Range; Rock Canyon, Wasatch Range, near Provo; and Virgin Range, southwest of St. George, Utah.

1876. *Spirifer cameratus.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey Group: Confluence of Grand and Green rivers, Utah.

1876. *Spirifer cameratus.* Newberry, Macomb's U. S. Expl. Exped. Santa Fe to Grand and Green rivers, p. 138.
Upper Carboniferous: New Mexico and Utah.

1876. *Spirifer camerata.* Meek, Simpson's Expl. Great Basin, Utah, p. 353, pl. 2, figs. 3a, b.
Yellow limestone (Upper Carboniferous?): Summit Spring Pass, east of Zuni Valley, etc.

1877. *Spirifer* (*Trigonotreta*) *cameratus.* Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 91, pl. 9, figs. 2, 2a.
Carboniferous limestone: Fossil Hill, White Pine district; Ruby Group, Nevada. Also, latitude 39° 33′ north, longitude 115° 12′ west.

1880. *Spirifer cameratus.* White, 2d Ann. Rept. Dept. Stat. and Geol. Indiana, p. 517, pl. 8, fig. 3.
Coal Measures: Waterman, Parke County, Ind.

1881. *Spirifera camerata.* White, Geol. Surv. Indiana, 10th Rept., p. 149, pl. 8, fig. 3.
Coal Measures: Waterman, Parke County, Ind.

1883. *Spirifera camerata.* Hall, Rept. New York State Geol. for 1882, pl. (32) 57, figs. 9–15.
Coal Measures: Ohio; Illinois; Iowa; Missouri, etc.

1884. *Spirifer cameratus.* White, Geol. Surv. Indiana, 13th Rept., p. 132, pl. 35, figs. 3–5.
Coal Measures: Indiana.

1887. *Spirifer camerata.* Herrick, Sci. Lab. Denison. Univ., Bull., vol. 2, p. 45, pl. 2, fig. 22.
Coal Measures: Flint Ridge, Ohio.

1888. *Spirifera camerata.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 230.
Lower Coal Measures: Des Moines, Iowa.

1893. *Spirifer cameratus.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 26, 38, pl. 32, figs. 9–15. (Advance distribution in fascicles.)

Coal Measures: Ohio; Illinois; Missouri; Iowa.

1894. *Spirifer cameratus.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 26, figs. 7, 8.

Coal Measures: Missouri; Illinois.

1895. *Spirifera camerata.* Keyes, Missouri Geol. Surv., vol. 5, p. 83, pl. 40, figs, 5a–c. (Date of imprint, 1894.)

Coal Measures: Clinton, Kansas City, and Lexington, Mo.

1895. *Spirifer cameratus.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 26, 38, pl. 32, figs. 9–15.

Coal Measures: Ohio and Illinois; Missouri; Iowa.

1896. *Spirifer cameratus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 241.

Upper Coal Measures: Sebastian County, Ark.; Poteau Mountain, Indian Territory.

Lower Coal Measures: Conway County, Ark.

1896. *Spirifer cameratus.* Smith, Leland Stanford Junior Univ., Pub.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 31.

Upper Coal Measures: Sebastian County, Ark.; Poteau Mountain, Indian Territory.

Lower Coal Measures: Conway County, Ark.

1898. *Spirifer cameratus.* Beede, Kansas Univ. Quart., vol. 9, p. 21, pl. 5.

1900. *Spirifer cameratus.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 99, pl. 12, figs. 5–5e.

Upper Coal Measures: Kansas City, Lawrence, Lecompton, Topeka, Grand Summit, Kans.

This species, like the preceding, has a long range and an extended distribution both in the Mississippi Valley and the Rocky Mountains. In Colorado it is frequently present, but has not yet come to light in the Leadville region.

Among the material referred to this species variation more or less marked has been noticed in the fineness of the striæ and the degree to which they are gathered into fascicles. Nevertheless it has not been found practicable to establish satisfactory subdivisions. Most of the material examined, however, is imperfect in one way or another.

Locality and horizon.—San Juan region (stations 2198, 2200, 2201, 2205, 2210, 2213, 2216, 2233, 2239, 2246, 2284, 2331, 2332); lower, middle, and upper portions of the Hermosa formation. Ouray (station 2194); Hermosa formation. Crested Butte district (stations 2293, 2303, 2305); Maroon formation. Grand River region (station 2324), Glenwood Springs (stations 2329a, 2329b). Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

SQUAMULARIA Gemmellaro, 1899.

The name *Reticularia* was proposed by McCoy in 1844[a] as a distinct genus, to which he gave the following characters:

"*General character.*—Hinge line shorter than the width of the shell; cardinal area triangular; cardinal angles very obtusely rounded; mesial fold very slightly raised, or none; surface ornamented with either fine longitudinal or transverse striæ, or most usually reticulated by both; dental lamellæ perfectly parallel.

[a] Synopsis Characters Carb. Limestone Foss. Ireland, Dublin, 1844, p. 142.

"This beautiful little group includes all those spirifers analogous to the *S. imbricata*, *S. lineata*, *S. microgemma*, *S. reticulata*, *S. decussata*, etc., having a reticulated or striated surface combined with the general form and cardinal area of *Martinia* McCoy, in which genus I formerly placed them, although they obviously formed a very marked group, distinguished by its small size, reticulated or striated surface, and very remarkably by the entire absence of the mesial fold in most of the species (in the one or two species which possess a trace of the mesial fold it is very slightly elevated). But the internal structure which I have recently seen in three of the species presents a very distinct and important character; the dental lamellæ, instead of converging toward the beak, as in all the other forms of *Spirifer*, are in those perfectly parallel to each other and to the central septum, in their whole length, thus confirming by a very interesting internal peculiarity the easily recognizable external characters. The genus is Carboniferous and Devonian."

The term *Reticularia* seems to have gained but little acceptance, and the species distinguished under it were for the most part merged with the genus *Spirifer*.

Waagen, however, in 1887 employed the name in a full generic sense, assigning distinctive characters both externally and internally. The distinctive external characters of this group mentioned by this author are the general orbicular shape, short hinge line, and the surface ornamentation, consisting of hollow, double-barreled spines. "Internally," he says, "the ventral valve is without any partition; neither dental plates nor a median septum is present. The muscular impressions are situated in an elongately oval groove. In the dorsal valve also not a trace of any partitions can be found; no septum nor shelly support of the dental sockets has been observed by me. A hinge plate does not exist."[a]

In 1892 Hall and Clarke commented upon the term *Reticularia* as follows, assigning to it the same characters as Waagen:[b]

"Reticularia (op. cit., pp. 128, 142). First species cited, *Terebratula imbricata* Sowerby=*Anomites lineatus* Martin=*Spirifer lineatus* of authors. Shells of this type have the short hinge and the smooth or gently plicated surface characterizing *Martinia*, and like the latter have neither dental plates nor septa on the interior. The name is based upon a species whose surface is covered with concentric fimbriæ of double-barreled spines bearing single rows of lateral spinules, and must probably be restricted to this type of exterior, as in the more strongly plicated of the fimbriated spirifers the surface spines are simple."

These authors, however, reduce the value of this term below that of a subgenus, and employ it as a collateral or synonymic title for the group of spirifers which they call "the *duplicispinei*." To this group Hall and Clarke refer "*S. fimbriatus* Conrad, *S. subundiferus* Meek and Worthen, of the Hamilton group; *S. hirtus* White and Whitfield, of the Choteau limestone; *S. pseudolineatus* Hall, of the Kinderhook and Keokuk groups; *S. setigerus* Hall, *S. lineatus* Martin, and *S. perplexus* McChesney,

[a] Mem. Geol. Surv. India, Palæontologia Indica, Salt Range Fossils, vol. 1, 1887, p. 538.

[b] Pal. New York, vol. 8, pt. 2, 1894, p. 20.

of the Coal Measures." Now, it is evident that internally the shells included under *Reticularia* by McCoy are very different from those which the usage of Waagen and of Hall and Clarke embrace. McCoy in 1854, commenting upon *Spirifer lineatus*, speaks again of the dental lamellæ and septa of *Reticularia* in the following terms:

"This species, from the peculiar structure of the surface and the slight divergence of the dental lamellæ with their strong mesial septum, was originally combined in my Synopsis (of Carb. Foss.) with the *S. imbricata*, *S. reticulata*, *S. microgemma*, etc., into a little group called *Reticularia*. There is a fine submedial impressed line, apparently a fracture, visible in many specimens from the beak to the front margin."[a]

Waagen, after quoting this passage, says:

"Now, it does not seem to me probable that the British specimens of *Reticularia* possess an internal structure different from that of the specimens from Visé, with which the Indian specimens entirely agree. It seems far more probable that there has occurred a mingling of different things by McCoy, and that he described the above characters from a specimen of *Martiniopsis*, or something like it. Nevertheless, it would be very desirable to learn more particularly about these British fossils."[b]

Examining our American species of this type, I find that the Mississippian forms, without exception, so far as my examination goes, possess internal structures as described by McCoy, while the Upper Carboniferous ones are structureless, as in the group described by Waagen and by Hall and Clarke. The species referred to *Reticularia* by McCoy were found in strata of the age of our Mississippian series, while Waagen's material from India came from high up in the Upper Carboniferous, or Permian. It thus appears that the groups of shells characterized by these internal differences are characterized also by a difference of occurrence in the geologic column. Hall and Clarke evidently handled species of both stratigraphic occurrences and representatives of both types of internal structure, but apparently they passed over these, to me, important distinctions in favor of a certain agreement in general external expression.

I think there can be no doubt to which group the term *Reticularia* was originally applied, and I propose to restrict it to the original implication and to employ a distinct term for the shells without septa or dental lamellæ, as Waagen has described *Reticularia*.

I had, in manuscript, proposed for this group a distinctive name, when there came into my hands a work by Gemmellaro,[c] in which he proposes the name *Squamularia* for some fossils very similar to those which it was my purpose to include in a new genus. A full and, in the main, literal translation of Gemmellaro's remarks upon *Squamularia* is here appended.

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[a] British Paleozoic Rocks and Fossils, Sedgwick and McCoy, Cambridge, 1854, p. 430.

[b] Loc. cit., p. 538.

[c] La Fauna dei Calcari con Fusulina, fasc. 4, pt. 1, p. 325, Palermo, 1898–99.

In the Fusulina limestones of Sicily there is found a group of spiriferoids which differs from the known genera. These fossils have an ornamentation which in some ways recalls that of *Athyris*. However, the complete absence of dental and septal plates, and the form of the brachial apparatus, which I was able to observe in two specimens, have convinced me that they differ from that genus; while, on the other hand, they are more closely allied to the *Martiniæ* and the *Reticulariæ*. These spiriferiods, to which I give the generic name *Squamularia*, have the following characters.

They are thick shells, imperforate, and ornamented with thin, concentric laminæ, narrowly undulated, squamose, fringed, and imbricated one above the other. Here and there, at nearly equal distances, some of these laminæ are thicker, more prominent, welt-like, and with margins more distinctly fringed. The surface of the shell shows numerous scars and imprints of spines, particularly distinct on the edge of the varices. The hinge line, which is much shorter than the major breadth of the shell, is slightly arched. The area is often indistinct. Beneath the beak of the ventral valve is seen the delthyrium, which is triangular and narrow. The epidermis is not punctate.

They have no dental or septal laminæ whatever. The crural plates start from the hinge margin of the dorsal valve, more specially from the internal face of the dental fossettes. These plates at first diverge, forming an elbow, and then converge toward the median line, approaching each other so as to circumscribe in the internal subapical region a space with pentagonal outline. Having come close together and almost in contact, they give rise to the descending laminæ, which extend parallel along the median line as far as the anterior third of the length of the dorsal valve. Thence they diverge toward the sides, to give rise to the formation of the laterally directed spiral cones. The latter are large enough almost to fill the internal cavity of the shell, and are the result of broad gyrations, few in number.

The relationship of the *Squamulariæ* with the *Martiniæ* and the *Reticulariæ* is close, but not so intimate that they can be embraced within the same generic limits. The *Martiniæ* have a punctate epidermis, and never present the ornamentation peculiar to these fossils. When they are provided with lamellose, concentric striæ, as, for example, *Martinia lamellosa* Gemm., these striæ are neither fringed nor wavy, and, with the exception of *Martinia distefanoi*, lack spines. As regards their brachial apparatus also there are differences. In the *Martiniæ* the crural plates converge abruptly toward the median line, and leave between them in the rostral region a larger or smaller triangular space. The descending laminæ are close together for a short distance, and then diverge toward the sides to give rise to the spiral cones, which are rather small.

As regards their affinity with the *Reticulariæ*, there is some analogy in the conformation of the various parts of the apical region and in the sum total of their ornamentation, but certainly this analogy is of no importance in view of the diversity that exists between the characteristic structure of the shell surface of these species and that of the *Squamulariæ*. As regards their internal characters, the spiral cones of the *Reticulariæ* ordinarily have the apex directed toward the hinge line, and in the species in which it is turned sideways, as in the *Squamulariæ*, the crura do not form an elbow, but, on the contrary, have very nearly the same direction as in *Martinia*; that is to say, they converge directly toward the median line, leaving in the internal infra-apical region a larger or smaller triangular space, and the descending laminæ do not run parallel for a long distance, but, having approached each other, suddenly diverge toward the sides, and give rise to the spiral cones.

These fossils belong to two species, to which I have given the names of *Squamularia rotundata* Gemm. and *Squamularia dieneri* Gemm.

The *Squamulariæ* were found in the compact Fusulina limestone of the Rock of San Benedetto, in the vicinity of Palazzo-Adriano, in the province of Palermo.

The first species described, which must be taken as the type, is *Squamularia rotundata* Gemm., and upon its characters accordingly rests the validity of Gemmellaro's genus. It is quite evident that this author did not apprehend the more obvious differences which distinguish *Reticularia* from his species of *Squamularia*, and that he considered McCoy's genus to be devoid of dental lamellæ and septa. If the characters by which he sought to distinguish *Squamularia* from *Reticularia* are valid, there can be no doubt but that the forms referred by him to *Reticularia* constitute a yet undescribed genus. But I very much doubt the importance of the characters to which Gemmellaro calls attention, and believe that the real characters of distinction are the septa and dental plates which are present in *Reticularia* and absent in *Squamularia*. This opinion seems to be confirmed by Schellwien, who regards *Squamularia* as a synonym of *Reticularia*, the latter name evidently being employed in the sense in which Waagen and Hall and Clarke interpret it.

To *Squamularia*, therefore, would belong all of Waagen's species of *Reticularia* and also those of Gemmellaro himself, together probably with most American, European, and Asiatic Upper Carboniferous types that have been included by authors under McCoy's genus. More specifically with regard to our American species, *Squamularia* will include only, so far as I know, the two Upper Carboniferous forms *Recticularia perplexa* McChesney and *Reticularia guadalupensis* Shumard, both of which I have examined and know to be without septa or dental lamellæ.

To *Reticularia* will belong the Mississippian species *R. clara* Swallow (?), *R. cooperensis* Swallow, *R. lineatoides* Swallow (?), *R. pseudolineata* Hall, *R. setigera* Hall, *R. temeraria* Miller (?), *R. tenuispinata* Herrick, and *R. translata* Swallow (?). These Mississippian forms are usually characterized by two powerful dental plates in the ventral valve, and a median septum in both dorsal and ventral valves. The dorsal septum varies in degree, being sometimes low and sometimes moderately high.

The dental lamellæ are often not quite parallel, as they are described by McCoy in *Reticularia*, but this difference I can not regard as of prime importance. The type of *Reticularia*, as already pointed out by Hall and Clarke, will have to be taken as *R. imbricata* Sowerby, the first species included by McCoy under his genus.

Squamularia and *Reticularia* stand related to one another very much as do *Martinia* and *Martiniopsis*, but with this difference, that while the *Reticulariæ* with internal plates precede those without, the Martinias with internal structures were a late development.

Hall and Clarke, as already mentioned, do not apparently give *Reticularia* the place of even a subgenus, while Waagen allows it full generic rank. It seems to me that the names *Martinia*, *Martiniopsis*, *Reticularia*, and *Squamularia* stand about on a par in genetic station, and while I am in doubt about their value as full generic groups, it seems to me that they should at least be considered subgenera of *Spirifer*.

Squamularia perplexa McChesney.

Pl. VI, figs. 8, 8a, 9 to 9b, 10, 10a, 11 to 11c.

1855. *Spirifer lineatus.* Shumard, Missouri, Geol. Surv., p. 216. (Not *Sp. lineatus* Martin.)
Coal Measures.

1856. *Spirifer lineatus.* Hall, Pacific Railroad Rept., vol. 3, p. 101, pl. 2, figs. 6–8. (Not *Sp. lineatus* Martin, 1809.)
Carboniferous: Pecos Village, N. Mex.

1858. *Spirifer lineatus.* Marcou, Geol. North America, p. 50, pl. 7, figs. 5–5c. (Not *Sp. lineatus* Martin.)
Mountain limestone: Pecos Village and Tigeras, N. Mex.

1859. *Spirifer lineatus.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 28.
Upper Coal Measures: Leavenworth, Kans.

1860. *Spirifer perplexa.* McChesney, Desc. New Pal. Foss., p. 43.
Upper Coal Measures: Almost every part of the country where rocks of that age occur.

1861. *Spirifer lineatus.* Newberry, Ives's Colorado River Expl. Exped., p. 127. (Not *Sp. lineatus* Martin.)
Upper Carboniferous: Cherty limestone west of Little Colorado River; vicinity of Santa Fe, N. Mex.

? 1864. *Spirifer lineatus.* Meek, Pal. California, vol. 1, p. 13, pl. 2, figs. 6–6d.
Carboniferous: Bass's Ranch, Shasta County, Cal.

1866. *Spirifer lineatus.* Swallow, Acad. Sci. St. Louis, Trans., vol. 2, p. 408. (Not *Sp. lineatus* Martin.)
Coal Measures: Mississippi Valley.

1866. *Spirifer lineatus* var. *perplexa.* Swallow, Acad. Sci. St. Louis, Trans., vol. 2, p. 408.
Coal Measures: Mississippi Valley.

1866. *Spirifer lineatus* var. *striato-lineatus.* Swallow, Acad. Sci. St. Louis, Trans., vol. 2. p. 408.
Upper and Middle Coal Measures: Missouri.

1872. *Spirifer lineatus?* Meek, U. S. Geol. Surv. Nebraska, pl. 2, figs. 3*a*, *b*.
Upper Coal Measures: Platte River, Nebraska.

1874. *Spirifera (Martinia) perplexa.* Derby, Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 16, pl. 3, figs. 27, 39, 40, 45, 50; pl. 8, fig. 13.
Coal Measures: Bomjardim and Itaituba, Brazil, and River Pichis, Peru.

1881. *Spirifera (Martinia) lineata?* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Appendix, p. xii.
Coal Measures: Upper Mississippi River region.

1882. *Spirifer (Martinia) lineatus.* White, Geol. Surv. Indiana, 11th Rept., p. 372, pl. 42, figs. 4–6.
Coal Measures: Eugene, Ind.

1884. *Spirifer (Martinia) lineatus.* White, Geol. Surv. Indiana, 13th Rept., p. 133, pl. 27, figs. 4–6.
Coal Measures: Fountain, Park, Vermilion, Vigo, Sullivan, Gibson, Pike, Knox, Posey, Vanderburg, and Warrick counties, Ind.

1886. *Spirifer lineatus?* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 453.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Spirifer lineatus?* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 269.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1887. *Spirifera (Martinia) lineata?* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 46, pl. 1, figs. 13*a–c*.
Coal Measures: Flint Ridge, Ohio.

1888. *Spirifera lineata.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 230.
Lower Coal Measures: Des Moines, Iowa.

1891. *Spirifer (Martinia) lineata.* Whitfield, New York Acad. Sci., Ann., vol. 5, p. 603, pl. 16, figs. 3–5.
Coal Measures: Hocking County, Ohio.

1893. *Spirifer lineatus.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 10, 11, 17, 21, 30, 39, pl. 38, figs. 2, 4, 7, 8. (Not *Sp. lineatus* Martin.) (Advance distribution in fascicles.)
Coal Measures: Iowa.

1894. *Spirifera perplexa.* Keyes, Missouri Geol. Surv., vol. 5, p. 84. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1895. *Spirifera (Martinia) lineata.* Whitfield, Geol. Surv. Ohio, Rept., vol. 7, p. 488, pl. 12, figs. 3–5.
Coal Measures: Hocking County, Ohio.

1895. *Spirifer lineatus.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 10, 11, 17, 21, 30, 39, pl. 38, figs. 2, 4, 7, 8. (Not *Sp. lineatus* Martin.)
Coal Measures: Iowa.

1899. *Reticularia perplexa.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 577, pl. 72, fig. 1a.
Upper Coal Measures: McAlester quadrangle.

1900. *Reticularia perplexa.* Beede, Univ. Geol. Surv. Kansas, Rept., p. 102, pl. 12, figs. 4–4*c*.
Upper and Lower Coal Measures to base of Permian: Fort Scott, Iola, Lawrence, Topeka, Kans.

This species is more numerous, if not more widely distributed, perhaps, than any in the collection, having been found at no less than 30 localities. While perfect and well-preserved examples could scarcely be mistaken, in practice it has not always been found an easy matter to distinguish individual specimens when poorly preserved or imperfect, or both, from *Seminula subtilita*, or in the case of young examples, from *Ambocœlia planiconvexa.* The peculiarities of surface ornamentation, which in exfoliated specimens or even in internal casts can usually be relied on to distinguish this species, are sometimes so obscured that the shell appears quite smooth. Very small shells in this condition bear a strong resemblance to *Ambocœlia planiconvexa*, the character which was most used in distinguishing them being the convexity of the dorsal valve. Some of the specimens from the forks of Cement Creek, in the Crested Butte quadrangle (station 2318), especially, I rather suspect, if more perfectly preserved would prove to be large examples of *Ambocœlia.*

McChesney states that this species seldom attains a greater diameter than five-eighths of an inch. This is true as a rule in the collection studied, but specimens have been noted both from Colorado and the Mississippi Valley which measure 20 mm. (over three-fourths of an inch) and more. Considerable variation has also been noted in frequency of the bands of spines with which the surface was covered. In some specimens the spinous rows are less than 1 mm. apart, and in others they are separated by intervals of 3 mm. Usually the widely spaced bands are found upon the larger-sized specimens. All degrees occur between specimens with distant bands and those with proximate ones, and I believe that this character can not be given even varietal value.

Locality and horizon.—San Juan region (stations 2196, 2196a, 2196b, 2196c, 2197, 2202, 2208, 2213, 2220, 2221, 2222, 2223, 2224, 2225, 2233, 2238, 2283, 2286, 2301, 2332); lower, middle, and upper portions of the Hermosa formation. Ouray (station 2194); Hermosa formation. Crested Butte district (stations 2245, 2291, 2292, 2293, 2297, 2299, 2300, 2303, 2305, 2306, 2316, 2318); Weber limestone and Maroon formation. Leadville district (stations 2260, 2272?); upper part of Weber formation and Robinson limestone.

AMBOCŒLIA Hall, 1860.

Ambocœlia planiconvexa Shumard.

1855. *Spirifer planoconvexa.* Shumard, Missouri Geol. Surv., p. 202.
Upper Coal Measures: On Missouri River, near mouth of Platte River.

1859. *Spirifer planoconvexa.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 28.
Upper Coal Measures: Manhattan, Juniata, and Leavenworth, Kans.

1860. *Ambocelia gemmula.* McChesney, Desc. New Pal. Foss., p. 41.
Coal Measures: Peoria and Bureau counties, Ill.

1864. *Spirifer (Martinia) planoconvexa.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, pt. 1, p. 20, figs. a–e, ibidem, 1865, pl. 1, fig. 3.
Coal Measures: Manhattan and Upper Mill Creek, Kansas.

1866. *Spirifer plano-convexa.* Geinitz, Carb. und Dyas in Nebraska, p. 42, tab. 3, figs. 10–18.
Upper Coal Measures, Plattsmouth, Nebraska City, Nebr.

1868. *Martinia planoconvexa.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 34, pl. 1, 3a–c.
Coal Measures: Peoria and Bureau counties. Ill.

1872. *Spirifer (Martinia) planoconvexus.* Meek, U. S. Geol. Surv. Nebraska, p. 184, pl. 4, figs. 4a, b, pl. 8, figs. 2a, b.

Upper Coal Measures: Nebraska City, Bennett's Mill, Wyo.; Cedar Bluff, Rock Bluff, Plattsmouth, Brownville, Otoe City, Rulo, Bellevue, and Omaha, Nebr.

Coal Measures: Iowa; Missouri; Kansas; Pittsburg, Pa.; West Virginia.

1874. *Spirifera (Martinia) planoconvexa.* Derby, Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 19, pl. 8, figs. 12, 16, 18; pl. 9, fig. 7.

Coal Measures: Bomjardim and Itaitúba, Brazil, and Pichis River, Peru.

1875. *Spirifer (Martinia) planoconvexus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 135, pl. 10, figs. 3a–c. (Whole volume published in 1877.)

Carboniferous: Near Santa Fé, N. Mex.; Elko Mountain, Nevada.

1884. *Spirifer (Martinia) planoconvexa.* White, Geol. Surv. Indiana, 13th Rept., p. 134, pl. 32, figs. 23–24.

Coal Measures: Indiana. Occurs from Virginia to Utah and New Mexico.

1887. *Spirifera (Martinia) planoconvexa.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 46, pl. 1, fig. 12.

Coal Measures: Flint Ridge, Ohio.

1893. *Ambocœlia planoconvexa.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 58, pl. 39, figs. 10–15. (Advance distribution in fascicles.)

Coal Measures: Springfield, Ill.; Manhattan, Kans.

1894. *Ambocœlia planoconvexa.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 31, figs. 14–17.

Coal Measures: Illinois; Kansas.

1895. *Spirifera planoconvexus.* Keyes, Missouri Geol. Surv., vol. 5, p. 85. (Date of imprint, 1894).

Upper Coal Measures: Kansas City, Mo.

1895. *Ambocœlia planoconvexa.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 56, pl. 39, figs. 10–15.

Coal Measures: Springfield, Ill.; Manhattan, Kans.

1900. *Ambocœlia planoconvexa.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 101.

Upper and Lower Coal Measures: Fort Scott, Fredonia, Eudora, Lawrence, Lecompton, Topeka, Emporia, Kans.

Small shells more or less closely resembling this species were collected at several localities. The nature of the surface ornamentation or other characters has convinced me that they are merely young individuals of *Reticularia*, with large forms of which they are in most cases associated. Occasionally the evidence was less conclusive than others, but using such characters as the fossils still retained, I have identified *A. planiconvexa* at but two localities, where, however, its presence is tolerably certain. It is nevertheless possible that this species has really a somewhat better representation than I was led to believe. It is abundant at station 2282 in the San Juan region (Rico quadrangle, Sandstone Mountain section).

Locality and horizon.—San Juan region (stations 2220, 2282); middle portion of the Hermosa formation.

SPIRIFERINA d'Orbigny, 1847.

Spiriferina campestris White.

1874. *Spiriferina spinosa?*. Derby, Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 23, pl. 6, figs. 8, 13, 14.

Coal Measures: Itaituba, Brazil.

1874. *Spiriferina spinosa* var. *campestris*. White, U. S. Geog. Geol. Surv. W. 100th Mer., Prelim. Rept. Invert. Foss., p. 21.

Carboniferous Coal Measures: Near Santa Fé, N. Mex.; Camp Cottonwood, Lincoln County, Nev.

1875. *Spiriferina octoplicata*. White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 139, pl. 10, figs. 8a–c. (Whole volume published in 1877.)

Carboniferous: Near Santa Fé, N. Mex.; Camp Cottonwood, Lincoln County, Nev.

1877. *Spiriferina* sp. undet. Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 84, pl. 8, fig. 5, 5a, 5b.

Carboniferous limestone: Railroad Canyon, Diamond Mountains, Nevada.

1877. *Spiriferina gonionota*. Meek, ibidem, at end of description (p. 85).

Carboniferous limestone: Railroad Canyon, Diamond Mountains, Nevada.

1884. *Spiriferina cristata*. Walcott (pars), U. S. Geol. Surv., Mon., vol. 8, p. 218, pl. 18, fig. 13 (not fig. 12).

Lower Carboniferous: On the east slope of a small conical hill on the east side of Secret-Canyon-road Canyon, Eureka district, Nevada.

Upper Carboniferous limestone: Western slope and foothills of Diamond Peak, Eureka district, Nevada.

1896. *Spiriferina cristata*. Smith (pars), Am. Phil. Soc., Proc., vol. 25, p. 242.

Lower Coal Measures: Conway County, Ark., SW. ¼ of NW. ¼ of sec. 29, T. 6 N., R. 16 W.

Upper Coal Measures: Sebastian County, Ark., sec. 12, T., 8 N., R. 32 W.

Poteau Mountain, Indian Territory.

1896. *Spiriferina cristata*. Smith (pars), Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 32.

Lower Coal Measures: Conway County, Ark., SW. ¼ of NW. ¼ of sec. 29, T. 6 N., R. 16 W.

Upper Coal Measures: Sebastian County, Ark., sec. 12, T. 8 N., R. 32 W.

Poteau Mountain, Indian Territory.

The presence in our Upper Carboniferous faunas of members of the genus *Spiriferina* possessing two quite different types of surface ornamentation has been long, though imperfectly, known. One type which is much the more common has the ribs crossed by numerous fine, concentric, lamellose, imbricating striæ or crenulations. It was for a widely distributed representative of this division that Shumard proposed in 1855 the specific name *Spiriferina kentuckyensis*.[a] In the other type, which is rarer, the concentric markings are comparatively inconspicuous and the surface is more or less abundantly covered with postules or short spiniform projections. For a species of this type Meek suggested, in 1877, the name *Spiriferina gonionota*,[b] although, as the surface ornamentation of his typical specimen was not shown, he laid stress rather upon other characters in discriminating it from the

[a] First and Second Ann. Rept. Geol. Surv. Missouri, pt. 2, p. 203.

[b] U. S. Geol. Expl. 40th Par., Rept., vol. 4, 1877, p. 84, pl. 8, figs. 5, 5a, 5b.

more common *Sp. kentuckyensis.* The shells which Derby,[a] in 1874, and Walcott,[b] in 1884, in the one case from Brazil and in the other from Nevada, identified as *Sp. spinosa*, and also that from New Mexico which White[c] published in 1875 under the name of *Sp. octoplicata*, undoubtedly belong here. As the year previous, in a preliminary report upon the collections of the One Hundredth Meridian Survey, White had distinguished this form from *Sp. spinosa* by the varietal name *campestris*, it has been retained here, but in a specific sense.

The material studied by me consists of fossils from Colorado, New Mexico, Nevada, and Texas, and includes the types of Meek, of White, and of Walcott. The species may be briefly described as follows: The shell is rather large, transverse, the hinge line being usually as broad or a little broader than the width of the shell below. Dorsal valve moderately convex, ventral valve rather elevated with a high area, which is more or less strongly incurved. Fold and sinus simple; on either side are four or five lateral plications. The latter are thin, high, and subangular, and so are the reverse plications and also the fold and sinus, which are only distinguished by being somewhat more elevated than the others. The surface is essentially smooth. Several concentric growth lines, more or less elevated and lamellose, are frequently present, but they are sometimes practically absent, and never in frequency and regularity produce an effect similar to the lamellose ornamentation of shells of the type of *Spiriferina kentuckyensis* and its allies. These markings are usually inconspicuous, and the most striking character of the surface consists in its being covered by numerous rather coarse and sparse hollow spines, which, either by nature or by accident, are seen to be open at the outer end. The spines are more thickly distributed in some individuals than in others, but the range of variation is not excessive. In some, though not in all, a number of spines in the ventral sinus are serially arranged and more or less connected by a delicate ridge. Nothing to correspond with this has been noticed on the fold. The surface under different conditions of preservation presents appearances so unlike that I was nearly misled into subdividing the species into at least two groups varietally distinct. The outer shell layer, which is retained only on well-preserved specimens, seems to be itself impunctate, and often completely masks the punctate structure of the shell below. It is nearly smooth, except for the tubular excrescences above referred to, being marked by delicate, almost invisibly fine growth lines. Under slightly different conditions of preservation the appearance of the surface is very much changed, and the shell appears to be covered by innumerable closely set minute spinules, which are both much smaller, more numerous, and more thickly arranged than the large ones on the preceding. This appearance seems to be due to the removal of the delicate superficial layer and with it the larger spines. The spinules

[a] Cornell Univ., Bull., vol. 1, No. 2, 1874, p. 23, pl. 6, figs. 8, 13, 14.

[b] U. S. Geol. Surv., Mon., vol. 8, 1884, p. 218, pl. 18, fig. 13.

[c] U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, 1877, p. 139, pl. 10, figs. 8a–8c.

are evidently related to the punctate structure of the shell, each of the spinules representing a pore. Whether they are merely the tiny plugs of calcite which filled the perforations in the shell, the latter having been worn from about them, or whether the shell projected around each aperture in the shape of a minute tube, I have not been able to assure myself, but I am inclined to the latter opinion. The differences just pointed out are so striking and in the main so uniform that at first I was for recognizing the shells which were characterized by them as distinct species. Later, associated with shells of the first type were found a number of individuals intermediate between it and the other, and continued search resulted in finding on some specimens of *Spiriferina spinosa*, a species in the closest degree related to that under discussion, both kinds of surface developed in patches upon the same valve, the one condition clearly resulting from the other by a process of erosion. I think, therefore, that there is no room for doubt that the appearances described are conditioned entirely by preservation. The intermediate style of markings mentioned consisted of a surface thickly covered with fine spinules, among which at intervals were distributed larger ones of the usual size, the impunctate, striated, outer layer having been removed without destroying the larger spines. Often when the shell is silicified the outer layer is missing and the coarsely punctate structure is brought prominently to view. The shell then has a reticulated, almost spongy appearance. This is the condition of the type specimen of *Spiriferina gonionotus*. The specimen from Camp Cottonwood figured by White as *Sp. octoplicata* and the other material from the same locality resemble Meek's type very closely. These specimens are not silicified but exfoliated, showing only the strongly punctate shell structure. The other specimen figured by White is from Santa Fe, N. Mex. It and the rest of our Santa Fe material shows only the minute, closely set spinules. The specimen figured by Walcott was collected from the Pancake Mountains, north end of Coal Hill, White Pine County, Nev. It is silicified and shows the large spines and, indistinctly, the coarsely punctate shell structure. Other specimens from Coal Hill have the surface better preserved, but in the matter of shape are less perfect. Some of them show the large spinules, impunctate outer layer, and fine concentric markings above referred to, and others are intermediate between the two main types of preservation which I have been able to distinguish, having the large spines of the one distributed among the fine spinules of the other. My Colorado material is also exfoliated, but belongs with little doubt to this division of the genus. The type specimen of *Sp. gonionotus* is somewhat peculiar in its shape, and differs from the rest of the material by some of the same characters by which Meek sought to distinguish it from *Sp. kentuckyensis* and *Sp. octoplicata.* These are chiefly its highly inflated valves and prominent fold, which, projecting in front, gives to the outline a rather markedly triangular shape. The usual outline of the dorsal valve is transversely sub-semicircular, but Meek's specimen agrees with others from the same region in so many ways that I am disposed to regard its peculiarities as of an individual nature and due in part to old age. It is with considerable personal confidence, therefore, that I refer all this material to *Sp. campestris.*

Meek sought to distinguish *Sp. gonionotus* from *Sp. kentuckyensis* and *Sp. octoplicata* by reason of certain differences in shape. As the surface ornamentation of the type specimen was removed, he was not able to avail himself of these characters in making comparisons. The differences pointed out by Meek are veritable ones, but if I am not at fault in referring to his species other material from Nevada and adjacent territory, they are not constant and must be referred to individual peculiarities. On the other hand, on the same supposition, well-preserved specimens among the other material show surface characters which distinguish this species without a trace of doubt from *Sp. kentuckyensis* and possibly also from *Sp. octoplicata.* White identifies specimens originally described as *Sp. spinosa* var. *compestris* with *Sp. octoplicata.* He very correctly regards his material as distinct from *Sp. kentuckyensis* and recognizes its affinities with *Sp. spinosa*, which, he considers, may be only a variety of *Sp. octoplicata.* He believes that his specimens differ in lacking the spines which characterize Norwood and Pratten's species. As I have already explained, I believe that their absence is owing to circumstances of preservation. The form from Itaituba, Brazil, which Derby identifies with *Sp. spinosa*, probably belongs in the synonymy of White's species. One of his specimens showed very distinctly a rib in the sinus of the ventral valve, a character which he justly remarks is not found in *Sp. spinosa*, nor does it occur in the material of *Sp. gonionota* which has been studied by me. He further states regarding the surface ornamentation that it shows traces of spines, but not of the regular concentric lamellæ characteristic of *Sp. spinosa.* The latter, however, is evidently a lapsus calami, for this is a character by which *Sp. spinosa* is distinctly not characterized. Walcott also identifies his fossils with *Sp. spinosa*, figuring a specimen from the Coal Measures and one from the Chester to support this view, but he refers *Sp. spinosa* to *Sp. cristata* as a direct synonym and places *Sp. kentuckyensis* Shum. in the same category. It is not unlikely that the identification of this form with Norwood and Pratten's species is correct, but while it superficially resembles *Sp. kentuckyensis*, the character of the surface ornamentation is so unlike that there can be no question about the propriety of recognizing them as distinct species. The relations of *Sp. kentuckyensis* and *Sp. cristata* have been discussed in another place. It seems probable that *Sp. cristata* does not belong to the spinose section of the genus, a point upon which I have been unable certainly to inform myself; but if it does, and not otherwise, comparisons between *Sp. campestris* and *Sp. cristata* will be in order. These, however, I am at present in no position to undertake, lacking characteristic material of the foreign species, and the same is true of *Sp. octoplicata*, which is of the same type as *Sp. campestris* and which the latter seems to resemble closely.

The shape and surface ornamentation of *Sp. campestris* simulate those of *Sp. spinosa* in the closest manner. In fact, after studying the available material of both forms I find no constant or considerable differences by which they are to be distinguished. The evidence seen certainly indicates that *Sp. campestris* White is the same as *Sp. spinosa* N. and P., but I retain a distinct name for the Coal Measure species, fearing lest comparisons of more abundant or more favorable material will disclose differences which have escaped my notice. I believe, however, that the Chester species will be found to range into the Pennsylvanian and that these citations of Upper Carboniferous representatives will come to rest in the synonymy of *Sp. spinosa.*

Locality and horizon.—San Juan region (station 2219); upper portion of the Hermosa formation. Crested Butte district (station 2315); Weber limestone.

Spiriferina kentuckyensis Shumard.

1852. *Spirifer octoplicata?* Hall, Stansbury's Exped. Great Salt Lake, p. 409, pl. 4, figs. 4a,b. (Not *Sp. octoplicata* Sow.)
Carboniferous: Missouri River, near Weston.

1855. *Spirifer kentuckensis.* Shumard, Missouri Geol. Surv., p. 203.
Coal Measures: On the Missouri River near Weston, and Grayson County, Ky.

1856. *Spirifer kentuckensis.* Hall, Pacific Railroad Rept., vol. 3, p. 102, pl. 2, figs. 10, 11.
Carboniferous: Pecos Village, N. Mex.

1859. *Spirifer kentuckensis.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 27.
Upper Coal Measures: Leavenworth, Kans.

1866. *Spirifer laminosus.* Geinitz, Carb. und Dyas in Nebraska, p. 45, tab. 3, figs. 19a–d. (Not *Sp. laminosus* McCoy.)
Upper Coal Measures: Plattsmouth and Nebraska City, Nebr.

1872. *Spiriferina kentuckensis.* Meek, U. S. Geol. Surv. Nebraska, p. 185, pl. 6, figs. 3a–d; pl. 8, figs. 11a, b.
Upper Coal Measures: Nebraska City, Nebr.
Coal Measures: Kentucky; Illinois; Missouri; Iowa; Nebraska; Kansas; Texas; New Mexico.

1876. *Spiriferina kentuckensis.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower and Upper Aubrey Group: Confluence of Grand and Green rivers, Utah.

1877. *Spiriferina kentuckensis.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 138, pl. 10, figs. 4a–c.
Carboniferous: Santa Fé, N. Mex.; Meadow Creek, south of Fillmore, Utah; Camp Apache, Ariz.

1883. *Spirifera (Spiriferina) kentuckiensis.* Hall, Rept. New York State Geol. for 1882, pl. (36) 61, figs. 14–16.
Coal Measures.

1884. *Spiriferina kentuckensis.* White, Geol. Surv. Indiana, 13th Rept., p. 135, pl. 35, figs. 13, 14.
Middle and Upper Coal Measures: Vermilion, Vigo, Knox, Gibson, Posey, Vanderburg, Dubois, and Spencer counties, Indiana.

1888. *Spiriferina kentuckensis.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 231.
Lower Coal Measures: Des Moines, Iowa.

1893. *Spiriferina kentuckiensis.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 52, pl. 29, fig. 17; pl. 36, figs. 14–16. (Advance distribution in fascicles.)
Coal Measures: Vinton County, Ohio; Illinois.

1894. *Spiriferina kentuckiensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 86.
Upper Coal Measures: Kansas City and Lexington, Mo.

1895. *Spiriferina kentuckiensis.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 52, pl. 29, fig. 17; pl. 36, figs. 14–16.
Coal Measures: Vinton County, Ohio; Illinois.

1896. *Spiriferina cristata.* Smith (pars), Am. Phil. Soc., Proc., vol. 35, p. 242.
Lower Coal Measures: Conway County, Ark.
Upper Coal Measures: Sebastian County, Ark., and Poteau Mountain, Indian Territory.

1896. *Spiriferina cristata.* Smith (pars), Leland Stanford Junior Univ. Publ., Cont. Biol. Hopkins Seaside Lab., No. 9, p. 32.
Lower Coal Measures: Conway County, Ark.
Upper Coal Measures: Sebastian County, Ark., and Poteau Mountain, Indian Territory.

1900. *Spiriferina cristata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 96.
Upper and Lower Coal Measures: Fort Scott, Bronson, Bourbon County, Thayer, Kansas City, Lawrence, Lecompton, Topeka, Kans.

In connection with the preceding species attention was called anew to the fact that there are at least two distinct types of *Spiriferina* occurring in our Coal Measure strata, one, like *Spiriferina spinosa* Hall, of the Chester, with pustulose or spinose ornamentation, the other with fine imbricating concentric striæ.

The form described by Hall as *Sp. octoplicata* Sow.? which may be regarded as the type of *Sp. kentuckyensis* Shumard, certainly belongs to the striated group. *Spiriferina kentuckyensis* has often been placed in the synonymy of *Sp. cristata* Schlotheim.

The original description of *Sp. cristata*[a] gives no clue to the minuter surface ornamentation of that species, and the figures only imperfectly disclose it. The specimens examined by me, which seem to be most nearly typical of Schlotheim's species, come from the middle Zechstein of Posneck, Thuringia. The identification was made by Geinitz. This material resembles Schlotheim's figures, both in general configuration and in surface ornamentation. The latter is rather variable. It seems to consist of concentric lamellose striæ, in some specimens so distant as to answer to the growth lines of *Sp. gonionotus*, and in others so close together that they exhibit the type of ornamentation seen in *Sp. kentuckyensis*, but never in the specimens examined is there any development of the pustulose ornamentation characteristic of *Sp. gonionotus*, even when the concentric markings are as distant as in that species. The intervening spaces are left nearly smooth; and the punctation is so fine as to be scarcely discernible. Thus it would seem that *Sp. cristata* belongs to the division of *Sp. kentuckyensis* rather than to that of *Sp. gonionotus* and *Sp. spinosa*.

