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...The Texan Permian and its Mesozoic types of fossils...1891.

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WASHINGTON, D. C., *December*, 1890.

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UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

THE TEXAN PERMIAN

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BY

CHARLES A. WHITE

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CONTENTS.

ILLUSTRATIONS.

LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF MESOZOIC INVERTEBRATES,
Washington, D. C., November 21, 1890.

SIR: I herewith transmit manuscript and drawings for a bulletin of the Survey. A noteworthy feature of this brief memoir is the announcement of the commingling in one and the same stratum of fossil forms such as usually have been regarded as characteristic of Mesozoic strata with those which have been regarded as equally characteristic of Paleozoic strata.

The facts herein recorded indicate that extreme caution ought to be used in assigning certain formations to a predetermined geological horizon, especially those which lie upon the confines of recognized systems. They also suggest that some revision of former conclusions as to the true geological age of certain North American formations may be necessary.

Very respectfully,

C. A. WHITE,
Geologist in charge.

Hon. J. W. POWELL,
Director.

SYNOPSIS OF RESULTS.

In this bulletin is presented a summary of the various kinds of evidence that properly may be accepted as indicating the Permian age of a certain series of strata in western Texas, which have been by some geologists referred to the Trias, and by others to the Permian.

It also contains an announcement of the discovery in those strata of certain types of invertebrate fossils which usually are regarded as indicative of their Mesozoic age, commingled with a considerable number of Carboniferous types. A large proportion of the latter forms are well known Coal-Measure species.

All these species are illustrated on accompanying plates, and some of them are described as new. This discovery is the first of the kind that has been published concerning North American strata, but it is similar in character to those made by Waagen in India, Gemmellaro in Sicily, and Karpinsky in Russia.

The paleontological balance which is indicated by this commingling of earlier and later types in the Texan strata is treated as an item of evidence in favor of their Permian age.

The closing portion of the bulletin is devoted to a general discussion of the subject of the existence of the Permian in North America.

THE TEXAN PERMIAN AND ITS MESOZOIC TYPES OF FOSSILS.

By Charles A. White.

INTRODUCTION.

In the autumn of 1887, Mr. W. F. Cummins, Assistant State Geologist of Texas, placed in my hands a small suite of fossil shells which he had collected in Baylor and Archer Counties, in northern Texas, from the strata which furnished the large Permian vertebrate fauna that has been published by Prof. E. D. Cope.[1] A part of these shells I recognized as belonging to well known Coal-Measure[2] species; but among them were some unpublished forms which belong to types that strongly suggest their Mesozoic age. Mr. Cummins nevertheless assured me that they all came from the strata just mentioned, and that all the Mesozoic forms were found commingled in one and the same stratum with the greater part of the Coal-Measure species referred to. Although I had no reason to doubt either Mr. Cummins's statement or the accuracy of his observation, I was gratified upon beginning their study to find among the fossils themselves satisfactory evidence that they were really commingled in one and the same stratum. That is, upon examining the specimens under a lens I found the stony matrix of all of them to be of the same character, and I also discovered in the material adhering to them and filling their cavities numerous shells of a small ostracoid crustacean, which in this bulletin is referred to the *Cythere nebrascensis* of Geinitz, and which evidently formed a part of the same fauna as the mollusca with whose shells they were found associated.

The world has become familiar with Prof. W. Waagen's great discovery in the strata of the Salt Range in India of numerous molluscan forms of Mesozoic type commingled with a characteristic Carboniferous fauna;[3] and about two years ago Prof. G. G. Gemmellaro published

[1] See Systematic Catalogue of the Permian Vertebrate Fauna of North America. Trans. Am. Philos. Soc. 1888, vol. 16, pp. 285–288.

[2] The term Coal Measures is now often applied to the Mesozoic coal-bearing strata of western North America, but it is the middle division of the Carboniferous system that is here referred to.

[3] See Mem. Geol. Surv., India; Paleont. Indica, ser. XIII, Salt Range Fossils.

results of a similar discovery in Sicily, which evidently rivals that of India.[1]

The small collection of fossils which was obtained by Mr. Cummins seemed to indicate that we have in the upper part of the Carboniferous system in North America a commingling of Mesozoic and Paleozoic forms similar to that which has been discovered in India and in Sicily. The importance of such a discovery on this continent was so obvious that I decided to visit the locality from which the fossils were obtained and to make observations in person before publishing the discovery. Therefore, in the autumn of 1888, in company with Mr. Cummins, I examined a considerable part of the region in which the formation occurs and made important additions to the fossil collections which were before obtained. The principal results of that examination, together with other relevant matter, are recorded in this bulletin.[2]

The formation from which these Texan fossils were collected is the one which, upon the geological map compiled from previously published works by Mr. W. J. McGee,[3] as well as the one by Prof. C. H. Hitchcock,[4] is represented as Triassic; but, so far as I am aware, it has never been claimed by those who have so referred it that any Triassic fossils have been found in it. It is also the same formation that has for a number of years been referred to the Permian by Prof. Cope, who claims that its vertebrate fauna fully warrants such a reference. Although composed of ordinary sedimentary strata it is a copper-bearing formation, certain layers of it having long been known to contain considerable quantities of copper ore in the form of nodules and small xyloid masses. The former are composed of chalcocite, coated with a film of malachite, and the latter of melaconite, combined with which is some chloride of copper.[5]

A large part of the vertebrate fossils which Prof. Cope has published

[1] See Giornale di Sci. Nat. ed Econom., vol. 19, 1888. La Fauna dei Calcari con Fusulina della Valle del Fiume Sosio nella Provincia di Palermo: per Gaetano Giorgio Gemmellaro; pp. 2-106, Tav. A and I-X. After the manuscript of this bulletin had gone to the printer I received two important publications of a character similar to that of those which have just been referred to. The first is by Mr. A. Karpinsky, concerning certain Carboniferous strata in Russia. See Ueber die Ammoneen der Artinskstufe, etc., Mém. l'Acad. Imp. Sci. de St. Pétersbourg, VII[e] serie, tome 37, No. 2. The other is the second publication of Prof. G. G. Gemmellaro concerning the fauna of the Fusulina limestone of Sicily. See I Crostacei dei calcari con Fusulina della valle del fiume Sosio, vol. 8, series 3, No. 1, Mem. Soc. Italiana delle Scienze.

[2] Soon after this Texan discovery was made I published an article concerning it, with descriptions of some of its fossils, in the American Naturalist, vol. 23, pp. 109-128. Professor Gemmellaro's work had not then reached me, which accounts for the fact that it was not noticed in that article.

[3] See Fifth Annual Report Director U. S. Geological Survey.

[4] See Geol. Map U. S. and part of Canada; compiled by C. H. Hitchcock for the Amer. Inst. Mining Engineers, 1886.

[5] These qualitative determinations were made by Mr. W. S. Yeates, of the U. S. National Museum. The ores are found in Archer, and several other contiguous counties of Texas, and occur in friable sandy and clayey layers among strata which, unlike the Kupferschiefer of Germany, contain very little carbonaceous matter. They are not found in either true or gash veins, but the small masses of nearly pure ore are sporadically distributed in the soft, unaltered sedimentary layers of that part of the Texan Permian which is represented by No. 4 of the descriptive section, on page 15. Some years ago two companies were formed to mine these ores, but both of them soon suspended operations because they were unprofitable.

from this formation were collected by Mr. Cummins who, in making those collections and in other ways, has gained much information as to its character and extent in Texas and the Indian Territory. As my own observations have extended over only a part of the area which the formation is known to occupy in Texas, the following statements concerning its boundaries and extent are based mainly upon information derived from him.

In Texas this formation occupies an area many hundred square miles in extent, which constitutes the western part of the southern extension of the great central Paleozoic region of the continent. The southern boundary of this area is not now definitely known, but it lies at least as far south as the Concho River. Its eastern boundary may be approximately designated as extending from Red River to the Colorado through Clay, Young, Shackelford, Callahan and Runnels Counties; and its western border as extending from the Canadian River to the Concho through Hemphill, Wheeler, Donley, Briscoe, Motley, Dickens, Garza, Borden and Howard Counties. The formation is known to extend far within the Indian Territory, but in this bulletin special reference is made only to that portion of it which is found in Texas; and the description which is herein given is mainly drawn from observations made in Baylor, Archer, and other contiguous counties.

The strata in question rest directly and conformably upon another series in which a characteristic fauna of the Coal-Measure period prevails, but this Coal-Measure fauna is now not known to include any fossils of Mesozoic types, if we except the *Ammonites parkeri* of Heilprin, which he states was obtained from the Carboniferous rocks in Wise County.[1]

Notwithstanding the Mesozoic character of a part of the molluscan fauna of the upper strata the preponderance of evidence makes it necessary to regard it as belonging to the great Carboniferous system and as constituting an upper member of it. For these and other reasons yet to be stated I think this Texan formation may properly receive the designation of Permian which Prof. Cope has already applied to it, but I shall briefly discuss in the following paragraphs the propriety of using that name for at least the greater part of the North American strata to which it has been applied.

The Texan Permian, while not contrasting strongly with the Coal-Measure formation which underlies it, is readily distinguishable from it by general aspect and lithological character; and yet the Permian strata blend so gradually with those of the underlying Coal Measures and with the overlying gypsum-bearing beds, which are presently to be noticed, that it is difficult to designate a plane of demarkation in either case.

The Permian strata consist of materials which are somewhat difficult to characterize, but in a general way they may be described as consist-

[1] See Proc. Acad. Nat. Sci. Philad. 1884, vol. 36, pp. 53-55.

ing mainly of sandstones and sandy and clayey shales, which are sometimes calcareous, with here and there a few layers of impure limestone besides one somewhat persistent limestone horizon which has been observed in Baylor and Archer Counties. A common characteristic of many of the layers is the presence of an abundance of small, hard, rough concretions which usually become separated and accumulate upon weathered surfaces as the imbedding clayey material is removed by erosion, when they often present the appearance of a disintegrated coarse conglomerate. The observer is impressed with the prevailing reddish color of the whole formation, and during the rainy season the waters of the streams which traverse it are reddened by the abundant ferruginous clayey sediment which they receive as a product of erosion. This circumstance has given origin to the names of Red and Colorado Rivers, both of which traverse the Texan Permian.

The stratification is generally more or less regular, but in the district here specially referred to the formation contains comparatively few compact, evenly bedded strata. Because of this, and also because the strata have in this district been only slightly disturbed since their deposition, few striking features in the landscape occur. That is, the district is comparatively a plain country, the surface of which, in the general absence of forests, is diversified only by shallow valleys of erosion and low hills of circumdenudation, with here and there a hill or bluff of like origin which reaches a height of one or two hundred feet above the general level. From the top of these higher elevations extended landscape views may be obtained, which are of much advantage in the study of geological structure in that region.

Because of the slight disturbance which the Permian strata have suffered in the district referred to, and the general absence of bold escarpments, it is difficult to arrive at an accurate measurement of the thickness of the formation, but it is estimated at 1,000 feet. By distant view from the hills before mentioned, a general dip of the whole formation toward the west is plainly discernible. It is from a succession of such observations of the dip, together with measurements of the thickness of exposed strata and estimates of that of the unexposed, that the foregoing estimate of the thickness of the formation has been made.

