DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 389

THE MANZANO GROUP

OF THE

RIO GRANDE VALLEY, NEW MEXICO

BY

WILLIS T. LEE

AND

GEORGE H. GIRTY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

CONTENTS.

ILLUSTRATIONS.

THE MANZANO GROUP OF THE RIO GRANDE VALLEY, NEW MEXICO.

STRATIGRAPHY OF THE MANZANO GROUP.

By WILLIS T. LEE.

INTRODUCTION.

Purpose of report.—The purpose of the present paper is to describe the red beds of that part of the Rio Grande valley which lies between Santa Fe and Rincon, a distance of about 200 miles, and to establish their position in the geologic column. The rocks, consisting of sandstone and shale, prevailingly red in color, and containing gypsum and limestone, constitute a part of the so-called "Red Beds" of the Rocky Mountain region. On account of their general similarity in color and composition to the red beds that are exposed in the eastern foothills of the Rocky Mountains and that extend from the mountains eastward and southeastward into Kansas, Oklahoma, and Texas, they have been regarded as Permo-Triassic in age.

While my principal object is to present the evidence that tends to fix the geologic age of the red beds of the Rio Grande valley, the relation of these to other beds of similar nature is also considered. However, I have no intention to discuss the various aspects of the complicated "Red Beds" problem or even to review the numerous contributions to it. I purpose, rather, to confine attention to such phenomena as I have personally observed in the field and to such considerations as may have a direct bearing upon the interpretation of these observations.

Preliminary statement of results.—The red beds of the Rocky Mountain region are unfossiliferous in many places, but on account of their stratigraphic relations have frequently been called "Jura-Triassic"—a term still in common use. The name "Red Beds" has been so constantly applied to these rocks that it has come to have more or less of a time significance, and red sediments of undetermined age in the

Rocky Mountain region are sometimes referred to as the "Jura-Triassic Red Beds." In the Texas-New Mexico region the occurrence of red sediments that are older than the recognized Triassic beds and that are referred by many geologists to the Permian has given the name "Permo-Triassic" to some of the red beds in the Southwest.

Investigation has shown that some of the red beds of the Rocky Mountain region are much older than Triassic and that others are much younger, the geologic age extending from Mississippian ("Lower Carboniferous") to late Cretaceous. I have formerly called attention to the fact that the base of the red beds in Perry Park, Colorado,[a] is of lower Carboniferous age, and the evidence presented in this paper shows that a large part of the red beds in central New Mexico is of upper Carboniferous or Pennsylvanian age. Furthermore, there are red beds of late Cretaceous age, called Galisteo sandstone by Hayden,[b] and later described more fully by Johnson,[c] that are similar in general appearance to the older red beds and that have sometimes been mistaken for them. I have shown[d] that red sediments of late Cretaceous age occur also near Engle, N. Mex., about 150 miles south of Galisteo Canyon, the type locality of the Galisteo red beds.

The red beds of the Rio Grande valley, here called the Manzano group, are shown on faunal evidence to constitute the upper part of the Pennsylvanian ("Upper Carboniferous") series. It is not certainly known that the Manzano group is the exact time equivalent of any part of the red beds of the Rocky Mountain or Plains regions, as it has not been traced continuously from the one region to the other. However, certain data recently obtained indicate that the base of the red beds south and east of the mountains are of lower Pennsylvanian age, and it is reasonable to assume that some part of these apparently conformable beds is to be correlated with the Manzano or upper Pennsylvanian group.

Although the upper part of the red beds of the plains of eastern New Mexico is known from contained fossils to be of Triassic age,[e] I am disposed, because of lithologic resemblance, to correlate the lower part with the red beds of the Rio Grande valley. This opinion has recently found support in certain investigations made by Beede,[f] who has described a collection of invertebrates found in the Quartermaster formation near the top of the red beds in western Oklahoma and in the Panhandle of Texas. Beede refers the formation to the Permian; but after studying the Manzano fauna described in this

[a] Lee, W. T., The areal geology of the Castle Rock region: Am. Geologist, vol. 29, 1902, p. 97.

[b] Hayden, F. V., U. S. Geol. Survey Terr. for 1867 and 1869; reprint 1873, p. 166.

[c] Johnson, D. W., The geology of the Cerrillos Hills, New Mexico; School of Mines Quart., vol. 24, 1903, p. 36.

[d] Lee, W. T., Note on the Red Beds of the Rio Grande region in central New Mexico: Jour. Geology, vol. 15, 1907, pp. 52–58.

[e] Idem, p. 55.

[f] Beede, J. W., Invertebrate paleontology of the upper Permian red beds of Oklahoma and the Panhandle of Texas: Bull. Kansas Univ. Sci., vol. 14, 1907, pp. 115–171.

bulletin Girty finds that the Quartermaster fauna of Beede is more closely related to the Manzano than to the Guadalupian fauna,[a] which he has described as Permian and which, in turn, is younger than the Manzano. He correlates the Manzano and Quartermaster formations with the Hueco, which underlies the Guadalupian of Texas, and with the Gschelian, which is said to underlie the Permian beds of Russia.

Field work.—The investigations forming the basis of this report were carried on in the Rio Grande valley in central New Mexico during the summers of 1904 and 1905 in connection with economic work which required the greater part of my time. For this reason and also because of the intricate structure of the region, on account of which much detailed work would be required in order to map the formations, no attempt is here made to show the areal distribution of the rocks described. Parts of the various sections were not accurately measured where such measurements would have required considerable time, and the thicknesses are estimated, as indicated in the detailed descriptions. On account of their conspicuous red color and other physical peculiarities, the rocks are readily distinguished from both the underlying and the overlying formations and little difficulty is experienced in identifying them in the field, except where the younger or late Cretaceous red beds later referred to occur near them. Nevertheless, fossil collections were made wherever possible, and in every case the paleontologic evidence coincides with the physical in making the red beds of the Rio Grande valley a sharply defined group.

Field work was discontinued in 1905 before the relations of the Manzano group to the "Red Beds" of the Great Plains region to the east could be determined, and a short reconnaissance was made two years later (1907) in the foothills east and south of the Rocky Mountains in New Mexico for the purpose of making correlations. All of the work was rapid reconnaissance in character, and future investigations may require modification or change of opinions herein expressed.

LOCATION AND CHARACTER OF AREA.

The area examined is in the Rio Grande valley of New Mexico, mainly east of the river, and extends from Santa Fe southward to El Paso, a distance of about 275 miles. The rocks described are exposed at numerous places from Apache Canyon, at the north end of the region, southward beyond Rincon, a distance of more than 200 miles. A few miles south of Rincon they disappear beneath the surface of the Jornada del Muerto. This disappearance is not due to any original thinning of the beds, for the evidence at hand indi-

[a] Girty, G. H., The Guadalupian fauna: Prof. Paper U. S. Geol. Survey No. 58, 1908.

cates that they originally thickened toward the south. It is caused rather by recent erosion, which has removed the beds from the highlands, and by the accumulation of surface débris, which covers any remnants that may remain within the trough of the Jornada syncline.

The red beds are not continuously exposed, owing to profound displacements by faulting, some of the uplifted parts having been eroded and the downthrown parts covered with subaerial deposits. The exposures are not far enough separated, however, to make difficult the tracing of the formations or to render doubtful the identity of the beds, and in several places the beds are traceable continuously for long distances. The localities where the accompanying sections were measured and where fossils were collected are indicated by numbers on Plate I. The second set of numerals corresponds to the permanent lot numbers of fossils collected at the various localities and preserved in the collections of the United States Geological Survey.

The opportunities for stratigraphic study are exceptionally good throughout the Rio Grande region, owing to the occurrence of many small groups of mountains consisting of upturned blocks that expose to view rocks ranging in age from pre-Cambrian to Quaternary. The uplift of these mountain blocks was accomplished apparently in late geologic time, and the strata are exposed in scarplike faces, illustrated in Plate II, *A*. In this escarpment thicknesses of several thousand feet are exposed and the formations are traceable without break for long distances.

FORMATION NAMES.

Explanatory statement.—Several of the formation names used in this paper are new to science and others are so unfamiliar that definition is desirable. A number of papers have been published relating to the geology of the region, but apparently little detailed work has been done in the field and many of the names used have not been defined with sufficient care to make them intelligible even to one familiar with the geology of the region. In some cases the same name has been applied apparently to different formations, as shown by Gordon,[a] and in others the description of beds and the application of names are too ambiguous to be interpretable.

The names previously applied to formations are retained where type localities and adequate descriptions have been given. But for the older group of the Pennsylvanian series (Magdalena) and for the subdivisions of the younger group (Manzano) it has been deemed advisable to introduce new names.

[a] Gordon, C. H., Notes on the Pennsylvanian formations in the Rio Grande valley, New Mexico: Jour. Geology, vol. 15, 1907, pp. 805–816.

The question of the nomenclature of the Carboniferous formations of New Mexico has been discussed by Gordon in the article just referred to, and will be treated more fully in a paper in preparation describing the geology of a part of central New Mexico, to which readers interested in this question are referred. It should be added, however, that Doctor Gordon was writing his description at the same time that I was preparing this paper. Together we compared the literature relating to the geology of New Mexico, he making the suggestions and criticisms relating to the Magdalena group, while I am responsible for those relating to the Manzano group. The following classification is the result of our joint labor:

Pennsylvanian series	Manzano group	San Andreas limestone.
		Yeso formation.
		Abo sandstone.
	Erosional unconformity.	
	Magdalena group	Madera limestone.
		Sandia formation.

Magdalena group.—The name Magdalena is derived from the Magdalena Mountains in New Mexico, where the formations are well exposed, and has been applied to the lower group of the Pennsylvanian series by Gordon, who describes them as consisting of sediments 1,000 to 1,300 feet thick, made up of limestone with a subordinate amount of shale and sandstone. The Magdalena beds are found throughout the Rio Grande region and are readily recognized as the evenly bedded limestone formation intervening between the massive cherty limestone of Ordovician and Silurian age that forms the conspicuous cliffs, illustrated in Plate II, *A*, and the overlying red sediments of the Manzano group. The group is subdivided according to Gordon into the Sandia formation, a name given by Herrick[a] to the lower division, and the Madera limestone, a name applied by Keyes[b] to the upper division.

Sandia formation.—The Sandia formation derives its name from the Sandia Mountains, east of Albuquerque, N. Mex. It is 500 to 700 feet thick and consists of limestone, carbonaceous shale, and quartzitic sandstone. This character, however, is not constant. According to Gordon, the beds become more calcareous southward, until south of Socorro County the distinction between the Sandia beds and the overlying Madera limestone is apparently lacking.

[a] Herrick, C. L., Geology of the white sands of New Mexico: Jour. Geology, vol. 8, 1900, p. 115. Also, report of a geologic reconnaissance in western Socorro and Valencia counties, N. Mex.: Am. Geologist, vol. 25, 1900, p. 235.

[b] Keyes, C. R., Unconformity of the Cretaceous on older rocks in central New Mexico: Am. Jour. Sci., 4th ser., vol. 18, 1904, pp. 360–362. Also, Geology and underground-water conditions of the Jornada del Muerto, New Mexico: Water-Supply Paper U. S. Geol. Survey No. 123, 1905, p. 22.

Madera limestone.—According to the best information available, the type locality of the Madera limestone is in the Sandia Mountains, at the town of La Madera. The only reference to the origin of the name is that of Herrick,[a] who states that the town "seems to be upon a plateau of limestone." This limestone—the Madera—here constitutes the uppermost member of the Magdalena group. According to Gordon, the Madera is the uppermost member of the group also in the Magdalena Mountains, where it is 300 to 500 feet thick, and it is about 700 feet thick in the Socorro Mountains. Farther to the south, as previously stated, it is not readily distinguishable from the Sandia formation.

Manzano group.—The name Manzano is derived from the Manzano Mountains, one of the semidetached ranges of the Rocky Mountain system southeast of Albuquerque, N. Mex. The name was first applied by Herrick,[b] as follows:

> At the top of the gray lime [Madera] is a large series of coarse red quartzites and sandstones interbedded with dark earthy limestones and shales. There are few fossils except petrified wood, and the few found still preserve a Carboniferous habitus. This Manzano series is everywhere in evidence where a sufficiently high horizon is reached, but is often removed from the crests of the range, while it occurs in the eastern faulted extension. Following this is the group of red quartzites, sandstones, shales, and marls which we have recognized as the equivalent of the "red series" of Texas and Kansas. Three divisions can be made out in all parts of the territory examined, which have been named from their prevailing characteristic color, though it is not to be supposed that the color mentioned is constant. The lower or "red bed" division still retains some bands of limestone or lime breccias, the latter being a very characteristic element. Some 500 feet may be estimated as the average thickness of this division, and prior to the work recently done in the valley of the white sands we had no definite evidence as to the age of the entire division. We only knew that a narrow bed of quartzite near the base at a point east of the Sandia Mountains contained the well-known Permian forms, such as *Bakewellia parva*, *Myalina attenuata*, *Pleurophorus subcuneatus*,[c] etc. The major portion of the series proved obstinately barren. At the top of this division there are found in the most widely distant parts of the Territory enormous deposits of gypsum and salt. In fact, the presence of salines may be said to characterize the series, but especially at the passage from the red into the chocolate beds above it. The chocolate series has a thickness of at least 600 feet, and passes through quartzites and gray and red sandstone layers into the loose vermilion marls and clays of the upper division. So far we have no positive evidence as to the age of the two upper divisions, but may presume the chocolate beds to be Triassic and the vermilion division to represent whatever of Jurassic time is accounted for in the Territory, or at least in the central portion.[d]

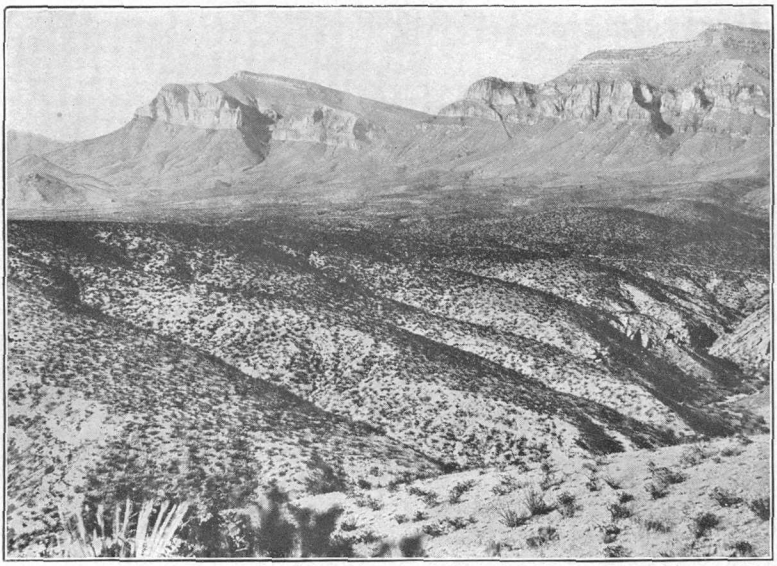
---

[a] Herrick, C. L., The geology of the San Pedro and Albuquerque districts: Bull. Univ. New Mexico, vol. 1, 1889, p. 104.

[b] Herrick, C. L., Geology of the white sands of New Mexico: Bull. Univ. New Mexico, vol. 2, 1900, fas. 3, p. 4; also Jour. Geology, vol. 8, 1900, pp. 112–128.

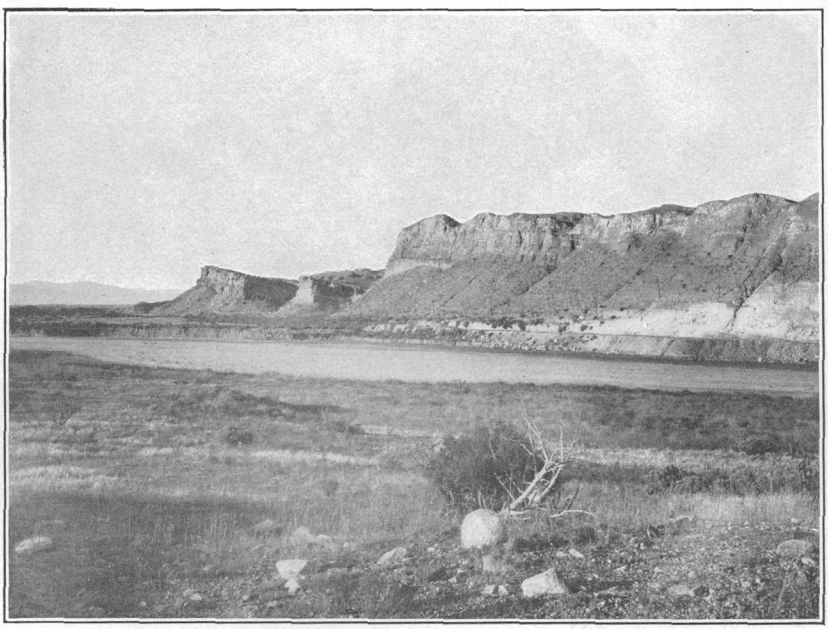
[c] There is room for doubt regarding the identity of these fossils. It is possible that Herrick may have mistaken for Permian certain Pennsylvanian forms which closely resemble the species named, as shown by Girty in the accompanying paper, pp. 44–45.

[d] The name Manzano has been applied to other formations, as, for example, Keyes's recent usage of the name for the lower part of the Magdalena group. (See Jour. Geology, vol. 14, 1906, p. 154.) Herrick was the first, however, to use the name in a definite manner, and, in accordance with the law of priority, his usage has been followed.



A. CABALLOS MOUNTAINS.

Showing the western escarpment, consisting of pre-Cambrian granite, the Shandon formation (Cambrian), the Ordovician limestone, and limestone of the Magdalena group.



B. GYPSUM BEDS IN GALISTEO CANYON.

Showing the gypsum at the base of the Yeso formation, underlain by the Abo sandstone at the left.

It is clear from this and other writings of Herrick that he included in the Manzano group only the three subdivisions mentioned, namely, the lower or red sandstone (Abo), with which he associated the overlying gypsum; the middle or chocolate-colored sediments; and the upper or vermilion beds, the last two of which are here combined as the Yeso formation. Herrick referred the lower division to the Permian because of the presence of certain fossils which he supposed to be Permian, although with these fossils he found well-known Pennsylvanian forms. He explains this occurrence on the ground that the Pennsylvanian fossils were contained in fragments of limestone derived from the older beds and cemented together by the lime that contains the forms which he interpreted as Permian.[a] Some grounds for this suggestion of a mixed fauna are found in the irregular texture of the limestone near the base of the Manzano group, and the argument might have force were it not for the fact that the same species of fossils are found at various horizons throughout the Manzano group.

The same writer in the article just quoted and also in collaboration with Johnson[b] states that the upper beds are unfossiliferous, and on "stratigraphic grounds" these authors assign the chocolate-colored beds to the Triassic and the vermilion beds to the Jurassic. It should be stated in this connection that I found this threefold subdivision based on prevailing color so uncertain that it could not safely be applied in the field. The color varies greatly from place to place, and in the light of paleontologic evidence the reference of the lowest division to the Permian and of the upper divisions to the Triassic and Jurassic breaks down, since the whole group proves to be Pennsylvanian.

In the quotation previously given from the article describing the white sands, and in other writings as well, Herrick states that the Manzano group contains beds of salt. I am not able to confirm this statement, although I looked for evidence of salt beds in the various sections examined. It is possible that more careful examination may establish their presence, although it is not clear from the literature that Herrick actually found salt deposits in the red beds of the Rio Grande region. His statement in this connection, that enormous deposits of gypsum and salt "are found in the most widely distant parts of the Territory" of New Mexico, indicates that he may have had in mind the thick beds of gypsum of eastern New Mexico which overlie strata known from paleontologic evidence to be of Triassic age, and the salt and gypsum beds in the so-called Texas-Permian of southeastern New Mexico, as well as the gypsum-

[a] Herrick, C. L., The Geology of the San Pedro and the Albuquerque districts: Bull. Univ. New Mexico, vol. 1, 1899, p. 103.

[b] Herrick, C. L., and Johnson, D. W., The geology of the Albuquerque, New Mexico, sheet: Bull. Univ. New Mexico, vol. 2, 1900, p. 49. Also, Bull. Denison Univ. Sci. Lab., vol. 11, 1900, pp. 175-239.

bearing beds which are here referred to the Pennsylvanian series of the Carboniferous, but which he supposed to be of Permo-Triassic age.

The massive limestone which overlies the gypsiferous shale and sandstone and which is here described as the San Andreas limestone is not described in any of the literature of the Rio Grande region, although Herrick includes it in his sections.[a] It contains an abundant fauna which clearly allies it with the red beds in the Pennsylvanian division of the Carboniferous, and is therefore included in the Manzano group, although it was not originally so included by Herrick.

Abo sandstone.—The Abo sandstone derives its name from Abo Canyon, at the southern end of the Manzano Range. It is the basal member of the Manzano group and rests unconformably upon the Magdalena group. It consists of coarse-grained sandstone, dark red to purple in color and usually conglomeratic at the base, with a subordinate amount of shale, which attains prominence in some places. This sandstone, together with the overlying gypsum, apparently constitutes Herrick's "Permian." In the classification here adopted the upper limit of the Abo formation is drawn below the gypsum for the obvious reason that in many places the overlying or Yeso formation contains beds of gypsum and gypsiferous shale at several horizons, through a thickness in some places of 1,000 feet or more.

Yeso formation.—The Yeso formation derives its name from Mesa del Yeso, a small table-land 12 miles northeast of Socorro, N. Mex., where it is typically exposed. (See section, p. 22.) It lies with apparent conformity upon the Abo sandstone, and consists of 1,000 to 2,000 feet of sandstone, shale, earthy limestone, and gypsum. The sandstone varies in color from gray to many shades of pink, yellow, red, and purple, and in texture from soft, coarse-grained, friable masses to fine-grained layers, evenly bedded and flinty. The shales, frequently gypsiferous, are soft, pink to yellow in color, and beds of massive white gypsum 100 to 200 feet thick occur in many places.

San Andreas limestone.—The third formation of the Manzano group derives its name from the San Andreas Mountains, at the north end of which it is typically developed, as described in the section on page 29. It consists essentially of massive limestone, which is often cherty and poorly fossiliferous, although several localities were found where fossils are abundant. This limestone was not included in the Manzano group by Herrick. He refers to it, however, in his description of the region east of Socorro[b] as an unfossiliferous limestone overlying the Manzano red beds, and includes it in the illustration of his section.

[a] Herrick, C. L., A Coal-Measure forest near Socorro, N. Mex.: Jour. Geology, vol. 12, 1904, p. 243.
[b] Idem, pp. 237–251.

The writer, however, found in it fossils which are said to be unquestionably of Pennsylvanian age and which prove that the San Andreas limestone should be included in the Manzano group.

So far as is known at present the San Andreas limestone is the uppermost member of the Manzano group, but it can not be confidently asserted without further investigation that no Pennsylvanian beds younger than the San Andreas limestone are to be found in the Rio Grande region, or that no Triassic rocks occur there. The red sediments near Carthage beneath the basal sandstone of the Cretaceous and apparently above the San Andreas limestone (see p. 25) are the only ones known which may represent Permian or Triassic time. These sediments differ considerably in general appearance from the known Manzano, but nothing was found to indicate whether they belong in the Manzano group or represent a younger formation.

STRATIGRAPHIC RELATIONS.

Underlying rocks.—The red sediments of the Manzano group rest unconformably upon the massive blue limestones of the Magdalena group. These limestones yield an abundant fauna, by which they are known to be of lower Pennsylvanian age, as will be shown in a forthcoming paper by G. H. Girty, of the United States Geological Survey. In the northern part of the region described the underlying limestone is the Madera, but in the southern part the Magdalena group is not readily separable into the Madera and Sandia formations, and the limestone, although probably equivalent in age to the Madera, is not yet definitely correlated with that formation and is here referred to as the limestone of the Magdalena group.

Throughout the Rio Grande Valley wherever the contact was seen the unconformity at the base of the Manzano group was noted. There is no marked discordance in dip, but the contact is sinuous, and in several places the underlying limestone clearly had been eroded previous to the deposition of the Manzano. A conglomerate frequently occurs at or near the base of the Manzano, and contains fragments of blue limestone, obviously derived from limestone of the underlying Magdalena group, and at several places water-worn fragments of fossils were found in the conglomerate. For these reasons, and because of the abrupt change throughout the Rio Grande region from the massive blue limestone of the Magdalena to the conglomeratic red sandstone at the base of the Manzano, the unconformity is regarded as indicating a time break of considerable duration.

The evidence, as stated, of this period of erosion is supplemented by the occurrence south and east of the Rocky Mountains of red sandstone and shale of Magdalena age, as described on pages 33–38. In other words, the Madera is apparently not the youngest member of the Magdalena group. This youngest member was probably red

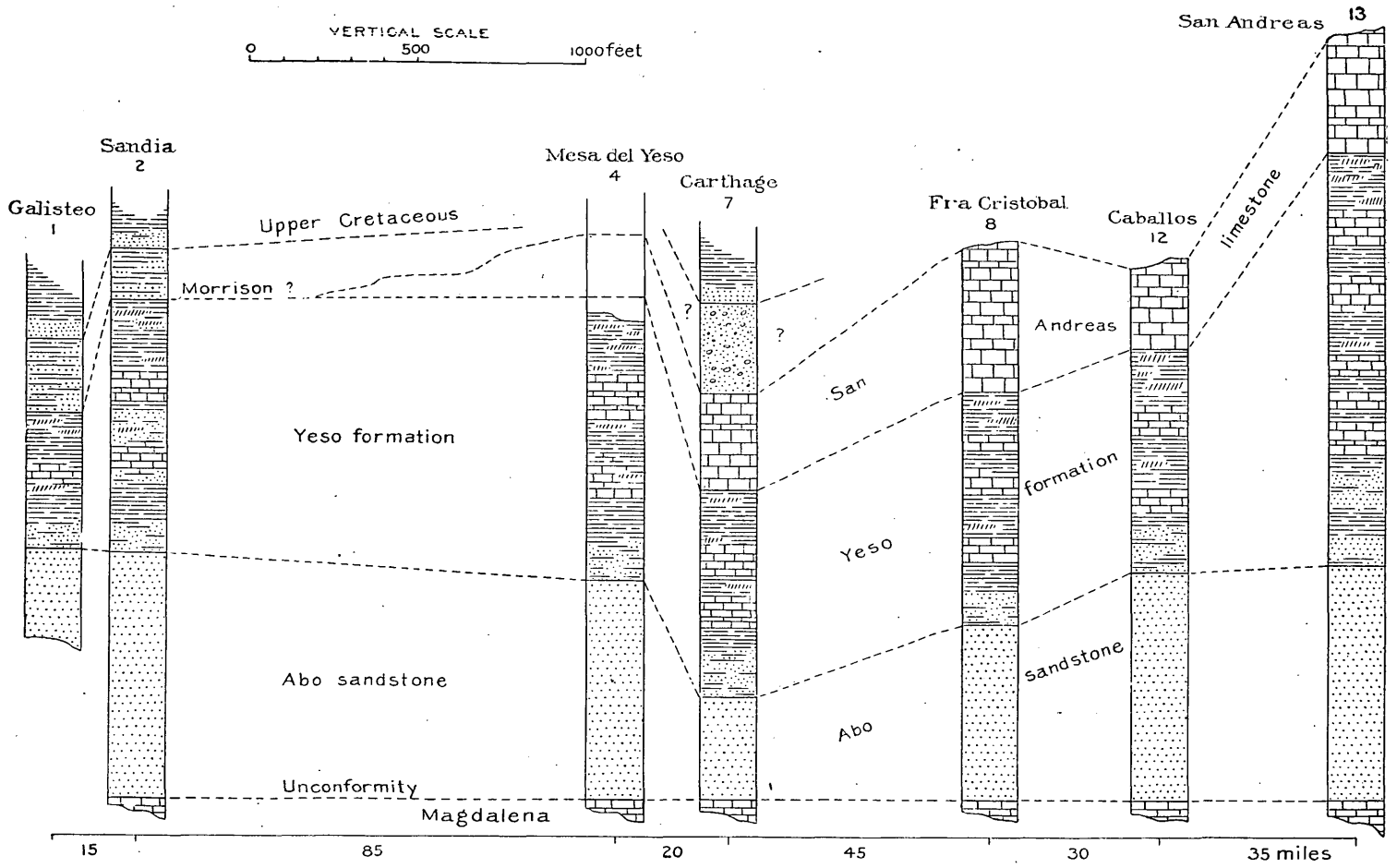
sandstone and shale, and was eroded away in the Rio Grande region previous to the deposition of the Manzano.

Subdivision of the Manzano group.—The Manzano group, as used in this paper, includes all Pennsylvanian rocks above the unconformity just described. So far as now known, it consists of three formations—the Abo sandstone, the Yeso formation, and the San Andreas limestone. Pennsylvanian beds younger than the San Andreas may exist near Carthage, as described on page 15, and the long time interval represented by the unconformity at the top of the group, described below, renders it possible that these as well as still younger formations may at one time have extended generally over the region and have been removed by erosion previous to the deposition of the Cretaceous sediments.

The oldest Manzano formation, the Abo sandstone, has a maximum estimated thickness of 800 feet, and is conspicuous in every locality examined. Its character is constant throughout the Rio Grande region and its fauna is abundant and easily recognized, although the fauna has yet been found at only two horizons. The most conspicuous forms are the large pelecypods *Allerisma capax* and *Allerisma terminale*, which are very numerous in the limestone near the base.

The Yeso formation, consisting of alternating strata of gypsum, shale, friable sandstone, and earthy limestone, is more variable than the Abo sandstone in color, composition, and general appearance. The color varies from the pure white of the massive gypsum, through a great variety of shades in the shale and sandstone, to the dull black of some of the earthy limestones. The colors are usually subdued, contrasting strongly with the deep red and purple tones of the Abo sandstone. The beds vary greatly both laterally and vertically, and no stratum was found that could be traced with confidence for any great distance. In composition, as in color, the Yeso formation contrasts strongly with the Abo. It is very fossiliferous at many horizons. The limestones in some places are composed mainly of shells, and furnished most of the material described by Girty in the accompanying paper.

Until further information is available the San Andreas limestone can not be definitely separated from the Yeso formation, except in its type locality in the San Andreas Mountains, where it is 500 feet or more in thickness and is clearly separable from the underlying beds. In the Caballos and Fra Cristobal Mountains to the west, and at Carthage to the north, the uppermost limestone of the sections is correlated with some confidence on lithologic evidence with the San Andreas limestone; but since the San Andreas fauna is apparently not sufficiently characteristic for purposes of correlation, it is not known whether the capping limestone shown in the sections from other localities is the San Andreas or one of the limestones within the



COLUMNAR SECTIONS SHOWING THE RELATIONS OF THE MANZANO GROUP TO NEIGHBORING FORMATIONS.

Yeso formation. The large coiled shells of the genus *Euomphalus*, the long pencil-shaped scaphopods *Plagioglypta canna* and *Dentalium mexicanum*, and the genus *Aviculipinna* are conspicuous in the uppermost limestones provisionally correlated with the San Andreas, but are not entirely absent from the lower ones.

The San Andreas limestone differs from the older formations of the Manzano group in having a more restricted geographic range. The beds provisionally correlated with it are well developed in the southern part, but become less prominent northward and are not represented in the northern part of the region described.

Overlying rocks.—In only two localities—near Carthage, including Blackinton's ranch, and at the northern end of the region—were rocks found between those of known Manzano and those of Upper Cretaceous age. The red beds between the San Andreas limestone and the base of the Cretaceous near Carthage may belong in the Manzano group or may be younger, as no evidence of age other than stratigraphic position was found. At the northern end of the region a considerable thickness of the upper part of the Manzano is missing. In the Sandia Mountain section the San Andreas limestone is wanting, but the gypsum-bearing shale and the friable sandstone of the upper part of the Yeso formation are characteristically developed, and are overlain by variegated beds that resemble the Morrison. The upper part of the Yeso and the San Andreas limestone are wanting in the northernmost section (Galisteo), and the Morrison (?) rests on the pink sandstone of the middle part of the Yeso formation.

The Manzano group is therefore separated from the overlying formations by an unconformity that, except for the beds of doubtful age, represents a period of time extending from near the close of the Pennsylvanian division of the Carboniferous to the beginning of the Upper Cretaceous. These relations are shown graphically in Plate III. It should be stated in this connection that, although the Cretaceous is shown in only three of the sections, it occurs above the Manzano throughout the region described. In every locality examined, with the exception of San Andreas Mountains, fossiliferous Cretaceous beds were found above the Manzano at no great distance from the place where the section was measured. In most cases an unfossiliferous sandstone, 10 to 75 feet thick, occurs at the base of the Cretaceous, and this is overlain by shale and limestone which yielded an abundant fauna at every locality described. The collections of fossils have been examined by T. W. Stanton, of the United States Geological Survey, and found to constitute a well-defined Benton fauna.

Generalized section.—The position of the Manzano group in the geologic column and its relation to other formations occurring in the Rio Grande region are shown in the table. The type localities of the various formations and the authors of the formation names are also given for reference.

Rock formations exposed near the Rio Grande in New Mexico.

System.	Series.	Group.	Formation.	Author.	Type locality.	Description.
Quaternary.			Palomas.	Gordon and Graton.[a]	Near Rio Palomas, N. Mex.	Unconsolidated gravel.
Tertiary.			Santa Fe.	Hayden.[b]	Rio Grande valley, near Santa Fe, N. Mex.	Unconsolidated sand and gravel.
			Puerco.	Cope.[c]		
Upper Cretaceous.			Galisteo, 2,000+ feet.	Hayden.[d]	Rio Galisteo, N. Mex.	Yellow and red sandstone and conglomerate.
			Madrid, 2,000± feet.	Johnson, 1903.[e]	Madrid, N. Mex.	Coal-bearing sandstone and shale.
			Montana and Colorado.			
Lower Cretaceous.	Comanche.			Hill, 1887.[f]		Sandstone, shale, and limestone; found in the Rio Grande region only near El Paso.
Jurassic?			Morrison?			Variegated shale and sandstone; found at north end of Rio Grande region.
Triassic.			Not identified.			
Carboniferous.	Permian.		Not identified.			
	Pennsylvanian.	Manzano.[g]	San Andreas, 500 feet.	Lee, 1908.[h]	San Andreas Mountains, near Rhodes ranch, N. Mex.	Limestone.
			Yeso, 1,000+ feet.	Lee, 1908.[h]	Mesa del Yeso, near Socorro, N. Mex.	Pink to yellow sandstone, and shale, gypsum, and earthy limestone.
			Abo, 300–800 feet.	Lee, 1908.[h]	Abo Canyon, in Manzano Mountains, N. Mex.	Red sandstone.
		Magdalena, [i] 1,000 to 1,300 feet.	Madera, 300–500 feet.	Keyes, 1905.[j]	La Madera (?) in Sandia Mountains, N. Mex.	Limestone.
			Sandia, 500–700 feet.	Herrick, 1900.[k]	Sandia Mountains, N. Mex.	Limestone and shale.
	Mississippian.		Lake Valley.	Cope, 1881.[l]	Lake Valley, N. Mex.	Limestone; found in Sierra Ladron, but usually not present in the Rio Grande region.

Devonian.						Dark-colored shale; found in a few places along the Rio Grande, but no faunal evidence of age.
Silurian.			Fusselman, 1,000 feet.	Richardson, 1908.[m]	Franklin Mountains, Tex., Fusselman Canyon.	Limestone.
Ordovician.[o]			Montoya, 250 feet.	Richardson, 1908.[n]	Franklin Mountains, Tex., near Montoya Station.	Limestone.
			El Paso, 1,000 feet.	Richardson 1904.[p]	Franklin Mountains, Tex., near El Paso.	Limestone.
Cambrian.			Bliss, 300 feet.[q]	Richardson, 1904.[r]	Franklin Mountains, Tex., near Fort Bliss.	Sandstone.
Pre-Cambrian.						Quartzites, schists, and argillites, found in many places in Rio Grande region.
Archean?						Granite, gneiss, and schist.

