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No. 3101: January 1, 1931

CONTRIBUTIONS TO GEOLOGY, 1931

Bureau of Economic Geology

J. A. Udden, Director   E. H. Sellards, Associate Director

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THE UNIVERSITY OF TEXAS PRESS

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of Democracy, and while guided and controlled by virtue, the noblest attribute of man. It is the only dictator that freemen acknowledge, and the only security which freemen desire.

Mirabeau B. Lamar

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E. H. SELLARDS,
Associate Director.

ERRATICS IN THE PENNSYLVANIAN OF TEXAS

BY

E. H. SELLARDS

INTRODUCTION

At the meeting of the Geological Society of America in Toronto, Canada, December, 1930, announcement was made of the discovery of erratics of large size in the Haymond formation of Carboniferous age in the Marathon region of Texas.[1] Smaller erratics, however, had previously been seen. As early as 1915, Mr. C. L. Baker observed detrital boulders in the Haymond formation on or near the Jones ranch in the southeastern part of the Marathon basin[2], and in 1928, Philip B. King and Robert E. King[3] described a conglomerate in this formation southeast of Gap Tank. This conglomerate is indicated on the recently published geologic map of the Glass Mountains of Texas.[4] In November, 1930, Philip B. King and A. G. Nance found pebbles and boulders of pre-Cambrian and Paleozoic rocks about two and one-half miles southeast of Haymond station. Pre-Cambrian detritals had not been previously observed in the Marathon area and their discovery at this locality, in connection with the other erratics, led Baker to suggest that they might possibly be ice-transported. Subsequent study of the Haymond locality was undertaken by Baker and Sellards, who traced the horizon of the erratics northeastward for several miles, finding particularly good exposures west of Housetop Mountain.

At the present time, therefore, these erratics are known in the Haymond formation at three localities, as follows:

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[1]Erratics of Large Size in the Carboniferous of West Texas. King, P. B., Baker, C. L., and Sellards, E. H. Abstract in Geological Society of America, Volume 42, 1931.

[2]Personal communication, 1931.

[3]The Pennsylvanian and Permian Stratigraphy of the Glass Mountains, Univ. Texas Bull. 2801, p. 114, 1928.

[4]King, Philip B. The Geology of the Glass Mountains, Texas, Part I, Descriptive Geology. Univ. Texas Bull. 3038, 1931.

Issued October, 1931.

In the southeastern part of the Marathon basin, observed by Baker in 1915; east of Gap Tank in the northern part of the basin, observed by King and King in 1928; and east and northeast of Haymond station, where the erratics are largest and most numerous. The locality east of Gap Tank may, for convenience of reference, be known as the Clark

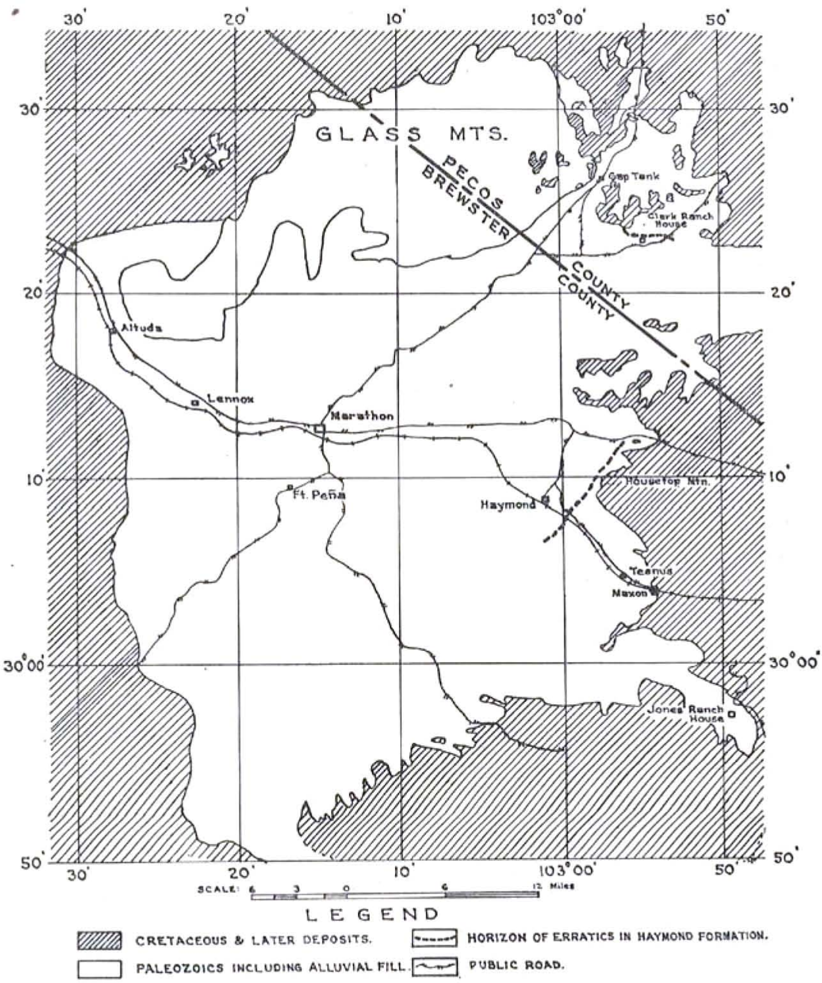

Fig. 1. Sketch map of the Marathon region showing localities where erratics have been found in the Haymond formation.

ranch locality, and that east of Haymond station as the Housetop Mountain locality (shown as House Mountain on the Glass Mountains geologic map, Univ. of Texas Bull. 3038). The locality in the southeastern part of the basin on the Jones ranch observed by Baker in 1915 has not been revisited.

An extensive study of these erratics is being made by C. L. Baker and P. B. King, each of whom is publishing on this subject. The present notice, therefore, will be confined to a brief account of the boulders and a discussion of their relationship to the regional geology.

THE MARATHON UPLIFT

The Marathon region is structurally an uplift which brings Paleozoic rocks to the surface through a Cretaceous covering now removed.[5] The area of exposed Paleozoics surrounded by a Cretaceous rim is 35 or 40 miles across and is irregularly circular in outline (Figure 1). Previous to the formation of this great dome, the early Paleozoic rocks had been folded, overturned, and in places overthrust. These movements, which have Appalachian trend, affect the Pennsylvanian and older formations, but not, so far as known, the Permian, which was but mildly folded and tilted. The formation of the uplift itself, aside from the thrusting and folding, was not completed until post-Cretaceous time, as shown by the fact that the Cretaceous of the rim rock dips gently away from the uplift.

The Paleozoic section of this uplift includes Cambrian, Ordovician, Devonian, Carboniferous, and Permian formations. A similar series, including formations as late as Carboniferous in age, is found in the Solitario, a smaller uplift located some 50 miles southwest of Marathon. The early Paleozoic of these two regions present striking resemblances in facies to the Ouachita Mountain region of

[5]Hill, R. T., Physical Geography of the Texas Region, U. S. Geol. Surv. Topographic Atlas, Folio 3, p. 4, 1900.

Udden, J. A., Notes on the Geology of the Glass Mountains, Univ. Texas Bull. 1753, pp. 3–59, 1917.

Baker, C. L., and Bowman, W. F., Geologic Exploration of the Southwestern Front Range of Trans-Pecos, Texas, Univ. Texas Bull. 1753, pp. 61–1722, 1917.

Oklahoma. This is particularly true of the cherts (Maravillas formation) and the novaculite (Caballos formation), which resemble the Big Fork chert and the Arkansas novaculite of the Ouachita region.

The Carboniferous of the Marathon region includes a thick series of sediments, grouped according to present usage into four formations: Tesnus, Dimple, Haymond, and Gaptank. Of these, the Tesnus consists largely of fine sandstone and dark shales. Its maximum thickness is in the southeastern part of the Marathon basin where it is approximately 7,000 feet.[6] It thins northwestward. The Dimple, overlying the Tesnus, is largely thin bedded limestone with few fossils, and has a thickness of about 1,000 feet. The Haymond formation is about 2,000 or 2,500 feet thick, and is lithologically much like the Tesnus. It consists of sandstone and shale strata often thin bedded. In that part of the formation containing the erratics, there is also a considerable development locally of arkosic sandstone. The Haymond contains relatively few fossils, but among those obtained there are fusulinids, indicating that the formation is not older than Pennsylvanian. The Gaptank formation, overlying the Haymond, contains limestone and shales, and in places is highly fossiliferous. The Permian of this region has been described in several publications.[7]

THE ERRATICS

The erratics occur in the upper part of the Haymond formation. It has not been possible to determine just how much of this formation formerly lay above the boulder horizon, although at the Clark ranch locality east of Gap Tank as much as 400 feet of strata lie between the conglomerate zone and the unconformably overlying Cretaceous.[8]

6Philip B. King. Personal communication, 1931.

7King, Philip B., The Geology of the Glass Mountains, Texas, Part I, Univ. Texas Bull. 3038, 1930.

King, Robert E., The Geology of the Glass Mountains, Texas, Part II, Univ. Texas Bull. 3042, 1931.

8King, Philip B., op. cit., p. 41.

THE HOUSETOP MOUNTAIN LOCALITY

Important differences are found between the exposures at the Housetop Mountain locality east of Haymond and those at the Clark ranch locality. At the Housetop Mountain exposures, the matrix contains much fine material, in part arkosic, nearly or entirely unstratified, and often relatively incoherent. In this matrix are rock inclusions varying in size from pebbles to rock masses 100 feet in length. This assemblage is totally unassorted. Matrix and boulders of this character may be followed from two and a half miles south of the Southern Pacific Railroad in a northeasterly direction to within a half-mile of the Marathon-Sanderson road, a total distance of about eight miles (see Figure 1).

As already stated, erratics occur in varying sizes, and without regularity of distribution, except that they are confined to definite zones in the formation. Abundant among the erratics are novaculite pieces, which vary in size from a fraction of an inch to masses 25 feet or more in thickness. The novaculite erratics are irregular in shape, often as thick as long. They are often strongly slickensided and brecciated. The horizon of erratics, where partly concealed by terrace gravel and wash, may often be followed by the novaculites, which persist because of their large size and resistance to erosion.

Chert is present, derived from the Maravillas formation, although no large cherts of this formation were seen. Occasional large erratics of the Tesnus formation are present, some of which are scratched. Among the smaller erratics are numerous quartzite, gneissoid, and schistose rocks. These are entirely foreign to any other rock exposed in the Marathon region. They are probably pre-Cambrian in age, their most likely source being a region to the south or southeast, now covered by Cretaceous, except for one small exposure of schist on the Mexican side of the Rio Grande River.

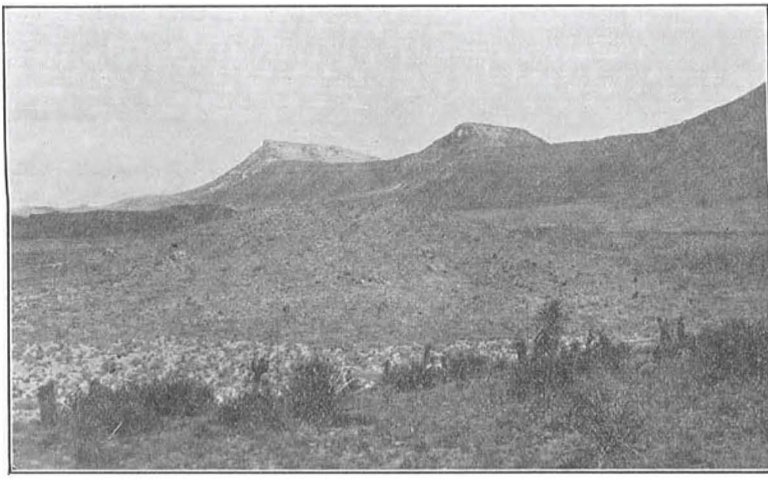

Fig. 2. Hill showing profusion of boulders, Housetop Mountain (Cretaceous rim rock) seen in the background. Near the center of the view is a large limestone boulder about 100 feet long and 25 feet thick. Several strata may be seen in this boulder.

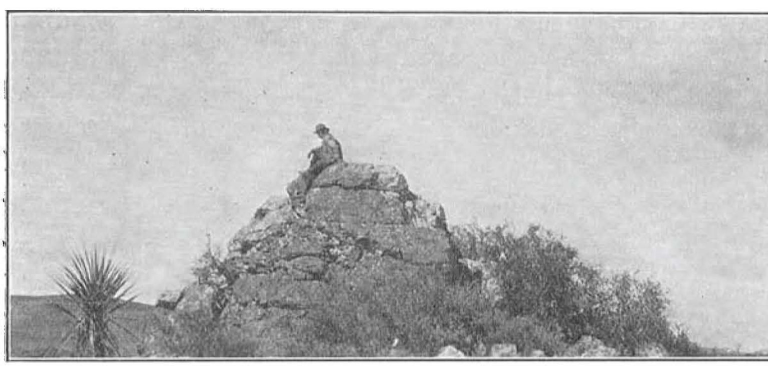

Fig. 3. Large novaculite boulder. This boulder is seen at the left center of Figure 2.

Limestone erratics are numerous and vary in size from small pebbles to rock masses 100 feet in length. Dr. P. B. King,[9] who has recently re-examined this locality, writes as follows:

9Letter of July 4, 1931.

> The more exposures seen, the more remarkable does the matrix of the bed appear. It is an arkosic mudstone with few bedding planes. Its contrast with the typical slabby Haymond is great. The boulder beds are long lenses. Two of them persist from Housetop Mountain to the Sanderson road but at the Housetop Mountain locality two more beds wedge in above and two below. The big boulders are clustered. For a stretch of a mile or so none larger than two-foot masses will be seen. Then for a mile or so they will be so thick they are hard to count—then they disappear again. There are five such clusters between the Sanderson road and the Bates place. . . . The fossiliferous boulders range in size from huge boulders to minute pebbles. The big ones are not at the base of the series but in all six members, but most abundantly in the middle two.

Professor Frank Carney, who has recently examined this locality, writes that he has found in the deposits many genuine soled boulders.*

Many of the limestone erratics are fossiliferous. Collections made by Baker and Sellards from several of these Pennsylvanian limestone masses have been examined by Mr. F. B. Plummer, whose report on them is given here.

> Report on Pennsylvanian Fossils by F. B. Plummer.
>
> Collections of invertebrate fossils were examined from eight boulders numbered as in the following list. The fossils listed are in the collections of the Bureau of Economic Geology of The University of Texas.
>
> Fusulinid. X-149.
> Trilophyllum sp. X-125.
> Lingula tighti Herrick (?). X-147.
> Derbya sp. X-205.
> Chonetes geinitzianus Waagen. X-217.
> Productus inflatus McChesney. X-149, 196, and 217.
> Marginifera sp. X-148.
> Squamularia perplexa McChesney. X-217.
> Composita subtilita Hall. X-217.
> Spirifer rockymontanus Marcoui (?). X-209 and X-217.
>
> All of the boulders are not from the same limestone ledge, but all except X-205 and X-147 are definitely middle Pennsylvanian. These two collections have long range fossils only, *Derbya* and *Lingula*. It is probable that these two are Pennsylvanian also. It is quite interesting to note that

*Letter of September 24, 1931.

the fauna as a whole resembles the fauna from the Pennsylvanian in the Big Lake oil field. Both faunas contain *Composita subtilita*, *Productus inflatus*, *Spirifer rockymontanus ?*, *Lingula*, and the spiny *Marginifera*. These faunas are suggestive of the Rocky Mountain province.

The Haymond formation, although containing but few fossils, is known from the presence of fusulinids to be of Pennsylvanian age. Since these limestone boulders are likewise of Pennsylvanian age, one is led to inquire whether they may not be in fact a part of the formation and not erratics. The question naturally arises as to whether they may not be lenses of limestone in the formation. This possibility has been considered, but such an explanation does not seem probable, for while the largest masses are suggestive of lenses they terminate abruptly and often with irregularly broken ends. The small boulders, often irregular in shape and fossiliferous, have no resemblance to lenses. They are not concretions, since many of them are blocks from well stratified limestones. The possibility of their representing a limestone stratum in the Haymond formation, broken up and dislocated by faulting, has also been considered. However, the several limestone masses present such differences in lithologic character as to show that they are not broken pieces of a single ledge. They represent Pennsylvanian limestone containing a fauna not seen elsewhere in the Marathon basin, but resembling the Pennsylvanian fauna found at a depth of 8,100 to 8,200 feet in the Big Lake oil field, Reagan County.[10] If of the age of the Haymond formation, these boulders represent limestone accumulated and solidified elsewhere and subsequently moved to this place, having been broken into pieces of varying size in transportation.