A list of all the species of invertebrate fossils that have been discovered in the Texan Permian is given on a following page. A full list of the vertebrate species from the same formation has been published by Prof. Cope,[1] but no determinations of its fossil plants have yet been made known. Prof. Cope's list comprises 10 species of fishes, 11 of batrachians, and 33 of reptiles; making 54 species in all.

The full thickness of the Coal-Measure series in Texas is not yet known, its base not having been observed; but the portion that has been examined reaches an estimated thickness of 1,800 feet. The strata

[1] See Trans. Am. Philos. Soc. 1888, vol. 16, pp. 285–288.

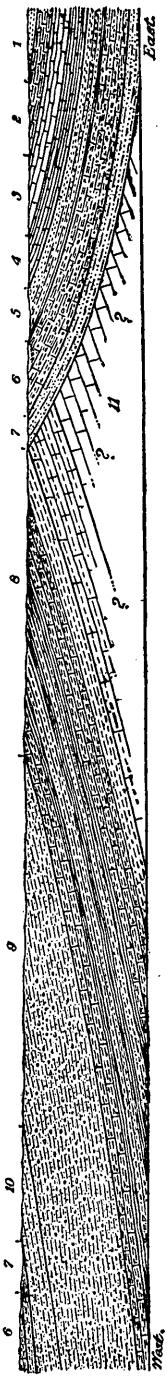
are generally somewhat evenly bedded and consist of bluish and gray limestones, gray and ferruginous sandstones, bluish and dark carbonaceous shales and clays; and several coal horizons are now known to exist there.[1] These strata have furnished at numerous localities and in greater or less abundance such characteristic Coal-Measure invertebrates as the following: *Terebratula bovidens* Morton, *Spirifer cameratus* Morton, *Athyris subtilita* Hall, *Productus cora* d'Orb., *P. nebrascensis* Owen, *P. costatus* Sowerby, *P. semireticulatus* Martin, *Hemipronites crassus* Meek & Hayden, *Myalina subquadrata* Shumard, *Allorisma subcuneata* M. & H., *Nuculana bellistriata* Stevens, *Pleurotomaria tabulata* Conrad, *Bellerophon carbonarius* Cox, *B. percarinatus* Conrad, and *Macrocheilus ponderosus* Swallow. Many other species have also been found associated with those which have just been named, but the latter are quite sufficient to characterize the strata containing them as belonging to the Coal-Measure series.

Along the western boundary of the Texan Permian, as it has been characterized in preceding paragraphs, a series of strata, about 250 feet in maximum thickness, now generally known as the gypsum-bearing beds and thought by some geologists to be of Triassic age, rests conformably upon the Permian. In general aspect, in a prevailing reddish color, and in general lithological character, except in the prevalence of gypsum in many of the layers, and the somewhat greater prevalence of clayey material, these overlying beds resemble the Permian strata upon which they rest. With only one known exception, these gypsum-bearing beds have furnished no fossils. The exception referred to is the discovery by Mr. Cummins in Hardeman County, in an upper stratum of those beds, of a thin magnesian layer containing numerous casts of a species of *Pleurophorus*. This being generally regarded as a characteristic genus among Permian molluscan faunas, and also being a prevailing form in the Permian strata beneath these gypsum-bearing beds, the question is suggested whether the latter ought not to be regarded as constituting an upper part of the Texan Permian. These beds have yet furnished no fossils which can with propriety be referred to the Trias, and it is questionable whether any Triassic strata exist in Texas.

It will be seen from the foregoing remarks that there is in the part of northern Texas to which special reference has been made a great conformable series of strata which has a gentle general dip toward the west, and which includes the strata that in this bulletin are referred to the Permian. It is overlain only by the débris resulting from its own disintegration except along the eastern and western bordersof the region which it occupies, where Cretaceous formations lap upon it. This overlapping conceals its base, but the estimated thickness of the whole series, so far as it is exposed to view, is 3,050 feet. The lower 1,800 feet, together with an unknown thickness beneath, is referred to the Coal Measures. The next overlying 1,000 feet of strata are referred to

[1] Mr. Cummins informs me in a letter that he has distinguished no less than nine coal horizons.

the Permian; and the upper 250 feet of the whole series, commonly known as the gypsum-bearing beds, probably constitute the upper part of the Permian.



The Cretaceous strata referred to rest unconformably and with a contrary dip upon the earlier, eastern portion of the whole series, while upon the later, western portion of it they rest with apparent conformity, although their real conformity may well be questioned because the Jura seems to be entirely wanting there.

The relation of the parts of this great series to one another and their relation to later formations is illustrated by the accompanying section, Fig. 1. The dips are, of course, exaggerated in the figure by the difference between its horizontal and vertical scales.

FIG. 1.—*Horizontal section from the eastern part of Navarro County to Swisher County, Texas.*

1. Lignitic Beds.....Tertiary.
2. Ripley Formation.....Cretaceous.
3. Austin Formation.....Cretaceous.
4. Eagle Ford Formation.....Cretaceous.
5. Timber Creek Formation.....Cretaceous.
6. Comanche Series.....Cretaceous.
7. Trinity Formation[1].....Cretaceous?
8. Coal Measures.....Paleozoic.
9. Permian.....Paleozoic.
10. Gypsum-bearing Beds.....Paleozoic?

As already stated and illustrated by the accompanying figure, the Cretaceous strata appear to rest conformably upon the gypsum-bearing beds at the western end of the section, and the latter beds lie quite conformably with the Permian and Coal Measures beneath, all having a westward dip. On the contrary, in the district embracing the eastern end of the section, all the overlying formations from the Trinity to the Eocene, inclusive, have an easterly dip and seem to lie unconformably with the Coal Measures and Permian. For want of positive evidence upon this point, however, it is not certain that the Coal-Measure and Permian strata do not finally dip toward the east beneath the Cretaceous formations, forming there an anticlinal axis.

Having shown the stratigraphical relation of the Texan Permian with other formations in the same region, the former only need be further considered. The following descriptive section of those strata is taken from Mr. Cummins's field notes, but it has been in large part verified by my own personal observations. The different members of the section, which are indicated

[1] The name Dinosaur Sands was formerly used for this formation. See Proc. Acad. Nat. Sci. Phila., 1887, pp. 39-47.

by consecutive numbers, are not distinctly definable from one another, but the section is presented in this form for convenience in referring to the respective horizons at which collections of fossils have been made.

Descriptive section of the Texan Permian.

1. Reddish and mottled sandy clays with layers of sandstone.
2. Variously colored clayey and sandy concretionary strata with a few irregular layers of impure concretionary limestone, a stratum of grayish blue limestone being usually observable near the middle of the member in Baylor and Archer Counties.
3. Sandstones, alternating with clayey and sandy concretionary layers, and with a few fine-grained, siliceous layers.
4. Reddish and buff colored clayey and sandy shales with occasional layers of sandstone.
5. Sandstones and sandy shales with beds of reddish sandy clays, passing gradually into the Coal Measures beneath.

The vertebrate remains, which by their faunal characteristics Prof. Cope confidently refers to the Permian, occur at numerous localities and at many horizons from the base to the top of the section; but invertebrate remains have hitherto been discovered only in strata which are included in numbers 2 and 3 of that section. The lowermost known horizon at which invertebrates occur is about 400 feet above the base of the series, and the uppermost is about as much below the top of the same; that is, the invertebrate fossils described and figured in this bulletin come from the middle 200 feet in thickness of the Permian series as it has just been defined.

The localities at which these fossils were obtained, only three in number, are in Baylor and Archer Counties, and as the greater part of the district is still unsettled, they can be designated only in an indefinite way. The first of these localities, which is in the northwestern corner of Archer County, will be designated as "Camp Creek." The second one is in Baylor County, near the middle of its eastern boundary line, and will be designated as "Godwin Creek." The third is in the northeastern part of Baylor County, near where the now unused military road, constructed by General Earl Van Dorn, crossed the Big Wichita River. This locality is by the settlers of that region called the "Old Military Crossing," but it will in this bulletin be designated as the Military Crossing of the Big Wichita, or simply as the Military Crossing. The strata of the two first mentioned localities occur in No. 3 of the foregoing descriptive section of the Permian, and those of the last named one in No. 2 of the same.

The following is a list of all the invertebrate species which are now known to have been found in the Texan Permian, all of which are discussed on succeeding pages and illustrated on the accompanying plates. The list is presented in tabular form for the purpose of giving a synoptical view of the invertebrate fauna so far as it is at present known, and also to indicate the localities at which the respective species have been discovered, as well as their interassociation there.

As to the latter condition, it is proper to state that specimens of all the species found at the locality which is indicated at the head of the following list as the "military crossing" were collected by myself from a single stratum, where they were so commingled as to leave no room for doubt that they were all members of one and the same fauna, nor any that they all lived contemporaneously. Specimens of the greater part of the other species were also collected by me at the localities indicated. When not collected by myself the fact will be mentioned in connection with remarks upon the respective species.

List of invertebrate species from the Texan Permian.

	Camp Creek.	Godwin Creek.	Military Crossing.
1. Goniatites baylorensis n. s			×
2. Waagenoceras cumminsi White			×
3. Medlicottia copei W			×
4. Popanoceras walcotti W			×
5. Orthoceras rushensis McChesney?			×
6. Nautilus winslowi Meek & Worthen			×
7. N. occidentalis Swallow			×
8. N. ——?			×
9. N. ——?		×	
10. N. ——?			×
11. N. (Endolobus) ——?			×
12. Naticopsis remex W		×	×
13. N. shumardi McChesney?		×	
14. Euomphalus subquadratus M. & W			×
15. E ——?			×
16. Murchisonia ——?		×	×
17. Patella ——?		×	
18. Bellerophon crassus M. & W		×	×
19. B. montfortianus Norwood & Pratten		×	
20. B. ——?			×
21. Sedgwickia topekaensis Shumard sp		×	
22. Pleurophorus ——?		×	
23. Clidophorus occidentalis Geinitz		×	
24. Yoldia? subscitula Meek & Hayden		×	
25. Myalina permiana Swallow	×	×	×
26. M. aviculoides M. & H		×	
27. M. perattenuata M & H	×	×	×
28. Gervillia longa Geinitz		×	
29. Aviculopecten occidentalis Shumard			×
30. Syringopora ——?	×	×	
31. Spirorbis ——?			×
32. Cythere nebrascensis Geinitz			×

SUMMARY.

		Species.
Mollusca	Cephalopoda	11
	Gasteropoda	9
	Conchifera	9
Articulata	Vermes	1
	Crustacea	1
Radiata	Polypi	1
Total		32

By reference to the foregoing list of species, and especially to the summary at the end of the list, it will be seen that the invertebrate

collections which have hitherto been made from the Texan Permian do not represent a fauna in its usual proportions, either as regards the classes and families to which the species of the list respectively belong, or as regards the classes and families which are usually expected to be represented in a Permian fauna. This is especially true when we compare these collections with Permian faunas already known in other regions. For example, it will be seen that the Cephalopoda are in unusually large proportion, that the Brachiopoda and Polyzoa are absent, and that the Polypi are represented by only a single species. In short, it is plain that the invertebrate fauna which existed during the period in which the Texan Permian was deposited, and in the same or in contiguous waters, is imperfectly and disproportionately represented by these collections.