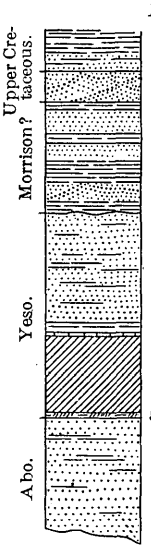
[a] Gordon, C. H., and Graton, L. C., Jour. Geology, vol. 15, 1907, p. 92; also Prof. Paper U. S. Geol. Survey (unpublished).
[b] Cope, E. D., Notes on the Santa Fe marls: Proc. Acad. Nat. Sci., Philadelphia, vol. 26, 1874, p. 147.
[c] Cope, E. D., Rept. Secretary of War to 44th Cong., vol. 2, pt. 2, 1875, p. 1012.
[d] Hayden, F. H., U. S. Geol. Survey Terr. for 1867 and 1869, reprint 1873, p. 166.
[e] Johnson, D. W., The geology of the Cerrillos Hills, New Mexico: School of Mines Quart., vol. 24, 1903, p. 36.
[f] Hill, R. T., The Comanche series of the Texas-Arkansas region: Bull. Geol. Soc. America, vol. 2, 1891, pp. 517–518. See also Stanton, T. W., and Vaughan, T. Wayland, Section of the Cretaceous at El Paso, Tex.: Am. Jour. Sci., 4th ser., vol. 1, 1896, pp. 21–26.
[g] Herrick, C. L., Geology of the white sands of New Mexico: Bull. Univ. New Mexico, vol. 2, 1900, fasc. 3, p. 4; also Jour. Geology, vol. 8, 1900, pp. 112–128. Report of a geologic reconnaissance in western Socorro and Valencia counties, N. Mex.: Am. Geologist, vol. 25, 1900, p. 337. A Coal-Measure forest near Socorro, N. Mex.: Jour. Geology, vol. 12, 1904, p. 244.
[h] Lee, W. T. This bulletin, p. 12.
[i] Gordon, C. H., Jour. Geol., vol. 15, 1907, pp. 805–816.
[j] Keyes, C. R., Geology and underground-water conditions of the Jornada del Muerto, N. Mex.: Water-Supply Paper U. S. Geol. Survey No. 123, 1905, p. 22. See also Herrick, C. L., The geology of the San Pedro and Albuquerque districts: Bull. Univ. New Mexico, vol. 1, 1899, p. 104.
[k] Herrick, C. L., Jour. Geology, vol. 8, 1900, p. 115; Am. Geologist, vol. 25, 1900, p. 235; Am. Geologist, vol. 53, 1904, p. 310.
[l] Cope, E. D., Eng. and Min. Jour., vol. 34, 1882, p. 214. Geology of the Lake Valley mining district: Am. Naturalist, vol. 15, 1881, pp. 831–832.
[m] Richardson, G. B., Paleozoic formations in trans-Pecos Texas: Am. Jour. Sci., 4th ser., vol. 25, 1908, p. 479.
[n] Idem, p. 478.
[o] Gordon, C. H. Ordovician limestone has also been described and correlated with the cherty limestones of the Caballos Mountains.
[p] Richardson, G. B., Reconnaissance in trans-Pecos Texas: Bull. Univ. Texas Min. Survey, No. 9, 1904, p. 29.
[q] Cambrian has been described also from the Caballos Mountains, near Shandon, from which it has been called the Shandon quartzite. See Gordon, C. H., and Graton, L. C., Jour. Geology, vol. 15, 1907, p. 91.
[r] Richardson, G. B., Reconnaissance in trans-Pecos Texas: Bull. Univ. Texas Min. Survey, No. 9, 1904, p. 27.

DESCRIPTIVE DETAILS OF SECTIONS.

GALISTEO CANYON.

A section (fig. 1) of the Manzano group was measured north of the Atchison, Topeka and Santa Fe Railway in Galisteo Canyon west of Cerrillos (locality 1 of the map, Pl. I). The rocks are upturned and well exposed, as shown in Plate II, *B*. The Abo sandstone is overlain by the massive white gypsum and the red and yellow sediments of the Yeso formation, which here consist mainly of sandstone, the shales so abundant farther south being imperfectly represented.

Lying with apparent unconformity upon the Yeso formation is a group of sandstones and shales that resembles the Morrison formation



Feet.	
	Sandstone and shale containing fossils of Benton (Cretaceous) age.
60	Sandstone (Dakota), coarse, white, friable, cross-bedded.
210	Shale, variegated, and sandstones, in thin alternating layers. The sandstones vary from fine-grained, flinty layers to coarse-grained, friable, cross-bedded masses.
	Unconformity.
210	Sandstone and shale, pink and buff-colored, lighter toward the top. The sandstones greatly predominate and are well indurated, coarse-grained, and spotted.
25	Shale, pink, and thin layers of blue limestone.
140	Gypsum, white, massive.
5-10	Gypsum, black, shaly, carbonaceous, in thin irregular plates; strong petroleum odor.
225	Sandstone, red, massive, with a subordinate amount of shale.
	(Base not exposed.)

FIGURE 1.—Partial section of sedimentary rocks exposed in Galisteo Canyon west of Cerrillos.

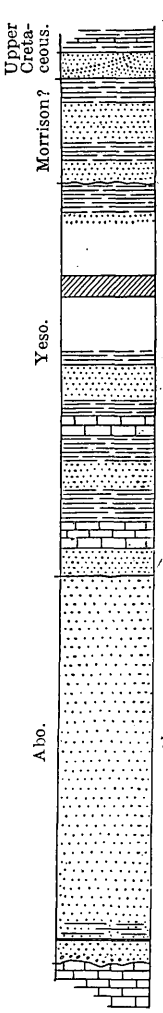
in color, composition, and general appearance, but no fossils were found to identify it. If these variegated sediments are correctly referred to the Morrison, the apparent unconformity must represent the time equivalent of the San Andreas limestone and all succeeding formations between it and the Morrison, and probably also an erosion interval of considerable importance.

The Morrison (?) is overlain by white, coarse-grained, cross-bedded sandstone, conglomeratic near the base and similar in general appearance to the Dakota, but without fossils so far as observed. This sandstone is succeeded in turn by fossiliferous shale and limestone of Upper Cretaceous age, including equivalents of the Colorado and Montana groups. Collections of Cretaceous fossils were obtained, and

these together with others made throughout the region described have been examined by T. W. Stanton.

SANDIA MOUNTAINS.

The second section (fig. 2) is located about 15 miles south of Galisteo Canyon, at the north end of the Sandia Mountains, near Te-



Feet.

Limestones and dark-colored shales.

50 Sandstone, white, friable, cross-bedded, conglomeratic.

200 Shale, variegated, and sandstone.

Probable unconformity.

Shale and friable sandstone, pink to yellow, with gypsum near the base (several hundred feet not continuously exposed).

400 Sandstone, shale, and earthy limestone, gray, pink, and yellow, variable in character, containing *Monopteria marian, Schizodus wheeleri?, Deltopecten coreyanus, Plagioglypta canna, Euphemus subpapillosus?, Bellerophon majusculus, Euomphalus* sp. *b, Phanerotrema manzanicum?, Murchisonia? tenebra?, Patellostium* aff. *nodicostatum.*

Possible unconformity of erosion.

700 Sandstone, red, massive, with partings of red shales. (Thickness estimated.)

2 Limestone, granular, earthy.

40 Sandstone, red, conglomeratic, with limestone pebbles at the base.

Unconformity.

Limestone (Magdalena group).

FIGURE 2.—Section of a part of the beds exposed at the north end of the Sandia Mountains, near Tejon.

jon, on the road between Bernalillo and the Hagan coal mines (locality 2, Pl. I). The strata are steeply upturned toward the east, and although they are well exposed it would require more time than I had at my disposal to make a complete detailed section.

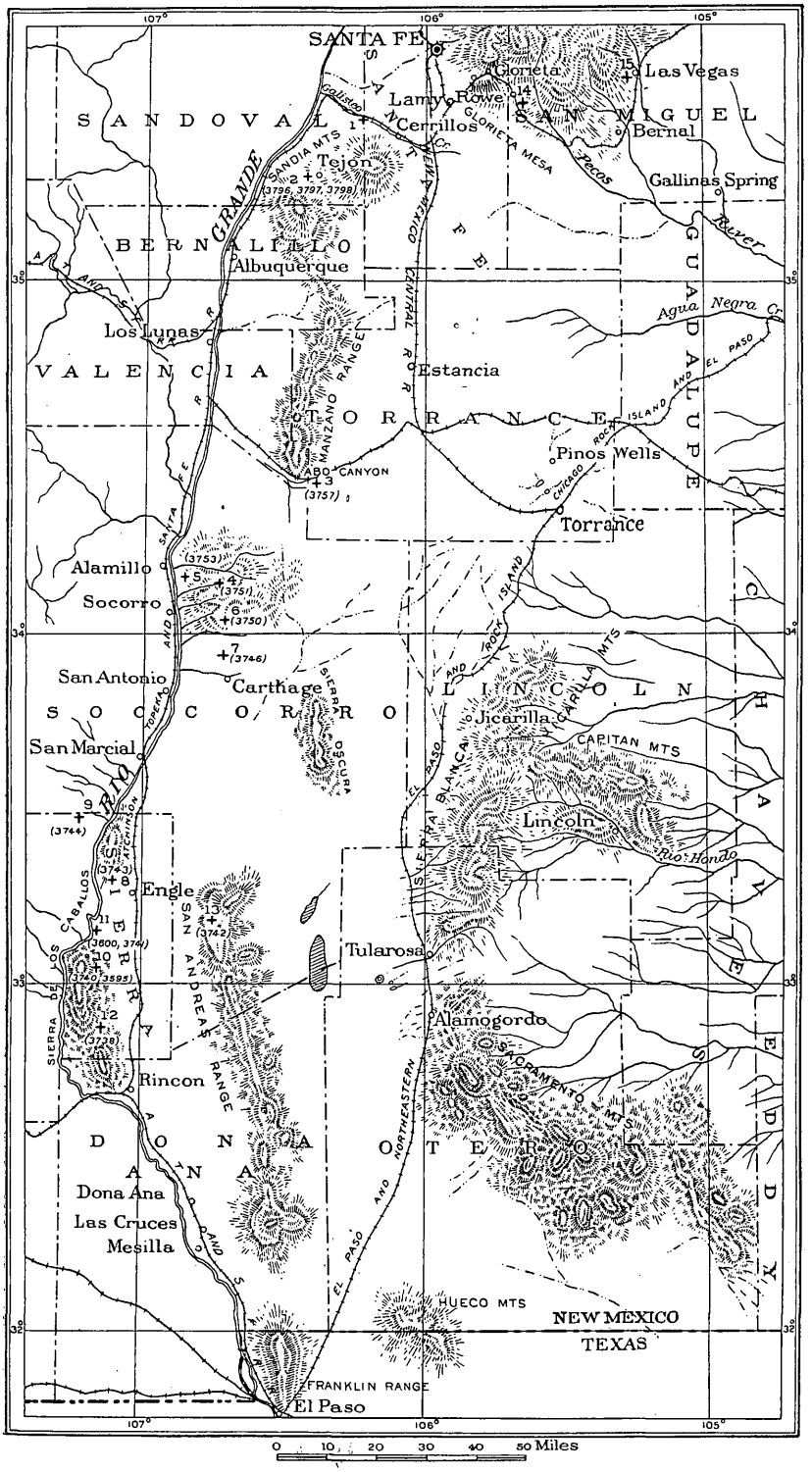
The Madera limestone is overlain unconformably by the Abo sandstone, the contact being well exposed near the spring known as Ojo de San Francisco. A band of fossiliferous earthy limestone 1 to 2 feet thick was found 40 feet above the basal conglomerate of the Abo. The fossils are abundant in some places, while in others none were found for considerable distances along the outcrop. Above this limestone the massive dark-red sandstone (Abo) occurs characteristically developed, but was not examined in detail.

The Abo is overlain by 400 feet of lighter colored sandstone, shale, and fossiliferous earthy limestone. Some indication of an unconformity of erosion, probably of local importance only, was noted between these lighter colored beds and the underlying dark-red sandstone. In general character and appearance the light-colored sediments resemble the pink and buff sandstone overlying the gypsum of the Galisteo section (fig. 1). If they are to be correlated with this sandstone a time break should be found here representing the gypsum of the Galisteo section which occurs between the light-colored sandstone of the Yeso and the dark-red sandstone of the Abo. On the other hand, about 2 miles northeast of Tejon gypsum similar in every way to the gypsum of the Galisteo section underlies the light-colored sediments.

There is a great thickness of red and yellow shale, friable sandstone, and gypsum above the light-colored sandstone of the Sandia section. These outcrop in a valley of erosion that runs parallel with the strike, and are not continuously exposed. The valley is about half a mile wide and the strata on either side dip steeply to the east. The gypsiferous sediments are overlain by the variegated shales provisionally referred to the Morrison, and the latter in turn are overlain by the same succession of Cretaceous beds that occur in Galisteo Canyon.

ABO CANYON.

The next section in order southward is about 75 miles south of Galisteo Creek, in Abo Canyon (locality 3, Pl. I), from which the Abo sandstone derives its name. The limestone of the Magdalena group occurs here in characteristic development and is overlain by 650 feet of the dark-red Abo sandstone, the upper part having been removed by erosion. The basal conglomerate of the Abo lies unconformably upon the unevenly eroded surface of this limestone. There are several thin layers of earthy limestone 30 to 50 feet above the base, which yielded the following fossils.



MAP OF THE RIO GRANDE REGION IN NEW MEXICO, SHOWING LOCATIONS OF SECTIONS AND FOSSIL LOCALITIES..

The numerals in parentheses refer to the lot numbers of fossils in the Geological Survey collection.

Fossils from earthy limestone near the base of the Abo sandstone in Abo Canyon.

Lophophyllum? sp.
Septopora aff. robusta.
Meekella striaticostata.
Productus cora.
Productus nebraskensis.
Composita subtilita.
Edmondia gibbosa.
Chænomya leavenworthensis.
Leda obesa.
Aviculipinna? peracuta.
Aviculipinna nebraskensis.
Monopteria marian.
Pseudomonotis hawni?
Myalina apachesi.
Schizodus wheeleri.
Deltopecten occidentalis.
Deltopecten manzanicus.
Deltopecten coreyanus?
Allerisma capax.
Pleurophorus aff. subcostatus?
Pleurophorus aff. oblongus.
Patellostium aff. nodicostatum.
Bucanopsis modesta?
Naticopsis deformis.
Soleniscus aff. altonensis.
Orthoceras sp.

In 1905 G. B. Richardson, of the United States Geological Survey, made a reconnaissance trip from Belen eastward across the Territory, along the line of the Belen cut-off of the Atchison, Topeka and Santa Fe Railway, and has kindly furnished the following information for this paper: In Abo Canyon he observed the Manzano group in the locality described above, and traced it eastward for a distance of 40 miles. At the east end of a mesa 5 miles south of Willard, a town on the Santa Fe Central Railway, he measured the following section:

Section 5 miles south of Willard, N. Mex.

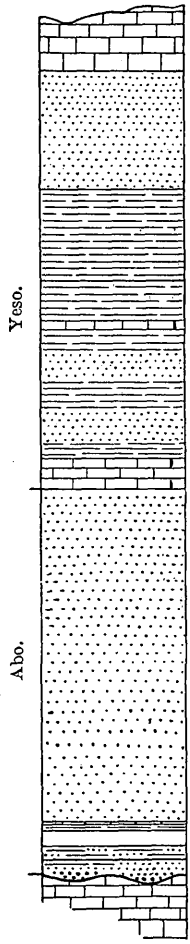
	Feet.
Limestone, gray, cherty, containing fossils of Pennsylvanian age, as follows: *Chætetes milleporaceus?*, *Schizodus* sp., *Myalina?* sp., *Bellerophon* sp	50
Sandstone, gray, friable	300
Sandstone, red	10
Gypsum, massive, bluish white	100
Base not exposed.	

Although the base was not exposed, Richardson thinks it probable that the gypsum rests upon the red sandstone exposed in Abo Canyon and described in this paper under the name of Abo sandstone. This accords with the relations shown in other sections described, where massive gypsum overlies this sandstone. The fossils from the limestone are Pennsylvanian, and this evidence, taken in connection with the character and succession of the beds, indicates that the gypsum and sandstone probably belong to the Yeso formation, with a possible representative of the San Andreas limestone at the top.

MESA DEL YESO.

The next section to the south is 12 miles northeast of Socorro and about 100 miles south of Galisteo Creek (locality 4, Pl. I). Although the rocks in the vicinity of Socorro are profoundly faulted and

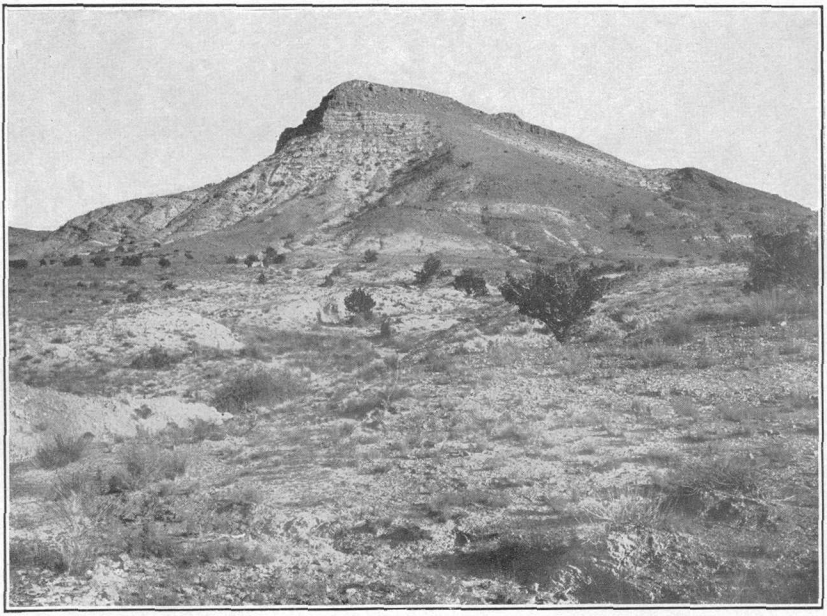
otherwise disturbed, an excellently exposed section of the Manzano group was found about 2 miles south of Mesa del Yeso (Pl. IV, *A*; fig. 3), the location of which is shown on the Socorro atlas sheet of the United States Geological Survey. The rocks included in the section are exposed from Canyoncito de la Uva northward across the low hills at the east edge of the Socorro quadrangle. It is from this



Feet.
75 Limestone, fossiliferous (top eroded).
200 Sandstone, pink and white.
150 Gypsum, with a subordinate amount of pink and yellow shale.
300 Sandstone, red, and gypsiferous shale with a subordinate amount of earthy limestone.
50 Limestone, fossiliferous.
550 Sandstone, red and purple, with a subordinate amount of shale and earthy limestone.
5 Limestone, fossiliferous.
10 Shale, blue.
30 Not exposed.
20 Sandstone and shale, brown to pink.
25 Conglomerate limestone pebbles in matrix of sand.
Erosional unconformity.
Limestone, massive (Magdalena group).

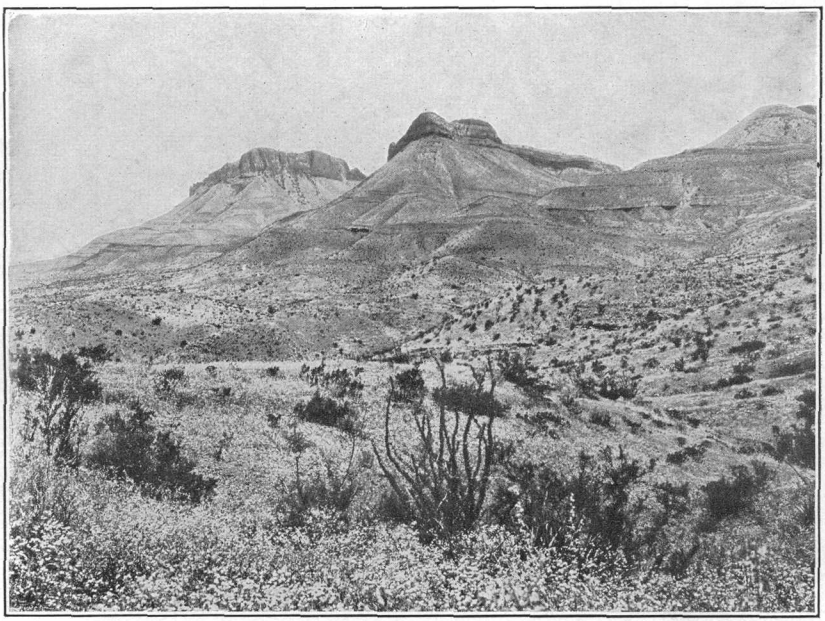
FIGURE 3.—Section near Mesa del Yeso, 12 miles northeast of Socorro. (For fossil contents see section on p. 23.)

mesa that the Yeso formation derives its name. The Abo sandstone here rests unconformably upon the Madera limestone. The basal conglomerate is 25 feet thick, and among the pebbles of various kinds of rock were found fragments of limestone and waterworn fossils apparently derived from the underlying Madera limestone. A thin limestone 85 feet above the base of the Abo yielded fossils, as shown in the following section:



A. MESA DEL YESO.

Showing the character of the Yeso formation.



B. SADDLE PEAK IN FRA CRISTOBAL MOUNTAINS.

Showing the Yeso formation, overlain by the San Andreas limestone.

Section near Mesa del Yeso, 12 miles northeast of Socorro.

	Feet.
Limestone, fossiliferous (top eroded). Contains *Productus ivesi, Clinopistha?* sp., *Myalina apachesi, Schizodus* aff. *magnus, Deltopecten coreyanus, Pleurophorus* aff. *taffi, Pleurophorus* aff. *subcostatus?, Astartella subquadrata?, Plagioglypta canna, Murchisonia?* aff. *terebra, Patellostium* aff. *nodicostatum, Bellerophon majusculus, Naticopsis* aff. *altonensis, Orthonema* sp. *a, Temnocheilus* sp. *a?*	75
Sandstone, pink and white	200
Gypsum with a subordinate amount of pink and yellow shale	150
Sandstone, red, and gypsiferous shale with a subordinate amount of earthy limestone	300
Limestone, fossiliferous. Contains *Productus ivesi?, Productus mexicanus, Productus nebraskensis, Squamularia perplexa?, Pugnax osagensis* var. *pusilla, Composita subtilita?, Nucula levatiformis, Manzanella elliptica, Leda obesa, Pteria* sp., *Myalina apachesi, Schizodus* aff. *magnus, Deltopecten coreyanus, Allerisma capax, Pleurophorus mexicanus, Pleurophorus* aff. *taffi, Pleurophorus* aff. *meeki, Astartella subquadrata, Plagioglypta canna, Phanerotrema manzanicum, Phanerotrema?* sp. *a, Euphemus inspeciosus?, Patellostium* aff. *nodicostatum, Bellerophon majusculus, Zygopleura* aff. *rugosa, Orthonema socorroense, Orthonema* sp. *a, Coloceras mexicanum, Temnocheilus* aff. *winslowi, Temnocheilus* sp. *a, Domatoceras* sp., *Anisopyge inornata*	50
Sandstone, red and purple, with a subordinate amount of shale and earthy limestone	550
Limestone, fossiliferous. Contains *Meekella striaticostata, Productus nebraskensis, Productus cora, Edmondia gibbosa, Chænomya leavenworthensis, Aviculipinna? peracuta?, Myalina apachesi, Deltopecten coryanus, Allerisma* sp., *Pleurophorus bipartitus, Pleurophorus* sp., *Plagioglypta canna?, Bellerophon majusculus, Temnocheilus* sp. *a*	5
Shale, blue	10
(Not exposed)	30
Sandstone and shale, brown to pink	20
Conglomerate; limestone pebbles in matrix of sand	25
(Erosional unconformity.)	
Limestone, massive (Magdalena group).	
	1,415

The Yeso formation at this place is very fossiliferous at two horizons, one near the base, the other at the top of the exposure. The limestone near the base yielded one of the most extensive and well-preserved collections found in the Manzano group. The limestone at the top yielded a smaller fauna. This upper limestone apparently does not represent the top of the Yeso. Six miles farther south a limestone similarly situated with reference to the gypsum occurs within the Yeso several hundred feet from the top and is presumably the same as the one at the top of the Mesa del Yeso section, although the faunal basis of correlation is poor, *Pleurophorus* aff. *subcostatus* being the only fossil found. This limestone is overlain by gypsiferous shale and pink sandstone, which in turn underlie the massive San Andreas limestone.

ALAMILLO.

In a small canyon cut into the Yeso formation 2 miles east of the Rio Grande (locality 5, Pl. I), opposite the Mexican village of Alamillo, the following fossils were collected:

Fossils from Yeso formation near Alamillo.

Nucula levatiformis.
Manzanella elliptica.
Pteria sp.
Schizodus wheeleri?
Pleurophorus aff. meeki.
Astartella subquadrata.
Plagioglypta canna.
Phanerotrema manzanicum.
Euphemus inspeciosus.
Zygopleura aff. rugosa.
Orthonema socorroense.
Coloceras mexicanum.
Anisopyge inornata.

BLACKINTON'S RANCH.

There is an exposure of the Yeso formation consisting of gypsum, gypsiferous shale, and earthy limestone near Charles F. Blackinton's ranch, 18 miles east of Socorro (locality 6, Pl. I). From a limestone near the top of the gypsum the following fossils were obtained: *Edmondia gibbosa?*, *Schizodus wheeleri?*, *Pleurophorus* aff. *subcostatus*, and *Temnocheilus* aff. *winslowi*.

A limestone, 50 feet or more in thickness, lying stratigraphically above the gypsum is presumably the San Andreas limestone. The rocks are not well exposed at this place, and it was not determined whether the space between the gypsum and the limestone is occupied by the light-colored sandstone which underlies the San Andreas limestone in well-exposed sections. No fossils were found in the limestone, but stratigraphically above it there are beds of red sandstone and shale unlike any observed below the undoubted San Andreas limestone. Lying unconformably upon these upper red sediments is a coarse-grained light-brown sandstone, about 15 feet thick, that constitutes the base of the Cretaceous and grades upward into shale and limestone containing fossils of Benton age. No fossils were found in these upper red beds, and their relation to the underlying limestone was not determined. It remains an open question whether they belong to the Manzano group or are younger.

CARTHAGE.

The next section in order southward (fig. 4) was measured a few miles north of Carthage, about 120 miles south of Galisteo Canyon (locality 7, Pl. I). The lower part of the section is not well exposed and the estimated thickness of 300 feet for the Abo sandstone and 610 feet for the Yeso formation made in the field is probably too small, as these beds are known to be thicker both north and south of this place. The upper part of the Yeso is well exposed in a westward-

facing cliff, in which an erosional unconformity also was noted, as shown in the section between the light-colored sandstone near the top and an underlying cherty limestone. But nothing was observed to indicate whether this unconformity is local or represents a time break of some importance.

The limestone at the top of the section is probably the San Andreas limestone, although no fossils were found in it at the point where the section was measured. But a little farther south, at the Carthage limekiln, the same limestone, here several hundred feet thick, yielded a few poorly preserved fossils, among which *Schizodus wheeleri?* was recognized. The limestone apparently underlies a bed of red shale, sandstone, and conglomerate. The contact was not observed, but the upper 200 feet of the red sediments are well exposed near the limekiln, where they are overlain unconformably by a coarse-grained yellow sandstone which constitutes the base of the Cretaceous beds and grades upward into fossiliferous limestone and shale of Benton age. No fossils were found in these upper red sediments and their age is a matter of conjecture. In physical character and stratigraphic position they resemble the upper red beds just described near Blackinton's ranch, a few miles to the north, and probably belong to the same formation.

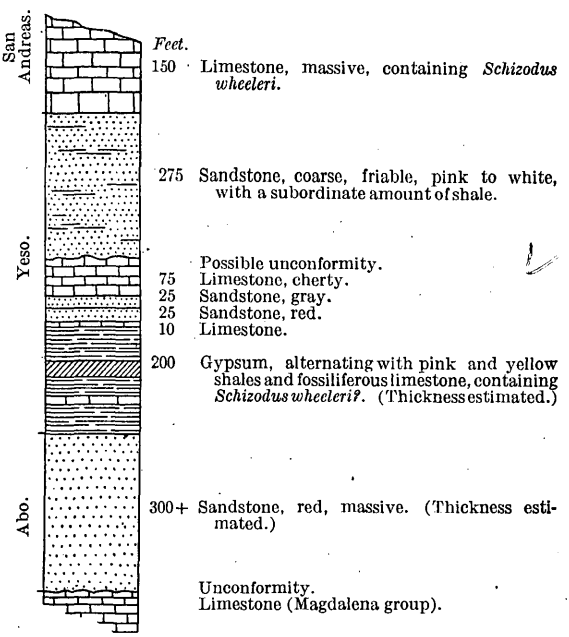


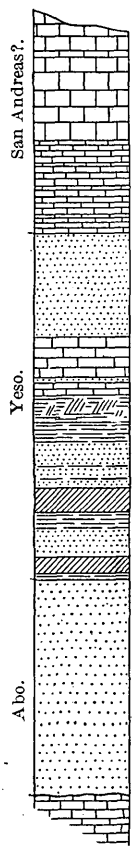
FIGURE 4.—Section 2 miles north of Carthage.

FRA CRISTOBAL MOUNTAINS.

The next section to the south (fig. 5) was measured at Saddle Peak (see Pl. IV, *B*), near the south end of the Fra Cristobal Mountains, about 165 miles south of Galisteo Creek (locality 8, Pl. I). The northern part of the range consists of limestone of the Magdalena group, inclined toward the southeast. The Abo sandstone comprises the central part and the Yeso formation the southern part of the mountains, the youngest stratum exposed being a fossiliferous limestone which is probably a part of the San Andreas formation.

The upper 1,000 feet are well exposed in the cliffs, and were easily measured by barometer. Although moderately well exposed the lower part was not measured, owing to lack of time, and the thicknesses are estimated.

The Fra Cristobal Mountains form a part of the western limb of the Jornada syncline and the strata are cut off abruptly on the west by faults, as illustrated in Plate V. The photographs and the accompanying section show the structural conditions at the north end of the mountains. In order southward the granite, the limestone of the Magdalena group, and finally the Manzano group, plunge beneath the detrital material filling the trough of the Jornada.



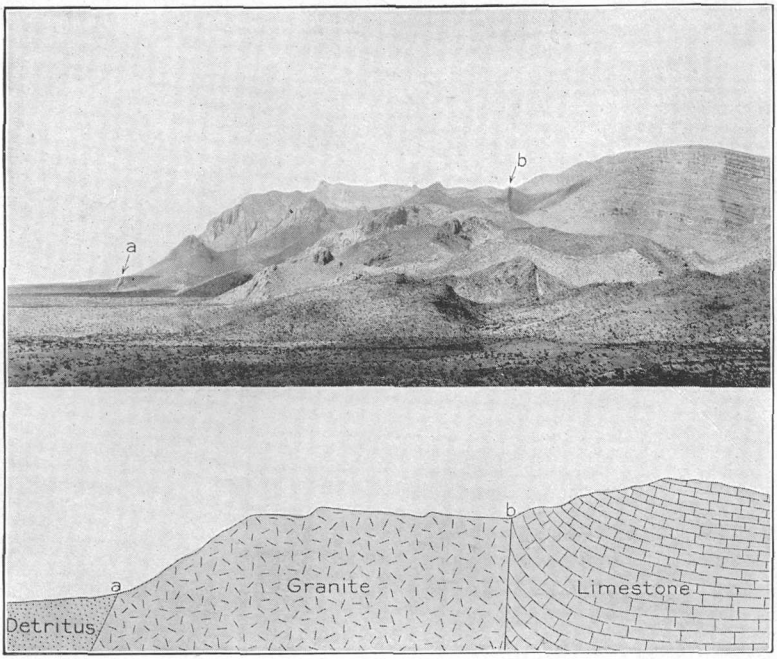
Feet.	
200+	Limestone, massive, containing *Marginifera? manzanica, Marginifera?* sp., *Composita subtilita? Solenomya? nænia, Clinopistha* sp., *Nucula levatiformis, Dentalium mexicanum, Murchisonia?* aff. *terebra, Bellerophon majusculus.*
175	Limestone, pink, thin bedded.
200	Sandstone, pink and yellow, calcareous.
75	Limestone containing *Nucula levatiformis* var. *obliqua, Schizoduswheeleri?, Astartella subquadrata,* and *Euphemus subpapillosus?.*
10	Sandstone, yellow.
25	Limestone containing *Schizodus wheeleri?.*
50	Shale, gypsiferous.
300	Gypsum, pink to yellow shale, and friable sandstone. (Thickness estimated.)
400	Sandstone, red. (Thickness estimated.)
	Unconformity.
	Limestone (Magdalena group).

FIGURE 5.—Section at Saddle Peak, near south end of Fra Cristobal Mountains.

NOGAL CREEK.

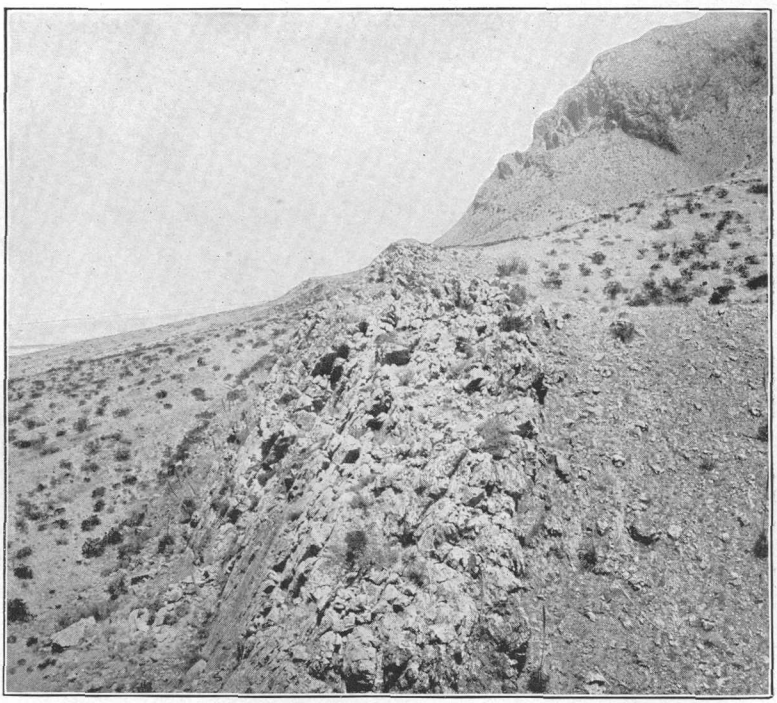
A small exposure of the Manzano group was visited on Nogal Creek west of the Rio Grande, opposite the north end of the Fra Cristobal Mountains (locality 9, Pl. I). A thickness of several hundred feet of red and yellow sandstone and shale was observed overlain by 300 feet of limestone. Near the middle of this limestone the following fossils were obtained: *Schizodus wheeleri?, Deltopecten coreyanus, Plagioglypta canna?, Murchisonia?* aff. *terebra, Bellerophon majusculus, Orthonema* sp. *a?, Temnocheilus* aff. *conchiferum.*

Fifty feet higher in the same limestone fossils were collected as follows: *Productus ivesi, Productus leei, Productus mexicanus, Euphemus inspeciosus?, Murchisonia?* aff. *terebra, Euomphalus* sp. *a?, Orthonema* sp. *a.*



A. WESTERN FACE OF THE FRA CRISTOBAL MOUNTAINS.

Showing two faults, a and b.



B. FAULT PLANE AT THE WESTERN BASE OF FRA CRISTOBAL MOUNTAINS.

Showing near view of a, above.

ENGLE.