Aside from the Pennsylvanian limestone boulders, there are, as already stated, many other boulders from other formations, including those from the Dimple, Tesnus, Caballos, Maravillas and earlier formations, all of which are

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[10]Sellards, E. H., Bybee, H. P., and Hemphill, H. A., Producing Horizons in the Big Lake Oil Field, Reagan County, Texas, Univ. Texas Bull. 3001, p. 155, 1930.

intimately associated with the boulders of Pennsylvanian limestone.

THE CLARK RANCH LOCALITY

In the Clark ranch locality east of Gap Tank, the matrix is notably clean and free of very fine material. The stratum is a conglomerate in which rocks of varying size occur, the smallest being about one-half inch in diameter. This conglomerate can be followed for three to four miles, although it is in places concealed by Cretaceous deposits (Figure 1). Pre-Cambrian detritals are almost wanting, although one has been found which probably belongs in the conglomerate. Limestone boulders containing pre-Pennsylvanian fossils are present, and novaculite pieces are numerous. The rock of maximum size seen in this conglomerate is novaculite and is about ten by six by two and a half or more feet.

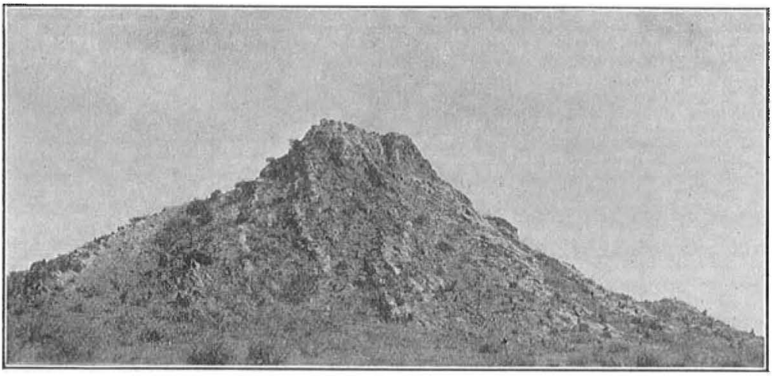

Fig. 4. The Haymond formation near the Clark ranch house, looking west. The boulder conglomerate of that locality passes at the north (right) side of this hill.

RELATION TO REGIONAL GEOLOGY

Erratics have been described from many parts of the world, and have reached their resting place in many ways. Stream transportation, mud flows, talus creep, earthquakes, sub-aqueous land slips, thrust faulting, and ice transportation are all possible means of transporting boulders into a formation. Whatever may be the means of transportation of the erratics in the Haymond formation to their present location, their relationship to regional geology is of great importance. It has now been very well shown that the Solitario and Marathon regions have a relationship with the Ouachita region of Oklahoma. Knowledge of this relationship has been gradually accumulated during the past several years, and it has now been shown by drill records that, although covered in central Texas by the Cretaceous formations, the belt of rocks of this character is continuous from the Ouachita Mountains to the Marathon region.[11]

These formations, where seen at the surface, are affected by mountain-making movements including folding, overturning, and thrusting. In each of the regions, thrust movements have come from the east, southeast, or south. Overthrusting is very pronounced in the Ouachita region and has been noted also in the Marathon region. Overthrusting of the same character occurs, likewise, in the Paleozoic rock of the Solitario.[12] The well records of the area between the Marathon and the Ouachita likewise establish folding and overturning or thrusting in this region.

The erratics are evidence of uplifts, mountainous in character, adjacent to the Marathon region. This mountain-making movement occurred, as shown by the character of the rock derived from it, within the belt of intensely folded rocks, as distinct from the relatively level lying Paleozoic of the foreland. The erratics, therefore, are evidence of mountain-making movements affecting the ancient land masses lying to the south and east of the Marathon region.

11Sellards, E. H., Map of Paleozoic of Ouachita Facies in Texas, Bureau of Economic Geology, Univ. of Texas, January, 1931.

12Geologic map of the Solitario of Texas by E H. Sellards, W. S. Adkins, and M. B. Arick, Bureau of Economic Geology, University of Texas, 1930.

SOME MAJOR STRUCTURAL FEATURES OF WEST TEXAS

BY

H. P. BYBEE[1]

INTRODUCTION

In this paper the major structural features in west Texas and southeastern New Mexico are briefly described; certain similarities between these major features are brought out; and an attempt is made to show that the features are similar in trend and magnitude, and possibly owe their existence to a similar origin. It is suggested that the elevated limestone platforms are positive in nature and that the basins between are negative. No attempt is made to review the literature on this subject or enter into discussion of the many problems which confront the investigator in this area. It is hoped, however, that the following suggestions may be of help in arriving at a clearer understanding of the structural conditions that exist in west Texas. For the purpose of this paper west Texas is defined as that part of Texas west of the 100th meridian, exclusive of the high plains or Panhandle region. The Marathon and Solitario regions of west Texas are not included in this discussion.

MAJOR STRUCTURAL FEATURES

The major structural features of west Texas may be divided into two natural groups, those belonging to extreme west Texas, and those of the southern end of the Permian Basin.

EXTREME WEST TEXAS

The major structural features of extreme west Texas and New Mexico consist of a series of down-throw blocks alternating with elevated or plateau areas, consisting largely

[1]Geologist to the Board for Lease of University Lands, San Angelo, Texas.

of limestone. Figure 5 has been prepared to bring out this relationship. The main structural divisions of this part of the state from west to east are the Franklin Mountains, the Hueco Bolson, the Diablo Plateau, the Salt Flat, and the Delaware Mountain scarp.

With respect to the El Paso region including the Franklin Mountains, G. B. Richardson[2] states:

> The main structural features of the El Paso district may be summarized as follows: The long, narrow Franklin Range, rising three thousand feet above the broad lowlands, resembles a "basin range" fault block of westward-dipping rocks, but it differs from the type by being part of a long chain of ranges and by being complexly faulted internally. The Hueco Mountains in the main form a monocline of low eastward dip along the western border of which the rocks have been disturbed.

The same author[3] makes the following comment regarding the structure of the Trans-Pecos region:

> The dominant structure of the Trans-Pecos region is expressed in the northwestward to northward trend of the highlands and intervening lowlands. The highlands are areas of relative uplift and the lowlands are troughs of corresponding depression. The chief movements of the rocks have been vertical, and the main structural features are normal faults. Most of the highland areas are bounded by faults that strike in general with the main trend of the region, though some cut this transversely. . . . The major faults apparently were initiated with the Tertiary continental emergence and developed between then and the late Tertiary or early Quaternary uplift.

THE FRANKLIN MOUNTAINS

The excellent description of the Franklin Mountains by G. B. Richardson[4] is considered quite adequate for the purposes of this paper.

> The Franklin Mountains are the southern extremity of the long, narrow chain that extends from the termination

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[2]Richardson, G. B., Description of the El Paso District, U. S. Geol. Surv., Geologic Atlas, El Paso Folio (No. 166), field edition, p. 56, 1909.

[3]Richardson, G. B., Description of the Van Horn Quadrangle, U. S. Geol. Surv., Geologic Atlas, Van Horn Folio (No. 194), p. 7, 1914.

[4]Richardson, G. B., Description of the El Paso District, U. S. Geol. Surv., Geologic Atlas, El Paso Folio (No. 166), field edition, p. 18, 1909.

of the main mass of the Rocky Mountains, in northern New Mexico, southward as far as El Paso. This chain occupies a belt about ten miles wide and two hundred and fifty miles long across central New Mexico immediately east of the Rio Grande Valley. Its continuity is broken in places, causing a separation into several units known as the Sandia, Manzano, Oscura, San Andreas, and Franklin ranges, named in order from north to south.

The Franklin Range trends slightly west of north and extends from El Paso to a point a few miles north of the New Mexico-Texas boundary, where it is separated by a low wash-filled pass from the Organ Mountains, which form the southern extremity of the San Andreas Range. The main part of the Franklin Range lies entirely within Texas and is fifteen miles long and about three miles wide, but low outlying hills extend the range eight miles beyond the State boundary. The mountains rise abruptly more than three thousand feet above the Rio Grande Valley on the west and the Hueco Bolson on the east, culminating in a peak 7152 feet above sea level. The western face of the range is relatively little eroded and in the main constitutes a dip slope; the eastern face, on the contrary, is more dissected and exposes cross sections of the rocks, deep valleys that extend back almost to the rim of the range separating several transverse ridges. Individuality is given to the topography by the varying character of the formations. The crest of the range, capped for the greater part of its length by westward-dipping limestone, presents a rugged scarp; the lower slopes and transverse ridges have characteristic irregular surfaces due to the varying resistance to the weathering of the component rocks. The mountains are practically bare of vegetation save for a scanty desert growth on the lower slopes, so that the rocks are plainly exposed except where they are covered by accumulations of debris. As a whole, the Franklin Range resembles an eroded block mountain of the Basin Range type.

THE HUECO BOLSON

The Hueco Bolson[5] is bounded on the west by the Franklin Mountains, which rise abruptly to a maximum of 3,000 feet above the valley floor, and on the east by the Hueco Mountains, which rise as much as 2,000 feet above the valley. The extent of movement of the down-throw block

5Hill, Robert T., Physical Geography of the Texas Region, U. S. Geol. Surv., Topographic Atlas, Folio 3, p. 9, 1900.

is not definitely known, but it is considerable. Something of the movement may be inferred from a study of the log of the Cinco Minas Company well, Burns and King No. 4, located in the southwest corner of Section 24, Block 80, Township 1, southeast of Newman, Texas. This well was drilled to a depth of 4,920 feet without encountering hard rock such as occurs in either the Franklin or Hueco Mountains. Thus the displacement is known to exceed 7,000 feet.

THE DIABLO PLATEAU

The Diablo Plateau is essentially an elevated limestone area which rises from 1,000 to 1,200 feet above the Hueco Bolson on the west and some 1,500 to 2,000 feet above the south end of Salt Flat. North of the Black Mountains the eastern rim of the plateau gradually fades into Salt Flat.

The major axis of the Diablo Plateau has a general northwest-southeast trend, and extends from Van Horn on the southeast into the northern end of the Hueco Mountains on the northwest, a distance of approximately 90 miles. Its northeast-southwest dimensions average approximately 40 miles.

The Texas portion of the Diablo Plateau is divided into two major provinces by a structural line of weakness extending from the southern extremity of the Hueco Mountains in a general easterly direction through the Black Mountains to Apache Canyon. Throughout the northern province the plateau gradually slopes towards the southeast in conformity with the regional dip of the bed rock. In the southern province the slope is in general southwest, and the structural features are more complex, resulting in a diversified topography.

THE SALT FLAT

The Salt Flat has as its west boundary the east margin of the Diablo Plateau, which forms an escarpment of 2,000 to 3,000 feet and is known as the Sierra Diablo Mountains. On the east is the Delaware Mountain scarp, which rises abruptly 1,500 to 2,200 feet above the valley floor. The amount of fill in Salt Flat has not been determined but may equal the visible depression. In this depression, between the Apache and Wiley Mountains, 10 miles east of Van Horn, in the Hickey-Stevens, Finley No. 1, the Permian bed-rock was encountered at a depth of 860 feet. The Salt Flat depression gradually rises towards the north and loses its identity in New Mexico as does also the Delaware Basin.

THE GUADALUPE-DELAWARE-APACHE MOUNTAINS

The three mountain groups, the Guadalupe, the Delaware, and the Apache, constitute a single structural feature.

The Guadalupe Mountains are essentially a limestone block whose westerly margin consists of a fault scarp approximately 50 miles long, terminating about 14 miles south of the New Mexico line, rising abruptly approximately 3,000 feet above Salt Flat and its New Mexico counterpart, Crow Flat. The eastern margin of the Guadalupe range is a gently eastward monoclinal dip into the Pecos Valley.

The Delaware Mountains constitute an echelon block extending about 40 miles southeast from the point of the Guadalupes. The formation is largely sandstone. The western margin of the Delaware Mountains is a fault scarp rising 1,500 to 2,200 feet above Salt Flat. The dip is to the east. The width of the Delaware range is approximately six miles.

The Apache Mountains constitute another limestone block, separated from the Delawares by a cross fault and swinging more to the southeast. The physical conditions are almost identical with the other two units of this structural feature, the principal difference being in direction of trend.

The Delaware unit of the Guadalupe-Delaware-Apache structural feature is the only exception to the statement made elsewhere in this report that the elevated areas are composed essentially of limestone.

SOUTHERN END OF THE PERMIAN BASIN

The main features of the southern end of the Permian Basin have been described by Lon D. Cartwright, Jr.,[6] as consisting of the Delaware Basin, the Central Basin Platform, and the Main Permian Basin. To these should be added the Eastern Platform in Tom Green, Sterling, and Schleicher counties. The black shale basin in Crockett and adjacent counties is also a marked structural feature, but no discussion of it will be included in this paper.

THE DELAWARE BASIN

The Delaware Basin in Texas occupies all of Reeves, the northwestern portion of Pecos, the western parts of Ward and Winkler, all of Loving, and the eastern portion of Culberson County. This basin reaches its maximum depth near its eastern margin, where it is 2,000 to 2,300 feet below sea level. The western slope of the basin is very gentle, while the eastern slope terminates rather abruptly against the Central Basin Platform. The Delaware Mountain sandstone is capped with a thin layer of black limestone, which underlies the evaporite section and forms the generally recognized bottom of the basin. This dark thin limestone at the top of the Delaware Mountain section is an excellent datum bed for structure contours. The position of the Delaware Basin is shown in Figure 5.

THE CENTRAL BASIN PLATFORM

The Central Basin Platform is an elevated limestone area extending from the Yates region in eastern Pecos County to Hobbs, New Mexico, a distance of almost 200 miles. Its width averages 30 miles or more. This platform consists largely of limestone, and stands some 2,000 feet above the bottom of the main Permian Basin on the east. This is a rather striking feature. The margin of this platform is the site of the major portion of the west Texas oil fields.

6Cartwright, Lon D., Jr., Transverse Section of Permian Basin, West Texas and Southeast New Mexico, Bull. Am. Assoc. Petr. Geol., Vol. 14, p. 969, 1930.

THE MAIN PERMIAN BASIN

The main Permian Basin is the largest structural feature in west Texas and occupies the area extending east of the Central Basin Platform to the Eastern Platform in Tom Green and adjacent counties. In Upton, Midland, and Martin counties, it reaches depths approaching 1,900 feet below sea level. In southeastern Gaines County a depth of 2,200 feet below sea level is recorded. From these areas of apparent maximum depths, the bottom rises gently towards the east, until it comes in contact with the Eastern Platform.

The southern portion of this basin overlaps the black shale basin. In Reagan County, under the Big Lake oil field, the Permian Basin evaporite section is 3,000 feet thick, and is underlain by a limestone section some 800 feet in thickness, below which are 4,000 feet of dark Permian and Pennsylvanian shales. The northern extension of the main Permian Basin reaches into north Texas, Oklahoma, and Kansas.

The logs of the many wells that have been drilled into the "Big Lime" of the Main Permian Basin indicate that the bottom of the basin is, in general, uniform and structureless. It is probable, however, that secondary structural features will be discovered with additional exploration and that the trend of these minor features will be similar to the trend of the major structural features.

THE EASTERN PLATFORM

The Eastern Platform, with its elevated lime mass, has been known for some time, having been located by well drilling. It has received considerable attention from the oil industry, but to date has been non-productive. The western boundary of the lime mass is well defined, while the eastern margin fades into the Permian section. The lime mass of this platform fingers into the black shale on the south and is overlain by Permian red beds on the north.

SIMILARITY OF MAJOR STRUCTURAL FEATURES OF WEST TEXAS

A comparison of the structural features of extreme west Texas with those of the southern end of the Permian Basin reveals that there are three points of marked similarity. The structural features are similar in size, in trend, and in composition, and may have had a somewhat similar origin. In Figure 5 the elevated areas, which are essentially limestone, with the exception of the Delaware Mountain uplift, are represented by the shaded portions of the map.

While there is an abundance of evidence supporting the fault origin of the major structural features in extreme west Texas, there is less positive evidence pointing toward the fault block origin of the Central Basin and Eastern Platforms. However, the abruptness with which the Central Basin Platform terminates both on the east and the west might be interpreted as faulting. The writer has been advised that cores from the Hendricks oil field, in Winkler County, have shown evidence of faulting.

The faulting of extreme west Texas occurred during Tertiary times and is therefore much later in age than any movement which might have raised up the Central Basin Platform or the Eastern Platform. The writer believes that the platforms of the Permian Basin are positive, and that the basins, themselves, are negative areas, having been formed by faulting in pre-Cretaceous time. The rim of these positive areas furnished ideal sites for the formation of the various types of reefs which are familiar features in west Texas.