[a] Schlotheim, 1816. Beitr. zur Naturg. der Versteinerungen; Kön. Bay. Akad. der Wissensch. zu München, Denkschr., p. 28, pl. 1, figs. 3a, 3b, 3c.

On the other hand Davidson[a] while describing the surface of *Sp. octoplicata* Sow. as pustulose, refers it to *Sp. cristata* in a varietal relation. Supposing that Davidson knew the characters of the real *cristata*, one would from this be led to infer that the latter was also of the pustulose division of the genus. Similarly the form identified by King[b] as *Sp. cristata* in his monograph on the Permian fossils of England, seems to be at least a coarsely punctate, and possibly a pustulose species. Some of his expressions undoubtedly refer to the punctate structure of the shell, but others perhaps involve the surface ornamentation. Furthermore he states:[c] "Having examined in Mr. J. de C. Sowerby's collection the originals (from Derbyshire) of the figures in the 'Mineral Conchology' [of *Sp. octoplicata*], the only difference I could perceive is that they are wider than any examples which have occurred to me of the present species." Since King noticed characters so minute as the punctate shell structure, it seems probable that the less microscopic surface ornamentation would not have escaped his observation, and as Davidson, who also examined the original specimens of *Sp. octoplicata*, describes that species in such terms as to leave no doubt that it belonged to the spinose type of spiriferinas, as just noted, it would appear that the shells which King believed to be identical with Schlotheim's species were also of the same character.

If *Sp. cristata* belongs to the spinose section of the genus, there can be no doubt that *Sp. kentuckyensis* is specifically distinct. If, on the other hand, it is of the type of *Sp. kentuckyensis*, I still believe Shumard's species to be worthy of at least varietal position. A comparison of well-characterized specimens of *Sp. kentuckyensis* with our European material, which is premised to truthfully represent Schlotheim's species, reveals several points of difference. The most constant and important of these seem to be the following: *Sp. cristata* is typically rounded at the hinge extremities and appears rarely, if ever, to have the cardinal diameter prolonged into mucronate points, as is frequently the case in the American species. Its plications are sharper and higher, and the furrows dividing them deeper than in our own form, while the concentric imbricating striæ are never, even when most closely set, as evenly disposed and as thickly crowded.

While *Spiriferina kentuckyensis* is perhaps no more than varietally distinct from the material from Posneck identified as *Sp. cristata*, because I am still somewhat in doubt, for reasons given above, as to what the surface ornamentation of typical *Sp. cristata* really is, Shumard's name is provisionally retained in full specific import.

Locality and horizon.—San Juan region (stations 2220, 2322); middle portion of Hermosa formation. Crested Butte district (station 2295); Maroon formation. Uinta

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[a] British Fossil Brachiopoda, vol. 2, 1858-63, p. 38.

[b] Monograph Permian Foss. England, 1850, p. 127.

[c] Loc. cit., p. 128.

Mountain region, Yampa plateau (station 2330); middle division of the Carboniferous. Grand River region, Glenwood Springs (station 2329b).

SEMINULA McCoy, 1844, emend. Hall and Clarke, 1893.

SEMINULA SUBTILITA Hall.

Pl. VII, figs. 1 to 1b, 2, 2a, 3, 3a, 4–7, 7a, 8–10.

1842. *Terebratula roissyi.* D'Orbigny (non L'Éveillé), Voyage dans l'Amérique Méridionale, Pal., p. 46.
Carboniferous: Yarbichambi.

1852. *Terebratula plano-sulcata.* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 5, fig. 9.
Carboniferous limestone: Near Council Bluffs.

1852. *Terebratula subtilita.* Hall, Stansbury's Exped. Great Salt Lake, p. 409, pl. 2, figs. 1a, b, 2a, b.
Carboniferous: Missouri River, near Weston.

?1853. *Terebratula subtilita.* Shumard, Marcy's Expl. Red River of Louisiana, Thirty-second Congress, Second session, Senate Doc. No. 54 (reprinted several times with different pagination), p. 202, pl. 4, fig. 8.
Carboniferous: Washington County, Ark.

1855. *Terebratula subtilita.* Schiel, Pacific Railroad Rept., vol. 2, p. 108, pl. 1, figs. 2a, b.
Carboniferous limestone: 8 miles west of Westport.

1856. *Terebratula subtilita.* Hall, Pacific Railroad Rept. vol. 3, p. 101, pl. 2, figs. 3–5.
Carboniferous: Pecos Village, N. Mex.

1857. *Terebratula* (?) *subtilita.* Davidson, Mon. British Carb. Brach., Pal. Soc., p. 18, pl. 1, figs. 21, 22.
Carboniferous: Mayen Wais, England.

1858. *Terebratula plano-sulcata.* Marcou, Geol. North America, p. 52, pl. 6, figs 8, 8b.
Mountain limestone: Tigeras, N. Mex.; Ohio; Indiana; Illinois; Kentucky; Arkansas.

1858. *Terebratula roysii.* Marcou, Geol. North America, p. 51, pl. 6, figs. 10, 10b.
Mountain limestone: Salt Lake City, Utah; El Paso, Chihuahua; headwaters of the Rio Colorado Chiquito.

1858. *Terebratula subtilita.* Marcou, Geol. North America, p. 52, pl. 6, figs. 9–9f.
Mountain limestone: Sierra Madre; Sierra de Magoyon; Great Salt Lake; Tigeras and Pecos Village, N. Mex.; summit of Sierra de Sandia and Sierra de Magoyon; El Paso, Chihuahua; junction of rivers San Pedro and Gila, Arizona; sources of Rio Colorado Chiquito; Shasta County, Cal.; Vancouver Island.

1858. *Terebratula subtilita.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 714.
Coal Measures: Ohio; Indiana; Illinois; Iowa; Missouri; Kansas; Nebraska; and Pecos Village, N. Mex.

1859. *Spirigera subtilita.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 28.
Upper Coal Measures: Kansas.

1860. *Athyris subtilita.* Davidson, Mon. British Carb. Brach., Pal. Soc., p. 86, pl. 1, figs. 21, 22; pl. 17, figs. 8–10.
Carboniferous: Mayen Wais, England; Tournay, Belgium.

1861. *Athyris subtilita.* Salter, Geol. Soc. London, Quart. Jour., vol. 17, p. 64, pl. 4, fig. 4.
Carboniferous: Isthmus of Copacabana, in the Lake of Titicaca.

1861. *Athyris subtilita.* Newberry, Ives's Colorado River Expl. Exped., p. 126.
Upper Carboniferous: Cherty limestone on banks of Colorado between Little Colorado and Diamond rivers; Pecos Village, east of Santa Fe.

1862. *Terebratula* (?) *subtilita*. Davidson, Mon. British Carb. Brach., Pal. Soc., p. 217, pl. 17, figs. 8–10.
Carboniferous limestone: Bolland; Kendal in Westmoreland.
1866. *Athyris subtilita*. Geinitz, Carb. und Dyas in Nebraska, p. 40, tab. 3, figs. 7–9.
Upper Coal Measures: Omaha City, Plattsmouth, Bennett's Mill, and Nebraska City, Nebr.
1869. *Spirifera* (*Athyris*) *subtilita*. Toula, Sitzb. der Kais. Akad. der Wissensch. Wien, 1. Abth., vol. 59, p. 438, pl. 1, fig. 5.
Carboniferous limestone: 10 miles from Cochebamba, Bolivia.
1872. *Athyris subtilita*. Meek, U. S. Geol. Surv. Nebraska, p. 180, pl. 1, fig. 12; pl. 5, fig. 8; pl. 8, fig. 4.
Upper Coal Measures: Nebraska City, Bennett's Mill, Wyo.; Cedar Bluff, Rock Bluff, Plattsmouth, Bellevue, and Omaha, Nebr.
Coal Measures: Illinois; Missouri; Iowa; West Virginia; Ohio; Kansas; Pecos Village, N. Mex.
1873. *Athyris subtilita*. Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 3, p. 570, pl. 25, fig. 14.
Coal Measures: Illinois.
1874. *Athyris subtilita*. Derby (pars), Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 7, pl. 1, figs. 5, 8 (not fig. 7 = *Spirigerella derbyi*); pl. 3, figs. 8, 16, 19; pl. 6, fig. 2; pl. 9, fig. 4.
Coal Measures: Bomjardim, Itaitúba, and Paredâo, Brazil.
1875. *Spirigera subtilita*. White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 141, pl. 10, figs. 6a–c. (Whole volume published in 1877.)
Carboniferous: Carizo Creek, Maricopa County; Camp Apache; Tenney's Ranch; Kaibab Plateau; confluence of White Mountain and Black rivers; Grass Mountain, 35 miles north of Pioche, and foothills of Dragoon Mountains, Arizona; Fossil Hill, White Pine County, and Camp Cottonwood, Nev.; 15 miles south of St. George; near Ophir City; Rock Canyon, Wasatch range, near Provo; and near Minersville, Utah.
1876. *Spirigera subtilita*. White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey group: Confluence of Grand and Green rivers, and near Echo Park, Utah.
Upper Aubrey group: Beehive Point, near Horseshoe Canyon, Utah.
1876. *Athyris subtilita*. Meek, Simpson's Expl. Great Basin, Utah, p. 350, pl. 2, figs. 4a, b.
Coal Measures: Yellow limestone, Humboldt Mountains.
1876. *Athyris subtilita*. Newberry, Macomb's U. S. Expl. Exped. Santa Fe to Grand and Green rivers, p. 138.
Upper Carboniferous: On the Colorado; west of the San Francisco Mountains; junction of Grand and Green rivers; in the Sierra la Plata; at Santa Fe; Pecos.
1876. *Athyris subtilita*. Derby, Mus. Comp. Zool., Bull., vol. 3, p. 279.
Coal Measures: Yampopata, Brazil.
1876. *Athyris subtilita*. Meek, U. S. Geol. Geog. Surv. Terr., Bull., vol. 2, p. 355, pl. 1, figs. 2, 2a.
Carboniferous: Katlahwoke, Rocky Mountains.
1877. *Athyris subtilita*. Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 83, pl. 8, figs. 6, 6a.
Carboniferous limestone: Ruby group; Moleen Peak, near Humboldt River, Nevada.
1884. *Athyris subtilita*. White, Geol. Surv. Indiana, 13th Rept., p. 136, pl. 35, figs. 6–9.
Coal Measures: Indiana.
1887. *Athyris subtilita*. Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 44, pl. 1, figs. 18 (16a–c?).
Coal Measures: Flint Ridge, Ohio.
1887. *Athyris subtilita*. De Koninck, Ann. du Musée Royal d'Histoire Naturelle de Belgique, vol. 14, p. 73, pl. 18, figs. 1–4, 7–10, 12–28; pl. 19, figs. 47–56.
1888. *Athyris subtilita*. Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 231.
Lower Coal Measures: Des Moines, Iowa.

1891. *Athyris subtilita.* Whitfield, New York, Acad. Sci., Ann., vol. 5, p. 604, pl. 16, figs. 7–9.
Coal Measures: Hocking County, Ohio.

1893. *Seminula subtilita.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 95, figs. 66, 67 on p. 95, and figs. 58, 59 on p. 86; pl. 47, figs. 17–31. (Advance distribution in fascicles.)
(?) Chester limestone: Caldwell County, Ky.; Chester, Ill.
Coal Measures: Manhattan and Miami County, Kans.; Kansas City and Chariton County, Mo.; Coppers Creek, and Winterset, Iowa; Ohio.

1894. *Seminula subtilita.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 35, figs. 16–19.
Coal Measures: Chariton County, Mo.; Winterset, Iowa; near Kansas City, Mo.

1895. *Athyris argentea.* Keyes, Missouri Geol. Surv., vol. 5, p. 92, pl. 39, figs. 11a–d. (Date of imprint 1894.)
Coal Measures: Kansas City, Lexington, and Clinton, Mo.

1895. *Seminula subtilita.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 95, figs. 66, 67, and 58, 59 on p. 86; pl. 47, figs. 17–31.
Coal Measures: Manhattan, Kans.; Coppers Creek, Iowa; Chariton County, Mo.; Winterset, Iowa; Miami County, Kans.; Kansas City, Mo.; Ohio.
(?) Chester limestone: Caldwell County, Ky.; Chester, Ill.

1895. *Athyris subtilita.* Whitfield, Geol. Surv. Ohio, Rept., vol. 7, p. 488, pl. 12, figs. 7–9.
Coal Measures: Falls Township and Webb Summit, Hocking County, Ohio.

1896. *Athyris subtilita.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 241.
Upper Coal Measures: Sebastian County, sec. 12, T. 8 N., R. 32 W., Arkansas; Poteau Mountain, Indian Territory.
(?) Burlington or Lower Keokuk: Boone chert, Stone County, N. W. ¼ sec. 9, T. 14 N., R. 10 W., Arkansas.

1896. *Athyris subtilita.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 19, p. 31.
Upper Coal Measures: Sebastian County, Ark., sec. 12, T. 8 N., R. 32 W.; Poteau Mountain, Indian Territory.
(?) Burlington or Lower Keokuk: Boone chert, Stone County, Ark., N. W. ¼ sec. 9, T. 14 N., R. 10 W.

1900. *Seminula argentea.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 105, text-fig. 3c.
Upper and Lower Coal Measures: Marmaton Station, Bourbon County, Iola, Kansas City, Eudora, Lawrence, Lecompton, Topeka, Manhattan, Grand Summit, Kans.

1900. *Seminula argentia.* Knight, Univ. Wyoming, Wyoming Exp. Sta., Bull. No. 45, pl. 3, fig. 6.

As shown by our collections, this seems to be the most universally distributed species of the entire Carboniferous fauna. It has been found at over fifty stations. Although many variations are to be seen in the material examined, it has not been found practicable to establish lines by which specific or varietal groups shall be defined. There are some forms which have a nearly circular outline. Others are elongate. In some the sinus is shallow and broad; in others narrow and deep; and in certain smaller types it is little more than a depressed line. The latter, though occurring alone, may probably be correctly regarded as young examples of the larger, more strongly characterized shells. Yet all this variety of form seems to be without break or interruption, but, on the contrary, variety passes into variety by the easiest gradations.

Young specimens are often nearly circular in shape, with the elements of fold and sinus almost imperceptible, and from certain localities such specimens only have come to hand. They sometimes assume much the aspect of the later forms of development of the genus *Cleiothyris.* I have identified *Cleiothyris* among the fossils examined in the case of only two specimens, but possibly among the shells just mentioned may occur representatives of this genus which their superficially exfoliated condition has prevented my recognizing as such.

Keyes and Schuchert have used for this species the specific term *argentea*, proposed by Shepard fourteen years before Hall's *Terebratula subtilita* was described. Relegating, for the time, the question whether *Terebratula argentea*, with its poor description and execrable figures, should replace *T. subtilita*, which was well figured and adequately described, it is by no means certain that Shepard's species is the same as that described by Hall, or even congeneric with it. There is little evidence to be derived from the original citation, and none has been produced outside, save the statement by Keyes, that *Seminula subtilita* is the commonest species at the locality where *T. argentea* was first found. This circumstance is of importance, but scarcely, it seems to me, of character sufficiently conclusive to warrant the replacement of Hall's name, which has a definite meaning, for one whose significance is still vague and uncertain. The small size, rotund shape, and elevated beak of the form represented by Shepard's figures seem to indicate, rather than *Seminula subtilita*, some other shell, perhaps *Reticularia perplexa*, to which the two lines of casual description equally apply. Shepard's mention of this shell is formulated in the following words: "It embraces occasionally * * * a small species of *Terebratula*, whose surface is delicately striated, and of a silvery white color and strong pearly luster."

Schuchert includes in the synonymy of this species *Terebratula antisiensis* and *T. peruviana*, both of d'Orbigny, which antedate Hall's description by ten years. If he is correct in this, one of these names may have to be substituted for *Seminula subtilita*, unless it develops that Shepard's form is the same species.

It is not improbable that *S. caputserpentis* Swallow, *S. singletoni* Swallow, *S. hawni* Swallow, *S. charitonensis* Swallow, and *S. differentius* McChesney, all of which were described subsequently to *S. subtilita*, belong in the synonymy of this species. I also believe that with *Seminula subtilita*, or, at any rate, with the genus *Seminula*, belong the shells which Marcou[a] identifies as *Terebratula planosulcata* Phillips and *T. royssii* l'Eveillé, though these have usually been placed with *Cleiothyris*, sc. *Cl. roissyi.*

Locality and horizon.—San Juan region (stations 2186, 2187, 2196, 2196a, 2196b, 2196c, 2201, 2202, 2204, 2205, 2209, 2211, 2213, 2214, 2216, 2219, 2220, 2222, 2223, 2224,

[a] Geol. North America, Zürich, 1858, pp. 51, 52, pl. 6, figs. 8, 8a, 8b, and figs. 10, 10a, 10b.

2229, 2231, 2233, 2236, 2237, 2239, 2240, 2242, 2243, 2246, 2247, 2248, 2249, 2284, 2309, 2323, 2331, 2332, 2337, 2340, 2341, 2342, 2349); Molas formation, lower, middle, and upper portions of the Hermosa formation, and in the Rico formation; Ouray (stations 2195, 2195a, 2195b); Hermosa formation. Crested Butte district (stations 2244, 2245, 2280, 2291, 2293, 2297, 2298, 2299, 2303, 2305, 2306, 2318); Weber limestone and Maroon formation. Leadville district (stations 2252, 2254, 2259, 2261, 2262, 2263, 2264 ?, 2267, 2273, 2274, 2275); lower, middle, and upper portions of the Weber formation, and in the Robinson limestone. Grand River region (station 2324), Glenwood Springs (stations 2193a, 2329).

CLEIOTHYRIS King, 1850.

CLEIOTHYRIS ORBICULARIS McChesney.

1860. *Athyrus orbicularis.* McChesney, Desc. New Pal. Foss., p. 47.
Coal Measures: Western States.

? 1860. *Spirigera missouriensis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 650.
Coal Measures: Montgomery and Chariton counties, Mo.

1866. *Athyris planosulcata.* Geinitz, Carb.. und Dyas in Nebraska, p. 42.
Coal Measures: Omaha City, and Plattsmouth, Nebr.

1874. *Athyris sublamellosa.* Derby, Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 10, pl. 2, figs. 9–12; pl. 3, figs. 15, 21, 29; pl. 6, fig. 16; pl. 9, figs. 5, 6.
Coal Measures: Bomjardim and Itaituba, Brazil.

1875. *Spirigera planosulcata.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 143, pl. 10, figs. 5a–d. (Whole volume published in 1877.)
Carboniferous: Santa Fe, N. Mex., Rush Creek, Lake County, Colo.

1897. *Cleiothyris orbicularis.* Schuchert, U. S. Geol. Surv., Bull. No. 87, p. 182.

? 1897. *Cleiothyris missouriensis.* Schuchert, U. S. Geol. Surv., Bull. No. 87, p. 182.

In its representation in American strata the genus *Cleiothyris* is restricted, so far as known, to the Carboniferous period. Throughout the existence of this type it follows few lines of variation, but within certain limits and in a few particulars these shells are very variable. The most obvious character is that of size, and it is at the same time the least significant.

A number of specific names have been proposed for American representatives of the genus, but experience shows that it would be difficult to establish the validity of many of them if reference were had only to the uniformity and persistence of differential characters.

In the Upper Carboniferous representatives of the *Cleiothyris* group are usually small of size and in numbers rare. The first specific name proposed for a Pennsylvanian *Cleiothyris* is *Athyris orbicularis* McChesney, which was published early in 1860. In the same year, though probably subsequent to the publication of

Athyris orbicularis,[a] Swallow described *Spirigera missouriensis*, basing his description upon what I feel confident was the same type of shell. The reasons for this conclusion are as follows:

McChesney states that his shell is closely allied to *Athyris sublamellosa* Hall, and that it had sometimes been referred to *Terebratula planosulcata* of Phillips. Both the species mentioned belong to the *Cleiothyris* group of *Athyris*, and, as the general character of the description indicates the configuration and surface ornamentation of *Cleiothyris*, it is practically certain that *Athyris orbicularis* belongs to that group. Furthermore, I find in the collections of the U. S. National Museum a species of *Cleiothyris* which bears Worthen's identification with *Cl. orbicularis*, and at the same time permits McChesney's description to be applied to it.

Swallow's description of *Spirigera missouriensis* would of itself lead one to infer that he had in hand shells of the *Cleiothyris* type, and such an inference receives corroboration from the circumstance that it is said much to resemble *Cl. hirsuta* Hall. To be sure, it is said to differ from that species in being ornamented with lamellæ instead of the spines, which are, of course, a distinctive character of *Cleiothyris*, but the lamellæ are described as imbricating, transversely costate, and as leaving granular ridges in falling off, details all of which indicate that the lamellæ were spiniferous. It is true, also, that the structure is described as punctate, but the same character is ascribed to several species of *Seminula* described under the names of *Spirigera charitonensis* and *Sp. hawni*. Furthermore, among the museum collections are specimens of a *Cleiothyris* from Chariton County, one of the localities cited by Swallow, which answer to his description in most particulars and yet clearly indicate the subgeneric group to which they belong.

The descriptions of *Cl. orbicularis* and *Cl. missouriensis* certainly indicate closely similar shells, and the specimens in our collections which seem to best represent each of those species I would feel no hesitation in referring to the same. Indeed, I find it impossible to discriminate between the Pennsylvanian representatives of *Cleiothyris* that have come under my observation, and must refer all to a single species. These facts, and a consideration of the narrow limits of variation habitually shown in *Cleiothyris* as a whole, lead me to regard *Cl. orbicularis* and *Cl. missouriensis* as one and the same species.

It is probable that the Upper Carboniferous form from Brazil which Derby identified with *Cl. sublamellosa* Hall can be referred to this species, though the South American shells attain a somewhat unusual size. It seems pretty certain that the shells from Nebraska which Geinitz identifies as *Athyris planosulcata* also belong here, and those from the west referred by White to the same species, after an examination of his specimens, I do not hesitate to add to this synonymy.

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[a] McChesney's publication was reviewed in the Am. Jour. Sci. for March, 1860. Swallow's paper was presented for publication in the St. Louis Acad. Sci. on July 2d of the same year.

The relations of *Cl. orbicularis* and *Cl. sublamellosa* are of the closest. I find that the characters pointed out by McChesney to distinguish them can not be generally relied upon, and only hold good in selected cases. The only distinction which I have been able to observe in the material examined is that the Pennsylvanian species seems to be, as a rule, somewhat more transverse than the older form, but I doubt if to this difference alone could be given specific significance, even if it proves to be a constant one. I am, therefore, prepared to see McChesney's name *orbicularis* succeed to Hall's *sublamellosa* for this species.

Under the name of *Spirigera planosulcata* White has already cited this species from Colorado, from Rush (Rock) Creek, in Lake County. I am not sure that the material upon which this identification rests has come into my hands, but I have it from other areas in the shape of two small, not very perfect shells, each from a separate station. The larger of these is less than 8 mm. in diameter, and therefore somewhat below the average size of Mississippi Valley specimens, but otherwise I see no characters by which to distinguish them.

McChesney's original description of *Cl. orbicularis*, to which access is usually difficult, I have cited below in full.

"ATHYRUS ORBICULARIS (n. s.).

"Shell subcircular or varying from transversely subelliptical to subovately elongate, moderately gibbous. Dorsal valve less than the ventral, depressed convex, rarely slightly elevated in front; beak closing the foramen of the opposite valve. Ventral valve convex, strongly gibbous toward the beak; front sometimes flattened, but without true sinus; beak prominent, slightly incurved, and vertically or somewhat obliquely truncated by a circular foramen.

"Surface distinctly marked by concentric lamellose bands of growth.

"This species is closely allied to *A. sublamellosa* of Hall (Geol. Rep. Iowa, p. 702), from which it is easily distinguished by having a larger ventral than dorsal valve, while in that the dorsal valve is much the largest, and by the much greater elevation or thickening of the ventral valve toward the beak.

"It has sometimes been referred to *Terebratula plano-sulcata* of Phillips, from which it differs in being a less rotund shell, and in the much less gibbosity or inflation of its ventral valve toward the front of the shell, as well as in other respects.

"Geological position and localities: In Coal Measures, particularly the upper portion, extensively distributed in the Western States."

Locality.—Grand River region, Glenwood Springs (station 2193a).

DIELASMA King, 1850.

DIELASMA BOVIDENS Morton?.

Pl. VII, figs. 11, 11a.

1836. *Terebratula bovidens.* Morton, Am. Jour. Sci., (1), vol. 29, p. 150, pl. 2, fig. 4.
Coal Measures: Ohio Valley.

1856. *Terebratula millepunctata.* Hall, Pacific Railroad Rept., vol. 3, p. 101, pl. 2, figs. 1, 2.
Carboniferous: Pecos Village, N. Mex.

1858. *Terebratula millepunctata.* Hall, Albany Inst., Trans., vol. 4, p. 35.
Upper Carboniferous: Topeka, Kans.

1858. *Terebratula bovidens?* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 711.

1859. *Terebratula millepunctata.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 26.
Upper Coal Measures: Leavenworth, and near Indianola, Kans.

? 1859. *Terebratula elongata.* Shumard (non Schlotheim), Acad. Sci. St. Louis, Trans., vol. 1, p. 392.
Permian: Guadalupe Mountains.

1861. *Terebratula geniculosa.* McChesney, Desc. New Spec. Pal. Foss., p. 82.
Coal Measures: Lasalle, Ill.

1865. *Terebratula geniculosa.* McChesney, Illustrations New Spec. Pal. Foss., pl. 1, fig. 2.

1869. *Terebratula bovidens.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 37, pl. 1, figs. 2a–c.
Coal Measures: Lasalle, Ill.

1872. *Terebratula bovidens.* Meek, U. S. Geol. Surv. Nebraska, p. 187, pl. 1, figs. 7a–d, pl. 2, fig. 4.
Upper Coal Measures: Plattsmouth, Nebr.; Indian Creek, Kansas; Lasalle, Ill.; New Mexico.
Coal Measures: Ohio, Iowa, Missouri, Kansas, Illinois.

1873. *Terebratula bovidens.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 572, pl. 25, fig. 15.
Upper and Lower Coal Measures: Illinois.

1874. *Dielasma? bovidens.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Prelim. Rept. Invert. Foss., p. 21.
Carboniferous (Coal Measures): (Far West.)

1877. *Terebratula (Dielasma) bovidens.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 144, pl. 11, figs. 10a–c.
Carboniferous: Near Santa Fe, N. Mex.; a few miles south of St. George, Utah; top of Grass Mountain, Ely Range, 30 miles north of Pioche, Nev.

1884. *Terebratula bovidens.* White, Geol. Surv. Indiana, 13th Rept., p. 137, pl. 32, figs. 17–19.
Coal Measures: Perrysville, Eugene, Newport, Lodi, and Terre Haute (west of), Indiana; Posey, Warrick, Perry, and Crawford counties, Ind.

1893. *Dielasma bovidens.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 295, 296, fig. 213; pl. 81, figs. 29–35. (Advance distribution in fascicles.)
Upper Carboniferous limestone: Kansas City, Mo.; Harrison County, Mo.; southern Indiana.

1894. *Dielasma bovidens.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 53, figs. 21–25.
Carboniferous limestone: Harrison County, Mo.

1895. *Terebratula bovidens.* Keyes, Missouri Geol. Surv., vol. 5, p. 105. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1895. *Dielasma bovidens.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, pp. 295, 296, fig. 213; pl. 81, figs. 29–35.
Upper Carboniferous limestone: Kansas City, Mo.; southern Indiana; Harrison County, Mo.

1897. *Terebratula hastata.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 30.
Lower Coal Measures: Conway County, Ark.
Upper Coal Measures: Poteau Mountain, Indian Territory.

1900. *Dielasma bovidens.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 95.
Upper Coal Measures: Kansas City, Eudora, Lawrence, Lecompton, Topeka, Grand Summit, Kans.

This species is rare in the collections from Colorado. It has been found at but three localities, each of which has furnished a single specimen. Two of these are imperfect and the other is not quite typical so that it can not be said to have been certainly found in the State at all so far as our collections are concerned.

Locality and horizon.—San Juan region (station 2196c?); Hermosa formation. Crested Butte district (stations 2245, 2280); Maroon formation.

HUSTEDIA Hall and Clarke, 1893.

HUSTEDIA MORMONI Marcou.

Pl. VII, figs. 12, 12a, 13.

1858 (February). *Terebratula mormoni.* Marcou, Geol. North America, p. 51, pl. 6, figs. 11–11c.
Mountain limestone: Salt Lake City, Utah.

1358 (June). *Retzia punctilifera.* Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 220.
Upper Coal Measures: Audrain and Howard counties, Mo.; below mouth of Platte River, Nebraska; near Manhattan, at Willowsprings, on Santa Fe road, and headwaters of Verdigris River, Kansas.

1859. *Retzia mormoni.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 27.
Upper Coal Measures: Manhattan and Leavenworth, Kans.

1860. *Retzia subglobosa.* McChesney, Desc. New Spec. Pal. Foss., p. 45.
Upper Coal Measures: Menard, Mason, Fulton, Peoria, Tazewell, Knox, and Marshall counties, Ill.

1864. *Retzia compressa.* Meek, Pal. California, vol. 1, p. 14, pl. 2, figs. 7–7c.
Carboniferous: Bass's Ranch, Shasta County, Cal.

1865. *Retzia subglobosa.* McChesney, Illustrations New Spec. Pal. Foss., pl. 1, fig. 1.

1866. *Retzia mormoni.* Geinitz, Carb. und Dyas in Nebraska, p. 39, tab. 3, fig. 6.
Upper Coal Measures: Plattsmouth, Nebr.

1868. *Retzia punctulifera.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 32, pl. 1, figs. 1a-c.
Upper Coal Measures limestone: Menard, Mason, Fulton, Peoria, Tazewell, Knox, and Marshall counties, Ill.

1872. *Retzia punctulifera.* Meek, U. S. Geol. Surv. Nebraska, p. 181, pl. 1, fig. 13; pl. 5, fig. 7.
Upper Coal Measures: Rock Bluff, Plattsmouth, and Nebraska City, Nebr.
Coal Measures: Nebraska; Kansas; Illinois.

1874. *Eumetria punctulifera.* Derby, Cornell Univ., (Science) Bull., vol. 1, No. 2, p. 4, pl. 8, figs. 4, 5, 7, 8, 10; pl. 9, fig. 3.
Coal Measures: Bomjardim and Itaituba, Brazil, and Pichis River, Peru.

1875. *Retzia mormonii.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 141, pl. 10, figs. 7a–c. (Whole volume published in 1877.)
Carboniferous: Near Santa Fe, New Mex.; top of Grass Mountain, Ely Range, 30 miles north of Pioche, Nev.

1875. *Terebratula mormoni.* Marcou, Acad. Sci. St. Louis, Trans., vol. 3, p. 252.

1883. *Retzia compressa.* Kayser, Richthofen's China, vol. 4, p. 176, pl. 22, figs. 1–4.
Upper Carboniferous: Lo-Ping, China.

1884. *Retzia radialis.* Walcott (non Phillips) (pars), U. S. Geol. Surv., Mon., vol. 8, p. 220, pl. 7, figs. 5f–h (not figs. 5–5e).
Upper Carboniferous: Eureka district, Nevada.

1884. *Retzia mormonii.* White, Geol. Surv. Indiana, 13th Rept., p. 136, pl. 35, figs. 10–12.
Coal Measures: Indiana.

1888. *Retzia mormoni.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 231.
Lower Coal Measures: Des Moines, Iowa.

1893. *Hustedia mormoni.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 120, fig. 106; pl. 51, figs. 1–9. (Advance distribution in fascicles.)
Coal Measures: Near Kansas City, Mo.

1894. *Hustedia mormoni.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 37, figs. 13–20.
Coal Measures: Near Kansas City, Mo.

1895. *Hustedia mormoni.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 120, fig. 106; pl. 51, figs. 1–9.
Coal Measures: Near Kansas City, Mo.

1895. *Retzia mormoni.* Keyes, Missouri Geol. Surv., vol. 5, p. 95, pl. 41, figs. 2a–c. (Date of imprint 1894.)
Upper Coal Measures: Kansas City and Lexington, Mo.

1896. *Retzia radialis.* Smith (non Phillips), Am. Phil. Soc., Proc., vol. 35, p. 241.
Upper Coal Measures: Sebastian County, Ark., and Poteau Mountain, Indian Territory.

1896. *Retzia radialis.* Smith (non Phillips), Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 31.
Upper Coal Measures: Sebastian County, Ark., and Poteau Mountain, Indian Territory.

1900. *Hustedia mormoni.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 103, pl. 9, figs. 10–10d, pl. 10, fig. 3.
Upper Coal Measures: Fort Scott, Iola, Kansas City, Lawrence, Lecompton, Topeka, Beaumont, Kans.

This also is one of the rarer species in our Colorado collections. Though abundant in the Elk Mountains at station 2280, but few individuals have been collected elsewhere.

Locality and horizon.—Crested Butte district (stations 2280, 2297, 2303, 2306); Maroon formation.

PUGNAX Hall and Clarke, 1893.

PUGNAX UTAH Marcou.

Pl. VII, figs. 14–14b.

1852. *Terebratula pugnus.* Roemer, Kreid. von Texas, p. 89.
Carboniferous: San Saba Valley, Texas.

1858. (February) *Terebratula uta.* Marcou, Geol. North America, p. 51, pl. 6, figs. 12–12c.
Mountain limestone: Near Salt Lake City, Utah.

1858. (June) *Rhynconella* (*Camarophoria*) *osagensis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 219.
Upper Coal Measures: Missouri and Kansas.

1859. *Rhynchonella uta.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 27.
Upper Coal Measures: Manhattan, Kans.

1861. *Rhynchonella uta.* Newberry, Ives's Colorado River Expl. Exped., p. 128.
Upper Carboniferous: Near mouth of Little Colorado River.

1861. *Rhynchonella* species. Salter, Geol. Soc. London, Quart. Jour., vol. 17, p. 64, pl. 4, fig. 5.
Carboniferous: Isthmus of Copacabana, Lake Titicaca.

1866. *Camarophoria globulina.* Geinitz, Carb. und Dyas in Nebraska, p. 38, tab. 3, fig. 5. (Not *C. globulina* Phillips.)
Upper Coal Measures: Bennett's Mill and Nebraska City, Nebr.

1872. *Rhynchonella osagensis.* Meek, U. S. Geol. Surv. Nebraska, p. 179, pl. 1, figs. 9a, b, pl. 6, figs. 2*a*, *b*.
Upper Coal Measures: Nebraska City, Nebr.
Coal Measures: Iowa, Missouri, Kansas.
Upper Middle, and Lower Coal Measures: Illinois.

1873. *Rhynchonella osagensis.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 571, pl. 26, fig. 22.
Coal Measures: Danville, Ill., and Fulton County, Ill.

1875. *Rhynchonella uta.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 128, pl. 9, figs. 2a–c. (Whole volume published in 1877.)
Carboniferous: North Fork of Lewiston Canyon, Oquirrh Range, and at Meadow Creek, south of Fillmore, Utah.

1884. *Rhynchonella uta.* White, Geol. Surv. Indiana, 13th Rept., p. 132, pl. 25, fig. 6.
Coal Measures: Indiana.

1891. *Rhynchonella uta.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 247.
Lower Coal Measures: Des Moines, Iowa.

1893. *Pugnax uta.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 204, pl. 60, figs. 39–42. (Advance distribution in fascicles).
Coal Measures: Manhattan, Kans.

1894. *Pugnax uta.* Hall and Clarke, Int. Study of Brach., pt. 2, pl. 44, figs. 17–19.
Coal Measures: Manhattan, Kans.

1895. *Rhynchonella uta.* Keyes, Missouri Geol. Surv., vol. 5, p. 103, pl. 41, fig. 7. (Date of imprint, 1895.)
Upper Coal Measures: Kansas City and Lexington, Mo.

1895. *Pugnax uta.* Hall and Clarke, Pal. New York, vol. 8, pt. 2, p. 204, pl. 60, figs. 39–42.
Coal Measures: Manhattan, Kans.

1897. *Rhynchonella uta.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 30.
Upper Coal Measures: Sebastian County, Ark., and Poteau Mountain, Indian Territory.

1900. *Pugnax utah.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 93, pl. 12, figs. 7–7c.
Upper Coal Measures: Bronson, Bourbon County, Kansas City, Iola, Olathe, Lawrence, Lecompton, Topeka, Beaumont, Grand Summit, Kans.

This also is a rare species, having been found at but two localities.

Locality and horizon.—Crested Butte district (stations 2280, 2305); Maroon formation.

PELECYPODA.

AVICULOPECTEN McCoy, 1851.

AVICULOPECTEN OCCIDENTALIS Shumard.

Pl. VIII, fig. 1.

1855. *Pecten occidentalis.* Shumard, Missouri Geol. Surv., p. 207, pl. C, fig. 18.
Coal Measures: Near Plattsburg, Clinton County, Mo.

1858. *Pecten cleavelandicus.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 184.
Permian: Valley of South Cottonwood, Kansas.

1861. *Pecten occidentalis.* Newberry, Ives's Colorado River Expl. Exped., p. 128.
Coal Measures: Banks of the Stranger, above Easton, Kans.

1864. *Aviculopecten* ——? Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 192, p. 50, pl. 2, fig. 10.
Permian: Near Chapman's Creek, 18 miles above Fort Riley, Kans.

1866. *Aviculopecten occidentalis.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 331, pl. 27, figs. 4, 5, 5a.
Upper Coal Measures: Saline Creek, Gallatin County, Ill.

1866. *Pecten missouriensis*? Geinitz, Carb. und Dyas in Nebraska, p. 35, tab. 2, fig. 18.
Upper Coal Measures: Nebraska City, Nebr.

1872. *Aviculopecten occidentalis.* Meek, U. S. Geol. Surv. Nebraska, p. 191, pl. 9, fig. 10.
Upper Coal Measures: Rock Bluff, Bennett's Mill, Wyoming, and Nebraska City, Nebr.; Illinois, Missouri, Iowa, Kansas, Kentucky.
Coal Measures: Black Hills, Dakota.

1876. *Aviculopecten occidentalis.* White, Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey group: 2 miles above Belleview, Utah.

1877. *Aviculopecten occidentalis.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 146, pl. 12, figs. 8a, b.
Carboniferous: Camp Apache, Ariz.

1884. *Aviculopecten occidentalis.* White, Geol. Surv. Indiana, 13th Rept., p. 143, pl. 28, fig. 2.
Coal Measures: Pike and Gibson counties, Ind.

1886. *Aviculopecten occidentalis.* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 455, fig. 5a, p. 442, fig. 5.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Aviculopecten occidentalis.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 270, fig. 5, p. 271, fig. 5a.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1891. *Aviculopecten occidentalis.* White, U. S. Geol. Surv., Bull. No. 77, p. 29, pl. 4, fig. 1.
Permian: Military Crossing, Baylor County, Tex.

1894. *Aviculopecten occidentalis.* Keyes, Missouri Geol. Surv., vol. 5, p. 110, pl. 42, fig. 3.
Upper Coal Measures: Plattsburg and Kansas City, Mo.

1897. *Aviculopecten occidentalis.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 34.
Lower Coal Measures: Conway County, Ark.

1899. *Aviculopecten occidentalis.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 578.
Upper Coal Measures: McAlester quadrangle; Atoka quadrangle.

1900. *Aviculopecten occidentalis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 114, pl. 13, fig. 7.
Upper Coal Measures: Turner, Eudora, Lawrence, Topeka, Wabaunsee County, Kans.

1900. *Aviculopecten occidentalis.* Knight, Univ. Wyoming, Wyoming Exp. Sta., Bull. No. 45, pl. 3, fig. 3.

This species is rare and small in the collections from the Hermosa formation, but in those from the Rico formation it is usually both large and fairly abundant.

The specimens from station 2219, in the Rico quadrangle, are poorly preserved, and some of them look much as if they might belong to *Lima retifera.* The fact can not, however, be satisfactorily ascertained, and since some of the specimens certainly do not belong to that species, it seems best to give the others no separate record.

Locality and horizon.—San Juan region (stations 2219, 2231, 2337, 2340, 2341, 2342, 2347); middle portion of the Hermosa formation and common in the Rico formation. Crested Butte district (station 2317 ?); Maroon formation.

AVICULOPECTEN PELLUCIDUS Meek and Worthen.

1860. *Aviculopecten pellucidus.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 455.
Coal Measures: Adams County, Ill.

1866. *Aviculopecten pellucidus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 327, pl. 26, figs. 5a, b.
Lower Coal Measures: Adams County, Ill.

Only one specimen of this species has come to hand, and that broken. In its small size and cancellated surface ornamentation the specimen resembles Meek and Worthen's species, but a satisfactory identification is not possible.

Locality and horizon.—San Juan region (station 2221); upper portion of the Hermosa formation.

AVICULOPECTEN RECTILATERARIUS Cox.

1857. *Avicula recta-laterarea.* Cox, Geol. Surv. Kentucky, vol. 3, p. 571, pl. 9, fig. 2.
Coal Measures: Union County, Ky.; Gallatin County, Ill.

1898. *Aviculopecten rectilaterarius.* Drake, Am. Phil. Soc., Proc., vol. 36, p. 405, pl. 9, fig. 6. Reprinted without change of date, page, etc., in Leland Stanford Junior University Pub.; Cont. Biol. Hopkins Seaside Lab., No. 14.
Upper Coal Measures, Poteau group: In shale overlying the Mayberry coal at the mines 4 miles northwest of Poteau, Ind. T.

1900. *Aviculopecten rectilaterarius.* Beede, Univ. Geol. Surv. Kansas, Rept., vol., 6, p. 15.
Upper Coal Measures: Leavenworth, Wyandotte County, Kans.

None of the material is well preserved, and from station 2226 (in the Rico quadrangle) but a single specimen was obtained. The fossils from Leadville received the same identification in the monograph of that region.[a]

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 67.

Locality and horizon.—San Juan region (station 2226); upper portion of the Hermosa formation. Leadville district (station 2264); base of the Weber formation.

AVICULOPECTEN? INTERLINEATUS Meek and Worthen.

Pl. VIII, fig. 3.

1860. *Aviculopecten interlineatus.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 454.
Upper Coal Measures: Lasalle, Ill.

1866. *Aviculopecten interlineatus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 329, pl. 26, fig. 7a, b.
Upper Coal Measures: Lasalle, Ill.

1877. *Aviculopecten? interlineatus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 149, pl. 11, fig. 3a.
Carboniferous: Confluence of White Mountain and Black rivers, Arizona.

1884. *Aviculopecten(?) interlineatus.* White, Geol. Surv. Indiana, 13th Rept., p. 145, pl. 30, fig. 9.
Coal Measures: Indiana(?).

1891. *Aviculopecten interlineatus.* Whitfield, New York Acad. Sci., Ann., vol. 5, p. 604, pl. 16, figs. 10, 11.
Coal Measures: Hocking County, Ohio.

1894. *Aviculopecten? interlineatus.* Keyes, Missouri Geol. Surv., vol. 5, p. 112, pl. 42, fig. 6.
Upper Coal Measures: Kansas City, Mo.