Some of the causes of the imperfection and disproportion referred to are too plainly apparent to need comment, and others are suggested by the lithological and stratigraphical character of the formation in which the remains are found. Besides the inevitable causes of imperfect representation of extinct faunas by their remains, a conspicuous reason for the imperfection of these collections is that the formation has yet been carefully examined in only a small part of the large region which it is known to occupy, and exhaustive search for invertebrate fossils has yet been made at only a few of the localities which have been visited by competent collectors.

Again, there are few strata entering into the composition of the Texan Permian, where it has been examined, the character of which indicates that they successively formed the bottom of waters where a large proportion of then existing invertebrates could have found a congenial habitat. That is, sandy and other siliceous strata, as has already been shown, prevail in this formation, while calcareous strata are comparatively rare. It is true that certain families, especially of the mollusca, find a siliceous, sandy bottom, such as most of those strata doubtless formed, more congenial than a muddy or a calcareous one; but to far the greater part of such invertebrate faunas the latter kind of bottom, other conditions being favorable, is much the more congenial. In short, the lithological character of a formation often presents an obvious reason, not only for the comparative paucity of all invertebrate fossils in its strata, but even for the absence of representatives of certain families which we have every reason to suppose existed contemporaneously in other, not far distant, places and in more congenial waters.

But these collections, imperfect as they are, present subjects for consideration which are of far greater interest than that which attaches to a mere addition to our knowledge of a few of the forms which constituted the fauna of any given epoch or period, such, for example, as the relation which the fauna of one period in a given region bore to faunas which were presumably contemporaneous with it, and to those of the periods which immediately preceded and followed it, and the

indication which these fossils give as to the geological age of the strata containing them.

For the purpose of presenting the latter subject as conspicuously as possible all the invertebrate forms which have hitherto been discovered in the Texan Permian, whether new or already published, will be discussed on the immediately following pages and figured on the accompanying plates.

DESCRIPTION OF SPECIES.

MOLLUSCA.

CEPHALOPODA.

Genus GONIATITES de Hahn.

GONIATITES BAYLORENSIS sp. nov.

Pl. II, Figs. 1–3.

Shell apparently reaching a moderately large size; its transverse diameter less than that of the plane of its coil; volutions moderately embracing; the peripheral and lateral portions regularly rounded from the border of one umbilicus to that of the other; umbilici deep and somewhat narrow, but showing a portion of each of the inner volutions, their borders abruptly rounded inward from the sides; the transverse diameter of the volutions nearly three times as great as the dorso-ventral diameter, a transverse section of them showing a lunate outline. Living chamber and aperture unknown. Septa moderately distant from one another; dorsal lobe longer than wide, deeply divided into two narrow, lanceolate, slightly diverging branches; dorsal and superior lateral saddles linguiform and nearly equal in size; the two saddles separated by the superior lateral lobe, which is simple, slightly constricted at the middle, and acutely pointed; the inferior lateral lobe similar in shape to the superior, but a little shorter, and less distinctly constricted; inferior lateral saddle a little shorter than the others, somewhat irregular in shape, and occupying the margin of the umbilicus. Surface apparently unornamented.

The only specimen in the collection, when perfect, probably reached a diameter of coil of about 55 millimetres.

This species bears considerable resemblance to the *G. globulosus* of Meek & Worthen, but the septa of the Texan form have each one more lobe and saddle between the periphery and the margin of the umbilicus than have those of the other form.

Locality: Military Crossing of the Big Wichita, Baylor County, Texas.

Genus WAAGENOCERAS Gemmellaro.

WAAGENOCERAS CUMMINSI White.

Pl. I, Figs. 4–8.

Ptychites cumminsi White, Am. Naturalist, 1889, vol. 23, p. 117, Pl. 1, Figs. 4–8.
Compare with *Waagenoceras stachei*, Gemm. Gior. Sci. Nat. ed. Econ., vol. 19, 1888, p. 11, Pl. 1, Figs. 4–6, and Pl. 11, Figs. 3–4.

Shell compressed subglobose, transversely rounded on the periphery, and more broadly rounded on the sides; transverse constrictions appearing at irregular intervals upon casts of the interior of the shell; volutions so deeply embracing as to form small, narrow umbilici, the borders of which are narrowly rounded inward from the sides, and which show a small portion of each of the inner volutions; transverse section of the outer volution deeply crescentic. Surface apparently plain, but upon the border of the umbilicus in a couple of specimens fine revolving lines appear. Septa numerous and complex. The siphonal lobe large, deeply divided into two strongly digitate branches. The first lateral lobe is a little larger than a single branch of the siphonal lobe, but it is similarly digitate. The second and third lateral lobes are visible before the suture reaches the umbilicus, toward which the three lobes gradually decrease in size and complexity. Living chamber and aperture unknown.

The largest example in the collection indicates that it reached a diameter in the plane of the coil not less than 50 millimetres, but the living chamber is not shown in any of them. The figures on Pl. I of this bulletin are all of natural size. Those given in the American Naturalist are (loc. cit.) a little less.

Specimens representing about 40 individuals were found at the Military Crossing locality, all of which are imperfect, but the species has not yet been elsewhere discovered. The greater part of these specimens were collected by myself, and they were found in such association with the other species there as to leave no doubt that they were all members of one and the same fauna.

When I published this species in the American Naturalist (loc. cit.) I referred it to *Ptychites Mojsisovics*, Prof. Gemmellaro's work (op. cit.) not having then reached me. Upon comparing it with his description and figures it was plain that the Texan and Sicilian forms are congeneric. It is also plain that *Waagenoceras cumminsi* and *W. stachei* are closely related species.

Genus MEDLICOTTIA Waagen.

MEDLICOTTIA COPEI White.

Plate I, Figs. 1–3.

Medlicottia copei White, Am. Naturalist, 1889, vol. 23, p. 117, Pl. I, Figs, 1–3.

Shell thinly discoid, the sides gently convex; periphery narrow, having a moderately deep median groove; volutions so deeply embracing that only a small part of each of the inner ones is seen in the very narrow umbilici. Siphonal lobe long and slender, occupying the bottom of the peripheral groove, each side bearing four or five small indentations. External saddle very long and irregular in shape, in part occupying the ridge which borders each side of the peripheral groove, and in part overlain by the corresponding part of the next preceding external saddle. Five or six small denticles of nearly equal size are observable upon the side of the saddle within the peripheral groove, and seven or eight denticles of unequal length are seen upon the outer side. The other saddles are plain, linguiform or sublanceolate. The external lobe is stronger than any of the others, having two bifid branches, one directed backward in the curved line of the shell coil, and the other extending toward the periphery into the external saddle. The other lobes gradually diminish in size toward the umbilicus, most of which are bifid at the extremity; but the latter character does not appear upon small lobes of the inner portion of the volutions.

The largest example in the collection indicates a diameter of 60 millimetres; but as no trace of the living chamber is present, its full size is not known. The figures on Pl. I of this bulletin are of natural size. Those in the American Naturalist (loc. cit.) are a little less.

Three or four imperfect examples of this species were found at the Military Crossing locality, and one other near San Angelo, Tom Greene County, Texas. The latter locality is fully 150 miles from the former, which shows that the species had a considerable geographical distribution. This appears to be the only species of *Medlicottia* that has yet been found in North America, if we except an unpublished form from the Meekoceras beds of Idaho, which will doubtless fall either into this genus or Sageceras.

Genus POPANOCERAS Hyatt.

POPANOCERAS WALCOTTI White.

Pl. I, Figs. 9–11.

Popanoceras walcotti White, Am. Naturalist, 1889, vol. 23, p. 117, Pl. I, Figs. 9–11.
Compare with *Popanoceras multistriatum* Gemmellaro; Gior. Sci. Nat. ed. Econ. 1888, vol. XIX, p. 19, Pl. III, Figs. 1–5.

Shell discoid, periphery rounded; sides gently convex, the inner volutions almost wholly embraced by the next preceding one, and the

umbilici are consequently minute. Surface marked with numerous slightly raised and slightly sinuous radiating ridges, apparently indicating stages of growth, which extend continuously from one umbilicus to the other across the periphery. Septa, showing numerous short lobes and saddles, the former being simple and regularly rounded at the end, and the latter more or less notched or pointed at the extremity. Those near the periphery have sometimes three digitations, and those near the umbilicus are simple and more or less pointed. In full-grown examples the saddles are probably still more digitate.

Only one example of this species is known, which was found at the Military Crossing locality. The diameter of its coil is about 26 millimetres, all being occupied by the septa. The living chamber and aperture are therefore unknown. The figures given on Pl. I of this bulletin are of natural size; those given in the American Naturalist (loc. cit.) are a little less.

The close specific relationship of *Waagenoceras cumminsi* with *W. stachei* has been mentioned, and by comparing *Popanoceras walcotti* with *P. multistriatum* it will be seen that these two species are also closely related in all their observable characteristics, both suggesting a close relationship of the Texan and Sicilian faunas.

Genus ORTHOCERAS Breynius.

ORTHOCERAS RUSHENSIS McChesney?

Pl. II, Figs. 14–16.

Orthoceras rushensis McChesney, 1859, New Paleozoic Fossils, p. 68.
Compare with *Orthoceras* sp. undet. Meek & Worthen, Geol. Survey Illinois, 1873, vol. 5, Pl. xxx, Fig. 5.

The collection from the Military Crossing of the Big Wichita contains numerous fragments of shells belonging to the genus *Orthoceras*, which possibly represent more than one species, but much the greater part of them evidently belong to one and the same. Shells of this genus usually present too few salient characters for satisfactory specific discrimination, and this is especially the case with the fragmentary specimens of the collection now in hand. The external shell is present upon some of the specimens, but the surface shows none of the markings which characterize the *O. cribrosum* of Geinitz from Nebraska City. I have therefore referred the Texan form to McChesney's species, the type specimens of which were obtained from the Coal Measures of Indiana and Illinois.

Genus NAUTILUS Breynius.

NAUTILUS (TEMNOCHEILUS) WINSLOWI Meek & Worthen.

Pl. III, Figs. 1–5.

Nautilus (*Temnocheilus*) *winslowi* M. & W. Geol. Survey, Illinois, 1873, vol. 5, p. 609, Pl. XXXII, Fig. 2.
Compare with *N.* (*T.*) *latus* M. & W., ib., p. 608, Pl. XX, Fig. 2.

A considerable number of imperfect specimens and fragments of a species of *Nautilus* occur among the fossils obtained at the Military Crossing of the Big Wichita, which are referred to the *N. winslowi* of Meek & Worthen. Although these specimens vary in certain respects from the type specimens as figured and described by the authors, they vary quite as greatly among themselves. These as well as other specimens indicate that the species is a very variable one, and its variability is believed to be so great as to include the *N. latus* of the same authors. The variability is observable in the different degree of acuteness of the lateral revolving angles, the prominence and shape of the nodes upon them, the difference of the convexity of the peripheral side, etc. The Texan specimens are also all smaller than the type specimens of *N. latus* and of *N. winslowi* respectively. Both the latter are from the Coal Measures of Illinois.