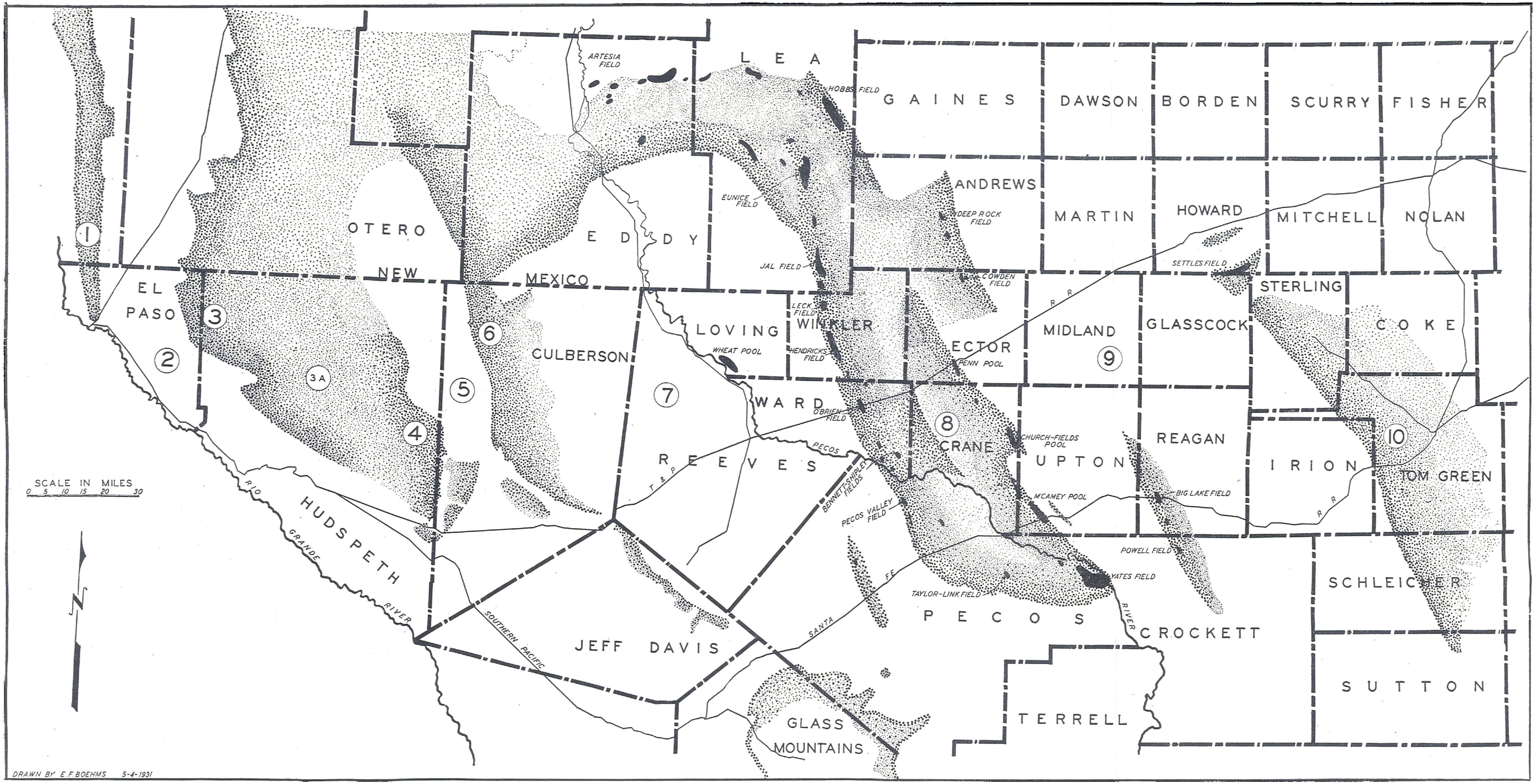

Fig. 5. Map showing the major structural features of extreme west Texas and the southern end of the Permian Basin.

The major structural features of extreme west Texas consist of (1) Franklin Mountains; (2) Hueco Bolson; (3) the Hueco Mountain Scarp and the Hueco Mountains; (3-A) the Diablo Plateau; (4) the Sierra Diablo Scarp and the Sierra Diablo Mountains; (5) Salt Flat; and (6) the Delaware Mountain Scarp and the Delaware Mountains.

The major structural features of the southern end of the Permian Basin consist of (7) the Delaware Basin; (8) the Central Basin Platform; (9) the Main Permian Basin, and (10) the Eastern Platform. These are chiefly limestone areas and are considered as being possibly raised limestone blocks, like those in extreme west Texas, the regions between being relatively depressed.

The oil fields of this region are indicated in solid black.

NEW EARLY FUSULINIDS FROM TEXAS

BY

NORMAN L. THOMAS[1]

INTRODUCTION AND ACKNOWLEDGMENTS

The two new species of early fusulinids described in this paper occur in a high bluff of Carboniferous rock located seven miles east-southeast of London, Texas, near the west boundary of Mason County on the Pfluger ranch at the junction of Big Saline Creek and Llano River. The study of these fossils has been made in connection with the work of the Pure Oil Company, and for permission to publish, I am indebted to the chief geologist of that company. I wish also to make grateful acknowledgment to Mr. M. E. Roberts, who took me to the locality and interested me in the fauna, and to Mr. Ralph Kaufman, who made most of the thin sections, took measurements, and aided in the photography. I am most grateful to Dr. C. O. Dunbar, who reviewed the manuscript. His notes are included in the study. Dr. Dunbar is the recognized authority on fusulinids and has done more than anyone else in confirming determinations. I wish also to express my thanks to Dr. E. H. Sellards and Mr. F. B. Plummer for their interest and help. While this paper was passing through the press, Lee and Chen erected the new genus *Fusiella* and Skinner described one of the species from this locality, referring it to this new genus.* Because of the unsettled nomenclature of the fusulinids I am referring both species in this paper to the genus *Fusulina*.

OCCURRENCE OF THE FOSSILS

The exposure at the locality where these fossils are found consists of massive, thickly bedded, gray limestone, which dips very steeply upstream. The *Fusulina* horizons are exposed in the bluff, and, by reason of the dip, descend to

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[1]Fort Worth, Texas.

*Skinner, John W., Primitive Fusulinids of the Mid-Continent Region, Jour. Paleo. Vol. 5, pp. 253–259, pl. 30, figs. 7–9, 11, 1931.

form ledges in the rapids of Llano River. The section exposed at the upstream end of the bluff is as follows:

	Feet
7. (Top of bluff) Massive limestone, especially fossiliferous in certain zones.	20
6. Massive limestone; *Fusulina llanoensis* Thomas n. sp., abundant.	1–2
5. Massive limestone, sparingly fossiliferous.	30–35
4. Black shale and conglomerate, limestone containing abundant brachiopods and cephalopods.	0.5
3. Massive limestone containing abundant corals.	1–2
2. Massive limestone containing abundant *Fusulina primaeva*	1
1. (Base of bluff) Massive limestone, fossils not common.	4

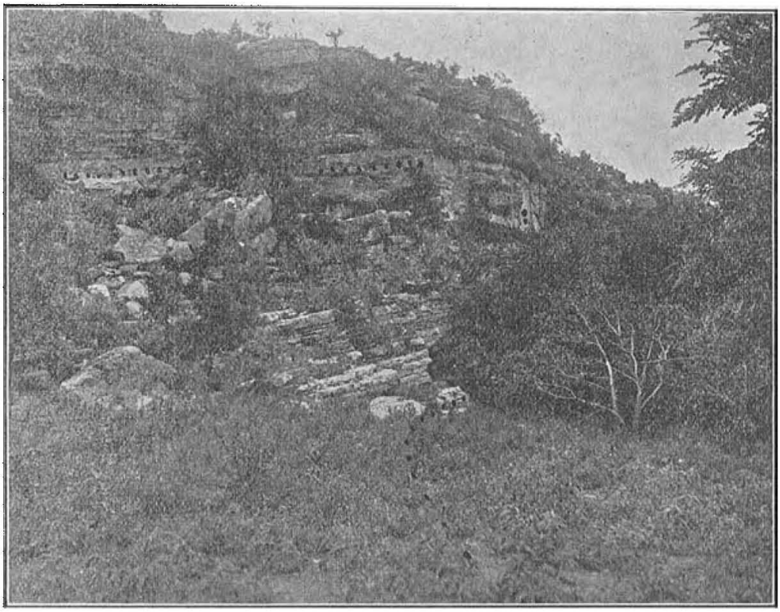

Fig. 6. View of bluff of Llano River on Pfluger ranch. The upper horizon contains *Fusulina llanoensis* n. sp. and the lower horizon, *F. primaeva* (Skinner).

For the most part the fusulinids are grouped in two horizons, and only in these two are they abundant. Each of these horizons has its distinctive *Fusulina,* and so far only one species has been noted in each. *F. llanoensis* n. sp. in the upper horizon is much larger than *F. primaeva* in the lower. The greater number of septa, the thicker walls, and the more complicated interior all indicate that it also attained better development, as well as greater size. *Fusulina llanoensis* n. sp. might easily have developed from *Fusulina primaeva,* but in this locality we have found no intergradations from one to the other. *Fusulina primaeva* seems to have appeared and thrived for a while and then disappeared, to be followed some time later by *F. llanoensis n. sp.* The *Fusulinas* in the upper horizon are associated with corals, and those in the lower horizon occur a short interval below other corals. Both species occur in limestones, rather than in the thin shale layers.

Weathering has caused replacement of the carbonate by chert, and most of the specimens which are in weathered or exposed limestone have been altered to pink chert. In most of the fossils the replacement has progressed from the centers outward. It is believed that if specimens were secured back in the fresh massive limestone, the tests would be composed wholly of carbonate and would afford better sections. The sections which have been figured are taken from the best material collected, and those which show internal characters in detail are composed of carbonate which has not been extensively replaced by silica. The small size of the shells, the poorly preserved characters, and the extensive alteration to chert have made sectioning and clear illustration difficult. For this reason the specimens presented here are far from satisfactory, although they were the best of more than a hundred thin sections. It is hoped that with continued study better specimens may be discovered.

Concerning the generic name and the geologic horizon, Dr. Dunbar[2] has written:

> The horizon is not too low for the genus *Fusulina,* for, as Henbest and I showed recently, the genotype of *Fusulina*

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[2]Letter to E. H. Sellards, June 10, 1931. The paper on *Fusulina* referred to in this letter was published in the Amer. Jour. Sci., (5), Vol. XX, 356–364, 1930.

is not a Permian shell but a very primitive species from the Middle Carboniferous of Russia. It has a thin wall with a structure essentially like that of *Fusulinella*. It therefore turns out that *Fusulina* and *Fusulinella* are very much alike, and it may be that *Fusulinella* will have to be regarded as a synonym of *Fusulina*. There are certain differences, however, in the genotypes so that I believe they should, for the present, be distinguished. The chief distinctions are that *Fusulina* is a subcylindrical shell with strongly and very regularly fluted septa and with weak chomata, whereas *Fusulinella* is fusiform, has very simple septa except where they are irregularly folded near the poles, and has very strong chomata. If both genera are to be recognized, I would not hesitate for a moment to refer the Bend species described by Thomas to genus *Fusulinella*. . . . I think they are of great interest because they are older than any others known in this country and possibly as old as any known elsewhere.

AGE OF FORMATION CONTAINING THE FOSSILS

Mr. F. B. Plummer, who has examined fossils associated with the fusulinids, has kindly made the following note on the age of the formation:

The ledges containing the fusulinids belong to the lower part of the Marble Falls formation of early Pennsylvanian age. They overlie massive strata thought to be Ellenburger limestone of Ordovician age and are overlain by thin bedded black limestones and shales of the Bend group. The following early Pennsylvanian fossils have been collected from the limestones closely associated with the fusulinids or coming from the shale bed No. 4 of the measured section between the fusulinid zones: *Gastrioceras compressum* Hyatt; *Pronorites llanoensis* n. sp. (ms.); *Spirifer musebachanus* Roemer; *Schizophoria resupinoides* Cox; *Productus morrowensis* Mather; *Productus welleri* Mather; *Productus inflatus* McChesney; *Dibunophyllum*, two species; *Chaetetes milleporaceus* Milne-Edwards and Haime; *Naticopsis tortum* Meek?; and an early Pennsylvanian bryozoa, *Tabulipora* n. sp. All of these fossils except *Pronorites llanoensis* occur in the Marble Falls limestone in San Saba County, Texas, and the Morrow formation of Arkansas. *Pronorites llanoensis* is a primitive pronoritid nearer to *Prolecanites* of the Mississippian, from which it evolved, than any American species of this genus so far discovered.

This assemblage of fossils, as well as the fusulinids themselves, indicate definitely a very early Pennsylvanian age, so early in fact that most of the forms, especially *Schizophoria resupinoides, Spirifer musebachanus,* and *Pronorites llanoensis,* and the corals seem to have come directly out of Mississippian stocks with little change.

The *Fusulinidae* described in this paper coming from the base of the Marble Falls formation are older than any known elsewhere in this country and are probably as old as any known from any part of the world.

DESCRIPTION OF SPECIES

Pl. I, figs. 1–7.

FUSULINA LLANOENSIS n. sp.

Description.—Shell fusiform, bluntly pointed ends, many specimens thickly fusiform; the axial length from 2.3 to 5 mm., and the sagittal width from 1 to 2 mm.; with a ratio of length to width of 2:1 to 3:1. Number of volutions, 4½ to 6; between 16 and 21 septa in third whorl, 18 to 24 in fourth whorl, and 12 to 27 in fifth whorl; wall thickness 20 to 40 microns in second whorl, 30 to 70 microns in fourth whorl, and 30 to 60 microns in sixth whorl.

Tunnel angle 20 to 27 degrees, increasing to 36 degrees in late whorls. Septal fluting very slight except near the poles, where it is strong but irregular. Wall of fine texture and distinctive of "fusulinella" types.

Dr. Dunbar says:

> It appears clear to me that the wall in "*Fusulina llanoensis*" consists of four layers. The tectum is extremely thin but perfectly definite. I believe it to be the primary element of the fusulinid wall. Just beneath it lies the light, translucent layer, the diaphanotheca, which in turn is coated by a much darker secondary layer which is continuous with the chomata and really lines the entire surface of each chamber. The secondary deposit is seen then as a dark covering on the outside of the tectum where it makes the fourth layer in the wall. As a matter of fact the outer layer of secondary deposit is only a basal deposit of the succeeding volution so that there are three fundamental elements in the wall, namely, the tectum, the diaphanotheca, and a secondary deposit. What I am calling the diaphanotheca shows in some

places transverse lines which resemble to a considerable degree the lamellae of the keriotheca in the higher fusulinids. . . . I am inclined to think that the structure seen here is merely a fibrous one instead of an alveolar one and that the dark lines are not real lamellae. . . . My reasons for thinking that the structure is fibrous rather than alveolar is that it can be seen in the secondary deposit both on the inside and the outside of the tectum as well as in the chomata. In some places also it is more or less clearly shown on the septa where they happen to cross the section. Now in all the higher fusulinids where there is an undoubted keriotheca, the alveolar texture is strictly limited to the inside of the spiral wall and is never seen on the septa or on the outside of the spiral wall. Particularly well preserved specimens of *Triticites* or *Pseudofusulina* do show, however, a fibrous texture in the chomata, a structure exactly like that seen in the chomata and secondary deposits of these little *Fusulinellas* from the Bend. In the case of the *Triticites* and *Pseudofusulinas*, however, the distinction between the fibrous structure in the chomata and the alveolar texture of the keriotheca is quite obvious because the fibres in the chomata are so very much finer than the alveoli in the keriotheca.

Chomata moderate to strong, fibrous. Proloculum 75 to 120 microns in diameter. Septal pores abundant and medium to large in size. Early volutions bilaterally symmetrical.

Locality.—Middle and upper coral-reef-limestone bluff on Pfluger ranch on Llano River at the mouth of Big Saline Creek, near the west edge of Mason County and about seven miles east-southeast of London, Texas. This species is abundant in a horizon above the *Fusulina primaeva* horizon and is distinct in characters as well as separate in zonal distribution at the type locality. Replacement by chert is not so pronounced as in the lower horizon but is nevertheless very common, and many of the specimens are pink.

Formation.—Marble Falls formation.

FUSULINA PRIMAEVA (Skinner)

Pl. I, figs. 8–15.

Fusiella primaeva Skinner. Journ. Paleont., V. 5, pp. 255–256; Pl. 30, figs. 7–9, 11, 1931.

Description.—Shell very small, thickly fusiform, with bluntly pointed ends; the axial length from 1 to 3 mm., and the sagittal width from 0.4 to 1.5 mm.; with a ratio of length to width of 1.5:1 to 2.7:1. Number of volutions 4 to 6; between 13 and 15 septa in third whorl, 16 to 20 in fourth whorl, and 17 to 24 in fifth whorl; wall thickness 15 to 25 microns in second whorl, 25 to 45 microns in fourth whorl, and 40 to 55 microns in sixth whorl.