1895. *Aviculopecten interlineatus.* Whitfield, Geol. Surv. Ohio, Rept., vol. 7, p. 489, pl. 12, figs. 10, 11.
Coal Measures: Falls Township, Hocking County, Ohio.

1900. *Aviculopecten interlineatus.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 116, pl. 13, fig. 6.
Upper Coal Measures: Kansas City, Kansas.

This well-marked species is represented by but two specimens, as usual each from a different locality. Both valves are present, one of which (the left) is shown by fig. 3 on Pl. VIII. Each of the broad concentric bands is terminated below by a thin, high ridge vertical to the surface, and there are a number of intermediate ridges which are considerably smaller and less prominent.

The right valve has much the shape of the right valve of *A. occidentalis.* It differs from the left in having the anterior ear narrower and bounded below by a deep sinus. The surface is marked by broad concentric bands and delicate sublamellose striæ, but seems to lack the elevated ridges by which the opposite valve is characterized. The striæ are more or less wavy and irregular. There are also indications of very faint, irregular, intermittent, radiating ribs which, though visible without a glass, can only be seen in a favorable light.

While the shape of the right valve of this species is very like the corresponding one of *A. occidentalis*, the difference in surface characters is such that, when once noted, there is little danger of mistaking one for the other.

Locality and horizon.—Crested Butte district (station 2293); Maroon formation.

AVICULOPECTEN sp. *a*.

Pl. VIII, fig. 2.

Of this little shell we have only the specimen which is illustrated by fig. 2 of Pl. VIII. I have not been able to refer it satisfactorily to any of our numerous pectinoid species, but it seems to be closely related to *A. coxanus* Meek and Worthen. I would scarcely consider it identical with the Nebraska form which Meek identified with *A. coxanus*, but it so closely resembles the figure of the original reference that I would probably have referred it to Meek and Worthen's species if it were not that in their figure the ears are clearly shown to be marked with radiating ribs, a character which my specimen does not possess. Besides this character, it differs from the Nebraska form in having the striæ finer and more crowded. Of these, there are 17 or 18 in the space of 5 mm. They are thin and sharp, somewhat alternating, and separated by intervals slightly greater than their own thickness. There are also faint concentric growth lines, and these are the only markings which appear upon the rather broad ears.

Locality and horizon.—Ouray (station 2194); Hermosa formation.

AVICULOPECTEN sp. *b*.

From Ouray we have a single specimen of an undetermined but fine and striking species of *Aviculopecten*. The fossil is crushed and very imperfect, and its configuration can not be ascertained. It is a large shell, however, and must have had a length of 45 mm. or more. The surface is marked by coarse, regular, somewhat flattened, rigid ribs, of which near the outer margin there are about 6 or 7 in the space of 10 mm. They are separated by flat shallow grooves about as wide as, or sometimes a little wider than, the intervening ribs. The whole is crossed at intervals of about 1 mm. by very regular, strongly lamellose concentric striæ.

This is a fine, large, and well-characterized species, and, as far as I have ascertained, it is as yet undescribed.

Locality and horizon.—Ouray (station 2194); Hermosa formation.

ACANTHOPECTEN new subgen.

This name is proposed to receive *Aviculopecten carboniferus* Stevens, and while at present no higher significance is assigned to it than as subgeneric to *Aviculopecten* (or possibly *Lima*) it is not improbable that it will subsequently be found to take rank as an independent genus.

The large, angular plications of this species and its spinose rim and growth lines give it an expression so strongly marked that even upon the consideration of its superficial characters I would be disposed to separate it from the more usual types referred to *Aviculopecten*, and Meek, who was, I believe, the first to suggest that it belonged to a hitherto undescribed genus, pointed out characters which, if not the result of imperfect preservation, as seems unlikely, would certainly entitle it to such a position. He says "The only specimens of this species I have seen consist entirely of what seems to be the thin outer layer of the shell, in which there appears to be a prismatic structure, as seen by the aid of the microscope and a strong transmitted light. They show no flattened cardinal plate, but a furrow along the inner side of the hinge margin of each valve. The cardinal plate or area was doubtless composed, as in other cases, of the inner laminated portion of the shell, that has been destroyed during the fossilizing process; if not, it would seem to be a new genus."[a]

The very characteristic spines with which *Acanthopecten* is armed, projecting from the surface and from the margin, are suggestive of a genus to be developed at a much later geologic period, *Spondylus*, in which the spines often play an important part in the matter of surface ornamentation.

Acanthopecten carboniferus Stevens.

1858. *Pecten carboniferus.* Stevens, Am. Jour. Sci., (2), vol. 25, p. 261.
Coal Measures: Crooked Creek, Marion County, Ill.

1863. *Pecten broadheadii.* Swallow, Acad. Sci. St. Louis, Trans., vol. 2, p. 97.
Upper Coal Measures: Harrison County, Mo.

1866. *Pecten hawni.* Geinitz, Carb. und Dyas in Nebraska, p. 36, tab. 2, figs. 19a, b
Coal Measures: Nebraska City, Nebr.

1872. *Aviculopecten carboniferus.* Meek, U. S. Geol. Surv. Nebraska, p. 193, pl. 4, fig. 8; pl. 9, figs. 4a, b.
Upper Coal Measures: Nebraska City, Nebr.
Coal Measures: Iowa; Illinois; West Virginia.

1874. *Aviculopecten carboniferus.* Meek, Am. Jour. Sci., (3), vol. 7, p. 489.

1884. *Aviculopecten carboniferus.* White, Geol. Surv. Indiana, 13th Rept., pt. 2, p. 144, pl. 28, figs. 5–6.
Coal Measures: Lick Branch, near Silverwood, Fountain County, and in Vermilion County, Ind.

1887. *Aviculopecten carboniferus.* Herrick, Sci. Lab. Denison Univ., Bull., vol 2, p. 67, pl. 3, fig. 13.
Coal Measures: Flint Ridge, Ohio.

1894. *Aviculopecten carboniferus.* Keyes, Missouri Geol. Surv., vol. 5, p. 111, pl. 43, figs. 4a, b.
Upper Coal Measures: Kansas City, Mo.

1897. *Aviculopecten carboniferus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 33.
Lower Coal Measures: White and Conway counties, Ark

1900. *Aviculopecten carboniferus.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 117, pl. 13, fig. 9.
Upper Coal Measures: Kansas City, Turner, Eudora, Lawrence, Lecompton, Topeka, Kans.

This strongly characterized species seems to be rare in the Colorado Carboniferous faunas. It has been found at but few localities, and is represented by no more than a single specimen at each.

Locality and horizon.—San Juan region (stations 2204, 2205, 2226, 2238, 2342); upper portion of the Hermosa formation and in the Rico formation. Leadville region (station 2259).

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[a] U. S. Geol. Surv. Nebraska, 1872, p. 194.

ENTOLIUM Meek, 1865.

Entolium? sp.

There is only one specimen representing this species. It is too poor for determination, and is considered here only because it seems to form the basis for the identification which is recorded in the faunal list of the Leadville monograph.[a]

Locality and horizon.—Leadville district (station 2275); upper portion of the Weber formation.

STREBLOPTERIA McCoy, 1851.

Streblopteria tenuilineata Meek and Worthen.

1860. *Pecten tenuilineatus.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 452.
Upper Coal Measures: South line of Clinton County, Ill.

1866. *Streblopteria? tenuilineata.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 334, pl. 26, figs. 9a, b.
Upper Coal Measures: South line of Clinton County, Ill.

We have this species from three localities, but it is represented by only a single specimen at each. The material is fragmentary as well as scanty, so that it is identified with some doubt. The surface appears to be the same in all, but is best shown by the example from station 2221 (Rico quadrangle, Sandstone Mountain), which is as to other characters very imperfect. Even with a glass only faint concentric striæ can be made out, which partake rather of the nature of growth lines than of ornamentation. A small area on the specimen from Ouray (station 2195b) shows very fine radiating striæ, which may be due to shell structure, or possibly to mineralization. The largest and most perfect specimen is that last mentioned. In size and configuration it closely resembles the right valve of *Streblopteria tenuilineata.* The anterior ear, however, shows some faint markings which might be interpreted as ribs if it could be shown that they are not accidental. This character rather suggests the form *Euchondria neglecta* Geinitz, but the shape is not right for that species. A smaller somewhat less perfect example from station 2216 (Rico quadrangle, Sandstone Mountain) has the shape of the larger one just mentioned, but the anterior ear is clearly seen to be marked with rather lamellose concentric striæ without a trace of ribs. I am not confident, owing to the fragmentary character of one of the specimens that all three belong to the same species, but those from stations 2216 and 2195b are probably conspecific with each other and with the species cited above.

Locality and horizon.—San Juan region (stations 2216, 2221); upper portion of the Hermosa formation. Ouray (station 2195b); Hermosa formation.

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 70.

MODIOLA Lamarck, 1801.

MODIOLA? SUBELLIPTICA Meek.

1866. *Clidophorus* (an *Pleurophorus*) *occidentalis.* Genitiz Carb. und Dyas in Nebraska, p. 23, tab. 2, fig. 6. (Not *Pleurophorus occidentalis* M. & H., 1858.)
   Upper Coal Measures: Nebraska City, Nebr.
1872. *Modiola? subelliptica.* Meek, U. S. Geol. Surv. Nebraska, p. 211, pl. 10, fig. 5.
   Upper Coal Measures: Nebraska City, Nebr.; Riverside, 3 miles below Atchison, Kans.
1881. *Pleurophorus subcostatus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Supp., Appendix, p. xxvii, pl. 3, fig. 8.
   Carboniferous: Coyote Creek, New Mexico.
1900. *Modiola subelliptica.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 136.
   Upper Coal Measures: Topeka, Kans.

This form is represented by only two specimens found each at a different locality. It is probable that it does not belong, strictly speaking, to the genus *Modiola*, but it is so thin and delicate that characters of hinge and muscle scars are not shown.

The form from New Mexico which White identifies with *Pleurophorus subcostatus* I am convinced, from a direct comparison of specimens, belongs with this species.

Locality and horizon.—San Juan region (stations 2221, 2233); upper portion of the Hermosa formation.

MYALINA de Koninck, 1844.

MYALINA CUNEIFORMIS Gurley.

Pl. VIII, figs. 14–17.

1883. *Myalina cuneiformis.* Gurley, New Carb. Foss., Bull. No. 1, p. 4.
   Upper Carboniferous: Ouray, Colo.

Through the courtesy of the geological department of the University of Chicago, I have been enabled to examine the type specimens of *Myalina cuneiformis* and to illustrate the species partially from Gurley's original material.

The original description of *M. cuneiformis* is given in the following terms:

"Shell small, nearly or quite equivalve, long, narrow, attenuated with prominent straight subangular umbonal ridge extending from the small, sharp-pointed terminal beaks across the shell to the posterior basal margin, attaining its greatest prominence about one-fourth of the length of the shell from the beaks, where the thickness of the shell is equal to two-thirds its greatest width.

"Cardinal margin nearly straight, extending almost half the length of the shell and gracefully curving into the posterior margin, which is slightly flattened and oblique, regularly rounding down and around, joining the anterior basal margin just anterior to the posterior extremity of the umbonal ridge, from thence the basal margin passes in a straight line to the beaks.

"The anterior basal area is nearly straight, flat, broad, slightly gaping and very much depressed, a great portion of the surface being almost on the same plane with the umbonal ridges.

"Surface marked by fine concentric lines of growth, which are barely perceptible along the more prominent parts of the shell.

"Length, 15 mm.; breadth, 5.5 mm; greatest thickness, 4 mm.

"This species somewhat resembles *M. perattenuata*, M. & H., but is readily distinguished from that shell by its more angular and prominent umbonal ridge, flattened, depressed anterior basal area, and by being more attenuated.

"*Position and locality.*—From a hard, dark micaceous sandy shale belonging to the Upper Carboniferous series and probably equivalent to the Middle Coal Measures, Ouray, Colo."

With the types of both species before me the differences pointed out by Gurley by which *M. cuneiformis* might be distinguished from *M. perattenuata* do not in the main hold good, though for the present at least I shall retain his species as distinct. *M. perattenuata* seems to have the umbonal ridge directed at a slightly less acute angle with the hinge line. It is possibly proportionally more elongate and has the posterior cardinal angle better marked. This portion of the shell has the appearance of being truncated (if the present specimens are not imperfect). The shape of *M. perattenuata*, in other words, approaches a parallelogram, that of *M. cuneiformis* a triangle.

At station 2314 in the Crested Butte region were collected several slabs of black limestone abundantly covered with a small species of *Myalina* in fragments and entire valves, which is closely related to *M. cuneiformis* Gurley. The geologic horizon is also probably the same. Though a number of individuals were collected, all the material is so badly weathered that only one or two specimens are at all available for illustration, while the entire series affords but an unsatisfactory concept of the species.

Since examining the types of Gurley's species I am somewhat more inclined to doubt the correctness of the identification of these Crested Butte fossils than when dependence was placed upon his description alone. I have not, however, altered the identification originally set down, but leave the decision as to its correctness to be decided by more complete material.

The configuration which my specimens originally possessed can at present only be estimated, but so far as I can judge the angle between the umbonal ridge and the hinge line is somewhat less acute than in the types.

Locality and horizon.—Originally described from the lowest exposed Carboniferous beds at Ouray, probably the same as station 2195. Crested Butte district (station 2314); Weber limestone.

MYALINA WYOMINGENSIS Lea.

Pl. VIII, figs. 8, 9, 10, 11, 12, 13.

1853. *Modiola wyomingensis.* Lea, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 2, p. 205, pl. 20, fig. 1a.
Coal Formation: Wilkesbarre, Pa.

1886. *Modiola wyomingensis.* Claypole, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 247.
Lower Coal Measures: Wilkesbarre, Pa.

1898. *Myalina wyomingensis.* Weller, U. S. Geol. Surv., Bull. No. 153, p. 365.

Shell of medium size; shape, subtriangular to subquadrangular. Hinge line straight, long; beak nearly but not quite terminal. Umbonal ridge well marked, meeting the hinge line at an angle of about 45°. Anterior outline sinuate, converging below with the umbonal ridge, which becomes less elevated in this direction. The posterior outline is often nearly straight in its upper portion and parallel with the anterior margin, but it is more strongly curved below and its junction with the anterior outline is subangular. The shape of such a specimen resembles that of a parallelogram. In some examples, however, the hinge line is proportionately longer, and the posterior margin makes a more or less regular, obliquely directed curve from the hinge line to its union with the anterior outline. The shape resulting is subtriangular, and all gradations exist between the two. Variation precisely similar is seen in *Myalina permiana* Swallow. The elongated form Swallow describes as *M. permiana;* to the triangular one he gave the name *M. concava.* This fact has been pointed out by Meek and Hayden,[a] who place the latter species in the synonymy of the former. I do not consider this variation of specific importance in the case of *M. wyomingensis*, and certainly it seems no more than varietal in the case of *M. permiana.*

The surface seems to be marked by lamellose striæ, which are particularly prominent on the peripheral areas of the shell.

This species is closely related to *M. permiana* and shows many points of resemblance. At first, indeed, I identified my material with Swallow's species with but little reserve, but a critical revision has compelled me to recall this decision. The differences which distinguish them reside chiefly in the anterior portion of the shell. In *M. permiana* the umbones are terminal and the umbonal ridge is so near the anterior outline that where the chief emargination of the latter occurs the umbonal ridge actually overhangs the shell margin. In *M. wyomingensis* the umbones are not quite terminal and there is always a more or less well-developed anterior lobe. The anterior outline is farther from the umbonal ridge in the upper part of the shell, and the anterior side there falls away less abruptly than is the case below, where, though the ridge is not so high, it slopes off to the plane of the shell edge in

[a] Smithsonian Cont. Knowledge, vol. 14, No. 172, 1865, p. 52.

a direction nearly normal to the latter. The anterior lobe seems to be always more or less developed, and though the extreme form in one direction comes close to *M. permiana*, it is even then strong enough to differentiate the two.

M. wyomingensis also resembles *M. aviculoides*, but a comparison of my material with the type specimens of the latter leaves me convinced that they are distinct. I need only point out the strong curve of the umbonal ridge at its upper end and its direction below for most of its length at nearly right angles to the hinge line. Other points of variance will readily be seen by comparing the figures of the two species. But perhaps the most similar form is *M. swallowi* McChesney, which is a modioliform shell much resembling *M. wyomingensis* in shape, but with a sharper backward sweep of the umbonal ridge. In Lea's species also the junction of the cardinal and the posterior outline is angular, while in McChesney's form the posterior outline merges imperceptibly into that of the cardinal margin. However, no comparison with *M. swallowi* seems to be necessary, because there is evidence for believing that it is generically distinct. It has a rather strong individuality of expression when compared with other specimens of *Myalina*, and certainly seems to show structural differences which make its removal from de Koninck's genus desirable. Meek[a] was, I believe, the first to call attention to this fact. Specimens from several localities preserved as internal casts show that this form does not possess the massive striated hinge plate which characterizes *Myalina*, but that, on the other hand, the cardinal margin is thin and linear, with a long cartilage groove. It would seem, therefore, that *M. swallowi* should be removed from *Myalina*. It can be referred, provisionally at least, to *Modiola*.

I hardly need compare with *M. kansasensis*, which, while it is somewhat similar, lacks the interior lobe of Lea's species and is distinguished from all others known to me by the fluted lamellæ with which the surface is covered.

The preceding description and comparisons are based upon material from the Rico formation of the San Juan region which I had prepared to publish as a new species when fortunately there came into my hands the types of *Myalina wyomingensis*, which Lea described in 1853, from the Northern Anthracite field of Pennsylvania. I find that my Rico fossils, which possibly hold about the same geologic horizon as the Pennsylvania fauna, agree in the closest manner with the types of *M. wyomingensis*, and I can not consider their specific identity as doubtful. As I shall seek an early opportunity to redescribe, refigure, and discuss from the type material all of Lea's species whose characters have so long been problematical, I have not introduced at this place typical figures for comparison.

Myalina wyomingensis is extremely abundant at Scotch Creek (station 2340). What I take to be the same form occurs also at Graham, Young County, Tex., and

[a] U. S. Geol. Surv. Nebraska, etc., 1872, p. 202.

at Beaumont, Butler County, Kans. A single specimen from the Leadville region also has been referred here. It can not be identified with certainty, but seems to be nearest to *M. wyomingensis.*

Locality and horizon.—San Juan region (stations 2340, 2341, 2342, 2345, 2349); Rico formation. Leadville district (station 2257); base of the Weber formation.

Myalina subquadrata Shumard?

Pl. VIII, figs. 6, 7.

1855. *Myalina subquadrata.* Shumard, Missouri Geol. Surv., p. 207, Pl. C, fig. 17.
Upper Coal Measures: On Missouri River, 2 miles below the mouth of the Little Nemaha.

1864. *Myalina subquadrata.* Meek and Hayden (pars), Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 32.
Coal Measures: Leavenworth City, Kans.

1866. *Myalina subquadrata.* Geinitz, Carb. und Dyas in Nebraska, p. 27, tab. 3, figs. 25, 26.
Upper Coal Measures: Nebraska City, Nebr.

1872. *Myalina subquadrata.* Meek, U. S. Geol. Surv. Nebraska, p. 202, pl. 4, fig. 12; pl. 9, fig. 6.
Upper Coal Measures: Nebraska City, Bennetts Mill, and Bellevue, Nebr.

1884. *Myalina subquadrata.* White, Geol. Surv. Indiana, 13th Rept., p. 140, pl. 29, figs. 1, 2; pl. 30, figs. 1, 2.
Upper Coal Measures: Knox, Gibson, and Posey counties, Ind.

1886. *Myalina subquadrata.* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 456; p. 446, fig. 15; p. 454, fig. 15a.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Myalina subquadrata.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 273, fig. 15a; p. 274, fig. 15.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1895. *Myalina subquadrata.* Keyes, Missouri Geol. Surv., vol. 5, p. 118, pl. 44, figs. 1a, b, 2a, b. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Myalina subquadrata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 138, pl. 16, figs. 10, 10b.
Carboniferous: Kansas City, Melvern (Osage County), Topeka, Lawrence, Kans.

1900. *Myalina subquadrata.* Knight, Univ. Wyoming, Wyoming Exp. Sta., Bull. No. 45, pl. 3, fig. 1.

This well-known and widely distributed species is represented in several of the collections examined, and by a number of specimens. In the Rico formation of the San Juan region it is abundant and attains a large size, especially on the Dolores River (station 2343) and on Scotch Creek (station 2340). I have identified it also in the Hermosa formation of the same region, in Big Percent Creek (station 2200), and on the west side of the Animas Valley (station 2205). In the Hermosa formation, however, it is represented by a few small shells, fragmentary and poorly preserved. Associated with the larger specimens at station 2205 an isolated left valve was found having a smaller size and a more oblique shape. The length along the hinge line is only 13 mm. and the axis is inclined to the hinge at an angle of about 45°. The general appearance of the shell is quite unlike *M. subquadrata*, but the growth lines on mature *subquadrata* show that certain of its younger stages must have closely resembled the shell under discussion, even suggesting the form commonly referred to *M. swallowi*. I have therefore provisionally included this specimen under the common title of *Myalina subquadrata*, though a different course might have resulted from the consideration of more complete material.

Most of this material exhibits departures more or less extensive from the type for which the name was originally proposed, and I am not sure that they can appropriately be considered to belong to Shumard's species, except as well-marked varieties. Two diverse types are shown by figs. 6 and 7 of Pl. VIII. In one case it was necessary, as indicated in the figure (7), to considerably restore the originally broken specimen, but the lines of growth have been followed as faithfully as possible, and the shape represented is probably close to the original.

Locality and horizon.—San Juan region (stations 2200?, 2205?, 2340, 2341, 2342, 2344, 2345); upper portion of the Hermosa formation, and abundant in the Rico formation.

MYALINA PERATTENUATA Meek and Hayden?

1858. *Myalina (Mytelus) perattenuata.* Meek and Hayden, Albany Inst., Trans., vol. 4, p. 77.
Permian: Smoky Hill Fork, Kansas and Missouri rivers.

1859. *Myalina (Mytilus) perattenuata.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 28.
Upper Coal Measures: Smoky Hill River, Kansas.

1864. *Myalina perattenuata.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 32, pl. 1, figs. 12a, b.
Coal Measures: Opposite the northern boundary of Missouri on the Missouri River.

1866. *Myalina perattenuata.* Geinitz, Carb. und Dyas in Nebraska, p. 27, pl. 2, figs. 10, 11.

1873. *Myalina perattenuata.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 582, pl. 26, fig. 11.
Coal Measures: Springfield, Illinois.

1891. *Myalina perattenuata.* White, U. S. Geol. Surv., Bull. No. 77, p. 28, pl. 4, figs. 13–15.
Permian: Goodwin Creek and Military Crossing, Baylor County, Tex.; Camp Creek, Archer County, Tex.

1895. *Myalina perattenuata.* Keyes, Missouri Geol. Surv., vol. 5, p. 118. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Myalina perattenuata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 141, pl. 16, fig. 8.
Upper Coal Measures: Topeka, Kans.

After eliminating the types referred to *Myalina subquadrata* and to *M. wyomingensis* several specimens remain, unfortunately in not very good condition, which resemble Meek and Hayden's species cited above. The shell, however, is a large one, as the fact that the larger examples exceed 100 mm. in length will attest. Some of these also approach *M. exasperata* Beede. Doubtless, were the material less imperfect, it would be possible to make a more satisfactory determination, and the identification might not in every case be *Myalina perattenuata.*

Locality and horizon.—San Juan region (stations 2337, 2340); Rico formation.

MYALINA PERNIFORMIS Cox?

1857. *Myalina pernaformis.* Cox, Geol. Surv. Kentucky, vol. 3, p. 569, pl. 8, fig. 8.
Coal Measures: Providence, Hopkins County, Ky.

At station 2187 was obtained a single specimen of *Myalina* which I have referred to *Myalina perniformis.* Its somewhat crushed condition prevents a satisfactory reference. The shape and size, which gives a measurement of 31 mm. in the longest diameter, are almost precisely those of *M. perniformis* as illustrated by Cox. The surface is largely exfoliated. The portions which remain, however, lead me to believe that it did not have the strong concentric, almost fimbriating, lines of growth described by Cox. My specimen is related also to *M. apachesi* and *M. perattenuata*, but it is nearest *M. perniformis.* It also resembles the species which I have referred to *M. cuneiformis* Gurley, but differs from it in having the umbonal ridge slightly less oblique to the hinge line, and in having a somewhat more quadrate shape.

Locality and horizon.—San Juan region (station 2187); Molas formation.

POSIDONIELLA de Koninck, 1885.

POSIDONIELLA PERTENUIS Beede?

1895. *Placunopsis carbonaria.* Keyes, Missouri Geol. Surv., vol. 5, p. 108, pl. 43, fig. 9 (date of imprint 1894).
Upper Coal Measures: Kansas City, Mo.

1899. *Posidonomya pertenuis.* Beede, Kansas Univ. Quart., vol. 8, p. 127, pl. 32, fig. 5.
Coal Measures: From near the dam at Lawrence, Kans., and from the same stratum at Camerons Bluff, 3 miles up the river.

1900. *Posidonomya? pertenuis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 136, pl. 19, fig. 5.
Upper Coal Measures: Lawrence, Kans.

This form is represented by a single specimen obtained at station 2341 in the Rico formation (Scotch Creek). Although not very perfectly preserved, the characters, made out as well as possible, would indicate that this specimen in its specific relations is very close to that which Keyes figures as *Placunopsis carbonaria* (see synonymy). Beede has called attention to the fact that this shell is quite unlike the form to which Meek and Worthen gave the name *P. carbonaria.* Although the latter is characteristically ornamented with radial markings, Meek and Worthen themselves figure a shell as *Pl. carbonaria* (their fig. 2b), which seems to be smooth, and which has, moreover, much the shape of Keyes's specimen. It would appear very much as if Meek and Worthen's fig. 2b and possibly also their fig. 2d belonged to the same species as the one figured by Keyes, and that this type were distinct from *P. carbonaria.* Beede also suggests that *P. carbonaria* of Keyes may belong to the species which he describes as *Posidonomya? pertenuis.* *P. pertenuis* is represented by Beede's figure as being a rather elongate form, and as Keyes's figure shows a nearly circular one the difference in shape is somewhat against this view. Nevertheless I have accepted it provisionally in identifying my Colorado specimen. The latter has a length of 33 mm. and a width slightly greater. The shape is thus shown to be a little transverse, and it is nearly bilaterally symmetrical. The convexity is moderate and is greatest just below the beak, which is small, incurved, and but slightly projecting. The hinge line, which is straight and about 18mm. long, merges easily into the nearly circular outline.

Comparing this specimen with Keyes's figure the straight hinge line seems to be a trifle longer and the beak incurved instead of erect. Supposing it to be the opposite valve the shape is otherwise nearly identical.

Both of these forms differ from the type of *P. pertenuis* in being more nearly circular. My specimen differs also in having the hinge line represented on both sides of the beak.

Inasmuch as the structural characters of these forms are not known, and as dependence has to be placed in determining their generic position upon their general configuration, it seems that they would be more correctly referred to *Posidoniella* than to *Posidonomya*.

Locality and horizon.—San Juan region (station 2341); Rico formation.

PSEUDOMONOTIS Beyrich, 1862.

PSEUDOMONOTIS HAWNI Meek and Hayden.

1858. *Monotis hawni.* Meek and Hayden, Albany Inst., Trans., vol. 4, p. 76.
Permian: Near mouth of Smoky Hill Fork of Kansas River and Helena, Kans.

1859. *Monotis hawni.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 28.
Upper Coal Measures: South of Kansas Falls, Smoky Hill River, and Cottonwood Creek, Kansas.

1864. *Eumicrotis hawni.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 54, pl. 2, figs. 5*a–c*.
Permian: Near mouth of Smoky Hill Fork of Kansas River and between there and Council Grove; also on Cottonwood Creek, Kansas.

1884. *Eumicrotis hawni.* White, Geol. Surv. Indiana, 13th Rept., p. 142, pl. 30, fig. 10.
Upper Coal Measures: Indiana.

1886. *Eumicrotis hawni.* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 455.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Eumicrotis hawni.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 271.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1899. *Pseudomonotis* cf. *hawni.* Beede, Kansas Univ. Quart., vol. 8, No. 2, p. 83, pl. 19, figs. 1–1*f*.
Upper Coal Measures: Turner, Wyandotte County, Kans.; Clemento, Topeka, Lawrence, Kans.

1900. *Pseudomonotis hawni.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 132, pl. 13, figs. 11–11*c*; pl. 15, figs. 1–1*f*, 2, 2*a*.
Upper Coal Measures: Turner, Lawrence, near Topeka, Kans.

Four representatives of this species were found at station 2341 (Scotch Creek) in the Rico formation, and it seems to be fairly abundant there. This material has been compared with the types of Meek and Hayden's species and the identification is believed to be correct. A single poorly preserved specimen which appears to belong to the same species was found in the Hermosa formation on the west side of Animas Valley (station 2205).

Locality and horizon.—San Juan region (stations 2205?, 2342); upper portion of the Hermosa formation and in the Rico formation.

PSEUDOMONOTIS EQUISTRIATA Beede.

Pl. VIII, fig. 5.

1899. *Pseudomonotis hawni equistriata.* Beede, Kansas Univ. Quart., vol. 9, p. 82, pl. 18, figs. 3–3*b*.
Upper Coal Measures: Turner, Wyandotte County, Kans.

1900. *Pseudomonotis hawni equistriata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 134, pl. 14, figs. 3–3*b*.
Upper Coal Measures: Turner, Kans.

Of this form but one specimen has come to hand. It differs from that referred to *Ps. kansasensis* chiefly in being more convex and in having its striæ persistently and regularly unequal, and from *Ps. hawni* in having them finer and with much less disparity between the coarser and the finer ones. The species to which this specimen belongs seems to be closely related to, if not identical with, Beede's *Pseudomonotis hawni* var. *equistriata.*

Locality and horizon.—San Juan region (station 2342); Rico formation.

PSEUDOMONOTIS KANSASENSIS Beede.

Pl. VIII, fig. 4.

1858. *Monotis radialis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 187.
Upper Permian: Smoky Hill Fork, Kansas.

1866. *Avicula speluncaria.* Geinitz, Carb. und Dyas in Nebraska, p. 28, tab. 2, fig. 12.
Upper Coal Measures: Nebraska City, Nebr.: Council Grove, Kans.

1872. *Pseudomonotis radialis?* Meek, U. S. Geol. Surv. Nebraska, p. 201, pl. 9, fig. 3.
Upper Coal Measures: Nebraska City, Nebr.

1887. Cf. *Pseudomonotis radialis.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 145, pl. 14, fig. 26.
Coal Measures: Flint Ridge, Ohio.

1899. *Pseudomonotis? tenuistriata.* Beede, Kansas Univ. Quart., vol. 8, p. 81, pl. 18, figs. 1–1*d*; pl. 19, fig. 3.
Upper Coal Measures: Turner, Wyandotte County, Kans.; Topeka, Kans.; Auburn, Shawnee County, Kans.

1900. *Pseudomonotis kansasensis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 133, pl. 14, figs. 1–1*d*.
Upper Coal Measures: Turner, Topeka, Auburn (Shawnee County), Kans.

Only one specimen has come to hand representing this species, which seems to be the one Beede described as *Pseudomonotis? tenuistriata*, but it differs from typical examples in being more contracted at the hinge line and in having the anterior ear more clearly defined. In the synonymy of this form probably belongs *Pseudomonotis radialis* Phillips? of Meek, and possibly also *Avicula speluncularia* Geinitz, as suggested by Meek.

Some of the figures given by Meek and Worthen of a form which they referred to *Placunopsis* with the specific name *P. carbonaria*[a] so much resemble Beede's figures of *Pseudomonotis kansasensis* as to suggest that the former species is generically, if not specifically, related to the latter. I am unable to make direct comparisons with specimens, as the Illinois form is not represented in our collections.

Locality and horizon.—San Juan region (station 2342); Rico formation.

Pseudomonotis sp.

This species is represented primarily by a specimen of medium size and preservation from Marguerite Creek (station 2344) in the Rico formation, but to it I have also referred two smaller and less perfect examples from two other stations in the same formation.

In shape this shell much resembles the form which Beede described as *Pseudomonotis hawni* var. *equistriata* and figured on pl. 14 of his report.[b] It is a narrow, elongate species, having a length of about 19 mm. and a transverse diameter at the widest point of about 15 mm. At the hinge line the width is 10 mm.

The posterior ear is flattened and scarcely distinguished by a gentle sinuosity in the outline. The anterior ear is rather inflated and it is defined by a very distinct emargination or notch. The posterior outline is nearly straight in its upper portion, which meets the hinge line at a slightly obtuse angle. It has a gentle outward curve below, and the inferior outline is strongly rounded. The anterior outline is withdrawn into a well-marked sinus beneath the anterior ear. The shell is rather strongly inflated.

The surface is marked by a number of moderately distinct wrinkles of growth. The ribs are very obscure, somewhat alternating in size, and not distributed with precise regularity. There are 8 or 9 in the space of 5 mm.

The foregoing description is derived from the large example already mentioned. The two other specimens are much smaller and much less perfect. Their length is slightly over 10 mm. The shape, as well as it can be determined, is similar to that of the larger example whose description has just been given. The surface seems to be without radial ribs.

The nearly obsolete character of the surface ornamentation in these specimens might seem to indicate that they are right valves, but the shape and strong convexity

[a] Geol. Surv. Illinois, Rept., vol. 5, 1873, pl. 27, figs. 2b and 2d.

[b] Univ. Geol. Surv. Kansas, Rept., vol. 6, 1900, p. 134, pl. 14, fig. 3.

may be taken as evidence that this is not the case. They seem to be quite distinct from any American species yet described.

Locality and horizon.—San Juan region (stations 2341, 2344, 2345); Rico formation.

MONOPTERIA Meek and Worthen, 1866.

MONOPTERIA POLITA White.

1880. *Anthracoptera polita.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 166, pl. 42, figs. 5a, b.
Coal Measures: Major's Mill, Vermilion County, Ill.

1895. *Monopteria* sp. Keyes, Missouri Geol. Surv., vol. 5, pl. 46, fig. 10. (Date of imprint, 1894.) Upper Coal Measures.

I have long harbored a belief, to which I now venture to give expression, that *Anthracoptera polita* White properly belongs to the genus *Monopteria.* The recent exposition of *Naiadites* (= *Anthracoptera*), which we owe to Dr. Wheelton Hind,[a] makes it highly probable that a shell with the configuration shown by White's figures does not belong in Dawson's genus, and in the same characters this fossil strongly suggests the genus to which it is now referred. This resemblance and the associations which arise from it have received some expression in geologic literature. I have no doubt that the shell figured by Keyes as *Monopteria* sp. is a representative of *Anthracoptera polita*, and Beede and Rogers practically suggest a generic relationship when describing *Monopteria ? subalata* by comparing their form with White's species. The former, it may be remarked, seems to be correctly referred to *Monopteria* if one may judge by its shape and by the other characters noted by its authors, but I would suggest that it is possibly founded upon young specimens of *M. longispina.* The growth lines in that form indicate that the auricle is comparatively undeveloped in its younger stages, taking on the alate condition gradually on advancing to maturity. Immature shells of *M. longispina* as outlined by growth lines on larger individuals have exactly the shapes of the types of *M. subalata.*

I have identified *Monopteria polita* in the Rico formation, where it is associated with another shell believed to represent *M. alata* Beede. The relationship of these species appears to be so close, however, that they should hardly be regarded as more than varietally distinct. At the same time I would be unwilling for the present to admit that they were specifically the same.

Locality and horizon.—San Juan region (station 2342); Rico formation.

MONOPTERIA LONGISPINA Cox.

1857. *Gervilla longispina.* Cox, Geol. Surv. Kentucky, vol. 3, p. 568, pl. 8, fig. 6.
Coal Measures: Providence, Hopkins County, Ky.

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[a] Mon. on Carbonicola, Anthracomya, and Naiadites; Paleontograph. Soc., 1894-1896.

1894. *Monoptera longispina.* Keyes, Missouri Geol. Surv., vol. 5, p. 114, pl. 43, fig. 1.
Upper Coal Measures: Kansas City, Mo.
1900. *Limopteria longispina.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 127, pl. 16, fig. 6.
Upper Coal Measures: Kansas City, Turner, Lawrence, Kans.

The form which I have referred to *Monopteria longispina* has been found only in the Rico formation, and it is represented at station 2341 (Scotch Creek) by two very imperfect specimens. The accuracy of the identification is qualified by the character of the material.

The strongly curved umbonal ridge and prolonged posterior portion of this form give it a shape much resembling that of *M. marian* and *M. longispina*, but the retracted anterior margin would prevent its reference to the first-named species.

Locality and horizon.—San Juan region (station 2341); Rico formation.

Monopteria alata Beede.

Pl. IX, fig. 3.

1898. *Monopteria gibbosa alata.* Beede, Kansas Univ. Quart., vol. 7, p. 189, fig. 5.
1900. *Limopteria alata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 130, pl. 5, fig. 5.
Upper Coal Measures: Turner, Lawrence, Kans.

Shell small, subpentagonal. Hinge line straight, about once and one-half as long as the width below. The body of the shell is marked by two angulations, the anterior one almost perpendicular to the hinge line, the other diagonally directed, nearly bisecting the angle thus formed. The anterior angulation is near the margin of the shell, which falls away very rapidly along this line. The anterior outline, therefore, is subrectilinear and is inclined to the hinge line at but little more than a right angle. An abrupt curve connects it with the inferior outline, which is also subrectilinear and nearly parallel to the hinge line. Where it intersects the diagonal angulation there is another sharp turn to a direction nearly normal to that which it had formally been pursuing. Continuing thus for a short distance it begins to assume a backward course, and, with a sigmoid curve, joins the superior outline. The posterior alation thus formed is strong, but broad and blunt. The surface is marked by numerous fine, regular, sublamellose striæ, crowded in the upper regions of the shell, but becoming spaced peripherally. The description just given is drawn up from the only specimen which has thus far been found. The fact that the body of the shell in this form is short and nearly erect instead of bending backward into a direction more or less parallel with the hinge line, distinguishes it from *M. longispina* and *M. marian*, and also to a less degree from *M. subalata* and *M. gibbosa*, and allies it more especially with *M. alata* and *M. polita*. I at one time regarded this form as representing a new variety subordinate to *M. polita*, but now feel that it should not be distinguished from *M. alata*. Although it is true that certain differences can be pointed out between my specimen and Beede's figure, they hardly seem to exceed such as might be reasonably ascribed to difference in age or to individual peculiarity. Certainly the expression of the two shells is very similar. On the other hand, the relationship between *M. polita* and *M. alata* is so close, at least in so far as it finds expression in external form, that I doubt whether the latter should be considered more than a varietal aspect of White's species.

Locality and horizon.—San Juan region (station 2342); Rico formation.

AVICULOPINNA Meek, 1867.

AVICULOPINNA ? PERACUTA Shumard.

Pl. IX, figs. 1, 2.

1858. *Pinna peracuta.* Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 214.
Upper Coal Measures: Iowa Point, Nebraska; Kansas.

1860. *Pinna adamsi.* McChesney, Desc. New Spec. Pal. Foss., p. 74.
Coal Measures: Lasalle, Ill.

1872. *Pinna peracuta.* Meek, U. S. Geol. Surv. Nebraska, p. 198, pl. 6, figs. 11a,b.
Upper Coal Measures: Bennett's Mill, Wyoming; Nebraska City, Plattsmouth, Rock Bluff, and Bellevue, Nebr.
Coal Measures: Iowa, Nebraska, Kansas, Missouri, and Illinois.

1875. *Pinna peracuta* (?). White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 151, pl. 11, fig. 5a. (Whole volume published in 1877.)
Carboniferous: Near Relief Spring, Ariz.

1884. *Pinna peracuta.* White, Geol. Surv. Indiana, 13th Rept., p. 145, pl. 28, figs. 1, 2.
Upper, Middle, and Lower Coal Measures: Indiana.

1886. *Pinna peracuta.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 272, fig. 12; p. 273, fig. 12a.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Pinna peracuta.* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 455; p. 444, fig. 12; p. 454, fig. 12a.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1892. *Aviculopinna peracuta.* Hyatt, Boston Soc. Nat. Hist., Proc., vol. 25, p. 388.

1895. *Pinna peracuta.* Keyes, Missouri Geol. Surv., vol. 5, p. 116, pl. 45, figs. 2a, b (date of imprint, 1894).
Upper Coal Measures: Kansas City, Mo.

1899. *Pinna peracuta.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 579.
Upper Coal Measures: McAlester quadrangle; Atoka quadrangle.

1900. *Pinna peracuta.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 144, pl. 17, figs. 3, 3b.
Upper Coal Measures: Kansas City, Lawrence, Topeka, Kans.

Meek described *Aviculopinna* in 1864,[a] designating for its type *Pinna prisca* Munster=*Avicula pinnæformis* Geinitz.[b] He says of the genus (loc. cit. p. 212):

"The typical species is an elongated, thin, nearly or quite equivalve shell, with the narrow tapering general form and very long hinge line of *Pinna;* from

[a] Am. Jour. Sci., (2), vol. 37, 1864, p. 212.

[b] Dyas, p. 77, pl. xiv, figs. 1, 2, 3, and 4.

which it differs in not having its beak terminal, but set back some distance from the rather obtusely pointed anterior extremity. The beaks, however, are depressed and scarcely distinct from the cardinal margin, and the general aspect of the shell seems to be intermediate between that of *Pinna* and *Avicula Modiola*."

At the time of writing Meek was unacquainted with the constitution of the shell in *Aviculopinna*, but later[a] he found that in the case of *A. americana*, a name which he proposed for *Avicula pinniformis* Geinitz (non. Geinitz, 1866), the very thin substance of the shell had a prismatic structure "like that of other types of the Aviculidæ." There is, in fact, an inner nacreous layer covering at least part of the shell, but this had probably disappeared, through leaching, in the specimens examined by Meek.

It seems generally to have escaped recognition that Hyatt[b] in 1892 referred *Pinna peracuta* Shumard to Meek's genus *Aviculopinna*, and at the same time he recorded having observed both the prismatic and the nacreous layers in that species. The latter were found to be "not present at the posterior part of one specimen of *A. peracuta* for at least one-half of the entire length, as estimated." He was not, however, able to study the distribution of the nacreous layer satisfactorily.

One who reads Hyatt's brief discussion of the Pinnidæ above referred to can not but be struck by the closeness which *Aviculopinna* maintains to the nomenclaturally older genus *Pinna*.

The character chiefly relied on by Meek as differentiating *Aviculopinna* from *Pinna* appears to have been the nonterminal position of the beaks of the latter genus and the attendant condition of possessing a small anterior lobe. Hyatt remarks regarding this feature in *Pinna:*

"Unfortunately the apex in all specimens of the Pinnidæ is destroyed by attrition. This is doubtless due to the habit of living partly buried in the sand. There is therefore no way of proving that the umbones are absolutely terminal, as has been generally asserted in all descriptions. The umbones are doubtless more nearly terminal than in *Aviculopinna*, but it is not safe to go beyond this assertion * * *."[c]

The fact that while all recent shells have lost the beak and anterior lobe a number of Carboniferous specimens have been found retaining them is significant, and would appear either to support Hyatt's statement or else to indicate that the habits of these Paleozoic shells were different from those of their living representatives.