NAUTILUS OCCIDENTALIS Swallow.

Pl. II, Figs. 11, 12.

Nautilus occidentalis Swallow, Trans. St. Louis Acad. Sci., 1860, vol. 1, p. 196.
Nautilus biserialis Hall, Geology of Iowa, Supp., p. 92.

Some fragments, evidently belonging to this species, occur among the collections made at the Military Crossing of the Big Wichita. This species was originally described as coming from Permian rocks in Kansas, but it was afterward recognized as a common fossil in the Coal Measures of Illinois and Iowa.

NAUTILUS ——— ?

Pl. III, Figs. 6–8.

Compare with *N. eccentricus* Meek & Hayden, Palaeont. Upper Missouri, Smithson. Cont., 172 (1865), p. 65, Pl. II, Figs. 14*a*, 14*b*.
Also with *N. chesterensis* Meek & Worthen, Geol. Survey Illinois, 1866, vol. 2, p. 306, Pl. XXIV, Figs. 4*a*, 4*b*.

Associated with all the foregoing species are many examples of a small, plain *Nautilus*, which are too imperfect to be either satisfactorily described or identified with any published species. They may be compared with the two forms above cited, the first of which is from reputed Permian strata in Kansas, and the other from the Chester limestone, the uppermost member of the Lower Carboniferous group of Illinois.

NAUTILUS ——— ?

Pl. II, Figs. 7–10.

A couple of fragments of a plain subglobose *Nautilus* were found at the Godwin Creek locality, which are too imperfect for specific characterization, but they evidently belong to a different species from any of the foregoing, and it is also larger than the one last noticed.

NAUTILUS ——— ?

Pl. II, Figs. 4–6.

A few fragments of a discoid *Nautilus* were found at the Military Crossing locality which I am not able to refer to any published species, but which is similar in form and structure to *N. gravesianus* d'Orb., Pal. Française, Ter. Jur., 1850–'60, vol. 1, Atlas, Pl. XXXVIII.

NAUTILUS (ENDOLOBUS) ——— ?

Pl. II, Fig. 13.

The collections made at the Military Crossing locality contain a single fragment of a Nautiloid species, which is too imperfect for characterization further than to say that the septa show a small lobe, such as forms the leading feature of *Endolobus*, Meek & Worthen.

GASTEROPODA.

Genus NATICOPSIS McCoy.

NATICOPSIS REMEX White.

Pl. III, Fig. 10.

Naticopsis remex White 12th Ann. Rept. for 1878, U. S. Geol. Survey Terr., 1883, Part I, p. 139, Pl. XXXIV, Fig. 6.

Some internal casts of this species were found at both the Military Crossing and Godwin Creek localities. The type specimens of the species were obtained from the junction of the Grand and Green Rivers in Utah, from Carboniferous strata that are probably equivalent to the Coal Measures.

NATICOPSIS SHUMARDI McChesney.

Pl. III, Fig. 11.

Naticopsis shumardi McChesney, 1868, Trans. Chicago Acad. Sci., vol. 1, p. 49, Pl. II, Fig. 15.

Several specimens of *Naticopsis* were found at the Godwin Creek locality which seem to answer McChesney's description and figures of *N. shumardi* too nearly to warrant their reference to any other species. The type specimens of the species were obtained from Coal-Measure strata at La Salle, Illinois.

Genus EUOMPHALUS Sowerby.

EUOMPHALUS SUBQUADRATUS Meek & Worthen.

Pl. III, Fig. 9.

Euomphalus subquadratus M. & W., 1873, Geol. Surv. Illinois, vol. 5, p. 605, Pl. XXIX, Figs. 12, 13.

Several specimens of this species were found at the Military Crossing locality. The type specimens of the species were found in the Coal Measures of Illinois.

EUOMPHALUS ——— ?

Associated with the foregoing species some fragments of a shell were found which evidently belong to a species of *Euomphalus* different from the preceding; but they are too imperfect to admit of specific characterization.

Genus MURCHISONIA d'Archiac.

MURCHISONIA ——— ?

Pl. III, Figs. 12, 13.

Compare with *Murchisonia terebra* White, 12th Ann. Rept. for 1878 U. S. Geol. Surv. Terr., 1883, Part I, p. 139, Pl. XXXIV, Fig. 4.

The collection from the Military Crossing locality contains numerous examples of a *Murchisonia* all of which are in a bad state of preservation, and most of which are in the condition of casts of the interior of the shell. Enough of the shell substance, however, remains upon a part of them to show the form and ornamentation, the latter being quite variable. In the form of the shell and its volutions these specimens closely agree with *M. terebra* (loc. cit.), and some of the specimens vary but little from it in ornamentation. Others, however, show subordinate crenulated revolving ridges between the prominent peripheral ridge and the suture. The Texan shell is probably only a variety of *M. terebra*, the type specimens of which were obtained from Carboniferous strata in northern Arizona.

Genus PATELLA Linnæus.

PATELLA? ——— ?

Pl. III, Fig. 14.

Compare with *Patella levettei* White, Geol. Indiana for 1881, p. 359, Pl. XXXIX, Figs. 4, 5.

Compare with *Leptopsis levettei* (White) Whitfield, Bull. Am. Mus. Nat. Hist., 1881–1886, vol. 1, p. 68, Pl. VIII, Figs. 8-12.

A single example of a Pattelloid shell was found at the Godwin Creek locality. In shape, size, and general character, it resembles the

shell from the Lower Carboniferous of Indiana which I described under the name of *Patella levettei;* but to which Prof. R. P. Whitfield afterward gave the generic name of *Leptopsis*. The Texan specimen, however, shows no indication of having had a coiled apex, and I therefore refer it provisionally to the genus *Patella*.

Genus BELLEROPHON Montfort.

BELLEROPHON CRASSUS, Meek & Worthen.

Bellerophon crassus, M. & W., Geol. Survey Illinois, 1886, vol. 2, p. 385, Pl. XXXI, Figs. 16*a*, 16*b*.

A couple of specimens of this species were found at the Military Crossing locality. They are too imperfect to be satisfactorily figured, but the specific characteristics are very well shown. The type specimens of the species are from the Coal Measures of Illinois.

BELLEROPHON MONTFORTIANUS, Norwood & Pratten.

Pl. III, Figs. 15, 16.

Bellerophon montfortianus, N. & P., Jour. Acad. Nat. Sci., Phila., 1855-1858, 2d ser., vol. 3, p. 74, Pl. IX, Fig. 5.

A single small example was found at the Godwin Creek locality, which is referred to the *Bellerophon montfortianus* of Norwood & Pratten with little or no hesitation. The type specimens were from the Coal Measures of Illinois, and it is not uncommon in strata of that age in adjacent States. It was also recognized by Prof. Geinitz among the Nebraska fossils, which he referred to the Dyas (Permian).

BELLEROPHON ———?

Many specimens of a moderately large *Bellerophon* were found among the fossils collected at the Military Crossing locality, all of which being in the condition of natural casts of the interior of the shell can not be satisfactorily figured and described. They seem to represent a different species from any of the others noticed in this bulletin.

CONCHIFERA.

Genus SEDGWICKIA McCoy.

SEDGWICKIA TOPEKAENSIS Shumard sp.

Pl. IV, Fig. 11.

Leptodomus topekaensis Shumard, Trans. St. Louis Acad. Sci., 1860, vol. 1, p. 208.

Sedgwickia topekaensis Meek & Hayden, Paleont. Upper Missouri (Smithsonian Cont., 172), 1865, p. 40.

At the Godwin Creek locality Mr. Cummins found a natural cast of the left valve of a shell which seems to be specifically identical with the form above indicated. The type specimens of the species which was used by both authors above cited were obtained from Coal-Measure strata in eastern Kansas.

Genus PLEUROPHORUS King.

PLEUROPHORUS ——?

Pl. IV, Figs. 5–10.

Natural casts of shells of *Pleurophorus* occur abundantly at the Godwin Creek locality. The extremes of difference in the form of these examples is so great that one can hardly forbear referring them at least to two species, but it is probable that the difference referred to is mainly that of sex, and in part that of age. Figures showing the principle varieties of form are given on Pl. IV. These specimens very likely represent one or more published species, but because of their imperfection no specific identification is attempted.

Genus CLIDOPHORUS McCoy.

CLIDOPHORUS OCCIDENTALIS Geinitz.

Pl. IV, Fig. 3.

Pleurophorus? occidentalis Meek & Hayden, Paleont. Upper Missouri (Smithsonian Cont., 172), 1865, p. 35, Pl. I, Fig. 2.

Clidophorus occidentalis Geinitz, Carbonformation u. Dyas in Nebraska, p. 23, Pl. II, Fig. 6.

Mr. Cummins obtained a single specimen at the Godwin Creek locality which seems to be identical with the form figured and described by Prof. Geinitz (loc. cit.).

Genus YOLDIA Möller.

YOLDIA? SUBSCITULA Meek & Hayden.

Pl. IV, Fig. 4.

Yoldia? subscitula Meek & Hayden, Paleont. Upper Missouri (Smithsonian Cont., 172), 1865, p. 60, Pl. II, Fig. 4.

Several specimens were obtained by Mr. Cummins at the Godwin Creek locality which closely answer the description and figure given by Meek & Hayden (loc. cit.). Their type specimen was obtained from reputed Permian strata in northeastern Kansas. There seems to be room for doubt whether this form ought not to be referred to the *Nucula* [*Nuculana*] *bellistriata* of Stevens, which is a common Coal-Measure species.

Genus MYALINA de Koninck.

MYALINA PERMIANA Swallow sp.

Pl. IV, Figs. 16–19.

Mytilus permianus Swallow, Trans. St. Louis Acad. Sci., 1860, vol. 1, p. 187.
Myalina permiana Meek & Hayden, Paleont. Upper Missouri (Smithsonian Cont., 172), 1865, p. 52, Pl. II, Fig. 7.

At the Camp Creek, Godwin Creek, and Military Crossing localities numerous specimens of *Myalina* were obtained which show a great variety of form, especially as regards marginal outline, but I think it not improbable that they nevertheless belong to one and the same species. Still the varieties that different authors have published under the respective names of *M. permiana*, *M. perattenuata*, and *M. aviculoides* are distinguishable among these Texan collections, and they will therefore be grouped under those three names respectively.

The form *M. permiana* was found at all three of the localities above named. The type specimens of both Swallow and Meek & Hayden were obtained from reputed Permian strata in Kansas.

MYALINA AVICULOIDES Meek & Hayden.

Pl. II, Fig. 12.

Myalina aviculoides M. & H., Paleont. Upper Missouri (Smithsonian Cont., 172), 1865, p. 51, Pl. II, Fig. 8.

A few specimens were found at the Godwin Creek locality, which have the outline and general features of the form to which Meek & Hayden gave the specific name of *aviculoides*. Their type specimens were obtained from the reputed Permian strata in Kansas.