Tunnel angle 24 to 40 degrees, increasing rapidly in last two whorls. Septal fluting very slight except near the poles, where it is strong but irregular. Wall of fine texture and distinctive of "fusulinella" types as previously described. Chomata moderate to strong. Early volutions bilaterally symmetrical. Proloculum 70 to 90 microns in diameter.

Locality.—Base of coral-reef bluff on Pfluger ranch on Llano River at the mouth of Big Saline Creek near the west edge of Mason County and about seven miles east-southeast of London, Texas. This species is very abundant at the base of the bluff and the horizon extends from the bluff out into Llano River. A great number of the specimens are composed of chert, some being almost wholly chert while others have chert centers and still others show that replacement has just begun. The specimens which are taken from exposed rocks in the river are more predominantly chert and are pink.

Formation.—Marble Falls formation.

SOME UPPER CRETACEOUS AMMONITES IN WESTERN TEXAS

By

W. S. ADKINS

The ammonites here recorded occur in the Chispa Summit-San Carlos region in southwestern Culberson, western Jeff Davis, and northwestern Presidio counties, Texas. They occupy a series of zones in a thick clay section, essentially of the Mancos facies, which starts at the Comanchean-Gulfian (Buda-Eagle Ford) boundary and in this region composes the equivalents of the Eagle Ford, Austin, and Taylor formations, and continues up to the base of the sandstones and lustrous black and carbonaceous shales of the "Rattlesnake"[1] formation (approximately Navarro level).

Besides these, one ammonite from the Buda limestone in central Texas is described, because of its bearing on the age of the Buda formation, and a *Coilopoceras* from the Austin chalk is described. The evidence as to the age of the respective formations is summarized at the end of this paper.

DESCRIPTION OF LOCALITIES

Chispa Summit

This area is located just south of the gap separating the Van Horn and Tierra Vieja Mountains, five miles west-southwest of Chispa station. The grade of the abandoned railway to the San Carlos coal mines traverses the area. Headwater erosion of Van Horn Creek is cutting through the gap into Chispa Bolson (Lobo Flat) and may eventually drain it. Above the Buda limestone, the Upper Cretaceous clay dips eastward and southward toward San Carlos, near which the "Rattlesnake" sandstones outcrop. Near Chispa Summit, on the Johnson and Colquitt ranches, there is an

[1]Name preoccupied; the formation will be renamed in a forthcoming paper.

Eagle Ford clay flat, in which a conical igneous body, Needle Peak, makes a prominent landmark.

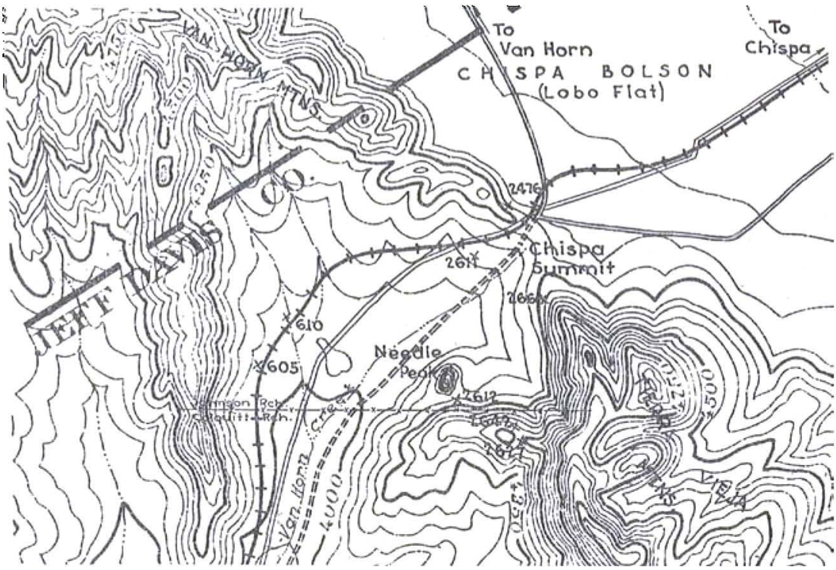

Fig. 7. Sketch map of Chispa Summit area, showing fossil localities. Scale 1:75,000.

The late Professor W. F. Cummins collected the holotype of *Romaniceras cumminsi* n. sp. in the foothills just east of Needle Peak several years ago, and placed it in the collections of the Rio Bravo Oil Company, by whom it was donated to the Bureau of Economic Geology. In 1927 Baker published a reconnaissance geologic map of southwestern Trans-Pecos Texas and a brief description of this area.* In 1931 Baker, O. M. Longnecker, A. N. Huddleston, Mr. and Mrs. M. B. Arick, with the writer, collected from this region; to them I wish to express my gratitude for their interest and help and for fossils donated by them to this Bureau.

*Baker, Charles Laurence, Exploratory Geology of a Part of Southwestern Trans-Pecos Texas, Univ. Texas Bull. 2745, 1927. Some notes on the geology near Chispa Summit are given by T. W. Vaughan, Reconnaissance in the Rio Grande Coal Fields of Texas, U. S. Geol. Surv. Bull. 164, pp. 84–85, pl. XI, 1900.

The equivalents of the Eagle Ford near Chispa Summit may be summarized as follows:

8. Upper flags: thin limestone flags and limy shales. Belemnites; *Metoicoceras*, *Scaphites*, aff. *aequalis; Inoceramus labiatus* Schlotheim, *Inoceramus* sp. Loc. 2613.

7. Shales.

6. Clay with flat calcareous mudstone nodules *(Coilopoceras* zone): *Coilopoceras eaglefordense* n. sp., *Coilopoceras chispaense* n. sp., *Acanthoceras* sp., pyritic micromorphs *(Prionotropis,* etc.). At north end of Colquitt ranch, shale hills south of Needle Peak. Loc. 2627.

5. Clay with nodules (transition zone): *Coilopoceras eaglefordense* n. sp., *Romaniceras cumminsi* n. sp., *Metacalycoceras* sp., micromorphs. Loc. 2642.

4. Sterile flagstone layer: flagstones with few fossils. Johnson ranch, cuesta south of Needle Peak.

3. Clay with septaria, concretions, conglomerate concretions, and nodules *(Romaniceras* zone): *Pseudaspidoceras (?) chispaense* n. sp., *Romaniceras loboense* n. sp., *Pseudotissotia* (?) sp. Johnson ranch, south, east, and northeast of Needle Peak. Loc. 2612.

2. Shales with subordinate thin flags: *Metoicoceras* sp., *Inoceramus* sp. Johnson ranch, cuesta face north of Needle Peak.

1. Lower flags with some interbedded chalky limestones and shales *(Pseudaspidoceras* zone): *Metoicoceras* 2 spp., *Scaphites* sp., *Kanabiceras* aff. *kanabense*, *Baculites* sp., belemnite, *Pseudaspidoceras*, echinoids, gastropods. North end of shale flat between creek and railroad grade. A higher level (2476) and a lower level (2611).

Top of Buda limestone.

This section was not measured, but the thickness of Eagle Ford equivalents is probably as much as 800 feet. Fossils were collected at the following localities:

605. Western Jeff Davis County (Chispa sheet), old railroad cut 2 miles southwest of Chispa Summit. Charles Laurence Baker, 1922. Basal Eagle Ford.

Kanabiceras sp.
Metacalycoceras sp.
Inoceramus labiatus Schlotheim

2611. Western Jeff Davis County (Chispa sheet), ½ mile south of deep railway cut at Chispa Summit and 200 yards east of railway grade; small hill in flat. Top of member No. 1 of above section. W. S. Adkins, 1931.

Metoicoceras
Mantelliceras aff. couloni (d'Orbigny)
Kanabiceras septem-seriatum (Cragin)
Baculites gracilis Shumard
Scaphites sp. aff. africanus Pervinquière
Acanthoceras ? (juvenile) sp.
"Acanthoceras" coloradoense Henderson
Allocrioceras n. sp.
Echinoid sp.
Gastropods

610. Western Jeff Davis County (Chispa sheet), 2 miles west-southwest of Chispa Summit near old railway grade. Baker, 1922.

Pseudaspidoceras sp. aff. footeanum (Stoliczka)
Pseudaspidoceras sp. aff. footeanum (Petraschek)

2612. Western Jeff Davis County (Chispa sheet), about 200 yards south of Needle Peak. *Romaniceras* zone, No. 3 of above section. Huddleston, Longnecker, Arick, and Adkins, 1931.

Romaniceras loboense n. sp. (holotype)
Pseudaspidoceras (?) chispaense n. sp. (holotype)
Pseudaspidoceras (?) n. sp. A.
Acanthoceras (?) sp.
Pseudotissotia (?) n. sp.
Pseudaspidoceras (?) spp.

2642. Western Jeff Davis County (Chispa sheet), near north fence of the Colquitt ranch, and about due south of Needle Peak (*Romaniceras cumminsi* zone, No. 5 of preceding section). Collections by Huddleston, Longnecker, Arick, and Adkins, 1931.

Romaniceras cumminsi n. sp.,
Metacalycoceras sp.
Coilopoceras eaglefordense n. sp.
Prionotropis sp. (micromorphs)

2627. Western Jeff Davis County (Chispa sheet), clay hills about 400 yards south of Needle Peak, in northern part of Colquitt ranch (*Coilopoceras* zone, No. 6). Collections by Longnecker, Huddleston, Arick, Mrs. Arick, Adkins, 1931.

Coilopoceras eaglefordense n. sp. (holotype)
Coilopoceras chispaense n. sp. (holotype)
Acanthoceras sp.
Prionotropis sp. (micromorphs)
Metaptychoceras n. sp. aff. smithi (Woods) (micromorphs)
Camptonectes sp.

2613. Jeff Davis County (Chispa sheet), about 3 miles south of Chispa Summit (upper Eagle Ford flags, No. 8 of preceding section). Arick, Mrs. Arick, Huddleston, Longnecker, Adkins, 1931.

Metoicoceras
Scaphites aff. aequalis Sowerby
Baculites
Belemnite
Prionotropis sp.
Inoceramus labiatus Schlotheim
Inoceramus sp.

2660. Western Jeff Davis County (Chispa sheet), prominent clay gullies on northwest spur of Tierra Vieja Mountains, about 1 mile southeast of deep abandoned railway cut at Chispa Summit. *Romaniceras* zone and *Coilopoceras* zone. Adkins, 1931.

(a) Romaniceras sp.
Prionotropis sp.
(b) Coilopoceras eaglefordense n. sp.

2476. Western Jeff Davis County (Chispa sheet), Chispa Summit, northwest side of gap on fault, 1¼ miles NNE. of Needle Peak. Baker, 1930. Lower Eagle Ford flaggy limestone (zone 1).

Metacalycoceras ? sp.
Pseudaspidoceras aff. footeanum (Stoliczka)
Prionotropis cfr. P. hyatti Stanton
? Helicoceras pariense White (impressions)
Scaphites sp.

Southwest Flank of Van Horn Mountains

C. L. Baker collected at these localities in 1922. Collections at hand contain Salmurian (Lower Turonian) ammonites, but no high Turonian forms such as the species of *Acanthoceras* and *Coilopoceras* which are abundant near Chispa Summit.

606. Southwestern Culberson County (Chispa sheet), on the west side of Van Horn Mountains, 11 miles west and 1½–2¼ miles north of Chispa station. Baker, 1922.

608. Southwestern Culberson County (Chispa sheet), on the west foot of Van Horn Mountains, 11 miles west and 1 mile north of Chispa station. Baker, 1922.

Pseudaspidoceras sp. aff. footeanum (Petraschek)
Thomasites sp.
Ammonite indet. (cf. "Hoplitoides mirabilis" Böse)
Metoicoceras sp.
Scaphites aff. africanus Pervinquière
Inoceramus labiatus Schlotheim
Inoceramus sp.

West of Glenn Creek

These localities, visited by Baker in 1922, contain Salmurian ammonites.

609. Southeastern Hudspeth County (Chispa sheet), southeast of Oxford Mountain, about 10 miles south of Dalberg section house on the Southern Pacific Railway. Baker, 1922.

Fagesia texana n. sp. (holotype)
Neoptychites aff. gourguechoni Pervinquière
Pseudaspidoceras eaglense (Adkins) (holotype)
Pseudaspidoceras aff. footeanum (Stoliczka)
Pseudaspidoceras aff. footeanum Petraschek
Pseudaspidoceras aff. armatum Pervinquière
Ammonite indet. (cf. "Hoplitoides mirabilis" Böse)

609a. Locality unknown, probably from near 609.* This unlabeled lot contained Salmurian (Lower Turonian) ammonites, among others a large species of *Fagesia,* and several *Pseudaspidoceras.*

Fagesia sp. cfr. F. haarmanni Böse
Pseudaspidoceras sp. aff. P. footeanum (Stoliczka)
Pseudaspidoceras sp. aff. P. footeanum (Petraschek)

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*Mr. Baker informs me that he considers the above two localities mislabeled, and that their correct location is on the east side of Glenn Creek in the western foothills of the Van Horn Mountains, near locality 608.

DESCRIPTIONS OF SPECIES

MANTELLICERAS BUDAENSE n. sp.

Pl. II, fig. 3; pl. IV, fig. 10

Form discoidal, serpental, subangustumbilicate. Whorl section elevated in young, more depressed in later stages. Umbilical wall nearly vertical, flanks gently convex in later stages, venter quadrituberculate, narrowly arched in young, more broadly arched later. Non-septate portion of about one-third volution preserved in holotype. The shell is ribbed and tuberculate. Straight, well-spaced ribs, some bifurcated in young, some of alternate lengths later, start on the vertical umbilical wall and pass across prominent umbilical (dorsal) tubercle and flank, and across the venter; there is no flank tubercle, but on either side at junction of flank and venter is a pair of prominent, rounded, spaced shoulder tubercles; the ventral mid-line is devoid of tubercles or swellings and appears concave. Dimensions: 89.6 mm. — .42 — .44 — .29; H/Th = .95 (holotype).*

Suture is typical of the genus, with three saddles and two lobes on the flank, the third and fourth lateral lobes being situated on the umbilical wall. The siphonal lobe is considerably taller than the first lateral lobe and terminally has a deep siphonal saddle, forming slender lateral lobules. The first lateral lobe is asymmetrically bifid, the second lateral lobe trifid, and the third pointed. The saddles are bifid, the first one being characteristically quadrate in outline. The internal portion of the latest suture of the holotype is well preserved. The antisiphonal lobe is about 15 mm. long, with two main lateral lobules in the terminal half and, terminally, a median denticulate lobule ending in a point. The next lobe lies on a facet between the edge of the dorsal facet and the line of involution, and between the impressions marking the position of the shoulder tubercles of the next inner whorl; it is slender and about four-fifths the length of the antisiphonal lobe, and is irregularly pointed terminally. The third internal lobe is short, asymmetrical

*Dimensions are: diameter (mm.); height (%); thickness (%) of whorl; umbilicus (%).

and pointed. The two internal saddles are bifid, each with a single simple lobule.

Buda (topmost stratum): Travis County, about one-half mile west of Manchaca, in bed of Bear Creek. The corroded top of the Buda is here overlain, concordantly so far as is visible, by a black shale generally referred to the Eagle Ford.

This genus marks the lower Cenomanian, the Mantelliceratan age of Spath.[2] The species most resembles certain forms which have been described as *M. mantelli* (Sowerby).[3] The individual figured by Schlüter[4] has, at the same diameter, almost the same form and dimensions as the present species, but differs in having the umbilicus narrower, the ribbing more sparse and the lobes less tall. That figured by Kossmat[5] differs in being more compressed and more densely ribbed. The form recorded by Lasswitz from the Eagle Mountains, Texas, as *Acanthoceras mantelli*[6] is apparently not a *Mantelliceras*.

MANTELLICERAS sp. aff. COULONI (D'Orbigny)

This corroded fragment has the form of the group of flattened *Mantelliceras*, as figured by D'Orbigny.[7] About half the ribs start near the mid-flank. On the dorsal half of the flank the ribs are very faint, but they are strong and subequal nearer the venter, which they cross without any tubercle or enlargement on the ventral mid-line. Each bears at the ventro-lateral shoulder a prominent clavate tubercle. The venter is truncated and concave; the umbilicus is narrow, its wall vertical and rounded above.

Eagle Ford (zone 1): Chispa Summit, locality 2611.

2Spath, L. F., On the zones of the Cenomanian and the uppermost Albian, Proc. Geol. Assoc., XXXVII, 420–432, 1926.

3Sowerby, Min. Conch. Pl. LV. 1814.

4Schlüter, Clemens, Ceph. ob. deutsch. Kreide, Pl. V, figs. 1–2, 1871.

5Kossmat, Fr., Unt. südind. Kr., Pl. IV, fig. 4, 1895.