As already noticed, Hyatt found the nacreous layer in *Aviculopinna ? peracuta* to be absent for at least half the length, while in *Pinna* the fibrous layer alone often occupies more than half the entire length.[d]

He describes the outer layer of the shell of *Pinna* as fibrous, while that of *Aviculopinna* is spoken of as prismatic, indicating a distinction which is more

[a] Am. Jour. Sci., (2), vol. 44, 1867, p. 282.
[b] Proc. Boston Soc. Nat. Hist., vol. 25, 1892, p. 338.
[c] Ibid., p. 337.
[d] Ibid., p. 336.

strongly suggested in his remark that *Aviculopinna* is "a true Aviculoid, both on account of the anterior wing and also because, as stated by Meek, his *Aviculopinna americana* has the prismatic layer which is characteristic of this group." What Meek does say in the passage referred to is that "it has the prismatic shell structure of the allied *Pinna* and *Avicula* groups." Agreeing with this expression, nearly all general treatises describe the shell of both the Aviculidæ and the Pinnidæ as prismatic.

Between shells referred to *Aviculopinna? peracuta* and *Aviculopinna* some well-marked and constant differences are maintained. Perhaps the most obvious of these is the character of the surface ornamentation, *Aviculopinna? peracuta* being nearly smooth, while the *Aviculopinnas* are marked by strong, equally distant, lamellose projections. The direction of these, and the shape of the posterior extremity also seems to constitute a rather constant differentiating character, since in *Aviculopinna? peracuta* the posterior cardinal angle is more or less acute, while in *Aviculopinna* it is sometimes obtuse, giving the outline below a backward swing. The apex in *Aviculopinna? peracuta* has never, I believe, been observed, so that it is not known whether the beaks were terminal or not. The convexity of the valves probably does not form a reliable character, since in these shells the curvature is often modified by compression.

It appears that the shell structure of *Pinna* and *Aviculopinna* are practically identical, the relative extent of the nacreous and prismatic layers not differing materially in the fossil and living forms. The nacreous layer in *Aviculopinna* appears to be entire, and this circumstance would ally the genus rather with *Atrina* than with *Pinna* itself. The accepted difference as to the position of the umbones in the two genera, on the strength of which chiefly the genus *Aviculopinna* was proposed, can not now be proved, and is perhaps not real. On the other hand, the surface ornamentation of *Aviculopinna* is not known in either *Pinna* or *Atrina*, and seems to be quite characteristic of that group, and to a less degree the straight, inferior margin and regular slowly enlarging shape and the linear thickening along the cardinal border. It seems to me, therefore, that the uniting of *Pinna* or *Atrina* and *Aviculopinna* is not to be considered. *Aviculopinna? peracuta* seems to agree with *Atrina* and *Aviculopinna* in the undivided condition of its nacreous layer, while there is nothing distinctive in the relative extent of it compared with the prismatic layer. In the gradual regular enlargement of the shell, and in possessing a cardinal thickening, this species is allied to *Aviculopinna* and differs from *Pinna* and *Atrina*. The nearly smooth surface and extended cardinal line distinguish it strongly from the *Aviculopinna* group, but the unplicated, unstriated surface distinguishes it from the living *Pinna* and *Atrina*, almost equally with the lamellose striation of *Aviculopinna*. *Aviculopinna? peracuta* seems to be more closely allied to *Aviculopinna* and *Atrina* than to

Pinna, and I will for the present accept Hyatt's assignment of it to the former genus. The persistent differences in shape and surface between *Aviculopinna? peracuta* and the other *Aviculopinnæ* would serve to discriminate two groups under *Aviculopinna*, and they seem to me as constant and important as those upon which *Sulcatopinna* was based. It should be remarked, however, that *Pinna* includes both shells having an acute posterior cardinal angle, like *Aviculopinna peracuta*, and an obtuse one, like the other *Aviculopinnæ*.

A very imperfect specimen of *Aviculopinna? peracuta* has been obtained from the Hermosa formation in the San Juan region. It has the smooth surface and elongate hinge line, with forward sloping growth lines, which characterize that species in the Mississippi Valley. The convexity, which may have been reduced by flattening, is in this specimen very slight, while the maximum height is 48 mm.

Another still more fragmentary example has been obtained from the Weber formation of the Leadville district. Its surface ornamentation is not retained, so that an estimate can not be formed of its original shape. It appears to have been a large, long form with subparallel upper and lower margins, and I doubt if it is conspecific with the form from the San Juan. The shell, so far as preserved, is composed largely, perhaps wholly, of a rather thick prismatic layer.

Locality and horizon.—San Juan region (station 2205); upper portion of the Hermosa formation. Leadville district (station 2257); base of the Weber formation.

AVICULOPINNA NEBRASKENSIS Beede.

Pl. IX, figs. 1, 2.

1901. *Aviculopinna nebrascensis.* Beede, Kansas Acad. Sci., Trans., vol. 17, p. 186, pl. 13, fig. 1–1d. Permian: Gage County, Nebr.

The collections from Colorado occur in a dark, siliceous limestone of the Rico formation, where the species is quite abundant. In size, some of the specimens must have been at least 8 inches long—as large as the ordinary *Pinna peracuta*. The growth lines are of course parallel to the lower and posterior margins of the shell, and are separated by intervals more or less proportional to its dimensions. They are very crowded, somewhat indistinct, and occupy but a small space along the inferior margin, disengage themselves when they assume an upward direction, and end abruptly at the hinge line, which they meet at an angle of about 60°. Where parallel to the posterior margin, they are regularly spaced (about 1 mm. apart), and their lamellose character is well shown. This appearance is present when the shell has a diameter of about 35 mm. The shell substance is seen to be composed of two layers, the outer one being distinctly prismatic, the prisms of course normal to the two surfaces, and an inner one, which in these specimens is coarsely crystalline. The surface of contact between these two structural elements is naturally one of cleavage, and it frequently happens that the outer layer adheres to the matrix and the inner to the internal cast of specimens. The direction of the growth lines indicates that the posterior outline is that of *Aviculopinna*, having a backward swing and an obtuse posterior cardinal angle. This feature is liable to variation, the posterior outline in some specimens being more nearly a right angle. The one phase is represented by fig. 1 of Pl. IX, and the other by fig. 2. In restoring the outline, which has been done in the case of these two figures, it is difficult to estimate from the existing parts what shape the missing ones would have had; and consequently I suspect that the backward sweep in fig. 1 is represented as somewhat too great. The shell in fig. 2 is largely exfoliated, but one small fragment shows the surface to have been marked with spaced lamellæ like that represented by fig. 1.

This shell resembles quite closely the figures given by Beede of the species from the Nebraska Permian, which he describes as *Aviculopinna nebraskensis*. Certain differences in detail of shape are obvious, but they hardly, it seems to me, validate the recognition of my Colorado specimens as belonging to a distinct species.

Locality and horizon.—San Juan region (stations 2341, 2342); Rico formation.

CHÆNOMYA Meek, 1864.

Chænomya leavenworthensis Meek and Hayden.

1858. *Allorisma? leavenworthensis.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 263.
Coal Measures: Leavenworth, Kans.

1864. *Chænomya leavenworthensis.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 43, pl. 2, figs. 1a–c.
Coal Measures: Leavenworth, Kans.

1866. *Allorisma leavenworthensis.* Geinitz, Carb. und Dyas in Nebraska, p. 15.

1872. *Chænomya leavenworthensis.* Meek, U. S. Geol. Surv. Nebraska, p. 216, pl. 2, fig. 9.
Upper Coal Measures: Rock Bluff, Nebr.; Leavenworth, Kans.
Coal Measures: Iowa, Missouri, Illinois.

1895. *Chænomya leavenworthensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 131. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Chænomya leavenworthensis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 172, pl. 19, figs. 3–3b.
Upper Coal Measures: Kansas City, Lawrence, Kans.

Two specimens from station 2200 (Big Percent Creek, in the San Juan region) by their general configuration and widely gaping posterior extremities leave little doubt of their generic relationship. They are, however, considerably crushed, and there is an element of specific uncertainty in their identification. Similarly tinctured with doubt is the identification of a single small specimen from station 2219 (south of Marguerite Draw). Another isolated specimen from Sinbads Valley (station 2285), imperfect, though rather well preserved, probably belongs to the same species as the above.

Locality and horizon.—San Juan region (stations 2200, 2219?); upper portion of the Hermosa formation. Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

ALLERISMA King, 1844.

ALLERISMA TERMINALE Hall.

Pl. IX, figs. 4, 5, 6.

1852. *Allerisma terminalis.* Hall, Stansbury's Exped. to Great Salt Lake, p. 413, pl. 2, figs. 4a, b.
Carboniferous: Big Blue River.

1852. *Allorisma regularis ?* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, pl. 5, fig. 13.
Carboniferous: Missouri River at Wayne City.

1858. *Allorisma subcuneata.* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., p. 263.
Upper Coal Measures: Leavenworth, Kans.

1860. *Allorisma ensiformis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 656
Coal Measures: Clay, Mo.

1864. *Allorisma subcuneata.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 37, pl. 1, figs. 10a, b.
Coal Measures: Leavenworth, Kans.

1866. *Allorisma subcuneata.* Geinitz, Carb. und Dyas in Nebraska, p. 14.
Upper Coal Measures: Plattsmouth and Wyoming, Nebr.; Kansas.

1872. *Allorisma subcuneata.* Meek, U. S. Geol. Surv. Nebraska, p. 221, pl. 2, figs. 10a, b.
Upper Coal Measures: Rock Bluff, 2½ miles southwest of Nebraska City, Wyoming, and Plattsmouth, Nebr.; Leavenworth and Atchison, Kans.
Upper and Lower Coal Measures: Illinois.

1875. *Allorisma subcuneata* (var.). White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 155, pl. 12, figs. 7a, b. (Whole report published in 1877.)
Carboniferous: Near Agua Azul, N. Mex.

1876. *Allorisma subcuneata.* White, Powell's Rept. Geol. Uinta Mountains, p. 91.
Lower Aubrey Group: Confluence of Grand and Green Rivers, Utah.

1881. *Allorisma subcuneata?* White, 2d Ann. Rept. Dept. Stat. and Geol. Indiana, p. 518, pl. 8, figs. 1, 2.
Coal Measures: Edwardsport, Knox County, Ind.

1884. *Allorisma subcuneata.* White, Geol. Surv. Indiana, 13th Rept., p. 148, pl. 31, figs. 1–3.
Coal Measures: Indiana.

1886. *Allorisma subcuneata.* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 457, fig. 10a, p. 444, fig. 10.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Allorisma subcuneata.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 272, fig. 10, p. 276, fig. 10a.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1887. *Allorisma subcuneata.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 34, pl. 4, figs. 1, 2.
Coal Measures: Flint Ridge, Ohio.

1895. *Allorisma subcuneatum.* Keyes, Missouri Geol. Surv., vol. 5, p. 129, pl. 47, figs. 5a–c. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Allorisma subcuneatum.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 169, pl. 20, figs. 1–1b. Upper Coal Measures: Westport (Missouri), Kansas City, Mont Ida (Anderson County), Lawrence, Lecompton, Topeka, Elmont, Grand Summit, Kans.

This form seems to have appeared in literature under a number of different names, several of which have chronological priority over *Allerisma subcuneatum.* Weller is doubtless correct in referring *Pholadomya elongata* Morton to *Allerisma*, and it seems likely that it is the same form which was subsequently described by Meek and Hayden. *Allerisma terminale* Hall also antedates *A. subcuneatum*, and was, I am confident, proposed for the same specific type. Meek suggests that *A. ensiformis* Swallow is probably a synonym of *A. subcuneatum*, and several others of Swallow's names may also prove to be synonyms. *A. capax* Newberry is probably distinct.

The first described of these forms was *A. elongatum*, and I believe that this name will ultimately supplant the more familiar *A. subcuneatum.* I have used *Allerisma terminale* for this species, while regarding it as highly probable that the other names were proposed for it, because this is the only instance in which I have been able to convince myself of their identity by direct comparison of material.

Allerisma terminale was described from the same region as *A. subcuneatum* and seemingly from the same horizon and the same beds. When the type specimen of *A. terminale* is compared with the types of *A. subcuneatum* and other typical material, it becomes clear that it is only a smaller example of the same species, somewhat distorted by pressure. The specimen shows compression in an unmistakable manner. The direction in which the force was applied is from above, and the effect upon the valves have been to lessen their height, exaggerate their convexity, and to thrust the umbones forward from their natural position so as almost to overhang the anterior edge of the shell.

Allerisma terminale is abundant in the Rico formation, especially at station 2342, some of the specimens attaining a large size. Associated with the normal type is a comparatively much shorter form, an example of which is represented by fig. 6 of Pl. IX. It is possible that this should be regarded as a distinct variety. In its proportions it approaches the specimen from New Mexico which White figured as *Allerisma subcuneatum* var. The latter is possibly a little more elongate and is more strongly corrugated by concentric ridges, though this difference is likely due to preservation. From the Hermosa formation a small imperfect specimen has come to hand. It is like White's specimen in the particular of its strongly rugose surface, but is perhaps a trifle more elongate, and though considerably smaller than fully grown *A. terminale* probably had, when complete, about the same proportions.

Locality and horizon.—San Juan region (stations 2204, 2342); rare in the upper portion of the Hermosa formation, and abundant in the Rico formation.

SEDGWICKIA McCoy, 1844.

Sedgwickia topekensis Shumard?

1858. *Leptodomus topekaensis.* Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 208.
Coal Measures: Missouri River bluffs, a short distance below mouth of Kansas River.

1864. *Sedgwickia topekaensis?* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 40, figs. A, B.
Coal Measures: Leavenworth City, Kans.

1891. *Sedgwickia topekaensis.* White, U. S. Geol. Surv., Bull. No. 77, p. 26, pl. 4, fig. 11.
Permian: Goodwin Creek, Baylor County, Tex.

1895. *Allorisma topekaensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 128. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Sedgwickia topekaensis.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 171, pl. 20, fig. 3.
Upper Coal Measures: Topeka, Kans.

Two poorly preserved specimens from the mouth of Marguerite Creek (station 2345) seem to belong to this species. They resemble very closely, as far as their characters are shown, the specimen figured by Meek and Hayden as belonging to Shumard's species.

Locality and horizon.—San Juan region (station 2345); Rico formation.

SCHIZODUS King, 1844.

Schizodus cuneatus Meek?

Pl. 9, fig. 10.

1875. *Schizodus cuneatus.* Meek, Pal. Ohio, vol. 2, p. 336, pl. 20, fig. 7.
Lower Coal Measures: Putnam Hill and Flint Ridge, Ohio.

1886. *Schizodus cuneatus?* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 456, fig. 9a, p. 442, fig. 9.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Schizodus cuneatus?* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 275, fig. 9.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1887. *Schizodus cuneatus* (?). Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 42, pl. 4, fig. 23.
Coal Measures: Flint Ridge, Ohio.

1896. *Schizodus cuneatus.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 35.
Upper Coal Measures: Crawford County, Ark.
Lower Coal Measures: Conway County, Ark.

1896. *Schizodus cuneatus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 245.
Upper Coal Measures: Crawford County, Ark.
Lower Coal Measures: Conway County, Ark.

This species has been found at three localities and seems not to be rare. It is a large shell and closely resembles Meek's type in its shape. The latter, however, is said to be "compressed," meaning, it is inferred, not very convex. My Colorado specimens, however, are strongly arched and show more modeling about the anterior portion than is seen in Meek's figure, the umbones being well defined. These shells also resemble *Schizodus ovatus*, but aside from being very much larger they have the umbones less central than that species.

Locality and horizon.—San Juan region (stations 2340, 2341, 2342); Rico formation.

SCHIZODUS MEEKANUS Girty.

1871. *Schizodus wheeleri* (pars). Meek, U. S. Geol. Surv. Nebraska, p. 209, pl. 10, figs. 1a, b, c, d (and 1e, 1f?).
Upper Coal Measures: Adams and Union counties, Iowa.

1894. *Schizodus wheeleri* (pars). Keyes, Missouri Geol. Surv., vol. 5, p. 123, pl. 46, figs. 3a, b.
Upper Carboniferous (Upper Coal Measures): Kansas City, Mo.

1899. *Schizodus meekanus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 583, pl. 72, figs. 7a–7c.
Upper Coal Measures: Atoka quadrangle.

One large elongate specimen from station 2337, in the San Juan region, agrees closely with the types of this species. The identification is made with some confidence.

Locality and horizon.—San Juan region (station 2337); Rico formation.

SCHIZODUS PANDATUS Girty?

1899. *Schizodus pandatus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 583, pl. 72, fig. 5a.
Upper Coal Measures: McAlester quadrangle.

In the red calcareous sandstones of the Rico formation, from which collections were made at stations 2340, 2346, and 2348, shells belonging to the genus *Schizodus* are extremely abundant. The preservation is unfortunately so poor that I am unable to ascertain definitely whether one or a larger number of species are present. Some of the more perfect specimens, however, seem to have the shape of *Schizodus pandatus*, and to that species I have referred the whole collection, except a few specimens from station 2340, identified as *Schizodus cuneatus*. In fact, it may be said of the whole representation of *Schizodus* that the shells are too poorly preserved or too fragmentary to permit of wholly satisfactory identification.

Locality and horizon.—San Juan region (stations 2340, 2345, 2346, 2348); Rico formation.

SCHIZODUS sp.

At station 2205, on the west side of the Animas Valley, in the San Juan region, a single specimen of *Schizodus* was obtained. Both valves are preserved, but both are more or less crushed, and the original shape can only be ascertained by a process of estimation. It is one of the suborbicular types with, however, a well-marked posterior truncation. The maximum transverse diameter is only about 15 mm., and the shell resembles the type referred by Meek to *Schizodus rossicus* de Vern. ?[a] more perhaps than any other. *Schizodus symmetricus* Calvin[b] is another similar though larger species, and *Sch. affinis* Herrick[c] is also closely related.

Locality and horizon.—San Juan region (station 2205); upper part of Hermosa formation.

NUCULA Lamarck, 1801.

Nucula ventricosa Hall ?

1858. *Nucula ventricosa.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 716, pl. 24, figs. 4, 5a, b.
Coal Measures.

1872. *Nucula ventricosa.* Meek, U. S. Geol. Surv. Nebraska, p. 204, pl. 10, figs. 17a–c.
Upper Coal Measures: Nebraska City and Rock Bluff, Nebr.
Lower Coal Measures: West Virginia.
Coal Meaures: Illinois.

1882. *Nucula ventricosa.* White, Geol. Surv. Indiana, 11th Rept., p. 371, pl. 42, figs. 9, 10.
Coal Measures: Sullivan County, Ind.

1884. *Nucula ventricosa.* White, Geol. Surv. Indiana, 13th Rept., p. 146, pl. 27, figs. 9, 10.
Coal Measures: Sullivan County, Ind.

1888. *Nucula ventricosa.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 233.
Lower Coal Measures: Des Moines, Iowa.

1895. *Nucula ventricosa.* Keyes, Missouri Geol. Surv., vol. 5, p. 121, pl. 45, figs. 3a, b. (Date of imprint, 1894.)
Lower Coal Measures: Clinton, Mo.
Upper Coal Measures: Kansas City and Gentry, Mo.

1896. *Nucula ventricosa.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 35.
Lower Coal Measures: Conway County, Ark.

1896. *Nucula ventricosa.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 245.
Lower Coal Measures: Conway County, Ark.

1900. *Nucula ventricosa.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 150, pl. 22, figs. 9, 9b.
Upper Coal Measures: Kansas City, Rosedale, Turner, Topeka, Grand Summit.

Indeterminable generically but probably a *Nucula*, *Schizodus*, or an *Edmondia*, this is the only material at present in the collection upon which the identification of *Nucula ventricosa* in the lists of the Leadville monograph[d] could have been based.

Locality and horizon.—Leadville district (station 2255); Weber formation (?).

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[a] Geol. Surv. Illinois, Rept., vol. 5, 1873, pl. 26, figs. 17a–e, 18.
[b] State Univ. Iowa Lab. Nat. Hist., Bull., vol. 1, p. 176, pl. 2, figs. 3a, b.
[c] Sci. Lab. Denison Univ., Bull., vol. 2, 1887, p. 41, pl. 4, figs. 22, 22a.
[d] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 70.

LEDA Schumacher, 1817.

Leda bellistriata Stevens?

1858. *Leda bellistriata.* Stevens, Am. Jour. Sci., (2), vol. 25, p. 261.
Coal Measures: Danville, Ill.; Summit, Ohio.

1858. *Nucula* (*Leda*) *kazanensis.* Swallow, Acad. Sci. St. Louis, Trans., vol. 1, p. 190. (Not *N. kazenensis* Verneuil, 1845).
Upper and Lower Permian: Valley of Cottonwood and near Smoky Hill Fork, Kansas.

1858. *Leda bellistriata.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 717, pl. 29, figs. 6a–d.
Lower Coal Measures: Illinois.

1862. *Leda bellistriata.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 419.
Marshall group: Moscow, Mich.

1865. *Leda bellistriata.* Winchell, Acad. Nat. Sci. Philadelphia, Proc., p. 128.
Marshall group: Hillsdale, Mich.

1866. *Nucula kazanensis.* Geinitz, Carb. und Dyas in Nebraska, p. 20, pl. 1, figs. 33, 34.

1869. *Leda bellistriata?* Winchell, Safford's Geol. Tennessee, p. 444.
Shales just above Black Shale: Hickman and Maury counties, Tenn.

1870. *Leda bellistriata?* Winchell, Am. Phil. Soc., Proc., vol. 11, p. 256.
Waverly group: Tennessee.

1884. *Nuculana bellistriata.* White, Geol. Surv. Indiana, 13th Rept., p. 146, pl. 31, figs. 8, 9.
Coal Measures: Vermilion, Sullivan, Vanderburg, and Warrick counties, Ind.

1887. *Nuculana bellistriata.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 40, pl. 4, fig. 26.
Coal Measures: Flint Ridge, Ohio.

1888. *Nuculana bellistriata.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 232.
Lower Coal Measures: Des Moines, Iowa.

1895. *Nuculana bellistriata.* Keyes, Missouri Geol. Surv., vol. 5, p. 122, pl. 45, figs. 4a, b. (Date of imprint, 1894.)
Upper Coal Measures: Gentry and Kansas City, Mo.

1896. *Nuculana* aff. *bellistriata.* Smith, Leland Stanford Junior Univ. Publ.; Cont. to Biol. Hopkins Seaside Lab., No. 9, p. 35.
Upper Coal Measures: Scott County, Ark.

1896. *Nuculana* aff. *bellistriata.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 245.
Upper Coal Measures: Scott County, Ark.

1900. *Nuculana bellistriata.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 148, pl. 20, figs. 14, 14b.
Upper Coal Measures: Kansas City, Rosedale, Lawrence, Topeka, Kans.

Two specimens from station 2219 in the San Juan region belong to the genus *Nuculana*, but as they appear in the shape of internal casts an exact specific identification is impossible. I have referred them to our common Coal Measures species, with which their general configuration accords.

Locality and horizon.—San Juan region (station 2219); upper portion of the Hermosa formation.

MACRODON Lycett, 1845.

Macrodon obsoletus Meek.

1871. *Macrodon obsoletus.* Meek, Rept. Regents Univ. West Virginia.
Lower Coal Measures: Monongahela County, W. Va.

1875. *Macrodon obsoletus.* Meek, Pal. Ohio, vol. 2, p. 334, pl. 19, fig. 9.
Coal Measures: Newark, Ohio.

1886. *Macrodon obsoletus.* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 456, fig. 19.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Macrodon obsoletus.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 275, fig. 19.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1887. *Macrodon obsoletus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 31, pl. 4, fig. 19.
Coal Measures: Flint Ridge, Ohio.

1891. *Macrodon obsoletus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 249.
Lower Coal Measures: Des Moines, Iowa.

1895. *Macrodon obsoletus.* Keyes, Missouri Geol. Surv., p. 120, pl. 46, fig. 1. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1896. *Macrodon obsoletus.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 34.
Upper Coal Measures: Sebastian County, Ark.; Poteau Mountain, Indian Territory.

1896. *Macrodon obsoletus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 244.
Upper Coal Measures: Sebastian County, Ark.; Poteau Mountain, Indian Territory.

1900. *Macrodon obsoletus.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 147, pl. 20, fig. 13.
Upper Coal Measures: Olathe, Turner, Lawrence, Kans.

This species is represented by three specimens from one locality in the Leadville region. The identification is the same as that recorded in the Leadville monograph.[a]

Locality and horizon.—Leadville district (station 2275); upper portion of the Weber formation.

Macrodon tenuistriatus Meek and Worthen?

1866. *Arca striata.* Geinitz, Carb. und Dyas in Nebraska, p. 20, tab. 1, fig. 32. (Not *Mytilites striata* Schlath., 1817.)
Upper Coal Measures: Nebraska City, Nebr.

1866. *Macrodon tenuistriata.* Meek and Worthen, Chicago Acad. Sci., Proc., vol. 1, p. 17.
Upper Coal Measures: Springfield, Ill.

1872. *Macrodon tenuistriata.* Meek, U. S. Geol. Surv. Nebraska, p. 207, pl. 10, figs. 20a, b.
Upper Coal Measures: Nebraska City, Nebr.; Springfield, Ill.; Iowa.
Lower Coal Measures: Illinois.

1873. *Macrodon tenuistriatus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 576, pl. 26, fig. 4.
Upper Coal Measures: Springfield, Ill.

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 70.

1887. *Macrodon tenuistriata.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 31.
Coal Measures: Flint Ridge, Ohio.

1888. *Macrodon* (allied to) *tenuistriata.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 4, pl. 10, fig. 15.
Waverly group: Cuyahoga Falls, Ohio.

1895. *Macrodon tenuistriatus.* Keyes, Missouri Geol. Surv., vol. 5, p. 120. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1896. *Macrodon tenuistriatus.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 34.
Upper Coal Measures: Poteau Mountain, Indian Territory.

1896. *Macrodon tenuistriatus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 244.
Upper Coal Measures: Poteau Mountain, Indian Territory.

This species is represented by a single poor specimen which seems to have been the basis for the citation of this species in the lists of the Leadville monograph.[a]

Locality and horizon.—Leadville district (station 2275); upper portion of the Weber formation.

PLEUROPHORUS King, 1844.

PLEUROPHORUS SUBCOSTATUS Meek and Worthen.

Pl. IX, figs. 11, 12.

1865. *Pleurophorus subcostatus.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 246.
Upper Coal Measures: North branch of Saline Creek, Gallatin County, Ill.

1866. *Pleurophorus subcostatus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 347, pl. 27, figs. 2, 2a.
Upper Coal Measures: North branch of Saline Creek, Gallatin County, Ill.

1887. *Pleurophorus subcostatus?* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 35, pl. 4, figs. 16, 16a.
Coal Measures: Flint Ridge, Ohio.

1900. *Pleurophorus subcostatus.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 161, pl. 20, figs. 11–11b.
Upper Coal Measures: Kansas City, Mo.

That part of the material in our collections which belongs to the genus *Pleurophorus* has proved most perplexing. The dispositions which I have made in the way of specific discrimination seem to be the best under existing conditions, but they are far from satisfactory. The material from each locality is generally scanty, and the preservation varies both in character and degree of perfection. I have not been able to satisfy myself in what measure the many differences which have been noted are due to preservation and what to specific differentiation.

The prevailing form in the Rico formation is closely related to *Pl. subcostatus.* Two examples of this form are shown on Pl. IX, figs. 11 and 12. These specimens, however, are smaller than others occurring in the black siliceous limestone of this formation, while in the red calcareous sandstones they grow still larger, some individuals attaining a width of 43 mm., agreeing with the smaller forms, meanwhile,

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 70.

in shape and other ascertained characters. These shells are remarkable for their straight and nearly parallel dorsal and ventral outlines, the latter being sometimes slightly concave, the small size of the portion of the shell anterior to the umbones, and the truncate posterior. The posterior edge is subrectilinear and inclined to the hinge line at an angle of about 60°. This truncated appearance, though not possessed by Meek and Worthen's figures, is noted by them as sometimes being a character of the species. Internal casts show the long cardinal tooth and the large anterior muscular scar characteristic of the genus, and in addition a faint posterior scar.

A small specimen from the mouth of Marguerite Creek (station 2345) has the shell partly preserved. It is considerably smaller even than the examples figured, but it is otherwise in agreement, save that the umbonal ridge is stronger and the convexity relatively greater. The shell itself is distinctly ribbed. There is a sharp ridge near the hinge line, the superior margin being strongly beveled and nearly horizontal when seen from above. Below this ridge there are three others which are sharp but not very prominent, the third one being on the diagonal angulation. So far as I can make out, these ridges do not extend to the interior of the thick shell. In all the characters noted, these shells are closely similar to *Pl. subcostatus*, but they are very much larger. The form from the red sandy bed above referred to, I at one time identified with *Pl. taffi*, partly on account of their large size, but they differ from that species in being higher in proportion to their width and in having the posterior outline less oblique to the subparallel superior and inferior margins. In their existing preservation it can not be told whether these large shells have the radiating ridges which have been observed in the smaller ones, but if so there can be little doubt that they are distinct from *Pl. taffi*.

Locality and horizon.—San Juan region (stations 2340, 2341, 2342, 2345, 2346); Rico formation.

PLEUROPHORUS ANGULATUS Meek and Worthen?

1865. *Pleurophorus? angulatus.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 247.
Coal Measures: Wabash Cut-off, near New Harmony, Ind.

1875. *Pleurophorus? angulatus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 6, p. 529, pl. 33, fig. 5.
Upper Coal Measures: Wabash Cut-off, near New Harmony, Ind.

This form has straight and nearly parallel dorsal and ventral margins. The posterior edge is subrectilinear and inclined to the cardinal line at an angle of about 60°. The posterior inferior angle is rather sharply rounded. The portion of the shell anterior to the umbones occupies about one-sixth of the entire width. The umbonal ridge is well marked, but no radiating ribs have been observed. The surface is ornamented by fine concentric striæ. The anterior muscular scar is strongly marked. The width is about 17 mm. and the height about half as much.

In shape this form resembles that identified as *Pl. subcostatus*, but it is a less elongate shell, the anterior portion is a trifle more prominent, and it lacks the radiating ribs which cross the upper and posterior half of shells of that species.

This form seems to be of the type of *Pl. angulatus*, but differs in being much larger and proportionately less transverse, in having the anterior end slightly less produced, and the anterior muscular scar more deeply marked.

Locality and horizon.—Grand River region, below mouth of canyon of Eagle River (station 2192); base of Weber formation.

PLEUROPHORUS OCCIDENTALIS Meek and Hayden?

1858. *Pleurophorus occidentalis.* Meek and Hayden, Albany Inst., Trans., vol. 4, p. 80.
Permian: In Nebraska, on Missouri, opposite north Missouri boundary.

1859. *Pleurophorus occidentalis.* Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 396.
White Permian limestone: Guadalupe Mountains.

1864. *Pleurophorus occidentalis.* Meek and Hayden, Smithsonian Cont. Knowledge, vol. 14, No. 172, p. 35, pl. 1, figs. 11a, b.
Coal Measures: Nebraska, nearly opposite northern boundary of Missouri.

1866. *Clidophorus pallasi.* Geinitz, Carb. und Dyas in Nebraska, p. 23, tab. 2, fig 3, 4. (Not *Mytilus pallasi* de Vern., 1845.)
Upper Coal Measures: Nebraska City, Nebr., light gray limestone of Wyoming, 7 miles north of Nebraska City.

1866. *Clidophorus occidentalis.* Geinitz, Carb. und Dyas in Nebraska, p. 23, pl. 2, fig. 6.
Upper Coal Measures: Stage C. c^{iv}, Nebraska City, Nebr.

1872. *Pleurophorus occidentalis?* Meek, U. S. Geol. Surv. Nebraska, p. 212, pl. 10, fig. 12.
Upper Coal Measures: Otoe City, Nebr.; Nebraska City, Nebr.; Grayville, Ill.

1891. *Clidophorus occidentalis.* White, U. S. Geol. Surv., Bull. No. 77, p. 27, pl. 4, fig. 3.
Permian: Goodwin Creek, Baylor County, Tex.

Of this form but a single not too perfect example has come to hand, and it is identified with some doubt. It is small, with a width of about 11 mm. and a height somewhat less than half as great. The general shape much resembles the Nebraska shell which Meek figures as *Pl. occidentalis*, and with that species I have provisionally identified it. The dorsal and ventral margins are nearly straight and converge somewhat anteriorly. The posterior end is rather evenly rounded. The umbones are so much inclined forward that they project nearly as far as the small anterior portion. The curvature is regular, and there is no distinct umbonal ridge. About halfway between the cardinal line and a diagonal joining the anterior superior and posterior inferior angles there is a well-marked radial rib, with possibly traces of one or two others below (?). The surface is marked by very fine concentric striæ.

The cardinal edge is angulated as in the shell referred to *Pl. subcostatus*, so that a narrow strip of shell along the hinge line is horizontal when the valve is viewed from above.

Probably with this species belongs a very imperfect specimen from the Leadville region which was likewise identified as *Pl. occidentalis* for the Leadville monograph.[a] In general configuration it closely resembles the specimen previously described, but has the surface above the umbonal ridge (if one were present) crossed by five or six delicate radial ribs, with two or three others of equal strength below.

Locality and horizon.—San Juan region (station 2343); Rico formation. Leadville district (station 2275?); upper portion of the Weber formation.

EDMONDIA de Koninck, 1844.

Edmondia gibbosa Geinitz (non Astarte gibbosa McCoy).

Pl. IX, figs. 7, 8, 9.

1866. *Astarte gibbosa.* Geinitz, Carb. und Dyas in Nebraska, p. 16, tab. 1, figs. 23, 24.
Upper Coal Measures: In the gray limestone of Plattsmouth, Nebr.

There are in the collection several specimens representing a form to which that described by Geinitz as *Astarte gibbosa* McCoy, seems to be, among available literature, the nearest related. Characteristic specimens of this form are found in the Rico formation at stations 2340 and 2341, and it seems to be represented by several young examples at station 2342. The specimens collected at stations 2340 and 2342 are in the closest agreement, just as are those from the Hermosa formation at stations 2204 and 2205 which I have identified as *E. subtruncata.*

The Colorado material is in the form of internal casts, upon which a number of low concentric folds are all that is left of the surface sculpture, but in shape, convexity, etc., it agrees with some finely preserved specimens from Graham, Young County, Tex., which are referred with confidence to the same species. Here the shell is seen to be ornamented with prominent lamellose concentric ridges, regularly disposed at intervals, with more or less inconspicuous growth lines intervening. The shell is rather tumid, suborbicular in shape, with the posterior outline slightly flattened, giving it a subtruncate appearance.

This species differs from *Edmondia subtruncata*, which it resembles in a general way in shape and possibly in surface ornamentation. It is smaller, more gibbous, and longer in proportion to its width.

The fossils from Colorado and Texas correspond closely to Geinitz's figures and description, and probably represent the same form with which he was dealing, but it is doubtful if the latter was correctly referred by him to McCoy's species.

This identification should not be confused with *Edmondia gibbosa* Swallow, which is probably quite different.

Locality and horizon.—San Juan region (stations 2340, 2341, 2342?); Rico formation.

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[a] U. S. Geol, Surv., Mon., vol. 12, 1886, p. 70.

Edmondia mortonensis Geinitz?

1866. *Astarte mortonensis.* Geinitz, Carb. und Dyas in Nebraska, p. 17, tab. 1, fig. 26.
Upper Coal Measures: Nebraska City, Nebr.

1898. *Edmondia mortonensis.* Weller, U. S. Geol. Surv., Bull. No. 153, p. 243.

One specimen from Sinbads Valley (station 2285) is the only example of this species known in our Colorado collections. It presents many points of resemblance to the shell which Geinitz figures under the name of *Astarte mortonensis.* It is marked by strong, equally spaced lamellæ, whose course is straightened and subrectilinear posteriorly. My shell differs from that figured in being less elongated transversely.

Locality and horizon.—Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

Edmondia subtruncata Meek.

1872. *Edmondia subtruncata.* Meek, U. S. Geol. Surv. Nebraska, p. 215, pl. 2, fig. 7.
Upper Coal Measures: Rock Bluff, Nebraska; Atchison, Kans.
Lower Coal Measures: Illinois.

1895. *Edmondia subtruncata.* Keyes, Missouri Geol. Surv., vol. 5, p. 127. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1899. *Edmondia subtruncata?* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 580.
Upper Coal Measures: Atoka quadrangle.

Two specimens have come to hand, one collected between Hermosa Creek and Animas Valley (station 2205) and the other on the west side of Animas Valley (station 2204). They are unfortunately rather crushed, but seem to belong to the species above cited. These are large shells with a transverse diameter of at least 43 mm.

Locality and horizon.—San Juan region (stations 2204, 2205); upper portion of the Hermosa formation.

Edmondia? sp.

At station 2219, in the San Juan, occurs a rare but very interesting lamellibranch shell, which is unlike any that I have met with or seen recorded from our American Carboniferous faunas. Unfortunately, the five specimens in our collection are too imperfect to permit its generic affinities to be ascertained. It is probably no true representative of the genus *Edmondia.*

In size this shell is small, having a width of about 12 mm. and a height of 10 mm. The shape is similar to that of an *Edmondia* or a *Nucula.* It is strongly gibbous, the eccentric umbones are oblique, produced, and incurved. The general shape is transversely elliptical and the outline is curved. There is a strong emargination (of the outline) below the umbones on the side nearer the anterior end. The superior margin on the other side, or hinge line, is nearly straight. It begins with the tip of the umbone, and sloping downward gradually merges with the strong posterior curvature. The most elevated portion of the shell is central. It is bounded by two indistinct diverging lines, which have their origin at the umbone. From this area the curvature is rapid in its descent upon either side.

The surface is marked by strong, regular, concentric ridges, which are crenulate or denticulate over the body of the shell, but laterally the crenulations increase in prominence until they become continuous radiating ribs, and dominate the concentric markings of which they are elsewhere a subordinate feature.

The ornamentation and configuration of this shell taken together are unlike any Carboniferous genus with which I am acquainted. It is to be regretted that none of the hinge characters could be ascertained so as to determinate its generic position, and it is possible that better preserved material than that before me may lead to the modification even of the description which I have thus far been able to draw up.

Locality and horizon.—San Juan region (station 2219); upper portion of the Hermosa formation.

CYPRICARDINIA Lamarck, 1801.

Cypricardinia carbonaria Meek.

1871. *Cypricardinia? carbonaria.* Meek, Acad. Nat. Sci. Philadelphia, Proc., p. 163.
Lower Coal Measures: Newark, Ohio.

1875. *Cypricardinia? carbonaria.* Meek, Pal. Ohio, vol. 2, p. 342, pl. 19, figs. 8a, b.
Lower Coal Measures: Newark, Ohio.

1887. *Cypricardinia (?) carbonaria.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 35, pl. 4, figs. 17, 18.
Coal Measures: Flint Ridge, Ohio.

1895. *Pleurophorus oblongus.* Keyes, Missouri Geol. Surv., vol. 5, p. 125, pl. 46, fig. 8. (Date of imprint 1894.)
Upper Coal Measures: Kansas City, Mo.

1900. *Cypricardinia? carbonaria.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 164, pl. 20, fig. 16.
Upper Coal Measures: In the Oolite at Rosedale and Turner, Kans.

There are a few specimens from station 2219 south of Marguerite Draw in the San Juan which probably belong to Meek's species cited above. They also closely resemble the Waverly form *Cypricardinia scitula* of Herrick. If one can rely upon his figures, the specimen represented by fig. 8 of pl. 46, which Keyes identifies as *Pleurophorus oblongus* is a member of the genus *Cypricardinia* and possibly a representative of the species under discussion. It almost certainly is incorrectly identified as *Pl. oblongus.*

Locality and horizon.—San Juan region (station 2219); upper portion of the Hermosa formation.

ASTARTELLA Hall, 1858.

Astartella? gurleyi White.

1878. *Astartella gurleyi.* White, Acad. Nat. Sci. Philadelphia, Proc., p. 35.
Coal Measures: Danville, Ill.

1880. *Astartella gurleyi.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 166, pl. 42, figs. 6a–b.
Coal Measures: Danville, Ill.

A single specimen from the Rico formation, found at station 2343, seems to belong to *Astartella? gurleyi*, which it certainly closely resembles in configuration. I think it highly probable that if the hinge characters of this species were known, it would be found to belong to the genus *Microdon*.

Locality and horizon.—San Juan region (station 2343); Rico formation.

SCAPHOPODA.

DENTALIIDÆ.

Owing, doubtless, to their comparative rarity and unimportance, the Paleozoic Scaphopods have been recipient of less investigation than any other group of the Mollusca.

Although, upon the system of sculpture and upon the conformation of the tube, recent *Dentalia* have been divided into a number of subordinate or subgeneric groups, these divisions have not, it is believed, been applied to the fossil forms occurring in our American Paleozoics. Many of the characters employed in distinguishing the recent forms would be difficult to ascertain in the imperfect preservation usually seen in fossils, and one whole class of them, the posterior notches and slits not infrequently characterizing the more recent Dentaliidæ, have not been recorded as occurring in their Paleozoic representatives. The system of surface ornamentation, therefore, seems to afford the most available basis for subdivision, and among the Carboniferous forms two, and perhaps three, different types of surface ornamentation can be recognized; *a*, surface crossed by longitudinal ribs or striæ; *b*, surface crossed by transverse, usually oblique, annulations or striæ; *c*, surface smooth or with growth lines only.

For forms characterized by surface of the first type it seems clear that the name *Dentalium*, sensu stricto, should be employed. For shells having surface ornamentation of the second type the name *Plagioglypta* has recently been proposed. I am in doubt as to the propriety of referring shells of the third type to *Plagioglypta;* still more doubtful of the propriety of withdrawing them under a new name or of referring them to one of the genera or groups already established, as, for instance, to *Lævidentalium.* The distinction between striations and growth lines, if they have the same trend, is not always an easy one to maintain in practice with fossils, and when the vicissitudes of preservation are taken into the reckoning it seems that to distinguish the third type of surface from the second would be to rob the classification of much of its utility. Therefore I am at present disposed to refer species whose surface is smooth or marked simply by growth lines to *Plagioglypta.*

DENTALIUM (sensu stricto) Linnæus, 1740.

The species from American Carboniferous rocks which belong here are three in number. They are *Dentalium acutisulcatum*, *Dentalium missouriense*, and *Dentalium sublæve.*

DENTALIUM SUBLÆVE Hall.

1858. *Dentalium obsoletum.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 724, pl. 29, figs. 16, 17, 17a. Coal Measures.

1877. *Dentalium sublæve.* Hall, Miller's Am. Pal. Foss., p. 244.

1891. *Dentalium sublæve.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 252. Lower Coal Measures: Des Moines, Iowa.

Three different localities have furnished each a poor specimen of a *Dentalium* which probably all belong to the same species. I have identified them with some hesitancy with *Dentalium sublæve.* Hall's brief description leaves the reader in ignorance of many characters of prime importance, and his figures yield but little additional to his description. The surface represented by the principal figures seems to be crossed by a large number of fine, closely arranged, longitudinal striæ, but the enlarged ornamentation shown by him consists of sharp, slender ridges, separated by intervals two or three times their own width. If the enlargement is veracious, the Colorado form is certainly not *Dentalium sublæve*, which is then probably the same as *D. acutisulcatum*, described not long since by Gurley.[a]

The shell from Colorado is rather large and massive. It has a maximum diameter of about 7 millimeter, tapers gradually, and is slightly curved. The surface is marked by numerous rather closely set, not very prominent, ribs, which are separated by shallow grooves of about the same width as the striæ. There seem to be about 10–15 striæ in a space of 5 mm. Rather strong oblique growth lines are also visible.