The next locality to the south at which the relations of the Manzano to the underlying and overlying formations were observed is near the north end of Caballos Mountains, at the head of Palomas Canyon, southwest of Engle (locality 10, Pl. I). A bed of red sandstone and shale here rests upon the massive limestone of the Magdalena group and dips gently toward the east. The red sediments are overlain by 300 feet of limestone, from which the following fossils were obtained:

Fossils from limestone near north end of Caballos Mountains.

Meekella mexicana.	Pleurophorus mexicanus.
Productus leei.	Plagioglypta canna.
Pseudomonotis hawni?	Euphemus inspeciosus?
Pseudomonotis occidentalis?	Bellerophon majusculus.
Schizodus wheeleri??	Euomphalus deformis.
Deltopecten manzanicus.	Sphærodoma aff. medialis.

This limestone is overlain by about 200 feet of shale, apparently gypsiferous although not well exposed where the observations were made, which in turn underlies fossiliferous limestone of Benton age.

The red beds at this point were observed before I became aware of their real significance and were not examined with the scrutiny that would later have been given them. Having in mind previously published descriptions,[a] I regarded the fossiliferous limestone as a part of the Magdalena, brought up to the observed position by faulting, although I was unable to find evidence of faults which would explain the observed relations. The fossil evidence proves that the limestone, instead of belonging to the Magdalena, is a member of the Manzano group.

ELEPHANT BUTTE.

At the north end of the Caballos Mountains (locality 11, Pl. I), 10 miles north of the Engle locality, the Manzano lies between the steeply upturned limestones of the Magdalena on the west and the Benton (Cretaceous) sediments on the east. From one of the limestones near the top of the Manzano the following fossils were collected: *Meekella mexicana, Schizodus wheeleri?, Aviculipinna nebraskensis?, Myalina apachesi, Deltopecten manzanicus, Bellerophon majusculus, Euomphalus* sp. *a, Euomphalus* sp. *b?*.

[a] Herrick, C. L., The occurrence of copper and lead in the San Andreas and Caballos mountains: Am. Geologist, vol. 22, 1898, p. 289. Keyes, C. R., Structures of basin ranges: Jour. Geology, vol. 13, 1905, p. 64.

CABALLOS MOUNTAINS.

The next section measured (fig. 6) is on the eastern slope of the Caballos Mountains, west of Upham and about 200 miles south of Galisteo Creek (locality 12, Pl. I). As at Palomas Canyon, this section was observed before the true stratigraphic position of the red

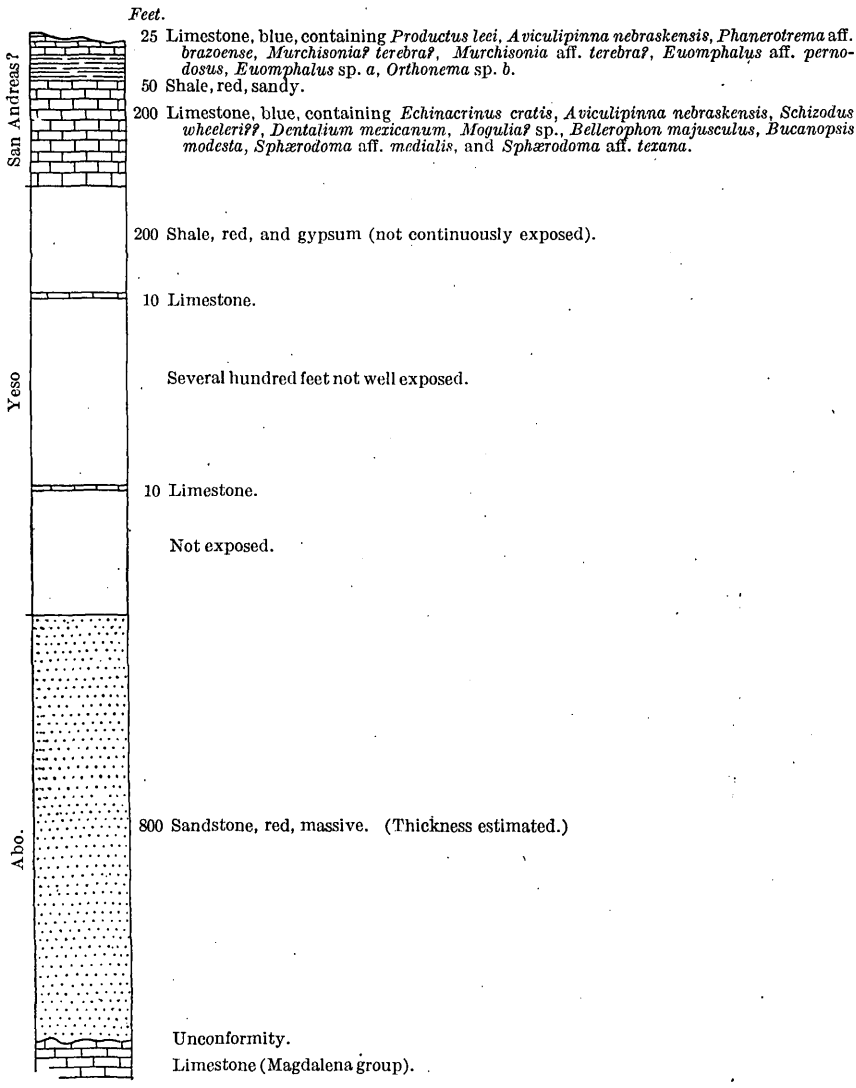


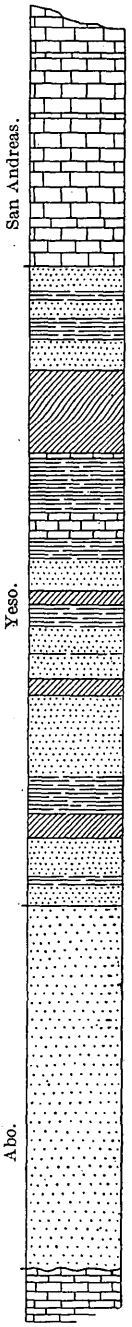
FIGURE 6.—Section in Caballos Mountains west of Upham.

beds was known and the examination was cursory, no effort being made to find fossils or recognize subdivisions of the beds. But although the thicknesses as given in the accompanying section are only estimates, the beds are shown in their correct sequence. The limestone at the base belongs to the Magdalena group, as proved by fossil

evidence, and the fauna of the upper limestone is that of the upper part of the Manzano, presumably the San Andreas limestone.

SAN ANDREAS MOUNTAINS.

Another section (fig. 7) was measured near the north end of the San Andreas Range, in the canyon through which the road passes from Engle to Rhodes's ranch (locality 13, Pl. I). At the time the rocks were observed, I was influenced by the opinion of previous writers and supposed that the red beds belonged in the Permo-Triassic system. The fossils which prove them to be Carboniferous were discovered in the upper part of the section as I was leaving the canyon, and no opportunity has been found since that time for making more extended collections. To judge from such observations as I was able to make, it is probable that one of the most complete sections of the Manzano group is to be found at this place.



Feet.

500 Limestone, massive, containing *Productus ivesi?*, *Productus leei?*, *Productus mexicanus?*, *Schizodus wheeleri*, *Deltopecten manzanicus*, *Bellerophon majusculus*, *Marginifera? manzanica?*, *Marginifera?* sp., *Squamularia perplexa?*, *Composita mexicana*, *Euomphalus* sp. *b*.

200 Shale and sandstone, pink and yellow, soft, friable.

150 Gypsum.

10 Limestone containing *Aviculipinna nebraskensis* and *Schizodus wheeleri?*.

150 Shale, alternating beds of pink to yellow, and fossiliferous limestones (A).

50 Limestone containing *Parallelodon* aff. *obsoletus*, *Pseudomonotis hawni?*, *Pseudomonotis occidentalis*, *Myalina apachesi*, *Schizodus wheeleri?*, *Pleurophorus* aff. *taffi*, *Pleurophorus* sp.

700 Gypsum, red sandstone, and shale, and earthy limestone. (Thickness estimated, not continuously exposed.)

700 Sandstone, red, massive (Thickness estimated.)

Unconformity.

Limestone (Magdalena group).

FIGURE 7.—Section near north end of San Andreas Mountains, near Rhodes's ranch.

The limestone of the Magdalena group at Rhodes's ranch is overlain by the dark-red Abo sandstone. These formations were observed hastily, as was also the lower part of the

Yeso formation, but fossils were found about 500 feet from the top of the red beds, and the upper part of the exposure was examined as carefully as the limited time would permit.

The San Andreas limestone, which derives its name from this locality, is the uppermost stratum exposed and has been deeply eroded. However, on the western slope of the range, where somewhat like its original thickness remains, it is about 500 feet thick.

EXTENSION OF MANZANO GROUP TO THE NORTHEAST.

INTRODUCTORY STATEMENTS.

My purpose to confine attention principally to my own observations precludes any attempt at correlating the Manzano group with the red beds of western New Mexico and Colorado, since my observations have been confined mainly to the formations south and east of the Rocky Mountains.

As previously stated (p. 6), the Manzano group has been regarded as part of the so-called "Permo-Triassic" red beds of the Southwest, and I found nothing during the course of my field work to indicate that they are not correctly so regarded, but further investigation must be made before final correlations are possible. There are at least two lines of investigation that promise good results by way of determining the relations of the Manzano to other red beds of the Southwest. (1) From the central and southern parts of the Rio Grande region the Manzano might be traced more or less continuously eastward and its relation to the Permo-Triassic rocks of eastern New Mexico be determined. (2) Its relation to the red beds east of the Rocky Mountains might be determined by tracing the latter around the south end of the mountains to the Rio Grande valley.

1. Although it is probable that the Manzano group is to be correlated with some part of the red beds of Texas and eastern New Mexico, as shown by Girty in the accompanying paper, little has been accomplished by way of tracing the formations. As previously stated (p. 21), Richardson traced the Manzano beds for a distance of 40 miles east of the Manzano Mountains. He found, however, that still farther toward the east, for a distance of 15 miles, the sedimentary rocks are interrupted by crystallines, beyond which red sediments again appear. But nothing was found to indicate whether the red beds east of the crystalline rocks are of Pennsylvanian (Manzano), Permian, or Triassic age. Furthermore, it is not known whether the crystalline area results from a local uplift around which the sedimentary formations might be traced, or is a ridge forming a barrier between the Manzano group on the west and red beds of perhaps different age on the east.

2. During the summer of 1905 I had observed the rock formations of the Rio Grande Valley northward to Santa Fe and eastward to Glorieta Pass. During the autumn of 1907 I made a hasty examination of the rocks between Glorieta Pass and Las Vegas, N. Mex., for the purpose of determining the relation of the Manzano group to the red beds of the foothill region east of the Rocky Mountains. On account of complicated structure the task proved to be a difficult one and unexpected results were obtained. Between Galisteo Canyon, where undoubted Manzano red beds occur, and Las Vegas, one of the localities at which Hayden[a] examined the so-called Jura-Triassic red beds of the eastern foothills, the rocks were examined and sections measured in Apache Canyon, near Rowe, and near Bernal—18 miles, 30 miles, and 50 miles, respectively, east of Galisteo—and near Las Vegas, 20 miles north of Bernal.

APACHE CANYON.

As described on page 18, the beds of the Manzano group in Galisteo Canyon dip steeply to the east beneath sediments of Cretaceous age, the upper member of which is the Galisteo or late Cretaceous red bed formation that occupies the plain between Lamy and Cerrillos. In Apache Canyon east of Lamy and about 2 miles southwest of Canyoncito an extensive series of red sediments occur in contact with the granitic core of the Rocky Mountains. These sediments are continuously exposed from Lamy eastward around the southern end of the mountains to Las Vegas and beyond. They are parts of the so-called "Red Beds" formation, but whether they are to be correlated with the older or Pennsylvanian red beds or with some younger group can not be definitely stated. They are not distinguishable without careful examination from the red beds of the lower Pennsylvanian (Magdalena group) of the Pecos Valley a few miles to the east, described on page 34, nor from the upper Pennsylvanian red beds (Manzano group) of the Rio Grande Valley to the west, nor from the Galisteo red beds of late Cretaceous age in the Lamy-Cerrillos region. However, they contain plant remains, as mentioned below, which apparently place them at a horizon much lower than the Galisteo.

In Apache Canyon the sedimentary rocks north of the railroad are upturned against the granitic mass of the mountains and dip about 40° SE., or toward Glorieta Mesa. South of the railroad they are more nearly horizontal and form the bordering cliffs of Glorieta Mesa. The following section was measured by pacing across the upturned

[a] Hayden, F. V., Rept. U. S. Geol. Survey of Colorado and New Mexico, Washington, 1869 (Third Annual Report), 1873, pp. 162-166.

edges of the beds north of the railroad. Lying stratigraphically above the beds described in the section and outcropping at the bottom of the canyon are a few hundred feet of red sediments whose eroded edges are now obscured by valley accumulations. One thousand feet or more of still younger red beds are exposed in the cliffs forming the south wall of the canyon.

Partial section of red beds exposed in Apache Canyon, New Mexico.

	Feet.
Sandstone, with partings of pink shale	150
Conglomerate, containing many subangular pebbles of blue limestone	10
Sandstone, prevailingly red in color, with partings of red shale	170
Sandstone, conglomeratic, locally cemented to an iron stone by iron oxide and containing small iron concretions and silicified trees	50
Sandstone, conglomeratic, and shale alternating; red, yellow to white in color (thickness estimated)	1,500
Sandstone, conglomeratic; pebbles mostly of limestone	20
Shale, red	25
Sandstone, coarse, light colored, massive	35
Sandstone, brown, calcareous, containing plant remains (mentioned below)	8
Shale and sandstone, red	90
Conglomerate	10±
Sandstone and shale, red, alternating	100
Conglomerate, red, consisting of angular and subangular pebbles of various crystalline rocks and fossiliferous limestone lithologically similar to the limestone of the Magdalena group found in the Pecos Valley a few miles to the east	10+
Granite.	

The actual contact of the red beds and the granite was not seen at the point where the section was measured, but the hill against which the sedimentary rocks lie is granite and the field relations are such as to lead me to believe that the lowest conglomerate lies upon the granite, and its composition suggests strongly that it is a basal conglomerate.

The limestone of the Magdalena group, identified by its fossils, is represented in Apache Canyon by only small remnants. The formation is 1,000 feet or more in thickness both east and west of Glorieta Mesa and presumably is continuous beneath the mesa. The uniformity in thickness and character of the Magdalena group over wide areas, the narrowness of the space from which it is absent in the vicinity of Glorieta Pass, and the presence in the overlying conglomerates of pebbles of limestone, apparently derived from the Magdalena, are regarded as sufficient evidence that these beds once extended continuously over this region and were removed by erosion previous to the formation of the red beds.

The only identifiable fossils obtained from the red sediments in Apache Canyon are certain plants that I found 210 feet above the basal conglomerate and some collected by T. W. Stanton from about the middle of the 1,500-foot member of the section. These have

been examined by F. H. Knowlton and David White, who state that the forms can not be satisfactorily identified, but express the opinion that they probably indicate Permian or Triassic age.

Since there are differences of opinion among paleontologists regarding the age of the so-called Permian beds of the Southwest, it is possible that these plant-bearing red beds are to be correlated with the Manzano red beds, which, although here described on faunal evidence as a group of the Pennsylvanian series, contain a fauna similar to that of the Quartermaster formation of Oklahoma, which Beede [a] and others regard as Permian. On the other hand, if "Permian" in this case is to be interpreted as indicating beds younger than the Manzano, it becomes difficult, in the light of the facts described in the following sections, to explain the observed relations, and if the beds are of Triassic age the problem is still more complex. In any case, it is clear that something more than reconnaissance examination is necessary before final conclusions can be reached.

The collections of plant remains contain two types of coniferous cones—a curious stem, branches, and branchlets of a conifer and fragments of a fern pinnule. In their report on these forms Knowlton and White state that—

> The coniferous branches and branchlets are probably to be referred to *Walchia*, of the group *W. pinniformis*, though somewhat slenderer than the usual forms of this species. We find fragments of cones which it does not seem possible with the material in hand certainly to separate generically from the cones of *Walchia*, and there are detached cone scales that apparently show the same affinity. There are also minute fragments of a fern pinnule that appear to belong to the genus *Laccopteris*. The larger cones are at least strongly suggestive of those of *Voltzia*, while the curious stem has somewhat the appearance of the pith of one of these ancient types. With these strongly suggestive facts in mind we regard the age as probably Permian or Triassic.

ROWE.

A section of the rocks exposed between Pecos River and the top of Glorieta Mesa was measured 1 mile east of Rowe (fig. 8), a railroad station 10 miles east of Apache Canyon. A great thickness of limestone and shale of the Magdalena group is exposed in the Pecos Valley, but only the upper 600 feet are included in the part measured. The red beds overlie the limestone with apparent conformity. The transitional bed is a subcrystalline limestone, 50 feet thick, in which are angular pieces of granite and yellowish pink feldspar like that in the granite of the mountains to the north. In some places the rock consists of nearly equal parts of feldspar and limestone.

Above this lime breccia occur the red beds, which through a thickness of 100 feet or more contain beds of fossiliferous limestone of

[a] Beede, J. W., Invertebrate paleontology of the upper Permian red beds of Oklahoma and the Panhandle of Texas: Bull. Kansas Univ. Sci., vol. 4, 1907, pp. 115–171.

varying character. In some places the limestone is gray and massive, in others it occurs in subcrystalline layers separated by red shale. I obtained from the limestone fossils that Girty regards as more nearly allied to the Magdalena than to the Manzano fauna.

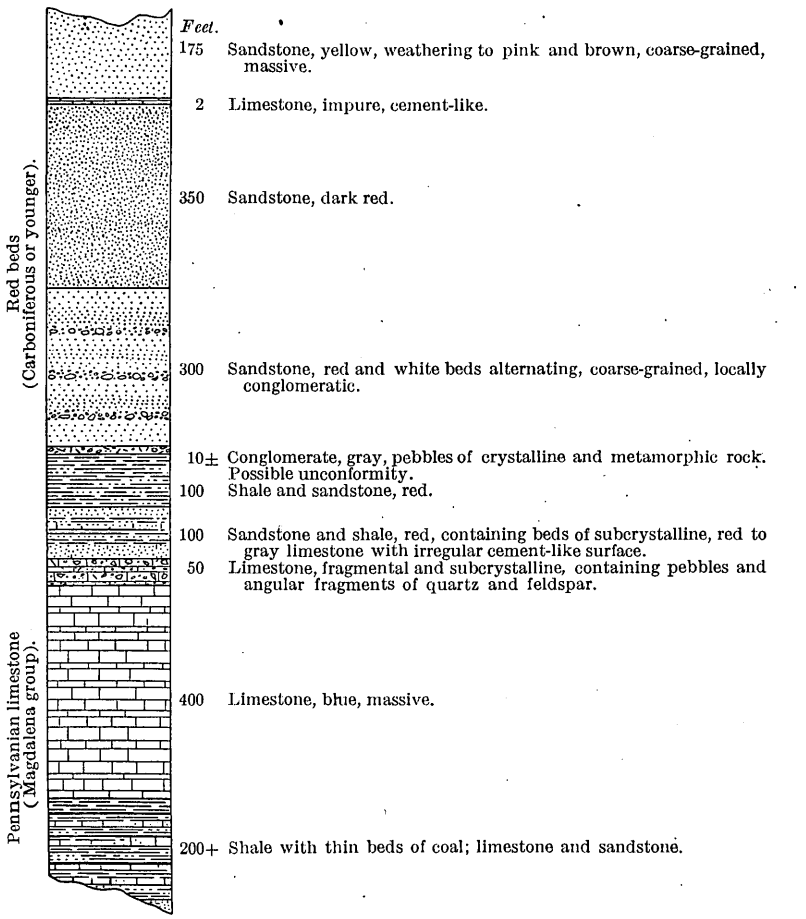


FIGURE 8.—Section of red beds 1 mile east of Rowe, N. Mex. (For fossil contents see following section.)

Two hundred feet above the base of the red beds, as shown in the following section, is a prominent conglomerate, which on further study may be found to mark a time break, but no fossils were found above it, and the age of the upper beds is not known.

Section of red beds 1 mile east of Rowe, N. Mex.

	Feet.
Sandstone, coarse grained, massive, yellow, weathering to pink and brown	175
Limestone, impure, cement-like	2
Sandstone, dark red	350
Sandstone, coarse grained, locally conglomeratic, red and white beds alternating	300

	Feet.
Conglomerate, gray, pebbles of crystalline and metamorphic rock	10±
Shale and sandstone, red	100
Sandstone and shale, red, containing beds of subcrystalline red to gray limestone with irregular cement-like surface. This limestone yielded the following fossils: *Lophophyllum?* sp., *Polypora* sp., *Fenestella* 3 sp., *Cyclopora* sp., *Fistulipora* sp., *Derbya* sp., *Chonetes* sp., *Productus cora*, *Productus nebraskensis*, *Spirifer cameratus*, *Spiriferina* sp., *Composita subtilita*, *Pugnax osagensis*, *Dielasma bovidens*, *Myalina subquadrata*, *Myalina* sp., *Modiola subelliptica*, *Deltopecten occidentalis?*, *Acanthopecten carboniferus*, *Aviculipecten* sp., *Parallelodon carbonarius*, *Pleurophorus?* sp., *Edmondia nebraskensis?*, *Schizodus* sp., *Pleurophorella costata*, *Euconospira* sp., *Bellerophon* sp., *Soleniscus altonensis?*, *Orthonema?* sp., *Naticopsis* sp., *Platyceras* n. sp., *Metacoceras?* aff. *walcotti*, *Nautilus* sp., *Tainoceras* aff. *occidentale*, *Orthoceras* sp., *Phillipsia* aff. *scitula*	100
Limestone, subcrystalline, containing pebbles and angular fragments of quartz and feldspar. Contains *Composita subtilita*	50
Limestone, blue, massive. Contains *Productus nebraskensis*, *Spiriferina kentuckyensis*, *Squamularia perplexa*, *Composita subtilita*, *Cleiothyridina missouriensis*, *Hustedia mormoni*, *Cardiomorpha?* sp., *Astartella* sp., *Aviculipinna peracuta*	400
Shale with thin beds of coal; limestone and sandstone. Contains *Fistulipora* sp., *Derbya?* sp., *Productus semireticulatus*, *Productus cora*, *Spirifer cameratus*, *Composita subtilita*, *Myalina wyomingensis?*, *Metacoceras* aff. *walcotti*	200

BERNAL.

About 5 miles southeast of Rowe conglomeratic red sandstone lies unconformably upon limestone of the Magdalena group, and again about 20 miles southeast of Rowe, at a point on the railroad 6 miles east of Pecos River and 1 mile west of the Mexican village of Old Bernal, the same red conglomeratic sandstone lies unconformably upon the Magdalena, which was here arched and eroded previous to the deposition of the red sediments. At the point where the contact is best exposed the limestone dips 30° and the overlying red beds are horizontal. Their lowest member is a coarse conglomerate-breccia containing angular and subangular fragments, some of which are several inches in diameter, composed of igneous and metamorphic rocks, red sandstone, and blue limestone apparently derived from the underlying limestone of the Magdalena. The limestone pebbles contain crinoid stems and fragments of spirifers and other brachiopods. The composition of this conglomerate and its unconformable relation to the underlying beds are regarded as sufficient evidence that the red beds at this point are younger than the lowest red beds at Rowe and at Las Vegas, which are conformable with the underlying limestone of the Magdalena, and although conglomeratic, do not contain limestone pebbles so far as now known. It is possible that this conglomerate may be the same as the one 200 feet above the base of the red beds at Rowe, a suggestion that finds support

in the lithologic resemblance of the beds above the conglomerate at both localities and in their continuity in the cliffs between the two points. Furthermore, these upper beds are continuously exposed in the cliffs of Glorieta Mesa, and it is possible that the conglomerate in the sections at Bernal and at Rowe may be the same as the basal conglomerate in Apache Canyon. However this may be, the known facts apparently warrant the conclusion that after the oldest red beds were deposited an uplift of the mountains occurred and extensive erosion took place. It is probable that this period of erosion is the same as that during which the Magdalena beds were removed from the Apache Canyon region, and may prove to be the same as that represented by the unconformity between the Magdalena and the Manzano groups of the Rio Grande region.

The following fossils were collected from the limestone of the Magdalena group at Bernal:

Fossils from limestone of the Magdalena group at Bernal.

Lophophyllum profundum.
Eupachycrinus sp.
Septopora sp.
Derbya sp.
Meekella striaticostata.
Productus punctatus.
Productus nebraskensis.
Productus nebraskensis?
Productus semireticulatus.
Dielasma bovidens.
Spirifer cameratus.
Spirifer rockymontanus.
Squamularia perplexa.
Spiriferina kentuckyensis.
Composita subtilita.
Aviculipecten sp.
Myalina sp.
Bellerophon crassus?
Platyceras nebraskense.
Dentalium? sp.
Metacoceras? aff. walcotti.
Orthoceras sp.
Phillipsia aff. major.

LAS VEGAS

Between Bernal and Las Vegas, a distance of 20 miles, red sedimentary rocks are exposed continuously. A section was measured about 5 miles northwest of Las Vegas, in the foothills south of Hot Springs. This section differs from others described in having rocks of known age both below and above the red beds, which are here apparently conformable with the underlying limestone of the Magdalena group and are overlain by the Morrison shale and the Dakota sandstone. Fossils contained in the lower 200 feet of the red beds prove that the lowest beds are of Magdalena (lower Pennsylvanian) age, but no evidence other than stratigraphic position was found that tends to reveal the age of the higher beds. There are several conglomerates, some one of which may be continuous with the basal conglomerate at Bernal and Apache Canyon, although it was my impression when I was in the field that the erosion interval so conspicuous at these places is not represented by a hiatus in the

Las Vegas section. The sediments are like those of Glorieta Mesa in that they are red and consist of shale and conglomeratic sandstone, but I found no beds in the Las Vegas section that resemble those of Glorieta Mesa closely enough to warrant even a provisional correlation.

The red beds at Las Vegas are parts of the so-called "Jura-Trias" of the eastern Rocky Mountains and were described as such by Hayden [a] as early as 1873. Hayden's section was measured at Hot Springs, a mile or more north of the point where I measured the following section and where the strata are much less disturbed than they are near Hot Springs. Some of the upper members of the Las Vegas section are presumably equivalent to the red beds of the plains to the east in which Triassic fossils have been found, and the uppermost massive member is similar in appearance, composition, and stratigraphic relations to the Exter sandstone,[b] which I have previously described as resting with angular unconformity upon the underlying red beds.

It is possible that between the lower Pennsylvanian red beds of the Las Vegas section and those of Triassic age may be found beds to be correlated with the upper Pennsylvanian or Manzano group of the Rio Grande Valley, and with the Permian of the Texas region, but no such subdivision of the section can be made without further examination.

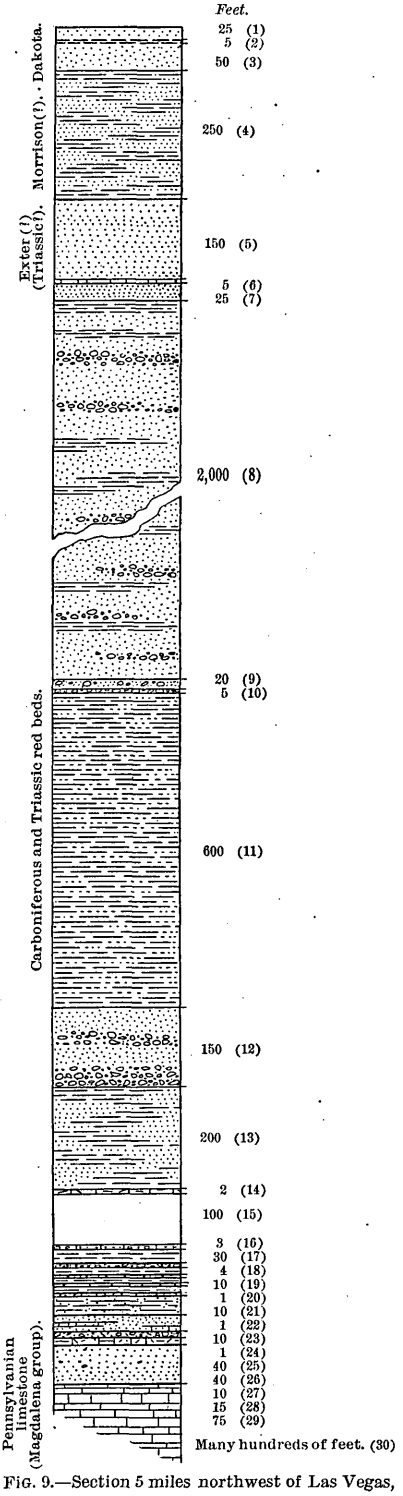


FIG. 9.—Section 5 miles northwest of Las Vegas, N. Mex. Figures in parentheses refer to detailed section given in text.

[a] Hayden, F. V., Rept. U. S. Geol. Survey of Colorado and New Mexico, Washington, 1869 (Third Annual Report), 1873, pp. 162–166.

[b] Lee, W. T., The Morrison shales of southern Colorado and northern New Mexico: Jour. Geology, vol. 10, 1902, p. 45.

The character and succession of the beds of this section are shown graphically in figure 9, and their relations to older and younger rocks are as follows:

Section 5 miles northwest of Las Vegas, N. Mex.

	Feet.
(1) Sandstone (Dakota)	25
(2) Fire clay (believed to be northward extension of Comanche)[a]	5
(3) Sandstone (formerly referred to Dakota)[a]	50
(4) Shale and sandstone, variegated (Morrison)	250
(5) Sandstone, massive, pink to brown (Exter?)	150
(6) Limestone, black, finely laminated, smelling strongly of petroleum	5
(7) Sandstone, light brown, massive	25
(8) Sandstone, red, with much red shale and several beds of conglomerate (thickness estimated)	2,000
(9) Sandstone, gray, coarse grained, conglomeratic	20
(10) Conglomerate	5
(11) Shale, sandy, red to purple (not continuously exposed)	600
(12) Sandstone, conglomeratic, pink to gray	150
(13) Shale and sandstone, red (not continuously exposed)	200
(14) Limestone, hard, brittle, containing crinoid stems	2
(15) Not exposed	100
(16) Limestone, brittle, conglomeratic	3
(17) Shale, red and yellow	30
(18) Sandstone, conglomeratic	4
(19) Shale, red	10
(20) Limestone, sandy	1
(21) Shale, red	10
(22) Limestone, brittle	1
(23) Shale, red	10
(24) Limestone, hard, brittle, weathering to rounded bowlders. Contains *Productus cora, Productus semireticulatus, Productus punctatus, Composita subtilita, Allerisma terminale?*	1
(25) Shale, red, sandy	40
(26) Sandstone, arkose, pink to yellow, with beds of impure limestone	40
(27) Sandstone, conglomeratic, consisting of coarse grains of quartz, pebbles of crystalline and metamorphic rocks, and angular fragments of feldspar and blue limestone; and subcrystalline limestone containing *Lophophyllum profundum, Rhombopora* sp., *Cyclopora* sp., *Fenestella* sp., *Derbya* sp., *Productus cora, Productus punctatus, Spirifer rockymontanus, Spirifer cameratus, Squamularia perplexa, Spiriferina kentuckyensis, Composita subtilita, Dielasma bovidens, Aviculipecten* sp., *Myalina* sp., *Conularia* sp.	10
(28) Limestone, subcrystalline, containing the same fossils as the limestone immediately above it	15
(29) Sandstone arkose, coarse grained, pink to yellow	75
(30) Pennsylvanian limestone, Magdalena group, many hundreds of feet, massive, blue, containing *Productus cora, Productus nebraskensis, Squamularia perplexa, Composita subtilita, Cleiothyridina missouriensis, Hustedia mormoni, Cardiomorpha?* sp., *Astartella* sp., *Aviculipinna peracuta.*	

[a] Stanton, T. W., The Morrison formation and its relations with the Comanche series and the Dakota formation: Jour. Geology, vol. 13, 1905, pp. 657-669.

SUMMARY.

Although the accumulation of red sandstone and shale began in Mississippian ("Lower Carboniferous") time at Perry Park and elsewhere in Colorado, in the mountain region of New Mexico it began in Pennsylvanian ("Upper Carboniferous") time, as shown by the occurrence of a Magdalena fauna in the oldest red beds near Rowe and Las Vegas.

In late Magdalena time (near the middle of the Pennsylvanian) some change, presumably uplift, occurred in the mountain region of New Mexico, which caused a change in character of the accumulating sediments from limestone to red shale and coarse-grained red sandstone. The change was apparently slow, as evidenced by the gradual transition shown in the Rowe and Las Vegas sections, but was of such magnitude, as evidenced by the occurrence of the feldspar breccia of the Rowe section, that it brought the basal crystallines of the mountains into a position where they furnished sediments. In case the limestone of the Magdalena group originally extended continuously over the crystalline rocks at this place, as there is some reason to believe, there must have been an uplift of 1,000 feet or more and erosion to an equal depth before the granitic débris could be furnished. This suggestion finds some support in the character of the breccia. The feldspar crystals are but slightly water worn and were evidently derived from sources near by.

In the Rio Grande region there is evidence of uplift and erosion in mid-Pennsylvanian time, immediately preceding the deposition of the Manzano beds. This uplift may have occurred early enough to prevent the deposition of the lower Pennsylvanian (Magdalena) red beds, but their absence from the Rio Grande valley is probably better explained as a result of erosion. Because of the uncertainty as to the age of the beds above the basal conglomerate at Bernal, Rowe, and Apache Canyon, it is not known whether this movement is the same as that just mentioned as occurring in late Magdalena time, or is to be associated with the uplift which caused the more extensive erosion evidenced by the greater unconformity at the base of the red beds in Apache Canyon, which are said to be of Permian or Triassic age.

The mid-Pennsylvanian erosion was followed in the Rio Grande region by the accumulation of the Manzano group of red beds, which are described in this bulletin. They constitute a part of the so-called "Red Beds formation" of the Rocky Mountain region, and in composition, physical character, and faunal relations they are similar to some of the so-called "Permian Red Beds" of the Texas region, with which they are probably to be correlated, although they are here

described as a group of the Pennsylvanian series, to which the fossils prove that they belong. They are also probably equivalent to some part of the red beds of the eastern Rocky Mountains, but final correlations can not now be made.

The San Andreas limestone, the youngest member of the Manzano group, is absent from the northern part of the region, but whether because of nondeposition or because of erosion is not definitely known. Near Carthage it is overlain by red beds, the lowest member of which is a basal conglomerate containing pebbles of crystalline and metamorphic rock that must have come from distant localities. In the northern part, where the San Andreas is absent, the variegated shales provisionally referred to the Morrison are in contact with the Yeso formation. It is probable that uplift and erosion followed the deposition of the Manzano group, removing parts of it, and that the red beds above the San Andreas near Carthage may be of Permian or Triassic age. Red-bed accumulation in the Rocky Mountain and Plains regions is now known to have covered a period of time extending from Mississippian to Jurassic, and the geologic history during this time was complex.

PALEONTOLOGY OF THE MANZANO GROUP.

By GEORGE H. GIRTY.

INTRODUCTION.

While by no means without intrinsic interest, the fauna of the Manzano group is perhaps more interesting for extrinsic reasons. It contains a considerable number of undescribed species, but at the same time does not present that novelty of facies, when compared with our typical Pennsylvanian faunas, which is sometimes found in the West. Furthermore, the Manzano shells are liable to be fragmentary and much inferior in preservation to the Pennsylvanian fossils of the Mississippi Valley. Through some peculiarity of preservation they are too often obscured in sculpture and in outline.

Some 84 varieties have been discriminated in the collection examined, which from one point of view may be distributed into three classes: Species described for the first time, and these are reasonably numerous; identifications with known species which have a purely western distribution; and identifications with certain species which have a wide distribution and occur in the more eastern faunas also. The first group is of value for correlation purposes only prospectively; the second carries suggestions of certain correlations in adjacent areas, while the last may, when properly interpreted, indicate certain relationships with faunas of the Mississippi Valley Pennsylvanian.