6Lasswitz, Rudolf, Die Kreide-Ammoniten von Texas. Geol. u. Pal. Abh. (N.F.) VI: 18, 36, 1904. Adkins, W. S., Handbook of Texas Cretaceous fossils, Univ Texas Bull. 2838, p. 242, Pl. XXVII, fig. 1, 1928.

7D'Orbigny, A., Pal. franç., ter. crét, Céph., Pl. CIV, 1840.

ROMANICERAS CUMMINSI n. sp.

Pl. III, fig. 6

Discoidal, serpental, sublatumbilicate, cross-section of whorl depressed, quadrangular, umbilical wall vertical, rounded above, flanks straight, venter arched, ribs and tubercles prominent. In the outer volution the ribs are of two lengths, roughly alternating; the longer ones start above the umbilical margin and bear usually four equally spaced and similar swellings or tubercles, the last of which lies on the ventral shoulder; the shorter ribs start at, or ventrad to, the mid-flank and bear two swellings. On crossing the venter all ribs are about equal and equally spaced, and each bears on the venter three tubercles, one of them on the mid-line. Each rib thus has five tubercles on each side, besides the one on the ventral mid-line. The last volution bears about 24 ribs. Three smaller individuals from locality 2612, with depressed section and similar ribs, are taken to represent the earlier stages of this species. The median tubercle is plainly visible to a shell diameter of 250 mm. and thereafter the ribs on crossing the venter are thicker and broader and the tubercles more indistinct. Dimensions: 330 mm. — .38 — .41 — .303; H/Th = .925.

Suture straight; two lobes and two saddles on the flank; inner margin of second lobe at edge of umbilical wall. Siphonal lobe tall, considerably inflected, saddle low, lateral lobules short. First lateral saddle broad, rectangular, broader than tall, asymmetrically bifid, being divided by a three-pointed lobule, its ventral portion subdivided by one prominent lobule, its dorsal portion by one prominent lobule internally and three small pointed lobules externally. First lateral lobe half as broad as first saddle and as long as the siphonal lobe, rectangular in outline and symmetrically bifid. Second saddle narrow and divided by three main lobules. Second lobe narrow and situated on the umbilical margin.

Middle *Eagle Ford* (horizon 5): Chispa Summit, south and east of Needle Peak; localities 2612 (three inner whorls, probably of this species); 2642 (one large individual). The holotype bears the label: "Sept. 10, 1923, E. of Needles on the Johnson Ranch, Lobo, Culberson County. Prof. Cummins." It is not known from which horizon the holotype was collected, but the species apparently occurs in both horizons 3 and 5.

Small individuals, possibly of the same species, show the internal suture.

ROMANICERAS LOBOENSE n. sp.

Pl. II, figs. 1, 21; pl. III, fig. 5

A species of this genus[9] is associated with species of *Acanthoceras* (?) at Chispa Summit. The form is *Acanthoceras*-like, evolute, whorl section depressed and subrectangular, flanks convex, venter arched, sublatumbilicate, umbilicus deep, its wall steep and rounded at the top; the holotype consists of a partly septate portion of the outer volution of an individual of estimated diameter of 240 mm. Other dimensions are:

	mm.	Per Cent
Umbilicus (estimated)	85	0.354
Height of last volution	73.1	0.305
Thickness of last volution	83.6	0.348
H/Th	0.87	

Ribs are continuous over flanks and venter; with age they are of roughly alternate lengths. Each rib bears: a clavate tubercle on the ventral mid-line, two calvate tubercles on either side of the mid-line, and generally two unequal tubercles on each flank, a total of nine tubercles, the five on the venter being subequal. The umbilical tubercle becomes bullate or round with age, the mid-flank tubercle, faint and elongate. The impression of the venter of the next inner whorl shows subequal lines of tubercles. This is the same tuberculation as in the genotype.[10]

9*Romaniceras* Spath 1923, Summ. Prog. Geol. Surv. Gt. Britain [etc.], p. 144. Genotype: *Ammonites deveriannus* D'Orbigny, Pal. franç., terr. crét., Céph., I, 1841, p. 356, Pl. CX, figs. 1–2.

10D'Orbigny, A., op. cit., Pl. CX. Roman and Mazerin, Monographie paléontologique de la faune du Turonien du bassin d'Uchaux et de ses dépendences. Arch. Mus. Univ. Lyon, XII, 25–27, fig. 4, Pl. III, figs. 1–2, 1920.

The external suture consists of two saddles and one lobe on the flank. The siphonal lobe is tall, rectangular and deeply divided by the squarish siphonal saddle. The first lateral lobe, situated about mid-flank, is somewhat shorter than the siphonal lobe, and is plainly trifid. The second lobe is oblique, small, and situated at the rounded junction of flank and umbilical wall; it has two small branches, the external one somewhat the longer. The saddles are quadrate and asymmetrically bifid. The first saddle is large and is divided by a long, slender, trifid lobule into a larger external and smaller internal portion, each subdivided by a pointed lobule. The second saddle, much smaller, is basally more constricted and is divided by a pointed lobule, the external portion being smaller. The internal suture is likewise simple. The antisiphonal lobe is long, slender, terminally trifid, with four points on each side. Just inside the line of involution is a slender, parallel but somewhat shorter lobe, irregularly bifid at the tip. The intervening saddle is tall and slender. The next two saddles are small, quadrate, and bifid, being divided by a slender lobule. They are separated on the umbilical wall by a short bifid, slender, terminally enlarged lobe. This suture agrees in detail with that of *R. ornatissimum* (Stoliczka),[11] differing mainly in the greater obliquity of the second lateral lobe and the corresponding lowness of the third saddle compared to the second.

Eagle Ford (Romaniceras zone, No. 3) : Chispa Summit, locality 2612. A species collected by Moreman[12] from central Texas in his *Metoicoceras whitei* zone was identified as *Romaniceras* by Reeside.[13]

METACALYCOCERAS (?) sp.

Pl. II, figs. 13–14

The ribs proceed uninterruptedly across the venter; neither tubercles nor suture visible; generic identification uncertain.

Eagle Ford: Chispa Summit, locality 2611.

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11 Stoliczka, Ferd., Foss. Ceph. Cret. Rocks South. India, Pl. XL, fig. e, 1865.

12 Moreman, W. L., Fossil zones of the Eagle Ford of North Texas, Jour. Pal., I: 95, Pl. XV, fig. 2, 1927.

13 Reeside, John B., Jr., and Weymouth, A. Allen, Mollusks from the Aspen shale (Cretaceous) of southwestern Wyoming, Proc. U. S. Nat. Mus., 78: 12, 1931.

COILOPOCERAS EAGLEFORDENSE n. sp.

Pl. IV, figs. 4, 8; pl. V, fig. 1

Discoidal, oligogyral, angustumbilicate, cross-section of volution elevated, sublanceolate, sharply rounded at venter; thickest at point about 2-5 the way from the umbilicus to the venter, dorsad to which the flank is rather sharply convex, and ventrad to which the flank is very gently convex, almost flat; umbilical wall practically vertical, but rounded above. The flank is devoid of ribs and tubercles, and appears smooth. The holotype, at 525 mm. diameter, is completely septate; living chamber not seen. The holotype has the dimensions: 525 mm. — .53 — .27 — .08. The venter is hollow: in weathered specimens portions of the large siphuncle, notched at the intersections with the septae, and having diameters up to 11 mm., weather free, leaving the venter grooved. Dimensions: 525 mm. — .53 — .27 — .08 mm.; H/Th = 1.96.

Suture curved, with seven saddles and six lobes on the flank. Siphonal lobe short, its branches spreading. First lateral saddle tall, divided by a long, slender median lobule and having on either side of it one shorter lobule, asymmetrically placed. First lateral lobe, reaching to center of flank, consists of two parts, an outer lobule, asymmetrically bifid, and an inner one, asymmetrically trifid. The outer one has both points bifid, the outer point less prominent than the inner; the inner lobule has its points asymmetrically bifid and considerably subdivided, the central and inner points being more prominent than the outer. The second saddle is asymmetrically bifid, being divided by a tall, slender lobule, on either side of which is a smaller lobule. The remaining lobes are roughly quadrate and trifid. The second lateral lobe is almost symmetrically trifid. The remaining saddles are all bifid and slightly asymmetrical. Dorsad from the second saddle, the suture is almost straight, and the elements gradually decrease in size. This arrangement seems almost constant in the material studied.

Non-costate species include *C. requienianum* (d'Orbigny), *C. lesseli* (Bruggen), *C. springeri* Hyatt, *C. eaglefordense* n. sp. and *C. austinense* n. sp. The present species differs from *C. requienianum* principally in its larger size and in the details of the suture; it has five, instead of four, lobes dorsal from the first lateral lobe; the lobes are more quadrate and less elongate; both portions of the first lateral lobe are less symmetrical; both lobes and saddles are more minutely subdivided. *C. lesseli* has a more simplified suture: the two portions of the first lateral lobe are more nearly equal, the remaining lobes are narrow and elongate, and most of the saddles are entire. It differs from *C. austinense* n. sp. in dimensions, and in the details of the first lateral lobe, as discussed under that species.

A closely similar species is *C. springeri,* only sutures of which were figured by Hyatt. From the description of the holotype, 400 mm. in diameter, in the Museum of Comparative Zoölogy, *C. springeri* has about the same dimensions as the species described above. It differs, however, in having the first lateral saddle broad, instead of narrow and tall; in having the first lateral lobe composed essentially of three parts (ventrally an asymmetrically bifid lobule, centrally a single lobule much subdivided, and dorsally an asymmetrically bifid lobule) instead of two parts (ventrally an asymmetrically bifid lobule and dorsally an asymmetrically trifid lobule); and in having the remaining lobes to the line of involution, seven instead of five, tall and narrow instead of quadrate.

Coilopoceras resembles *Hoplitoides* von Koenen in having a generally discoid form and a narrow umbilicus, and in the suture,[14] particularly in the form and size of the first lateral lobe. It differs from *Hoplitoides* in having a hollow, instead of a solid, venter, and the venter acute or sharply rounded, instead of bicarinate as in the young of some species or truncate as in the adults of others. Von Koenen

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14Douvillé, Henri, Évolution et classification des Pulchelliidés. Bull. Soc. Géol. France, (4) XI, 285–320, 1911. Koenen, A. von., Nachtrag zu Ueber Fossilen der unteren Kreide am Ufer des Mungo in Kamerun. Abh. Kön. Ges. Wiss. Gottingen, math.-Wiss. Kl., (N.F.) I: 56–62, Pls. V–VII, 1898 (genotype: *H. latesellatus* von Koenen).

(*op. cit.*, pl. V, fig. 3) indicates a *Coilopoceras*-like siphuncle in *Hoplitoides*, which Hyatt, who fails to mention Von Koenen's genus in this connection, considered the main diagnostic feature of *Coilopoceras*. In form and suture the two genera are practically identical. It is therefore possible that *Coilopoceras* Hyatt, 1903, is a synonym of *Hoplitoides* Von Koenen, 1898, a question which requires a study of comparative material for decision.

Eagle Ford (zone 6) : Chispa Summit, locality 2627.

COILOPOCERAS CHISPAENSE n. sp.

Pl. IV, figs. 5, 7; pl. V, fig. 2

Discoidal, oligogyral, angustumbilicate, lenticular, cross-section of whorl elevated, sharply rounded at venter, thickest a little dorsad of venter, umbilical wall steep, rounded above. The flank bears a few widely spaced, broad, straight, radial swellings which start a little distance out from the umbilical wall, are narrow and elevated to the middle of the flank, and farther ventrally broaden and disappear, being absent in the ventral part of the flank. Besides these, the cast bears numerous fine, nearly straight, radial striae. The holotype at 361 mm. diameter is wholly septate; living chamber not seen. The siphuncle reaches 11 mm. in diameter, and in weathered individuals, casts of the siphuncle, interrupted by septal walls, become disengaged, exposing the hollow venter described by Hyatt. Dimensions: 361 mm. — .56 — .28 — .10; H/Th = 1.95.

Suture curved, with seven lobes and seven saddles on the flank. The suture differs from that of *Coilopoceras eaglefordense* n. sp. in the following features: The sutural elements are more elongate and less quadrate; the first lateral saddle lacks the secondary points on each side of the central lobule; the first lateral lobe is deeply divided into three instead of two lobules, of which the external is smallest, the central lobule has its inner, not outer, branch prominent. In the second lateral saddle the middle lobule is relatively shorter and terminally less dissected. The remaining lobes are more elongate and less quadrate. The third lateral lobe is six-pointed instead of eight-pointed. The fourth saddle is trifid instead of bifid. The seventh instead of the sixth saddle lies above the umbilical wall, on the flank. The sixth saddle is entire instead of bifid.

This species differs from *C. eaglefordense* in its suture, in the presence of broad radial swellings, and in its correspondingly more inflated cross-section. The suture of *C. lesseli* Bruggen differs in having its second and third saddles entire, and its other elements more simplified. The suture of *C. springeri* Hyatt differs in the subdivision of the first lateral lobe into ventrally a bifid lobule, centrally a single lobule, and dorsally a trifid or symmetrically bifid (quadrifid) lobule, all terminally considerably subdivided. *C. springeri* has the third saddle simple instead of bifid, but like the present species has the fourth saddle trifid. *C. africanum* Pervinquière, *C. colleti* Hyatt (the genotype) and *C. novimexicanum* Hyatt, all have more delicate ribs than *C. chispaense.*

Middle *Eagle Ford* (horizons 5 and 6) : Chispa Summit, localities 2627, 2642.

COILOPOCERAS AUSTINENSE n. sp.

Pl. IV, fig. 9

The corroded holotype is discoidal, oligogyral, angustumbilicate, lenticular, cross-section of whorl elevated, inflated in the dorsal half, almost flat in the ventral half. The holotype consists of about one-third of a volution, and the umbilicus is not preserved. The flanks appear to be smooth. Dimensions: 625 mm. (est.) — .46? — .18? — ?; H/Th = 2.64.

Suture nearly straight, with at least five lobes and five saddles on the flank. First lateral saddle divided by four lobules, the next to the inner one most prominent. First lateral lobe consists of two portions, a shallowly and asymmetrically bifid outer portion and an irregularly trifid inner portion. The second saddle has one central deep simple lobule, and on either side a shorter simple lobule. The third and fifth saddles are symmetrically bifid, each being divided by a simple lobule; the fourth is trifid. The second lateral lobe is asymmetrically trifid. The third, fourth, and fifth lobes are trifid and broad. This ammonite is similar in form and suture to *C. eaglefordense,* but the suture is much less subdivided; the first lateral lobe has the same general plan. The fourth saddle in *C. austinense* and *C. springeri* is trifid; in *C. requienianum, C. lesseli* and *C. eaglefordense* it is bifid. The species is distinguished by the simplicity and squareness of its sutural elements.

Lowermost Austin chalk: Travis County, on Bear Creek about 3/8-mile west of Manchaca.

Professor J. M. Barcus reports an ammonite similar in form and size to *C. eaglefordense* from the Eagle Ford near Grand Prairie,* west of Dallas, Texas. Reeside[15] records *Coilopoceras* from the Colorado group in the Interior Province of North America. Stephenson[16] records a species of this genus from the uppermost two feet of the Eagle Ford formation on Bouldin Creek, 1 3/4 miles south-southwest of the Capitol at Austin, in association with species of *Prionotropis* and *Prionocyclus;* in the Bureau of Economic Geology there are examples from this locality of *Coilopoceras* cf. *eaglefordense* n. sp., *Prionotropis* sp., *Prionocyclus* cf. *wyomingensis, Scaphites?* aff. *aequalis, Kanabiceras* n. sp and some others. A corroded fragment of *Coilopoceras* (see Fig. 8) was collected from Eagle Ford float in Aldrich Place, Austin, in 1931 by Mr. Boyd Wells. Species of *Coilopoceras* have been recorded from England, France, Algeria, Peru and New Mexico.[17]

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*Professor Barcus writes that it was found in a creek running parallel to the White Rock Escarpment, at a point about five miles south of the Fort Worth-Dallas pike, and stratigraphically 100 feet below the top of the Eagle Ford formation.

15Reeside, J. B. Jr., U. S. Geol. Surv., Prof Paper 132, p. 31, 1925.

16Stephenson, Lloyd W., Unconformities in Upper Cretaceous series of Texas. Bull. Am. Assoc. Petr. Geol., 13: p. 1328, 1929.

17Diener, C., Ammonoidea neocretacea. Fossilium catalogus, I: Animalia, Pars. 29, pp. 218, 234, 239, 1925.