MYALINA PERATTENUATA Meek & Hayden.

Pl. IV, Figs. 13–15.

Myalina perattenuata M. & H., Paleont. Upper Missouri (Smithsonian Cont., 172), 1865, p. 32, Pl. I, Fig. 12.

Specimens answering the original description of *M. perattenuata* were found associated with *M. permiana* at all three of the localities named in the foregoing notice of that form. Meek & Hayden's type specimens came from the Coal Measures of Missouri. It is not uncommon in the Coal Measures elsewhere.

Genus GERVILLIA Defrance.

GERVILLIA LONGA Geinitz.

Pl. IV, Fig. 2.

Gervillia longa Geinitz, Carbonformation u. Dyas in Nebraska, p. 32, Pl. II, Fig. 15. Compare with *Avicula shawneensis* Shumard, Trans. St. Louis Acad. Sci., 1860, vol. 1, p. 211.

Two specimens of an Aviculoid shell were obtained by Mr. Cummins at the Godwin Creek locality which are identified with the *Gervillia longa* of Geinitz, and they are perhaps identical with the *Avicula shawneensis* of Shumard. From an examination of the hinge of the Texan specimens the hinge area, although well developed and much like that of *Gervillia*, is found to bear no transverse cartilage pits, nor has the hinge proper any longitudinal teeth such as characterize *Gervillia*. The species is also known to occur in the Upper Coal Measures of different parts of the Mississippi Valley.

Genus AVICULOPECTEN McCoy.

AVICULOPECTEN OCCIDENTALIS Shumard sp.

Pl. IV, Fig. 1.

Pecten occidentalis, Shumard, First and Second Rept. Geol. Survey Missouri, 1865, part 2, p. 207, Pl. C, Fig. 18.

Pecton cleavelandicus Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 184. Compare with *A. coreyanus* White, U. S. Geog. and Geol. Surveys West of 100th Merid., vol. 4, Part I, p. 147, Pl. II. Figs. 1*a*, 1*b*.

A single example of the left valve of this well known species was found at the Military Crossing locality. It is frequently found in characteristic Coal-Measure strata, and it has also been published as occurring in the reputed Permian strata of Kansas and Nebraska.

RADIATA.

POLYPI.

Genus SYRINGOPORA Goldfuss.

SYRINGOPORA ——— ?

A considerable number of specimens of a species of *Syringopora* were found at both the Camp Creek and Godwin Creek localities. They resemble the *S. multattenuatus* of McChesney, from the Coal Measures of Illinois, but the tubes are usually smaller.

ARTICULATA.

VERMES.

Genus SPIRORBIS Lamarck.

Pl. III, Fig. 17.

Numerous specimens of *Spirorbis* were found attached to the surface of the other fossils which were collected at the Military Crossing locality. It is not thought necessary to give a specific diagnosis of it, but it is figured for the purpose of presenting as complete an illustration of the fauna as is practicable.

CRUSTACEA.

Genus CYTHERE Müller.

CYTHERE NEBRASCENSIS Geinitz.

Pl. IV, Fig. 20.

Cythere nebrascensis Geinitz, Carbonformation u. Dyas in Nebraska, p. 2, Pl. I, Fig. 2.

The fossiliferous stratum at the Military Crossing locality contains multitudes of a small *Cythere* which I can not separate specifically from the *C. nebrascensis* of Geinitz.

GENERAL DISCUSSION.

It will be seen from the foregoing descriptions and notes that of the thirty-two species of invertebrates which are represented in the collections from the Texan Permian only four are recognized as new, all of these being cephalopods, and all belonging to the family *Ammonoidea*. The other species have been previously described and published, or their specific identity with published forms is in doubt because of the imperfection, either of the specimens in hand or of the manner of describing the species which they probably represent. Fifteen of the species are satisfactorily recognized as having been previously published. A part of them have been by some authors referred to the Permian, but the Coal-Measure age of the remainder has never been questioned. Some authors are of the opinion that not only all of the fifteen species just mentioned, but all North American invertebrates which have ever been referred to the Permian are really members of the fauna which characterizes the Coal-Measure period. Indeed, so generally has this view prevailed during the last twenty years that it is probable if the new cephalopods before mentioned were not present in the Texan collections no American paleontologist who is familiar with the Coal-Measure invertebrate fauna would hesitate to refer them all to that period.

So large a proportion of the invertebrate species which have been obtained from the reputed Permian strata in North America occur also in characteristic Coal-Measure strata that no satisfactory separation of them into two groups has hitherto been practicable upon the evidence of invertebrate fossils, and stratigraphical evidence also has hitherto been unsatisfactory. The collections, however, which are represented by the foregoing list and descriptions, although consisting mainly of Coal-Measure forms, contain at least two types which are so generally regarded as indicating the Mesozoic age of the strata containing them that if they alone and without any statement of correlated facts had been submitted to any paleontologist he would not have been warranted in referring them to an earlier period than the Trias if he had followed the usually accepted standard of reference. These two forms have been described on preceding pages under the names of *Waagenoceras cumminsi* and *Popanoceras walcotti* respectively. With the exception of *Ammonites parkeri* Heilprin,[1] also from Texas, similar types have not before been found associated with recognized Carboniferous species in North America.

This, however, is by no means the first nor the most important discovery of Mesozoic and Paleozoic types so commingled as to indicate that they all lived contemporaneously, and that they were all members of one and the same fauna. The remarkable discovery by Prof. Waagen in India (op. cit.) of many molluscan species belonging to Mesozoic types and associated with a characteristic Carboniferous fauna is well known. It is also known that Mesozoic characters are recognizable among some of the Carboniferous and Permian cephalopods of Armenia, as well as of Russia and certain other parts of Europe; and the later discovery in Sicily by Prof. Gemmellaro (op. cit.) is, next to that by Prof. Waagen in India, the most important of its kind.[2] These discoveries will be presently further referred to, but I wish first to consider briefly the bearing of the Texan discovery upon the question of the existence of the Permian in North America.

The special interest which these Texan collections possess lies, first, in the presence of the two cephalopods of Mesozoic types as members of an invertebrate fauna composed otherwise of Paleozoic types; second, in the association of these invertebrates with a vertebrate fauna composed mainly of Permian types, as determined by Prof. Cope; third, in the known superposition of the formation containing these faunas upon characteristic Coal-Measure strata; and fourth, in the probable absence of the Trias in the region where the Texan Permian occurs. The first point of interest relates to the paleontological interdelimitation of the Mesozoic and Paleozoic, and the second and third to the assumed Permian age of the Texan formation from which the collections discussed in this bulletin were made. The fourth point of interest relates to the upper delimitation of the Texan Permian.

[1] Proc. Acad. Nat. Sci., Philad., 1884, vol. 34, p. 53.

[2] See first foot-note on p. 10.

The paleontological interdelimitation of the Mesozoic and Paleozoic ages in geological history has long been regarded as clearly recognizable in all parts of the world. While it was well known that a considerable number of generic forms, especially of the invertebrates, occur in strata of both ages respectively, paleontologists have generally regarded it as a fundamental fact that certain orders, families, and even genera, which possess certain characteristics of structure and form, were rigidly confined to each age respectively. That is, they believed that the types which fall into the one category all ceased to exist at the close of the Paleozoic age, and that no member of the other category began its existence before the opening of the Mesozoic age. The presence of remains belonging to either the one or the other of these categories was therefore regarded as affording unquestionable proof of the geological age of the strata containing them. Attempts were made to explain the first discoveries of the commingling of earlier and later types in one and the same stratum, by assuming that the specimens showing earlier types of structure were derived in an already fossil condition from preexisting strata in the process of their destruction by which the materials for new strata were produced.

However unphilosophical those views concerning the chronological restriction of certain types may appear in the light of modern biology, it is not to be denied that until within comparatively few years paleontological observations in the field seemed, as a rule, to favor them, but such discoveries as those which have been made in India, Sicily, Russia and Texas show conclusively that animals belonging to both categories which have just been indicated lived contemporaneously. They show that some of those forms which have been regarded as exclusively Mesozoic in character began their existence while yet Paleozoic forms were far in the ascendant, and also that many Paleozoic forms survived their earlier associates, and lived in association with Mesozoic faunas. In the following general remarks upon the reputed North American Permian reference will be made to the bearing which the presence of Mesozoic types in the Texan Permian has upon the question of its true geological age.

From time to time during the last 30 years there have been discussions among geologists as to whether there is in North America any true equivalent of the Permian formation of Europe. Some writers have been uncompromising in their advocacy of the affirmative side of this question, and others have been equally positive in asserting the negative. Much of this difference of opinion has arisen from imperfect knowledge of essential facts, and much from want of a clear definition by the respective writers as to what they have regarded as constituting equivalency in this case. Within the last few years much addition has been made to our knowledge of facts bearing upon this question, and it is evident that clearer views upon it are now generally held than formerly prevailed, but it is too much to expect that the views of all

geologists should even now fully agree. The following statement presents the condition of this question, as the writer understands it. It is given to enable the reader to understand more clearly his views, and the reasons for the conclusions and opinions which are expressed in this bulletin.

In Europe the Carboniferous system is understood to be divided into three great groups, namely, the Lower Carboniferous, the Coal Measures, and the Permian, which are definable from one another, not only by paleontological, but by stratigraphical, characteristics. In North America the great Carboniferous system is quite as largely developed as in Europe. The Lower Carboniferous and Coal-Measure groups, upon both stratigraphical and paleontological grounds are as clearly recognizable and distinguishable from each other in some parts of this continent as they are in Europe, but the Permian has hitherto had no such undisputed recognition. Therefore, the question now to be considered is, whether the Permian of Europe has really an equivalent anywhere in North America, and if so, how that equivalency is recognizable.

In North America seven regions may be designated within which strata occur that have been, by different authors, referred to the Permian. These are: (1) southwestern Pennsylvania and northern West Virginia, (2) Prince Edward Island, (3) eastern Illinois, (4) northeastern Kansas and southeastern Nebraska, (5) South Park, Colorado, (6) isolated portions of New Mexico, Arizona, Utah, and western Colorado, and (7) northern Texas, together with the adjacent part of Indian Territory.

In all these cases there seems to be no room for doubt that the strata in question are not older than the Upper Coal Measures, as that formation is distinguishable in North America; but aside from their evidently high position in the Carboniferous system their recognition as Permian has been based upon different kinds of evidence, respectively. In the first and second mentioned cases it was based wholly upon plant remains; in the third upon vertebrate remains; in the fourth upon invertebrate remains; in the fifth upon plants and insects,[1] and in the sixth mainly upon stratigraphical position. The evidence in favor of the recognition of the strata as constituting a separate formation in the seventh case is presented in this article.

Two diverse ideas seem to have prevailed in the minds of those who have considered the question of the recognition of the Permian in North America. On the one hand the discovery on this continent of remains belonging to generic or other types of vertebrate, invertebrate, or plant life, which are respectively similar to forms found in the European Permian, has been regarded by some authors as surely indicating in each separate case the Permian age of the strata containing them, even if they were without any knowledge of correlated facts,

[1] These insects have, however, been referred to the Trias by S. H. Scudder, although they are associated with, perhaps, the most characteristic Permian flora that has been discovered on this continent.

whether paleontological or stratigraphical, or they formed that opinion without regard to them if known. On the other hand, it has been contended that no definite recognition of the Permian, even in the first-mentioned cases, ought to be made until after due consideration of all obtainable correlated paleontological and stratigraphical facts; and not then unless the preponderance of all that evidence should plainly favor such recognition.