This species is possibly the same as one which occurs in the Cisco division of the Carboniferous, near Graham, Young County, Tex. The two species are very similar, but the Texas form is practically straight, while that from Colorado is slightly bent. The Texas form, when mature, becomes large and heavy, attaining a length of some 250 or 300 mm., and is the one mentioned below as similar to *Dentalium* sp.

[a] New Carb. Foss., Bull. No. 1, p. 7, 1883.

Thus it is possible that *Dentalium* sp. and this form referred to *D. sublæve* may prove to be the same.

Locality and horizon.—San Juan region (stations 2219, 2238); upper portion of the Hermosa formation. Crested Butte district (station 2303); Maroon formation.

DENTALIUM sp.

At station 2287, in the southern portion of the Silverton quadrangle, occur rather plentiful fragments of an organism which, though not altogether problematical, is none the less interesting. I have little doubt that it is a *Dentalium* of an unusually large size. The largest fragment is 85 mm. long and not less than 20 mm. in diameter. As the shell substance is in places at least 8 mm. thick, the complete diameter of this portion of the shell was probably 25 or 30 mm. The fragment shows but little taper, and the shell must have been, when entire, of almost unexampled size and massiveness. The central portion, where exposed to view, is unchambered, and the shell can not, therefore, be an orthoceratoid, unless the fragment represents only the chamber of habitation. The microscopic structure is distinctly molluscan and agrees especially with *Dentalium*. In the Cisco division of the Carboniferous, near Graham, Young County, Tex., an equally large *Dentalium*, of a possibly undescribed species, is found. A single incomplete specimen of this form measures 200 mm. in length, and other shorter pieces of larger size indicate that it must have attained a length of 300 mm. and more. The diameter of these large fragments is upward of 30 mm. and the shell is 4 or 5 mm thick. There is no doubt about the affinities of the Texas form, whose existence relieves a reference to *Dentalium* of the specimen from Colorado of most of its incredible features.

Locality and horizon.—San Juan region (station 2287); middle portion of the Hermosa formation.

PLAGIOGLYPTA Pilsbry, 1900.

To *Plagioglypta* belong, probably, all the other American Carboniferous *Dentalia* known up to the present time. Among these species two, and possiby three groups are distinguishable, the *annulistriata* group, the *meekiana* group, and the *venusta* group.

Unique among our Carboniferous *Dentalia* in the strength of its annular markings stands Meek and Worthen's species, *Plagioglypta annulistriata*. It is too marked a form to require comment here, and is the only representative of the *annulistriata* group, to which it lends its name. Much finer and less conspicuous are the striæ which traverse *Plagioglypta meekiana*, yet still distinct enough to give character to its surface. With *Pl. meekiana* in the *meekiana* group can probably be associated *Pl. primaria*, *Pl. canna*, *Pl. grandæva*, and *Pl. granvillensis*. As *Pl.*

grandæva and *Pl. granvillensis* have not been figured at all, nor the surface of *Pl. primaria*, it is impossible to form a just estimate of this character or of their affinities. *Pl. granvillensis* may belong in the *annulistriata* group. The two other species probably go with *Pl. meekiana.* I am in some slight uncertainty as to the proper location of *Pl. canna.* If it is marked by longitudinal striæ, as White's description states, it belongs without doubt to *Dentalium*, but in the type specimen there are no indications of such striæ which are not so faint and so occasional that they might not be due to chance or to expectant imagination. As the transverse growth lines are clearly preserved in one specimen, it would seem that the longitudinal markings also, if present, would be visible. For this reason I place *Dentalium canna* with *Plagioglypta* in the *meekiana* group.

Plagioglypta venusta and *Pl. illinoisensis* are described as having a smooth surface, and constitute what may be desirable to separate as a distinct subdivision and designate the *venusta* group. At the famous Spergen Hill locality occurs in some abundance a dentalioid shell, probably *Pl. venusta*, whose surface appears to be entirely without markings. Whether its characters have been obscured or destroyed by attrition or fossilization I find myself at present unable to decide.

The surface of *Pl. annulistriata* is in strong contrast to that of *Pl. meekiana*, although the difference is one of degree merely. Intermediate between them in this particular stands *Pl. undulata*, the type of *Plagioglypta*, and Dr. Pilsbry, whom I have had the honor to consult in this matter, advises me that, according to its original extension, both Carboniferous forms can be admitted into his genus.

It still remains a debatable question what should be done with the *venusta* type. It certainly does not appear to have the characters of *Plagioglypta*, much less of *Dentalium*, and if what is recorded of this species and of *Pl. illinoisensis* is veritable, neither can properly be admitted into either of these genera. It is doubtful if *Lævidentalium* ranges back into Paleozoic time, and it therefore seems inadvisable to place them with that genus. Perhaps the course open to the least objection is to refer them as a separate and doubtful subdivision to *Plagioglypta* pending the absence of determinative data.

GASTEROPODA.

EUCONISPIRA Ulrich, 1897.

Euconispira taggarti Meek.

Pl. X, figs. 9, 9a.

1874. *Pleurotomaria taggarti.* Meek, U. S. Geol. Geog. Surv. Terr., [Seventh] Ann. Rept., for 1873, p. 231.

Carboniferous: Canyon of Four-Mile Creek, Colorado.

1880. *Pleurotomaria taggerti.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 140, pl. 34, figs. 1a, b.

Carboniferous: Near Horseshoe Mountain, South Park, Colo.

Of this species our collections from Colorado still contain only the specimen for which the name *Pleurotomaria taggarti* was originally proposed. It scarcely seems necessary at this place to repeat Meek's excellent description, but the figures published by White are shown on Pl. X.

Locality and horizon.—Leadville district (station 2281); base of the Weber formation.

EUCONISPIRA BICARINATA McChesney.

1860. *Pleurotomaria bicarinata.* McChesney, Desc. New Spec. Pal. Foss., p. 90. (Not *P. bicarinata* Sowerby, 1818.)
Coal Measures: Lasalle, Ill.

1860. *Pleurotomaria turbiniformis.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 461.
Upper Coal Measures: Lasalle, Ill.

1866. *Pleurotomaria turbiniformis.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 359, pl. 28, figs. 8a–c.
Upper Coal Measures: Lasalle, Ill.

1884. *Pleurotomaria turbiniformis.* White, Geol. Surv. Indiana, 13th Rept., p. 160, pl. 32, figs. 7, 8.
Upper Coal Measures: Lasalle and Paris, Ill.; Vigo County, Ind.

1894. *Pleurotomaria turbiniformis.* Keyes, Missouri Geol. Surv., vol. 5, p. 135, pl. 48, figs. 6a, b.
Upper Coal Measures: Kansas City, Mo.

1897. *Euconispira turbiniformis.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, pp. 949, 956, figs. d, e, on p. 1080.
Upper Carboniferous: Kansas City, Mo.

Of this species we have a single specimen from the Hermosa formation which is not very perfect but shows sufficient characters to make possible a specific determination of considerable accuracy. After a comparison with authentic specimens of *Pleurotomaria turbiniformis* from the original locality, the conclusion has been reached that the two forms are with but little doubt identical.

Meek noted that his name *Pl. turbiniformis* had been proposed for the same species as *Pl. bicarinata* McChesney, which antedates it by several months, but his reason for retaining *Pl. turbiniformis*, that the name *Pl. bicarinata* is thrice preoccupied, is invalidated by the removal of that species to another genus.

Locality and horizon.—San Juan region (station 2196b); Hermosa formation.

EUCONISPIRA sp. *a*.

This form in size and configuration very closely resembles *Eu. bicarinata*, but several differences can be pointed out which indicate that it should be considered a distinct species. The single specimen representing it was obtained from the red sandy beds of the Rico formation. The surface ornamentation is almost entirely obscured, but there are in places certain markings, which may be accidental, that might be interpreted as indicating that the surface was traversed by a small number of rather coarse revolving ridges. The underside of the shell, moreover, is somewhat strongly concave, while that of *Eu. bicarinata* is generally convex

Locality and horizon.—San Juan region (station 2340); Rico formation.

EUCONISPIRA sp. *b*.

This species is derived from the same locality and horizon as the preceding. It attains a rather large size, and is distinguished from the other members of the genus noted here by the lowness of its spire and the rapidity of its expansion. The largest specimen seen has a diameter of 45 mm. One whose diameter is 28 mm. has a height of probably not over 15 mm. The base is concave. The surface ornamentation is entirely obscured.

Locality and horizon.—San Juan region (station 2340); Rico formation.

PHANEROTREMA Fischer, 1885.

PHANEROTREMA cf. GRAYVILLENSE Norwood and Pratten.

1855. *Pleurotomaria grayvillensis.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 75, pl. 9, figs. 7a, b.
Coal Measures: Grayville, Ill.; near mouth of Rush Creek, Posey County, Ind.; Shawneetown and Galatia, Ill.

1866. *Pleurotomaria grayvillensis.* Geinitz, Carb. und Dyas in Nebraska, p. 9, tab. 1, fig. 9.
Upper Coal Measures: Nebraska City, Nebr.

1872. *Pleurotomaria grayvillensis.* Meek, U. S. Geol. Surv. Nebraska, p. 233, pl. 11, fig. 9.
Upper Coal Measures: Nebraska City, Nebr.; Illinois, Kentucky, Iowa, Missouri, Kansas.
Lower Coal Measures: Illinois and West Virginia.

1879. *Pleurotomaria grayvillensis.* White, U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, p. 219.
Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south from Pipe Spring.

1880. *Pleurotomaria grayvillensis.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 140, pl. 34, fig. 5a.
Upper Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south from Pipe Spring.

1888. *Pleurotomaria grayvillensis.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 238.
Lower Coal Measures: Des Moines, Iowa.

1895. *Pleurotomaria grayvillensis.* Keyes, Missouri Geol. Surv., vol. 5, p. 141 (date of imprint 1894).
Lower Coal Measures: Kansas City and Pleasant Hill, Mo.

1897. *Phanerotrema grayvillense.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, p. 952.

This species is represented by two small shells resembling *Phanerotrema grayvillense*, but they are too poorly preserved to be determined with certainty. They form the basis for the appearance of *Pleurotomaria grayvillensis* in the faunal list of the Leadville monograph.[a]

Locality and horizon.—Leadville district (station 2275); upper portion of the Weber formation.

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[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 70.

PHANEROTREMA sp.

Near Glenwood Springs, at station 2193, a small collection was obtained which indicates the presence at that place of an interesting and extensive fauna. The fossils are chiefly gastropods and are of very minute size. As I have indicated, the fauna, if carefully collected, would probably prove an extensive one. It would also be difficult to study. As the entire shell is very small, the surface ornamentation is almost microscopic, and, unless well preserved, can not satisfactorily be made out. Fortunately the preservation at this locality is generally good. I have discriminated about six species in the material collected and suspect that there may be several others. Without doubt these represent only a small proportion of the entire fauna. I have found it sufficiently difficult to arrive at approximate determinations of these species, to believe that many of them are new. No new names have been proposed, however, because it seems that a miniature fauna, such as this is, should be studied only from especially abundant and especially perfect material.

One of the most abundant types among the gasteropods is a little *Phanerotrema* which is related to *Ph. grayvillense* and *Ph. constrictum.* Many species of this group have been considered, but none with which this can be satisfactorily identified. The height is between 3 and 4 mm., and the diameter nearly the same. The height of the spire is 2 mm., or a little over. There are about 4 volutions. The lower portion of the outer whorl is marked by a number of comparatively large striæ, which also transgress upon the flattened periphery. This striated portion is succeeded by a broad, flat slitband whose direction is nearly vertical. Above the slitband is a carina which constitutes the most prominent portion of the entire peritreme. It is probably somewhat nodose. The upper portion of the peritreme declines from the vertical by an angle of about 45°. It is slightly concave and appears to be without ornamentation. Just below the suture is a row of small nodes or possibly a nodose revolving ridge. Most of the striæ marking the lower portion of the peritreme are of course covered over by the succeeding volution, but a few of the upper ones are left exposed.

Locality.—Grand River region, Glenwood Springs (station 2193).

WORTHENIA de Koninck, 1883.

WORTHENIA TABULATA Conrad?

1835. *Turbo tabulata.* Conrad, Geol. Soc. Pennsylvania, Trans., vol. 1, pt. 2, p. 267, pl. 12, fig. 1.

1842. *Pleurotomaria tabulata.* Conrad, Acad., Nat. Sci. Philadelphia, Jour., (1), vol. 8, p. 272.
Carboniferous: Inclined plane of the Allegheny Mountains.

1858. *Pleurotomaria tabulata.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 721, pl. 29, figs. 12a, b.
Coal Measures: Pennsylvania, Indiana, and Illinois.

1881. *Pleurotomaria tabulata.* White, Dept. Stat. and Geol. Indiana, 2d Ann. Rept., p. 519, pl. 18, figs. 4, 5.
Coal Measures: Rush Creek, Posey County, Ind.

1884. *Pleurotomaria tabulata.* White, Geol. Surv. Indiana, 13th Rept., p. 160, pl. 32, figs. 4, 5.
Upper Coal Measures: Rush Creek, Posey County; Wagon-defeat Creek, Sullivan County, and Warrick County, Ind.

1895. *Pleurotomaria tabulata.* Keyes, Missouri Geol. Surv., vol. 5, p. 142. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1897. *Worthenia tabulata.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, pp. 949, 950, 953.

This type is represented by a single specimen from Sinbads Valley. It is reduced nearly to the condition of an internal cast, but probably can be referred to Conrad's species.

Locality and horizon.—Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

WORTHENIA? LASALLENSIS Worthen?

1890. *Murchisonia lasallensis.* Worthen, Geol. Surv. Illinois, Rept., vol. 8, p. 141, pl. 25, figs. 7, 7a.
Upper Coal Measures: Lasalle, Ill.

In using for this form the name of Worthen's species, I desire to indicate a resemblance rather than to express an identification, for the single specimen which has so far come to hand is too poor to permit a determination of that degree of accuracy. The surface ornamentation is entirely obscured, but the shape and size are those of *Murchisonia lasallensis.* It might almost as well be referred to *Murchisonia terebra* White, but it is a smaller form with deeper indented sutures.

This species has been placed with the genus *Worthenia* because of its configuration alone. It is certainly not a *Murchisonia*, and while it departs somewhat widely from the type represented by the species *tabulata* and *subscalaris*, the range is no greater than that shown by the related genus *Lophospira.* As already intimated, I have not been able to examine representatives of this species in which the essential generic characters are shown.

Locality and horizon.—San Juan region (station 2217); middle portion of the Hermosa formation.

WORTHENIA? MARCOUIANA Geinitz?

1866. *Murchisonia marcouiana.* Geinitz, Carb. und Dyas in Nebraska, p. 11, tab. 1, fig. 16.
Upper Coal Measures: Rock Bluff, Nebr.

1899. *Murchisonia marcouiana.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 588.
Upper Coal Measures: McAlester quadrangle, Indian Territory.

The form which I have referred to *Worthenia marcouiana* seems to be abundant in the Rico formation at stations 2340 and 2345. The condition of preservation of my material does not favor an identification of the greatest accuracy.

At station 2275, in the upper part of the Weber grits in the Tenmile district, occurs a specimen which probably answers to *Murchisonia* sp. in the list of the Leadville monograph.[a] It seems to belong to this species.

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[a] U. S. Geol. Surv., Mon., vol. 12, p. 70.

I have placed *Murchisonia marcouiana* in the genus *Worthenia* with some hesitation. It clearly belongs to the group of *Pleurotomaria*, and is more nearly related to *Worthenia* than it is to *Murchisonia*.

Locality and horizon.—San Juan region (stations 2340, 2345); Rico formation. Leadville district (station 2275); upper portion of the Weber formation.

WORTHENIA? sp. *a*.

This form was identified as *Murchisonia* sp. in the list of the Leadville monograph,[a] and it is too poorly preserved to be determined with certainty. Even its generic position is a matter of doubt. It is one of those forms with a lofty spire and very gradual taper. Its dimensions must have been 24 mm. in height, with a proximal diameter of about 8 mm. The peritreme appears to have been carinated, and I judge that its specific relations are near the two species just discussed.

Locality and horizon.—Leadville district (station 2275); upper portion of the Weber formation.

WORTHENIA? sp. *b*.

This form is allied to the species which Geinitz[b] described under the name of *Murchisonia nebraskensis*, but it is certainly specifically distinct. It is much smaller, as will appear from the fact that the entire height is only about 2 mm. The width is nearly half as much, and there are 6 volutions. It has therefore proportionally a somewhat lower spire than *M. nebraskensis*, and the sutures are less oblique to the axis. The shape of the peritreme is strongly arched but not subangular. The surface of the final volution is crossed by four thin elevated ridges, which are about equal distances apart. The upper one is near the suture, but the others are disposed very much as in *M. nebraskensis*. The lower side of the peritreme is crossed by several revolving ridges, which are less prominent than the ones above. While there are four of the latter on the final volution, there are but three on that which precedes it.

I am by no means sure that this form possessed a slit band and its position with the Pleurotomariidæ is therefore uncertain. If this structure is really present it probably occurs on the periphery between the two lower strong revolving ridges. Even if it belongs to *Pleurotomaria*, however, I am doubtful whether it should be referred to the genus *Worthenia*.

Locality.—Grand River region, Glenwood Springs (station 2193).

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[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 70.

[b] Carb. und Dyas in Nebraska, 1866, p. 12, pl. 1, fig. 17

PLEUROTOMARIA Defrance, 1824.

Pleurotomaria? cf. carbonaria Norwood and Pratten.

1855. *Pleurotomaria carbonaria.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 75, pl. 9, fig. 8.
Coal Measures: Rockcreek, Williamson County, Ill.

1888. *Pleurotomaria carbonaria.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 239.
Lower Coal Measures: Des Moines, Iowa.

1891. *Pleurotomaria carbonaria.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 253.
Lower Coal Measures: Des Moines, Iowa.

1891. *Pleurotomaria harii.* Miller, Geol. Surv. Indiana, Adv. Sheets, 17th Rept., p. 83, pl. 14, figs. 3, 4.
Upper Coal Measures: Kansas City, Mo.

1892. *Pleurotomaria harii.* Miller, Geol. Surv. Indiana, 17th Rept., p. 693, pl. 14, figs. 3, 4.
Upper Coal Measures: Kansas City, Mo.

1895. *Pleurotomaria carbonaria.* Keyes, Missouri Geol. Surv., vol. 5, p. 138. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1896. *Pleurotomaria harii.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 40.
Lower Coal Measures: Conway County, Ark.

1896. *Pleurotomaria harii.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 250.
Lower Coal Measures: Conway County, Ark.

This shell, of which we have one specimen only, is so small that it seems almost grotesque to compare it with the robust species mentioned above. It has, nevertheless, much the proportions and markings of *Pl. ? carbonaria* and *Pl. ? beckwithiana*. It is a somewhat more depressed type than either of those mentioned, but in the relative coarseness of its striæ it can be compared with the former species rather than with the latter. The height is about 0.5 mm. and the diameter possibly a trifle greater. There are three volutions. The peritreme is highly and regularly convex and marked by a number of subequal revolving striæ which are somewhat finer and more crowded on the lower than on the upper portion of the peritreme. The slit band appears to be situated about medially.

Locality.—Grand River region, Glenwood Springs (station 2193).

ACLISINA de Koninck, 1881.

Aclisina stevensiana Meek and Worthen?

1866. *Turritella ? stevensana.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 382, pl. 27, figs. 8–8a.
Upper Coal Measures: North Branch Saline Creek, Gallatin County, Ill.

1895. *Aclisina stevensana.* Keyes, Missouri Geol. Surv., vol. 5, p. 202. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

One of the species occurring in the gasteropod fauna found near Glenwood Springs is an elongate, turreted shell with three or four revolving striæ, which closely resembles *Aclisina stevensiana* Meek and Worthen. We have only a few not very perfect examples of this species and all of its characters can not be made out. The height of one specimen is about 2 mm., and the greatest diameter about 0.75 mm. This specimen has 6 whorls.

Locality.—Grand River region, Glenwood Springs (station 2193.)

LOXONEMA Phillips, 1841.

LOXONEMA PARVUM Cox?

1857. *Chimnitzia parva.* Cox, Geol. Surv. Kentucky, vol. 3, p. 567, pl. 8, figs. 3, 3a
Coal Measures: Daviess County, Ky.

1898. *Loxonema parvum.* Weller, U. S. Geol. Surv., Bull. No. 153, p. 335.

This is a pretty little species, but we have of it only a single specimen. The length is somewhat over 2 mm. and the greatest diameter about 1 mm. The volutions are 6 in number, the rate of expansion is rather rapid, and the final volution at the aperture makes up about one third the full length of the shell. The ornamentation consists of moderately strong longitudinal costæ, of which there are about 11 on one side of the volution next the last. The aperture is rather large.

This shell in size, shape, and ornamentation is very similar to Cox's species, *Loxonema parvum.* It differs in having the sutures between the volutions more nearly horizontal, and in the fact that the volutions themselves instead of being convex are much flattened.

Locality and horizon.—Grand River region, Glenwood Springs (station 2193).

LOXONEMA PLICATUM Whitfield.

1882. *Loxonema plicatum.* Whitfield, New York Acad. Sci., Ann., vol. 2, p. 231.
Coal Measures: Carbon Hill, Hocking County, Ohio.

1891. *Loxonema plicatum.* Whitfield, New York Acad. Sci., Ann., vol. 5, p. 601, pl. 15, figs. 14, 15.
Coal Measures: Carbon Hill, Hocking County, Ohio.

1895. *Loxonema plicatum.* Whitfield, Geol. Surv. Ohio, Rept., vol. 7, p. 486, pl. 11, figs. 14, 15.
Coal Measures: Hocking County, Ohio.

The two not very perfect specimens which I have referred to *Loxonema plicatum* are certainly nearly related to Whitfield's species, even if not specifically identical with it, as is believed probable. They much resemble in shape the form which I identified as *Loxonema peoriense*, but even as internal casts preserve traces of the characteristically notched or rugose surface ornamentation.

Locality and horizon.—San Juan region (stations 2342, 2344); Rico formation.

LOXONEMA? PEORIENSE Worthen.

Pl. X, fig. 8.

1884. *Loxonema peoriense.* Worthen, Illinois State Mus. Nat. Hist., Bull. No. 2, p. 7.
Coal Measures: Peoria County, Ill.

1890. *Loxonema peoriense.* Worthen, Geol. Surv. Illinois, Rept., vol. 8, p. 139, pl. 23, figs. 10, 10b.
Coal Measures: Peoria County, Ill.

This form has been found at two localities in the Rico formation, stations 2345 and 2342, at the latter of which it is fairly common. The Colorado specimens are closely similar to Worthen's species and are probably identical. *Loxonema? peoriense* is so different in the character of its surface ornamentation from at least our American Carboniferous representatives of *Loxonema* as to suggest that its affinities are elsewhere, possibly with *Streptacis* Meek.

Locality and horizon.—San Juan region (stations 2342, 2345); Rico formation.

Loxonema sp.

The only specimen representing this species is unfortunately very imperfect. It seems to be a rare form, more nearly related to *Loxonema halli* Norwood and Pratten than to any with which I am acquainted.

Locality and horizon.—Leadville district (station 2275); upper portion of the Weber formation.

PLATYCERAS Conrad, 1840.

Platyceras parvum Swallow.

Pl. X, figs. 1, 1a, 2, 2a.

1858. *Capulus parvus.* Swallow, Acad. Sci., St. Louis, Trans., vol. 1, p. 205.
Coal Measures: Valley of the Verdigris, Kans.

1872. *Platyceras nebrascensis.* Meek, U. S. Geol. Surv. Nebraska, p. 227, pl. 4, figs. 15a, b.
Upper Coal Measures: Three-fourths of a mile west of Nebraska City Landing, Nebr.
Middle Coal Measures: Illinois.

1875. *Platyceras nebrascense.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 159, pl. 12, figs. 5a–d (Whole volume published in 1877.)
Carboniferous: Near Santa Fe, N. Mex.

1884. *Platyceras nebrascene.* White, Geol. Surv. Indiana, 13th Rept., p. 159, pl. 32, figs. 15, 16.
Coal Measures: Eugene, Edwardsport, and New Harmony, Ind.

1890. *Capulus parvus.* Keyes, Am. Geol., vol. 6, p. 9.

1890. *Capulus parvus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 177, pl. 2, figs. 14a–c.
Upper Coal Measures: Indiana; Iowa; Nebraska; Kansas; and New Mexico.

1895. *Capulus parvus.* Keyes, Missouri Geol. Surv., vol. 5, p. 180, pl. 54, figs. 5a, b. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

Only two specimens in the collections were found representing this species, but one of them is the largest individual I have ever seen belonging to it. It measures no less than 35 mm. across the base, and its longest diameter is 47 mm.

Keyes places *Platyceras nebraskense* Meek in the synonymy of *Capulus parvus* Swallow. Swallow's description seems to apply to *Platyceras nebraskense*, and the figures given by Keyes of a specimen supposed to be the type of *Pl. parvum* certainly look as if the original might have been a young example of Meek's species. On the other hand, we have the statement by Meek, "This species resembles more or less nearly several of those described from different horizons in the Western States, but after a critical comparison I have been unable to identify it with any of them." It is, therefore, with hesitation that I adopt the synonymy suggested by Keyes. My reasons for using the generic term *Platyceras* instead of *Capulus* will be found stated on a previous page of this report.

Locality and horizon.—San Juan region (stations 2218, 2279); lower and upper portions of the Hermosa formation.

STROPHOSTYLUS Hall, 1859.

Strophostylus cf. nanus Meek and Worthen

1860. *Platyostoma nana.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 463.
Upper Coal Measures: Springfield, Ill.

1861. *Naticopsis nana.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 148.

1866. *Naticopsis nana.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 365, pl. 31, figs. 4a, b.
Upper Coal Measures: Springfield, Ill.

1875. *Naticopsis nana.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 159, pl. 12, figs. 4a, b. (Whole volume published in 1877.)
Carboniferous: Camp Cottonwood, near Spring Mountain, Lincoln County, Nev.

1884. *Naticopsis nana.* White, Geol. Surv. Indiana, 13th Rept., p. 162, pl. 36, figs. 6, 7.
Middle and Upper Coal Measures: Indiana.

1888. *Naticopsis nana.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 4, pl. 11, fig. 8.
Coal Measures: Fultonham, Ohio.

1891. *Naticopsis nana.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 257.
Lower Coal Measures: Des Moines, Iowa.

1895. *Strophostylus nana.* Keyes, Missouri Geol. Surv., vol. 5, p. 196. (Date of imprint, 1894.)
Upper Coal Measures: Clinton and Kansas City, Mo.

1896. *Naticopsis nana.* Smith, Leland Stanford Junior Univ. Publ.; Cont. Biol. Hopkins Seaside Lab., No. 9, p. 40.
Upper Coal Measures: Sebastian County, Ark.

1896. *Naticopsis nana.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 250.
Upper Coal Measures: Sebastian County, Ark.

This little form probably finds its closest American ally in *Strophostylus nanus* Meek and Worthen, which, though itself a small species, is fairly gigantic when compared with its Colorado relative. The latter rarely exceeds 2 mm. in height, but in configuration it greatly resembles the larger shell. The spire is depressed. There are three volutions, increasing rapidly in size, but the final one is probably not as inflated as in typical *S. nanus*.

Locality and horizon.—Grand River region, Glenwood Springs (station 2193).

Strophostylus subovatus Worthen?

Pl. X, figs. 3, 3a.

1873. *Naticopsis subovatus.* Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 595, pl. 28, fig. 9.
Upper Coal Measures: Lasalle, Ill.
1898. *Strophostylus subovatus.* Weller, U. S. Geol. Surv., Bull. No. 153, p. 615.

This identification is based upon a single specimen, which is distinguished from *St. remex* by its lower spire and more rapidly enlarging volutions. It is much smaller than fully grown *St. subovatus*, but resembles it in shape closer than any other form with which I am acquainted.

Locality and horizon.—San Juan region (station 2217?); middle portion of the Hermosa formation.

Strophostylus remex White.

Pl. X, figs. 4, 4a, 5 to 5b.

1876. *Naticopsis remex.* White, Powell's Rept. Geol. Uinta Mountains, p. 109.
Lower Aubrey group: Confluence of Grand and Green rivers, Utah.
1880. *Naticopsis remex.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 139, pl. 34, fig. 6a.
Middle Carboniferous: Confluence of Grand and Green rivers, Utah.
1883. *Naticopsis remex.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 391, pl. 34, fig. 6a.
Middle Carboniferous: Confluence of Grand and Green rivers, Utah.
1891. *Naticopsis remex.* White, U. S. Geol. Surv., Bull. No. 77, p. 24, pl. 3, fig. 10.
Permian: Military Crossing and Goodwin Creek, Baylor County, Tex.
1895. *Strophostylus remex.* Keyes, Missouri Geol. Surv., vol. 5, p. 197, pl. 55, figs. 7a, b. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

This form occurs in the Rico formation at station 2345 and is abundant at station 2340. An imperfect specimen from the Leadville region (station 2273) seems to belong to this species. Some of the smaller individuals approach *St. nanus.*

Locality and horizon.—San Juan region (stations 2340, 2345); Rico formation. Leadville district (station 2273); Robinson limestone.

NATICOPSIS McCoy, 1844.

Naticopsis altonensis McChesney.

1865. *Natica altonensis.* McChesney, Illustrations New Spec. Foss., pl. 2, figs. 14a, b.
Coal Measures: Alton, Ill.
1868. *Naticopsis altonensis.* McChesney, Chicago Acad. Sci., Trans., vol. 1, p. 50, pl. 2, figs. 14a–c.
Coal Measures: Alton, Ill.

1873. *Naticopsis altonensis.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 595, pl. 28, figs. 11a, 11b. (Naticopsis altonensis? on description of plates.)

Coal Measures: Macoupin County, Ill.

1881. *Naticopsis altonensis.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Supp., Appendix, p. xxxv, pl. 3, fig. 6a.

Carboniferous: Near Taos, N. Mex.

Only four specimens have been referred to this species, and they are, unfortunately, in an imperfect condition. One of them, from station 2223, in the Rico quadrangle, closely resembles the elongate shell upon which the original description was based. It is, however, considerably larger, having a length of not less than 55 mm., and possibly belongs to the variety which Meek and Worthen figured under the varietal name of *giganteus.*[a] Another shell, from station 2340 in the same area, is more compact and has the shape depicted by Meek and Worthen's figures 11a and 11b, which they identify as *N. altonensis?* It is about the size of the specimen represented by these figures and is smaller than the example previously mentioned.

Two shells from Sinbads Valley, whose mutual relations are not quite certain, have been doubtfully identified with *N. altonensis.* They are internal casts, not very perfect at that, and their real affinities are obscure. It is possible that one of them may be a *Soleniscus*, related to *S. ponderosus.*

Locality and horizon.—San Juan region (stations 2223, 2340); middle portion of the Hermosa formation and in the Rico formation. Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

Naticopsis monilifera White.

1880. *Naticopsis monilifera.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 168, pl. 42, figs. 3a–c.

Upper Coal Measures: Pleasant Hill, Cass County, Mo.

1881. *Naticopsis monilifera.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, Supp., Appendix, p. xxxiv, pl. 3, figs. 3a–d.

Carboniferous: Near Taos, N. Mex.

1895. *Pleurotomaria monilifera.* Keyes, Missouri Geol. Surv., vol. 5, p. 144. (Date of imprint, 1894.)

Upper Coal Measures: Pleasant Hill and Kansas City, Mo.

My specimens are so much exfoliated as to be reduced almost to the condition of internal casts. The beaded ornamentation on the upper portion of the peritreme near the suture line is plainly visible, but otherwise, from such evidence as is available, I judge that the surface was without ornamentation. In general conformation these specimens are in the closest agreement with White's figures and descriptions, and as they also agree with the specimen from Taos, N. Mex., which he figures as *N. monilifera*, it is with little hesitation that they are referred to that species.

[a] Geol. Surv. Illinois, Rept., vol. 5, 1873, pl. 28, figs. 12a, 12b.

Although the shell, aside from the ornamental feature just mentioned, appears to be plain, yet, thinking that such characters might be obscured by the exfoliated condition which prevails, I at first identified these specimens as *Pleurotomaria? spironema* M. and W. They much resemble that species in shape, and might readily be mistakenly referred to it in their present condition. My material was compared with exfoliated specimens of *Pl.? spironema* from Menard County, Ill. (identification by Worthen), and close agreement was found. The one fairly constant character that I can point out is that in *Pl.? spironema* the beading is stronger and more elongate in a direction perpendicular to the suture.

Keyes places this species with *Pleurotomaria* because he thinks that some time it will be shown to possess a slit band, though the type specimen seems to be without that character. I do not see, however, that matters are improved by this course, as a *Pleurotomaria* without a slit band is certainly more anomalous than a *Naticopsis* with a row of ornamental nodes. Accordingly I have replaced it with the genus to which it was ascribed by White.

Locality and horizon.—San Juan region (stations 2231, 2342, 2345); Hermosa and Rico formations.

EUOMPHALUS Sowerby, 1812.

Euomphalus catilloides Conrad.

1842. *Inachus catilloides.* Conrad, Acad. Nat. Sci. Philadelphia, Jour., (1), vol. 8, p. 273.
Coal Measures.

1858. *Euomphalus rugosus.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 722, pl. 29, figs. 14a–c.
Coal Measures: Illinois.

1866. *Serpula* (*Spirorbis*) *planorbites.* Geinitz, Carb. und Dyas in Nebraska, p. 3, tab. 1, fig. 6.
Upper Coal Measures: Nebraska.

1872. *Straparollus* (*Euomphalus*) *rugosus.* Meek, U. S. Geol. Surv. Nebraska, p. 230, pl. 6, figs. 5a, b pl. 11, figs. 4a, b.
Upper Coal Measures: Nebraska City, Rock Bluff, Aspinwall, and Cedar Bluff, Nebr.
Coal Measures: Kansas; Missouri; Iowa; Illinois.

1873. *Straparollus* (*Euomphalus*) *subrugosus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 607, pl. 29, fig. 11.
Coal Measures: Springfield, Ill.

1874. *Euomphalus rugosus.* Meek, Am. Jour. Sci., (3), vol. 7, p. 583.
Coal Measures: Illinois.

1884. *Euomphalus* (*Straparollus*) *subrugosus.* Walcott, U. S. Geol. Surv., Mon., vol. 8, p. 255, pl. 18, fig. 19.
Lower Carboniferous: Eureka district, Nevada.

1884. *Euomphalus rugosus.* White, Geol. Surv. Indiana, 13th Rept., p. 161, pl. 32, figs. 11, 12.
Coal Measures: Indiana.

1888. *Euomphalus rugosus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 241.
Lower Coal Measures: Des Moines, Iowa.

1891. *Straparollus catilloides.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 255.
Lower Coal Measures: Des Moines, Iowa.

1895. *Straparollus catilloides.* Keyes, Missouri Geol. Surv., vol. 5, p. 160. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.; Atchison, Kans.

There can be little doubt that the shell described by Hall as *Euomphalus rugosus*, and to which Meek and Worthen afterwards gave the specific name *subrugosus*, is the same for which Conrad had already proposed the name *Inachus catilloides*, a circumstance which was, I believe, first pointed out by Keyes. *Eu. catilloides* has been recognized at but three localities in Colorado and is represented by only four specimens in all.

Locality and horizon.—San Juan region (station 2333); middle portion of the Hermosa formation. Crested Butte district (station 2298); Maroon formation. Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

BULIMORPHA Whitfield, 1882.

BULIMORPHA CHRYSALIS Meek and Worthen.

Pl. X, figs. 6, 6a, 7, 7a.

1866. *Polyphemopsis chrysalis.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 267.
Lower Coal Measures: Hodges Creek, Macoupin County, Ill.

1873. *Polyphemopsis chrysalis.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 5, p. 596, pl. 28, fig. 7.
Coal Measures: Hodges Creek, Macoupin County, Ill.

1889. *Bulimorpha chrysalis.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 300.

1891. *Bulimorpha? chrysalis.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 264.
Lower Coal Measures: Des Moines, Iowa.

The form which has been referred to *B. chrysalis* is not abundant, and identification has not in every case been accomplished with complete satisfaction. Though slight differences have been observed, this species has been identified at stations 2342, 2345, and 2347, all of which are in the Rico formation. At station 2271, in the Leadville district, occurs a somewhat larger though otherwise very similar shell, which the faunal list of the Leadville monograph[a] suggests may belong to this species.

Locality and horizon.—San Juan region (stations 2342, 2345, 2347); Rico formation. Leadville district (station 2271).

SOLENISCUS Meek and Worthen, 1860.

SOLENISCUS cf. PALUDINIFORMIS Hall.

1858. *Macrocheilus paludinæformis.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 719, pl. 29, fig. 10.
Lower Coal Measures: Des Moines Valley, Iowa.

1884. *Soleniscus (Macrocheilus) paludinæformis.* White, U. S. Nat. Mus. Proc., vol. 6, p. 187, pl. 8, fig. 17.
Carboniferous: Indiana.

[a] U. S. Geol. Surv., Mon., vol. 12, 1886, p. 67.

1884. *Soleniscus* (*Macrocheilus*) *paludinæformis*. White, Geol. Surv. Indiana, 13th Rept., p. 154, pl. 34, fig. 17.
Coal Measures: Vermilion County, Ind.

1888. *Macrocheilus paludinæformis*. Herrick, Sci. Lab. Denison Univ., Bull., vol. 4, pl. 11, fig. 10.
Coal Measures: Fultonham, Ohio.

1889. *Soleniscus paludinæformis*. Keyes, Am. Nat., vol. 23, p. 423, pl. 20, fig. 16.

1889. *Soleniscus paludinæformis*. Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 308.

1891. *Soleniscus paludinæformis*. Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 262.
Lower Coal Measures: Des Moines, Iowa.

1895. *Soleniscus paludinæformis*. Keyes, Missouri Geol. Surv., vol. 5, p. 211. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

Of this species we have a single representative which, when complete, had a length of about 5 mm. There are 5 volutions visible, the lower one of which is inflated and comprises well-nigh two-thirds of the entire length. The spire is somewhat attenuated. In general character this shell is very close to *S. paludiniformis* Hall, especially the form figured by White under that name. Besides being very much smaller, however, the Colorado specimen is probably a trifle more slender and has a slightly higher spire.

Locality.—Grand River region, Glenwood Springs (station 2193).

Minute gasteropods.

At several stations collections were made consisting almost entirely of minute gastropods in sufficient abundance to give character to the strata. Although they are too imperfect to be identified, and no serious attempt to do so has been made, the circumstance is perhaps worthy of mention. At station 2213 in the Durango quadrangle and 2294 in the Crested Butte quadrangle they occur in chert bands and are quite numerous; at 2296, also in the Crested Butte, in a limestone conglomerate; at 2269, in the Leadville district, they are common, but not equally abundant. It is possible that station 2193, near Glenwood Springs, from which a number of minute gastropod forms have been obtained, is on the horizon of one or other of the stations above mentioned. The fossils from the former are in a fair state of preservation and have been provisionally identified with known species.

Locality and horizon.—San Juan region (stations 2212, 2213); lower and middle portions of the Hermosa formation. Crested Butte district (stations 2294, 2296); Maroon formation. Leadville district (station 2269); upper portion of the Weber formation.

BELLEROPHON Montfort, 1808, emend. Waagen, 1884.

Bellerophon crassus Meek and Worthen.

1860. *Bellerophon crassus.* Meek and Worthen, Acad. Nat. Sci. Philadelphia, Proc., p. 458.
Lower Coal Measures: Pittsburg, St. Clair County, Ill.

1866. *Bellerophon crassus.* Meek and Worthen, Geol. Surv. Illinois, Rept., vol. 2, p. 385, pl. 31, figs. 16a, b.
Lower Coal Measures: Pittsburg, St. Clair County, Ill.

1875. *Bellerophon crassus.* White, U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 4, p. 157, pl. 12, fig. 1a. (Whole volume published in 1877.)
Carboniferous: Camp Cottonwood, near Spring Mountain, Nev.

1884. *Bellerophon crassus.* White, Geol. Surv. Indiana, 13th Rept., p. 157, pl. 33, figs. 1, 2.
Upper Coal Measures: Sullivan and Posey counties, Ind.

1886. *Bellerophon crassus* (var.)? Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 457.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Bellerophon crassus* (var.)? Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 277.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1887. *Bellerophon* (cf. *crassus*).—Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 20, pl. 5, fig. 6.
Coal Measures: Flint Ridge, Ohio.

1891. *Bellerophon crassus.* White, U. S. Geol. Surv., Bull. No. 77, p. 26.
Permian: Military Crossing, Baylor County, Tex.

1895. *Bellerophon crassus.* Keyes, Missouri Geol. Surv., vol. 5, p. 151, pl. 50, figs. 1a, b. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City and Lexington, Mo.

1896. *Bellerophon crassus.* Smith, Leland Stanford Junior Univ. Publ., Cont. Biol. Hopkins Seaside Lab., No. 9, p. 39.
Lower Coal Measures: Conway County, Ark.

1896. *Bellerophon crassus.* Smith, Am. Phil. Soc., Proc., vol. 35, p. 249.
Lower Coal Measures: Conway County, Ark.

1897. *Bellerophon crassus.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, p. 853.
Coal Measures.

1899. *Bellerophon crassus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 592.

As almost all the specimens of this species occur in the form of internal casts, it can scarcely be said that the identification suggested above is worthy of entire reliance. At the same time they agree with specimens of *B. crassus* from the Mississippi Valley similarly preserved in all the characters of which their imperfect condition permits recognition. It is not at all improbable, however, that among the smaller shells referred to this species there are some which should be placed with other groups, especially with *Euphemus.*

Locality and horizon.—San Juan region (stations 2216, 2217, 2234?, 2340, 2341, 2342); middle and upper portions of the Hermosa formation and in the Rico formation. Crested Butte district (station 2293); Maroon formation. Leadville district (stations 2273, 2275); upper portion of the Weber formation and in the Robinson limestone.

BELLEROPHON GIGANTEUS Worthen?

1884. *Bellerophon giganteus.* Worthen, Illinois State Mus. Nat. Hist., Bull. No. 2, p. 8.
Lower Coal Measures: Monroe County, Ill.

1890. *Bellerophon giganteus.* Worthen, Geol. Surv. Illinois, Rept., vol. 8, p. 143, pl. 25, figs. 5, 5a.
Lower Coal Measures: Monroe County, Ill.

1897. *Bellerophon giganteus.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, p. 853.

1899. *Bellerophon giganteus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 592.

At station 2338 in the Rico formation occurs a *Bellerophon* of so large size that I have tentatively referred it to *B. giganteus* Worthen. This species was founded upon an internal cast and no determinative characters are known except its shape as such and its large size. The character last mentioned seems to have even less specific significance among the Bellerophontacea than in other groups. Among what seem to be mature examples well-known species show unusual variation in this regard. For instance, in the case of *B. percarinatus*, which is not often a large form and where an axial diameter of 25 mm. would not, perhaps, be under the average, an example now before me, apparently belonging to the same species, would have had, if perfect, a dimension of over 100 mm. So that, as far as known, *B. giganteus* might well be an unusual example of one of the well-known species.