Intrinsically there seems to be no marked difference between the assemblages of species which occur in the three divisions of the Manzano group that can be discriminated on lithologic grounds. Collections made at different horizons in the same section show no greater faunal distinctions than collections made at the same horizon in different sections. Nevertheless, certain peculiarities of range are, in fact, indicated, and it may be restated in this connection, though almost a truism, that the tendency of imperfect material is always toward the obliteration of faunal differences. On the other hand, every collection must necessarily show certain idiosyncrasies, in failing to represent the real range and distribution of organic types. Tables, then, both in the differences which they indicate and in those which

they fail to indicate, are merely approximations that should be verified and corrected by subsequent data.

The subjoined tables are arranged to show the species identified at each locality and their known range in the different sections where collections were made. It would appear that in but a single section (No. 4) are the three divisions faunally represented. The Abo and Yeso faunas appear together only in section 4, while the Yeso and San Andreas appear together in sections 4, 7, 8, and 13. Much space might be covered in pointing out the species which are common to two or to all three formations and those which are restricted to one of them, but anyone who is interested can readily note these facts for himself in the table. The two species which are most persistent in all the sections and at all the horizons are those identified as *Schizodus wheeleri* and *Bellerophon majusculus*, but in these types the limit of error is especially great because of their imperfect preservation.

Regarding the fauna from the biologic rather than the stratigraphic side, it is perhaps worthy of remark that the Mollusca exhibit more than the usual abundance and differentiation, while the Brachiopoda are less abundant and differentiated than is usual in the ordinary Pennsylvanian fauna.

Different as they are in physical aspect, it is highly probable that the Manzano and Hueco are equivalent formations. The Manzano faunas are more closely related to those of the upper Hueco than to those of the lower, in which brachiopods are abundant. Whether the Magdalena group, which underlies the Manzano, is represented in the Hueco has not been definitely determined. Faunally the Hueco presents many aspects not known in either the Magdalena or the Manzano.

In the Grand Canyon section the Manzano appears to find its representation in the Aubrey group. Probably both the upper and lower Aubrey correspond to the Manzano. The beds in these two areas have in common the three very characteristic species *Productus ivesi*, *Allerisma capax*, and *Dentalium canna*, while no doubt other types can be cited when the faunas have been worked out in detail. Upon this basis the limestone (Magdalena group) which underlies the Manzano would probably correspond to the upper part of the Redwall limestone, from which a Pennsylvanian fauna is cited by Gilbert.[a] The lower part of the Redwall, with its lower Mississippian fauna, is more or less exactly equivalent to the Kelly and the Lake Valley limestones of New Mexico, whose position is below the Magdalena.

In Colorado the equivalent of the Manzano is, I am now disposed to believe, the Rico formation. Lithologically, stratigraphically, and faunally the Hermosa and Rico formations show many points of resemblance to the Magdalena and Manzano. It is proposed to

[a] Gilbert, G. K., U. S. Geog. Surveys W. 100th Mer., Rept., vol. 3, 1875, p. 178.

speak of the Magdalena and Hermosa in another paper, but accepting the equivalence as a working hypothesis, the correlation of the Manzano and Rico seems justified in view of the close proximity geographically and the fact that both are "Red Beds" formations, occupying corresponding positions in the section. The faunas of the Rico and Manzano show a general resemblance in the limitation of the brachiopod forms and the abundance of the pelecypods and gasteropods. Generically they exhibit a striking correspondence, while a number of species are common to both faunas, such as *Productus cora*, *Composita subtilita*, *Deltopecten occidentalis*, *Pseudomonotis hawni*, *Aviculipinna nebraskensis*, *Allerisma terminale*, and *Edmondia gibbosa*. Besides these many instances could be cited of kindred forms and forms which upon revision might prove to be the same.

The correlations here adopted of the Manzano group with the Aubrey on the one hand and the Rico on the other naturally bring the Arizona formation into alignment with that of Colorado in spite of the fact that the Rico fauna is very different from that of the Aubrey. Although none of the characteristic Aubrey forms has been found in the Rico, the Manzano fauna to a certain extent presents a combination of types which occur in the Rico, but not in the Aubrey, and those which occur in the Aubrey, but not in the Rico.

As to the relationship of the Manzano group to the Pennsylvanian section as it is developed in the Mississippi Valley, it would be inadvisable to write at length at present. The Manzano fauna differs considerably from any of the Carboniferous faunas known from that region, whether of Pennsylvanian or so-called Permian age. The assemblage of forms which perhaps more closely than any other suggests that contained in the Manzano beds occurs in the Whitehorse sandstone and Quartermaster formation of Oklahoma and Texas.[a] These rocks are, relatively speaking, not so very remote in the two areas, and the fact that in both cases they form part of the "Red Beds" makes the correlation a rather inviting one. Mr. Beede in his discussion of the Whitehorse and Quartermaster faunas seems to adopt this correlation with the Manzano group, at least in a general way. Although the two faunas contain some closely related and possibly equivalent species, there is only one which at the time of writing seems to be identical in the two formations, namely, *Deltopecten vanvleeti*. The brachiopod element seems to be entirely lacking from the Quartermaster and Whitehorse faunas, and though fairly abundant in the Manzano the representation is distinctly limited.

On the whole, however, it seems rather probable that the Manzano and Whitehorse-Quartermaster horizons will prove to be in a general way equivalent, but if so, some remarkable and interesting relations

[a] Beede, J. W., Bull. Kansas Univ. Sci., vol. 4, 1907, pp. 115-171.

between other formations are opened up. It would appear, in brief, upon this hypothesis, that if the Guadalupian beds are equivalent to the Russian Permian, the so-called Kansas Permian is much older; and if, on the other hand, the Kansas "Permian" is equivalent to that of Russia, the Guadalupian represents a distinct and still younger epoch. This involves, on the one hand, the equivalence of the Manzano beds and the Hueco formation and the superposition of the Guadalupian series upon the Hueco, and, on the other, the determination of the Whitehorse and Quartermaster rocks as higher than the highest fossiliferous "Permian" of Kansas. Given, then, the equivalence of the Manzano and the Whitehorse-Quartermaster horizons, as hypothetized above, the Guadalupian must be considerably younger than the Kansas "Permian."

As to the correlation of the Manzano and the Hueco, I feel at present very little doubt, and it is certainly true that the Manzano fauna is extremely unlike that of the Guadalupian beds. At present also it seems practically impossible that the stratigraphic relations of the Hueco and Guadalupian formations are different from what they have generally been considered to be—that the former underlies the latter. Regarding the relations of the Whitehorse and Quartermaster rocks to the Kansas "Permian," I have no independent opinion to advance. The crux of the whole matter seems to lie in the relation of the Manzano beds to the Whitehorse and Quartermaster rocks. As to the probability of their being equivalent, two additional points may be noticed. In the first place, only the most remote relationship can be traced between the Guadalupian fauna and the faunas of the Whitehorse and Quartermaster beds as at present known. In the second place, Beede remarks that the American types experience a decided decrease and the foreign ones a decided increase in passing from the Whitehorse to the Quartermaster horizons. Already I have called attention to the striking foreign facies which appears in the Hueco formation, from which circumstance the Hueco would appear to be no older at least than the Quartermaster beds.

I have spoken more fully elsewhere as to what seemed to me the probabilities of correlation between the Hueco and Guadalupian series and the Russian Permian. The Hueco fauna in many respects is strikingly similar to the Gschel fauna, which underlies the Permian and Artinsk in Russia.

Herrick[a] has employed the designation "Permian" for part of the Manzano group, citing as Permian forms the three following species: *Bakewellia parva*, *Myalina attenuata*, and *Pleurophorus subcuneatus*, which probably are *Pteria* sp., *Myalina apachesi*, and *Pleurophorus*

[a] Herrick, C. L., Bull. Univ. New Mexico, vol. 2, fasc. 3, 1900, p. 4; Jour. Geology, vol. 8, 1900, p. 115.

aff. *subcostatus* of the present report. He evidently has in mind in this correlation the "Permian" of Kansas and Nebraska. That there is any substantial evidence for correlating the Manzano with the Russian Permian I am not disposed to believe, but that it may be more or less equivalent to the Kansas "Permian" seems, as already stated, not improbable.

The accompanying table shows the range and distribution of the Manzano species thus far obtained by Mr. Lee, who made all the collections on which this paleontologic account is based. The first series of columns show the local faunas, the numbers at the top being lot numbers, which refer to localities described in detail in the locality register given on pages 119–120. To the right are the composite faunas, in columns grouped under the formation names Abo, Yeso, and San Andreas. It seemed best to make a geographic subdivision of the formational faunas, and consequently the numbers heading these columns stand for certain districts or sections, as used by Mr. Lee in his portion of the paper and shown on Plate I, to wit:

1. Galisteo Canyon.
2. Sandia Mountains.
3. Abo Canyon.
4. Mesa del Yeso.
5. Alamillo.
6. Blackinton's ranch.
7. Carthage.
8. Fra Cristobal.
9. Nogal Creek.
10. Engle.
11. Elephant Butte.
12. Caballos Mountains.
13. San Andreas Mountains.

The lots combined to make up the composite formational faunas in the different areas are as follows:

Abo sandstone:
- Sandia Mountains (2), comprising lots 3796, 3797, and 3798.
- Abo Canyon (3), comprising lot 3757a.
- Meso del Yeso (4), comprising lot 3751.

Yeso formation:
- Mesa del Yeso (4), comprising lots 3751a, 3751b, and 3751c.
- Alamillo (5), comprising lot 3751e.
- Blackinton's ranch (6), comprising lot 3750.
- Carthage (7), comprising lots 3753, 3747a.
- Fra Cristobal (8), comprising lots 3743a, 3743b.
- San Andreas Mountains (13), comprising lots 3742b, 3742c, 3742d, 3742e, and 3742g.

San Andreas limestone:
- Mesa del Yeso (4), comprising lot 3751d.
- Carthage (7), comprising lots 3746, 3746a.
- Fra Cristobal (8), comprising lot 3743.
- Nogal Creek (9), comprising lot 3744, 3744a.
- Engle (10), comprising lots 3595, 3740, 3740a.
- Elephant Butte (11), comprising lots 3741, 3600.
- Caballos Mountains (12), comprising lots 3738, 3738a.
- San Andreas Mountains (13), comprising lots 3742, 3742f.

Range and distribution of the fossil invertebrates found in the Manzano group of the Rio Grande valley.

	3595.	3600.	3738.	3738a.	3740.	3740a.	3741.	3742.	3742b.	3742c.	3742d.	3742e.	3742f.	3742g.	3743.	3743a.	3743b.	3744.	3744a.	3746.	3746a.	3747a.	3750.	3751.	3751a.	3751b.
Echinocrinus cratis				×																						
Meekella mexicana		×			×		×				×															
Meekella striaticostata																								×		
Productus ivesi													?						×						×	×
Productus leei	×		×		×								?						?							
Productus mexicanus?													?						×						×	
Productus cora																								×		
Productus nebraskensis																								×	×	
Marginifera? manzanica													?		×											
Marginifera? cristobalensis													?		×											
Pugnax osagensis var. pusilla																										×
Squamularia perplexa													×													
Composita mexicana													×													×
Composita subtilita?															×											×
Solenomya? nænia															×											
Clinopistha? sp															×											
Edmondia gibbosa																							?	×		
Chænomya leavenworthensis																								×		
Nucula levatiformis	×										×				×											
Nucula levatiformis var. obliqua																	×									
Leda obesa																									×	
Parallelodon aff. obsoletus									×																	
Aviculipinna? peracuta																								?		
Aviculipinna nebraskensis		?	×	×								×														
Pseudomonotis hawni?					×				×																	
Pseudomonotis sublævis					?				×	×	×															
Myalina apachesi		×							×															×		
Schizodus wheeleri?	?			?	×		×	×	?	×	×	×			×		×	×		?	?	?	×			
Deltopecten vanvleeti		×			×			×																		
Deltopecten coreyanus											?							×						×	×	
Pleurophorus mexicanus	×																									
Pleurophorus bipartitus																								×		
Pleurophorus aff. taffi									×																	
Pleurophorus aff. subcostatus																							×			
Astartella subquadrata																	×									
Dentalium mexicanum				×											×											
Plagioglypta canna	×																	?						?	×	
Phanerotrema aff. brazoense			×																							
Murchisonia? terebra			?								×															
Murchisonia? aff. terebra			?								×				×			×	×							
Euphemus subpapillosus					×						×						?									
Euphemus inspeciosus?	×																		?							
Bellerophon majusculus	×	×		×		×	×	×			×			×	×			×						×	×	×

Patellostium aff. nodicostatum																									×	
Mogulia? sp				×																						
Bucanopsis modesta				×																						
Euomphalus aff. pernodosus			×																							
Euomphalus sp. a			×				×												?							
Euomphalus sp. b				?		×	?						×	×												
Naticopsis deformis						×																				
Sphærodoma aff. medialis	×			×																						
Sphærodoma aff. texana				×																						
Orthonema sp. a																		?	×						×	
Orthonema sp. b			×																							
Temnocheilus aff. winslowi																							×			
Temnocheilus aff. conchiferum																		×								
Temnocheilus sp. a																								?	?	
Bairdia occidentalis											×															
Cytherella benniei											×															
Hollina herrickana											×															
Entomis shumardiana											×															

Range and distribution of the fossil invertebrates found in the Manzano group of the Rio Grande valley—Continued.

	3751c.	3751d.	3751e.	3753.	3757a.	3796.	3797.	3798.	Abo. 2.	Abo. 3.	Abo. 4.	Yeso. 4.	Yeso. 5.	Yeso. 6.	Yeso. 7.	Yeso. 8.	Yeso. 13.	San Andreas. 4.	San Andreas. 7.	San Andreas. 8.	San Andreas. 9.	San Andreas. 10.	San Andreas. 11.	San Andreas. 12.	San Andreas. 13.
Lophophyllum? sp.					×					×															
Echinocrinus cratis																								×	
Septopora aff. robusta					×					×															
Meekella mexicana																	×					×	×		
Meekella striaticostata					×					×	×														
Productus ivesi	?	×			×							×						×			×				?
Productus leei																					?	×		×	?
Productus mexicanus?												×									×				×
Productus cora					×			×	×	×	×														
Productus nebraskensis					×			×	×	×	×	×													
Marginifera? manzanica																				×					×
Marginifera? cristobalensis																				×					×
Pugnax osagensis var. pusilla												×													
Squamularia perplexa	×											×													×
Composita mexicana												×													×
Composita subtilita?	×				×					×		×								×					
Solenomya? nænia																				×					
Clinopistha? sp		×																×		×					
Edmondia gibbosa					×			×	×	×	×			?											
Chænomya leavenworthensis					×					×	×														
Nucula levatiformis			×										×				×			×		×			
Nucula levatiformis var. obliqua																×									
Manzanella elliptica			×										×												
Leda obesa	×				×					×		×													
Parallelodon aff. obsoletus																	×								
Aviculipinna? peracuta					×			?	?	×	?														
Aviculipinna nebraskensis					×			?	?	×							×						?	×	
Monopteria marian					×	×			×	×															
Pteria sp			×										×												
Pseudomonotis hawni?					×					×							×				×				
Pseudomonotis sublævis																	×				?				
Myalina apachesi	×	×			×			×	×	×	×	×					×	×					×		
Schizodus aff. magnus	×	×										×						×							
Schizodus wheeleri?	×		×		×	?	×		×	×		×	×	×	?	×	×		?		×	×	×	?	×
Deltopecten occidentalis					×					×															
Deltopecten vanvleeti					×					×												×	×		×
Deltopecten coreyanus	×	×			?	×	×	×	×	×	×	×					?	×			×					
Allerisma capax	×				×					×		×													
Allerisma terminale								×	×																
Pleurophorus mexicanus	×							?	?			×										×			
Pleurophorus bipartitus											×														

Pleurophorus aff. taffi	×	×			?		?		?	?		×					×	×							
Pleurophorus aff. meeki			×										×												
Pleurophorus aff. oblongus					×					×															
Pleurophorus aff. subcostatus		?		×	?					?				×	×			?							
Astartella subquadrata		?	×										×			×		?							
Dentalium mexicanum																				×				×	
Plagioglypta canna	×	×	×			×	×		×		×	×	×					×			?	×			
Phanerotrema manzanicum			×			?			?				×												
Phanerotrema aff. brazoense																								×	
Worthenia alamillana			×										×												
Murchisonia? terebra						?			?								×							?	
Murchisonia? aff. terebra		×															×	×		×	×			?	
Euphemus subpapillosus							?		?							?	×					×			
Euphemus inspeciosus?	×		×									×	×								?	×			
Bellerophon majusculus	×	×					×		×		×	×					×	×		×	×	×	×	×	×
Patellostium aff. nodicostatum		×			×	×			×	×		×						×							
Mogulia? sp.																								×	
Bucanopsis modesta					?					?														×	
Euomphalus aff. pernodosus																								×	
Euomphalus sp. a																					?		×	×	
Euomphalus sp. b							×		×								×					×	?	?	×
Naticopsis deformis					×			×	×	×												×			
Naticopsis aff. altonensis		×																×							
Zygopleura aff. rugosa			×										×												
Soleniscus aff. altonensis					×					×															
Sphærodoma aff. medialis																						×		×	
Sphærodoma aff. texana																								×	
Orthonema socorroense			×										×												
Orthonema sp. a	×	×										×						×			×				
Orthonema sp. b																								×	
Orthoceras sp.					×					×															
Coloceras mexicanum			×										×												
Temnocheilus aff. winslowi	×											×		×											
Temnocheilus aff. conchiferum	×											×									×				
Temnocheilus sp. a	×	?									?	×						?							
Domatoceras? sp.	×											×													
Bairdia occidentalis																	×								
Cytherella benniei																	×								
Hollina herrickana																	×								
Anisopyge inornata	×		×									×	×												

DESCRIPTION OF SPECIES.

CŒLENTERATA.

LOPHOPHYLLUM? sp.

Of this species our collection has furnished a single specimen embedded in matrix and partially weathered through. The corallum is small, straight, rather rapidly expanding, 15 mm. long, 8 mm. in diameter at the larger end. Tabulæ and dissepiments wanting. Fossula large and distinct. Septa 19 in number. Their ends unite at the center, and with the sides of two of them form an apparently continuous wall around the fossula. Nevertheless, on close inspection they are, by reason of the union of their inner ends, distinctly divisible into three groups. Opposite the fossula three of the septa form a wedge-shaped mass, whose extremity projects somewhat farther toward the center than the other combinations of septa, and doubtless form the pseudocolumella, if such a structure was present. Eight septa on each side, possibly divisible into two groups of four each, occur between the fossula and the wedge-shaped group immediately opposite, their ends uniting so as to be distinct from each other and also, to a less degree, from the third group, which lies between them.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a).

ECHINODERMATA.

ECHINOCRINUS Agassiz.

I am, with regret, employing the generic name *Echinocrinus* instead of the more familiar and more appropriate *Archæocidaris*, but if the facts have all come before me no other course seems open.

Echinocrinus was first introduced by Agassiz in 1841. No complete or formal description was given, but after mentioning a few characters the genus was stated to include *Cidaris urii* and one or two other forms. In 1844 McCoy[a] gave a very good discussion of the genus, under the title proposed by Agassiz, mentioning the fact that he had long before distinguished it in manuscript by the name *Archæocidaris*. Meek animadverts to this fact, saying that *Echinocrinus* has usually been passed over by naturalists because Agassiz supposed the form to be a crinoid and the name is inappropriate for an echinoid.[b]

Though by some considered adequate ground for rejecting a name in zoology, the fact that a name is inappropriate or suggests mistaken

[a] Syn. Carb. Foss. Ireland, Dublin, 1844, p. 173.
[b] Rept. Geol. Survey Illinois, vol. 2, 1866, p. 294.

biological affinities is not generally regarded as invalidating it, and more than one example can be brought forward to illustrate the confusion which would spring up were such a principle adopted.

It seems, therefore, that *Archæocidaris* has no real standing in nomenclature. McCoy himself evidently did not seek to introduce it. It is anticipated by *Echinocrinus* Agassiz, and if Agassiz's somewhat casual definition is thought insufficient to fix the name, *Archæocidaris* is still anticipated by McCoy's own definition of the genus under the title of *Echinocrinus*.

The genotype of *Echinocrinus* Agassiz would undoubtedly have to be *Cidaris urii* Fleming, while that of *Echinocrinus* McCoy would probably be the species which McCoy identifies as *Echinocrinus münsterianus* De Koninck(?). The former has characters more like those of the American Carboniferous species usually referred to *Archæocidaris*. *Cidaris münsteriana* is now regarded as belonging to the genus *Eocidaris*. Apparently, therefore, if the genus be given to McCoy at all, whether as *Archæocidaris* or *Echinocrinus*, by the method of generic fixation by type species whichever name is adopted passes to the group now called *Eocidaris*, that term falling into synonymy.

It has been a matter of some difficulty to ascertain the facts relating to the literature of *Echinocrinus* and *Archæocidaris*. McCoy states that Agassiz had anticipated him in naming the group in question, but gives no reference to Agassiz's work. In his Nomenclator, Agassiz cites the genus as described in the second of his Echinoid monographs (1841). Goeppert and Meyer give the same volume and date, and also name the page, which was not given by Agassiz. Goeppert and Meyer give page 15 of the introduction. In the volume which I consulted, that from the Library of Congress, the genus was discovered with difficulty in a part bound in with Monograph I, 1838. This arrangement, however, is erroneous, for the fascicle in question is subscribed "Neuchâtel en juillet 1841." Although this date is the same as that of the second monograph, there is good reason to believe that it did not form part of that work, the evidence consisting partly of the fact that this fascicle has a separate title-page and independent pagination. There is reason to believe, indeed, that this fascicle, which is entitled "Observations sur les progrès récens de l'histoire naturelle des Echinoderms," appeared as a separate brochure between the first and second monographs, though intended to form a part of the Echinoderm volume. Goeppert and Meyer's reference is, therefore, incorrect, not only as to the volume, but also as to the statement that the description of *Echinocrinus* occurs in the introduction. Monograph II has both a preface and an introduction of its own, while the fascicle in which this description does occur bears neither the one title nor the other.

Echinocrinus cratis White.

1876. *Archæocidaris cratis.* White, U. S. Geol. Geog. Surv. Terr., Second Division, 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. Surv. (F. V. Hayden in charge); Cont. to Paleontology Nos. 2–8, p. 130, pl. 33, fig. 2*a*.
Middle Carboniferous: Confluence of Grand and Green rivers, Utah.
1883. *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.
1903. *Archæocidaris cratis.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 331.
Weber limestone: Crested Butte district, Colorado.
Hermosa formation: Ouray, Colo.
Leadville district, Colorado.
1904. *Archæocidaris cratis.* Klem, St. Louis Acad. Sci., Trans., vol. 14, p. 47.

This species is represented in our collection by only three or four fragmentary specimens, which have been worn about half way through as they lie flat on the rock surface. They are characterized by having a few stout spinules disposed at rather long intervals. So far as can be determined, they agree with *E. cratis*, except that they are larger, the largest having a diameter of 5 mm. In size and to a certain extent in other characters these specimens suggest *E. triplex*, but I have seen no evidence that the radiole was triangular in section, a characteristic feature of *E. triplex*, while the spinules are more prolonged and tapering.

Horizon and locality.—San Andreas limestone, Caballos Mountains (station 3738a).

BRYOZOA.

Septopora aff. robusta Ulrich.

This species is represented in our collection by two specimens exposed on blocks of limestone and for the most part considerably weathered. On this account it has been possible to determine their characters only in part. The Manzano form is a large, fine species, apparently having a flabellate shape, more or less flexuous. The larger specimen measures 60 mm. in one direction. The branches increase by division and by intercalation, and sometimes this process has been so much more active in one part of the zoarium than in another that there is wide variation from point to point in the number of branches which occur in a given distance. Ten is perhaps the average number in 10 mm., but the range is from 8 to 11 or 12. Some 9 or 10 fenestrules occur in the same distance. The fenestrules vary from subcircular to transversely subquadrate, though the latter type is not common. Usually the length and breadth are approximately

equal and the shape roundish, for the characteristic construction of the dissepiments as formed by the union of two oblique branchlets is only here and there obvious. The dissepiments are depressed, expanding at their ends and varying from larger to considerably smaller than the branches, many of which remain slender for a relatively long distance after their introduction. The obverse side is probably striated, and the branches also appear to have been swollen or nodose at their junction with the dissepiments.

On the reverse the branches contain two rows of cells apparently separated by a fairly well-defined carina. The zoœcial apertures come about four to the fenestrule or two opposite the fenestrules and two more or less opposite the dissepiments. There are about 20 in a distance of 5 mm., and they are considerably less than their own diameter apart. On the dissepiments the apertures are irregularly distributed in one to three rows. The number and distribution of the accessory pores have not been determined. This form is evidently related to *S. robusta*, but almost as evidently not identical with it. It is somewhat less robust and has the obverse face marked by nodes.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a).

BRACHIOPODA.

MEEKELLA MEXICANA n. sp.

Plate VI, figures 1-5.

Shell of medium size, growth usually regular. Ventral valve having a subtriangular or spatulate outline, subconical, more or less flattened and produced backward. Hinge narrower than the greatest width. Area high, moderately well defined at the sides. Pseudodeltidium occupying about one-fourth of its width, sometimes more, sometimes less.

Dorsal valve transverse, subquadrate in outline, strongly inflated, especially in the umbonal region.

Plications rather fine and faint, sometimes obscure, often beginning some distance from the beak. Liræ fine and rigid, apparently thin and sharp when not exfoliated, 16 to 19 in 5 mm., generally subequal, sometimes distinctly and regularly unequal, and of three or four degrees of prominence.

Some of the variable features of this species have already been pointed out. The area varies considerably in altitude and also in direction, from being nearly perpendicular to the plane of the aperture to almost in line with it. The width of the pseudodeltidium also is subject to variation as well as the degree of strength in the plications. In some cases the latter are so faint and begin so far from the apex that if only specimens were seen which were not quite mature one would feel compelled to place them in the genus *Orthothetina*. (See

fig. 4, Pl. VI.) Such seems in fact to be the case with our material from station 3742d, in which the largest specimens examined do not exceed 16 mm. in length and show no trace of plications. They agree so well in other respects with typical *M. mexicana* that I have referred them without much hesitation to that species.

There can be little question that the present form is distinct from *Meekella striaticostata* of the Mississippi Valley Pennsylvanian. A number of differences at once appear when characteristic specimens are compared, and they remain rather constant in all comparisons. The area of the ventral valve is generally more strongly inclined backward, frequently more flat and less distorted. The plications are much less distinct. It is difficult to make a count of the liræ upon *M. striaticostata* owing to the plications, but they appear to be considerably finer and less regular.

Horizon and locality.—San Andreas limestone, Engle (station 3740) and Elephant Butte (stations 3600 and 3741); Yeso formation, San Andreas (station 3742d).

MEEKELLA STRIATICOSTATA COX.

Plate VI, figure 6.

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, Final Rept., p. 175, pl. 5, figs. 12*a–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 striatocostata.* White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 126, pl. 9, figs. 4*a–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, U. S. Geol. Geog. Surv. Terr., Second Division; Powell's Rept. Geol. Uinta Mountains, p. 90. Lower Aubrey group: Confluence of Grand and Green rivers, Utah.

1883. *Streptorhynchus* (*Meekella*) *striatocostata.* Hall, New York State Geol. Sec. Ann. Rept. for 1882, pl. (10) 40, figs.18–23.

1883. *Meekella striatocostata.* Kayser, Richthofen's China, vol. 4, p. 178, pl. 23, fig. 8.
Upper Carboniferous: Lo-Ping, China.

1884. *Meekella striatocostata.* White, Geol. Surv. Indiana, Thirteenth 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, Geol. Surv. New York, Pal., 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., Rept., vol. 5, p. 68, pl. 39, figs. 1*a–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. 9–9*c*.
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.

1903. *Meekella striaticostata.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 350.
Hermosa formation: San Juan region, Colorado.
Carboniferous: Leadville district, Colorado.

A few specimens obtained at different localities from those at which *M. mexicana* was abundant possess characters which at the same time tend to discriminate them from that species and ally them with *M. striaticostata.* The beak of the ventral valve is twisted. The area is not very high and is nearly perpendicular to the plane of junction of the two valves. On the one hand, the surface is plicated more strongly than in *M. mexicana,* but, on the other, it is not as strongly folded as is often the case with *M. striaticostata.* The liræ are finer than in *M. mexicana* and tend to bend outward from the bases of the sulci up onto their sides in a manner common to *M. striaticostata* but rare in *M. mexicana.* In one ventral valve the dental plates are very closely arranged, more so than is usually the case with *M. mexicana.*

Horizon and locality.—Abo sandstone, Mesa del Yeso (station 3751) and Abo Canyon (station 3757a).

PRODUCTUS IVESI Newberry.

1861. *Productus Ivesi.* Newberry, Ives's Colorado Expl., Exped., Rept., p. 122, pl. 2, figs. 1-8.

Middle Carboniferous limestone: Banks of Colorado River, near mouth of Diamond River.

This species has sometimes been regarded as identical with *P. semireticulatus* or as a mere variety of it. *P. ivesi* belongs to the *semireticulatus* group, but is without much question specifically distinct from *P. semireticulatus* itself, or at least from the form found in the Pennsylvanian of the Mississippi Valley which passes under that name and which is probably closely allied to the original English variety. *P. ivesi* is narrower, with less regular sculpture and more numerous spines. It more nearly resembles the Pennsylvanian species which was designated, I judge, by Swallow as *P. calhouni-anus,* but I am quite in accord with Meek in believing the western form to be distinct.[a]

For the time being at least I shall not include with *P. ivesi* the form from Nevada which Meek identified as *P. ivesi?,* with the reversional name of *P. longus.*

The fossils under consideration, though somewhat imperfect, appear to be typical in every way.

Horizon and locality.—San Andreas limestone, Nogal Creek (station 3744a), Mesa del Yeso (station 3751d), and San Andreas (station 3742f?); Yeso formation, Mesa del Yeso (stations 3751a, 3751b, and 3751c?).

PRODUCTUS LEEI n. sp.

Plate VII, figure 1.

Shell rather small, subquadrate. Width slightly greater than the length and greatest at the hinge. Ventral valve strongly convex. Ears small, depressed, triangular, arched. Sinus gentle, more or less obscure.

Dorsal valve similar to the ventral, except that the visceral area is flattened or gently concave.

Surface of ventral valve marked by moderately strong costæ, which are rather irregular, subangular, and separated by relatively wide rounded striæ. The visceral area is somewhat regularly, strongly, and finely wrinkled. A few small spines are scattered over the surface, but along the hinge line they are large and directed obliquely away from the beak. The sculpture of the dorsal valve is similar to that of the ventral, but the ribs are more rounded and the striæ more narrow and angular.

[a] Meek's comment really applies to the Nevada shell and not to typical *P. ivesi.* (King, Rept. U. S. Geol. Expl. 40th Par., vol. 4, 1877, p. 68.)

This form is related to other members of the *semireticulatus* group, being distinguished chiefly by the somewhat irregular, angular, widely spaced, and possibly evanescent ribs. Of the associated species, that identified as *P. mexicanus* is probably the most closely allied. The present form is larger, broader, with not only relatively but even absolutely finer costæ. As to *P. ivesi* there can be little question of identity. The form which I described from the Hermosa formation of Colorado as *P. hermosanus* is probably more closely similar than any of the American *Producti* known to me. *P. leei* is smaller and has a different distribution of the spines. I am not sure that the Manzano form should be regarded as more than a variety of the other, but with these differences, in conjunction with different stratigraphic position and faunal association, it seems hardly wise to regard them as the same species.

Horizon and locality.—San Andreas formation, Engle (stations 3740 and 3595), Caballos Mountains (station 3738), Nogal Creek (station 3744a?), and San Andreas (station 3742f?).

PRODUCTUS MEXICANUS Shumard?

Plate VII, figure 4.

1858. *Productus Mexicanus.* Shumard, St. Louis Acad. Sci., Trans., vol. 1, p. 291.
White [Permian] limestone: Guadalupe Mountains.

1859. *Productus Mexicanus.* Shumard, St. Louis Acad. Sci., Trans., vol. 1, p. 389.
White [Permian] limestone: Guadalupe Mountains.

?1877. *Productus Mexicanus?* White, U. S. Geog. Surv. W. 100 Mer., Rept., vol. 4, p. 120, pl. 8, figs. 6*a–c*.
Carboniferous: Camp Cottonwood, old Mormon road, Lincoln County, Nevada; near Salt Lake, New Mexico.

?1883. *Productus Mexicanus.* Kayser, Richthofen's China, vol. 4, p. 182, pl. 28, figs. 7a–b.
Upper Carboniferous: Lo-Ping, China.

?1902. *Productus Mexicanus.* Tschernyschew, Com. Geol. [St. Petersburg], Mem., vol. 16, No. 2, p. 264, pl. 52, fig. 10.
Schwagerina zone: Ural Mountains.

1908. *Productus mexicanus.* Girty, U. S. Geol. Surv., Prof. Paper No. 58, pp. 255–256.
Capitan limestone: Guadalupe Mountains, Texas.

P. mexicanus was not figured by its author, and we must almost perforce go back to White's figure of the species, which agrees fairly well with Shumard's description. At the same time, as typical *P. mexicanus* was found in the Guadalupe Mountains in a faunal relation widely different from that in which White's specimen occurred it seems rather probable that the latter is not really identical with the Guadalupian form. Nevertheless, about the only difference that can be pointed out between White's specimen and Shumard's description is that the latter indicates a larger size than is possessed by the former.

The form here under consideration appears to be very closely related to, if not identical with, White's *P. mexicanus*. It is, however, a little larger, in this respect agreeing more closely with the typical variety, and it is frequently more elongate.

From observations here and elsewhere I have been led to believe that *P. ivesi* may represent one extreme of a varied group of forms other extremes of which have been called *P. subhorridus*, *P. mexicanus*, and *P. leei*. *P. mexicanus* as here identified and as identified by White also may possibly be thought of as a small and narrow *P. ivesi*, in which the sculpture remains but little changed, the ribs, therefore, being relatively very large for the size. *P. subhorridus* can be derived from the same stock through a tendency of the costæ to become evanescent. Much variation is shown by all three species, and in given cases it is not easy to distinguish them satisfactorily.

This group of forms is abundant in the limestones at Cloudcroft, N. Mex., affording better opportunities for study than the collection in hand. One form hardly if at all to be distinguished from *P. subhorridus* occurs in great numbers. The ribs are obsolete or obsolescent, and spines are more or less abundant. A closely related form, connected with it by intermediate types, is the same species which I am here identifying as *P. mexicanus*. It has more distinct and more closely arranged costæ than *P. subhorridus*. A small variety of *P. mexicanus* is indistinguishable from *P. mexicanus* as identified by White. The specimen from Fort Wingate figured by White as *P. costatus* is intermediate between *P. subhorridus* and *P. mexicanus*. *P. costatus* of Marcou and *P. occidentalis* of Newberry also belong to this group.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751a); San Andreas formation, Nogal Creek (station 3744a) and San Andreas (station 3742f?).

PRODUCTUS CORA d'Orbigny.

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 Tarousa; 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. 4*a*, *b*; pl. 5, figs. 2*a–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.
[Carboniferous] sandstone above the Black shale: Elk River, Tennessee.

1852. *Productus semireticulatus.* Hall, Stansbury's Exped. Great Salt Lake, Rept., p. 411, pl. 3, figs. 3, 5*a*, *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, Rept., 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, Rept., 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, 4*a*.
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, Bennetts 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. 98*a*, *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, Kais. Akad. der Wissensch, Wien, Sitzb., vol. 59, 1. Abth., p. 441.
Carboniferous limestone: 10 miles from Cochabamba, Bolivia.