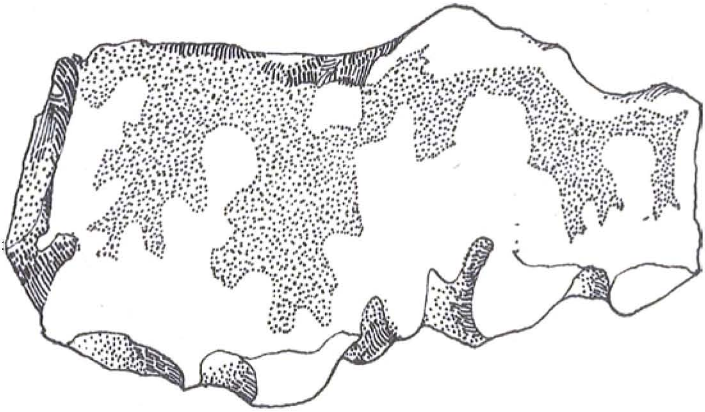

Fig. 8. *Coilopoceras* sp. from Eagle Ford formation, Aldrich Place, Austin, Texas.

COILOPOCERAS sp. aff. C. SPRINGERI Hyatt

Pl. V, fig. 3

This ammonite, having the proportions: diameter 186. mm.; height 0.65; thickness 0.32; umbilicus 0.048, has a suture much like that of *Coilopoceras springeri* Hyatt *(op. cit.,* pl. XII, figs. 1–2), especially in the details of the first lateral lobe. However, the third and fourth saddles are simply bifid in the Texas species.

Eagle Ford: Chispa Summit, locality 2660.

PSEUDASPIDOCERAS (?) CHISPAENSE n. sp

Pl. III, figs. 1–2

Discoidal, serpental, sublatumbilicate, cross-section of whorl depressed, trapezoidal, umbilical wall vertical, rounded at margin, flanks inflated, venter arched, tubercles and ribs prominent. The holotype consists only of about one-third of an outer volution, and with the material at hand it has been impossible to identify positively the earlier stages. The holotype bears indistinct, widely spaced principal ribs, each with a coarse rounded to bullate tubercle or swelling at about the mid-flank, and on the ventral shoulder a much coarser clavate or alate projection; in the holotype the direction of this alation is longitudinal (along the perimeter of the volution), but in other individuals it is radial or oblique. The ribs over the venter are reduplicated, as in the *Acanthoceras cunningtoni* group. The ventral mid-line bears a small clavate tubercle on the principal ribs and indistinct swellings on other ribs. The smaller end of the fragment shows only coarse nodes on the ribs at the ventral shoulder, evidently the condition in the earlier stages; immediately past these is the last suture, so that the septate portion ends where the alations begin. This species shows an extreme stage of the usual *Acanthoceras* ornamentation, serving in part to strengthen the large shell.

Proportions of the holotype are:

	mm.	Per Cent
Diameter, estimated	360	1.00
Umbilicus, estimated	210	0.58
Height of last volution	82.2	0.23
Thickness of last volution		
between tubercles	90.8	0.25
over tubercles, estimated	120	
H/Th 0.91		

This irregular suture consists externally of three saddles and two lobes, the third lateral lobe being at the top of the umbilical wall. The siphonal lobe is as tall as the first lateral lobe, is rectangular in form, and is divided terminally by a deep saddle, producing long slender lateral lobules. The first lateral lobe lies in the upper half of the flank, and is tapering and irregularly bifid. The most aberrant feature of the suture is the first lateral saddle, which finds some analogies in that of *Mammites*, especially *M. nodosoides* as figured by Laube and Bruder.[8] It is unusually broad, extending almost to the middle of the flank, and is divided by a long, slender, pointed, outwardly directed lobule into a smaller bifid external portion, and a broad, bifid, denticulate internal portion. The second lateral saddle, slightly broader than the first lobe, is quadrate and irregu-

[8]Laube, Gustav. C., and Bruder, Georg, Ammoniten der böhmischen Kreide. Palaeontographica, 33: 229, Pl. XXV, fig. 1, and text figure on page 230, 1887.

larly bifid. The second lobe is more slender and pointed. The third saddle is broad, low and bifid.

Eagle Ford (Romaniceras zone, No. 3) : Chispa Summit, locality 2612.

PSEUDASPIDOCERAS (?) sp.

Pl. II, fig. 2

In the *Romaniceras* zone there were collected many fragments which are in some respects similar to this genus. They have strong, elevated, single ribs, each bearing typically a strong bullate enlargement in the dorsal half of the flank, a pronounced, outwardly projecting, conical enlargement on the ventro-lateral shoulder, and a thin clavate elevation lying on a low, irregular keel-like enlargement, on the ventral mid-line. The section is elevated (H/Th = 1.1). The suture is as in *Mammites:* broad first lateral saddle, asymmetrically bifid, first lateral lobe prominent, second saddle less broad, second lobe small, third saddle small, third lobe on umbilical wall. Another species differs in having the elevation on the mid-line reduced to a thin, linear elevation. The section is elevated (H/Th = 1.09).

Eagle Ford: Chispa Summit, locality 2612.

PSEUDASPIDOCERAS (?) n. sp. A.

Pl. III, figs. 3–4

This species, doubtfully referred to *Pseudaspidoceras,* is large, evolute, elevated, and is ornamented with remote, heavy ribs and laterally directed coarse alar enlargements which project straight out from the ventro-lateral shoulder. The section is about twice as tall as broad, if measured between the tubercles. The broken tubercles, if restored, would make the section broader than tall. The species cannot be described until better material is available.

Eagle Ford: Chispa Summit, locality 2612.

PSEUDASPIDOCERAS EAGLENSE (Adkins)

This ammonite, erroneously referred by the writer[18] to *Prionotropis,* has the features of *Pseudaspidoceras:* the

[18]Adkins, W. S., Handbook of Texas Cretaceous fossils, Univ. Texas Bull. 2838, p. 250, Pl. XXXII, figs. 1–2, 1928.

coiling is evolute, with little overlap on the inner volutions, the section of volution is almost square, the ribs are coarse and widely spaced and bear each a coarse swelling or node on the ventral shoulder, the venter is truncated and bears a continuous low keel or ridge corresponding to the position of the siphuncle, and the suture agrees with that of *Pseudaspidoceras.* This species may be identical with that described by Böse from Mohóvano, Coahuila-Chihuahua, as *P.* aff. *pedroanum* (White), and with the depressed individuals from Chispa Summit; and resembles *P. footeanum* (Stoliczka) in some features, degree of evoluteness, sparse ribbing, but differs in being less depressed (H/Th = 1.0 in this species, 0.92 in *P. footeanum)*, and in having coarser ribs and nodes. This species shows the very broad first lateral saddle, with a median lobule, seen in *Mammites nodosoides* Schlotheim, but lacks the broad first lateral lobe characteristic of *Mammites michelobensis* and *Pseudaspidoceras footeanum.* It has three saddles and three lobes on the flank; the saddles are bifid, the first lateral lobe irregularly bifid, and the other two lobes pointed.

Eagle Ford: Culberson County, west foot of Van Horn Mountains, locality 609.

PSEUDASPIDOCERAS sp. aff. FOOTEANUM (Stoliczka)

Corroded material, too poor for illustration, represents two or possibly three species of this genus. One species, from localities 609, 609a, 610 and 2476 has the volution as depressed as in *Pseudaspidoceras footeanum* (Stoliczka)[19] but the nodes fewer and coarser, and has straight, remote, weak ribs, and prominent umbilical and shoulder tubercles. It resembles closely the form described by Böse[20] as *P.* aff. *pedroanum* (C. A. White), but differs from *P. pedroanum* (C. A. White)[21] in having a more depressed whorl and much coarser umbilical and shoulder tubercles and more continuous ribs.

Another species from localities 608, 609, 609a, and 610 has a volution 1½ times as tall as broad, ribs narrow and

[19]Stoliczka, Ferd., *op. cit.*, 101, Pl. LII, figs. 1–2, 1865.
[20]Böse, Emil, Univ. Texas Bull. 1856, p. 209, Pl. XIII, fig. 1; Pl. XV, fig. 1, 1920.
[21]White, C. A., Arch. Mus. Nac. Rio de Janeiro, VII: 212, Pl. XXII, figs. 1–2, 1887.

straight, and small round umbilical and ventral shoulder tubercles. It resembles the form described by Böse[22] as *P.* aff. *footeanum* Petraschek (not Stoliczka), and differs from *P. footeanum* (Stoliczka) in its taller volution.

One corroded fragment from locality 609 has the form, ribbing and tuberculation of *P. armatum* Pervinquière,[23] but its state of preservation forbids specific determination. About a mile south of Chispa Summit near the railroad grade are many badly corroded *Pseudaspidoceras* in a soft chalky limestone, in the basal Eagle Ford. Reeside has reported *Pseudaspidoceras* from the early Benton of the Western Interior.

FAGESIA TEXANA n. sp.

Pl. II, figs. 4, 10, 15

One young individual, entirely septate and superficially most resembling *Fagesia thevestensis* (Peron), has the features of this genus: section depressed and coronate, umbilicus deep, its walls vertical, one line of tubercles, ribs directed forwards, the external suture with four saddles, which are slender, rounded above and asymmetrically trifid, the first lobe deeply bifid, the second less so, the third more or less pointed.

Form inflated, subglobular, section of whorl depressed, coronate, with venter and flanks rounded, latumbilicate, umbilicus deep, wall vertical, rounded at top. The later part of the shell is smooth, but has one or more constrictions. Umbilical tubercles few; ribs, forwardly directed on crossing venter, about 15 in a half-volution. Dimensions: 60.4 mm. — .43 — .605 — .376; H/Th = .71.

Two lateral lobes and three saddles on flank; third lateral lobe on the steep umbilical wall. First lateral lobe deeply and asymmetrically bifid, with the peculiarity of having the external lobule longer and more prominent; second lateral lobe prominently bifid; third lateral lobe, on upper part of umbilical wall, irregularly bifid with the internal lobule more prominent; fourth lobe pointed. The lobes decrease

22Böse, Emil, Univ. Texas Bull. 1856, p. 208, 1920.

23Pervinquière, L., Ét. Pal. Tun., p. 317, Pl. XIX, figs. 2, 3, 4 a, b, 1907.

in height from the siphonal lobe, which is tallest. There are three saddles on the flank; they are tall, narrow, and in general trifid. The first lateral saddle is slightly taller than the second; and the following saddles are distinctly less tall than the second. The internal suture is not visible on the holotype.

Eagle Ford: Culberson County, west flank of Van Horn Mountains, locality 609.

FAGESIA sp. cf. F. HAARMANNI Böse

Pl. II, fig. 19

One very corroded fragment, probably from Glenn Creek (609a), shows the typical coronate form of *Fagesia,* and a suture much simplified by wear. Its dimensions are: length of fragment, 136 mm.; width, 96 mm.; height, 62 mm. Details of ribbing or of tubercles are not shown. The suture has two lobes and three saddles on the flank.

In shape it resembles *Fagesia thevestensis* (Peron),[24] *Fagesia haarmanni* Böse[25] from the Salmurian at Mohóvano and Piedra de Lumbre, Coahuila, and *Fagesia californica* Anderson[26] from the middle Chico (middle Turonian) in Shasta County, California, and in Oregon.

THOMASITES sp.

Pl. II, figs. 16–17

One ammonite has the general features of this genus. The form is involute, the umbilicus small, the flanks in the young stage subparallel and the volution compressed and elevated, in later stages the flanks divergent and the cross-section trapezoidal; ribbed and tuberculate in the young stage, more nearly smooth in the later stage. There are three saddles and two lobes on the flank; the third lateral lobe lies on the junction of flank and umbilical wall. The first and second lateral lobes are asymmetrically bifid; the third lobe appears to be oblique as in *Thomasites* and *Neoptychites.* The siphonal lobe is longer than the first lateral

24Pervinquière, Léon, Ét. pal. tun., Céph., Pl. XX, figs. 6 a–b, 1907.

25Böse, Emil, Univ. Texas Bull. 1856, p. 211, Pl. XIV, figs. 1–2, Pl. XV, fig. 2, 1920.

26Anderson, Frank M., The genus *Fagesia* in the Upper Cretaceous of the Pacific Coast. Jour. Pal., 5: 123–124, Pl. XV, Pl. XVI, figs. 1–2, 1931.

lobe, as in *Thomasites* (the opposite is true of *Neoptychites);* the form, the presence of three, instead of two, lobes on the flank, and the occurrence of bifid instead of trifid to irregular lobes, distinguish this species from *Vascoceras.* More material is necessary for a good description of this species.

Reeside has reported *Thomasites* from the Western Interior Benton.

Lower *Eagle Ford:* Van Horn Mountains, locality 608.

NEOPTYCHITES sp. aff. N. GOURGUCHONI Pervinquière

Pl. II, figs. 18, 20

Discoidal, section tall-oval, thickest near umbilicus and tapering to the sharply rounded venter, subangustumbilicate. Living chamber one-half volution. The surface is smooth except for a few faint, forwardly directed rib-like swellings, which thicken on crossing the ventral mid-line and at each ventral shoulder bear one faint circular tubercle-like swelling. Umbilicus deep, wall vertical, rounded above. Dimensions: 63 mm. — .55 — .46 — .097; H/Th = 1.2.

Suture straight with three saddles and three lobes on the flank. Siphonal lobe shorter than first lateral, with fairly deep median saddle. First lateral lobe tall, narrow, irregularly trifid, the external lobule being least developed; second lobe lower and narrower, pointed; third lobe small, quadrate, undivided. First lateral saddle broad, squarish, with three pointed lobules, the internal one most prominent; second saddle smaller, divided by two equal lobules; third saddle small, asymmetrically bifid; fourth saddle on umbilical wall.

In form and suture this ammonite resembles *N. gourguchoni* Pervinquière[27] and *N. perovalis* (von Koenen),[28] with, however, important differences: the saddles are broader than tall; the third saddle is narrower than the second;

27Pervinquière, Léon, Ét. Pal. tun., Céph., p. 400, figs. 155-156, Pl. XXVII, figs. 8 a–b, 9 a–b, 1907.

28von Koenen, A., Ueber Fossilen der unteren Kreide am Ufer des Mungo in Kamerun. Abh. kön. Ges. Wiss. Göttingen, math-phys. Kl., (N.F.) I:10, Pl. I, fig. 3; Pl. II, fig. 6, 1897.

the lobes are less inflected; the siphonal lobe is practically as long as the first lateral lobe; the third lobe is undivided and not oblique. This suture greatly resembles that of young *Neoptychites*.[29] This resemblance and the similarity of form seem to justify the generic identification, but more material is necessary for specific determination.

Eagle Ford: Culberson County, west flank of Van Horn Mountains, locality 609.

PSEUDOTISSOTIA (?) n. sp.

Pl. II, fig. 5; pl. IV, figs. 3, 6

Discoidal, keelless, involute, subangustumbilicate, ribbed and tuberculate up to about 55 mm. diameter, thereafter smooth, flanks gently convex, venter broad and sharply truncated, flat or gently concave, umbilicus deep, wall vertical, rounded above. In its truncated venter it resembles *Haresiceras* Reeside, *Roemeroceras* Hyatt, or *Placenticeras sancarlosense* Hyatt. Four saddles and three lobes on flank, fourth lobe on top of umbilical wall. First lateral saddle wide, asymmetrically bifid, being divided by a slender pointed lobule, the larger external and smaller internal portions each bifid by a smaller lobule. First lateral lobe shorter than siphonal lobe, simple, tall, narrow, terminally digitate and only slightly enlarged. Second saddle asymmetrically divided by a single lobule. Second lobe pointed. Third saddle narrower than second, asymmetrically bifid. Third lobe low, irregularly bifid, oblique. Fourth saddle low, trifid. Internal suture unknown.

Roemeroceras Hyatt has a similar suture and form but is keeled and ribbed. Certain species of *Tissotia,* which with age lose keel and tubercles and acquire a broad truncated venter, resemble the present species in both form and suture, as *Pseudotissotia tunisiensis* Hyatt,[30] but in the Texas species no keel is visible at any stage examined in

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[29]Such as *N. xetriformis,* radius 15 mm., figured by Pervinquière, *op. cit.*, p. 398, fig. 153.

[30]Hyatt, Alpheus, Pseudoceratites of the Cretaceous. U. S. Geol. Surv., Mon. XLIV, p. 36, 1903. Pervinquière, Léon, *op. cit.*, pp. 369–372, Pl. XXVI, figs. 1–4, 1907. Douvillé, H., Évolution et classification des *Pulchelliidés,* Bull. Soc. Géol. France (4), XI: 302–304, 1911.

the material at hand. This species bears a few prominent umbilical tubercles and on each rib at the ventro-lateral angle a pair of shoulder tubercles. The ribs cross the venter as broad swellings, with no enlargement or tubercle on the mid-line.

Eagle Ford (Romaniceras zone, 5) : Johnson Ranch near Needle Peak, locality 2612 (two individuals, found by Messrs. Huddleston and Arick).