The specimens from Colorado are much broken, but some of them must have attained a size much greater than ordinary. Another specimen in our collections which, so far as my material permits me to judge, is the same species as that from Colorado is said to have been found at Alton, Ill., and in the Coal Measures. The following notes are taken from the Colorado material. Fully grown specimens probably had a diameter of at least 85 mm. measured in the plane of revolution. A transverse section near the aperture is not a regular curve, but rather has the shape of a Gothic arch, being somewhat pointed at the top with a raised slit band. The surface is marked by rather strong transverse striæ or sublamellose growth lines which bend backward more or less strongly as they approach the band. The shell is thick and massive, and the interior section is not far from a regular curve, the difference of contour between the inside and the out residing entirely in a median thickening of the shell. In the earlier stages the outside curvature also seems to be regular. There is some evidence for believing that *B. giganteus?* together with *B. crassus* and *B. stevensianus* represent a single ontogenetic type. The chief, seemingly the only, points of difference between *B. giganteus?* and what may be called typical *B. crassus* are its large size and its keeled dorsum, but younger specimens of the former do not present the carinate condition and are of course of smaller dimensions. What I have reason to believe are young specimens of *B. crassus* are about the size and shape of *B. stevensianus*, while the growth lines are stronger and more regular than in the mature form. I am prepared to believe that half-grown shells of *G. giganteus?* can not be distinguished from *B. crassus*, and that young specimens of *B. crassus* (and probably of the large form also) are indistinguishable from *B. stevensianus*.

As regards the specific relationship of the Colorado (and the Illinois) form with Worthen's species, it is evident that an internal cast of the former would have the rounded contour of the latter, and the large size of both lends probability to the identification. It need not be pointed out, however, that *B. giganteus* differs in shape from the form provisionally referred to it, at least in that it is a more rapidly expanding and somewhat more flaring type. The circumstance that Worthen's specimen is an internal cast and perhaps otherwise not well preserved, while the aperture of my own is defective, widens the field of individual judgment.

Locality and horizon.—San Juan region (station 2287); middle portion of the Hermosa formation.

BELLEROPHON (sensu strictu) PERCARINATUS Conrad?

1842. *Bellerophon percarinatus.* Conrad, Acad. Nat. Sci. Philadelphia, Jour., (1), vol. 8, p. 268.
Coal Measures: Inclined plane of the Alleghany Mountain, in black shale overlying the stratum of coal No. 7, Huntingdon, Pa. (?).

1855. *Bellerophon percarinatus.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 74, pl. 9, figs. 4a–c.
Coal Measures: Grayville, Ill.; Posey County, Ind., 5 miles below New Harmony.

1872. *Bellerophon percarinatus.* Meek, U. S. Geol. Surv. Nebraska, p. 227, pl. 11, fig. 14.
Upper Coal Measures: Nebraska City and Brownville, Nebr.; Grayville, Ill.; Illinois, Iowa, Missouri.
Lower Coal Measures: West Virginia.

1884. *Bellerophon percarinatus.* White, Geol. Surv. Indiana, 13th Rept., p. 158, pl. 33, figs. 9–14.
Coal Measures: Indiana.

. *Bellerophon percarinatus.* Claypole, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 246.
Lower Coal Measures: Wilkesbarre, Pa.

1887. *Bellerophon percarinatus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 17, pl. 2, fig. 14.
Coal Measures: Flint Ridge, Ohio.

1888. *Bellerophon percarinatus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 234.
Lower Coal Measures: Des Moines, Iowa.

1895. *Bellerophon percarinatus.* Keyes, Missouri Geol. Surv., vol. 5, p. 153, pl. 50, figs. 2a–f. (Date of imprint 1894.)
Upper Coal Measures: Kansas City, Mo.

1897. *Bellerophon percarinatus.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, p. 853.
Coal Measures.

1899. *Bellerophon percarinatus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 592.

The material studied, though poorly preserved, is sufficiently well characterized to show that it certainly belongs to the group of *Bellerophon percarinatus*. Whether it belongs precisely to that species or to the closely related *B. harrodi* I am not able to say. The species seems to be abundant in the Hermosa formation at station 2327.

Locality and horizon.—San Juan region (stations 2217, 2327); middle portion of the Hermosa formation. Leadville district (station 2275); upper portion of the Weber formation. Dolores River region, Sinbads Valley (station 2285); top of the Hermosa formation.

PATELLOSTIUM Waagen, 1880, emend. Ulrich, 1897.

PATELLOSTIUM OURAYENSE Gurley.

Pl. X, figs. 10 to 10b.

1884. *Bellerophon ourayensis.* Gurley, New Carb. Foss., Bull. No. 2, p. 8.
Upper Carboniferous: Ouray, Colo.

1899. *Patellostium ourayense.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 589.

It is unfortunate and somewhat surprising that among the collections examined, many of which must have come from the same horizon, and some from near the type locality of *Patellostium ourayense*, which Gurley described without figures in 1884, no representative of that species has come to hand. Through the courtesy of the department of geology of Chicago University, however, I am enabled to figure the typical specimen of that species which will be found represented by figs. 10, 10a, 10b of Pl. X. The original description of *Patellostium ourayense*, quoted in full, is as follows:

"Shell medium size, subglobose, moderately expanding, slightly depressed laterally. Aperture reniform, arcuate. Umbilicus distinct, rather small. Lip conforming to the general direction of the growth of the shell, thin, slightly reflexed at the junction with the inner whorl. Lip divided into two lobes by a shallow mesial sinus formed by the gentle backward curve of the margin as it approaches the center of the lip.

"Mesial band consisting of a sharply raised smooth ridge which is scarcely more than a prominent well-developed revolving line.

"Surface marked by several sparsely arranged revolving striæ which become very numerous and crowded close to the mesial band, there being seven striæ within a space of 2 millimeters on each side of the mesial band, while on the remaining portion to the umbilicus there are only five striæ occupying a space of about 5 millimeters in width. These lines increase by implanation with the growth of the shell.

"There are numerous fine, sharply defined transverse lines of growth which curve gracefully backward as they approach the carina. These lines of growth are equally as prominent as the revolving striæ, and terminate a short distance from the sharp, raised mesial band. The revolving striæ and transverse lines of growth give the surface a rather coarse imbricate appearance, although in crossing each other the lines are uninterrupted.

"This species has the general form of *B. stevensanus* McChesney, possessing the laterally depressed sides and sharply raised mesial band seen in that form, but differing very materially in the ornamentation.

"*Position and locality.*—From a hard, dark micaceous sandy shale belonging to the Upper Carboniferous series and probably equivalent to the Middle Coal Measures, Ouray, Colo."

A comparison of the terms of this description with the type specimen shows several inaccuracies of expression and one or two additional points to which I desire to call attention. The statement describing the mesial band is misleading, for that structure is not smooth but crossed by distinct sublamellose striæ, and it is many times as large as the revolving lines which cross the surface of most shells of this group. In fact, it is proportionately as large if not a little larger than it is usual for the slit band to be. The surface ornamentation consists of transverse and revolving elements which, however, are different in character from one another. The revolving lines are sharply elevated, threadlike striæ which in the specimen in hand are irregular in size and distribution, so that in it the two sides of the shell are differently marked. As shown by the figure (fig. 10), the striæ which traverse the left side, some 5 or 6 in number, while irregularly distributed, are in every case separated by intervals many times their own width. Between these I think there can be discerned traces of much finer revolving lines. On the other side, the striæ are somewhat finer and crowded near the band, but the outer or umbilical portion of this side is marked similarly to the other. Both sides, where the inner end of the whorl is about to be lost in the aperture, are marked alike by fine, crowded striæ, among which some, more or less regularly distributed, are larger and stronger than the others. On the whole, the surface of the average specimen probably consisted of fine, crowded, revolving lines with larger ones at intervals. Transversely, the shell is marked by many fine-growth lines and by rugæ, which are not only much coarser than the revolving striæ, but different in character, inasmuch as they are poorly defined instead of being sharply and suddenly elevated. They seem to be similar to the rugose elevations which form so marked a character in *P. montfortianum*, but are more numerous and much less prominent. Growth lines and striæ are directed as in the original description, but both can be traced quite to the slit band. The vault of the shell is not of the rounded, circular type, but, being elevated medially and somewhat flattened laterally, the shape of the section is rather that of a Gothic arch.

This species is related to *P. bellum* and *P. nodocostatum*, but seems to be distinct from either. I have compared the type specimen of *P. ourayense* with a large series of specimens from Rulo, Nebr. which probably can be referred to *P. bellum*, and am able to point out the following differences: The peritreme of *P. bellum* is flattened on top with a circular section, while that of *P. ourayense* is compressed and pointed at the slit band. The surface ornamentation is very similar in the two species. It differs chiefly in that the transverse rugæ are stronger and more sharply defined in *P. bellum*, being, in fact only slightly different from the revolving striæ with which they regularly decussate, forming indistinct nodes at the points of intersection. The revolving striæ in *P. bellum* are somewhat stronger and coarser, while the transverse markings go nearly straight across instead of being curved, with a backward inclination. The slit band also is marked by strong rugæ alternating with those of the lateral surface, while the slit band of *P. ourayense*, though marked by striæ, is but slightly rugose.

Locality and horizon.—Near Ouray at about the same locality and horizon as station 2195.

PATELLOSTIUM MONTFORTIANUM Norwood and Pratten.

1855. *Bellerophon montfortianus.* Norwood and Pratten, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 74, pl. 9, figs. 5a–c.
Coal Measures: Galatia, Ill., and 5 miles below New Harmony, Ind.

1866. *Bellerophon montfortianus.* Geinitz, Carb. und Dyas in Nebraska, p. 8, tab. 1, fig. 13.
Coal Measuree: Nebraska City, Nebr.

1866. *Bellerophon interlineatus.* Geinitz, Carb. und Dyas in Nebraska, p. 8, tab. 1, fig. 14.
Coal Measures: Nebraska City, Nebr.

1872. *Bellerophon montfortianus.* Meek, U. S. Geol. Surv. Nebraska, p. 225, pl. 11, figs. 15 (12?).
Upper Coal Measures: Nebraska City, Nebr.
Coal Measures: Nebraska, Kansas, Iowa, Missouri, and Illinois.
Lower Coal Measures: West Virginia.

1876. *Bellerophon montfortianus.* White, Powell's Rept. Geol. Uinta Mountains, p. 92.
Upper Aubrey Group: Confluence of Grand and Green rivers, Utah.

1887. *Bellerophon montfortianus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 19, pl. 2, fig. 1; pl. 5, fig. 8.
Coal Measures: Flint Ridge, Ohio.

1888. *Bellerophon montfortianus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 235.
Lower Coal Measures: Des Moines, Iowa.

1891. *Bellerophon montfortianus.* White, U. S. Geol. Surv., Bull., No. 77, p. 26, pl. 3, figs. 15, 16.
Permian: Goodwin Creek, Baylor County, Tex.

1891. *Bellerophon montfortianus.* Keyes, Acad. Nat. Sci. Philadelphia, Proc., p. 254.
Lower Coal Measures: Des Moines, Iowa.

1895. *Bellerophon montfortianus.* Keyes, Missouri Geol. Surv., vol. 5, p. 151. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1897. *Patellostium montfortanus.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, p. 854.
Coal Measures.

1899. *Patellostium montfortianum.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 589.

Though the material representing this species is imperfect, the identification may be considered fairly reliable in some cases. A poorly preserved individual found at station 2275 in the Tenmile district has been referred to *P. montfortianum* with doubt. It may be a very large example of *P. bellum.*

Locality and horizon.—San Juan region (stations 2204?, 2221?, 2327); upper portion of the Hermosa formation. Leadville district (station 2275?); upper portion of the Weber formation.

PATELLOSTIUM BELLUM Keyes.

1895. *Bellerophon bellus.* Keyes, Missouri Geol. Surv., vol. 5, p. 148, pl. 50, fig. 7. (Date of imprint 1894.)

Upper Coal Measures: Kansas City, Mo.

1899. *Patellostium nodocostatum.* Girty (non Gurley), U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 590.

Upper Coal Measures: Atoka quadrangle.

The material representing this species is so very scanty, fragmentary, and poorly preserved that I find myself unable to identify it with the accuracy desirable. That from the Hermosa formation (Rico quadrangle, Sandstone Mountain, station 2217), though the surface ornamentation is partially obscured, is close to *P. bellum*, and probably better material would sanction the identification. From the Rico formation but two specimens have been obtained. One from station 2340 is practically indeterminable, but probably is conspecific with the other. The specimen from station 2337 seems to be somewhat different from the form obtained from the Hermosa formation. It shows a small area of surface in fairly good preservation, whose ornamentation differs from that of *P. bellum* in having the transverse striæ finer and sharper and the revolving striæ finer and more nearly equal. It is possible, therefore, that the *Patellostium* which occurs in the Hermosa formation is not the same as that from the Rico formation.

On a former occasion I ventured to throw *Patellostium bellum* Keyes into the synonymy of *P. nodocostatum* Gurley, basing the opinion upon Gurley's description on one hand and on the other upon specimens from Rulo, Nebr., thought to belong to *P. bellum*. Through the courtesy of the department of geology of Chicago University I have enjoyed the privilege of examining the types of Gurley's species of *Bellerophon*, and now feel compelled to reverse the judgment expressed at that time. In view of its intimate relations with several of Gurley's species, the small figure and brief description of Keyes afford an inadequate conception of *P. bellum*. Nevertheless the Rulo specimens are still believed to belong to that species. From these *P. nodocostatum* differs in having the transverse striæ somewhat stronger and the revolving striæ finer. The latter, therefore, instead of being equal to the transverse ones, as in *P. bellum*, and merging with them at the intersection into indistinct nodes, are in *P. nodocostatum* considerably finer and cross the transverse ridges without becoming confluent. They become, in fact, stronger and more prominent on their crests.

The ornamentation of *P. textiliforme* is similar to that of *P. nodocostatum*, but it is upon a much smaller scale, the striæ, both revolving and transverse, being finer and consequently more numerous. The statement that in this species the transverse striæ do not cross the slit band is certainly erroneous. In some specimens, owing apparently to abrasion, they are partially removed on this portion of the shell, but in general they seem to be about as prominent on the slit band as over the more lateral areas. It is possible that *P. bellum*, which was obtained from Kansas City, as was also *P. textiliforme*, may belong to the same species. In that case the form from Rulo and the present material would represent an undescribed form.

The surface of the form from the Rico formation, to which reference has been made above, is more like that of *P. bellum* than of the other American species I have seen, and if it proves to be different from *P. bellum*, as seems likely, it is probably a new variety.

Locality and horizon.—San Juan region (stations 2217, 2337, 2340); middle portion of the Hermosa formation and in the Rico formation.

EUPHEMUS McCoy, 1862, emend. Waagen, 1880.

EUPHEMUS NODOCARINATUS Hall.

1858. *Bellerophon nodocarinatus.* Hall, Geol. Surv. Iowa, vol. 1, pt. 2, p. 723, pl. 29, figs. 15a–c.
Coal Measures: Illinois and Iowa.

1884. *Bellerophon nodocarinatus.* White, Geol. Surv. Indiana, 13th Rept., p. 159, pl. 33, figs. 3–5.
Coal Measures: New Harmony, Ind.

1886. *Bellerophon nodocarinatus?* Heilprin, 2d Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 457, fig. 13.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1886. *Bellerophon nodocarinatus?* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, pt. 2, p. 277, fig. 13.
Upper Coal Measures: Mill Creek limestone, Wilkesbarre, Pa.

1887. *Bellerophon nodocarinatus.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 18, pl. 3, fig. 3.
Coal Measures: Flint Ridge, Ohio.

1895. *Bellerophon nodocarinatus.* Keyes, Missouri Geol. Surv., vol. 5, p. 152, pl. 50, figs. 4a–c. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1897. *Euphemus nodocarinatus.* Ulrich, Geol. Nat. Hist. Surv. Minnesota, Final Rept., vol. 3, pt. 2, p. 855.

1899. *Euphemus nodocarinatus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 592.

With the exception of stations 2340 and 2344 in the Rico formation, the specimens which I have referred to *Eu. nodocarinatus* are preserved as internal casts. Even those which show the characteristic revolving striæ are not sufficiently complete so that I am able to determine whether they are strictly identical with *Eu. carbonarius*, with *Eu. subpapillosus*, with *Eu. inspeciosus*, or with *Eu. nodocarinatus.* Of the casts, some specimens represent, perhaps, young examples of *Bellerophon crassus.*

Some of this material must belong, I think, to the *carbonarius-subpapillosus* type, but a part, that from stations 2340 and 2344 especially, seems nearer to *Eu. inspeciosus* and *Eu. nodocarinatus*.

Locality and horizon.—San Juan region (stations 2217?, 2340, 2344, 2345, 2349); middle portion of the Hermosa formation and in the Rico formation.

EUPHEMUS SUBPAPILLOSUS White?

1876. *Bellerophon carbonarius* var. *subpapillosus*. White, Powell's Rept. Geol. Uinta Mountains, p. 92. Upper Aubrey Group: Beehive Point, near Echo Canyon, and near Echo Park, Utah.

1879. *Bellerophon subpapillosus*. White, U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, p. 218. Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south of Pipe Spring.

1880. *Bellerophon subpapillosus*. White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 138, pl. 34, fig. 3a.
Upper Carboniferous: Northwestern Colorado and northern Arizona.

1883. *Bellerophon subpapillosus*. White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 138, pl. 34, fig. 3*a*.
Upper Carboniferous: Northwestern Colorado and Northern Arizona.

1899. *Euphemus subpapillosus*. Girty, U. S. Geol. Surv., 19th Ann. Rept., pt. 3, p. 592.

The only specimens referred to this species are those from the Uinta Mountains, which were so identified by White. Although they are mere casts, so that I have been able to see none of the surface ornamentation, from their size and configuration it seems not improbable that White's identification may be correct.

Some of the exfoliated specimens which have been placed with *Euphemus nodocarinatus*, or even with *Bellerophon crassus* may, however, belong here. I am disposed to give this type, for which White proposed only a varietal name, full specific rank.

Locality and horizon.—Uinta Mountain region, near the south fork of the Vermilion and near the east base of Diamond Peak (station 2189); Bellerophon limestone at the very top of the Carboniferous.

CEPHALOPODA.

DOMATOCERAS Hyatt, 1891.

DOMATOCERAS sp.

It is probable that the same species occurs at both the localities cited below, though the condition of my material does not permit me to speak with confidence. The form is not determinable from the specimens in the collections.

Locality and horizon.—Leadville district (stations 2275 and 2276); upper portion of the Weber formation.

TAINOCERAS Hyatt, 1883.

Tainoceras sp.

A single specimen, crushed in shale and macerated, has been found. It is evidently related to *T. occidentalis* Swallow, but it is too poorly preserved to admit of identification.

Locality and horizon.—San Juan region (station 2201); upper portion of the Hermosa formation.

CRUSTACEA.

PHILLIPSIA Portlock, 1843.

Phillipsia major Shumard.

1823. *Trilobus.* Say, Long's Exped. to Rocky Mountains, vol. 1, p. 148 (footnote).
Missouri River, 5 miles below Council Bluffs.

1858. *Phillipsia major.* Shumard, Acad. Sci. St. Louis, Trans., vol. 1, p. 226.
Upper Coal Measures: Clinton County, Mo.; Valley of Verdigris, and 12 miles south of Lecompton on the Santa Fe road, Kansas.

1872. *Phillipsia major.* Meek, U. S. Geol. Surv. Nebraska, p. 238, pl. 3, figs. 2a–c.
Upper Coal Measures: Bellevue and Plattsmouth, Nebr.; Clinton County, Mo.; Vermilion River, 12 miles south of Lecompton, Kans.

1887. *Phillipsia major.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 60.
Upper Coal Measures: Kansas.

1887. *Phillipsia major.* Vogdes, New York Acad. Sci., Ann., vol. 4, p. 85, pl. 3, fig. 14.
Upper Coal Measures: Clinton County, Mo.; Valley of the Verdigris River, 12 miles south of Lecompton on the Santa Fe road, Kansas; Kansas City, Mo.; Bellevue, Nebr.

1891. *Phillipsia major.* Hare, Kansas City Scientist, vol. 8, p. 33, pl. 1, figs. 5, 8a–c.
Coal Measures: Kansas City, Mo.

1895. *Phillipsia major.* Keyes, Missouri Geol. Surv., vol. 4, p. 238, pl. 32, figs. 8a–e. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.

1897. *Trilobus.* Harris, Am. Pal., Bull., vol. 1, p. 382 (112).
Sandstone of the Missouri; near Engineer Cantonment.

This species has been identified at three localities, but at each only one specimen was found. They are very imperfect, being more or less crushed and exfoliated. Differences have been noted which, were the material better and more abundant, might have justified me in discriminating two groups where now I recognize but one. The form from Ouray, especially, shows characters which, if constant, should separate it from the two other specimens, which are mutually more alike. Herrick[a] casts doubt upon Meek's identification, in his Nebraska report, of Shumard's species. The Colorado forms are of the type figured by Meek, but show departures which might, with adequate material, prove varietal, or even specific.

[a] Loc. cit., p. 60.

Locality and horizon.—San Juan region (station 2332); middle portion of the Hermosa formation. Ouray (station 2195); Hermosa formation. Leadville district (station 2257); lower portion of the Weber formation.

PHILLIPSIA TRINUCLEATA Herrick.

Pl. X, figs. 15, 16.

1887. *Phillipsia trinucleata.* Herrick, Sci. Lab. Denison Univ., Bull., vol. 2, p. 64, pl. 1, fig. 23; pl. 2, fig. 32; pl. 3, fig. 21.
Coal Measures: Flint Ridge, Ohio.

1888. *Proetus trinucleatus.* Vogdes, New York Acad. Sci., Ann., vol. 4, p. 81, pl. 2, figs. 7–9.
Waverly group [in error]: Flint Ridge, Licking County, Ohio.

Two or three specimens from Colorado seem to belong to Herrick's species cited above. None of the material is very good and that from station 2297 in the Crested Butte district and from station 2210 in the Durango quadrangle of the San Juan region is so imperfect that I am not certain that it is conspecific with the others.

Locality and horizon.—San Juan region (station 2210); upper portion of the Hermosa formation. Crested Butte district (station 2297?); Maroon formation. Leadville district (stations 2259, 2265); Weber formation.

LEPERDITIA Rouault, 1851

LEPERDITIA sp.

Ostracoda belonging to the genus *Leperditia* are very abundant at station 2212 in the San Juan region, and station 2269 in the Leadville region. The most perfect material is that from the San Juan region. The prevailing form is a transversely elongate, nearly equilateral shell, which rarely attains a width of 2 millimeters. The latter dimension is a little less than twice as great as the height. The eye spot must be very small or very obscure, and I have not been able to detect it with certainty. The surface appears to be quite smooth and solid.

It is possible that among the shells included under this title more than a single species may exist.

Locality and horizon.—San Juan region (station 2212); middle portion of the Hermosa formation. Leadville district (station 2269); upper portion of the Weber formation.

BAIRDIA McCoy, 1844.

BAIRDIA sp.

But a single species belonging to this genus has been described from American Carboniferous rocks, *Bairdia cestriensis* Ulrich,[a] and though from a higher horizon,

[a] Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 210, pl. 17, figs. 6a–c, 7a, b.

the Colorado form is of the same general type. It is, however, without much doubt a distinct species, but since only a single specimen has come to hand I do not feel justified in giving it a new name. The length is about 1.5 mm., thus making it larger than the Mississippian species, and it is also more transverse. The posterior extremity is probably not as pointed as the older specimen figured by Ulrich (fig. 6), and much less so than the younger one (fig. 7). The upper and lower margins are nearly rectilinear and parallel, though they gradually converge toward the anterior margin, which is rather regularly and strongly rounded.

This species occurs associated with several ostracode forms at Empire Hill in the Leadville district (station 2265), a locality which, with larger collections, would probably furnish an extensive fauna of this group. In addition to the types mentioned here under a separate heading, still another very minute form is found whose relations I have not been able to make out.

Locality and horizon.—Leadville district (station 2265).

BEYRICHIA McCoy, 1844.

Beyrichia sp.

This form is extremely abundant at Glenwood Springs (station 2193). The following brief description is offered:

The width is usually from 1 to 1.5 mm., and this dimension is from one and one-half to twice the height. The upper margin is long and straight. The ends are strongly, and the inferior margin gently, rounded. The posterior end of the hinge line is more or less angular. The shape is nearly symmetrical with respect to a vertical axis. Somewhat anterior to the middle, as it appears, the shell is divided by a deep, strong sulcus, which is vertical to the hinge and has a length about one-third as great as the height of the shell. Not far anterior to this another fainter groove can usually be detected. The lower ends of these two depressions are sometimes seen to be deflected and to unite, thus inclosing a small median lobe. The surface is delicately and beautifully hachured.

This species appears to be one of the simple Beyrichian types related to *B. arcuata* of the Carboniferous rocks of Great Britain.

A closely related and possibly identical form is found at Empire Hill, in the Leadville district. My material is very scanty, and at the same time somewhat imperfect, so that I have not entirely assured myself as to the relations of these two forms.

Locality.—Grand River region, Glenwood Springs (station 2193). Leadville district (station 2265).

KIRKBYA Jones, 1869.

KIRKBYA sp.

Of this form a single specimen has been discovered. The shell has a subcentral protuberance and two or three heavy concentric furrows. The surface is coarsely reticulate.

It is evidently related to *Kirkbya plicata* Jones and Kirkby, and is probably identical with that species.

Locality and horizon.—Leadville district (station 2265); Weber formation.

PLATES.

PLATE I.

PLATE I.

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FIG. 1. MENOPHYLLUM ULRICHANUM	271

A nearly perfect specimen, slightly broken at the tip, showing the rapid expansion and curved shape characteristic of the species.

Side view. Somewhat turned toward the eye, actual curvature diminished by perspective.

Ouray limestone: Cascade Creek, in the Engineer Mountain quadrangle (station 2379).

FIG. 2. MENOPHYLLUM ULRICHANUM 271

A cast in chert of the calice of an individual belonging to this species.

Cast seen from above. The relation of the primary to the secondary septa, the main fossula (that in the center), the two secondary fossulæ (especially that on the left), and the tripartite arrangement of the septa resulting therefrom, are well shown.

Ouray limestone: Canyon Creek, in the Needle Mountains quadrangle (station 2386).

FIG. 3. SPIRIFERINA SOLIDIROSTRIS? 294

A small dorsal valve preserved as a cast in chert, considerably enlarged. The punctate character of the shell is well shown by the pustules on the cast. The specimen is too young to show clearly the slight median division of the fold.

Specimen seen from above.

Millsap limestone: Perry Park (station 2389).

FIG. 4. SPIRIFERINA SOLIDIROSTRIS? 294

A somewhat larger ventral valve, similarly preserved and also enlarged. The incipient plication in the middle of the sinus is shown in this individual, also the impression of the median septum and dental lamellæ.

Specimen seen from above.

Millsap limestone: Perry Park (station 2389).

FIG. 5. SEMINULA SUBQUADRATA? 296

Small example; larger specimens closely resemble *Seminula subquadrata* Hall.

Ventral valve seen from above.

Leadville limestone: Leadville district, Oolite mine, Leadville (station 2375).

FIG. 6. CRANÆNA SUBELLIPTICA 299

An example from the typical locality, presenting the usual characters. Preserved chiefly as an internal cast, with small fragments of the shell adhering.

Dorsal view of specimen.

Waverly group: Sciotoville, Ohio.

FIG. 7. CRANÆNA SUBELLIPTICA 299

Another example preserved as an internal cast, having the usual shape and size and showing many of the structural features of the genus.

Dorsal view. This specimen shows the two dental lamellæ of the ventral valve. The broken part at the right is along one of these. The posterior portion of the cast of the dorsal valve has been chiseled away so as to show the hinge plate with its two carinæ, which project as the two limbs of the crura.

Waverly group: Sciotoville, Ohio.

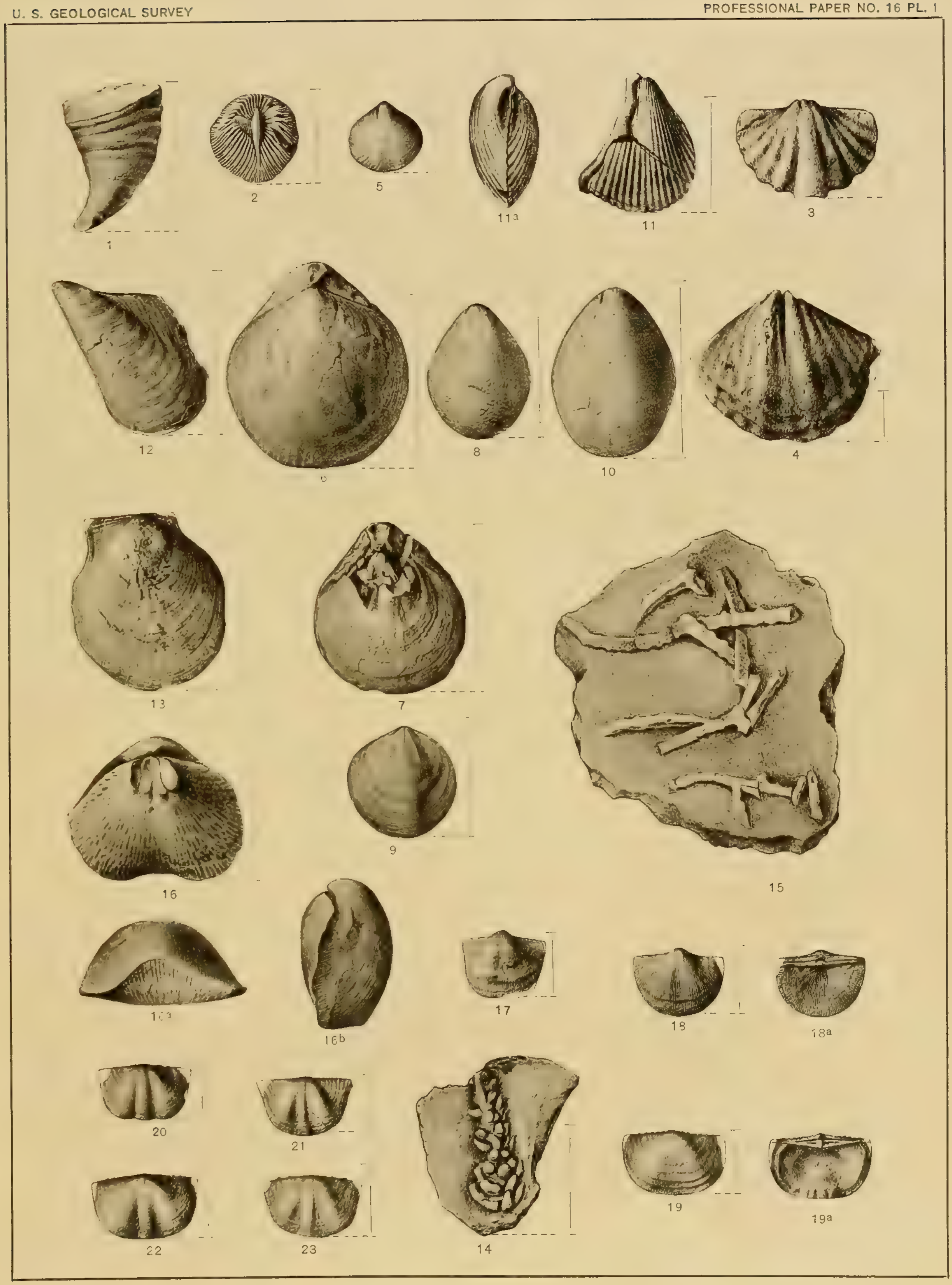

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FIG. 8. CRANÆNA SUBELLIPTICA var. HARDINGENSIS 299

A ventral valve of somewhat near the average shape and size, preserved in chert. Other specimens are more rotund.

Specimen seen from above, showing the two dental lamellæ.

Millsap limestone: Harding's quarry, Canyon, Colo. (station 2370).

FIG. 9. CRANÆNA SUBELLIPTICA var. HARDINGENSIS 299

Dorsal valve of the same species.

Specimen (an internal cast) seen from above. A very faint median septum is shown; the marks on either side are connected with the muscular attachment. Near the posterior margin appear the cavities left by the socket plates.

Millsap limestone: Garden Park, Colo. (station 2365).

FIG. 10. CRANÆNA SUBELLIPTICA var. HARDINGENSIS 299

Ventral valve of somewhat more than the average size and proportionate length.

Specimen seen from above. This example also is preserved as an internal cast in chert.

Millsap limestone: Garden Park, Colo. (station 2371).

FIGS. 11 AND 11a. EUMETRIA WOOSTERI 302

Type and original specimen figured by White. Artificial impression from a natural mold.

Fig. 11. Ventral view.

11a. Side view.

Pebbles in the Wyoming sandstone (?), 32 miles west and 18 miles north of Greeley, Colo. (station 2364).

FIG. 12. MYALINA KEOKUK 309

A left valve believed to belong to this species. Preserved as a cast in chert.

Specimen seen from above.

Ouray limestone: Near Cascade Creek, Engineer Mountain quadrangle (station 2382).

FIG. 13. STREBLOPTERIA MEDIA 307

An isolated right valve referred to Herrick's species.

Specimen seen from above.

Millsap limestone: Perry Park, Colo. (station 2389).

FIG. 14. ARCHÆOCIDARIS OURAYENSIS 329

A somewhat imperfect specimen partially embedded in matrix, showing the peculiar and characteristic ornamentation.

Specimen seen from the side, and somewhat enlarged.

Hermosa formation (?): Ouray, Colo. (station 2194).

FIG. 15. PRISMOPORA TRIANGULATA 340

A group of specimens partially embedded in limestone. This is the specimen originally figured by White.

Specimen somewhat enlarged, showing the external characters of the species.

Middle division of the Carboniferous series: Yampa Plateau, northwestern Colorado.

FIG. 16 TO 16b. ORTHOTICHIA SCHUCHERTENSIS 345

The most perfect specimen obtained, preserving both valves.

Fig. 16. Ventral view. The shape and peculiar surface characters are well shown, also the septum and strong dental plates of the ventral valve.

16a. Anterior view, showing the shape and relations of the valves and the somewhat different character of their surface ornamentation.

16b. Side view of the same.

Weber shale: Glenwood Springs, Colo. (station 2193a).

PLATE II.

PLATE II.

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FIGS. 1 TO 1c. PRODUCTUS SEMIRETICULATUS var. HERMOSANUS	358

A very characteristic specimen. The ears are somewhat broken away.

Fig. 1. Ventral valve seen from above.
1a. Anterior view.
1b. Posterior view.
1c. Side view.

Hermosa formation: Between Hermosa Creek and Animas Valley, Durango quadrangle (station 2204).

FIGS. 2 TO 2b. PRODUCTUS SEMIRETICULATUS var. HERMOSANUS	358

Another somewhat smaller specimen of the type common in the Hermosa formation.

Fig. 2. Ventral valve seen from above. This figure represents the specimen too much tilted downward and forward.
2a. Anterior view of the same.
2b. Side view. The pose of the specimen is not quite correct, the near cardinal angle being evidently somewhat depressed from the line of sight.

Hermosa formation: Hermosa Creek (?), Durango quadrangle (station 2333).

FIGS. 3 TO 3b. PRODUCTUS SEMIRETICULATUS var. HERMOSANUS	358

A rather small dorsal valve which is somewhat imperfect.

Fig. 3. Specimen seen from above. Possibly the cardinal angles should be restored as more projecting.
3a. Side view.
3b. Posterior view.

Hermosa formation: Animas River, Durango quadrangle (station 2335).

FIGS. 4 TO 4b. PRODUCTUS SEMIRETICULATUS var. HERMOSANUS	358

Ventral valve of a finely striated type more or less intermediate between this species and *Productus inflatus*, to which, on the whole, I am disposed to regard it as nearer related.

Fig. 4. Specimen seen from above.
4a. Posterior view.
4b. Side view.

Weber formation: Weston Gulch, Leadville district (station 2268).

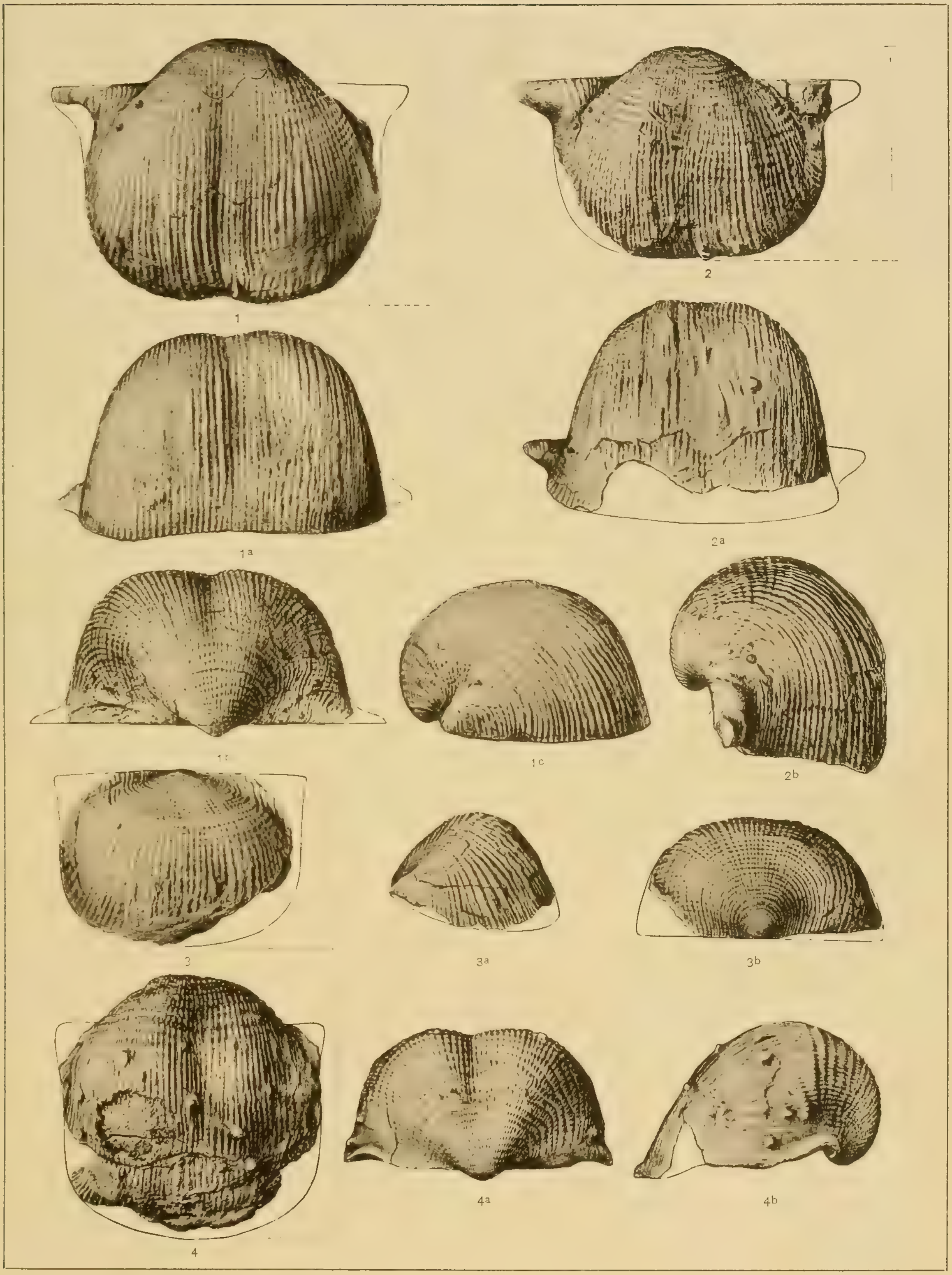

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PLATE III.

PLATE III

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FIGS. 1 TO 1b. PRODUCTUS INFLATUS	359

A typical ventral valve of the form referred to McChesney's species.

Fig. 1. Specimen seen from above.

1a. Side view.

1b. Posterior view.

Weber formation (?): Horseshoe Mountain, Leadville district (station 2281).

FIGS. 2 TO 2a. PRODUCTUS INFLATUS 359

A ventral valve in which the cardinal angles have been broken away.

Fig. 2. Specimen seen from above. The figure shows the striæ as proportionally too coarse.

2a. Posterior view.

Weber formation (?): Horseshoe Mountain, Leadville district (station 2281).

FIG. 3. PRODUCTUS INFLATUS 359

A specimen in which both valves are retained in place.

Dorsal view.

Weber formation (?): Horseshoe Mountain, Leadville district (station 2281).

FIGS. 4 AND 4a. PRODUCTUS GALLATINENSIS 361

A specimen of the ordinary size and character.

Fig. 4. Anterior view.

4a. Side view.

Hermosa formation: Near Cascade Creek, in the Engineer Mountain quadrangle (station 2247).

FIG. 5. PRODUCTUS GALLATINENSIS 361

Another characteristic specimen, somewhat smaller than the foregoing and of unsymmetrical growth.

Posterior view. The specimen is represented as too much tilted forward, by which the height appears unnaturally diminished.

Hermosa formation: Near Cascade Creek, in the Engineer Mountain quadrangle (station 2247).

FIGS. 6 TO 6b. PRODUCTUS GALLATINENSIS 361

Another ventral valve belonging to this species.

Fig. 6. Anterior view.

6a. Posterior view. In this case also the tilting of the specimen causes the height to appear less than it should be.

6b. Side view.

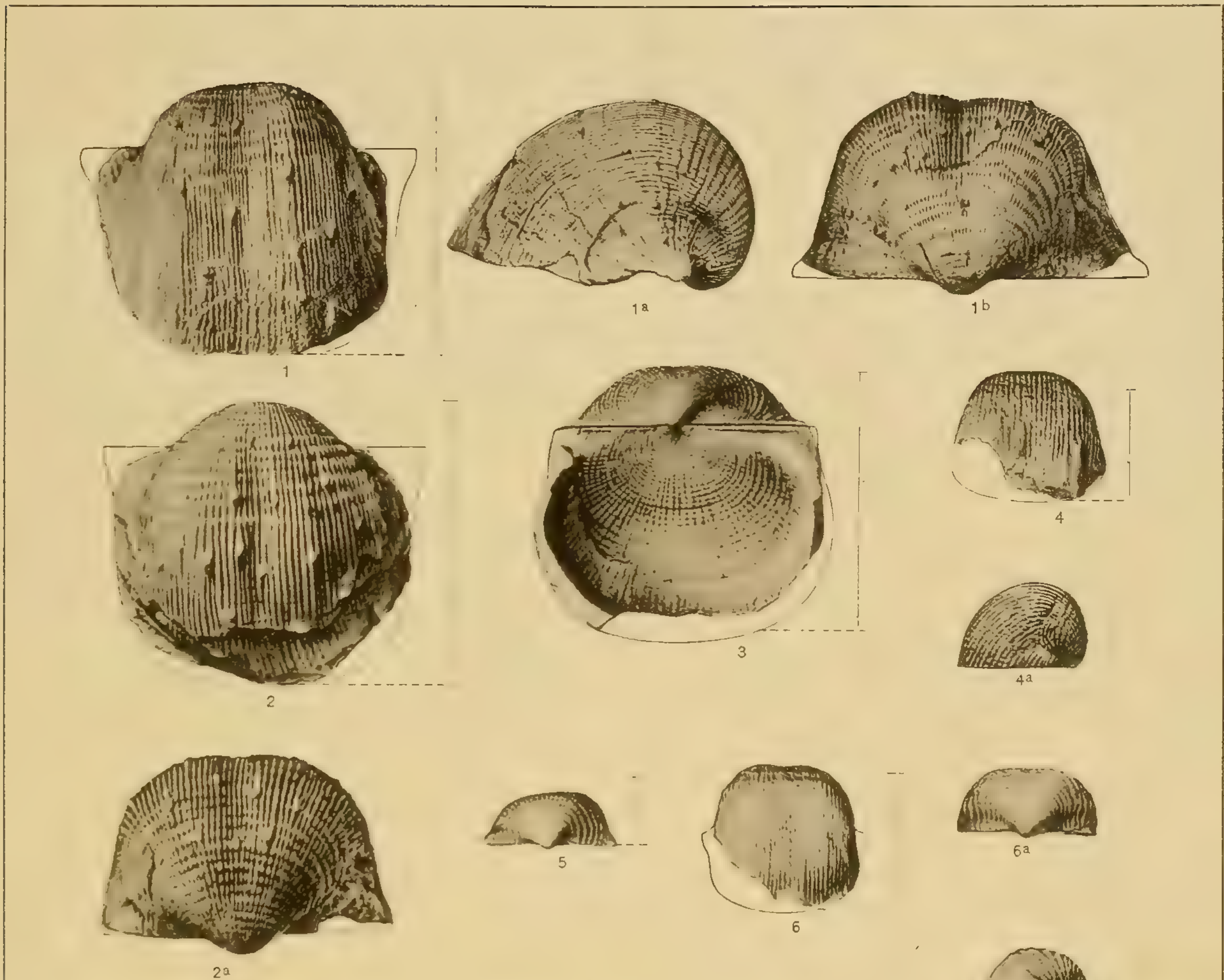
Hermosa formation: Bear Creek, in the Durango quadrangle (station 2213).