The untenableness of the position indicated in the case first stated is shown by the facts mentioned in preceding paragraphs of the occurrence in one and the same stratum of forms which have been held to be characteristic of separate geological periods, and even of separate ages. It is conspicuously shown in the case of the Texan formation, which is specially discussed in this bulletin, because both its Coal-Measure age and its Triassic age can be even more readily proved, in an ex parte way, by special selections from its fossils, than its Permian age. And yet the sum of all the evidence is in favor of the latter.

The following paragraph from the work of Profs. William M. Fontaine and I. C. White[1] tersely states the principle which ought to govern the investigator in these cases, although it was written only with reference to the Permian age of the flora which they were then investigating:

> It is good evidence that we have to deal with a more recent formation when we find it to show a decadence of old forms and an introduction of new ones destined to reach their culmination at a later period. Thus if we find in a series of rocks plants characteristic of the Carboniferous formation, and perceive that these die out and disappear, we should not conclude from their mere presence that the age of the strata is Carboniferous, but rather that it is Permian. So also the finding of genera and species, even identical with those of the Trias or Jurassic would not necessarily imply a Triassic or Jurassic age. If we find them to be exceedingly rare, their presence is rather indicative of a formation older than the Trias or the Jurassic.
>
> It is only by taking into consideration all the above-named characters, and other points which may be presented by the entire body of specimens, that we can determine the nature of the evidence offered by the life of a formation. It will not suffice to say arbitrarily that this or that feature is without value as evidence. Circumstances might reverse the normal relative weight of evidence from the several sources and give preponderating weight to what would, if unaffected by them, have slight value.

Besides the observance of the principle enunciated by those authors, the investigator should remember the entire improbability that forms representing any distinguishing faunal or floral type have ever been simultaneously introduced in all parts of the world, and the now no less evident fact that forms representing certain types in some parts of the world long survived their extinction in other parts. He should also bear in mind the now evident fact that the rate of progressive development of vertebrate, invertebrate, and plant life respectively has not been uniform in all parts of the world. It therefore ought not to

[1] Permian or Upper Carb. Flora of West Virginia and S. W. Pennsylvania. Second Geol. Survey Pa., Rept. Prog. PP. 1880, pp. 109, 110.

be expected that precisely the same association of types would be found on this continent that is found in Europe and elsewhere.

The difference of opinion which has prevailed concerning the existence of the Permian in North America has been shared even by those who recognize the importance of considering all the facts which bear upon each case of assumed equivalency of North American strata to the Permian of Europe. Some have believed that it should be strictly chronological as regards the whole of a given formation, while others claim that the most we can reasonably assume in any case is approximate contemporaneity, and all that we can ever certainly know in such cases is the homotaxial relation of formations with one another in different parts of the world, respectively. The scope of this bulletin, however, will admit of only a partial discussion of those views.

If all the time which is represented by the entire Carboniferous system in Europe is represented by the entire Carboniferous system of North America, the Permian of Europe must necessarily have a complete time equivalent somewhere on this continent. If that system is everywhere incomplete at the upper limit on this continent, and the same is complete in Europe, it necessarily follows that the stratigraphical time equivalent of the European Permian is either absent or incomplete in North America. But all the known facts which bear upon this case are of such doubtful value in their application to the question of strict chronological equivalency that it seems to be unprofitable to discuss it. Therefore the only question that remains to be considered in this connection is that of homotaxy.

The question, even after being reduced to these limits is a complex one, for it still involves the consideration of conflicting or disagreeing paleontological evidence, as well as a recognition of upper and lower delimiting boundaries of the formation. Besides this, formulary taxonomy has no real existence because geological systems are not subdivisible into the same, or even similar, units in widely separated parts of the world. Still there can be no good reason for doubting that there are in various parts of North America strata which are homotaxially equivalent, at least in part, to the Permian of Europe. But it is equally true that much of the reputed North American Permian can not be satisfactorily separated from the Coal Measures, and even those strata which have been separated more or less satisfactorily are found to be so intimately related to the Coal Measures as to make the lower limit indefinable.[2]

Heretofore also it has been impracticable to say whether the upper limit of the Carboniferous system in North America is complete or not. For example, none of the reputed Triassic strata, which occur in various

[2]In view of the last mentioned condition several American and European writers have applied the compromising term "Permo-carboniferous" to that undefinable upper portion of the Carboniferous system. Unfortunately, however, some American authors have of late applied that term to the whole Carboniferous series, seeming thereby to imply that the series includes an inseparable equivalent of the Permian, as well as of the remainder of the Carboniferous system.

parts of the continent, have been found in such relation to the reputed Permian as to indicate that there was continuous sedimentation from the one formation to the other; nor have those Triassic strata been found to contain any conclusive paleontological evidence of their immediate succession to the Permian. Indeed, as regards the remains of invertebrate life, the existence of any Triassic strata in North America rests upon comparatively slight evidence; slighter, indeed, than it might have seemed to be before the discovery of Triassic types associated with well known Carboniferous forms.[1]

The conflicting character of a part of the evidence afforded by the reputed North American Permian as to its age has already been shown, but there is an important case of want of harmony of different portions of certain accepted paleontological evidence that deserves mention. In Prof. Cope's Systematic Catalogue of the Permian vertebrate fauna of North America,[2] he shows that these remains have been discovered mainly in two limited districts, one in eastern Illinois and the other in Texas. His catalogue also shows that of the seventy-six species enumerated not one is, and of the thirty-two genera only five are, common to the two divisions. He also says that "the Permian vertebrate fauna of Illinois and Texas[3] exhibits close parallels, but not yet generic identity, on this continent."

On the contrary, the marine invertebrates which characterize the North American Coal Measures, a part of which usually range up into the reputed Permian, are widely distributed on this continent, and their geographical range includes both the Illinois and Texan vertebrate localities. That is, the invertebrate fauna referred to is uniform over a region in which the vertebrate fauna is diverse. In all the vertical and geographical range of these invertebrate fossils there has been observed no evidence of the decadence of old forms such as would be taken to indicate an approaching close to the geological period[4] which they have especially characterized; and it is only in the case of the Texan Permian that an introduction among them of new forms has yet been observed which might be regarded as forerunners of a new one.

Finally, while it is freely admitted that a considerable number of the

[1] The Triassic character of a part of the Permian fauna of Texas has been sufficiently stated, but it is also true that certain Carboniferous types occur in the Meekoceras beds of southeastern Idaho. Besides this those beds appear to have an intimate stratigraphical relation to the characteristic Carboniferous strata beneath them. Add to these facts the further one that types similar to those which have been relied upon in referring the Idaho beds to the Middle Trias also occur in undisputed Carboniferous strata, and it seems possible that those reputed Triassic beds ought to be referred to the Permian rather than to the Trias.

[2] Trans. Am. Philos. Soc., 1888, vol. 16, pp. 285–288.

[3] U. S. Geol. Survey Terr., 1884, vol. 3, p. 25.

[4] It has been pointed out by some authors that certain of the Brachiopods, and other species which characterize the Coal Measures, have never been found in any of the reputed Permian strata, and it seems to have been assumed that their absence was due to a final decadence of those forms before the Permian period was reached. It seems, however, not at all unreasonable to infer that intervening conditions differently affected certain of the classes of animals then living, in consequence of which they were differently dispersed.

invertebrate species which characterize the Permian of Europe have closely related representatives on this continent, it should not be forgotten that the latter are as characteristic of our undisputed Coal Measures as they are of the reputed Permian. Even if those forms are really specifically identical on the two continents it does not necessarily prove the contemporaneity of the respective formations containing them. In fact those formations must necessarily be of a difference in age equal to the time required by the geographical distribution of the species.

The recognition of the Permian in Texas as a separate upper group of strata belonging to the Carboniferous system is based upon both stratigraphical and paleontological evidence, and this evidence is fuller than that which has been adduced in favor of any other reputed Permian strata of North America. First, it contains invertebrate species which have been referred to the Permian in other districts northward from Texas, some of which are closely related to Permian species of Europe. Second, it contains the large vertebrate fauna published by Prof. Cope which he regards as characteristically Permian. Third, the Texan formation evidently constitutes an upper, apparently the uppermost, portion of the Carboniferous system. Fourth, the lithological difference between this formation as a whole and the Coal Measures beneath it, while not great, is sufficiently marked to make it conveniently distinguishable by the eye. Besides this the Mesozoic element which has been shown to exist among the invertebrates of the Texan Permian may properly be regarded as holding an opposite relation to the Paleozoic element, and thus to suggest a balance of paleontological evidence in favor of the Permian age of the formation.[1]

The present state of our knowledge, or of warranted opinion, as to the existence of the Permian formation in North America may be summed up briefly as follows:

Although in the region traversed by the Mississippi River the two earlier divisions of the Carboniferous system, namely, the Lower Carboniferous and the Coal Measures, are as clearly recognizable as they are in Europe, in many parts of this continent where Carboniferous strata are largely developed no separate recognition of either of those divisions, or of the Permian, is practicable.

In those regions where the Coal Measures or their equivalent are recognizable certain strata are sometimes found resting upon them which have been referred to the Permian, but those strata are, as a rule, not distinctly separable from the Coal Measures upon either stratigraphical or paleontological grounds. That is, no distinct stratigraphical plane of demarkation between the Coal Measures and the reputed Permian is observable. Besides this, many of the common Coal-Meas-

[1] It is admitted that the value of this suggestion is somewhat lessened by the known presence of the *Ammonites parkeri* of Heilprin in the underlying Texan Coal Measures, and by the presence of similar types beneath the Permian in certain parts of the Old World. Still, such forms as *Waagenoceras cumminsi* may properly be regarded as immediate harbingers of the Mesozoic age.

ure species range up into those Permian strata, and many acknowledged Permian types, according to the European standard, occur in the unquestioned Coal-Measure strata beneath them.

The upper limit of the Carboniferous system and the lower limit of the Trias have never been clearly recognized upon this continent, and it is therefore not now known that either of these systems are here at any point complete in that respect. But the upper limit of the Carboniferous system is known to be incomplete at most places where strata of that age occur.

A large part of the North American strata, which various authors have referred to the Permian, have no valid claim to be either so considered or to be considered as separate from the Upper Coal Measures. But a part of them may reasonably be assumed to be homotaxially equivalent with at least a part of the European Permian, although their delimitation from the Coal Measures may in most cases be difficult or impracticable.

The evidence upon which the Texan strata have been referred to the Permian is fuller than that which has been adduced with regard to any other North American strata that have been so referred. That is, the evidence both of the vertebrate and invertebrate fossils is in favor of such reference, and the difference in the character of the strata from those of the underlying Coal Measures, although not great, is conveniently distinguishable. Still, it is true that the Texan Permian strata bear many Coal-Measure invertebrate species, and that its flora at present is unknown.