HOPLITOIDES (?) MIRABILIS Böse (not Pervinquière)

Pl. IV, fig. 2

Near Chispa Summit there have been found a few ammonites like those described and figured by Böse from Mohóvano, Chihuahua-Coahuila, as *Hoplitoides* aff. *mirabilis* Pervinquière, and like those from Piedra de Lumbre, Coahuila.[31] The Chispa Summit individuals lack the suture, and therefore, for purposes of record, an individual from Piedra de Lumbre, collected by Messrs. Wellings and Tappolet and donated to the Bureau of Economic Geology by the Aguila Company, is here figured. It will be noted that the ammonite is not a *Hoplitoides,* because *Hoplitoides* has a *Coilopoceras*-suture, a narrow umbilicus, and a lenticular form.

This ammonite is discoidal, somewhat involute, half of the flank being overlapped by the next outer volution, sublatumbilicate, the flanks gently inflated, the venter sharply rounded, the umbilicus shallow, its wall steep and rounded at the top. In the younger stages, up to about 100 mm. diameter, a median, low ventral keel is plainly visible, and each ventro-lateral shoulder, where uneroded, is marked by a broader but distinct ridge, producing the effect of three ventral keels. These keels apparently become reduced and disappear with age. The flanks are smooth; ribs and tubercles are absent. Dimensions of plesiotype: 123 mm. — .38 — .31 — .306; H/Th = 1.22.

The suture is straight. There are three saddles and two lobes on the flank. Saddles irregularly bifid, decreasing in

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31Bose, Emil, and Cavins, O. A., The Cretaceous and Tertiary of southern Texas and northern Mexico, Univ. Texas Bull. 2748, pp. 29, 169, 1928.

width toward the umbilical wall; the first lateral saddle is considerably taller and less quadrangular than the other two. First and second lateral lobes digitate and obscurely bifid. The form of shell and the suture resemble those of *Neoptychites cephalotus* Courtiller[32] as refigured by Pervinquière,[33] except for the much narrower umbilicus of the African species and the associated presence on the flank of the fourth lateral saddle and fourth lobe.

Eagle Ford: Culberson County, southwest flank of Van Horn Mountains, locality 609. *Salmurian:* Piedra de Lumbre, Coahuila; Mohóvano, Coahuila-Chihuahua.

KANABICERAS SEPTEM-SERIATUM (Cragin)*

Scaphites septem-seriatus CRAGIN, 1893. Geol. Surv. Texas, 4th Ann. Rept., p. 240.

Acanthoceras ? kanabense STANTON, 1894. U. S. Geol. Surv. Bull. 106, p. 181, pl. XXXVI, figs. 6–8.

Acanthoceras kanabense MOREMAN, 1927. Jour. Pal., I: 95, pl. XV, fig. 5.

Kanabiceras kanabense REESIDE AND WEYMOUTH, 1931. Proc. U. S. Nat. Mus., 78: 1, 11–12.

Stanton's "The Colorado formation and its invertebrate fauna," United States Geological Survey Bulletin 106, was transmitted for publication on July 30, 1892, and was published at some later date, presumably not earlier than August, 1893 (see page vi); Cragin's "Contribution to the Invertebrate paleontology of the Texas Cretaceous" was published in June, 1893, having been transmitted for publication to the Commissioner on May 31, 1893, and to the Governor on June 11, 1893. So far as these printed records show, Cragin's species has priority over Stanton's species.

An examination of the holotype of *Scaphites septem-seriatus* Cragin, now in the Department of Geology of The University of Texas and examined through the courtesy of Dr. F. L. Whitney, shows that it is undoubtedly a *Kanabiceras*, and according to the specific standards now in vogue, it would likely be referred to *Kanabiceras kanabense*. If

32Courtiller, Les ammonites du tuffeau, Ann. Soc. Linn. de Maine-et-Loire, Vol. IX, p. 3, Pl. I, figs. 1–3, Pl. II, figs. 1-2, 1867.

33Pervinquière, Léon, Ét. pal. tun., Céph., Pl. XXVII, figs. 2–2a, 1907.

*For Kanabiceras read Neocardioceras. See page 72.

so, the correct name of this species, the genotype, becomes *Kanabiceras septem-seriatum* (Cragin).

A description of Cragin's holotype follows:

Form discoidal, serpental, depressed, sublatumbilicate, flanks inflated, venter broadly arched, umbilicus deep, its wall almost vertical, rounded above. The ornamentation consists of ribs, tubercles, spines and growth lines. The ribs are of two strengths, arched forward over the venter, flexuous, and all arising at the umbilicus, the strong ones being continuous all around, the weak ones (2 to 4 between every two strong ones) faint or absent on the mid-flanks. Interspersed between them is a variable number of fine growth lines. The tubercles and spines are in seven rows, as follows: a row on the ventral mid-line, two rows near the ventro-lateral shoulder, bounding between them a distinct facet, and one row near the umbilical border. The mid-line tubercles occur on every rib; on the strong ribs they are prominent and conical, on the weakest ribs reduced and bullate (transverse). The outer ventro-lateral tubercles occur on every rib, being strong and spinate on the strong ribs, weak and bullate on the weak ribs. The inner ventro-lateral row on the strong ribs is spinate with a prominent conical (in some, clavate) base and a long spine (more than 10 mm.) as in Moreman's figure, and on the weak ribs obsolescent or absent. The umbilical row is elongate-bullate on all ribs, being more sharply elevated on the strong ribs. The holotype, about half a volution, non-septate and apparently not crushed, occurs in an ironstone boulder; the nacreous shell is preserved. Its dimensions follow:

	mm.	Per Cent
Greatest diameter	67.5	
Height of volution	22.7	.34
Thickness of volution	25.7	.38
Umbilicus	28.7	.425
H/Th	0.88	

The material from Chispa Summit occurs in the basal zone (No. 1, loc. 2611), and consists of several young individuals and two larger fragments. Dr. J. B. Reeside, Jr., compared material from locality 2611 with the types in the United States National Museum, and writes:

> One specimen, unnumbered, I believe to be inseparable from "*Acanthoceras*" *coloradoense* Henderson. It is, of course, not an *Acanthoceras*, but I have not yet placed it to my own satisfaction. Some of the material in my hands even suggests an ankyloceratid type, i.e., partly unrolled in large adults.
>
> Most of the specimens are so close to *Kanabiceras kanabense* that I see no appreciable differences. This material is numbered 2611. Two fragments are so much coarser in sculpture as to suggest a variety or perhaps even another species of *Kanabiceras*. They are also numbered 2611.

The Cragin holotype does not show the young stages, but Stanton's material is intermediate between it and the material from Chispa Summit. The diameters of these various specimens are: Cragin's holotype, about 67.5 mm.; Moreman's plesiotype, 75 mm.; Stanton's two specimens, 49 mm. and 12 mm.; Chispa Summit, 42.5 mm., 19 (?) mm. down to 5 mm. The smaller individuals from Chispa Summit have the same general form and cross-section as Cragin's holotype. One individual has the dimensions 9.5 mm. — .46 — .59 — .29; H/Th = 0.8. The ribs are curved forward ventrally and are unbranched, and all start at the umbilical border; principal ribs are appearing. The mid-ventral and the external ventro-lateral tubercles are bullate, as are the internal ventro-lateral ones on the weak ribs; the internal ones on the strong ribs are already conical and more prominent. The umbilical swellings are elongate-bullate. At 19 (?) mm. diameter the shell is depressed (H/Th = .84), and the spinate processes no more advanced. At 42.5 mm. diameter, the cross-section is depressed (H/Th = .43?), and the shell is comparable to that of Stanton's pl. XXXVI, fig. 7. The external, and to a lesser degree the internal, ventro-lateral rows are spinose, but the spines are destroyed.

Eagle Ford: Chispa Summit (zone 1, locality 2611). The species is recorded from Britton (Moreman); and from

"Keenan's Crossing of Trinity River, Dallas County" (Cragin's holotype). Related species: another species or variety exists at Chispa Summit *(vide supra)*; a species with very reduced tubercles occurs in the uppermost Eagle Ford, Bouldin Creek, Austin, Texas; "another specimen collected from the Austin limestone near New Braunfels, Texas, belongs to the same or a closely related species" (Stanton, *op. cit.*, p. 182); Reeside and Weymouth describe a species, *K. wyomingense* from the Lower Turonian Aspen shale in southwestern Wyoming.

In this connection it may be noted that the holotype of *Pulchellia bentonianum* Cragin, having the dimensions 55.4 mm. — .36 — .32 — .37; H/Th = 1.14, is a *Eucalycoceras,* differing from *E. leonense* Adkins in being more compressed, the ribs sharper, thinner, and not in regular long-short alternation, and the three lines of ventral tubercles much less pronounced.

ALLOCRIOCERAS n. sp.

Pl. II, figs. 6, 8

This hamite-like species has one row of tubercles on the ribs on either margin of the venter. The ribs are continuous all around, weakest dorsally and strongest across the venter. Rib index,[34] 5. The shell is curved and tapers somewhat. This species differs from *A. ellipticum* (Mantell) H. Woods,[35] and resembles that recorded by Billinghurst,[36] in having the ribs similar and equal.

SCAPHITES sp. aff. AFRICANUS Pervinquière

Pl. II, figs. 11–12

This species, although not closely similar to any which has come to the writer's attention, resembles Pervinquière's species in its flattened form, its narrow umbilicus and its reduced ribbing. In the ribbing of its straight portion it

[34]The number of ribs on the mid-flank along a distance taken equal to the dorso-ventral dimension at the point measured.

[35]Woods, Henry, The mollusca of the Chalk rock. Q.J.G.S., 52: p. 64, Pl. III, figs. 8–10, 1896.

[36]Billinghurst, S. A., On some new ammonoidea from the Chalk rock. Geol. Mag., LXIV: 5–17, Pl. XVI, figs. 4 a–c, 7 a–b, 1927.

resembles *S. tenuicostatus* Pervinquière. Both the coiled and the extended portions are preserved intact but without the aperture. This species bears about 16 principal, equal, relatively coarse ribs on the coil; they are strongest on the flanks and weaker (in part from wear) over the venter; finer ribs are not visible on the coil. The straight portion bears a few principal scattered ribs, and, on the venter, numerous fine ribs.

Another smoother form bears on the coil several fine, irregularly spaced riblets and, scattered between them, still finer lines. The straight portion bears a few irregularly spaced ribs which are coarsest on the flanks.

Eagle Ford (zone 1): Chispa Summit, localities 2476, 2611.

SCAPHITES sp. aff. AEQUALIS Sowerby

The upper flags of the Eagle Ford in this region contain a species of the *aequalis* group, associated with *Metoicoceras, Prionotropis,* and *Inoceramus labiatus* Schlotheim.

Upper *Eagle Ford:* Chispa Summit region, locality 2613; Judge Love ranch house, northeast flank of Devil's Ridge (Sierra Blanca sheet). Species of this group are known in the Eagle Ford in central Texas.

BACULITES sp. aff. GRACILIS Shumard

Small individuals with the same taper, cross-section and ornamentation as this species in central Texas are frequent at locality 2611. A *Baculites* with the same taper and cross-section was found in the upper flags at locality 2613; its specific identification cannot be positively stated. The genus is fairly common in this section.

METAPTYCHOCERAS n. sp. aff. M. SMITHI (H. Woods)

Ptychoceras smithi Woods 1896, The mollusca of the Chalk rock, pt. I, Q.J.G.S., 52: p. 74, pl. II, figs. 1–2.

Metaptychoceras smithi (Woods), Spath 1926. On new ammonites from the English Chalk. Geol. Mag., LXIII: 81 (genotype).

The Chispa Summit species is more coarsely ribbed (rib index 5) than the English species (rib index 6–9). It is a pyritic micromorph, associated with *Prionotropis* and other dwarfs, as is also a species, probably the same, from the Eagle Ford at Potato Hill and other localities along the Bosque Escarpment in McLennan County, Texas.

Upper *Eagle Ford* (zones 5–6) : Chispa Summit, localities 2627, 2642.

CAMPTONECTES sp.

Pl. IV, fig. 1

This species, collected by Mr. M. B. Arick, in general resembles *C. virgatus* Nilson, as figured in Roman and Mazerin, *op. cit.*, pl. IX, fig. 10, from the Upper Turonian of Uchaux, southern France.

Eagle Ford: Chispa Summit, locality 2627.

STATUS OF CORRELATION OF FORMATIONS

It has been stated that in the Chispa Summit section, the presumable equivalents of the Eagle Ford, Austin and Taylor formations of the standard central Texas section, up to the base of the "Rattlesnake" sandstones near San Carlos village, are represented by a nearly unbroken clay-shale succession. This body of sediments affords an excellent series of well preserved ammonites in well marked zones. This paper contains a preliminary summary of the Eagle Ford zones. The ammonites of the Austin equivalents have not yet been well studied, but include *Peroniceras*, *Gauthiericeras*, *Mortoniceras*, *Phlycticrioceras* and others. Some Taylor species were described by Hyatt in 1903[37] from near San Carlos and elsewhere, and others by the writer[38] from newly discovered and richer localities. The "Rattlesnake" formation, both here and in the Terlingua-Chisos area, contains several ammonite species, among which are *Placenticeras intercalare* Meek, *Placenticeras meeki* Böhm, *Mortoniceras* cf. *delawarense* (Morton), and *Submortoniceras* n. sp. aff. *woodsi* Spath.

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[37]Hyatt, Alpheus, Pseudoceratites of the Cretaceous, U. S. Geol. Surv., Mon. XLIV, 1903.

[38]Adkins, W. S., Some Upper Cretaceous Taylor ammonites from Texas, Univ. Texas Bull. 2901, pp. 203–211, Pls. V–VI, 1929.

The Eagle Ford equivalents at Chispa Summit are divisible as follows:

3. Upper Turonian (= Angoumian): *Prionotropis, Coilopoceras,* an abundance of *Inoceramus labiatus.*

Upper Turonian (?): *Romaniceras, Prionotropis, Metoicoceras.*

2. Lower Turonian (= Salmurian, Ligerian): *Pseudaspidoceras, Metoicoceras;* in the Van Horn Mountains, *Fagesia, Thomasites, Neoptychites.*

1. Upper Cenomanian (= Rotomagian): *Mantelliceras, Scaphites, Metoicoceras.*

The *Fagesia* ammonite assemblage was not found at Chispa Summit, though it may occur in the basal part of that section. Zone 1 contains fossils of apparently mixed Cenomanian *(Mantelliceras couloni, Scaphites africanus)* and Turonian *(Kanabiceras, Pseudaspidoceras)* affinities, which indicates that the Western American strata at the Cenomanian-Turonian boundary may contain a fuller zonation than at many other published localities, and that this zonation is still in need of much detailed study, in order to define the zones and establish the correlation more accurately.

At Chispa Summit the above described Eagle Ford section immediately and probably unconformably overlies the Buda limestone, which in central Texas is of Mantelliceratan (upper part of lower Cenomanian) age at its top. In Trans-Pecos Texas, south of the Southern Pacific Railway, the Eagle Ford is elsewhere almost invariably in the Boquillas (Val Verde) flag facies, thin-bedded yellow-brown, salmon, reddish or varicolored, laminated limestone flags, carrying abundant *Inoceramus* but few ammonites.

The ammonites collected at Chispa Summit are distributed vertically as follows:

Zone	*Turonian affinities*	*Cenomanian affinities*	*Doubtful affinities*
8	Inoceramus labiatus Metoicoceras Prionotropis		Scaphites aff. aequalis Baculites

Zone	*Turonian affinities*	*Cenomanian affinities*	*Doubtful affinities*
6 (Coilopoceras zone)	C. eaglefordense C. chispaense Prionotropis Allocrioceras Metaptychoceras		Acanthoceras ?
5 (Transition zone)	Romaniceras cumminsi C. eaglefordense Prionotropis		Metacalycoceras ?
3 (Romaniceras zone)	Romaniceras loboense Pseudaspidoceras (?) chispaense Pseudotissotia (?) sp. Prionotropis		Acanthoceras ?
2	Metoicoceras		
1a (Pseudaspidoceras zone)	P. aff. footeanum Prionotropis Helicoceras pariense? Inoceramus labiatus		
1 (loc. 2611)	Kanabiceras? Metoicoceras	Mantelliceras aff. couloni Scaphites aff. africanus Metacalycoceras ?	Acanthoceras Baculites

From zone 1 (locality 2611) there were collected principally genera recorded from the Cenomanian, as *Scaphites* aff. *africanus* Pervinquière and *Mantelliceras* aff. *couloni* (D'Orbigny). This level contains a species of *Kanabiceras* Reeside, a genus reported from beds supposed to be of Lower Turonian age, and *Metoicoceras*, hitherto known from the United States only in the Turonian. From zone 1a (locality 2476) Baker collected only fossils hitherto reported from the Turonian: *Pseudaspidoceras* spp., *Prionotropis, Helicoceras pariense?,* and *Inoceramus labiatus.*

From these two localities alone it would appear that if any Cenomanian is present, it is restricted to the basal part of the Eagle Ford, zone 1. Even this fails to account for the apparently mixed Cenomanian and Turonian character of locality 2611. From zone 2 only *Metoicoceras* and *Inoceramus* were collected. Zone 3 is characterized by highly ornamented *Romaniceras* having the general form of *Acanthoceras,* although more nodose and specialized than is common in that genus. Species referred to *Acanthoceras* are found as high as zone 6, associated with *Coilopoceras* and *Prionotropis,* which are everywhere considered Turonian. Zone 3 also contains species referred to *Romaniceras,* which if the assignment is correct, is taken to indicate Turonian. This zone also contains, imbedded in a *Romaniceras,* a small *Prionotropis,* supposedly a Turonian genus. It is true that *Acanthoceras* s.s. has been recorded from the Turonian; and it is also true that the Chispa Summit species are not typical.