FIG. 7. PRODUCTUS GALLATINENSIS 361

A large ventral valve, somewhat distorted through compression.

Posterior view.

Hermosa formation: San Juan region (station 2233).



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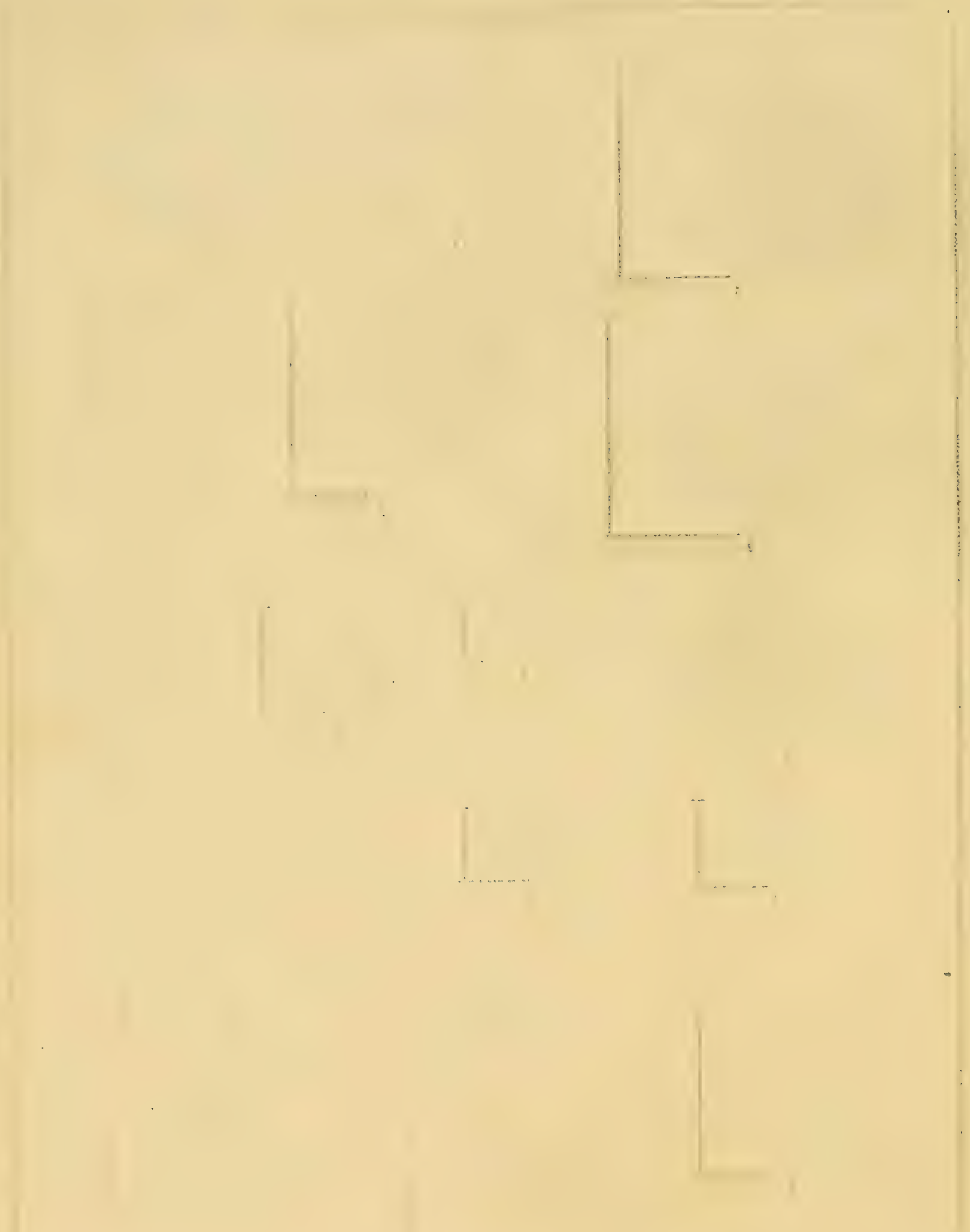

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FIGS. 8 AND 8a. PRODUCTUS GALLATINENSIS 361

A dorsal valve belonging to this species.

Fig. 8. Specimen seen from above.

8a. Side view.

Hermosa formation: Bear Creek, in the Durango quadangle (station 2213).

FIGS. 9 TO 9b. PRODUCTUS sp. b 363

A ventral valve from which the shell has been largely exfoliated.

Fig. 9. Specimen seen from above.

9a. Side view, in which the pose is not quite satisfactory.

9b. Posterior view.

Hermosa formation: Bear Creek, in the Durango quadrangle (station 2214).

FIG. 10. PRODUCTUS sp. b 363

An interior of a dorsal valve referred to this species.

Side view.

Hermosa formation: Bear Creek, in the Durango quadrangle (station 2214).

FIG. 11. PRODUCTUS sp. b 363

Interior of a somewhat smaller dorsal valve.

Specimen seen from above.

Hermosa formation: Bear Creek, in the Durango quadrangle (station 2214).

PLATE IV.

PLATE IV.

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FIGS. 1 TO 1b. PRODUCTUS CORA 364

A large dorsal valve from the Rico formation.

Fig. 1. Specimen seen from above.

1a. Posterior view.

1b. Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIGS. 2 AND 2a. PRODUCTUS CORA 364

A large dorsal valve from the Hermosa formation. A specimen in which a number of conformable shelly layers are seen, possibly representing parts of several superposed individuals.

Fig. 2. Specimen seen from above. The striæ are represented as somewhat too coarse in this figure.

2a. Side view. The striæ in this figure are shown in their natural relation to the size of the shell.

Hermosa formation: Sandstone Mountain, Rico quadrangle (station 2216).

FIGS. 3 AND 3a. PRODUCTUS CORA 364

Another ventral valve from the Hermosa formation, more coarsely and regularly striated than the last. It is somewhat crushed by pressure.

Fig. 3. Specimen seen from above. The figure shows the anterior end of the specimen tilted too far downward.

3a. Side view of the same.

Hermosa formation: Bear Creek, Durango quadrangle (station 2213).

FIGS. 4 AND 4b. PRODUCTUS CORA 364

A ventral valve of a small, finely striated variety, probably considerably broken in its anterior portion.

Fig. 4. Specimen seen from above.

4a. Posterior view.

4b. Side view.

Hermosa formation: Big Percent Creek, Durango quadrangle (station 2300).

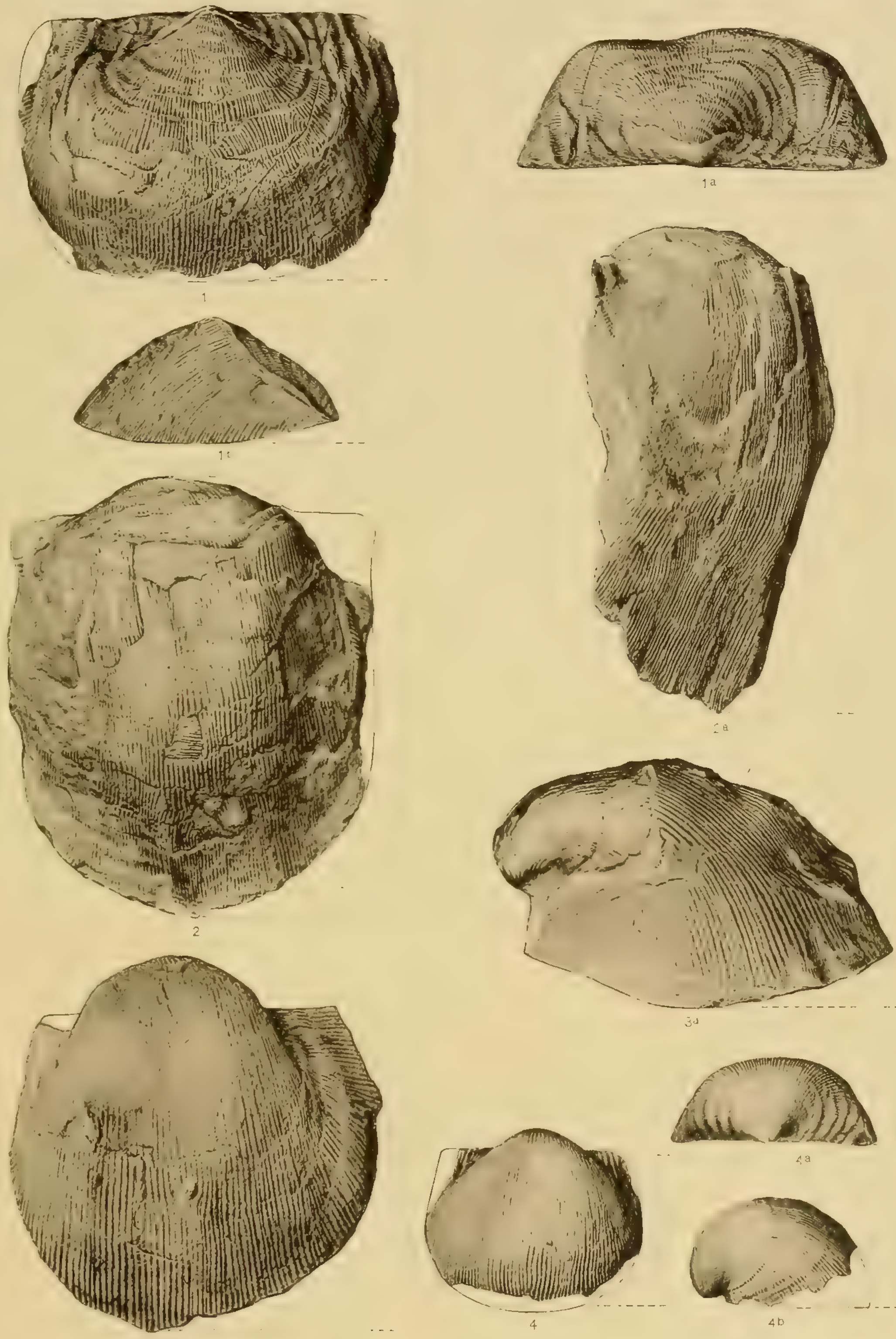

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PLATE V.

PLATE V.

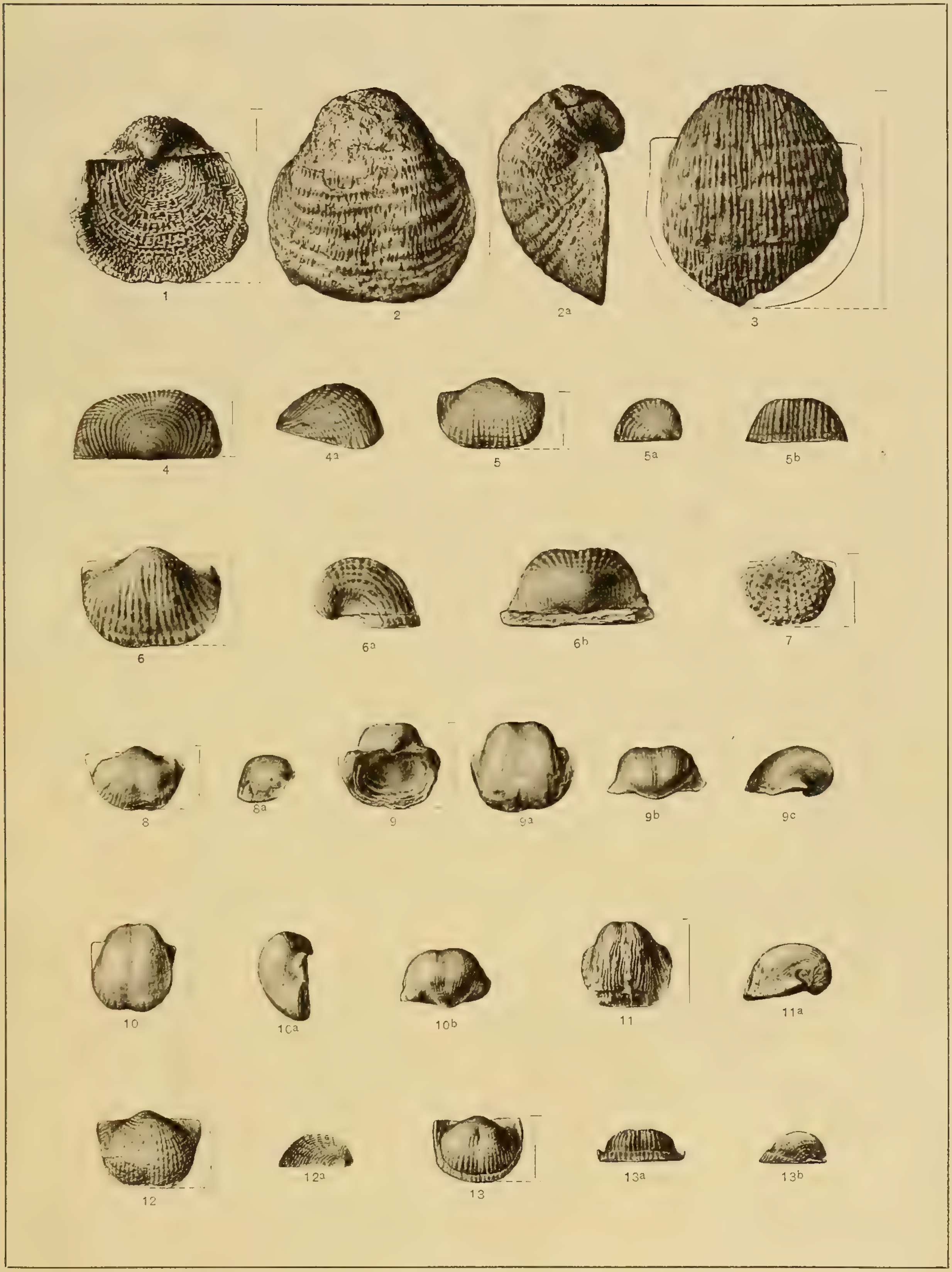

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FIG. 7. MARGINIFERA MURICATA 373

An imperfect specimen of the same character as the foregoing, but one which retains the original spinose surface.

Ventral valve seen from above.

Maroon formation: Southeast of Italian Peak, Elk Mountain region (station 2280).

FIGS. 8 AND 8a. MARGINIFERA WABASHENSIS var 375

A small but typical specimen referred to this species. The specimen is very imperfect, but it is the best which our collections contain.

Fig. 8. Specimen seen from above, considerably restored.

8a. Side view.

Hermosa formation: Silver Creek, San Juan region (station 2220).

FIGS. 9 TO 9c. MARGINIFERA HAYDENENSIS 380

A very characteristic specimen of the type upon which the species is based.

Fig. 9. Dorsal view.

9a. Ventral view.

9b. Posterior view.

9c. Side view.

Near Grand River, Colorado (?) (station 2324).

FIGS. 10 TO 10b. MARGINIFERA HAYDENENSIS 380

Another very characteristic example which is elongated in shape, instead of transverse.

Fig. 10. Ventral valve seen from above.

10a. Side view.

10b. Posterior view.

Near Grand River, Colorado (?) (station 2324).

FIGS. 11 AND 11a. MARGINIFERA HAYDENENSIS 380

Another specimen belonging to the same species. The two specimens previously figured have been almost devoid of striæ. The striæ of the present specimen are quite distinct, but very irregular. The difference is not believed to be specific.

Fig. 11. Ventral valve seen from above.

11a. Side view.

Near Grand River, Colorado (?) (station 2325).

FIGS. 12 AND 12a. MARGINIFERA INGRATA 379

A well-preserved specimen belonging to this species.

Fig. 12. Specimen seen from above. The striæ in the figure are represented as too coarse.

12a. Side view.

Weber shale: Little Ella Hill, Leadville district (station 2253).

FIGS. 13 TO 13b. MARGINIFERA INGRATA 379

An internal cast of a ventral valve referred to this species. The striation is somewhat coarser than on the specimen previously figured, but it is represented as somewhat too coarse in the figure.

Fig. 13. Specimen seen from above.

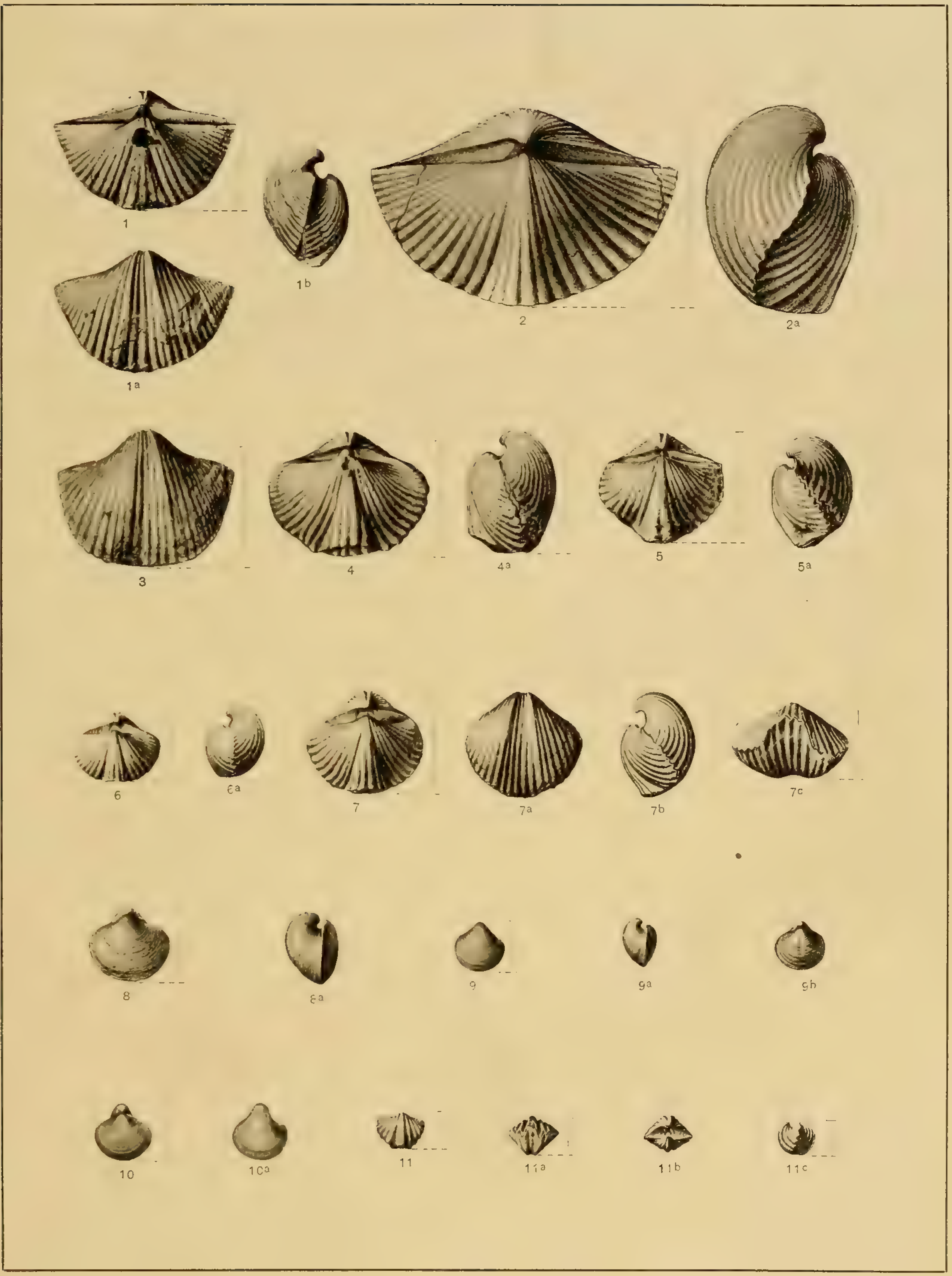
13a. Anterior view.

13b. Side view.

Weber formation (?): Horseshoe Gulch, Leadville district (station 2259).

PLATE VI.

PLATE VI.



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FIGS. 7 TO 7c. SPIRIFER ROCKYMONTANUS 383

A specimen somewhat larger than the last, well preserved, and very characteristic.

Fig. 7. Dorsal view.

7a. Ventral view.

7b. Side view.

7c. Anterior view. In this figure the accidental varix of growth is too prominently represented.

Weber formation (?): Horseshoe Mountain, Leadville district (station 2281).

FIGS. 8 AND 8a. SQUAMULARIA PERPLEXA 392

A rather large specimen belonging to this species.

Fig. 8. Dorsal view.

8a. Side view.

Maroon formation: Punch Gulch, Crested Butte quadrangle (station 2291).

FIGS. 9 TO 9b. SQUAMULARIA PERPLEXA 392

A specimen smaller than the foregoing, but of more nearly the usual dimensions.

Fig. 9. Ventral view.

9a. Side view.

9b. Dorsal view.

Hermosa formation: Deadwood Gulch, Rico quadrangle (station 2224).

FIGS. 10 AND 10a. SQUAMULARIA PERPLEXA 392

A specimen somewhat larger than the last, but from the same locality. This example is not quite symmetrical in its growth.

Fig. 10. Dorsal view.

10a. Ventral view.

Hermosa formation: Deadwood Gulch, Rico quadrangle (station 2224).

FIGS. 11 TO 11c. SPIRIFERINA KENTUCKYENSIS 400

A very small example which may belong to Shumard's species, but is possibly värietally different.

Fig. 11. Dorsal view.

11a. Anterior view.

11b. Posterior view.

11c. Side view.

Hermosa formation: Rico quadrangle (station 2322).

PLATE VII.

PLATE VII.

	Page.
FIGS. 1 TO 1b. SEMINULA SUBTILITA	403

A slightly unsymmetrical specimen from the lowest Upper Carboniferous horizon of the San Juan region. Represented by the figures as somewhat enlarged.

Fig. 1. Dorsal view.

1a. Side view.

1b. Anterior view.

Hermosa formation: Bear Creek, Durango quadrangle (station 2214).

FIGS. 2 AND 2a. SEMINULA SUBTILITA 403

A small and presumably immature specimen from the same locality and horizon as the foregoing.

Fig. 2. Dorsal view.

2a. Front view.

Hermosa formation: Bear Creek, Durango quadrangle (station 2214).

FIGS. 3 AND 3a. SEMINULA SUBTILITA 403

A large and characteristic specimen.

Fig. 3. Dorsal view.

3a. Side view.

Hermosa formation: Hermosa Creek, Durango quadrangle (station 2239).

FIG. 4. SEMINULA SUBTILITA 403

A small and somewhat peculiar specimen belonging to this species.

Dorsal view.

Hermosa formation: Cliff south of Carson Creek, Durango quadrangle (station 2211).

FIG. 5. SEMINULA SUBTILITA 403

A slightly unsymmetrical specimen of smaller size than the original of fig. 3.

Dorsal view.

Hermosa formation: Hermosa Creek, Durango quadrangle (station 2239).

FIG. 6. SEMINULA SUBTILITA 403

A specimen somewhat similar to the original of fig. 4, but a trifle larger.

Dorsal view.

Hermosa formation: Animas River, Durango quadrangle (station 2246).

FIGS. 7 AND 7a. SEMINULA SUBTILITA 403

An unusually gibbous specimen.

Fig. 7. Dorsal view.

7a. Side view.

Hermosa formation: Lower end of Animas Park (station 2243).

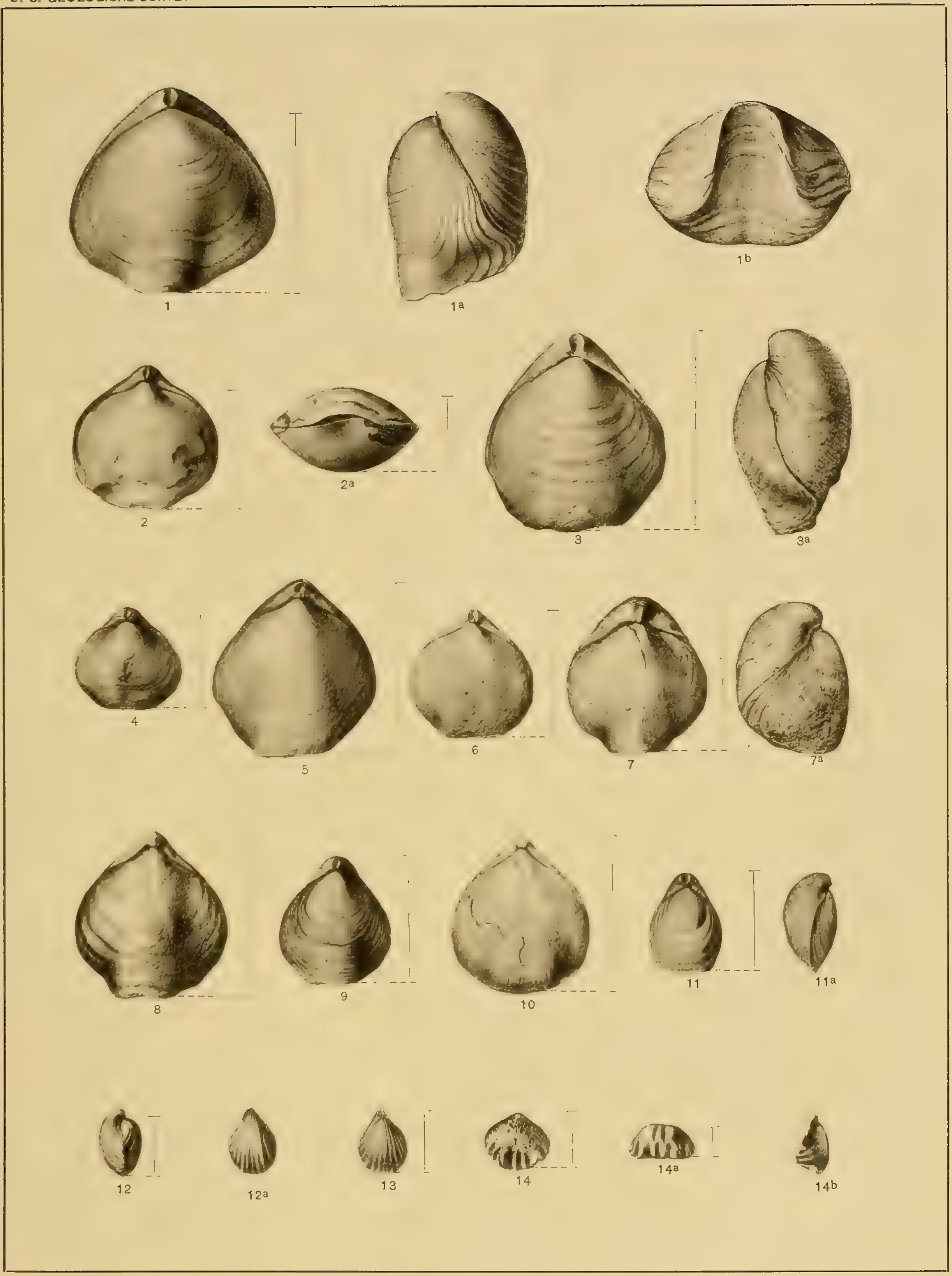

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FIG. 8. SEMINULA SUBTILITA 403

A specimen from the highest known Carboniferous horizon in the San Juan region somewhat distorted by pressure.

Dorsal view.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 9. SEMINULA SUBTILITA 403

A small specimen of this species.

Dorsal view.

Hermosa formation: Hermosa Creek, Durango quadrangle (station 2239).

FIG. 10. SEMINULA SUBTILITA 403

A rotund specimen with fold and sinus less strongly marked than usual.

Dorsal view.

Hermosa formation: Sandstone Mountain, Rico quadrangle (station 2216).

FIGS. 11 AND 11a. DIELASMA BOVIDENS ? 409

An immature or not very characteristic representative of the species to which it is doubtfully referred.

Fig. 11. Dorsal view.

11a. Side view.

Formation (?): Rock Creek, Elk Mountains.

FIGS. 12 AND 12a. HUSTEDIA MORMONI 411

A characteristic specimen.

Fig. 12. Side view.

12a. Ventral view.

Maroon formation: Southeast of Italian Peak, Elk Mountain region (station 2280).

FIG. 13. HUSTEDIA MORMONI 411

A somewhat smaller specimen than the preceding, slightly distorted by pressure.

Dorsal view.

Maroon formation: Southeast of Italian Peak, Elk Mountain region (station 2280).

FIGS. 14 TO 14b. PUGNAX UTAH 412

A characteristic specimen.

Fig. 14. Ventral view.

14a. Anterior view.

14b. Side view.

Maroon formation: Southeast of Italian Peak, Elk Mountain region (station 2280).

PLATE VIII.

PLATE VIII.

		Page.
Fig. 1.	Aviculopecten occidentalis	414

Internal cast of a right valve referred to this species.
Specimen seen from above.
Rico formation: Silver Creek, Rico quadrangle (station 2347).

Fig. 2. Aviculopecten sp. a 417

Internal cast of a left valve, somewhat enlarged.
Specimen seen from above.
Hermosa formation: Ouray, Colo. (station 2194).

Fig. 3. Aviculopecten? interlineatus 416

A right valve belonging to this species.
Specimen seen from above.
Hermosa formation: Ouray, Colo. (station 2194).

Fig. 4. Pseudomonotis kansasensis 428

A left valve of the type referred to this species.
Specimen seen from above.
Rico formation: Scotch Creek, Rico quadrangle (station 2342).

Fig. 5. Pseudomonotis equistriata 428

A specimen representing the type referred to this species.
Shell seen from above.
Rico formation: Scotch Creek, Rico quadrangle (station 2342).

Fig. 6. Myalina subquadrata? 424

Left valve showing one variety of shape assumed by the fossils from Colorado.
Specimen seen from above.
Rico formation: Scotch Creek, Rico quadrangle (station 2342).

Fig. 7. Myalina subquadrata? 424

A left valve of different shape from the preceding but associated with it. Possibly these two shells are not really conspecific.
Specimen seen from above.
Rico formation: Scotch Creek, Rico quadrangle (station 2342).

Fig. 8. Myalina wyomingensis 422

A small left valve.
Specimen seen from above.
Rico formation: Scotch Creek, Rico quadrangle (station 2340).

Fig. 9. Myalina wyomingensis 422

A larger left valve of a somewhat different shape from the preceding.
Specimen seen from above.
Rico formation: Scotch Creek, Rico quadrangle (station 2340).

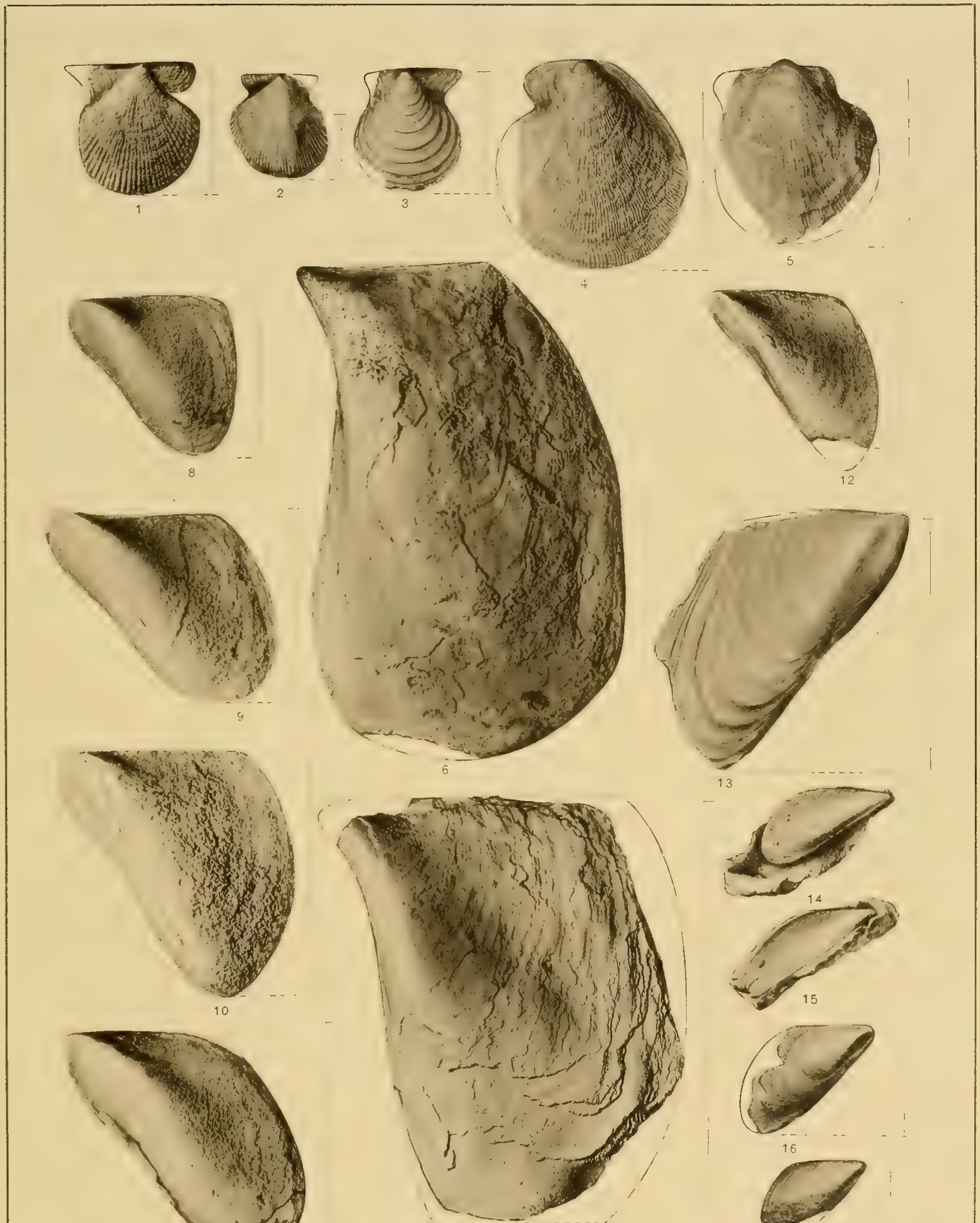

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FIG. 10. MYALINA WYOMINGENSIS 422

A large left valve whose shape resembles fig. 8.

Specimen seen from above.

Rico formation: Scotch Creek, Rico quadrangle (station 2340).

FIG. 11. MYALINA WYOMINGENSIS 422

A large left valve of a still different shape.

Specimen seen from above.

Rico formation: Scotch Creek, Rico quadrangle (station 2340).

FIG. 12. MYALINA WYOMINGENSIS 422

A small left valve somewhat similar to fig. 10.

Specimen seen from above.

Rico formation: Scotch Creek, Rico quadrangle (station 2340).

FIG. 13. MYALINA WYOMINGENSIS 422

A specimen from Texas which seems to belong to this species, and which closely resembles the original of fig. 11.

Right valve seen from above.

Cisco division of the Upper Carboniferous: Graham, Young County, Tex.

FIG. 14. MYALINA CUNEIFORMIS 420

One of the type specimens of this species which I am enabled to figure through the courtesy of the geological department of the University of Chicago.

A right valve seen from above.

Hermosa formation (?): Ouray, Colo. (Probably about the same locality and horizon as station 2195.)

FIG. 15. MYALINA CUNEIFORMIS 420

Another type specimen, also loaned by the University of Chicago.

Right valve; specimen seen from above.

Hermosa formation (?): Ouray, Colo. (Probably about the same locality and horizon as station 2195.)

FIG. 16. MYALINA CUNEIFORMIS 420

Right valve from the Crested Butte region referred to Gurley's species.

Specimen seen from above.

Weber formation: Branch of Cement Creek, Crested Butte quadrangle (station 2314).

FIG. 17. MYALINA CUNEIFORMIS 420

Another specimen from the same locality as the preceding. The originals of both figures are very imperfect, and the shape represented is, to a considerable extent, a matter of restoration.

Specimen seen from above.

Weber formation: Branch of Cement Creek, Crested Butte quadrangle (station 2314).

PLATE IX.

PLATE IX.

Page.

FIG. 1. AVICULOPINNA NEBRASKENSIS 435

A rather small specimen in which both valves are preserved nearly in place.

Left valve seen from the side. The specimen is very imperfect, and restoration has been made as far as possible from growth lines.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 2. AVICULOPINNA NEBRASKENSIS 435

Right valve of a much larger specimen than the preceding. Outline restored from the lines of growth, showing a shape somewhat different from the small specimen, the original of fig. 1.

Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 3. MONOPTERIA ALATA 431

The only specimen in the collection referred to this species.

Shell seen from the side.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 4. ALLERISMA TERMINALE 437

The type specimen upon which Hall's species was based. The obliquity of this specimen is clearly the result of compression, and the species is, I feel little doubt, the same which Meek and Hayden subsequently described as *Allerisma subcuneatum.*

Left valve seen from the side. The papillose surface which this specimen retains is present on well-preserved examples of *A. subcuneatum.*

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 5. ALLERISMA TERMINALE 437

A right valve whose size is much smaller than is sometimes attained by this species.

Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 6. ALLERISMA TERMINALE 437

A small left valve whose size and proportions suggest that it may possibly be a distinct species or variety.

Specimen seen from the side.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 7. EDMONDIA GIBBOSA 447

A right valve preserved as an internal cast, and not very perfect.

Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2341).

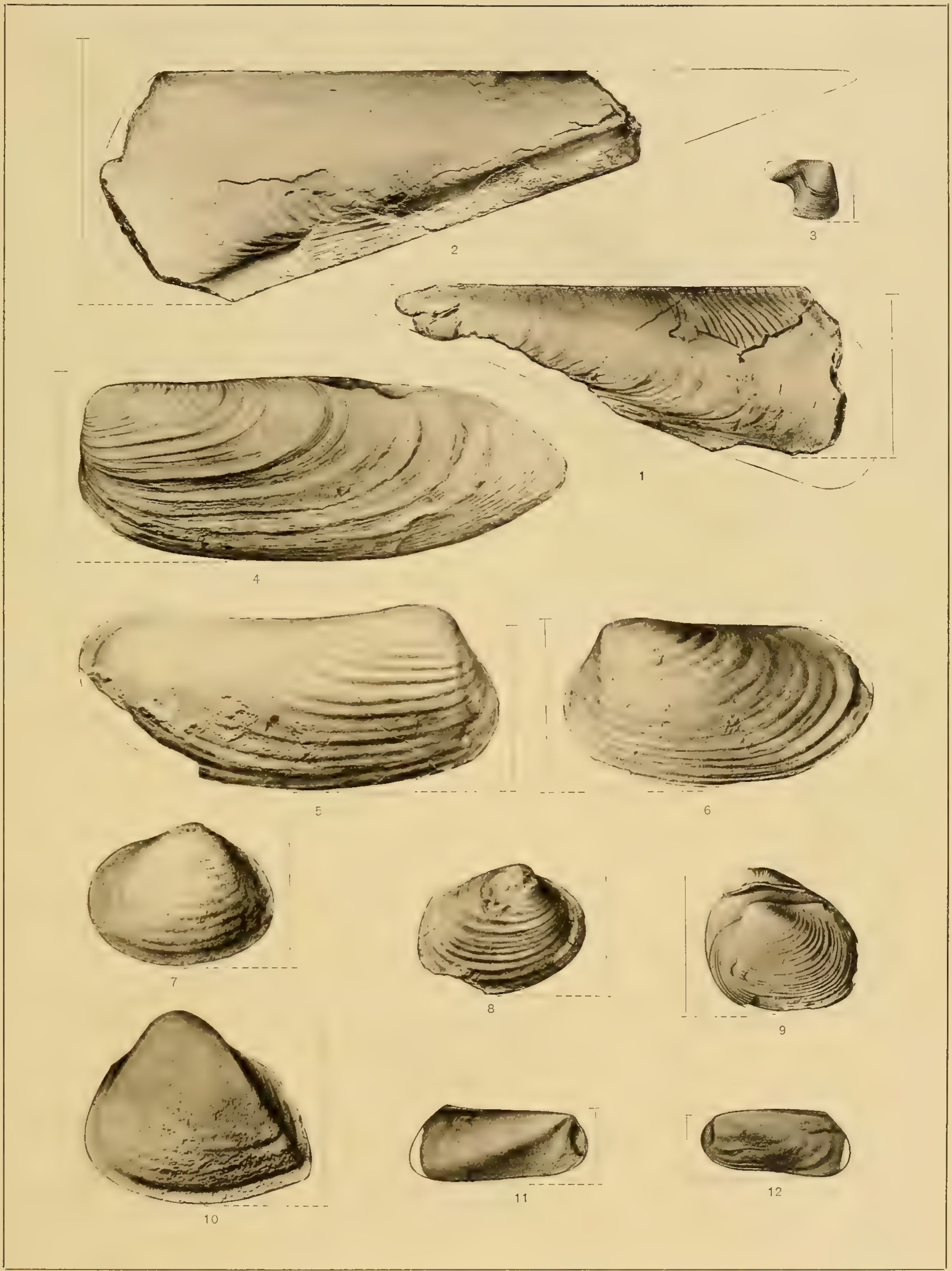

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FIG. 8. EDMONDIA GIBBOSA 447

A somewhat smaller specimen referred to the same species.

Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2341).

FIG. 9. EDMONDIA GIBBOSA 447

A specimen from Texas which preserves the shell. Believed to be the same species as figs. 7 and 8. The shell, whose interior is partially shown by the illustration, gives a view of the hinge of the right valve of this species. It is seen to be practically edentulous, with a long, narrow, external ligamental furrow.

Side view of left valve.

Cisco division of the Upper Carboniferous: Graham, Young County, Tex.

FIG. 10. SCHIZODUS CUNEATUS? 439

An internal cast of a left valve believed to belong to this species.

Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2341).

FIG. 11. PLEUROPHORUS SUBCOSTATUS 444

Internal cast of a right valve.