1872. *Productus Prattenianus.* Meek, U. S. Geol. Surv. Nebraska, Final Rept., p. 163, pl. 2, figs. 5*a–c;* pl. 5, fig. 13; pl. 8, figs. 10*a–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 prattenianus* (pars). White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 113, pl. 7, figs. 1*a–c*. (Entire volume published in 1877.)
Carboniferous: Near Santa Fe and Sandia 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 prattenianus.* White, U. S. Geol. Geog. Surv. Terr., Second Division; 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 Prattenianus.* 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, Thirteenth 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, Second Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 452; p. 440, figs. 1, 1a.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.

1886. *Productus Cora.* Heilprin, Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. 2, p. 268, figs. 1, 1*a*.
Upper Coal Measures, Mill Creek limestone: 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., Rept., 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, Kans.
1900. *Productus cora.* Herrick and Bendrat, Am. Geol., vol. 25, No. 4, p. 240.
Coal Measures: Sandia Mountains, N. Mex.
1903. *Productus cora.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 364, pl. 4.
Hermosa formation: San Juan region and Ouray, Colo.
Rico formation: San Juan region, Colo.
Weber and Maroon formations: Crested Butte and Leadville districts, Colo.

Only a few examples of this form have come to hand, all rather imperfect and badly worn. In general aspect they are like specimens of *P. cora* from the Mississippi Valley Pennsylvanian. One difference can be noted, namely, that while spines are not entirely absent they are decidedly less numerous on the forms from the Manzano group. Nor can this difference with much probability be ascribed to imperfect preservation. As to the presence of spines along the hinge, the Manzano specimens leave one in doubt.

Tschernyschew's figure of the type specimen of *P. cora* [a] makes it fairly clear that the Pennsylvanian species which has so often been called *P. prattenianus* in our literature is really the same as the South American form.

Horizon and locality.—Abo sandstone, Mesa del Yeso (station 3751), Abo Canyon (station 3757a), and Sandia Mountains (station 3798).

[a] Tschernyschew, Th., Mém. Comité géol. [Russia], vol. 16, No. 2, 1902, p. 622.

PRODUCTUS NEBRASKENSIS Owen.

Plate VII, figures 5 and 6.

1852. *Productus nebrascensis.* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, Rept., 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., Rept., 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 Kayserling.)
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. 7*a–b*.
Coal Measures: Lasalle and Springfield, Ill.

1872. *Productus Nebrascensis.* Meek, U. S. Geol. Surv. Nebraska, Final Rept., p. 165, pl. 2, fig. 2; pl. 4, fig. 6; pl. 5, figs. 11*a–c*.
Upper Coal Measures: Nebraska City, Wyoming, Bennett's Mill, Rock Bluff, Plattsmouth, Bellevue, and Omaha, Nebr.
Coal Measures: Illinois, Missouri, Iowa, Kansas, New Mexico.

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. 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, U. S. Geol. Geog. Surv. Terr., Second Division; 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 asperus.* Hall, New York State Geol., Rept. for 1882, pl. (19) 50, figs. 5–7.
Coal Measures: Lasalle, Ill.

1884. *Productus Nebrascensis.* White, Geol. Surv. Indiana, Thirteenth Rept., p. 122, pl. 24, figs. 7–9.
Coal Measures: Fountain, Vermilion, Parke, and Vigo counties, Ind.

1886. *Productus Nebrascensis?* Heilprin, Second Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 453, fig. 4*c;* p. 440, figs. 4–4b.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.

1886. *Productus Nebrascensis?* Heilprin, Wyoming Hist. and Geol. Soc., Proc. and Coll., 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, State Geol. [New York], Eleventh Ann. Rept., for 1891, pl. 22, fig. 7.
Coal Measures: La Salle, Ill.

1892. *Productus Nebrascensis.* Hall and Clarke, Geol. Surv. New York, Pal., vol. 8, pt. 1, pl. 19, figs. 5–7.
Coal Measures: La Salle, Ill.

1895. *Productus Nebrascensis.* Keyes, Missouri Geol. Surv., Rept., vol. 5, p. 48; pl. 37, figs. 3*a–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. 7–7*f.*
Upper Coal Measures: Kansas City, Turner, Eudora, Lawrence, Lecompton, Topeka, Manhattan, and Grand Summit, Kans.

1900. *Productus Nebrascensis.* Herrick and Bendrat, Am. Geol., vol. 25, no. 4, p. 241.
Coal Measures: Sandia Mountains, N. Mex.

1903. *Productus Nebrascensis.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 370, pl. 5, figs. 1, 2, 2*a.*
Hermosa formation: San Juan region and Ouray, Colo.
Rico formation: San Juan region, Colo.
Weber formation: Leadville district, Colo.

1904. *Productus Nebraskensis.* Girty, U. S. Geol. Surv., Prof. Paper No. 21, p. 53, pl. 11, figs. 7–9.
Pennsylvanian (Naco formation): Bisbee quadrangle, Ariz.

The fossils from the Manzano group included under this title are so exfoliated that the detailed sculpture can not be made out. In general configuration they resemble *P. nebraskensis,* and in other ways also appear to be rather closely related to that species. The outline of the ventral valve is subcircular, the ears very small and depressed. The cardinal line is shorter than the width in front; the body of the shell is rather strongly convex, narrow, elongate. The sinus is obscure. The surface is marked by elongated spine bases, which end more or less abruptly below with the development of the spine which gives rise to them. They tend to produce irregular, interrupted costæ. Obscure concentric striæ are present also, some fine and some coarse.

The dorsal valve resembles the ventral in outline. It is gently concave, nearly plane over the visceral region, more strongly curved upward about the margins. The ears are small, flattened, on a level with the edges. The surface is marked by concentric wrinkles, especially distinct near the hinge, and by radially elongated pits.

This form lacks the strong, regular, concentric corrugations which cross the surface of typical *P. nebraskensis*. I have seen no evidence of the second set of large spines, which in the latter project at right angles to the surface, though it seems to be true that in exfoliated specimens, even of typical *nebraskensis*, these spines are not easily seen.

At one time I thought to discriminate this form from *P. nebraskensis* as a distinct variety, but have withdrawn the name which was bestowed upon it. It is not certain that the characters in which the Manzano form seemed to differ are constant and real, though adequate if they prove to be so.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a), Mesa del Yeso (station 3751), and Sandia Mountains (station 3798); Yeso formation, Mesa del Yeso (station 3751a).

MARGINIFERA? MANZANICA n. sp.

Plate VII, figure 3.

Shell small, outline subquadrate, slightly transverse.

Ventral valve strongly convex, with a shallow, indistinct sinus, which marks the anterior half of the shell or a little more. Hinge line slightly longer than the greatest width in front. Ears small, depressed.

Surface marked by relatively coarse, somewhat irregular costæ, about 18 in number. A few not very distinct wrinkles cross the posterior portion, while a small number of relatively large spines spring from the costæ.

The dorsal valve is not known. A less typical specimen has this valve, gently concave over the visceral portion, strongly curved around the margin. The visceral area is marked by a number of rather fine, regular, indistinct, concentric wrinkles, beyond which, toward the margin, are coarse, not very strong, radial ribs.

This little form is probably a *Marginifera*, but the data at hand do not show clearly whether it is a member of that group or of *Productus*.

It is, with little question, distinct from our common Pennsylvanian Marginiferas. It is smaller than *M. wabashensis*, with coarser ribs and less pronounced sinus. It is smaller than *M. splendens*, with a different shape and fainter sinus. *M. haydeniana* is a similar form, though its shape is different and its ribs are finer. *M. ingrata* is perhaps more similar than any other species mentioned. It is, however, broader and has finer costæ. The type which White identified as *Productus mexicanus* is also like the form under consideration, though broader and with distinctly coarser ribs. Nevertheless, *Marginifera? manzanica* is possibly only a member of that series of

closely related species of *Productus* which includes also *P. ivesi*, *P. mexicanus*, and *P. subhorridus*.

Horizon and locality.—San Andreas formation, Fra Cristobal (station 3743) and San Andreas (station 3742f?).

MARGINIFERA? CRISTOBALENSIS n. sp.

Plate VII, figure 2.

In general appearance this form much resembles that described as *Marginifera? manzanica*, from which it is distinguished by being without radial costæ. The ventral valve is very small, highly convex, somewhat flattened along the mesial line, but without a distinct sinus. The width is only slightly in excess of the length, the hinge line being probably a little longer than the width at any anterior point. The ears are small, subquadrate, depressed. The surface is crossed by fine, indistinct wrinkles over the visceral region. The costæ seem to be altogether undeveloped. A number of rather small spines are distributed over the surface, springing directly from it without being mounted upon distinct bases.

This form differs from any of the American Marginiferas in its noncostate condition, and resembles, among the different species known to me, especially *Productus latidorsatus* and *P. subhorridus* var. *rugatulus* of the Guadalupian fauna, the latter more than the former. It is narrower and more globose than *P. subhorridus* var. *rugatulus*, with fainter sinus and less distinct wrinkles, besides being much smaller. I suspect that this also will prove to belong to that group of species of *Productus* of which *P. subhorridus* is a member.

Horizon and locality.—San Andreas formation, Fra Cristobal (station 3743) and San Andreas (station 3742f?).

PUGNAX OSAGENSIS var. PUSILLA n. var.

Plate VIII, figures 2 and 3.

We have this species from but one locality in the Manzano group, where, however, it appears to have been rather common. The eight specimens collected are uniformly of small size, nearly circular outline, and high convexity. The fold has three plications (in one instance four) and the sides three, one of them indistinct.

This form is closely related to the common *P. osagensis* (usually *P. utah*) of the Pennsylvanian fauna, and while differing in certain minor particulars from the common and typical form of *P. osagensis* it probably is indiscriminable from certain varieties which pass under that specific name. Because the specimens from the Manzano group so uniformly present this more or less individual expression and are associated with a fauna considerably different from the typical

Pennsylvanian, it seemed to me desirable to recognize them as a variety, though only provisionally, since further collections may show variations merging them with the typical form.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751b).

SQUAMULARIA PERPLEXA McChesney.

1855. *Spirifer lineatus.* Shumard, Missouri Geol. Surv., Rept., p. 216. (Not *Sp. lineatus* Martin.)
Coal Measures: [Missouri].

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 Spec. 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., Rept., 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. 6–6*d*.
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, Final Rept., 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. Surv. W. 100th Mer., Rept., vol. 3, Appendix, p. xii.
Coal Measures: Upper Mississippi River region.

1882. *Spirifer* (*Martinia*) *lineatus.* White, Geol. Surv. Indiana, Eleventh Rept., p. 372, pl. 42, figs. 4–6.
Coal Measures: Eugene, Ind.

1884. *Spirifer* (*Martinia*) *lineatus.* White, Geol. Surv. Indiana, Thirteenth 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, Second 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, Geol. Surv. New York, Pal., 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., Rept., 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, Geol. Surv. New York, Pal., 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. 1*a*.
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.
1900. *Martinia lineata.* Herrick and Bendrat, Am. Geol., vol. 25, No. 4, p. 240.
Coal Measures and Lower Carboniferous: New Mexico.
1903. *Squamularia perplexa.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 392, pl. 6, figs. 8, 8*a*, 9–9*b*, 10, 10*a*.
Hermosa formation: San Juan region and Ouray, Colo.
Weber formation: Crested Butte and Leadville districts, Colo.
Maroon formation: Crested Butte district, Colo.
Robinson limestone: Leadville district, Colo.

Of this species our collection from the Manzano group contains but two examples, one a small silicified ventral valve, the other an external mold in limestone, also of a ventral valve, which must when complete have been fully 25 mm. long. The former shows the surface characters very obscurely. The latter is characterized by fine, regular but obscure, transverse plications, which mark the position of closely arranged rows of very small spines. I am hardly prepared to state definitely that the Manzano form belongs to the Pennsylvanian species, though it would be difficult to discriminate them

under existing conditions. The larger specimen suggests by its size the Guadalupian form *Squamularia guadalupensis*, and from this species also a separation will at present be difficult.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751c); San Andreas formation, San Andreas (station 3742f).

Composita mexicana Hall.

Plate VIII, figure 1.

1857. *Terebratula mexicana.* Hall, Emory's Rept. U. S. and Mexican Boundary Surv., vol. 1, pl. 20, fig. 2.
[Carboniferous: Texas?]

1908. *Composita mexicana.* Girty, U. S. Geol. Surv., Prof. Paper No. 58, pp. 389–390.
Delaware Mountain formation: Comanche canyon, Glass Mts., Texas.

The genus *Composita* is more or less abundant in several of our collections from the Manzano group, and the dominant form, there can be no question, is the same to which Hall gave the name *Terebratula mexicana.* It is characterized by its small size, rather transverse shape, and strongly developed fold and sinus. The bending downward of the sides near the fold tends to give the outline a pentagonal shape. These characters are, however, by no means constant. Occasionally the shape is narrow, instead of transverse, or the size somewhat larger than in the small typical variety. More often the fold and sinus are not as well developed as in the latter, sometimes scarcely developed at all.

I do not know whether precisely this variety occurs in the Mississippi Valley, but if so there is little doubt that it would in that region be called *Composita subtilita* (or *argentea*). It probably is not common there, at all events, and, on the other hand, some of the distinguishable Pennsylvanian varieties of *Composita subtilita* are not known from the Manzano. While availing myself of the specific designation introduced by Hall, I may state that there appears to be no well-marked boundary between *C. mexicana* and *C. subtilita.*

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751b); San Andreas formation, San Andreas (station 3742f).

Composita subtilita Hall?

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, Rept., pl. 5, fig. 9.
Carboniferous limestone: Near Council Bluffs.

1852. *Terebratula subtilita.* Hall, Stansbury's Exped. Great Salt Lake, Rept., p. 409, pl. 2, figs. 1*a*, *b*, 2*a*, *b*.
Carboniferous: Missouri River, near Weston.

?1853. *Terebratula subtilita.* Shumard, Marcy's Expl. Red River of Louisiana, Rept., 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, 8*b*.
Mountain limestone: Tigeras, N. Mex.; Ohio; Indiana; Illinois; Kentucky; Arkansas.

1858. *Terebratula roysii.* Marcou, Geol. North America, p. 51, pl. 6, figs. 10, 10*b*.
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. 9–9*f*.
Mountain limestone: Sierra Madre; Sierra de Mogollon; Great Salt Lake; Tigeras and Pecos Village, N. Mex.; summit of Sierra de Sandia and Sierra de Mogollon; 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, Rept., 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. *Terebratula? 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., Rept., 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, Kais. Akad. der Wissensch. Wien, Sitzb. vol. 59, 1. Abth., p. 438, pl. 1, fig. 5.
Carboniferous limestone: 10 miles from Cochebamba, Bolivia.

1872. *Athyris subtilita.* Meek, U. S. Geol. Surv. Nebraska, Final Rept., p. 180, pl. 1, fig. 12; pl. 5, fig. 8; pl. 8, fig. 4.
Upper Coal Measures: Nebraska City, Bennett's Mill, Wyoming City, 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 Paredão, Brazil.

1875. *Spirigera subtilita.* White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 141, pl. 10, figs. 6*a–c*. (Whole volume published in 1877.)
Carboniferous: Carizo Creek, Maricopa County; Camp Apache; Tenney's Ranch; Kaibab Plateau; confluence of White Mountains 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, U. S. Geol. Geog. Surv. Terr., Second Division; 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, Rept., p. 350, pl. 2, figs. 4a, b.
Yellow limestone, Coal Measures: Humboldt Mountains.

1876. *Athyris subtilita.* Newberry, Macomb's U. S. Expl. Exped. Santa Fe to Grand and Green rivers, Rept., 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, 2*a*.
Carboniferous: Katlahwoke, Rocky Mountains.

1877. *Athyris subtilita.* Meek, U. S. Geol. Expl. 40th Par., Rept., vol. 4, p. 83, pl. 8, figs. 6, 6*a*.
Carboniferous limestone: Ruby group; Moleen Peak, near Humboldt River, Nevada.

1884. *Athyris subtilita.* White, Geol. Surv. Indiana, Thirteenth 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 (16*a–c*?).
Coal Measures: Flint Ridge, Ohio.

1887. *Athyris subtilita.* De Koninck, Musée Royal d'Histoire Naturelle de Belgique, Ann., 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, Geol. Surv. New York, Pal., 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.

1895. *Seminula subtilita.* Hall and Clarke, State Geologist [New York], Fourteenth Ann. Rept., for 1894, pl. 35, figs. 16–19.
Coal Measures: Chariton County, Mo.; Winterset, Iowa; near Kansas City, Mo.

1895. *Athyris argentea.* Keyes, Missouri Geol. Surv., Rept., vol. 5, p. 92, pl. 39, figs. 11*a–d.* (Date of imprint 1894.)
Coal Measures: Kansas City, Lexington, and Clinton, Mo.

1895. *Seminula subtilita.* Hall and Clarke, Geol. Surv. New York, Pal., 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, 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.

1900. *Seminula argentea.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 105, text-fig. 3*c*.
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.

1900. *Athyris argentea* (*subtilita*). Herrick and Bendrat, Am. Geol., vol. 25, No. 4, p. 240.
Coal Measures: Sandia Mountains, N. Mex.

1902. *Seminula argentia.* Beede, Kansas Univ. Sci. Bull., vol. 1; pp. 155–157, pl. 6.

1903. *Seminula subtilita.* Girty, U. S. Geol. Surv.; Prof. Paper No. 16, p. 403, pl. 7, figs. 1–1*b*, 2, 2*a*, 3, 3*a*, 4–7, 7*a*, 8–10.
Molas formation: San Juan region, Colorado.
Hermosa formation: San Juan region and Ouray, Colo.
Rico formation: San Juan region, Colorado.
Maroon formation: Crested Butte district, Colo.
Robinson limestone: Leadville district, Colo.
Carboniferous: Glenwood Springs, Colo.

1904. *Seminula subtilita.* Girty, U. S. Geol. Surv., Prof. Paper No. 21, p. 53, pl. 11, figs. 15, 16.
Pennsylvanian (Naco limestone): Bisbee quadrangle, Arizona.

Associated in some cases with typical *C. mexicana* are a number of examples which have a fold and sinus less strongly or even very faintly developed. Some of these are small and may perhaps correctly be regarded as immature examples of that species. In other cases the size is rather large and no such interpretation can be given them. They must either be mature examples of a species somewhat

different from *C. mexicana* or young ones of a much larger species. While no well-defined limits can be given to either one form or the other, it seems expedient to assemble them under two different groups. The present group has been placed under *C. subtilita*, and would unquestionably be so called if found in the Mississippi Valley. While it clearly does not represent the typical variety, I do not feel justified in attempting, especially from the Manzano material, to establish any new subdivision.

Horizon and locality.—Yeso formation, Mesa del Yeso (stations 3751b and 3751c); San Andreas formation, Fra Cristobal (station 3743); Abo sandstone, Abo Canyon (station 3757a).

PELECYPODA.

SOLENOMYA? NÆNIA Walcott.

1884. *Sanguinolites? nænia.* Walcott, U. S. Geol. Surv., Mon. 8, p. 249, pl. 19, fig. 9. Lower Carboniferous: Eureka district, Nevada.

A single small specimen strongly resembling the form from the Eureka district, but only one-fourth as large. No better identification can at present be suggested. It is rather more probable that this form is a *Solenomya* than a *Sanguinolites*, in which genus Walcott provisionally placed it.

Horizon and locality.—San Andreas formation, Fra Cristobal (station 3743).

CLINOPISTHA? sp.

Plate X, figure 5.

This form is represented in our collection by three specimens, none of them in very good condition. They suggest at first sight *C. radiata* var. *lævis*, and even a comparison of specimens shows few, and possibly not important or constant, differences. Such as have been noted are the more slender shape of the Manzano form, its less prominent anterior extremity, and the more contracted outline of the posterior extremity, which has less of a quadrate shape by reason of the lower margin's bending upward more gradually. Until more complete data are available about the Manzano form it seems inadvisable either to identify it with *C. radiata* var. *lævis* or to describe it as new. In fact, sufficient is not yet known to determine whether it belongs to Meek and Worthen's singular genus or not. The general shape is suggestive of a *Nucula*, but so far as determined the hinge appears to be edentulous, in which of course it agrees with *Clinopistha*.

Horizon and locality.—San Andreas formation, Mesa del Yeso (station 3751d) and Fra Cristobal (station 3743).

EDMONDIA GIBBOSA McCoy.

1844. *Astarte gibbosa.* McCoy, Syn. Carb. Foss. Ireland, p. 55, pl. 8, fig. 11.
Carboniferous: Ireland.
1866. *Astarte gibbosa.* Geinitz, Carb. und Dyas in Nebraska, p. 16, Tab. 1, figs. 23, 24.
Carboniferous: Plattsmouth, Nebr.
1903. *Edmondia gibbosa.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 447, pl. 9, figs. 7, 8, 9.
Rico formation: San Juan region, Col.
Cisco group: Graham Young Co., Tex.

The fossils from the Manzano group are unfortunately imperfectly preserved, but they appear to agree very closely with the form from Kansas which Geinitz identified as *Astarte gibbosa* McCoy. In 1903 I identified with this same species a form from the Rico formation of Colorado which also appears closely allied to that under consideration. At that time I cited the name as *Edmondia gibbosa* Geinitz non *Astarte gibbosa* McCoy, which would unquestionably be the proper form if McCoy's original species were an *Astarte,* or any other genus than an *Edmondia,* to which the American form with little question belongs. But if one may judge by his figures McCoy's *Astarte gibbosa* is also an *Edmondia* and a form very similar to that from the Mississippi Valley which Geinitz identified with it. It seems probable that were good specimens of both brought into comparison distinguishing characters would be discovered, but I do not find it practicable on the strength of the poor fossils which have come under my observation to attempt to discriminate between them.

The form from the Manzano group has a subcircular or slightly transverse shape, with high convexity, rather gibbous, strongly down-curved umbones, and projecting anterior portion. The surface is marked by rather regular lamellose concentric ridges, which are more closely arranged in some specimens than in others.

This is not to be confused with the species described by Swallow and bearing the same name, *Edmondia gibbosa.* The latter is presumably a different form, and if it proves to be an *Edmondia* will have to receive another name.

Horizon and locality.—Abo sandstone, Sandia Mountains (station 3798), Abo Canyon (station 3757a), and Mesa del Yeso (station 3751); Yeso formation, Blackinton's ranch (station 3750?).

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, Final Rept., 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., Rept., 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, Kan.

1903. *Chænomya leavenworthensis.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 436.
Hermosa formation: San Juan region and Sinbads Valley, Colo.

This type is represented in our collection by two specimens, both of them in a rather unsatisfactory state of preservation. In their present obscured condition I am unable to discriminate them from the species cited above, and even more perfect specimens could hardly do more than show that they are very closely allied to it.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a) and Mesa del Yeso (station 3751).

NUCULA LEVATIFORMIS Walcott.

Plate X, figures 7 and 8.

1884. *Nucula levatiforme.* Walcott, U. S. Geol. Surv., Mon. 8, p. 241, pl. 22, figs. 1, 1a.
Lower Carboniferous: Eureka district, Nevada.

Shell small, seldom attaining a width of more than 7 mm. Shape subtriangular, width not greatly in excess of the height. Superior outline rounded. Inferior outline more strongly curved than the superior and converging with it toward the front. Anterior outline narrowly rounded. Posterior outline subrectilinear, nearly perpendicular to that above and meeting it in somewhat of an angle defined by the umbones; sometimes joining the lower outline more or less abruptly. Convexity high. Posterior end of shell beneath the beaks rather abruptly deflected or flattened. Surface marked by very fine, regular, concentric striæ.

There are about 6 posterior teeth and 10 anterior ones, the 3 or 4 nearest the beak being rather small and obscure.

I feel little doubt that this species is the same as Walcott's *N. levatiformis.* It also resembles *N. parva,* differing in having the superior outline convex, instead of straight or concave, so that it is somewhat broader behind.

Horizon and locality.—Yeso formation, Alamillo (station 3751e) and San Andreas (station 3742d); San Andreas formation, Fra Cristobal (station 3743) and Engle (station 3595).

USGS B 887 p. 75, pl. 10,
Figs. 3-7

average of type specimens.

NUCULA LEVATIFORMIS var. OBLIQUA n. var.

Plate X, figure 9.

At station 3743b occurs what appears from present indications to be a distinct variety of the Nevada species to which the other fossils have been referred. This form is distinguished by being much smaller and somewhat more oblique, so that the cardinal and anterior margins meet at an acute angle, whereas in typical *N. levatiformis* the angle is usually almost a right angle. All of the specimens agree in possessing this peculiarity, a fact which seems to warrant a partial separation from the typical form.

Horizon and locality.—Yeso formation, Fra Cristobal (station 3743b).

MANZANELLA n. gen.

Shell small, transverse, elliptical, wider at the anterior end. Umbones rather large, subcentral, distinctly turned toward the longer side. The thickened hinge posterior to the umbones bears a small number of taxodont teeth similar to those of *Nucula*. Anterior to the umbones there are developed two rather short, slightly diverging teeth which form an abrupt columnar thickening of the cardinal margin. In the right valve the lower of these two teeth is much larger and more prominent than the other. In the left valve the upper is the larger. A large muscle scar seems to be situated at the anterior end of the shell at the foot of the columnar thickening which supports the two anterior teeth. The character of the pallial line has not been determined.

The orientation of this shell can not be positively made. On a number of specimens there are indications, often very indistinct it is true, of a ligamental area just above the row of taxodont teeth. The beaks would therefore be normal in pointing toward the anterior end, but the present type would traverse the common run of pelecypod shells in having the anterior end longer than the posterior. This orientation is here adopted.

The relationship of *Manzanella* to other genera is a matter of much uncertainty, and I anticipate that it will ultimately prove advisable to make it the type of a new family. In its taxodont dentition, at least upon one side, and the fact that it is produced upon the anterior rather than the posterior end, this genus strongly suggests the Nuculidæ, but the pair of stout anterior teeth is of course quite alien to the typical Nuculoid dentition. The absence of a chondrophore and the fact that the anterior extremity is broad instead of contracting are also minor points of difference.

MANZANELLA ELLIPTICA n. sp.

Plate X, figures 3 and 4.

Shell small, transversely elliptical, slightly wider at the anterior end, otherwise nearly bilateral. The shape, which is in other respects rather regularly elliptical as outlined by the aperture, is interrupted by the umbo, which is large, strongly projecting, and distinctly turned toward the larger end of the shell. Although one end is clearly longer than the other, the beak is subcentral. The convexity is rather high.

The surface is nearly smooth, marked only by somewhat irregular concentric striæ and by occasional inequalities of growth. In a few instances traces of regular, closely arranged concentric striæ have been noted.

Upon the interior the hinge posterior to the beak is thickened and bears about four arched denticles (and four sockets), similar to those in *Nucula*. In front of the beak also the hinge is thickened and supports a rather small, longitudinal, platelike, anterior tooth. Springing from the bottom of the valve, though for some distance consolidated with its cardinal margin, a second anterior tooth is developed. It is very stout, and diverges somewhat with the other, so that a large socket is left between. In the other (left) valve the dentition is of course the complement of this. The upper of the two anterior teeth is in this case larger and more strongly projecting.

Horizon and locality.—Yeso formation, Alamillo (station 3751e).

LEDA OBESA White.

1879. *Nuculana obesa.* White, U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, p. 216.
Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south of Pipe Spring.

1880. *Nuculana obesa.* White, U. S. Geol. Surv., F. V. Hayden in charge, Cont. to Pal. Nos. 2–8, p. 136, pl. 34, figs. 2*a–c*.
Upper Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south from Pipe Spring.

1883. *Nuculana obesa.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 136, pl. 34, figs. 2*a–c*.
Upper Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south from Pipe Spring.

Although rather unsatisfactorily preserved, there is not much question but that the Manzano form belongs to White's species. One specimen retains part of the thick shell, thus showing the sculpture, which consists of delicate raised lines separated by flattened interspaces of much greater width. They are apt to be wavy, and they do not always follow the growth lines, running in some cases

oblique to them. The fossils in the present collection are all somewhat smaller than those upon which the species was founded.

Horizon and locality.—Yeso formation, Mesa del Yeso (stations 3751a and 3751c); Abo sandstone, Abo Canyon (station 3757a).

PARALLELODON aff. OBSOLETUS Meek.

Of this form but a single example has come to hand, preserved as an internal mold. It is of small size, about 18 mm. in width, and the posterior portion is marked by rather coarse radial ribs. The exact identification is at present hardly possible.

Horizon and locality.—Yeso formation, San Andreas (station 3742b).

AVICULIPINNA? PERACUTA Shumard.

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, Final Rept., p. 198, pl. 6, figs. 11*a*, *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. Surv. W. 100th Mer., Rept., vol. 4, p. 151, pl. 11, fig. 5*a*. (Whole volume published in 1877.)
Carboniferous: Near Relief Spring, Ariz.

1884. *Pinna peracuta.* White, Geol. Surv. Indiana, Thirteenth Rept., p. 145, pl. 28, figs. 1, 2.
Upper, Middle, and Lower Coal Measures: Indiana.

1886. *Pinna peracuta.* Heilprin, Wyoming Hist. and Geol. Soc., Proc. and Coll., vol. 2, pt. 2, p. 272, fig. 12; p. 273, fig. 12*a*.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.

1886. *Pinna peracuta.* Heilprin, Second Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 455; p. 444, fig. 12; p. 454, fig. 12*a*.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.

1892. *Aviculopinna peracuta.* Hyatt, Boston Soc. Nat. Hist., Proc., vol. 25, p. 338.
Coal Measures: Kidder, Mo.; La Salle, Ill.

1895. *Pinna peracuta.* Keyes, Missouri Geol. Surv., Rept., vol. 5, p. 116, pl. 45, figs. 2*a*, *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, Ind. Ter.

1900. *Pinna peracuta.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 144, pl. 17, figs. 3, 3*b*.
Upper Coal Measures: Kansas City, Lawrence, Topeka, Kans.

1903. *Aviculopinna? peracuta.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 432, pl. 9, figs. 1, 2.
Hermosa formation: San Juan region, Colo.
Weber formation: Leadville district, Colo.

This form as it occurs in the Manzano group is represented primarily by a single specimen, which is distinguished by its very slender proportions and subparallel upper and lower margins. This fragmentary specimen has a length of 155 mm. The height at the small end is 33 mm. and at the larger one about 45 mm. The rate of expansion is perhaps a little more gradual than in the specimen of *Aviculopinna peracuta* figured by Meek. It is preserved as an internal mold, and while at present there are no characters which satisfactorily distinguish it from the Pennsylvanian species, possibly when more complete data can be obtained it will prove not to be the same.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a), Mesa del Yeso (station 3751?), and Sandia Mountains (station 3798.?)

AVICULIPINNA NEBRASKENSIS Beede.

1901. *Aviculopinna nebraskensis.* Beede, Kansas Acad. Sci., Trans., vol. 17, p. 186, pl. 13, figs. 1–1*d*.
Permian: Gage County, Nebraska.
1903. *Aviculopinna nebraskensis.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 435, pl. 9, figs. 1, 2.
Rico formation: San Juan region, Colorado.

The fossils referred to this species vary much in size, the largest fragment having a height at the larger end of 50 mm. They are at once distinguished from the form referred to *A. peracuta* in being broader and in tapering more rapidly. So far as can be told this is the same species which occurs in the Rico formation and to which I there gave the same identification. It is true, however, that the present specimens leave many points in obscurity. The apical angle is about the same as in *A. nebraskensis*, but owing to exfoliation the sculpture and the posterior outline can often not be determined. In one or two instances the sculpture consists of regularly spaced lamellose lines having the character and direction shown by the Colorado specimens. Usually, however, though perhaps owing to preservation, they do not appear to be lamellose and are more or less obscure. Although attaining a size larger than heretofore known for the species, I can hardly do otherwise than identify the Manzano specimens with *Aviculipinna nebraskensis.*

Horizon and locality.—San Andreas formation, Caballos Mountains (stations 3738 and 3738a) and Elephant Butte (station 3600); Abo sandstone, Abo Canyon (station 3757a) and Sandia Mountains (station 3798?); Yeso formation, San Andreas (station 3742e).

MONOPTERIA MARIAN White.

1874. *Monopteria Marian.* White, U. S. Geog. Surv. W. 100th Mer.; Prel. Rept. Inv. Foss., p. 22.
Carboniferous (Coal Measures): Camp Apache, Arizona.

1877. *Monopteria Marian.* White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 151, pl. 11, figs. 4*a–c*.
Carboniferous: Camp Apache, Maricopa County, Arizona.
1900. *Limopteria Marian.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 128, pl. 16, figs. 5–5*c*.
Upper Coal Measures: Turner, Topeka, Kans.

This species is represented in our Manzano collection by fragments merely, but there can be little doubt, in view of their angular and greatly prolonged posterior extension, that they belong to the species cited above. This feature is indicated as even more pronounced than represented in White's figure.

Horizon and locality.—Abo sandstone, Sandia Mountains (station 3796) and Abo Canyon (station 3757a).

PTERIA sp.

Our collection contains two specimens of this little form, too imperfect to permit of the determination of their specific relationship with any degree of certainty. They seem to resemble *P. ohioensis* more closely than any other species of *Pteria* found in our American Carboniferous rocks, but I would hesitate to identify them definitely with that species.

They closely resemble also *Bakewellia? parva.* It is true that the serially repeated resilium characteristic of *Bakewellia* can not be seen on these specimens, but that character is absent, so far as I have been able to observe, in the Pennsylvanian species also, so that the present form may prove to be identical, not only generically but also specifically, with *B. parva.*

Horizon and locality.—Yeso formation, Alamillo (station 3751e).

PSEUDOMONOTIS HAWNI Meek and Hayden?

PLATE IX, figure 4.

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, Thirteenth Rept., p. 142, pl. 30, fig. 10.
Upper Coal Measures: Indiana.
1886. *Eumicrotis Hawni.* Heilprin, Second 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.; Clements, 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.
1903. *Pseudomonotis hawni.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 427.
Hermosa and Rico formations: San Juan region, Colorado.

A few specimens, some of them found associated with *P. sublævis*, are distinguished by having the sculpture much more strongly developed.

These shells seem to be very similar to *P. hawni*, but it is doubtful whether they should be referred to that species or should be regarded merely as young examples of *P. sublævis*, in which the striation, always more pronounced at that stage than later, is more sharply developed than common.

Horizon and locality.—San Andreas formation, Engle (station 3740); Yeso formation, San Andreas (station 3742b); Abo sandstone, Abo Canyon (station 3757a).

PSEUDOMONOTIS SUBLÆVIS n. sp.

Plate IX, figures 1–3.

Shell large. Shape subovate, rather irregular. Hinge shorter than the width below, ears small.

Surface of the left valve with obsolescent sculpture. In the umbonal region it is marked by fine, irregular, more or less wavy costæ, a few of which, arranged at rather regular intervals, are somewhat larger than the others. In the course of growth the smaller costæ as a rule soon die out, while a few of the larger ones, from 1 to 12 or more in number, much increased in size, pass on to the ventral border. More rarely some of the smaller costæ are persistent. The whole surface is also crossed by closely arranged, irregular, concentric, lamellose lines and wrinkles.

This species is related to *P. hawni*, but is distinguished by its obsolescent sculpture and by the rarity or absence of spinelike scales springing from the larger costæ. These could hardly fail to be preserved upon our specimens if originally present, and they were apparently developed very rarely, perhaps not at all.

Horizon and locality.—Yeso formation, San Andreas (stations 3742b, 3742c, and 3742d); San Andreas formation, Engle (station 3740?).

MYALINA APACHESI Marcou.

Plate IX, figures 6 and 7.

1858. *Myalina apachesi.* Marcou, Geol. North America, p. 44, pl. 7, figs. 6, 6*a*.
Mountain limestone: Near Pecos Village, New Mexico.