In the foregoing discussions I have referred to the discovery of a molluscan fauna in Texan strata which contains both Mesozoic and Coal-Measure types as indicating that those strata are later in their origin than the Coal Measures; or, in other words, that they are of Permian age. While I think such a conclusion is correct in this case, especially when correlated facts are considered, it is by no means certain that Mesozoic forms similar to those found in the Texan strata were not introduced at a still earlier Carboniferous period than that which the Texan fauna is understood to represent.

That is, in view of our present knowledge of those Indian and Sicilian faunas that have been referred to on preceding pages, it seems probable that a considerable number of their Mesozoic molluscan types were really introduced in those parts of the world at an earlier epoch than the Permian. I am not now prepared to express a definite opinion upon this subject, but after examining the published works of Profs. Waagen and Gemmellaro, I am inclined to think that the strata from which they respectively obtained their commingled Mesozoic and Carboniferous forms are homotaxially equivalent to the Upper Coal Measures of North America, which strata belong beneath the Texan Permian.

In all the preceding discussions, as well as in the last paragraph, I have referred to certain of the mollusca of the Indian, Sicilian, and Texan faunas as being of Mesozoic types, and in accordance with the generally accepted views of paleontologists it is entirely proper to do so, but it is not to be denied that a part of the genera which have been recognized among those faunas have not yet been discovered in any other faunas, or in any other geological horizon than that of the upper portion of the Carboniferous system. In view of this fact the propriety of positively referring the types mentioned to the Mesozoic rather than to the upper portion of the Carboniferous may well be questioned. That is, it seems to be probable that while there is no error in referring a part of those commingled forms to the Paleozoic and a part to the Mesozoic, it is likely that certain members of those faunas which will be found to be characteristic of the upper portion of the Carboniferous system rather than of the earlier Mesozoic.

PLATES.

PLATE I.

PLATE I.

MEDLICOTTIA COPEI (page 21).

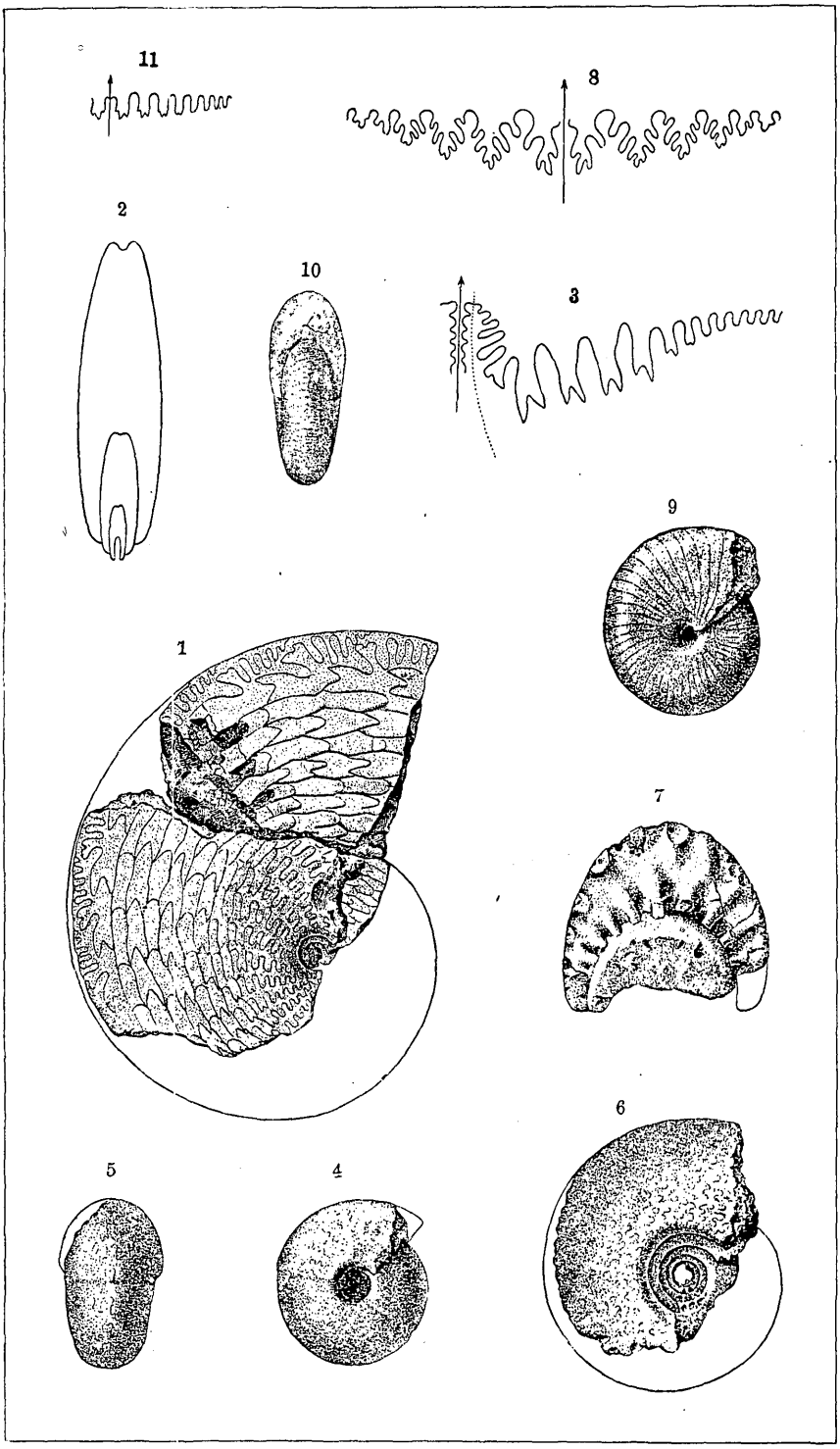
Fig. 1. Lateral view of an imperfect example.
Fig. 2. Diagrammatic section of the volutions.
Fig. 3. Septal suture.

WAAGENOCERAS CUMMINSI (page 20).

Fig. 4. Lateral view of a small example.
Fig. 5. Peripheral view of the same.
Fig. 6. Lateral view of a larger, imperfect example.
Fig. 7. View of septum of a still larger example.
Fig. 8. Septal suture of the same.

POPANOCERAS WALCOTTI (page 21).

Fig. 9. Lateral view of a small example.
Fig. 10. Peripheral view of the same.
Fig. 11 Septal view of the same.



INVERTEBRATE FOSSILS FROM THE TEXAN PERMIAN.

PLATE II.

PLATE II.

GONIATITES BAYLORENSIS (page 19.)

Fig. 1. Lateral view.
Fig. 2. Outline showing general form by peripheral view.
Fig. 3. Septal suture.

NAUTILUS ——? (page 24).

Fig. 4. Lateral view of an imperfect example.
Fig. 5. Outline of outer volution; restored from imperfect examples.
Fig. 6. Septal sutures from a broken example.

NAUTILUS ——? (page 24).

Figs. 7, 8, 9. Different views of a portion of a natural cast of interior of the shell.
Fig. 10. Outline of transverse section of a larger example, probably belonging to this species. Both examples are from Godwin Creek. Compare with Figs. 6, 7, 8. Pl. III.

NAUTILUS OCCIDENTALIS (page 23).

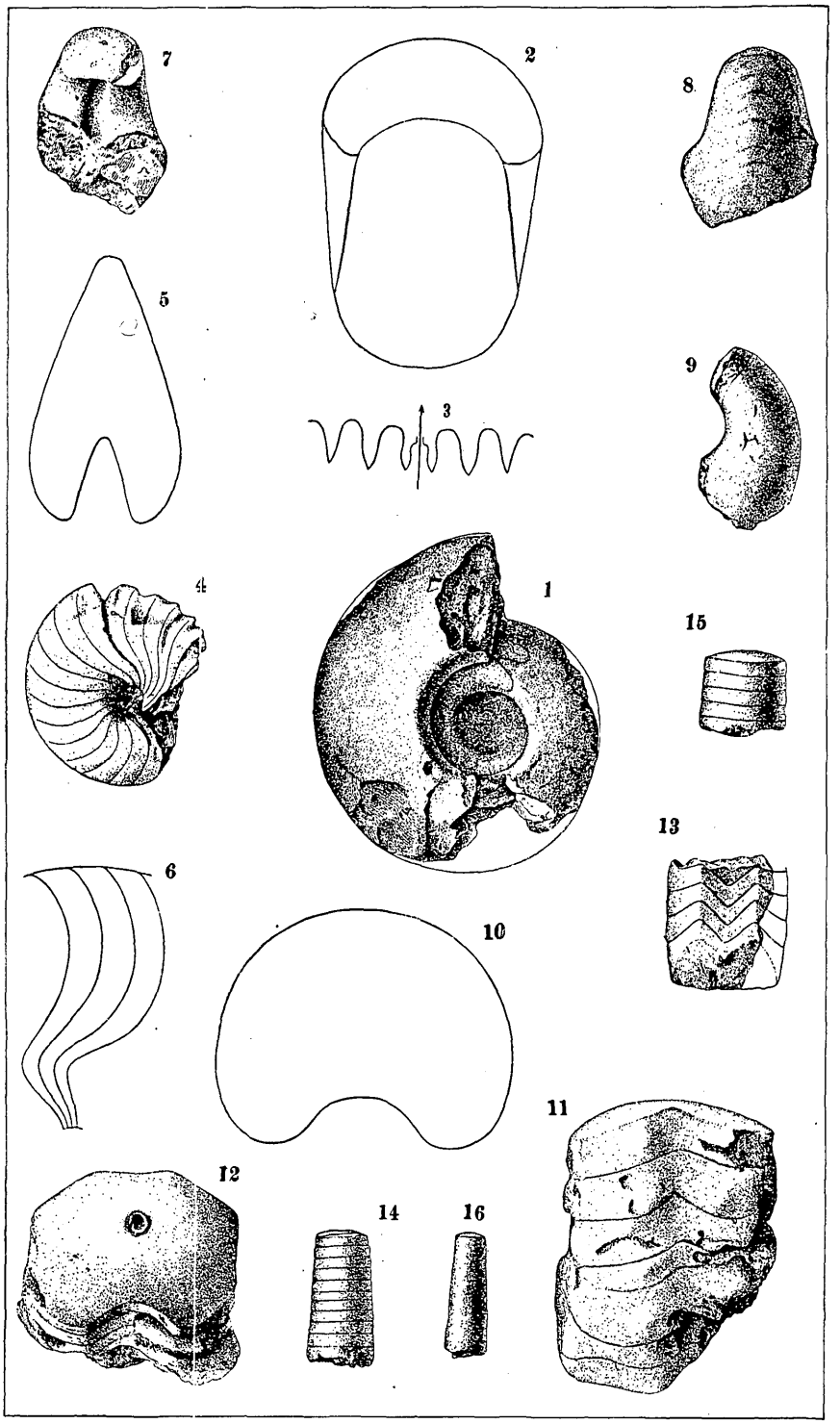
Fig. 11. Peripheral view of a fragment of a natural cast of the interior of the shell.
Fig. 12. End view of the same, showing septum and siphuncle.