Side view. The anterior and posterior muscle scars are shown by this figure.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIG. 12. PLEUROPHORUS SUBCOSTATUS 444

A left valve retaining portions of the shell.

Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2341).

PLATE X.

PLATE X.

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FIGS. 1 AND 1a. PLATYCERAS PARVUM 461

A specimen of the usual size, or somewhat larger than usual. The apex is slightly broken.

Fig. 1. Side view.

1a. Posterior view.

Hermosa formation: Sandstone Mountain, Rico quadrangle (station 2218).

FIGS. 2 AND 2a. PLATYCERAS PARVUM 461

An extremely large specimen which seems to belong to the same species.

Fig. 2. Side view.

2a. Posterior view. This figure shows the specimen tilted forward and downward.

Hermosa formation: Head of Bear Creek, Needle Mountains quadrangle (station 2286).

FIGS. 3 AND 3a. STROPHOSTYLUS SUBOVATUS? 463

A specimen referred to this species.

Fig. 3. Apical view.

3a. Side view. Neither of these figures show adequately the rapid expansion which characterizes this specimen.

Hermosa formation: Sandstone Mountain, Rico quadrangle (station 2217).

FIGS. 4 AND 4a. STROPHOSTYLUS REMEX 463

A large but imperfect specimen of this species.

Fig. 4. Apical view.

4a. Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2340).

FIGS. 5 TO 5b. STROPHOSTYLUS REMEX 463

A smaller specimen referred to this species.

Fig. 5. Side view.

5a. Apical view.

5b. Side view, somewhat different from 5.

Rico formation: Marguerite Creek, Rico quadrangle (station 2345).

FIGS. 6 TO 6b. BULIMORPHA CHRYSALIS 466

A large specimen referred to this species.

Fig. 6. Side view.

6a. Apertural view. The specimen in this figure is inclined away from the vertical.

6b. Apical view.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIGS. 7 AND 7a. BULIMORPHA CHRYSALIS 466

A somewhat smaller and more slender specimen than the foregoing.

Fig. 7. Side view.

7a. Apertural view.

Rico formation: Marguerite Creek, Rico quadrangle (station 2345).

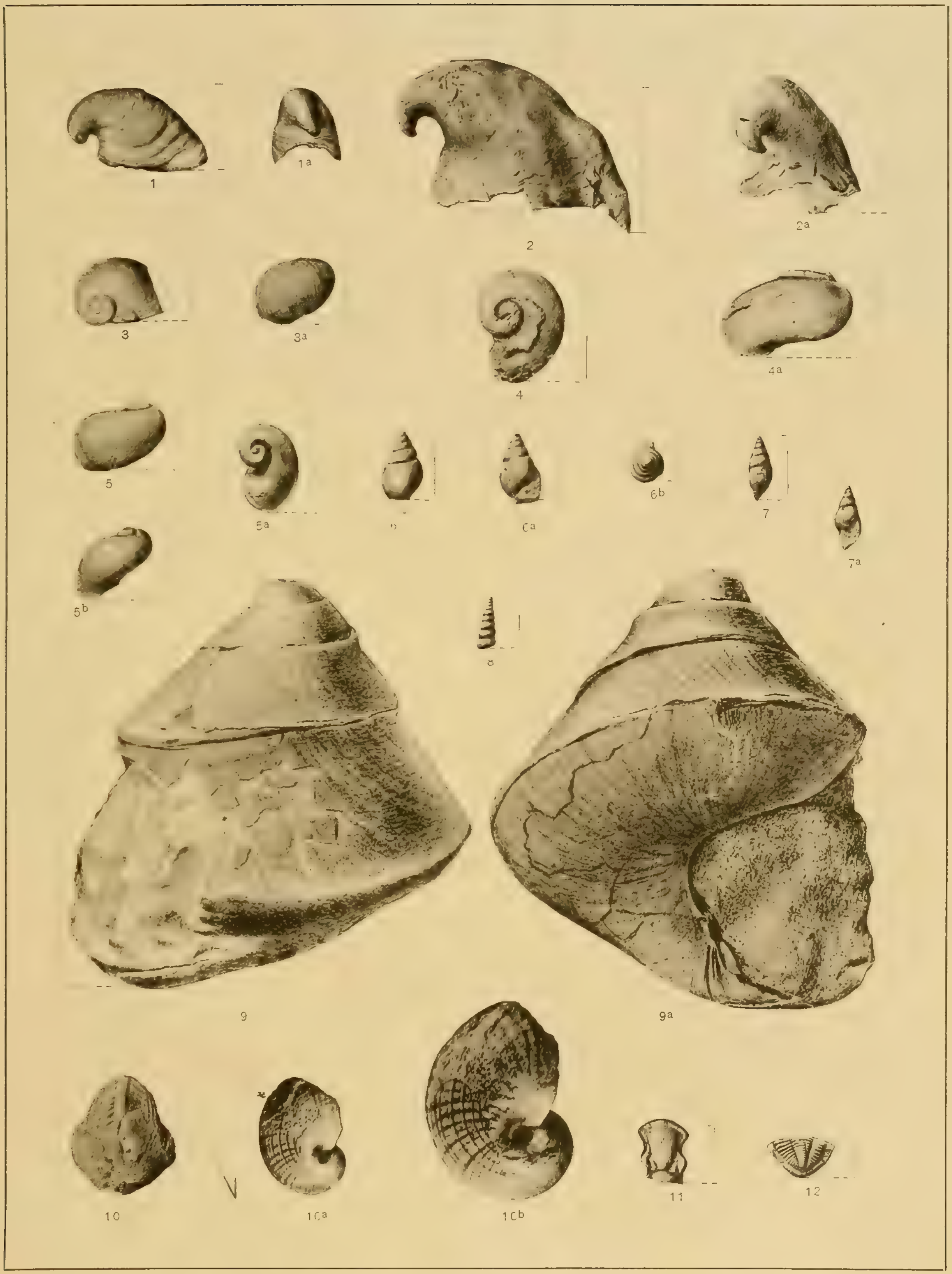

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FIG. 8. LOXONEMA ? PEORIENSE 460

A very imperfect specimen partially embedded in rock.

Side view.

Rico formation: Scotch Creek, Rico quadrangle (station 2342).

FIGS. 9 AND 9a. EUCONISPIRA TAGGARTI 453

The type specimen of this fine species. It is somewhat deformed by pressure. The figures are copied from White, and slightly enlarged.

Fig. 9. Side view.

9a. Apertural view. In this figure the apex is somewhat tilted away from the observer.

Weber shales: Near mouth of canyon of Four Mile Creek, Leadville district (station 2281).

FIGS. 10 TO 10b. PLATELLOSTIUM OURAYENSE 471

The typical specimen of this species, which I have been enabled to figure through the courtesy of the department of geology of the University of Chicago.

Fig. 10. Dorsal view. This figure shows the character of the striation, which is somewhat different on the two sides of the band.

10a. Side view.

10b. Side view enlarged.

Hermosa formation (?): Ouray, Colorado.

FIG. 11. PHILLIPSIA TRINUCLEATA 478

A cephalic shield referred to this species.

Specimen seen from above.

Weber formation: Empire Hill, Leadville district (station 2265).

FIG. 12. PHILLIPSIA TRINUCLEATA 478

A pygidium from the same locality as the cephalic shield of fig. 11.

Specimen seen from above.

Weber formation: Empire Hill, Leadville district (station 2265).

REGISTER OF LOCALITIES.

2186. Needle Mountains quadrangle; Molas formation. Southwestestern corner of Stag Mesa, on the northeastern base of a high knoll, at an elevation of 11,600 feet plus. This collection and the three following occur close together and within a vertical distance of 20 or 30 feet.
Whitman Cross, 1901.

2187. Needle Mountains quadrangle. Stag Mesa, south slope of Needle Mountains, Colorado; nearly the same as 2186.
Whitman Cross, 1901.

2188. Needle Mountains quadrangle. Stag Mesa, southeastern slope of Needle Mountains, Colorado; nearly the same as 2186.
Whitman Cross, 1901.

2189. Near the South Fork of the Vermilion and near the east base of Diamond Peak, Uinta Mountains; Upper Carboniferous, not *in situ*.
C. A. White, August 9, 1875. Mentioned on page 92 of White's report in Powell's Geology of the Uinta Mountains. (U. S. Geol. Geog. Surv. Terr., 1876.)

2190. Grand River, 1 mile below Eagle River.
A. R. Marvine, November 10, 1874.

2191. Overlooking Yampa River.
S. F. Emmons.

2192. Above volcanic layer near camp 49, below the mouth of the canyon of Eagle River. Bed 12, top of Weber limestone (?).
A. C. Peale, September 22, 1873. This locality is described on pages 242–243, U. S. Geol. Geog. Surv. Terr., Ann. Rept., for 1873, 1874.

2193. Glenwood Springs, Colo. First bend in trail leading up to Hubbard's Cave, possibly 50 feet above the bottom of the gully.
H. E. Dickhaut, August, 1900.

2193a. Glenwood Springs, Colo. Near the top of hill, west side of gully on trail leading to Hubbard's Cave.
H. E. Dickhaut, August, 1900.

2194. Cliffs west of Ouray, Colo. Northeast side of a little canyon coming from the northwest. Shaly and limy layers beneath the coarse conglomerate below a great series of grits. Elevation, 8,175 feet.
G. H. Girty, August 15, 1900.

2195. East of Ouray, Colo. Cliffs on either side of a little cascade just east of town. Probably the horizon of *Myalina cuneiformis* Gurley. Elevation, 8,075 feet.
G. H. Girty, August 16, 1900.

2195a. Cliffs east of Ouray, Colo., near small cascade east of town. Elevation, 8,125 feet.
G. H. Girty, August 15, 1900.

2195b. Cliffs east of Ouray, Colo., near small cascade east of town. Elevation, 8,175 feet.
G. H. Girty, August 15, 1900.

2195c. Cliffs east of Ouray, Colo., and south of a little canyon and falls just east of town. Elevation, 8,525 feet.
G. H. Girty, August 15, 1900.

2196. Engineer Mountain quadrangle; Hermosa formation. Cliff on the north side of Elbert Creek. Barometric elevation, 9,800 feet.
G. H. Girty, July 30, 1900.

2196a. Engineer Mountain quadrangle; Hermosa formation. Same section as 2196, but at an elevation of 10,300 feet.
G. H. Girty, July 30, 1900.

2196b. Engineer Mountain quadrangle; Hermosa formation. Same section as 2196; 0 to 25 feet below massive limestone bed at an elevation of 10,375 to 10,400 feet.
G. H. Girty, July 30, 1900.

2196c. Engineer Mountain quadrangle; Hermosa formation. Same section as 2196. Base of massive limestone capping cliff. Elevation, 10,455 feet.
G. H. Girty, July 30, 1900.

2197. Engineer Mountain quadrangle; Hermosa formation. Isolated ledges near the base of the Hermosa, east side of road south of west of Columbine Lake.
Cross and Girty, August 1, 1900.

2198. Engineer Mountain quadrangle; Hermosa formation. West of and near the Silverton road, below grade of road to Hermosa Park; south of small stream from the pass. Second of several ledges of lowest Hermosa cropping out in a low ridge from the bottom land.
Cross and Girty, August 1, 1900.

2199. Engineer Mountain quadrangle; Hermosa formation. On Silverton road grade, about where it crosses the boundary of the Engineer Mountain and Needle Mountains quadrangles. The horizon is in the lower portion of the Hermosa formation.
Cross and Girty, August 11, 1900.

2200. Durango quadrangle; Hermosa formation. The highest fossiliferous limestone exposed in Big Percent Creek. Upper part of Hermosa formation.
Whitman Cross, 1897.

2201. Durango quadrangle; Hermosa formation. South Fork of Hermosa Creek. Upper part of Hermosa formation.
Whitman Cross, August 30, 1898.

2202. Durango quadrangle; Hermosa formation. Cliff at the head of Carson Creek. Probably about the lower part of the middle series of the Hermosa formation.
Whitman Cross, July 8, 1898.

2203. Durango quadrangle; Hermosa formation. Cliff facing Hermosa Creek on ridge between the Hermosa and Animas rivers. Topmost shale of the Hermosa formation.
A. C. Spencer, October, 1897.

2204. Durango quadrangle; Hermosa formation. Between Hermosa Creek and Animas Valley. Upper part of the formation, 100 feet below the top.
A. C. Spencer, October, 1897.

2205. Durango quadrangle; Hermosa formation. West side of Animas Valley, on Conely's trail. Upper part of Hermosa formation.
A. C. Spencer, October, 1897.

2206. Durango quadrangle; Hermosa formation. Gypsum cliff. Chert from top of a stratum of shale. Hermosa Creek and Buck Hollow.
Whitman Cross, July 11, 1898.

2207. Durango quadrangle; Hermosa formation. Just north of Tripps Gulch. Upper part of Hermosa formation.
Cross and Spencer, July 11, 1898.

2208. Durango quadrangle; Hermosa formation. Just north of Tripps Gulch. Upper part of Hermosa formation.
Cross and Spencer, July 11, 1898.

2209. Durango quadrangle; Hermosa formation. North side of Coon Creek. Lowest part of Hermosa formation, just above the Devonian.
A. C. Spencer, July 12, 1898.

2210. Durango quadrangle; Hermosa formation. North of Stevens Creek. Upper part of Hermosa formation.
A. C. Spencer, July, 1898.

2211. Durango quadrangle; Hermosa formation. Cliff south of Carson Creek. Next fossiliferous layer above 2202.
A. C. Spencer, July, 1898.

2212. Engineer Mountain quadrangle; Hermosa formation. West side of Animas Valley, near south edge of quadrangle. Heavy limestone series near middle part of formation.
A. C. Spencer, July, 1898.

2213. Durango quadrangle; Hermosa formation. North side of Bear Creek. Very lowest part of Hermosa formation, just above Devonian. Same horizon as 2209.
A. C. Spencer, July, 1898.

2214. Durango quadrangle; Hermosa formation. North side of Bear Creek. Red limestone about 25 to 35 feet above the principal ledge of the Devonian and below 2213.
A. C. Spencer, July, 1898.

2215. Durango quadrangle; Hermosa formation. Exact locality not recorded.

2216. Rico quadrangle; Hermosa formation. Sandstone Mountain. Black shale above heavy limestone series; base of upper third of the formation.
Whitman Cross, October 18, 1897.

2217. Rico quadrangle; Hermosa formation. Sandstone Mountain. Middle part of Hermosa formation; heavy limestone series, about 150 feet below 2216.
Whitman Cross, October 19, 1897.

2218. Rico quadrangle; Hermosa formation. Sandstone Mountain. Upper part of Hermosa formation, a few feet above black shale of 2216.
Whitman Cross, October 19, 1897.

2219. Rico quadrangle; Hermosa formation. South of Marguerite Draw. Upper part of Hermosa formation; black shale series, not so high as 2216.
Whitman Cross, October 20, 1897.

2220. Rico quadrangle; Hermosa formation. Silver Creek, near Argentine shaft. Crinoidal limestone layer in heavy limestone series, middle part of Hermosa formation.
Whitman Cross, October 23, 1897.

2221. Rico quadrangle; Hermosa formation. Same as 2218
Whitman Cross, October 19, 1897.

2222. Rico quadrangle; Hermosa formation. Angle of road south of Deadwood Gulch. Near top of middle or heavy limestone series.
E. Howe, September, 1898.

2223. Rico quadrangle; Hermosa formation. Deadwood Gulch. Heavy limestone series.
E. Howe, September, 1898.

2224. Rico quadrangle; Hermosa formation. Deadwood Gulch. Heavy limestone series.
E. Howe, September, 1898.

2225. Rico quadrangle; Hermosa formation. Road above Black Hawk vein. Heavy limestone series.
Whitman Cross, September 21, 1898.

2226. Rico quadrangle; Hermosa formation. Sandstone Mountain. Black shale about 125 feet above heavy limestone series.
Whitman Cross, October 1, 1898.

2227. Rico quadrangle; Hermosa formation. Exact locality not recorded.

2228. Rico quadrangle; Hermosa formation. Slope of Dolores Mountain back of Newman Hill. Heavy limestone series.
Whitman Cross.

2229. Rico quadrangle; Hermosa formation. Deadwood Gulch. Heavy limestone series.
Cross and Spencer.

2230. Rico quadrangle; Hermosa formation. West side of Dolores River, south of Deadwood fault. Heavy limestone series.
A. C. Spencer, September, 1898.

2231. Rico quadrangle; Hermosa formation. Fusulina limestone. Marguerite Draw. Upper layer of the Hermosa formation.
A. C. Spencer.

2232. Rico quadrangle; Hermosa formation. Ridge west of Papoose Creek. Topmost fossiliferous layer.
A. C. Spencer, 1898.

2233. Several unknown localities in the Animas region. Probably entirely from the Hermosa formation.

2234. Rico quadrangle; Hermosa formation. South side of Deadwood Creek.
A. C. Spencer, 1898.

2235. Rico quadrangle; Hermosa formation. South side of Deadwood Gulch. Heavy limestone series.
A. C. Spencer, 1898.

2236. Rico quadrangle; Hermosa formation. South side of Deadwood Gulch. Heavy limestone series.
A. C. Spencer, 1898.

2237. Rico quadrangle; Hermosa formation. Sandstone Mountain. Talus from heavy limestone series.
Cross and Spencer, 1898.

2238. Durango quadrangle; Hermosa formation. Near mouth of Hermosa Creek. Upper portion of the Hermosa formation.
E. B. Mathews, 1894.

2239. Durango quadrangle; Hermosa formation. Same locality and horizon as 2238.
E. B. Mathews, 1894.

2240. Durango quadrangle; Hermosa formation. Same locality and horizon as 2238.
E. B. Mathews, 1894.

2241. Durango quadrangle; Hermosa formation. Same locality and horizon as 2238.
E. B. Mathews, 1894.

2242. San Juan region; Hermosa formation. Lower end of Animas Park, on east side of river. Within the red sandstones, nearly 1,000 feet above its lower limits.
F. M. Endlich, 1873. This locality appears to be described in U. S. Geol. Geog. Surv. Terr., [8th] Ann. Rept., for 1874, 1876, p. 216. If the locality is not the one described above, it is probably that mentioned as station 49 (east side of Animas River at elevation 11,700 feet) higher on the same page.

2243. San Juan region; Hermosa formation. Lower end of Animas Park, on east side of river. A short distance below the red sandstones.
F. M. Endlich, 1873. This locality is mentioned on the same page of the report cited above.

2244. Elk Mountain region; Maroon formation. Near the head of Rock Creek.
J. J. Stevenson, 1873. This locality seems to be bed 1 of Stevenson's section described on p. 362 of U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875. None of the fossils mentioned have come to hand except *Marginifera muricata* and *Seminula subtilita.*

2245. The only locality at present known is "Pass from Rock to Rock Creek, Colorado." I can not find that this collection has been mentioned in literature.
W. H. Holmes, 1876.

2246. Durango quadrangle; Hermosa formation. East side of Animas River, opposite Hermosa Creek. Middle part of Hermosa formation. Same as 2335.
E. B. Mathews, 1894.

2247. Engineer Mountain quadrangle; Hermosa formation. Animas section, near Cascade Creek, on Silverton road. Thin limestone series above supposed Devonian at the base of the Hermosa formation.
A. C. Spencer, 1898.

2248. Engineer Mountain quadrangle; Rico formation. Bottom portion of the formation in the vicinity of Hermosa Park.
Cross and Spencer.

2249. Engineer Mountain quadrangle; Hermosa formation. Section on the south edge of the quadrangle. Middle part of the Hermosa formation.
Cross and Spencer.

2250. Leadville district. Esmeralda mine, Prospect Mountain. Depth 100 feet. Fossils in shale 6 feet thick. Weber shale, base of the Weber formation.
E. Jacob.

2251. Leadville district. Esmeralda mine, Prospect Mountain. Weber shale, base of the Weber formation.
E. Jacob.

2252. Leadville district. Little Ella Hill. Central lode. Black shale fossils. Weber shale, base of the Weber formation.
S. F. Emmons.

2253. Leadville district. Little Ella Hill. Central lode. Black shale fossils. Weber shale, base of the Weber formation.
S. F. Emmons.

2254. Leadville district. Little Ella Hill, Lake County, Colo. Weber formation.
Bronson.

2255. Leadville district. Several localities in Hoosier Pass. Probably from the Weber formation.
A. Lakes, September 8, 1880.

2256. Leadville district. Hill beyond Dyer mine. Horizon uncertain.
Bronson.

2257. Leadville district. Two localities in Horseshoe Gulch, 100 and 150 feet, respectively, above the Leadville porphyry. Probably from the Weber shales at the base of the Weber formation.
Cross and Emmons, August 19, 1880.

2258. Leadville district. Horseshoe Gulch, Park County, Colo. Second series of black shales, 50 feet above fossiliferous limestone. Weber shales, base of the Weber formation.
S. F. Emmons, August 17, 1880.

2259. Leadville district. Horseshoe Gulch, Park County, Colo. Several localities in upper fossiliferous shale near forks of creek. Probably from the Weber formation.
A. Lakes, August 21, 1880.

2260. Tenmile district. Robinson mine, Kokomo. Robinson limestone, base of the Maroon formation.
E. Jacob.

2261. Tenmile district. Below the Robinson mine. Robinson limestone, base of the Maroon formation.
E. Jacob.

2262. Leadville district. Sacramento Gulch, head of North Fork. Dark limestone in sandstone, Weber formation, middle part.
Whitman Cross, September 12, 1880.

2263. Leadville district. Head of Big or North Fork of Sacramento Gulch. Probably near middle of Carboniferous sandstone belt. Weber formation, middle part.
S. F. Emmons, September 12, 1880.

2264. Leadville district. Two localities in the Weber formation on Empire Hill, Lake County, Colo.
S. F. Emmons.

2265. Leadville district. Empire Hill, Lake County, Colo. Limestone 300 feet thick, above Middle Carboniferous sandstone. Weber formation.
Whitman Cross, September 20, 1880.

2266. Leadville district. Head of North Fork of Weston Gulch, Lake County, Colo. Weber formation.
Whitman Cross, September 20, 1880.

2267. Leadville district. Fossils from two localities in the black shale and limestone, the one in Empire Gulch, the other in Weston Gulch. Weber shale, base of the Weber formation.
Cross and Emmons, September 20, 1880.

2268. Leadville district. Head of north fork of Weston Gulch, Lake County, Colo. Weber formation.
A. Lakes.

2269. Leadville district. From two localities probably in the upper part of the Weber formation. Near Beaver Creek, Park County, Colo.
A. Lakes, September 11, 1880.

2270. Leadville district. Upper part of the belt of black limestone on the ridge north of Silverheels Mountain, Park County, Colo. Base of the Maroon formation.
S. F. Emmons, September 8, 1880.

2271. Leadville district. Fossils from Twelvemile Creek, Colorado.
J. Long.

2272. Tenmile district. Thin limestone, the first on the steep cliff of Sheep Mountain, Kokomo. Upper part of the Weber grits formation.
E. Jacob.

2273. Tenmile district. Wheel of Fortune mine, 500 feet northwest. Robinson limestone, base of the Maroon formation.
E. Jacob.

2274. Tenmile district. White Quail mine, 25 feet above the ore. Robinson limestone, base of the Maroon formation.
W. B. Fisher.

2275. Tenmile district. Several localities in the Weber grits formation. Eagle River Peak, Kokomo Gulch, and Searles Gulch.
Cross, Emmons, and Jacob.

2276. Tenmile district. Near the top of the Carboniferous, Eagle River Peak, Colorado. Weber grits formation, upper part.
E. Jacob.

2277. Leadville region; Lingula shales. Iron mine fault. Weber shale, base of the Weber formation.

2278. Leadville region. Road to Mount Lincoln by Quartzville, near Milk ranch, southwest of Platte, Montgomery County, Colorado. Weber formation.
A. Lakes, September 8, 1880.

2279. Silverton quadrangle; Hermosa formation. Near Molas Lake. Upper of two thin limestones just above the Devonian; lowest part of the Hermosa formation.
A. C. Spencer.

2280. Elk Mountain region; Maroon conglomerate. Southeast of Italian Peak.
A. C. Peale, 1873. This locality is bed 11 of section 24 described on p. 251 of U. S. Geol. Geog. Surv. Terr., [7th] Ann. Rept., for 1873, 1874.

2281. Leadville district; Weber shales, base of Weber formation (?). Near mouth of canyon of Fourmile Creek.
A. C. Peale, 1873. This locality is bed 38 (and possibly 39) of section 18, described on p. 229 of U. S. Geol. Geog. Surv. Terr., [7th] Ann. Rept., for 1873, 1874.

2282. Rico quadrangle; Hermosa formation. Sandstone Mountain section. Middle portion of the Hermosa formation.
E. B. Mathews, 1894.

2283. Rico quadrangle; Hermosa formation. Sandstone Mountain section. Upper part of Hermosa formation.
E. B. Mathews, 1894.

2284. Rico quadrangle; Hermosa formation. Fossils from baked sandy limestone, center of Rico dome. Horizon identical with that of certain beds occurring within a few feet of the Devonian strata on the Animas River.
A. C. Spencer, 1899.

2285. Sinbads Valley, Colorado, near La Sal Mountains. West side of valley, near its southern end. Near top of gray series below the red. Not more than 100 feet of gray shales and light-colored sandstones separate this horizon from the typical Red Beds.
A. C. Spencer, November, 1899.

2286. Needle Mountains quadrangle; Hermosa formation. Main divide between the Animas and Florida rivers, head of Bear Creek of the Durango quadrangle. Middle part of the Hermosa formation.

Cross and Spencer, July 14, 1898.

2287. Silverton quadrangle; Hermosa formation. Southern portion of the quadrangle, and middle portion of the formation.

A. C. Spencer.

2288. Grand River region; Weber formation (?). East side of Eagle River, 6 miles below Tennessee Pass.

W. H. Holmes, 1873. This locality is mentioned on p. 242 of U. S. Geol. Geog. Surv. Terr., [7th] Ann. Rept., for 1873, 1874.

2289. Grand River region; Maroon formation. Forks of Eagle River.

J. J. Stevenson, 1873. This collection came from bed 19 in the section described on p. 368 of U. S. Geog. Geol. Surv. W. 100th Mer., Rept., vol. 3, 1875.

2290. Crested Butte district. Punch Gulch, about 2 miles inside the Trias quartzite ridge, near bottom of gulch. From limestone making up a limestone conglomerate in situ.

G. H. Eldridge, 1885.

2291. Crested Butte district. Same as 2290. Gulch on the ridge forming the northern side of Punch Gulch. Carboniferous limestone 140 feet beneath "Trias quartzite," and separated from it by a red sandstone.

G. H. Eldridge, 1885.

2292. Crested Butte district. Same as 2291. Carboniferous limestone 337 feet below the white quartzite, separated from 2291 by three distinct occurrences of conglomerate sandstone.

G. H. Eldridge, 1885.

2293. Crested Butte district. Same as 2291. 500 to 539 feet below white quartzite, immediately overlain by 90 feet of conglomerate.

G. H. Eldridge, 1885.

2294. Crested Butte district. Same as 2291. Limestone 600 feet below the white quartzite, separated by a sandstone from 2293.

G. H. Eldridge, 1885.

2295. Crested Butte district. Same as 2291. Twelve hundred and fifty-five feet beneath white quartzite. Separated from 2294 by sandstone and limestone conglomerate.

G. H. Eldridge, 1885.

2296. Crested Butte district. From Carboniferous limestone in a gulch without a name, midway between Punch and Roaring Judy gulches, inside Triassic quartzite ridge.

G. H. Eldridge, 1885.

2297. Crested Butte district. Same as 2296.

G. H. Eldridge, 1885.

2298. Crested Butte district. Same as 2296. From a Carboniferous limestone about 75 feet west of, or above, 2297.

G. H. Eldridge, 1885.

2299. Crested Butte district. Round Mountain Gulch, on north side, a considerable distance east of the fault line. One of the bands of Carboniferous limestone associated with limestone conglomerates, 300 to 400 feet above, or west of, the junction of these with the Archean.

G. H. Eldridge, 1885.

2300. Crested Butte district; Maroon formation, lower part. From float in the vicinity of 2299.
G. H. Eldridge, 1885.

2301. Rico quadrangle; Hermosa formation. Iron mine, Silver Creek, Rico, Colo. Middle portion of the Hermosa formation.
H. S. Gane, 1896.

2302. Crested Butte district; Maroon formation, lower part (?). Northern slope of the long spur just north of Round Mountain Creek, and on one of the secondary spurs running northward from this to the gulch passing into East River Valley between Red Mountain and Cement Creek. From a band of gray limestone just west of the first prominent limestone conglomerate ridge east of the long Trias quartzite forming a ridge running up to Cement Spur.
G. H. Eldridge, 1885.

2303. Crested Butte district; Maroon formation, lower part (?). From another Carboniferous limestone band 50 feet west of 2302 and above it geologically.
G. H. Eldridge, 1885.

2304. Crested Butte district; Maroon formation, lower part. On the eastern slope of Round Mountain, descending into Round Mountain Gulch. From a band of Carboniferous limestone west of a prominent bed of limestone conglomerate.
G. H. Eldridge, 1885.

2305. Crested Butte district; Maroon formation, lower part. From a float piece of Carboniferous linestone on the high Trias quartzite ridge north of Cement Creek.
G. H. Eldridge, 1885.

2306. Crested Butte district. Same as 2305. From limestone pebbles forming a prominent limestone conglomerate (Maroon series) about 285 feet thick, occurring about one-third the way up this hill.
G. H. Eldridge, 1885.

2307. Crested Butte district; Weber limestone. On a spur running from the ridge on which locality 2305 is situated. From a limestone quite low down geologically and topographically, which is overlain by about 20 feet of limestone similar to it, and then by papery black shales about 30 feet thick.
G. H. Eldridge, 1885.

2308. Crested Butte district; Weber limestone. Same section as 2305. From the lower part of the section, not far above the main Eocarboniferous limestone, in the dark shale and dark cherty limestone.
G. H. Eldridge, 1885.

2309. Rico quadrangle; Hermosa formation. Rico, Colo. Carboniferous limestone under sandstone. One hundred feet above shop at iron mine, Silver Creek.
C. W. Purington, 1896.

2310. Crested Butte district; Maroon formation, lower part. On main ridge running northeast and north from Cement Peak, one-sixth the way from Cement Peak to Deadmans Gulch. From a limestone in a series of sandstones and conglomerates considerably above the black shales and Eocarboniferous limestones geologically.
G. H. Eldridge, 1885.

2311. Crested Butte district; Maroon formation, lower part. Close to 2310, but a little west of it. Geologically a little lower than the latter, but with the same association of sandstone and grits.
G. H. Eldridge, 1885.

2312. Crested Butte district; Weber limestone. On same ridge as 2310 and 2311. Geologically just below the black shale, in the upper member of the black, cherty limestone series which overlies the Eocarboniferous limestone.
G. H. Eldridge, 1885.

2313. Crested Butte district; Weber limestone. Same as 2312 and about 10 feet below it.
G. H. Eldridge, 1885.

2314. Crested Butte district; Weber limestone. Branch of Cement Creek containing mines. From the débris of the lower black slate series. One of the limestones contained in the series.
G. H. Eldridge, 1885.

2315. Same locality and about the same horizon as 2314.
G. H. Eldridge, 1885.

2316. Crested Butte district; Weber limestone. On west side of first gulch west of Cement Creek, running south from steep part of Double Top. Well down in gulch. From a blue limestone seemingly between the yellow grits and the great red conglomerate and limestone conglomerate beds of the upper series.
G. H. Eldridge, 1885.

2317. Crested Butte district; Maroon formation, lower part. Nearly at the top of a spur running east from the very southern end of Double Top. From a limestone at summit of grits and under great red conglomerate with limestone and Archean pebbles. A small occurrence in an Archean fold at its crest.
G. H. Eldridge, 1885.

2318. Crested Butte district; Maroon formation, lower part. In forks of Cement Creek opposite Italian Peak, 400 feet up the gulch. From a limestone associated with carbonaceous, shaly layers above some green beds of sandstone and conglomerate overlying the Red Beds.
G. H. Eldridge, 1885.

2319. Crested Butte district; Maroon formation, lower part. Just below and east of the summit of Hunters Hill. From a limestone resembling that at 2318.
G. H. Eldridge, 1885.

2320. Crested Butte district; Weber limestone. In a saddle of Cement Creek, west of Mount Tilton. From a limestone and black shales of the series immediately overlying the Eocarboniferous limestone.
G. H. Eldridge, 1885.

2321. Crested Butte district; Maroon formation, lower part. Dyke Creek, one-third to one-half mile above its mouth, just above first creek crossed by road, 1 mile beyond and just above heavy limestone and Archean conglomerate.
G. H. Eldridge, 1885.

2322. Rico quadrangle; Hermosa formation. Locality uncertain.
C. W. Purington, 1896.

2323. Deadwood, Colo.

2324. Ranch west of "camp 59," Colorado.
A. R. Marvine, prior to November, 1880.

2325. "Grand River, northwestern Colorado."
E. A. Barber, November 16, 1874.

2326. Glenwood Springs, Colo.; Weber formation. From 100 to 200 feet above the base of the Blue limestone.
T. W. Stanton, August, 1889.

2327. San Juan region; Hermosa formation. Animas River, from a pinkish conglomerate underlying the Red Beds.

R. C. Hills, prior to 1890. This locality is referred to in footnotes on pp. 366 and 373, Colorado Sci. Soc., Proc., vol. 3, pt. 3, 1890.

2328. Hermosa Creek, in La Plata Mountains, Animas Valley.

2329. Glenwood Springs; Weber formation 100 to 200 feet above the base of the Blue limestone. T. W. Stanton, August, 1889.

2329a. Glenwood Springs; Weber formation 150 to 200 feet above the base of the Blue limestone. T. W. Stanton, August 24, 1889.

2329b. Glenwood Springs. Between Denver and Rio Grande Railroad tunnel and Springs bath house, possibly 200 or 300 feet east of Spring House.

H. E. Dickhaut, August, 1900.

2330. Middle division of the Carboniferous series, Yampa Plateau, northwestern Colorado.

C. A. White, 1876.

2331. San Juan region; Hermosa formation. Rio Animas, from a formation below the one yielding collection 2327.

R. C. Hills, prior to 1890. This locality is mentioned in footnotes on pp. 366 and 373, Colorado Sci. Soc., Proc., vol. 3, pt. 3, 1890.

2332. Durango quadrangle; Hermosa formation. Near the mouth of Hermosa Creek, and in the middle part of the formation. Same as 2334.

E. B. Mathews, 1894.

2333. Probably the same as 2335.

2334. Durango quadrangle; Hermosa formation. Near the mouth of Hermosa Creek, and in the middle part of the Hermosa formation.

E. B. Mathews, 1894.

2335. Durango quadrangle; Hermosa formation. East side of Animas River, opposite Hermosa Creek. Near the middle part of the Hermosa formation.

E. B. Mathews, 1894.

2336. Needle Mountains quadrangle; Hermosa formation. Near the southwestern corner of the quadrangle.

A. C. Spencer, July 14, 1898.

2337. Engineer Mountain quadrangle; Rico formation. In the vicinity of Hermosa Creek, bottom part of Rico formation.

A. C. Spencer.

2339. Silverton quadrangle. Exact locality not recorded.

2340. Rico quadrangle; Rico formation. Red, fossiliferous, sandy limestone exposed in Scotch Creek, about 125 feet above the base of the formation.

Cross and Spencer, August 26, 1898.

2341. Rico quadrangle; Rico formation. Blue limestone in shaly series. Highest fossiliferous layers about 230 feet above the base of the formation. Scotch Creek.

Cross and Spencer, August 26, 1898.

2342. Rico quadrangle; Rico formation. Same layers as 2341. Exposed in the bed of Scotch Creek. Cross and Spencer, August 27, 1898.

2343. Rico quadrangle; Rico formation. West bank of Dolores River, near Monte Lores.
Cross and Spencer, August 29, 1898.

2344. Rico quadrangle; Rico formation. Mouth of Marguerite Draw. Near base of formation.
Whitman Cross, September, 1898.

2345. Rico quadrangle; Rico formation. Mouth of Marguerite Creek. Near base of formation, but somewhat above 2344.
Whitman Cross, September, 1898.

2346. Rico quadrangle; Rico formation. Southwest slope of Dolores Mountain. Near base of formation.
Whitman Cross, September 14, 1898.

2347. Rico quadrangle; Rico formation. Silver Creek, west of Uncle Ned Draw. Middle of formation.
Whitman Cross, September 20, 1898.

2348. Rico quadrangle; Rico formation. West slope of Dolores Mountain. Near the base of the formation.
Cross and Spencer.

2349. Rico quadrangle; Rico formation. Burnett Creek. Probably 200 feet above the base of the Rico.
Whitman Cross, November 6, 1898.

2350. Crested Butte district; Leadville limestone. North side of Round Mountain Gulch, considerably east of fault line. From float associated with 2299.
G. H. Eldridge, 1885.

2351. Crested Butte region; Leadville limestone. Ridge between Mine and Frenchmans gulches, i. e., the second ridge south of Cement Creek.
G. H. Eldridge, 1885.

2352. Crested Butte district; Leadville limestone. Second section on hills bordering Cement Creek on the north, at a point 200 feet east of Thompson's stake 12.
G. H. Eldridge, 1885.

2353. Crested Butte district; Leadville limestone. Section a little east of the last, in the same bluffs, on Cement Creek. From the upper member of the cliff forming Eocarboniferous limestone.
G. H. Eldridge, 1885.

2354. Crested Butte district; Leadville limestone. Same locality and horizon as 2353.
G. H. Eldridge, 1885.

2355. Crested Butte district; Leadville limestone. Same locality and horizon as 2353.
G. H. Eldridge, 1885.

2356. Crested Butte district; Leadville limestone. Same locality and horizon as 2353.
G. H. Eldridge, 1885.

2357. Crested Butte district; Leadville limestone. Same locality and horizon as 2353, but from débris at base of cliff.
G. H. Eldridge, 1885.

2358. Crested Butte district; Leadville limestone. High, flat, timbered ridge between Spring Creek and the large fork of Deadmans Gulch, near trail on summit of ridge and about 10 miles after reaching the top of the ridge.
G. H. Eldridge, 1885.

2359. Crested Butte district; Leadville limestone. On same ridge as 2358, but about a half mile to the south.
G. H. Eldridge, 1885.

2360. Salida region, Monarch district; Leadville limestone. On the east side of trail to town; black limestone. Highest horizon of all the Salida fossils from the Monarch district.
G. H. Eldridge, 1885.

2361. Salida region; Leadville limestone. Sedimentary canyon of Arkansas River, 5 miles below Salida; from the quarried Eocarboniferous limestone which overlies all of the preceding Salida horizons.
G. H. Eldridge, 1885.

2362. Aspen district; Leadville limestone. Fryingpan Creek, near Aspen, Colo.
Manuel, prior to 1887. This collection is mentioned on p. 60, Colorado State School of Mines, Biennial Report for 1886, 1887.

2363. Aspen district; Leadville limestone. Tourtelotte Park, Aspen Mountain, Colorado.
A. Lakes, prior to 1887. This collection is mentioned on p. 60, Colorado State School of Mines, Biennial Report for 1886, 1887.

2364. Obtained from some pebbles in a conglomerate resting upon the eroded face of the granite 32 miles west and 18 miles north of Greeley, Colo.
L. C. Wooster, prior to 1880. See under *Retzia woosteri*, p. 134 of U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, 1883.

2365. Pikes Peak quadrangle; Millsap limestone. Head of Garden Park.
Russell, July 1, 1888.

2366. North bank of Arkansas River, about 1 mile west of Canyon, Colo.; Millsap limestone, band a few feet thick.
T. W. Stanton, 1890.

2367. Castle Rock quadrangle; Millsap limestone. Perry Park, Colo. Lowest sedimentary beds upturned against the gneisses. North side of West Plum Creek.
Whitman Cross, 1894.

2368. Pikes Peak quadrangle; Millsap limestone. East side of Garden Park.
Whitman Cross.

2369. Pikes Peak quadrangle; Millsap limestone. East side of Garden Park.
Whitman Cross.

2370. Canyon; Millsap limestone. No. 6 of section at Harding's sandstone quarry, Canyon, Colo.
T. W. Stanton, July 16, 1890. See section on p. 155 of Geol. Soc. America, Bull., vol. 3, 1892. No. 5 of section.

2371. Garden Park, 15 miles north of Canyon, Colo.; Millsap limestone.
T. W. Stanton, July 14, 1890.

2372. Leadville district; Leadville limestone. Long & Drury mine, Dana shaft. No. 1 of record.
E. Jacob.

2373. Leadville district; Leadville limestone. Long & Drury mine. No. 2 of record.
E. Jacob.

2374. Leadville district; Leadville limestone. Swamp Angel tunnel, about 400 feet from the entrance.
S. F. Emmons.

2375. Leadville district; Leadville limestone. Oolite mine, Leadville.
E. Jacob.

2376. Leadville district; Leadville limestone. Carbonate mine, Leadville, Colo.
S. F. Emmons.

2377. Leadville district; Leadville limestone. South slope of Mount Bross, below first spur of porphyry. Top of black limestone in loose concretions of chert covering the upper portion of slope.

A. Lakes, August 31, 1880.

2378. Leadville district; Leadville limestone. Fossils from ore-bearing limestone, head of Sacramento Gulch.

J. Long.

2379. Engineer Mountain quadrangle; Ouray limestone. West bank of Cascade Creek, about one-half mile below the bridge on the Silverton road. Seemingly in place at the top of the Ouray limestone.

Cross and Girty, August 7, 1900.

2380. Engineer Mountain quadrangle; Ouray limestone. Just east of old trail up Coalbank Hill, at elevation of 9,975 feet. Loose pieces on, and probably derived from, the top of the Ouray limestone.

G. H. Girty, August 8, 1900.

2381. Needle Mountains quadrangle. "Chert Mesa," 11,600 feet elevation. West of West Fork of Canyon Creek. Fossils from chert nodules in the Molas formation, above the Ouray limestone.

G. H. Girty, July 23, 1900.

2382. Engineer Mountain quadrangle; Ouray limestone. Cherty limestone at the top of the formation Near Cascade Creek, on its west bank, about one-half mile below the bridge where crossed by Silverton road.

Stose and Girty, August 7, 1900.

2384. Engineer Mountain quadrangle; Ouray limestone. Just west of old trail up Coalbank Hill, at elevation of 9,900 feet. The ledge of limestone just above the typical Ouray limestone.

G. H. Girty, August 8, 1900.

2385. Engineer Mountain quadrangle; Ouray limestone. On old trail outlet of lake east of Coalbank Hill Pass.

Cross and Girty, August 11, 1900.

2386. Needle Mountains quadrangle. South side of Canyon Creek. Exposures near the trail to a point at 10,000-foot elevation near the quadrangle line.

Cross, Howe, and Girty, July 25, 1900.

2387. Engineer Mountain quadrangle. Near old trail on Coalbank Hill, about 10,000-foot elevation. Green cherts above the Ouray limestone.

Cross and Girty, August 7, 1900.

2388. Durango quadrangle; Ouray limestone. Top of formation on the east side of Animas River, near Baker's bridge.

Cross and Spencer, 1889.

2389. Castle Rock quadrangle; Millsap limestone. North bank of West Plum Creek, Perry Park, Colo.

W. T. Lee, 1901. See map and page 97 of American Geologist, Vol. XXIX, No. 2, 1902.

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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Professional Paper No. 16.]

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