As identified in the present collection this species has an elongate triangular shape, with rather short hinge line. The anterior outline, marking the edge of the umbonal ridge, makes an angle of about 45° with the hinge, while the posterior outline makes an angle of from 60° to possibly almost 90° with the same margin. The anterior and posterior outlines thus gradually approach each other below, where they round together in a regular curve. The umbonal ridge is very high in front, projecting in a long down-curved beak. It spreads out and flattens down toward the inferior border. The anterior-superior margin of the shell bends downward and inward below the umbonal ridge, which in this portion forms the outline of the shell when viewed from above. A distinct sinus occurs in this deflected portion, but it is scarcely visible except when the shell is looked at from the anterior side, instead of from above. The surface is marked by regularly disposed, deeply imbricating lamellæ, the development of which produces concentric striæ or corrugations, a very noticeable character even on internal molds. The largest specimen referred to this species is of large size. It is imperfect, but must have measured about 100 mm. along the umbonal ridge.

It is not quite certain that the Manzano form is the same as that which Marcou gave the name *Myalina apachesi*, for his specimens seem to have been imperfect and his illustrations poor. They show the same strongly elevated umbonal ridge and deflected anterior margin which is a striking feature of the form under consideration; and Marcou's description seems to refer to the presence upon his specimens of the concentric striæ due to the development of lamellæ, which is also a character of the Manzano species. *Myalina apachesi* was described from near Pecos village, N. Mex., and there is good reason for believing that the Manzano group outcrops near the railroad station called Pecos, in the Pecos Valley, in the immediate vicinity of which it is presumed Marcou found his specimens. On the other hand, Marcou recognized the present form as Carboniferous, whereas he everywhere refers the "Red Beds" to the Trias. Inferentially, therefore, he did not obtain his fossils in place, or they came from the underlying Magdalena group, or the Manzano had lost its characteristic "Red Beds" aspect. On the other hand, Marcou says that *M. apachesi* is associated with *Productus semireticulatus* and *Spirifer striatus*. *P. semireticulatus* of Marcou's report I believe to be *P. ivesi*, while *Spirifer striatus* has since become *S. marcoui*. Neither *S. marcoui* nor *P. ivesi* is known from the Magdalena group. *P. ivesi*

is a rather characteristic fossil of the Manzano, and *S. marcoui*, while at present not known from the Manzano, occurs in the Hueco formation, with which the Manzano is believed to be in correlation. The Magdalena group, however, furnishes a small *Myalina* very similar and perhaps identical with the form under consideration.

Of the figured specimens the larger retains evidence of a fairly well-developed anterior lobe, in this case partly broken away, and a similar structure has been restored on the smaller specimen also, which is likewise broken. This lobe is usually present, but in various degrees of development, while in the larger examples especially it is often largely obscured, when the specimen is viewed from above, by the retraction of the anterior-superior margin and the overhanging of the umbonal ridge. Where the lobe is well developed and obvious this form looks less like *M. apachesi* and more like the type from the Rico formation of Colorado which I identified as *M. wyomingensis*. In the latter the anterior margin is more spread out, not vertical or retracted, but they may prove to belong to the same species.

Myalina apachesi as here identified appears to be closely similar to *Myalina kansasensis* of the Mississippi Valley Pennsylvanian. There is perhaps a certain amount of difference in the configuration, especially of the umbonal region, and the present form, so far as observed, is entirely without the frilled condition into which the lamellæ of the Kansas species usually develop.

Typical *Myalina apachesi* is very closely related to the form which Walcott subsequently described from the Eureka district, Nevada, as *Myalina congeneris*. The associated faunas are similar and it is very probable that the Nevada species will prove to be a synonym of that described by Marcou.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751c) and San Andreas (station 3742b); San Andreas formation, Mesa del Yeso (station 3751d) and Elephant Butte (station 3600); Abo sandstone, Abo Canyon (station 3757a), Sandia Mountains (station 3798), and Mesa del Yeso (station 3751).

SCHIZODUS WHEELERI Swallow?

Plate X, figure 6.

1858. *Schizodus obscurus.* Swallow, St. Louis Acad. Sci., Trans., vol. 1, p. 193. (Not *Axinus obscurus* Sowerby, 1823.)
Lower Permian: Kansas.

1863. *Cypricardia (?) Wheeleri.* Swallow, St. Louis Acad. Sci., Trans., vol. 2, p. 96.
Upper Coal Measures: Caldwell County, Missouri.

1866. *Schizodus obscurus.* Geinitz, Carb. und Dyas in Nebraska, p. 20, tab. 1, figs. 30, 31.
Nebraska City, Nebr.

1872. *Schizodus Wheeleri* (pars). Meek, U. S. Geol. Surv. Nebraska, Final Rept., p. 209, pl. 10, figs. 1*a–d*.
Upper Coal Measures: Caldwell County, Mo.; Nebraska City, Nebr.; Adams and Union counties, Iowa.
Coal Measures: Illinois.

1876. *Schizodus Wheeleri.* White, U. S. Geol. Geog. Surv. Terr., Second Division; Powell's Rept. Geol. Uinta Mts., p. 91.
Lower Aubrey group: Confluence of Grand and Green rivers, Utah.
1877. *Schizodus Wheeleri.* White, U. S. Geog. Surv. W. 100th Merid., Rept., vol. 4, p. 154, pl. 11, figs. 6*a*, *b*.
Carboniferous: Near Bear Spring, Camp Wingate, N. Mex.
1884. *Schizodus Wheeleri.* White, Thirteenth Rept. Geol. Surv. Indiana, p. 147, pl. 30, figs. 3–5.
Coal Measures: Indiana (?).
1886. *Schizodus Wheeleri.* Heilprin, Second Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 456, p. 442, fig. 7.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.
1886. *Schizodus Wheeleri.* Heilprin, Wyoming Hist. and Geol. Soc., Proc. and Coll., vol. 2, pt. 2, p. 275; p. 270, fig. 7; p. 274, fig. 7*a*.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.
1887. *Schizodus wheeleri.* Herrick, Bull. Sci. Lab. Denison Univ., vol. 2, p. 42, pl. 3, fig. 15.
Coal Measures: Flint Ridge, Ohio.
1895. *Schizodus wheeleri.* Keyes (pars), Missouri Geol. Surv., Rept., vol. 5, p. 123, pl. 46, fig. 3*c*. (Date of imprint, 1894.)
Upper Coal Measures: Kansas City, Mo.
1896. *Schizodus wheeleri.* Smith, Stanford Univ. Pub., Cont. Biol. IX, p. 36, pl. 22, fig. 4.
Lower Coal Measures: Conway County, Ark.
1897. *Schizodus wheeleri.* Smith, American Phil. Soc., Proc., vol. 35, p. 36, pl. 22, fig. 4.
Lower Coal Measures: Conway County, Ark.
1900. *Schizodus Wheeleri.* Beede, Univ. Geol. Surv. Kansas, Rept., vol. 6, p. 155, pl. 22, figs. 1–1*c*.
Upper Coal Measures: Kansas City, Mo.

Shells belonging to the genus *Schizodus* are rather plentiful in the Manzano beds, but they occur so exfoliated and generally imperfect that it has proved impossible to make a special study of them. It is seldom that the true outline or configuration can be more than estimated. Several varieties can be discriminated, one of which is found at station 3742, and appears to be closely related to *S. wheeleri* Swallow; not the form which Meek identified with that species and to which I gave a distinctive name, but the typical one. Material from other points shows the same general character and appears to belong to the same species. One apparent difference is that the Manzano form has a very indistinct umbonal ridge, while that of typical *S. wheeleri* is subangular, but this condition is in part due to the fact that the former are internal molds and show the umbonal ridge less prominently than testiferous examples. The shells from station 3742, together with others referred to the same species, present a certain variation in the proportion of length and breadth, such that while the transverse forms resemble *S. wheeleri* the less extended ones suggest *S. affinis* Herrick and also *S. curtiformis* of the Eureka district, Nevada. Some specimens referred to *S. wheeleri* attain a very considerable size.

Where the surface of these shells is preserved it is seen to be marked by regularly disposed concentric raised lines, about nine in 5 mm. This seems to be a feature not found in typical *S. wheeleri*.

White has identified *S. wheeleri* from Fort Wingate, N. Mex., and his form is probably the same species as that here receiving the same reference.

Horizon and locality.—Yeso formation, San Andreas (stations 3742b?, 3742c, 3742d, and 3742e), Fra Cristobal (stations 3743a and 3743b), Alamillo (station 3751e), Mesa del Yeso (station 3751c), Carthage (station 3747a?), and Blackinton's ranch (station 3750); San Andreas formation, Elephant Butte (station 3741), Engle (stations 3595? and 3740), Caballos Mountains (station 3738a?), Nogal Creek (station 3744), San Andreas (station 3742), and Carthage (stations 3746? and 3746a?); Abo sandstone, Abo Canyon (station 3757a) and Sandia Mountains (stations 3796? and 3797).

SCHIZODUS aff. MAGNUS Drake.

What appears to be a second species of *Schizodus* is represented by a few specimens whose most striking characteristic is an elevated and very angular umbonal ridge. They are in addition considerably elongated posteriorly and abruptly truncated, and their size is considerable, though not notably larger than some of the shells referred to *S. wheeleri*. They strongly suggest the form which Drake described as *S. magnus*, except that the beak is not so nearly central and the anterior extremity in consequence is smaller. Even, however, if this proves a constant difference I feel that my Manzano material is almost too imperfect to justify describing it as new.

Horizon and locality.—San Andreas formation, Mesa del Yeso (station 3751d); Yeso formation, Mesa del Yeso (station 3751c).

DELTOPECTEN OCCIDENTALIS Shumard.

1855. *Pecten occidentalis.* Shumard, Missouri Geol. Surv., Rept., 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., Rept., 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, 5*a*.
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, Final Rept., 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, U. S. Geol. Geog. Surv. Terr., Second Division; Powell's Rept. Geol. Uinta Mountains, p. 90.
Lower Aubrey group: 2 miles above Belleview, Utah.

1877. *Aviculopecten occidentalis.* White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 146, pl. 12, figs. 8*a*, *b*.
Carboniferous: Camp Apache, Ariz.

1884. *Aviculopecten occidentalis.* White, Geol. Surv. Indiana, Thirteenth Rept., p. 143, pl. 28, fig. 2.
Coal Measures: Pike and Gibson counties, Ind.

1886. *Aviculopecten occidentalis.* Heilprin, Second Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 455, fig. 5*a;* p. 442, fig. 5.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.

1886. *Aviculopecten occidentalis.* Heilprin, Wyoming Hist. and Geol. Soc., Proc. and Coll., vol. 2, pt. 2, p. 270, fig. 5; p. 271, fig. 5*a*.
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.

1895. *Aviculopecten occidentalis.* Keyes, Missouri Geol. Surv., Rept., vol. 5, p. 110, pl. 42, fig. 3. (Date of imprint 1894.)
Upper Coal Measures: Plattsburg and Kansas City, Mo.

1896. *Aviculopecten occidentalis.* Smith, Stanford Univ. Pub., Cont. Biol. IX, p. 34.
Lower Coal Measures: Conway County and elsewhere, Arkansas.

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. *Aviculopectin occidentalis.* Knight, Univ. Wyoming, Wyoming Exp. Sta., Bull. No. 45, pl. 3, fig. 3.

1902. *Aviculopecten occidentalis.* Beede, Okla. Geol. Surv., Adv. Bull., First Bien. Rept., p. 9.
Red Beds: Whitehorse Springs, Okla.

1903. *Aviculopecten occidentalis.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 414, pl. 8, fig. 1.
Hermosa and Rico formations: San Juan region, Colo.
Maroon formation: Crested Butte district, Colo.

This species occurs in the Manzano group in considerable abundance at station 3757a, and though the specimens studied are exfoliated and imperfect it seems highly probable that the New Mexico specimens belong to Shumard's species. White has cited *D. occidentalis* from Camp Apache, and his specimens agree well with mine.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a).

DELTOPECTEN VANVLEETI Beede.

Plate IX, figure 5.

1877. *Aviculopecten McCcyi.* White, U. S. Geog. Surv. W. 100th Mer., vol. 4, p. 149, pl. 11, fig. 2a.
Carboniferous: Near Bear Spring, Camp Wingate, N. Mex.
1902. *Aviculopecten vanvleeti.* Beede, Oklahoma Geol. Surv., Adv. Bull., First Bien. Rept., p. 6, pl. 1, figs. 8–8*b*.
Red beds: Whitehorse Springs, Okla.
1907. *Aviculopecten vanvleeti.* Beede, Kansas Univ. Sci. Bull., vol. 4, No. 3, p. 159, pl. 5, figs. 2–2*e*.
Upper Permian: Whitehorse Springs, Okla.; Dozier, Tex.

Shell attaining a rather large size, 50 mm. or more in length. Hinge line somewhat shorter than the greatest width. Outline of left valve contracting below the hinge and spreading again to its maximum, about one-third the whole length up from the lower margin. Axis nearly perpendicular to the cardinal line. Ears large, triangular, well defined, the anterior abruptly depressed.

Sculpture consisting of numerous fine radii, which increase in size from apex to lower margin. New ones are rather irregularly introduced by intercalation, so that they are alternating and of many grades of size. About six primary ones are much larger than any of the others, and very much larger than what may be called the average. They stand at varying intervals, most widely separated near the middle, closer together laterally. There are also fine, concentric, lamellose lines which tend to form scalelike spines upon the costæ, the size and frequency of the spines bearing a direct relationship to the size of the costæ themselves. Those upon the large primary ribs are large, producing nodes upon them, and they are a long distance apart.

The posterior ear is defined by the last of the primary costæ. It is marked by a few fine, widely spaced radii and by concentric lamellose lines. The anterior ear, as already stated, is strongly and rather abruptly depressed. It appears to be marked by fine, closely arranged, but subequal radii similar to those upon the body of the shell.

There is a broad oblique cardinal area with a shallow triangular cartilage pit beneath the beak, an arrangement which characterizes the genus *Deltopecten.*

The foregoing description is based upon specimens from New Mexico, chiefly upon the one which White described and figured under the identification *Aviculipecten mccoyi* Meek and Hayden. While related to *Deltopecten mccoyi,* there can be little question that the Western form is a distinct species. In the type specimen of *D. mccoyi* the primary radii are very nearly the same size as those of the second degree, so that it is not easy to distinguish them in some cases. The intervening radii are therefore larger and less numerous

than in *D. vanvleeti*. As many as 13 intermediate ones occur between the median principal radii in the Manzano specimens of *D. vanvleeti*. The scalelike spines are also much smaller and less conspicuous in typical *D. mccoyi*.

On the other hand, after having had the privilege of comparing the Manzano specimens with the types of *D. vanvleeti*, I have been led to the conclusion that they belong to the same species. In point of sculpture no constant or important differences have been detected. The fossils from Oklahoma show a wide variation in shape, a feature of which the range is scarcely indicated by my rather fragmentary material from New Mexico. I would judge that the Manzano specimens were round and erect and that the elongate varieties shown by Beede's figure 2a of Plate V and the oblique variety shown by his figure 2c of the same plate are not represented among them. I can, however, hardly do otherwise than refer my fossils to Beede's species.

This author seeks to distinguish *D. vanvleeti* from *D. mccoyi* by the distance from the apex at which the enlarged costæ are conspicuously developed. He names 15 to 20 mm. for *D. vanvleeti* and 3 to 5 mm. for *D. mccoyi*. In the original of his Plate XV, figure 2a, the primary ribs are abruptly enlarged at a point about 20 mm. from the beak, but this peculiarity does not appear in other specimens. In them and in the Manzano material alike the principal ribs can be traced as larger than the others well-nigh to the apex, but they begin to be what I should call conspicuously larger about 8 mm. from the apex. I am somewhat doubtful as to the importance of this character within the limits named for the discrimination of the two species. The real differences which in my estimation differentiate *D. vanvleeti* from *D. mccoyi* as based upon the type specimen, with which comparisons have been made, are given above. It is possible that Beede has in mind a false *D. mccoyi*, for in citing this species in 1900 he used White's figure of a specimen probably from the Manzano group which I regard as almost certainly identical with the other Manzano specimens (and also with *D. vanvleeti*) and distinct from typical *D. mccoyi*.

Horizon and locality.—San Andreas formation, Elephant Butte (station 3600), San Andreas (station 3742), and Engle (station 3740); Abo sandstone, Abo Canyon (station 3757a).

Deltopecten coreyanus White.

1874. *Aviculopecten Coreyana.* White, U. S. Geog. Surv. W. 100th Mer.; Prel. Rept. Inv. Foss., p. 21.
Carboniferous (Coal Measures): East of Mount Taylor, 1 mile south of Pajnata, N. Mex.

1877. *Aviculopecten Coreyanus.* White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 147, pl. 11, figs. 1*a*, *b*.
Carboniferous: Bear Spring, near Camp Wingate, N. Mex.

1895. *Aviculopecten coryanus.* Keyes, Missouri Geol. Surv., Rept., vol. 5, p. 113. (Date of imprint 1894.)
Upper Coal Measures: Kansas City, Mo.

This fine species is abundant in the Manzano group, but is usually imperfectly preserved, much inferior in that respect to the specimens upon which the species rests. But little can be added to White's description. It is possible, however, to give some data regarding the right valve. This is considerably less convex than the left, but by no means entirely flat. It has almost the same shape as the other, the byssal sinus being not as deep as in some species. The surface I am inclined to believe is destitute of any radial markings but crossed by fine lines of growth, some of which are sublamellose.

White describes the sculpture of the left valve as consisting of fine radiating costæ marked by fine radiating striæ, but I am rather disposed to doubt that this is the real sculpture. Amongst the typical material one specimen, with fairly well-preserved surface, shows rather delicate concentric striæ but no radiating ones on the ribs. The specimens which show this particular feature are more or less worn, so that the concentric lines are obscured, while the fine radiating striæ have much the appearance of having been produced by delicate, probably discontinuous tubules in the substance of the shell which, brought to view by wear or exfoliation, give the semblance of fine liration superimposed upon the costæ.

D. coreyanus proves to have a broad beveled cardinal area, with a triangular cartilage pit beneath the beaks. This structure is characteristic of the genus *Limipecten*, which I now believe to be a synonym of *Deltopecten*.

D. coreyanus will need to be compared with Walcott's *Crenipecten hallanus*. The types of both species, but especially of the Nevada form, leave the observer in doubt upon many points, but my comparisons seem to show that the two are extremely similar in specific characters.

The broad hinge plate of *C. hallanus* bears transverse crenulations, a character not observed on *Deltopecten coreyanus*, but I have come to doubt whether this character of a crenulated hinge may not after all be an individual peculiarity or the result of some circumstance of preservation. A parallel case may be found in the genera *Pernipecten* and *Entolium*, the former of which has a crenulated hinge and the latter not. Weller has made *Entolium* a synonym of *Pernipecten*, and I am adopting the same course. If in the case immediately under consideration the difference in the character of the hinge plate can for one reason or another be passed over, it appears probable at present that *Crenipecten hallanus* will prove to be a synonym of *Deltopecten coreyanus*.

Deltopecten coreyanus appears to be rather closely related to the form recently described as *Aviculipecten oklahomensis* Beede. Some of the specimens (all fragmentary) which I have placed with the former species resemble the latter in a striking manner. *D. coreyanus*

attains a size much larger than any specimens of *D. oklahomensis* yet known, but despite this fact and the shape of the Oklahoma species, which if not deformed by compression is considerably narrower, the two forms may yet prove identical. On the other hand, the small right valve which Beede figures as belonging to *D. oklahomensis* is very different in shape from the right valve which seems to belong to *D. coreyanus*. It appears to have the same characters as the right valve of *D. vanvleeti*, and if it really belongs to *D. oklahomensis* there can be little question that the latter is distinct from *D. coreyanus*. In the Manzano specimens the right valves were in some cases found in natural position with the lefts, which, though badly exfoliated, seem to belong with *D. coreyanus*. Among the very imperfect Manzano fossils, some of which are probably identical with *D. coreyanus*, it may well be that more than a single species is included.

Horizon and locality.—Abo sandstone, Mesa del Yeso (stations 3751 and 3751a), Sandia Mountains (stations 3796, 3797, and 3798), and Abo Canyon (station 3757a?); Yeso formation, Mesa del Yeso (station 3751c) and San Andreas (station 3742d?); San Andreas formation, Mesa del Yeso (station 3751d) and Nogal Creek (station 3744).

ALLERISMA CAPAX Newberry.

1861. *Allorisma capax.* Newberry, Ives's Colorado Expl. Exped., Rept., p. 120, pl. 1, figs. 9-9*a*.

Upper Carboniferous or Permian limestone: Agua Azul, near base of Mount Taylor.

As at present known there is nothing to distinguish this form from *A. terminale*, save its rather more robust proportions, and especially the greater height in relation to the width. *A. capax* was described from the horizon of the Aubrey group and, as specimens usually occur, is badly preserved. It seems probable that when good specimens of both species can be compared other differences will come to light in configuration or in sculpture.

Two types are found in the Allerismas of the Manzano group. They can be distinguished with reasonable ease on the basis of the proportion of length and breadth. The less slender ones with little question belong to *A. capax*, and reach a very considerable size. The largest could hardly have been less than 150 mm. in width.

Small and immature examples of this species resemble the form from the Rico formation which I referred with some hesitation to *A. terminale*,[a] and it may be that there, as well as in the Manzano beds, the two species occur in association. It should be noted, however, that as yet no mature typical examples of *A. capax* are known in the Rico.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a) and Yeso formation, Mesa del Yeso (station 3751c).

[a] Prof. Paper U. S. Geol. Survey No. 16, 1903, Pl. IX, fig. 6.

ALLERISMA TERMINALE Hall.

1852. *Allorisma terminalis.* Hall, Stanbury's Exped. to Great Salt Lake, Rept., p. 413, pl. 2, figs. 4*a*, *b*.
Carboniferous: Big Blue River.

1852. *Allorisma regularis ?* Owen, Geol. Surv. Wisconsin, Iowa, and Minnesota, Rept., tab. 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. 10*a*, *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, Final Rept., p. 221, pl. 2, figs. 10*a*, *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. Surv. W. 100th Mer., Rept., vol. 4, p. 155, pl. 12, figs. 7*a*, *b*. (Whole report published in 1877.)
Carboniferous: Near Agua Azul, N. Mex.

1876. *Allorisma subcuneata.* White, U. S. Geol. Geog. Surv. Terr., Second Division; Powell's Rept. Geol. Uinta Mountains, p. 91.
Lower Aubrey group: Confluence of Grand and Green Rivers, Utah.

1881. *Allorisma subcuneata?* White, Dept. Stat. and Geol. Indiana, Second Ann. Rept., p. 518, pl. 8, figs, 1, 2.
Coal Measures: Edwardsport, Knox County, Ind.

1884. *Allorisma subcuneata.* White, Geol. Surv. Indiana, Thirteenth Rept., p. 148, pl. 31, figs. 1–3.
Coal Measures: Indiana.

1886. *Allorisma subcuneata.* Heilprin, Second Geol. Surv. Pennsylvania, Ann. Rept. for 1885, p. 456, 457, fig. 10*a*; p. 444, fig. 10.
Upper Coal Measures, Mill Creek limestone: Wilkesbarre, Pa.

1886. *Allorisma subcuneata.* Heilprin, Wyoming Hist. and Geol. Soc., Proc. and Coll., vol. 2, pt. 2, p. 272, fig. 10; p. 276, fig. 10*a*.
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. 5*a–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.

1903. *Allerisma terminale.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 437, pl. 9, figs. 4, 5, 6.
Hermosa and Rico formations: San Juan region, Colo.

This well-known species occurs quite plentifully in the Manzano group, but invariably in a poor state of preservation. The fossils so identified resemble *A. capax,* except that they are distinctly and persistently narrower. It can not definitely be stated that they belong to *A. terminale,* but their shape, so far as can be told, is the same, and there is no reason for supposing that the other characters also would not be in agreement.

Horizon and locality.—Abo sandstone, Sandia Mountains (station 3798).

PLEUROPHORUS MEXICANUS n. sp.

Plate X, figure 1.

Shell large, very transverse. Greatest width about two and one-half times the greatest height. Beak subterminal, slightly projecting. Cardinal line about two-thirds the entire width. Basal outline gently rounded, bending upward behind, so that that portion is somewhat contracted. Posterior outline rather distinctly truncated in an oblique direction. In front the inferior outline curves strongly upward and is withdrawn beneath the beak. The convexity is high; the umbonal ridge is strongly elevated, but not angular. A broad, obscure sinus or constriction marks off the anterior third of the shell.

The surface is crossed by fine concentric striæ and coarser ones at more or less regular intervals. A strong angular costa passes backward nearly parallel to the hinge, probably demarking an elongate escutcheon, and a short distance from it another more obscure costa intervenes between this and the umbonal ridge, while a third, hardly perceptible, one appears to be developed near the umbonal ridge itself.

Though several other fragmentary and immature examples have been provisionally referred to the same species, the foregoing description is based upon the type specimen alone.

Pleurophorus mexicanus is an unusually robust form, and appears to be most closely related to *P. taffi,* of the Carboniferous of Indian Territory. It differs from the latter species in having the anterior portion less extended and nasute, in contracting instead of expanding behind, and in having a less angular umbonal ridge.

This is possibly the species which Walcott described as *Modiomorpha? desiderata,* but his specimens were so imperfect that a comparison can not be carried out. The anterior portion is shorter than in one of his types, and the postcardinal slope is costate, a feature which he does not mention and which perhaps could not be determined from his specimens.

A silicified right valve provisionally referred to this species shows some of the internal characters. The point of attachment of a nar-

row elongate ligament occurs just back of the umbo and below the sharp angulation defining the escutcheon. A stout cardinal tooth with a socket immediately above it is situated just below the umbo. The anterior extremity was the site of a large anterior muscle whose scar is defined posteriorly by a high, strong ridge extending downward at right angles to the hinge line.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751c); Abo sandstone, Sandia Mountains (station 3798?); San Andreas formation, Engle (station 3595).

PLEUROPHORUS BIPARTITUS n. sp.

Plate X, figure 2.

Shell of medium size, rather short and high. Outline subcuneate, somewhat contracting in front and abruptly truncated behind. Beak small and depressed. Anterior extremity moderately projecting; hinge line equaling about three-fourths the entire width. The lower margin is convex, rounding gradually upward in front, where it is strongly retracted under the beak. Convexity rather high, especially toward the posterior portion. Umbonal ridge elevated into a coarse, strong costa, while another of about the same size lies between it and the hinge line, though somewhat farther from the latter. The anterior half of the shell is marked by broad concentric striæ, leaving between them rather strong angular ridges. Apparently from the type specimen these do not pass beyond the umbonal ridge, but they may occur on the postcardinal portion and be somewhat fainter there.

This species is possibly identical with one of the several forms which Walcott includes under *Sanguinolites æolus* in his Eureka district report, especially figures 7 and 9 of Plate XX. Though some differences of configuration can readily be noted, especially about the anterior end, the general expression is certainly close. About the identity of the Manzano form with typical *Sphenotus æolus* there is, I think, call for little discussion. *P. bipartitus* also resembles Walcott's *Sanguinolites retusus*, but is a much more transverse species.

The type specimen is more or less of an internal mold, but seems to show the specific characters with reasonable clearness. A second, still less well-preserved specimen is also known, agreeing in all respects with the other so far as can be determined.

Besides the three types of *Pleurophorus* specifically mentioned in this report, there appear to be representatives of several other species of the same genus, but too imperfect for description.

Horizon and locality.—Abo sandstone, Mesa del Yeso (station 3751).

PLEUROPHORUS aff. TAFFI Girty.

This species is represented by some very imperfect and some immature examples. The largest specimen had a width of at least 55 mm. Its convexity is low and its umbonal ridge not strongly marked, but the specimen has evidently been more or less crushed. Another example referred here shows only the anterior portion, which is more strongly produced even than in *P. taffi*. A third example is immature, with a rather prominent umbonal ridge and strongly projecting anterior extremity. None of the specimens examined seems to have any costæ developed on the postcardinal slope save an angular ridge near the cardinal line, presumably marking the limit of an elongated escutcheon.

This form suggests the species described by Walcott as *Modiomorpha? desiderata*, but both are too imperfectly known to permit a determination of their relationship.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751c) and San Andreas (station 3742b); San Andreas formation, Mesa del Yeso (station 3751d); Abo sandstone, Abo Canyon (station 3757a?) and Sandia Mountains (station 3797?).

PLEUROPHORUS aff. MEEKI Walcott.

This species is represented by four imperfect silicified specimens, the largest of which is 10 mm. wide or about half the size of the type specimen. They are characterized by very small and very nearly terminal umbones and by a smooth surface devoid of costæ. In this they are very suggestive of Walcott's species, but whether they expand as strongly toward the posterior end can not be determined. Apparently they do not.

They also resemble *Modiola subelliptica* of the Pennsylvanian fauna, a species which should be carefully compared with *P. meeki*.

Horizon and locality.—Yeso formation, Alamillo (station 3751e).

PLEUROPHORUS aff. OBLONGUS Meek.

Here belongs a single specimen having much the general appearance of *P. oblongus*, though about twice the size. The anterior end is imperfect, so that a comparison of this part is impossible. The shape only moderately transverse, it would appear, expands behind, where it is subtruncated. The umbonal ridge is distinct, though not angular. There is perhaps a costa, extremely obscure, between the umbonal ridge and the hinge line, somewhat nearer to the latter.

This form also resembles *P. tropidophorus*, but seems to show stronger resemblance with the species named above, since it expands more strongly behind, has not an angular umbonal ridge, and has the postcardinal costa, if present at all, less distinct.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a).

PLEUROPHORUS aff. SUBCOSTATUS Meek and Worthen.

Under this title is included a group of forms which might prove rather heterogeneous if its constituents were less imperfect. All that it seems necessary to say of them at present is that, so far as can be told, in size and proportion they seem to resemble Meek and Worthen's species rather closely.

Horizon and locality.—Yeso formation, Blackinton's ranch (station 3750) and Carthage (station 3753); San Andreas formation, Mesa del Yeso (station 3751d?); Abo sandstone, Abo Canyon (station 3757a?).

ASTARTELLA SUBQUADRATA n. sp.

Plate X, figures 10–13.

Shell small, subquadrate, width and height sometimes almost equal, the width being, however, always slightly greater. Cardinal margin and lower margin gently curved, more or less distinctly contracting behind. Posterior outline nearly perpendicular to the upper and lower margins; gently convex, rounding into the lower margin, but meeting the upper one in an obscure angle. Beak small. Below it the outline is concave, extending downward and somewhat forward for about two-thirds or three-fourths the length of the shell. It then meets the upward-curving anterior end of the lower outline, usually in a rather distinct angle. Convexity low. No appreciable umbonal ridge.

The sculpture consists of regularly arranged concentric lamellæ, of which 6 to 8 occur in 3 mm., though the number varies according to the size of the shell, since upon the same specimen the distance between the lamellæ increases regularly from beak to margin.

In its small size and less transverse shape this species most resembles *Astartella gurleyi*, but it differs in a number of points. *A. gurleyi* usually expands posteriorly instead of contracting in that direction, and the anterior extremity is rounded and not pointed. The convexity is considerably greater, and there is a more or less distinct umbonal ridge. The characteristic concentric lamellæ are also much more closely arranged, being, when compared with *A. subquadrata*, about in the ratio of two to one.

Horizon and locality.—Yeso formation, Alamillo (station 3751e) and Fra Cristobal (station 3743b); San Andreas formation, Mesa del Yeso (station 3751d?).

SCAPHOPODA.

DENTALIUM MEXICANUM n. sp.

Plate XI, figure 10.

Shell rather large; length not determined; greatest diameter observed 7 mm. Straight, very gradually tapering. Sculpture consisting of longitudinal costæ, from 25 to 30 in number, which are obscure, broadly rounded, and separated by shallow, narrow striæ. Transverse striæ fine or absent upon the younger portion, but the older portion has well-developed transverse striæ, due to irregular growth. They are distinctly oblique. The intervening spaces have obscure striæ running lengthwise of the shell, but they do not produce continuous costæ. The general effect is of costæ finer and much more numerous than upon the younger portion.

The characters of the older parts of the shell are not taken from the type specimen, but from an associated fragment supposed to belong to the same species. Other large fragments show only irregular incremental striæ.

This form is more closely related to *D. acutisulcatum* and *D. sublæve* than to any other American species. It appears to be straight and not curved, and consequently differs from both in this particular. Furthermore, the ribs are more numerous than in *D. acutisulcatum*, and instead of consisting of sharp ridges with rounded striæ the ridges are rounded and the striæ narrow and angular. Growth lines seem to be wanting over all but the older portions of the shell. Similar differences exist between *D. mexicanum* and *D. sublæve*, which closely resembles *D. acutisulcatum*.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738a) and Fra Cristobal (station 3743).

PLAGIOGLYPTA CANNA White.

Plate XI, figure 11.

1874. *Dentalium canna.* White, U. S. Geog. Surv. W. 100th Mer.; Prel. Rept. Inv. Foss., p. 23.
Carboniferous (Coal Measures): Near Salt Lake, N. Mex., and near Relief Spring, Ariz.

1877. *Dentalium canna.* White, U. S. Geog. Surv. W. 100th Mer., Rept., vol. 4, p. 156, pl. 12, figs. 6*a*, *b*.
Carboniferous: Near Salt Lake, N. Mex., and near Relief Spring, Ariz.

1903. *Plagioglypta canna.* Girty, U. S. Geol. Surv., Prof. Paper No. 16, p. 452.

1908. *Plagioglypta canna?* Girty, U. S. Geol. Surv., Prof. Paper No. 58, p. 450, pl. 23, figs. 11 to 13.
Delaware Mountain formation: Guadalupe Mts., Texas.

Though described by White as curved and marked by obscure longitudinal ribs, I am satisfied that *P. canna* was straight and without longitudinal markings. This is true both of the type specimen and of the material found in the present collection. It appears probable that he may have observed the longitudinal striæ upon a specimen of *Dentalium mexicanum*, which occurs associated with *P. canna* in the Manzano group and doubtless elsewhere too. The type specimen of *P. canna*, so far as I can observe, is entirely without them. In the present collection silicified specimens show no traces of longitudinal costæ, though delicate transverse lines and striæ are obvious. In general appearance this form is almost like *Dentalium mexicanum*, which occurs in the same fauna, though of course when well preserved the costæ of *D. mexicanum* afford a ready means of discrimination. In the case of internal molds it is hopeless to distinguish them. Some specimens show striæ upon the interior, but as they are only local it is doubtful whether even specific importance can attach to them. In both species probably the shell is distinctly thicker toward the apex than toward the aperture, consequently internal molds taper more rapidly than the shell itself.

The hypothesis that the more slender portions of *D. canna* may bear costæ, so that *P. canna* and *D. mexicanum* are founded upon different portions of the same type of shell, may be dismissed at once, since specimens of *P. canna*, even when very small, are entirely smooth, save for growth lines.

Horizon and locality.—Abo sandstone, Sandia Mountains (stations 3796 and 3797) and Mesa del Yeso (station 3751?); San Andreas formation, Mesa del Yeso (station 3751d), Nogal Creek (station 3744?), and Engle (station 3595); Yeso formation, Alamillo (station 3751e) and Mesa del Yeso (stations 3751a and 3751c).

GASTEROPODA.

PHANEROTREMA MANZANICUM n. sp.

Pl. XI, figures 3 and 4.

Shell of medium size, turreted, consisting of about seven volutions. Volutions angular, with depressed sutures. The upper third of the external portion of each volution is nearly flat and directed obliquely downward at an angle of about 60° from the axis. This upper portion is terminated by a carina, whose top is channeled and contains the slit band, which is bounded above and below by the sharp elevated edges. The remaining two-thirds of the outer half of the peritreme is marked by angular revolving liræ, about 10 in number, separated by broadly rounded striæ. The latter gradually diminish in width toward the umbilicus, and that immediately below the carina is con-

spicuously wider than any of the others. It is also wider than the carina itself. The volutions are deeply embracing, the upper edge of one falling upon the first liræ below the carina or a little lower. There is no other sculpture than this, except obscure incremental lines, which are slightly deflected backward, both above and below the carina. These are not strong enough to produce nodes or crenulations upon the liræ.

Umbilicus nearly closed. Inner lip practically undeveloped. Aperture subrhombic.

A single specimen referred to this species has the upper surface (that between the suture and the carina) divided about midway by a distinct revolving lira.