NAUTILUS (ENDOLOBUS) ——? (page 24).

Fig. 13. View of a fragment showing the small median lobe at the inner border of the septum.

ORTHOCERAS RUSHENSIS (page 22).

Figs. 14, 15. Lateral view of two fragments showing septa.
Fig. 16. Similar view of a small example.



INVERTEBRATE FOSSILS FROM THE TEXAN PERMIAN.

PLATE III.

PLATE III.

NAUTILUS WINSLOWI (page 23).

Figs. 1, 2. Two views of a small example showing numerous small lateral lobes.
Figs. 3–5. Different views of three different examples showing varation as regards surface features.

NAUTILUS ——? (page 23).

Fig. 6. Lateral view of a very imperfect natural cast of the interior of the shell.
Figs. 7, 8. Two views of another example. Both examples are from Military Crossing. Compare with Figs. 7–10, Pl. II.

EUOMPHALUS SUBQUADRATUS (page 25).

Fig. 9. Apical view of a large example, somewhat distorted by pressure.

NATICOPSIS REMEX (page 24).

Fig. 10. Upper view of a natural cast of the interior of the shell.

NATICOPSIS SHUMARDI (page 24).

Fig. 11. Lateral view.

MURCHISONIA ——? (page 25).

Figs. 12, 13. Lateral view of two examples showing difference in surface ornamentation.

PATELLA ——? (page 25).

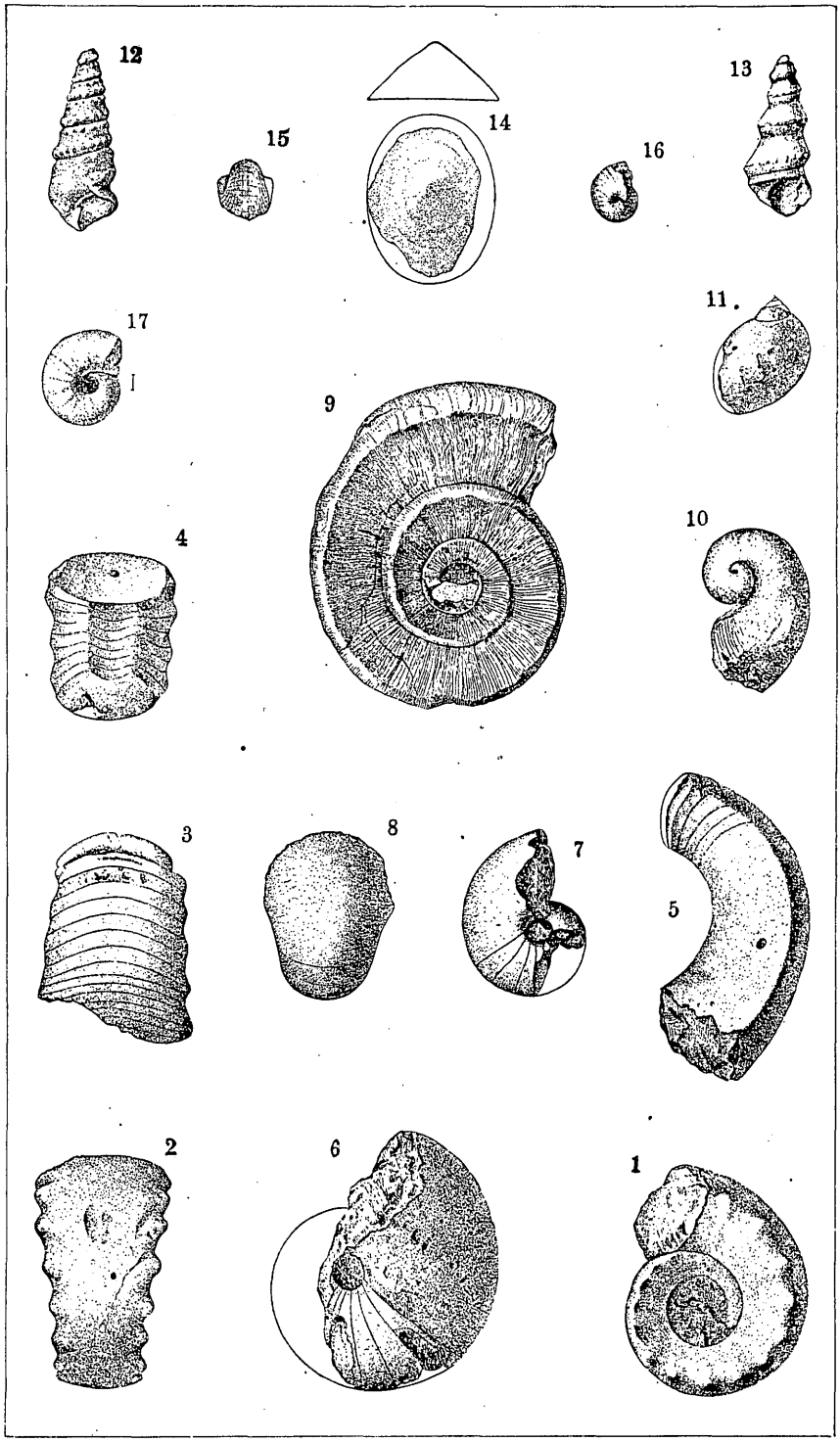
Fig. 14. Dorsal view and surface outline of transverse section.

BELLEROPHON MONTFORTIANUS (page 26).

Figs. 15, 16. Two views of a small example.

SPIRORBIS ——? (page 30).

Fig. 17. Upper view, much enlarged.
All figures of natural size except the last, which is much enlarged.



INVERTEBRATE FOSSILS FROM THE TEXAN PERMIAN.

PLATE IV.

PLATE IV.

AVICULOPECTEN OCCIDENTALIS (page 29).

Fig. 1. Left valve.

GERVILLIA LONGA (page 29).

Fig. 2. Left side view.

CLIDOPHORUS OCCIDENTALIS (page 27.)

Fig. 3. Right side view.

YOLDIA? SUBSCITULA (page 27.)

Fig. 4. Left side view.

PLEUROPHORUS——?

Fig. 5. Left side view of a natural cast of the interior of the shell.
Fig. 6. Dorsal view of the same.
Figs. 7, 8. Right side view of the two natural casts of the interior of the shell.
Fig. 9. Similar view of another broader example.
Fig. 10. Right side view of an artificial cast, showing surface markings.

SEDGWICKIA TOPEKAENSIS (page 26).

Fig. 11. Lateral view of a natural cast of the interior of a left valve.

MYALINA AVICULOIDES (page 28.)

Fig. 12. Right side view of a natural cast of the interior of the shell.

MYALINA PERATTENUATA (page 28.)

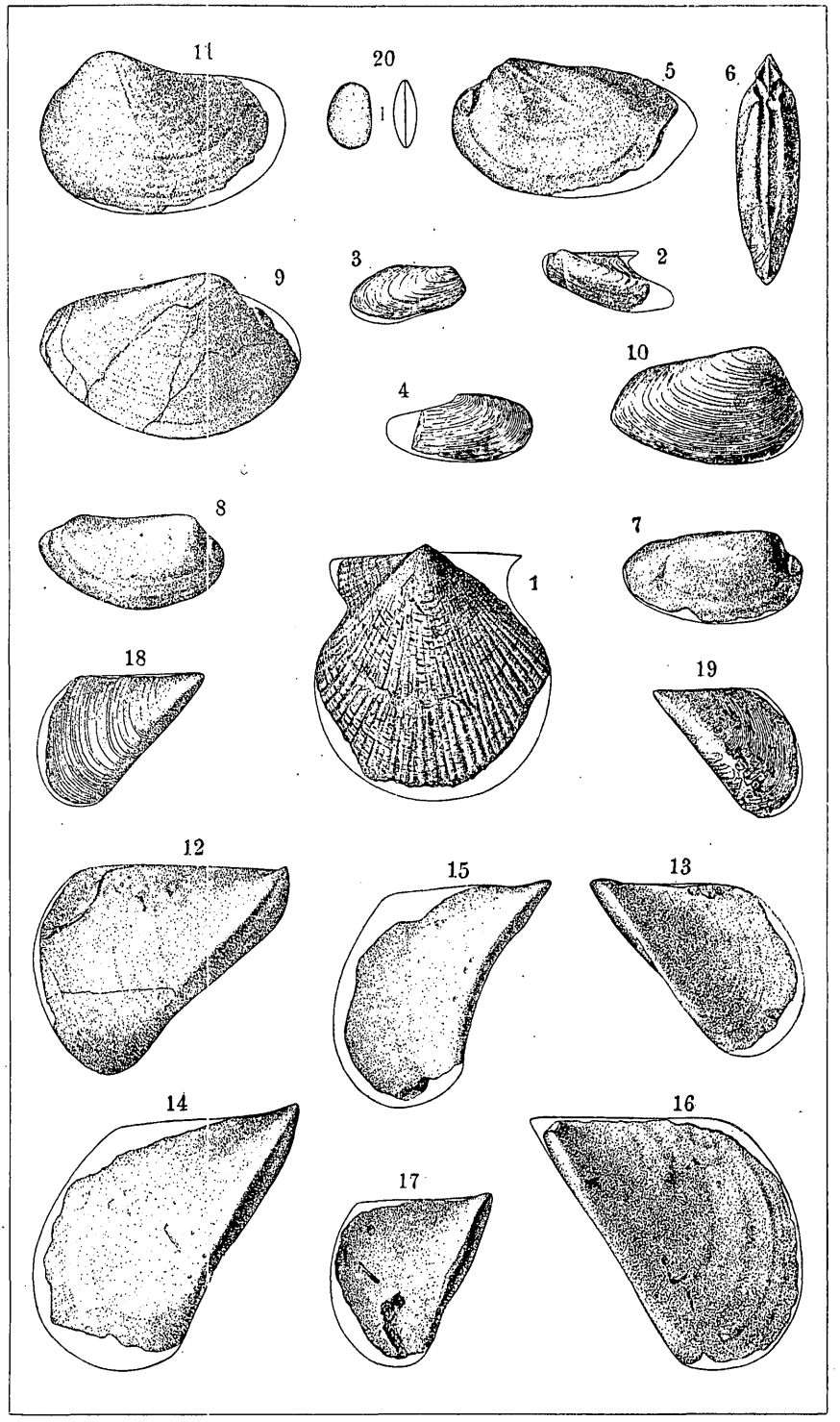
Fig. 13. Left side view of an example from Camp Creek.
Fig. 14. Right side view of an example from Godwin Creek.
Fig. 15. Similar view of an example from Military Crossing.

MYALINA PERMIANA (page 28.)

Fig. 16. Left side view of an example from Godwin Creek.
Fig. 17. Right side view of an example from Camp Creek.
Figs. 18, 19. Right and left side views of two examples from the Military Crossing.

CYTHERE NEBRASCENSIS (page 30.)

Fig. 20. Lateral view and vertical outline, much enlarged. All except Fig. 20 are of natural size.



INVERTEBRATE FOSSILS FROM THE TEXAN PERMIAN.

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