After reviewing with some care the Carboniferous Pleurotomarioids hitherto described from North America, no doubt remains that this is a new species. In fact, I find it hard to name a species which is closely related to it. It differs from a large number in having the upper surface of the peritreme without sculpture and in having upon no part of it those transverse lines which in so many forms produce nodes or crenulations upon the revolving liræ. *Phanerotrema marcouianum* is perhaps the most closely similar, but the differences mentioned exist also between it and *P. manzanicum*. The latter has a somewhat higher spire and is a much larger shell.

Horizon and locality.—Yeso formation, Alamillo (station 3751e) and Abo sandstone, Sandia Mountains (station 3796?).

PHANEROTREMA aff. BRAZOENSE Shumard.

This type is represented in our collection by a small, imperfect, silicified specimen. The characters shown are as follows:

Size small, about 7 mm. in height, somewhat less in diameter. Spire low, rapidly enlarging, deeply turreted. The outer portion of the volution is subquadrate in section. The upper surface is nearly flat and perpendicular to the axis, with a raised band just below the suture marked by a row of large nodes. The lateral surface is about as wide as the upper surface and nearly vertical. These two portions are separated by a thin, laterally directed carina of extraordinary prominence. It constitutes the peripheral portion of the shell and gives the lateral surface a concave, somewhat retreating effect. The junction of the lateral and inferior surfaces is also subangular. The inferior surface is gently convex, rounding rapidly inward, so that the three divisions are approximately equal in height. The lower surface is marked by nine sharp, strong revolving liræ, separated by intervals considerably wider than themselves, and they apparently tend to degenerate into rows of nodes near the umbilicus, which is small and open. Two or three fine liræ are developed

on the lateral surface. The lower portion of the peritreme, and possibly the upper also, seems to be crossed by fine sublamellose growth lines, which tend to produce crenulations on the revolving liræ. Each volution embraces the lower half of the preceding one up to the angulation which defines the lateral and lower surfaces.

Though very suggestive of *P. brazoense*, this form differs in having the upper surface much less elevated and the carina more prominent.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738).

WORTHENIA ALAMILLANA n. sp.

Plate XI, figure 5.

Shell rather small, subconical, consisting of seven or eight gradually enlarging volutions. Spire about equal in height to the final chamber. Volutions carinated along the peripheral line, which is slightly above the middle, though in the spire the carina occurs a short distance above the suture. The outer surface above the carina is strongly oblique and slightly sinuous, being convex above, near the suture, and concave below, near the carina. The lower surface is gently convex.

The upper surface between the carina and suture is nearly smooth, marked, however, by fairly distinct, fine, closely arranged, regular transverse costæ. A sharp lira passes around the peritreme just above the carina, defining with the latter a narrow rounded channel, but with this exception the upper surface seems to be without revolving lines. A rather wide sulcus, somewhat wider than the carina, occurs just below the latter, but beneath it the surface is regularly crossed by rather coarse, rounded striæ and liræ of about equal size, nine or ten of each. The aperture is strongly oblique and subrhombic in shape. The inner lip is somewhat thickened.

This form rather resembles *Phanerotrema manzanicum*, with which it is associated, but many differences besides the more elongate shape are disclosed by a detailed comparison.

Worthenia alamillana has a higher spire than either *W. tabulata* or *W. subscalaris* and a lower spire than *W. marcouiana*. In some respects it resembles the latter species not a little, but besides the configuration, which has already been mentioned, there are other differences, such as the complete covering by striæ of the lower part of the whorls in *W. alamillana*.

Of the American species usually placed under *Pleurotomaria* few resemble the present form closely in configuration, and from these the absence of revolving lines on the upper half of the volutions will prove a distinguishing character.

This form resembles Beede's *Murchisonia collingsworthensis*, but is at once distinguished by having the lower portion of the volutions striated.

Horizon and locality.—Yeso formation, Alamillo (station 3751e).

MURCHISONIA? TEREBRA White.

1879. *Murchisonia terebra.* White, U. S. Geol. Geog. Surv. Terr., Bull., vol. 5, p. 219.
Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south of Pipe Spring.

1880. *Murchisonia terebra.* White, U. S. Geol. Surv., F. V. Hayden in charge; Cont. Inv. Pal., Nos. 2-8, p. 139, pl. 34, fig. 4*a*.
Upper Carboniferous: Wild Band Pockets, northern Arizona, 15 miles south of Pipe Spring.

1883. *Murchisonia terebra.* White, U. S. Geol. Geog. Surv. Terr., Twelfth Ann. Rept., for 1878, pt. 1, p. 139, pl. 34, fig. 4*a*.
Carboniferous: Wild Band Pockets, northern Arizona.

1895. *Murchisonia terebra.* Keyes, Missouri Geol. Surv., vol. 5, p. 146, pl. 49, fig. 4. (Date of imprint 1894.)
Upper Coal Measures: Kansas City, Mo.

The best specimen referred to this species is an internal mold, but the identification is made with some confidence. In the general shape of the whole, as well as in that of the whorl section, it agrees very closely with White's figure. The imprint of crenulations along the carina is shown in the clearest manner, but the spiral lines upon the upper part of the peritreme are not retained.

Horizon and locality.—Abo sandstone, Sandia Mountains (station 3796?); San Andreas formation, Caballos Mountains (station 3738?); Yeso formation, San Andreas (station 3742d).

MURCHISONIA? aff. TEREBRA White.

This form is represented in our collection by five or six specimens, but is still very imperfectly known. It closely resembles *M. terebra*, but for the following reasons I have been unwilling to identify it with that species. The spire seems to be more rapidly tapering, but as my specimens are fragments, or in some cases somewhat compressed, this can not be stated definitely. The volutions appear to have much the same shape as in White's species, with a strong carina at a point three-fourths to two-thirds the distance down from the upper suture, the surfaces above and below being flat and oblique, but the carina is only obscurely nodose, if at all, and the surface above the carina is smooth, instead of marked by revolving liræ.

Horizon and locality.—San Andreas formation, Mesa del Yeso (station 3751d), Caballos Mountains (station 3738?), Nogal Creek (stations 3744 and 3744a), and Fra Cristobal (station 3743); Yeso formation, San Andreas (station 3742d).

EUPHEMUS SUBPAPILLOSUS White.

1876. *Bellerophon carbonarius* var. *subpapillosus.* White, U. S. Geol. Geog. Surv. Terr., Second Division; 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., Contributions to Paleontology Nos. 2–8, p. 138, pl. 34, fig. 3*a*.
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., Nineteenth Ann. Rept., pt. 3, p. 592.
1903. *Euphemus subpapillosus?* Girty, U. S. Geol Surv., Prof. Paper No. 16, p. 476.
Bellerophon limestone: Diamond Peak, Uinta Mountains, Colo.

This very characteristic fossil was obtained in considerable abundance at several points in the Manzano group, but most of the specimens are imperfectly preserved. It can readily be distinguished from *E. carbonarius*. The revolving costæ are fewer and farther apart, and near the aperture develop into rows of nodes. The slit band, instead of being occupied by two or three of the costæ, is smooth and defined upon each side by one of them.

Horizon and locality.—San Andreas formation, Engle (station 3740); Yeso formation, San Andreas (station 3742d) and Fra Cristobal (station 3743b?); Abo sandstone, Sandia Mountains (station 3797?).

EUPHEMUS INSPECIOSUS White?

1881. *Bellerophon inspeciosus.* White, U. S. Geog. Surv. W. 100 Mer., Rept., vol. 3, Supp. Appendix, p. xxx, pl. 4, figs. 1a–d.
Carboniferous: Near Taos and at Taos Peak, N. Mex.
1889. *Euphemus inspeciosus.* Girty, U. S. Geol. Surv., Nineteenth Ann. Rept., pt. 3, p. 592.

Only a small number of specimens belonging to this species have been found, and they are of rather doubtful affinity. *E. carbonarius* and *E. subpapillosus* may be dismissed from the comparison without comment. While of about the same size as *E. nodicarinatus* or a little smaller, they are narrower and lack the node-bordered slit band on the smooth outer lip. They are of course much smaller than *E. inspeciosus*, and do not show the irregular curvature which characterizes that species. The irregular curvature, I am inclined to believe, is a character of the mature shell not found in the earlier stages, and the present specimens are referred to White's species on the hypothesis that they are immature.

Horizon and locality.—Yeso formation, Alamillo (station 3751e) and Mesa del Yeso (station 3751c); San Andreas formation, Nogal Creek (station 3744a?) and Engle (station 3595).

BELLEROPHON MAJUSCULUS Walcott.

Plate XI, figure 2.

1884. *Bellerophon majusculus.* Walcott, U. S. Geol. Surv., Mon. 8, p. 256, pl. 23, figs. 1, 1*a*; pl. 24, fig. 6.
Lower Carboniferous: Eureka district, Nevada.

Under this title are included a large number of Manzano specimens, but as many of them are internal molds the identifications are provisional. What is regarded as the typical form, as shown by the best preserved specimens, possesses the following characters. The size is large, but in no instance equal to that of the specimens upon which the species was based, and in most cases much smaller. The peritreme enlarges gradually and is not much expanded at the aperture. The umbilicus is only partially closed, at least in young specimens, by a fold of the shell. The section is somewhat narrow and helmet shaped, contracting rather gradually to the keel-like slit band. The surface is marked by not very distinct, regular, closely arranged ridges, whose direction follows that of the growth lines. They are sometimes nearly transverse, but at others, particularly, it may be, in young specimens, they are strongly bent backward on approaching the band.

This species is closely related to *B. crassus,* and is chiefly distinguished by the more pointed and highly carinated dorsum. As both forms vary a good deal, not only as individuals but at different stages of growth, it is doubtful whether the other differences which have been noticed, such as the character and direction of the sculpture, will be found valid. The other characters, however, appear to be independent of stages of growth.

Although my specimens are smaller, often much smaller, than those from Nevada upon which the species was based, I can not but make the identification with some confidence. They seem to agree with *B. majusculus* in just the points in which they differ from *B. crassus.*

Horizon and locality.—San Andreas formation, Engle (stations 3595 and 3740a), Elephant Butte (stations 3600 and 3741), San Andreas (station 3742), Fra Cristobal (station 3743), Nogal Creek (station 3744), Mesa del Yeso (station 3751d), and Caballos Mountains (station 3738a); Yeso formation, San Andreas (stations 3742d and 3742g) and Mesa del Yeso (station 3751a, 3751b, and 3751c); Abo sandstone, Mesa del Yeso (station 3751) and Sandia Mountains (station 3797).

PATELLOSTIUM aff. NODICOSTATUM Gurley.

Our collection contains nine specimens of this species, but they are so poorly preserved, retaining only here and there patches of the shell, that nothing but an imperfect description can be given. The peritreme is rather rapidly expanding, transverse, broadly rounded across the dorsum. Slit band sharply defined but not much elevated. Outer lip deeply notched.

Sculpture consisting of fine revolving liræ, about 12 in 10 mm., which are subequal or slightly alternating, separated by narrow, rather indistinct striæ. These are crossed by transverse undulations, which are regular, closely arranged, and when the surface is well preserved apparently angular. They occur usually about 6 or 7 in 5 mm. They vary somewhat in direction, being in some specimens nearly straight, in others strongly curved, and they are always more or less bent backward near the slit band. The revolving liræ sometimes produce nodes as they cross the transverse ridges.

It is hardly probable that this is the same form which occurs in the Eureka district and was there identified by Walcott as *Bellerophon textilis?*

Horizon and locality.—Abo sandstone, Sandia Mountains (station 3796) and Abo Canyon (station 3757a); San Andreas formation, Mesa del Yeso (station 3751d); Yeso formation, Mesa del Yeso (station 3751a).

MOGULIA? sp.

The subject of this sketch is a single small specimen, silicified, and partially freed from matrix. It seems rather probable that the present characters, so far as they are observable at all, are true to the original condition, from which probably little has been lost or altered in course of fossilization. The fact, therefore, that the specimen is entirely smooth, without transverse or revolving striæ and without a visible slit band, invests it with unusual interest. The section would be regularly and strongly rounded across the dorsum, the volutions rather rapidly expanding in the same plane. The aperture was probably sublunate, transverse. The inner lip was not thickened. The outer lip, unfortunately, is broken, so that in the absence of any distinct growth lines its shape can not be even inferred. It projected at the sides and was much thickened, producing a solid axis and obscuring any trace of an umbilicus.

So far as can be determined the generic affinities seem to be partly with *Mogulia* and partly with *Warthia*, and the decisive evidence of the shape of the outer lip is unfortunately wanting. The shell has the general aspect, the solid axis, and the laterally projecting outer lip of *Mogulia*, but lacks the transverse plications of that genus, which follow the growth lines and betray the shape of the lip. In its lack of

sculpture it is like *Warthia*, but has the lateral expansion of the outer lip which is so common in other Bellerophons, but which seems to be absent in the Indian genus.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738a).

BUCANOPSIS MODESTA n. sp.

Plate XI, figure 1.

Shell small, the largest specimen examined having a diameter of 9 mm. Peritreme rather rapidly expanding, transverse, broadly rounded over the dorsum. Aperture sublunate. Outer lip not flaring. Slit narrow and deep. Umbilicus open. Inner lip imperfectly developed.

Slit band rather broad, not sharply defined, slightly elevated. Surface marked by fine revolving liræ, about 10 in 3 mm., which vary somewhat in appearance, being now apparently slender and somewhat widely separated, and now broader and more closely arranged. These varying appearances are probably due to preservation. There are also fine, obscure, transverse lines, which are chiefly visible upon the slit band.

I am not altogether satisfied that this form is an undescribed species, but it unfortunately happens that most of the types with which it would be desirable to compare it have not been figured, and it is impossible to make satisfactory comparisons with the descriptions alone. *B. marcouiana*, from figures of Geinitz's fragmentary specimen, appears to be a distinct species, by reason of the different shape of the peritreme. The Mississippian species *B. textilis* is very suggestive, but has not so broad a whorl section.

It seems hardly probable that these are young examples of the form identified as *Patellostium* aff. *nodicostatum*, as the liration is finer and the transverse costæ are absent.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738a) and Abo sandstone, Abo Canyon (station 3757a?).

EUOMPHALUS aff. PERNODOSUS Meek and Worthen.

This form is represented in our collection by fragments of one rather small specimen. It was found associated with *Euomphalus* sp. *a;* but while the latter species has nodes upon the upper surface the present one as clearly has them upon the lower, and therefore it resembles *E. pernodosus*. Whether it can definitely be identified with *E. pernodosus* can hardly be determined from the material at hand.

The Manzano specimen had a diameter of about 25 mm. The upper surface was probably nearly flat, or slightly concave, the lower

broadly and somewhat deeply umbilicated. The upper surface of the peritreme was nearly plain, almost horizontal, slightly sloping downward from the outer margin, which was probably angulated, effecting a marginal or submarginal carina. The lower surface is also carinated about midway, the carina being marked by nodes 5 mm. apart. From the carina the lower surface of the peritreme slopes upward rather symmetrically in either direction.

The characters thus briefly sketched indicate a species similar in a general way to *E. pernodosus*. So far as can be told, the Manzano form has its upper carina more marginal and its lower one less marginal than the typical variety. Other specimens, however, might show that these characters are not constant or not quite as described. Considerable change also takes place with the growth of the shell, and the present seems to be an immature example.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738).

EUOMPHALUS sp. *a*.

This type is represented in our collection by two specimens, and although many of its characters can be determined so that it is without much question a new species, I hardly feel justified at present in introducing for it a new name. At first sight one would hardly fail to compare it with *Euomphalus pernodosus*, but a more careful examination shows that the nodes in the present instance are situated upon the upper instead of the lower surface. The size is large, at least 45 mm. in diameter, the upper surface flat, or even slightly depressed. The under surface is scarcely known, but is probably broadly and deeply umbilicated. The volutions are about 5 or 6. They are flat above and descend gently toward the center. The sides also are flattened and nearly normal to the upper surface, with which they join in a pronounced angulation, marked at rather long intervals by large, moderately well-developed nodes. The latter are 8 or 9 mm. apart in one specimen, but are more closely arranged in the other. They are developed only upon the mature volution, premature and postmature whorls showing only the marginal angulation. The volutions overlap, so that the inner edge of the upper surface of one is a little lower than the outer edge of the upper surface of the other. The shape of the lower portion of the volution is imperfectly known. The vertical lateral surface appears to be bent inward rather gradually until, about midway of the peritreme by an abrupt change of direction which results in a median carina, its course is inward and upward.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738), Nogal Creek (station 3744a?), and Elephant Butte (station 3741).

EUOMPHALUS sp. *b*.

The species which is the subject of the following remarks constitutes a rather important feature of the Manzano fauna, but of the sundry specimens examined the majority are more or less completely reduced to the internal mold. Many are also fragmentary, and a few presumably belong to a small immature stage. The size is large, 55 mm. or more in diameter, and in number of volutions 4 or 5. The upper surface is gently and the lower surface deeply concave. The upper surface of the peritreme is marked by a strong angular carina, which in the younger volutions seems to be almost marginal, so that the upper surface is nearly flat and horizontal. In the older volutions it still tends to be marginal, but is situated nearer the center. The upper surface of the peritreme is then concave, and it descends strongly inward from the carina, which is often considerably elevated above the larval part of the shell. In these large volutions the lateral surface curves downward and slightly outward from the upper carina, then slightly inward, where it receives another abrupt deflection upward, thus producing a second carina on the lower surface, submarginal and more or less directly below that upon the upper surface. A sufficient extent of either the upper or the lower portion has not been observed to permit me to determine whether one or both of the carinæ were nodose. So far as observed they were not, but may have had nodes at rather long intervals. The lower surface of the peritreme is nearly plane and strongly oblique. The peritreme section resulting from this configuration is strikingly triangular.

The foregoing account is composite, made up from observations upon several fragments, but it is probably true of most of the specimens placed in this group, rather, however, of the mature than of the younger stages. Still some of the fossils assembled here can not be definitely determined, for the carinæ are produced by thickenings of the shell, which take up most of the inequalities of configuration and leave the internal mold almost circular in section. In some cases the carinæ appear to have been hollow.

This form also seems to be an undescribed species, but the description which I have been able to compose is too incomplete and too open to question in some particulars to make the introduction of a new name desirable.

Horizon and locality.—Abo sandstone, Sandia Mountains (station 3797); San Andreas formation, Engle (station 3740a), San Andreas (station 3742f), Elephant Butte (station 3741?), and Caballos Mountains (station 3738a?); Yeso formation, San Andreas (station 3742g).

NATICOPSIS DEFORMIS n. sp.

Plate XI, figures 8, 9.

Shell small, globose. Volutions rapidly enlarging, ventricose, each one embracing almost the whole of the preceding, so that the spire projects little, and sometimes not at all, above the final whorl. In the largest specimen referred to this species, which has a height of 12 mm. and a diameter very nearly the same, the final whorl is greatly inflated and irregular. It has broad, gently convex upper and lateral surfaces connected by more strongly rounded portions. The lateral surface abruptly turns upward at the oblique lower side, and is marked toward the margin by two angular plications, one about midway and the other some distance below. These plications may be due to crushing, but this does not seem to be the case. The surface is marked by fine transverse striæ. In the smaller of the two figured specimens these are nearly perpendicular to the suture, or even are directed slightly forward. In the larger one they are directed obliquely backward.

I am not quite satisfied that the forms here distinguished as a new species are not in fact mere immature examples of that cited as *Naticopsis* aff. *altonensis*. In the smaller of the two figured specimens we note a slight sulcus just below the suture on the last volution. Otherwise, in the height of the spire, the direction of the growth lines, and in other points, it is very different from *Naticopsis* aff. *altonensis*. In the larger specimen figured the direction of the growth lines is as in the species last mentioned, and, furthermore, the liræ are possibly somewhat fasciculated toward the suture. The spire appears to be much lower, but the last volution is not as deeply embracing as the others, and if continued on in the same plane would leave a moderately high spire in specimens the size of *Naticopsis* aff. *altonensis*.

No more than a passing reference is needed to other American species from which the present form is distinguished by its very low spire and inflated body whorl. *Naticella?? transversa* Beede hardly needs to be named here, since while somewhat similar in configuration the sculpture is very different and the spire distinctly higher.

Horizon and locality.—Abo sandstone, Sandia Mountains (station 3798) and Abo Canyon (station 3757a); San Andreas formation, Engle (station 3740a).

NATICOPSIS aff. ALTONENSIS McChesney.

Under this title are included two specimens; only one of them moderately perfect and well preserved. Both are much smaller than normal *N. altonensis*. The following brief account is taken from the better specimen:

The complete height was probably about 15 mm. The spire is low, about as in typical *N. altonensis*, the volutions rapidly enlarging, deeply embracing. The whorl section is elliptical, strongly oblique to the axis. The upper part of the peritreme just below the suture is flattened to a horizontal direction. The long lateral surface is also somewhat flattened, perhaps even slightly depressed above. It is oblique to the upper surface, which it joins in a distinct shoulder. The lower side is probably strongly and regularly rounded. The surface is marked by fine, regular liræ, which are distinctly fasciculate on the upper half. Their direction is strongly oblique to the suture, from which they extend backward at an angle of at first about 45°. There are also fine, wavy, and irregular revolving striæ on the lower half of the peritreme.

Naticopsis altonensis represents a rather distinct type among the *Naticopsis* forms of our American Carboniferous, by reason not only of its configuration and sculpture but because the shell as at present preserved is frequently of a brownish color, indicating either some peculiarity of composition or, somewhat more probably, as the color is apt to be superficial, an epidermis thicker or more persistent than that which occurs in other groups. This is the case with the Manzano specimens. The outer layer alone is brown, and when exfoliated contrasts strongly with the white shell beneath.

White cites *Naticopsis altonensis* also from New Mexico, but it is somewhat doubtful whether it is quite the same species or from the same horizon as the one under consideration.

The Manzano form is possibly the same species which Beede has recently described as *Strophostylus permianus*, but his material is so imperfect that a determination of this point is not possible. The Manzano form appears to have a slightly lower spire and a higher, more laterally flattened body whorl, but as Beede's specimen is crushed and more completely reduced to an internal mold these differences may be misleading.

Horizon and locality.—San Andreas formation, Mesa del Yeso (station 3751d).

Zygopleura aff. rugosa Meek and Worthen.

Our collection contains but a single specimen of this species, which, though poorly preserved, agrees closely in all its determined characters with the description and figures of *Loxonema rugosum*. White has cited the same or a related species (as *Loxonema rugosum*) from Taos and Coyote Creek, New Mexico.

Horizon and locality.—Yeso formation, Alamillo (station 3751e).

SOLENISCUS aff. ALTONENSIS Worthen.

Plate XI, figure 6.

1884. *Macrocheilus* sp.? Walcott, U. S. Geol. Surv., Mon. 8, p. 260, pl. 24, fig. 8. Lower Carboniferous limestone: Eureka District, Nev.

This species is represented in our collection by two specimens, but as they are internal molds for the most part, they form an unsatisfactory basis for comparison with species in the literature which have usually been described from testiferous examples. The present form is intermediate between the elongated and the subglobose species of the genus, and has little to characterize it. So far as can be determined it is related to several known forms, though I hesitate to identify it definitely with any of them.

One of those most closely resembling it is *S. altonensis*. In that species the point of greatest convexity is farther from the top of the peritreme, which gives to the volutions of the spire a less inflated appearance, and a slightly different shape to the whole. The same is true of *S. hallanus*, which is perhaps the same species as *S. altonensis*. *S. newberryi* and *S. planus* are also related, but appear to have a more elevated spire than the Manzano form.

The circumstance that the highest convexity of the volution in these specimens occurs so near the suture may be connected with their condition as internal molds and the thickening of the test, which usually occurs near the suture.

This is, with little question, the same form which Walcott identified from the Eureka district as *Macrocheilus* sp.?

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a).

SPHÆRODOMA aff. MEDIALIS Meek and Worthen.

This species is represented in our collection by but two specimens. The better one, though otherwise excellently preserved, has the spire partly concealed by closely adhering chert. It is less than half the size of the specimen figured by Meek and Worthen, but the shape is closely similar, especially to their apertural view, which seems to be a little tilted, thus foreshortening the spire. My specimen has a lower spire than that shown in the opposite view of the type. The apertural view, which, in fact, corresponds rather badly with the other, is also somewhat more gibbous. Another related species, though also a much larger one, is *S. intercalaris*. The Manzano form is somewhat more gibbous and has a lower spire.

The second specimen, which is very imperfect, agrees with the first in everything except size. It is much larger, very nearly as large as the typical example.

The fossil under consideration has a fold or denticle on the columella near the lower extremity of the aperture, a feature which is rather characteristic of *Soleniscus*. Indeed, it is somewhat doubtful whether any but an artificial line distinguishes *Sphærodoma* from *Soleniscus*, as the two genera are at present recognized in the American Carboniferous faunas.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738a) and Engle (station 3595).

SPHÆRODOMA aff. TEXANA Shumard.

Plate XI, figure 7.

This form is represented by two specimens, one of them in fairly good preservation. It seems to differ from *S.* aff. *medialis* in being much smaller and rather more inflated. It is characterized by its low spire and gibbous body whorl, and in this particular suggests several described species, but perhaps is as near to White's identification of *S. texana* as to any. It is only about one-fourth the size of White's specimen, however, but otherwise agrees with it closely. Another species of the same general type, though greatly exceeding it in size, is *S. primigenia*. *S. ponderosa* is likewise similar in configuration.

Like the specimen identified as *Sphærodoma* aff. *medialis*, the present one also has a denticle near the extremity of the columella.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738a).

ORTHONEMA.

The group of shells here assigned to the genus *Orthonema* was at first provisionally placed with *Murchisonia*, and it may even yet prove to be necessary to return them to the Pleurotomariidæ. The carina in some examples of *O. socorroense* has much the appearance of a slit band, and while it seems in reality to be a carina, a band may occur just below or even upon it. No structure definitely functioning as a slit band has, however, been discovered, while in their general appearance these Manzano forms are certainly more like the Orthonemas than any Pennsylvanian species of *Murchisonia* or *Pleurotomaria*.

ORTHONEMA SOCORROENSE n. sp.

Plate XI, figures 12, 13.

Shell small, terete, elongate-conical. Height of a rather large specimen 15 mm., diameter at base 4 mm., volutions about 11. The sides of this gradually tapering shell are almost absolutely straight and smooth. The volutions have a flat, oblique lateral face and, the upper edge of one being flush with the lower edge of the

other, form a continuous surface from apex to aperture. The change of direction from lateral to inferior surface is abrupt. The inferior surface is gently convex and nearly normal to the axis, so that almost the entire height of each volution is seen. The angulation formed by the lateral and inferior surface is the position of a somewhat broad very low carina resembling a slit band, or, rather, its position is on the lateral surface just above the angulation. The volutions overlap only to the angulation, and consequently to the lower edge of the carina, so the latter is seen at recurring intervals, marking their junction, which otherwise might have been hardly visible. Aside from the carina, the volutions appear to have been without markings or sculpture of any sort. Even growth lines do not appear on the silicified specimens.

Figure 13 of Plate XI represents an extreme example, between which and the typical one there are intermediate gradations. The structure which in the typical variety has been referred to as a carina and is scarcely elevated above the general surface, in this specimen projects as a distinct ridge near the base of the peritreme. It tends to appear as a spiral elevation throughout the whole length of the shell just above the suture. The tendency of some of the whorls to have gently concave instead of flat lateral surfaces, and in some cases to meet the preceding one, not flush with its lower edge, but somewhat withdrawn beneath it, doubtless contributes to this effect.

The relation of this form to typical *O. socorroense* is somewhat doubtful. At first I was disposed to regard it as a wholly distinct species, and perhaps it would have been at least preferable to give it rank as a variety. In many respects its relations to *O. socorroense* are so close, however, that it seemed best for the present to consider it merely as a variation within normal specific limits. To a certain extent this form may be said to be intermediate between typical *O. socorroense* and the much larger species designated *Orthonema* sp. *a* and *Orthonema* sp. *b*.

O. socorroense is closely related to *O. carbonarium*, especially the variety with more projecting carina, but even so it is a less distinctly turreted, more evenly conical shell than *O. carbonarium*, besides being much smaller, so that if of the same length it would have perhaps twice as many volutions.

This form is so much like *O. dozierense*[a] that at first I was disposed to regard both as belonging to the same species. A detailed comparison, however, seems to indicate that they are really distinct. *O. dozierense* is based upon a smaller specimen, which if developed to the same size as *O. socorroense* would have contained a considerably larger number of volutions. *O. socorroense* has an appreciable carina at the junction of the lateral and inferior surfaces, and in some cases

[a] Beede, J. W., Kansas Univ. Sci., Bull., vol. 4, No. 3, 1907, p. 168.

the carina is rather striking, while no such feature seems to be developed in *O. dozierense*. Finally, the lower surface of *O. socorroense* is smooth, while *O. dozierense* has a revolving ridge or lira just below the angulations formed by the lateral and basal portions of the peritreme.

The irregular, strongly carinated variety of *O. socorroense* resembles *O. texanum*, but the lateral face of *O. socorroense* is much flatter and the lower face deeper, and it is smooth instead of striated underneath.

Horizon and locality.—Yeso formation, Alamillo (station 3751e).

ORTHONEMA sp. *a*.

This species, which is best known from a fragmentary specimen, is somewhat similar to *O. socorroense* in that the spire is elongate and terete, with but little to interrupt its almost continuous lateral surface. It is, however, very much larger and shows other differences as well, which indicate that it is a quite distinct species. In the present specimen the diameter of the last whorl is 15 mm. The lateral surface of the peritreme is very gently concave. Its junction with the lower surface is marked by a strong carina. The lower surface of the peritreme is gently convex and inclined but slightly to the axis away from the apex. The lateral surfaces of the volutions are, so far as observed, entirely without sculpture or markings of any sort, but the lower portion is crossed by 6 or 7 revolving striæ, that below the carina being somewhat stronger than any of the others. The volutions overlap only to the carina, which is somewhat emphasized by the slightly concave lateral surfaces above and below.

This species also seems to be quite distinct from any described from the American Carboniferous, but my material is almost too imperfect to make the introduction of a new name justifiable.

While the foregoing description has been drawn from a specimen which though imperfect shows many of the superficial characters, there have been provisionally referred here a number of fragments more or less completely reduced to the condition of internal molds, some of which indicate a much larger size than the described specimen. The largest has a diameter of 33 mm., while the height from suture to suture is about 18 mm.

This form in some respects much resembles *Orthonema texanum* Beede. The prominence of the carina, which is greater than in *O. socorroense*, suggests *O. texanum*, but the lateral surface is flatter. The lower surface is also striated, as in *O. texanum*. On the other hand, if of the same size as *Orthonema* sp. *a*, *O. texanum* would have two or three times as many volutions.

Horizon and locality.—San Andreas formation, Mesa del Yeso (station 3751d) and Nogal Creek (stations 3744? and 3744a); Yeso formation, Mesa del Yeso (stations 3751a and 3751c).

ORTHONEMA sp. *b*.

This species is represented by a single imperfect specimen, and is related to sp. *a*, though by no means to be considered identical with it. The specimen under consideration must have been, when complete, about 22 mm. long, the diameter at the base measuring 8 mm. Probably 10 volutions were present. The general shape of the shell is elongate, conical, but not regularly so, for the upper portion seems to have been more rapidly tapering than the lower, which is subcylindrical. The general shape of the whorls is as in *Orthonema*? sp. *a*, the sides being gently concave, with the carina located where the lateral surface joins the lower one, this feature being more distinct upon the upper half of the shell. No sculpture seems to have been present, and in this respect the present form differs from *Orthonema*? sp. *a*, in which the lower surface of the whorls is striated.

This also appears to be an undescribed species, but for the same reason as in other cases it has seemed best not to give it a new name.

Horizon and locality.—San Andreas formation, Caballos Mountains (station 3738).

CEPHALOPODA.

ORTHOCERAS sp.

Plate XII, figure 2.

Of this type our collection has furnished a single specimen preserving the living chamber and a few of the septal chambers below. The size is rather large and the taper rather rapid. The section is somewhat elliptical and the siphuncle distinctly eccentric. The smaller end is 20 mm. by 19 mm. in diameter. The longer diameter of the larger end must have been about 26 mm. The length of the fragment is 46 mm. On the smaller end the siphuncle is 12 mm. from the farther side and 7 mm. from the nearer. It is very small. The sutures are not straight, but have a well-developed, broad lobe upon what may provisionally be called the ventral side. It is this side near which the siphuncle is situated and upon which the flattening chiefly occurs. Upon the dorsal side the sutures are directly transverse, but laterally they naturally bend upward in process of forming the ventral lobe. The normal height of the chambers at this size is 4 mm., or one-fifth the larger diameter, as shown by the final chamber on the specimen as figured and by two imperfect detached chambers, but the chamber just below the living chamber is almost 8 mm., while there is some indication of another septum 22 mm. above that forming the base of what is here regarded as the living chamber. This narrow groove upon the interior mold may indicate a septum, but is provisionally considered a varix of growth near the real aperture. At all events, the irregularity in the height of the chambers may probably

be interpreted as an indication that the specimen is mature, with a rather short chamber of habitation.

The specific relations of this form are in some doubt, but it may be said to be probably distinct from any of the species yet cited from our Western Carboniferous. By reason of its locality and horizon Marcou's *Orthoceras novamexicanum* would invite comparison; but Marcou's description and figure give very few of the really important characters. *O. novamexicanum* is very much larger, however, and if the present specimen is indeed mature, it seems probable that it is a different species. Meek's *O. baculum* is also similar in some respects. The siphuncle is larger and less eccentric.

Horizon and locality.—Abo sandstone, Abo Canyon (station 3757a).

Coloceras mexicanum n. sp.

Plate XII, figure 1.

Shell rather small, subglobose, rapidly expanding. Umbilicus of medium size. Diameter of type specimen about 55 mm., width at aperture about 35 mm., width of umbilicus 8 mm. Section subcircular or somewhat subquadrate. Umbilical shoulder distinct, the umbilical portions of the volutions being almost parallel to the axis. The sides are slightly flattened, contracting above and rounding gradually into the broad ventral surface, which is gently depressed or concave. Surface smooth. Suture slightly sinuated. Indistinct lobes seem to occur upon the ventral and lateral surfaces, separated by equally obscure saddles, whose position is on the umbilical shoulder and the ventri-lateral shoulder. Height of the chambers 4 mm. Siphuncle situated below the middle, about halfway between the middle and the dorsal surface.

This form probably belongs to the genus *Coloceras*, though the faintly impressed ventral surface and the presence of an obscure ventral lobe sustain some doubt on this point. *C. mexicanum* is certainly distinct from the two other American species, not only in possessing the two features just mentioned, but in being narrower as well.

Horizon and locality.—Yeso formation, Alamillo (station 3751e).

Temnocheilus aff. winslowi Meek and Worthen.

The subject of this description is a single fragment having a closely quadrate section 35 mm. in both directions. The sides are straight and parallel. The ventral surface is gently convex. The dorsal side is concave for an undetermined distance, and runs upward rather strongly at the sides, making this surface on the whole more convex than the other. The umbilical shoulder probably not well defined.

While the ventral and lateral surfaces are fairly distinct, they apparently do not meet in an angle. This line, however, is marked by a row of very large nodes, which are subcircular, somewhat elongate, basally at least, in the direction of revolution, and are probably 20 mm. or more apart. The siphuncle is of medium size and is about 7 mm. from the ventral border. The sutures are very nearly straight and very nearly transverse. There is perhaps a faint ventral lobe. The chambers are low, about 4 mm. in height along the ventral surface.

This form appears to be related to *T. winslowi*, but is with little question distinct, one difference being the less transverse shape of the cross-section. The Manzano form is too incompletely known, however, to determine its relationship to other species. More perfect material would probably verify the foregoing description in the main.

Horizon and locality.—Yeso formation, Blackinton's ranch (station 3750) and Mesa del Yeso (station 3751c).

Temnocheilus aff. conchiferum Hyatt.

This form, like the other, is represented by very fragmentary specimens, the following notes being taken from one of them:

The volutions appear to have been rather gradually enlarging, and but slightly embracing, so that the shape of the whole was discoidal, with wide umbilicus. The shape of the section is transversely elliptical, with a barely perceptible flattening of the sides. The width is 34 mm. and the height 24 mm. The dorsal surface is impressed for about one-third the entire width. Indistinct traces of nodes have been observed along the obscure ventrilateral shoulder.

The character of the suture is not shown by the specimen furnishing the above data, and other examples too doubtfully belong to the same species to make it desirable to include here data derived from them.

This form suggests *T. conchiferum* in its section, but is a less rapidly enlarging species.

Horizon and locality.—San Andreas formation, Nogal Creek (station 3744) and Yeso formation, Alamillo (station 3751e).

Temnocheilus sp. *a*.

The form included under this title appears to be closely related to the last, and may prove even identical with it when both come to be better known. The chief reason for distinguishing them has to do with the septa. In the best and most characteristic specimen referred to this division the height of the chambers is about 6 mm., or considerably more than in the other. The sutures are also more strongly curved. There is a distinct ventral lobe or sinus and a distinct lateral lobe, with saddles more or less well marked upon the ventrilateral and umbilical shoulders.

Not all the specimens referred here show nodes upon the ventrilateral shoulder, but, especially in the older whorls, those structures are largely taken up by the thickness of the shell, leaving often very indistinct elevations upon the internal mold, the condition in which most of our specimens are found.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751a? and 3751c); Abo sandstone, Mesa del Yeso (station 3751?); San Andreas formation, Mesa del Yeso (station 3751d?).

DOMATOCERAS? sp.

This form is represented in our collection by the merest fragments, but nevertheless seems of sufficient interest to warrant a brief mention. The shell was probably rather small and the shape flat, discoidal, with large umbilicus (?). The section was tetragonal, with nearly flat sides and ventral surface. The sides converged toward the latter, and their abrupt junction with it is emphasized in the best fragment by a strong carina. The septa are closely arranged, the height of the chambers being 2 mm.

Horizon and locality.—Yeso formation, Mesa del Yeso (station 3751c).

OSTRACODA.

HOLLINA HERRICKANA n. sp.

Plate VIII, figures 10, 11.

Shell equivalve, subrhomboidal, nearly twice as wide as high. Dorsal border straight, two-thirds to three-fourths the entire width. Ventral border curved, subparallel to the dorsal, somewhat contracting toward the front and curving upward more and more strongly, so that the anterior cardinal angle is a right angle, or even somewhat rounded. The posterior end is obliquely truncated at an angle of about 120°. The higher and thinner end of the shell is posterior. There is a large tubercle near the dorsal border a little anterior to the median line, and a considerably smaller tubercle somewhat farther from the dorsal margin and a little posterior to the median line. The two tubercles are separated by a deep sulcus. The median portion of the shell is occupied by a transverse ridge which seems to begin just below the large anterior tubercle, with which it is partially confluent, curving in its forward extension and following the outline so as to meet the dorsal margin behind the smaller tubercle, which it thus partially surrounds. In some cases it seems to be traceable around the anterior tubercle also, but it is depressed and indistinct. Near the margins there is a projecting platelike flange which extends from anterior to posterior cardinal border, but is narrower toward its ends. It is somewhat oblique to the plane of contact of the valves. The surface is smooth.

In some respects this species appears to be closely related to *H. fœtoidea*, especially in the topography of the shell. The shape, however, is different, and *H. fœtoidea* seems to lack the frill-like lamella which projects from *H. herrickana* near its margin. The English species *H. radiata* is also similar, but seems to be without the inflated ridgelike median portion which partially incloses the two tubercles. The projecting submarginal plate is broader and striated. Jones and Kirkby represent that structure as abruptly terminating on the posterior end, but although one or two of the American specimens show a corresponding appearance it must in these cases probably be ascribed to breakage. Most similar of all, however, is *H. emaciata* from which it is distinguished by the extreme prominence of the ventral ridge and its continuation as such to the cardinal border behind the posterior tubercle. It seems to lack also the short ridge in the postdorsal angle and the rimlike border ascribed to *H. emaciata*. This is clearly a species of *Hollina*, resembling, perhaps, in its essentials, the Devonian *H. kolmodini* rather than the Carboniferous species.

Horizon and locality.—Yeso formation, San Andreas (station 3742d).

CYTHERELLA BENNIEI Jones, Kirkby, and Brady.

Plate VIII, figures 7–9.

1884. *Cytherella Benniei.* Jones, Kirkby, and Brady, Pal. Soc., Mon. British Foss. Biv. Entom. Carbf. form., pt. 1, No. 2, p. 70, pl. 6, figs. 3*a*, *b*, 4*a*, *b*, 5*a*, *b*; 7*a*, *b*; pl. 7, figs. 12*a–d*.

The shells referred to this species are rather small, seldom exceeding 1 mm. in diameter, very nearly elliptical, though occasionally with one end slightly narrower than the other. The convexity is low, thicker at one end, which is the wider end when difference of width is developed. Surface smooth.

Two varieties of this species are already known from the American Pennsylvanian, but the form under consideration is perhaps more nearly like the typical English form. It would be extremely difficult to point out constant differentiating characters.

Horizon and locality.—Yeso formation, San Andreas (station 3742d).

BAIRDIA OCCIDENTALIS n. sp.

Plate VIII, figure 6.

Shell very elongate transversely. Outline of dorsal border slightly sinuate. Ventral border convex, most strongly bowed in the middle. Anterior end bluntly rounded. Posterior end acuminate. Convexity high, so that the cross section is nearly circular. One valve strongly overlapping upon the straight border. Surface smooth.

This form differs from *B. cestriensis*, the only other American representative of the genus, but is extraordinarily similar to the Waverly species which Ulrich described as *Pontocypris? acuminata*, suggesting,

however, that it might be an elongated *Bairdia*. The Manzano form presents few differences from that found in Ohio, the most important which I am able to indicate being the more pointed anterior end of the latter. *B. occidentalis* should perhaps not be considered as more than a variety of the other, but in view of their wide difference in geologic age it would be inexpedient to unite them completely.

Horizon and locality.—Yeso formation, San Andreas (station 3742d).

ENTOMIS SHUMARDIANA n. sp.

Plate VIII, figures 4, 5.

Shell small, subovate to subelliptical. Strongly convex, distinctly thinner at one end, which is that having the greater height when any appreciable difference in height occurs. Dorsal border straight, ventral convex. A deep narrow sulcus begins a little below the middle and extends to the dorsal border. On either side the inflated valve puffs up into two lobelike elevations. On the more convex side the elevations sometimes appear to be bluntly pointed, or, as it were, terminating in a little tubercle near the sulcus. The two valves are distinctly unequal, one overlapping the other along the ventral border, and to a certain extent at the ends. Surface smooth.

I am in some uncertainty as to the generic relations of this form and also as to its orientation. The nuchal furrow suggests both *Entomis* and *Primitia*, by its strength perhaps the former more than the latter. While the present form is distinctly inequivalve, *Primitia* appears to have the two valves equal and *Entomis* nearly so. Typically *Entomis* is highly sculptured, though a group of smooth species is known. Perhaps the least important disagreement lies with *Entomis*. By analogy with both genera the border against which the furrow is directed is the dorsal. If the identification with *Entomis* is correct, the narrower, more inflated, possibly tuberculated end is anterior, since the tubercle of *Entomis* is said to be in front of the sulcus. It may prove desirable to withdraw shells of this type from *Entomis* into a distinct and possibly a new genus, because of their smooth surface and strongly inequivalve configuration.

No American species of *Entomis* are known from the Carboniferous, though an undescribed form from the Caney shale of Indian Territory appears to belong to that genus.

Two American species of *Primitia* resemble the form under consideration rather closely. I refer to *P. cestriensis* and *P. simulans* of the Kaskaskia. Both species are presumably more equivalve, and both have a flattened border or flange the like of which is not found in the Manzano form. They are also less inflated and less distinctly furrowed. *P. simulans*, however, though larger, is very similar in shape.

Horizon and locality.—Yeso formation, San Andreas (station 3742d).

TRILOBITA.

ANISOPYGE INORNATA n. sp.

Plate VIII, figure 12.

This species is founded upon the pygidium, of which the following description can be given.

Shape subtriangular, strongly convex, slightly wider than long. Lateral outlines gently convex, meeting behind in a bluntly rounded angle. Axis strongly elevated, sharply defined, extending almost to the posterior outline. Axial segments about 27 or 28, becoming narrower and less distinct toward the extremity; sharply defined by striæ. The axis narrows posteriorly, but less rapidly than the pleural portions. Toward the front it occupies less than one-third the width. A fairly distinct grocve occurs upon each side of the axis, less than one-fourth the width up from the axial furrows, and, being parallel one with the other, each meets the groove before reaching the posterior end. The axis spreads a little more rapidly below these grooves, and the segments, elsewhere directly transverse, make a backward turn and sometimes become less sharply defined at them. Nine broad, strongly oblique segments on the plural portion. Sometimes narrow raised lines occur in the striæ which separate them. The segments terminate laterally in a smooth flattened border, defined on its inner side by a groove. Near its outer margin it is marked by the slender, oblique, irregularly inosculating liræ rather characteristic of crustacean tests. The border, from being nearly horizontal on the sides, bends downward posteriorly to a more vertical position, which makes the end of the axis appear almost terminal when the pygidium is viewed from above.

The surface is finely granular, but without other ornamentation.

This species is closely related to *A. perannulata* Shumard. The sharpest distinction is in the absence of rows of granules along the crests of the segments. Other differences in configuration, such as the greater width and the persistence of the axial segments to the furrow, may also prove serviceable in distinguishing them.

Horizon and locality.—Yeso formatior, Mesa del Yeso (station 3751c) and Alamillo (station 3751e).

REGISTER OF LOCALITIES.

3595. East of Caballos Mountains, at entrance to Palomas Gap, west of Ward's ranch.
W. T. Lee. 1904.

3600. North point of Caballos Mountains.
W. T. Lee. 1904.

3738. Pass through Caballos Mountains, west of Upham. Limestone overlying the red beds.
W. T. Lee. 1905.

3738a. Same as 3738. Limestone within the red beds, and 100 feet below top of section.
W. T. Lee. 1905.

3740. Caballos Mountains. Palomas Gap, east end. From lime above red beds and 50 feet from top of lime. On wagon road west of Ward's ranch.
W. T. Lee. 1905.

3740a. Same as 3740; 25 feet from top of lime.
W. T. Lee. 1905.

3741. Caballos Mountains, north end. From lime above red beds, top of Manzano group.
W. T. Lee. 1905.

3742. San Andreas Mountains, east of Engle. Foothills at edge of Jornada.
W. T. Lee. 1905.

3742b. Same as 3742. In red beds 700 feet above top of massive red sandstone.
W. T. Lee. 1905.

3742c. Same as 3742; 50 feet above 3742b.
W. T. Lee. 1905.

3742d. Same as 3742; 100 feet above 3742c.
W. T. Lee. 1905.

3742e. Same as 3742; 10 feet above 3742d.
W. T. Lee. 1905.

3742f. Same as 3742; lime above red beds, top of section.
W. T. Lee. 1905.

3742g. Same as 3742. From slide, midway of section.
W. T. Lee. 1905.

3743. Fra Cristobal Mountains, opposite mouth of Montocello Gap. At 5,500 feet.
W. T. Lee. 1905.

3743a. Same as 3743; in 25 feet of lime, in upper part of (red beds) Manzano.
W. T. Lee. 1905.

3743b. Same as 3743; 20 feet above 3743a.
W. T. Lee. 1905.

3744. Nogal Creek, west of Paraja; from about midway of 300 feet of lime, above pink and red sandstones.
W. T. Lee. 1905.

3744a. Same as 3744; near top of lime.
W. T. Lee. 1905.

3746. Carthage. Massive lime near the kiln.
W. T. Lee. 1905.

3746a. Same as 3746; in massive lime south of kiln.
W. T. Lee. 1905.

3747. Hills east of San Antonio. Lime in upper portion of red beds. Two miles north of limekiln at Carthage.
W. T. Lee. 1905.

3747a. Same as 3747. Lime resting on gypsum division of red beds.
W. T. Lee. 1905.

3750. Near C. F. Blackinton's ranch, about 15 miles east of Socorro. Lime near top of gypsum series of red beds.
W. T. Lee. 1905.

3751. Section measured south of Mesa del Yeso, near Socorro. Lime near base of red beds.
W. T. Lee. 1905.

3751a. Same as 3751. Lime between massive part of base of red beds and upper or gypsum series.
W. T. Lee. 1905.

3751b. Same as 3751a, but 20 feet higher.

3751c. Same as 3751a; same stratum as 3751a.
W. T. Lee. 1905.

3751d. Same; lime above the gypsum of the red beds.
W. T. Lee. 1905.

3751e. Two miles east of river near Alamillo.

3753. Hills 10 miles east of Socorro. Lime in upper red beds.
W. T. Lee. 1905.

3757a. At head of canyon south of railroad line and ½ mile east of a deserted stone cabin. About 50 feet above base of red beds. Abo Canyon at south end of Manzano Mountains.
W. T. Lee. 1905.

3796. Two miles south of Tejon, middle of red beds.
W. T. Lee. 1905.

3797. Road between Ojo de San Francisco and Tejon. Middle of red beds. Road runs from Bernalillo to Hague coal fields.
W. T. Lee. 1905.

3798. Ojo de San Francisco, north of Sandia Mountains.
W. T. Lee. 1905.

PLATES VI TO XII.

PLATE VI.

PLATE VI.

MEEKELLA MEXICANA n. sp. (p. 53).

FIGURE 1. Ventral view of a characteristic specimen.
1*a*. Side view of same in outline.
1*b*. Dorsal view of same.
2. Ventral view having more the configuration of *M. striaticostata* but with very obscure plications.
2*a*. Side view of same in outline.
2*b*. Dorsal view of same.
3. Ventral view of a somewhat distorted specimen with rather strong plications.
3*a*. Side view of same in outline.
3*b*. Dorsal view.
4. Dorsal view of an immature specimen which has at this stage all the characters of an *Orthothetina*.
4*a*. Ventral view.
4*b*. Side view in outline.
5. A large dorsal valve with very faint plications.
5*a*. Side view of same in outline.

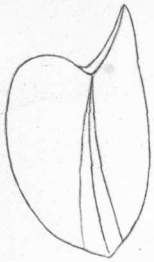
The originals of figures 1–4 are from station 3740; that of figure 5 is from station 3741.

MEEKELLA STRIATICOSTATA COX (p. 54).

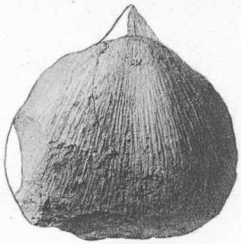
FIGURE 6. Ventral view of a specimen referred to this species.
6*a*. Side view of same in outline.
6*b*. Dorsal view of same.

The original of figure 6 is from station 3751.

1

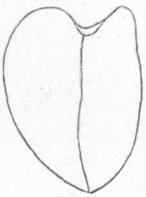


1a

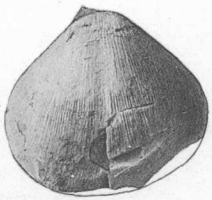


1b

2



2a



2b

3

3a

5a

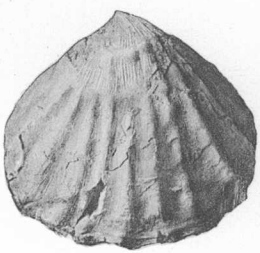
3b

4

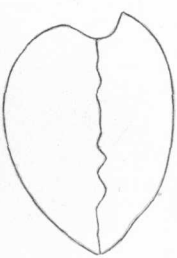
4a

4b

5



6



6a

6b

THE MANZANO FAUNA

PLATE VII.

PLATE VII.

PRODUCTUS LEEI n. sp. (p. 56).

FIGURE 1. Dorsal view of the type specimen.
1*a*. Side view of same in outline.
1*b*. Ventral view of same.
1*c*. Posterior view of same.
The original of figure 1 is from station 3738.

MARGINIFERA? CRISTOBALENSIS n. sp. (p. 65).

FIGURE 2. Anterior view of the type specimen, ×2.
2*a*. Posterior view of same, ×2.
2*b*. Side view of same in outline.
2*c*. Same, seen from above.
The original of figure 2 is from station 3743.

MARGINIFERA? MANZANICA n. sp. (p. 64).

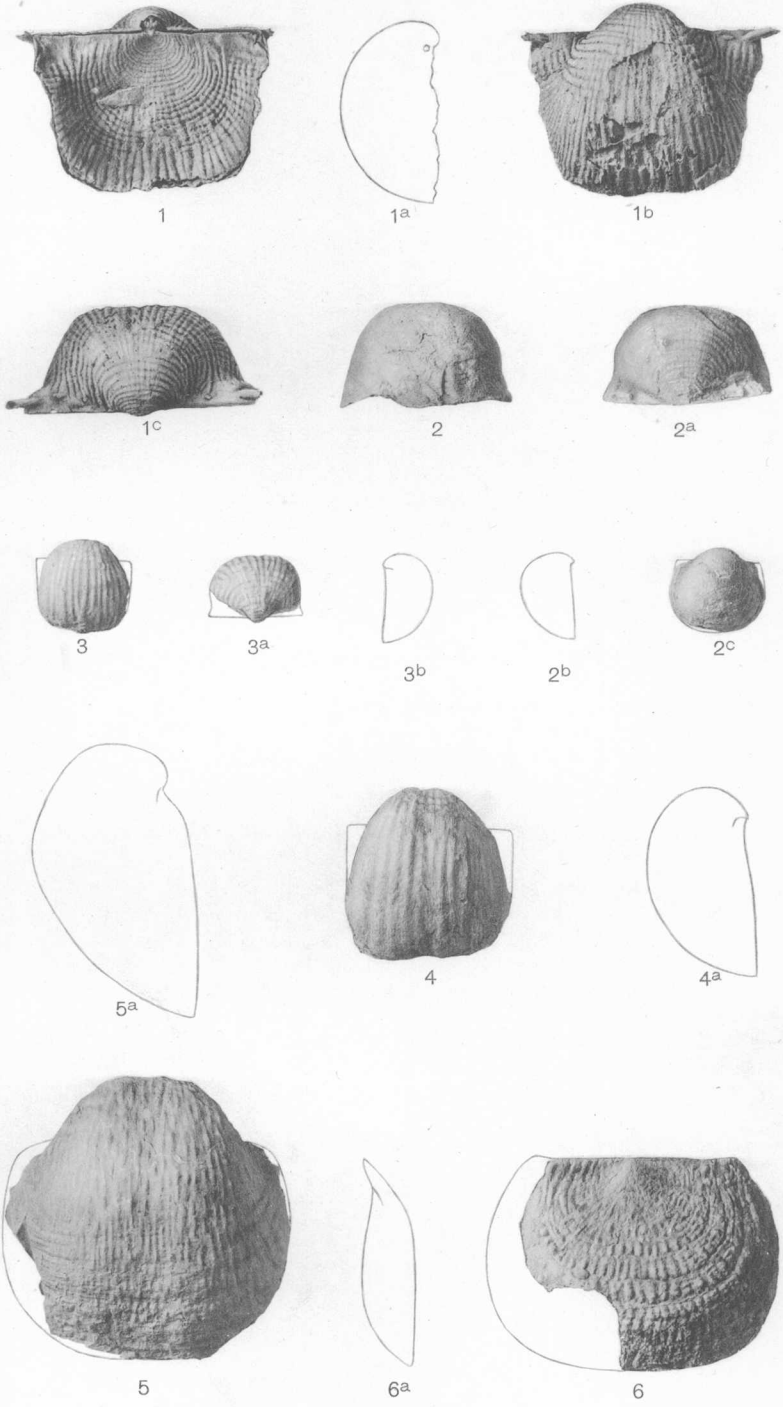
FIGURE 3. The type specimen seen from above.
3*a*. Posterior view.
3*b*. Side view of same in outline.
The original of figure 3 is from station 3743.

PRODUCTUS MEXICANUS Shumard? (p. 57).

FIGURE 4. An imperfect ventral valve referred to this species.
4*a*. Same, side view in outline.
The original of figure 4 is from station 3744a.

PRODUCTUS NEBRASKENSIS Owen (p. 62).

FIGURE 5. A ventral valve, considerably exfoliated.
5*a*. Same, side view in outline.
6. A dorsal valve reduced nearly to the condition of an external mold.
6*a*. Side view of same, outline.
The originals of figures 5 and 6 are from station 3757a.



THE MANZANO FAUNA

PLATE VIII.

PLATE VIII.

COMPOSITA MEXICANA Hall (p. 68).

FIGURE 1. Anterior view of a characteristic specimen.
1*a*. Dorsal view of same.
1*b*. Side view of same in outline.
The original of figure 1 is from station 3742f.

PUGNAX OSAGENSIS var. PUSILLA n. var. (p. 65).

FIGURE 2. Dorsal view of a rather broad specimen, × 2.
2*a*. Ventral view of same, × 2.
2*b*. Anterior view of same, × 2.
3. Dorsal view of a narrow specimen, × 2.
3*a*. Ventral view of same, × 2.
3*b*. Anterior view of same, × 2.
3*c*. Same, side view in outline, × 2.
The originals of figures 2 and 3 are from station 3751b.

ENTOMIS SHUMARDIANA n. sp. (p. 117).

FIGURE 4. Side view of a specimen with both valves, × 20.
4*a*. Dorsal view of same, × 20.
5. Side view of another specimen similar to the first, × 20.
5*a*. Dorsal view of same, × 20.
The originals of figures 5 and 6 are from station 3742d.

BAIRDIA OCCIDENTALIS n. sp. (p. 116).

FIGURE 6. Side view of a specimen retaining both valves, × 20.
6*a*. Dorsal view of same, × 20.
The original of figure 6 is from station 3742d.

CYTHERELLA BENNIEI Jones, Kirkby, and Brady (p. 116).

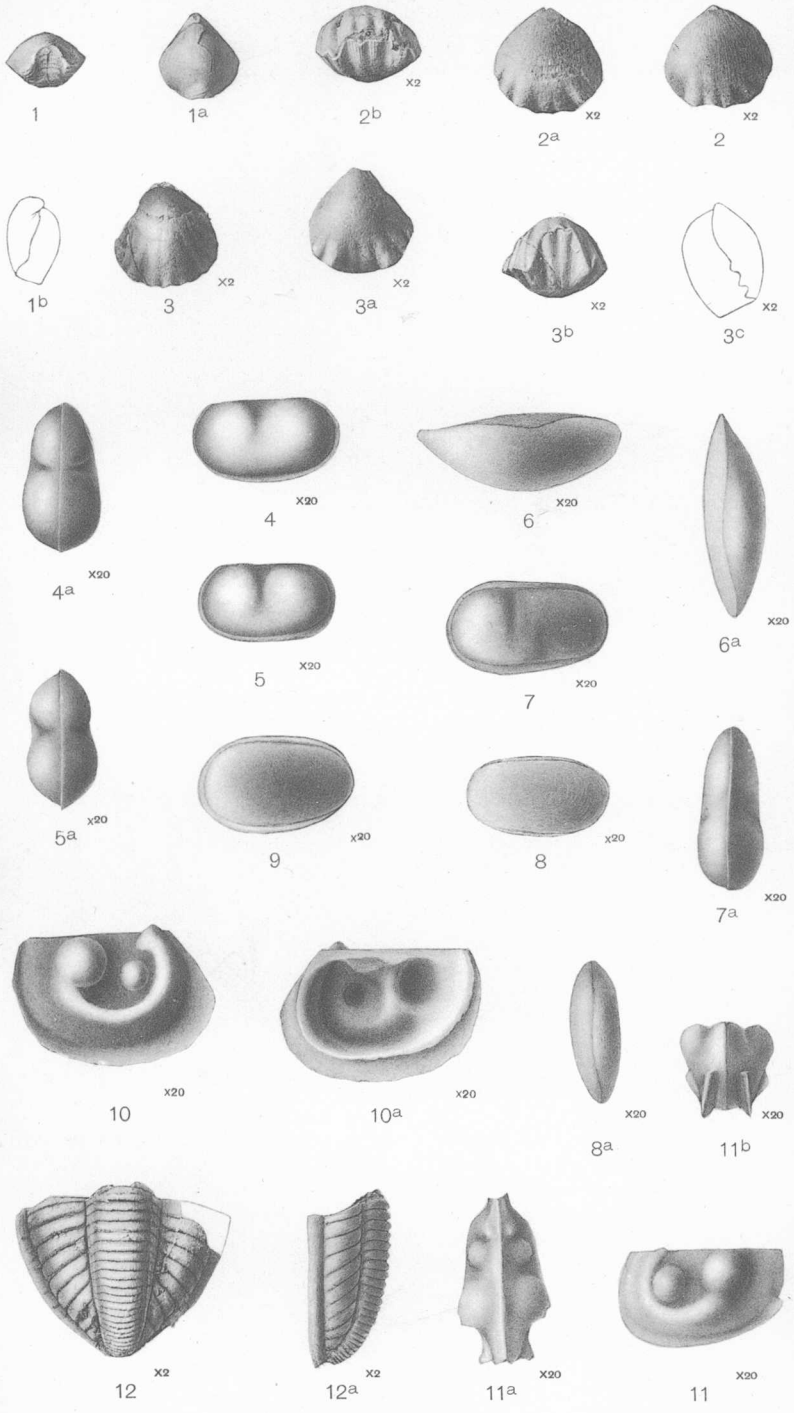
FIGURE 7. Side view of a specimen referred to this species, × 20.
7*a*. Dorsal (?) view of same, × 20.
8. Side view of a second specimen, × 20.
8*a*. Dorsal view of same, × 20.
9. Side view of another specimen, × 20.
The originals of figures 7–9 are from station 3742d.

HOLLINA HERRICKANA n. sp. (p. 115).

FIGURE 10. Exterior of a right valve, × 20.
10*a*. Interior of same, × 20.
11. Side view of a small specimen retaining both valves, × 20.
11*a*. Dorsal view of same, × 20. The anterior extremity, as represented in the figure, is below.
11*b*. Anterior view of same, × 20.
The originals of figures 10 and 11 are from station 3742d.

ANISOPYGE INORNATA n. sp. (p. 118).

FIGURE 12. A silicified pygidium, × 2.
12*a*. Side view of same, × 2.
The originals of figure 12 are from station 3751e.



THE MANZANO FAUNA

PLATE IX.

PLATE IX.

PSEUDOMONOTIS SUBLÆVIS n. sp. (p. 80).

FIGURE 1. A very characteristic specimen.
2. A narrow specimen considerably exfoliated.
3. A small, nearly perfect specimen.
The originals of figures 1–3 are from station 3742b.

PSEUDOMONOTIS HAWNI Meek and Hayden? (p. 79).

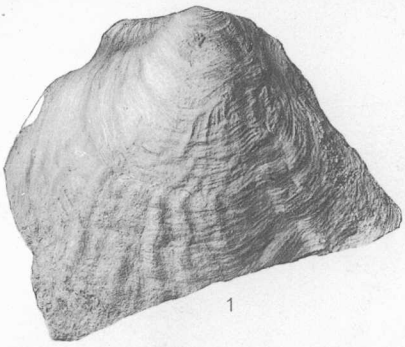
FIGURE 4. A small specimen provisionally referred to this species.
The original of figure 4 is from station 3740.

DELTOPECTEN VANVLEETI Beede (p. 86).

FIGURE 5. A fragment of the umbonal portion of a specimen referred to this species, × 2.
5*a*. View of the hinge plate, showing the triangular ligamental pit.
5*b*. Side view of same.
The original of figure 5 is from station 3742.

MYALINA APACHESI Marcou (p. 81).

FIGURE 6. A small specimen referred to this species.
7. A fragmentary specimen larger than the other but considerably smaller than the largest forms placed in this species.
The originals of figures 6 and 7 are from station 3757a.



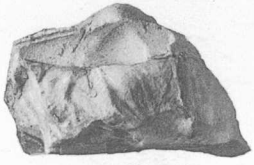
1

3

4

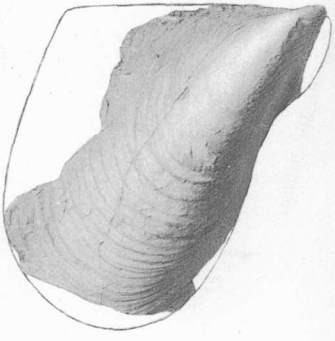
2

6

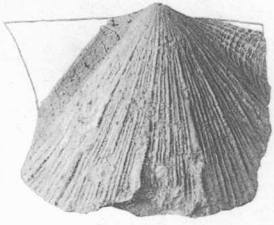


5a

5b



7



5

THE MANZANO FAUNA

PLATE X.

PLATE X.

PLEUROPHORUS MEXICANUS n. sp. (p. 91).

FIGURE 1. Side view of the somewhat imperfect specimen on which the description was based.

1*a*. Cardinal view of same.

The original of figure 1 is from station 3751c.

PLEUROPHORUS BIPARTITUS n. sp. (p. 92).

FIGURE 2. Side view of the type specimen.

The original of figure 2 is from station 3751.

MANZANELLA ELLIPTICA n. gen. et sp. (p. 76).

FIGURE 3. Interior of a left valve, × 3.

4. Interior of a right valve, × 3.

4*a*. Same, exterior, ad nat.

The originals of figures 3 and 4 are from station 3751e.

CLINOPISTHA? sp. (p. 72).

FIGURE 5. A form of doubtful affinities.

The original of figure 5 is from station 3743.

SCHIZODUS WHEELERI Swallow? (p. 82).

FIGURE 6. An imperfect specimen referred to this species.

The original of figure 6 is from station 3742d.

NUCULA LEVATIFORMIS Walcott (p. 74).

FIGURE 7. A specimen of the size usual in our collection. Side view of left valve, × 2.

7*a*. Posterior view in outline, × 2.

The original of figure 7 is from station 3751e.

8. Side view of an unusually large left valve, × 2.

8*a*. Same, natural size in outline.

The original of figure 8 is from station 3743.

NUCULA LEVATIFORMIS var. OBLIQUA n. var. (p. 75).

FIGURE 9. Side view of a characteristic right valve, × 2.

9*a*. Posterior view of same in outline, × 2.

The original of figure 9 is from station 3743b.

ASTARTELLA SUBQUADRATA n. sp. (p. 94).

FIGURE 10. Interior of a characteristic right valve, × 4.

10*a*. Exterior of same, ad nat.

11. A right valve of somewhat unusual shape.

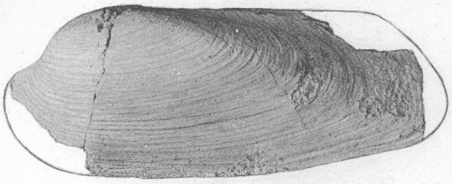
12. Exterior of a characteristic left valve.

12*a*. Anterior view in outline, × 2.

13. Interior of a left valve, × 4.

14. Cardinal view of a specimen having the two valves in conjunction.

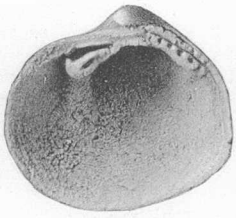
The originals of figures 10–14 are from station 3751e.



1

3

1a



4

2

9a

4a

5

7

7a

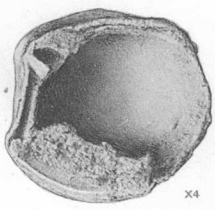
9

6

8

8a

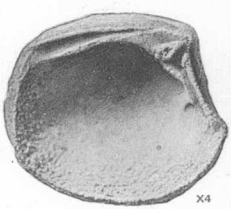
14



10

11

12



13

10a

12a

THE MANZANO FAUNA

PLATE XI.

PLATE XI.

BUCANOPSIS MODESTA n. sp. (p. 103).

FIGURE 1. Dorsal view of a silicified specimen, × 2.
1*a*. Side view of same, × 2.
1*b*. Anterior view, showing character of the slit, × 2.
1*c*. Apertural view, × 2.
The original of figure 1 is from station 3738a.

BELLEROPHON MAJUSCULUS Walcott (p. 101).

FIGURE 2. Dorsal view of a small specimen than which much larger, though less perfect, ones occur in the collection, × 2.
2*a*. Side view.
2*b*. Apertural view.
The original of figure 2 is from station 3738a.

PHANEROTREMA MANZANICUM n. sp. (p. 96).

FIGURE 3. Side view of a large specimen with imperfect spire, × 2.
3*a*. Opposite side of the same, natural size.
4. Side view of a small specimen with complete spire.
The originals of figures 3 and 4 are from station 3751e.

WORTHENIA ALAMILLANA n. sp. (p. 98).

FIGURE 5. Side view of the type specimen.
5*a*. Opposite side of same, × 2.
The original of figure 5 is from station 3751e.

SOLENISCUS aff. ALTONENSIS Worthen (p. 108).

FIGURE 6. Side view of a specimen reduced almost to an internal mold.
The original of figure 6 is from station 3757a.

SPHÆRODOMA aff. TEXANA Shumard (p. 109).

FIGURE 7. Side view of a specimen resembling Shumard's species, × 2.
The original of figure 7 is from station 3738a.

NATICOPSIS DEFORMIS n. sp. (p. 106).

FIGURE 8. A large specimen, seen from above.
8*a*. Side view of same.
The original of figure 8 is from station 3757a.
9. A small specimen, seen from above, × 2.
9*a*. Same, side view, × 2.
The original of figure 10 is from station 3740a.

DENTALIUM MEXICANUM n. sp. (p. 95).

FIGURE 10. Side view of the typical specimen, × 3. Associated fragments indicate a considerably larger size.
10*a*. Same, natural size in outline.
The original of figure 10 is from station 3738a.

PLAGIOGLYPTA CANNA White (p. 95).

FIGURE 11. The younger portion of a specimen, showing the straight shape and the absence of longitudinal striæ, × 2.
The original of figure 11 is from station 3751e.

ORTHONEMA SOCORROENSE n. sp. (p. 109).

FIGURE 12. Side view of the type specimen, showing very regular growth, × 2.
13. Side view of specimen of less regular construction.
The originals of figures 12 and 13 are from station 3751e.

1

1a

1b

1c

2


2a


2b

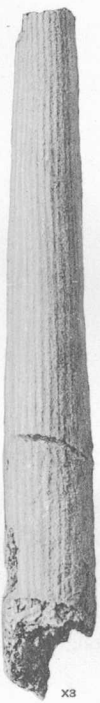
3


5

5a


4


3a



10


6


8

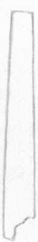

8a

7

9

9a

11


10a

13

12

THE MANZANO FAUNA

PLATE XII.

PLATE XII.

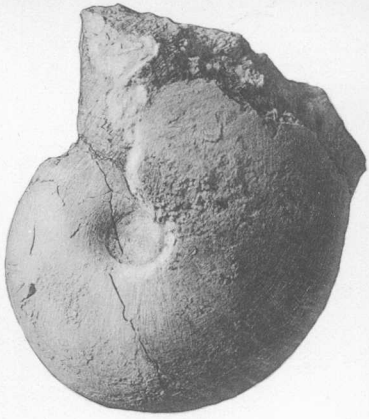
COLOCERAS MEXICANUM n. sp. (p. 113).

FIGURE 1. Side view of the type specimen, showing the septation.
1*a*. Opposite side, which retains the shell and so shows the configuration.
1*b*. Ventral view of same.
The original of figure 1 is from station 3751c.

ORTHOCERAS sp. (p. 112).

FIGURE 2. View of ventral (?) side of a specimen of undetermined affinities.
2*a*. Side view of same, showing the curved suture.
2*b*. End view in outline.
The original of figure 2 is from station 3757a.

1



1a

1b

2

2b

2a

THE MANZANO FAUNA

GENERAL INDEX.

INDEX OF FOSSILS.

Names in *italic* are synonyms; figures in *italic* denote illustrations; figures in **black face** indicate descriptions.