Briefly, the Chispa Summit section probably contains only a small portion of Cenomanian, if any, in its basal zone overlying the Buda limestone. It will be noted that the *Mantelliceras* aff. *mantelli,* described from the topmost Buda in central Texas, refers that level to the Mantelliceratan age, i.e., Lower Cenomanian, in that area. This therefore leaves most of the Upper Cenomanian, characterized by normal *Acanthoceras,* to be accounted for at Chispa Summit. The portions of the section containing *Pseudaspidoceras, Fagesia* and *Thomasites* are referred to the Lower Turonian. The *Coilopoceras* beds and higher zones are referred to the Upper Turonian. The following sections may be used for comparison with Chispa Summit.

Böse[39] records a thin section correlated by him with Upper Cenomanian and Lower Turonian, from the Hacienda del Mohóvano on the Coahuila-Chihuahua line:

[39]Bose, Emil, On a new ammonite fauna of the Lower Turonian of Mexico, Univ. Texas Bull. 1856, pp. 179–252, Pls. 12–20, 1920.

III. Gray limestone containing *Vascoceras, Neoptychites, Hoplitoides* aff. *mirabilis (vide supra), Inoceramus labiatus, Avicula, Trigonia, Crassatella, Tylostoma.* ...... 5–6 meters. II. Gray-bluish marls containing *Mammites, Pseudaspidoceras,* aff. *footeanum* (Petraschek), *Vascoceras, Fagesia.* .... 2.5 meters	Lower Turonian (= Salmurian)
I. Yellow and reddish marls and limestones with *Metoicoceras* aff. *whitei, M.* sp., *Exogyra, Hemiaster.* .... 2 meters	Upper Cenomanian

Moreman[40] considers the main *Acanthoceras* zone in central Texas as the base of the Eagle Ford; this is certainly Upper Cenomanian. His preliminary zonation follows:

6. *Alectryonia lugubris* zone.
5. *Prionotropis* zone.
4. *Helicoceras pariense* zone; *Baculites gracilis.*
3. *Metoicoceras whitei* zone; *M. whitei* var., *Placenticeras pseudoplacenta* Cragin and its var. *occidentale, Romaniceras* sp.[41], *Baculites gracilis* Shumard, *Kanabiceras kanabense* (Stanton), *Inoceramus fragilis* Hall and Meek.
2. *Metoicoceras irwini* zone; *Hemitissotia* sp. A. Moreman, *Pachydiscus, Placenticeras* sp.
1. *Acánthoceras* zone.[42]

The obvious differences between Moreman's section and Chispa Summit indicate the need for more collecting in both sections.

Reeside[43] details a section on Vermilion Creek, Moffat County, Colorado, its Turonian portion composed of 457 feet of rocks referred to the Carlile and 155 feet referred

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40Moreman, W. L., Fossil zones of the Eagle Ford of north Texas, Jour. Pal., I: 89-101, Pls. XIII–XVI, 1927.

41Reeside, John B., Jr., and Weymouth, A. Allen, Mollusks from the Aspen shale (Cretaceous) of southwestern Wyoming, Proc. U. S. Nat. Mus., 78: 1–24, Pls. 1–4, 1931.

42Adkins, W. S., Handbook of Texas Cretaceous fossils, Univ. Texas Bull. 2838, pp. 29, 238–248, 1928.

43Reeside, John B., Jr., The Cretaceous faunas in the section on Vermilion Creek, Moffat County, Colorado, Jour. Wash. Acad. Sci., 19: 30–37, 1929.

to the Greenhorn and Graneros. The Graneros and Greenhorn contain *Metoicoceras whitei, Inoceramus labiatus* and fish scales. The Carlile portion contains, basally *Prionocyclus wyomingensis* Meek, *Scaphites* and *Inoceramus fragilis* Hall and Meek; medially *Prionocyclus, Lingula, Inoceramus,* pelecypods, gastropods and fish; and near the top *Prionocyclus, Scaphites warreni* Meek and Hayden, *Inoceramus fragilis* Hall and Meek.

In a section of Black Mesa near Kayenta, Arizona, Reeside and Baker[44] record a lower bluish-gray Benton shale containing *Inoceramus labiatus, Ostrea soleniscus, Gryphaea newberryi, Metoicoceras* sp., *Baculites gracilis;* and in an upper black Benton shale *Prionotropis woolgari.*

Roman[45] has detailed the Turonian zones in the Rhone valley. A Lower Turonian (Salmurian) zone is characterized by *Mammites nodosoides* Schlotheim, *Mammites revelieranus, Neoptychites cephalotus* Courtiller, *Prionotropis papalis* D'Orbigny, and contains *Pachydiscus peramplus* Mantell, *Gaudryceras* aff. *mite* (von Hauer), *Mammites pseudonodosoides* Choffat, and *Thomasites rollandi* (Peron). An Upper Turonian zone contains *Romaniceras deverianum* (D'Orbigny), *Coilopoceras requienianum* (D'Orbigny), *Prionotropis bravaisianum* (D'Orbigny), *Pachydiscus peramplus* (Mantell), *"Macroscaphites" rochatianus,* and other Uchaux fossils.

Eck[46] lists the cephalopods characteristic of Cenomanian, Lower Turonian (Salmurian), and Upper Turonian. As Salmurian markers he lists: *Leoniceras segne* (Solger), *Vascoceras kossmati* Choffat, *V. durandi* (Thomas and Peron), *V. barcoicense* Choffat, *Fagesia bomba* Eck, *F.* cf.

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[44]Reeside, John B., Jr., and Baker, Arthur A., The Cretaceous section in Black Mesa, Arizona. Jour. Wash. Acad. Sci., 19: 30–37, 1929.

[45]Roman, F., Coup d'oeil sur les zones de céphalopodes du Turonien du Vaucluse et du Gard. C. R. Assoc. fr. Avanc. Sci., Congrès de Nîmes, pp. 1–15, Pls. I–III, 1912.

[46]Eck, Otto, Vorläufige Mitteilungen über d'e Bearbeitung der Cephalopoden der Schwe'nfurthschen Sammlung und über die Entwicklung des Turons in Agypten. Monatsber. deutsch, geol. Ges. f. 1910, pp. 379–386, 1911.

Eck, Otto, Die Cephalopoden der Schweinfurthschen Sammlung aus der oberen Kreide Agyptens. Zts. deutsch. geol. Ges., 66: 179–216, Pls. IX–XX, 20 text figs., 1914.

thevestensis (Peron), and *Pseudaspidoceras* cf. *footeanum* (Stoliczka).

Spath has published the most detailed zonations of the Cenomanian[47] and the Turonian.[48] Reeside[49] has outlined a general zonation for the Western Interior. To what extent these zonations apply to Texan localities will remain an open question until much more collecting has been done. Relevant to the Chispa Summit section, Spath's zones clearly indicate the Lower Turonian age of *Metoicoceras whitei* and *Pseudaspidoceras footeanum,* and the Upper Turonian age of *Prionotropis, Romaniceras* and *Coilopoceras.* Reeside's Benton zones are (a) *Exogyra columbella* Meek and *Gryphaea newberryi* Stanton, as in the Graneros shale; (b) zone of abundance of *Inoceramus labiatus* Schlotheim, as the Greenhorn limestone (*Vascoceras* zone in Wyoming); (c) zone of *Scaphites warreni* Meek and Hayden, containing *Prionotropis* spp., *Prionocyclus* spp., *Alectryonia lugubris* Conrad, *Inoceramus fragilis* Hall and Meek, *I. dimidius* White, and only rare *I. labiatus,* as in the Carlile shale. He also records[50] in the Graneros shale: *Acanthoceras* aff. *rotomagense* (Defrance), *Pseudaspidoceras, Turrilites,* a member of the Engonoceratidae, and *Inoceramus labiatus;* from the Greenhorn, *Thomasites* n. sp., *Metoicoceras whitei* Hyatt, *Baculites gracilis* Shumard, "*Acanthoceras*" *coloradoense* Henderson, *Helicoceras corrugatum* Stanton and *Inoceramus labiatus;* from the top of the Carlile, *Prionocyclus wyomingense* Meek, *Scaphites warreni* Meek and Hayden, and *Alectryonia lugubris* (Conrad). These lists suggest the same problem regarding the Cenomanian-Turonian boundary as is outlined above for Chispa Summit.

47Spath, L. F., On the zones of the Cenomanian and the uppermost Albian, Proc. Geol. Assoc., XXXVII: 420–432, 1926.

48Spath, L. F., On new ammonites from the English Chalk, Geol. Mag., LXIII: 77–83, 1926.

49Reeside, John B., Jr., A new fauna from the Colorado group of southern Montana, U. S. Geol. Surv., Prof. Paper 132, pp. 25–31, Pls. XI–XXI, 1925.

50Reeside, John B., Jr., An *Acanthoceras rotomagense* fauna in the Cretaceous of the Western Interior, Jour. Wash. Acad. Sci., 17: 453–454, 1927.

SUPPLEMENTARY STATEMENT RELATING TO NEOCARDIOCERAS

In this paper *Neocardioceras* Spath replaces the name *Kanabiceras* throughout. Indentification of the Chispa Summit material was kindly made by Dr. L. F. Spath. (W. S. Adkins, British Museum of Natural History, South Kensington, London, September 19, 1931.)

THE LOWER CLAIBORNE ON THE BRAZOS RIVER, TEXAS

BY

B. COLEMAN RENICK* AND H. B. STENZEL†

INTRODUCTION

The lower Claiborne group described in this paper includes the Mount Selman and Cook Mountain formations. The Mount Selman formation consists of the Carrizo (?), Reklaw, Queen City, and Weches members, and the Cook Mountain formation consists of the Sparta and Crockett members. These several members occur in belts crossing the Brazos River in Robertson, Brazos, Burleson, and Milam counties. In this area all of these members are non-marine and lignitic except the Weches and Crockett, which are marine and abundantly fossiliferous. The fauna of the Crockett differs from that of the Weches. A few poorly preserved fossils have locally been found in the Reklaw. In the upper part of the Sparta sand in eastern Robertson County, there is a glauconitic sand lentil containing numerous casts.

Acknowledgments are made to the Vacuum Oil Company and S. A. Thompson, Chief Geologist, for permission to publish the stratigraphic data contained in this paper. Paul Nash of the same company has rendered valuable help by operating the plane table and otherwise assisting in the measurement of most of the sections. He has also drafted the illustrations.

PREVIOUS INVESTIGATIONS

The Claiborne group exposed along the Brazos River has been of interest to geologists for many years. In 1847

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Roemer[1] visited Moseley's Ferry on the Brazos. He remarked on the abundance of fossils and noted the paleontologic similarity to the Claiborne of Alabama. Gabb[2] obtained and described fossils from Cedar Creek near Wheelock, Robertson County. In 1889 Penrose[3] made a boat trip down the Brazos examining the Tertiary and describing the various bluff sections along the river. This classical report contains the first systematic description of the geologic section.

Later Kennedy[4] examined these same rocks and made extensive fossil collections from the marine Claiborne, which he sent to Harris[5] for identification. Deussen[6] in 1907 visited all of the exposures of Claiborne on the river and gave a columnar section. The fossils which he collected were sent to T. W. Vaughan for identification. Dumble[7] also subsequently reported on the section along the Brazos River.

PRESENT INVESTIGATION

The present paper is the result of detailed mapping of Brazos, Burleson, Robertson, and southern Milam counties by Renick. The geologic mapping was done on a property ownership map of a scale of two inches equal one mile and the geologic sections were measured by alidade and plane table. All exposures previously described by geologists have been visited. Stenzel's collection of fossils from

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1Roemer, Ferdinand, Contributions to the Geology of Texas, Amer. Jour. Sci. and Arts, Vol. VI, 2d ser., p. 23, 1848.

Roemer, Ferdinand, Die Kreidebildungen von Texas und ihre organischen Einschlüsse, pp. 4–5, 1852.

2Gabb, W. M., Description of new species of American Tertiary and Cretaceous fossils, Jour. Acad. Nat. Sci. Phila., Vol. IV, 2d ser., pp. 375–389, 1860.

3Penrose, R. A. F., Jr., A Preliminary report on the geology of the Gulf Tertiary of Texas from Red River to the Rio Grande, Geol. Surv. Texas, 1st Ann. Rept., pp 3–101, 1889. See also Heilprin, Angelo, The Eocene Mollusca of the State of Texas, Proc. Acad. Nat. Sci. Phila., pp. 393–406, 1890.

4Kennedy, William, Report on Grimes, Brazos, and Robertson Counties, Geol. Surv. Texas, 4th Ann. Rept., 1893.

The Eocene Tertiary of Texas East of the Brazos River, Proc. Acad. Nat. Sci. Phila., pp. 89–160, 1895.

5Harris, Gilbert D., Catalogue of Tertiary Fossils, MS, The University of Texas, 1893. Harris, Gilbert D., New and Otherwise Interesting Tertiary Mollusca from Texas, Proc. Acad. Nat. Sci. Phila., pp. 45–88, 1895.

6Deussen, Alexander, Geology and Underground Waters of the Southeastern part of the Texas Coastal Plain, U. S. Geol. Surv., Water Supply Paper 335, pp. 56–61, 1914.

7Dumble, E. T., Geology of East Texas, Univ. Texas Bull. 1869, pp. 97–101, 1918.

the Crockett, collected over a period of several years, was augmented by joint trips of both authors to some of the best collecting places. It is believed that representative collections have been obtained from the entire marine Claiborne in the counties adjoining the Brazos River.

The portions of this paper pertaining to lithology, stratigraphy, and correlation have been prepared by Renick. Those parts relating to paleontology are entirely the work of Stenzel.

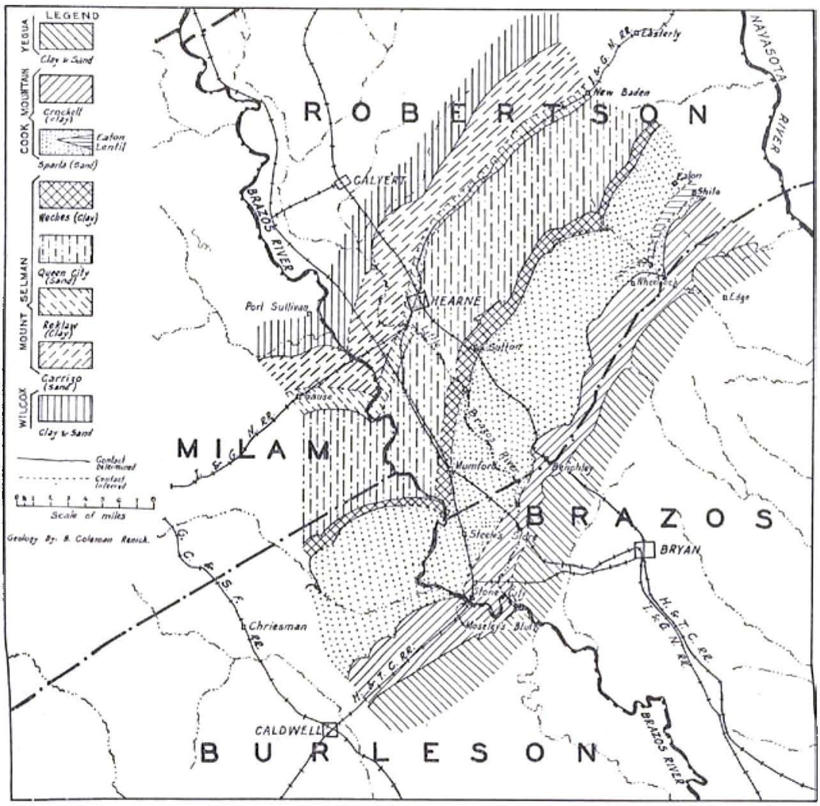

Fig. 9. Geologic map of the lower Claiborne in the vicinity of the Brazos River.

GEOLOGY

The Claiborne group of Texas contains the Yegua formation which is mostly non-marine (upper Claiborne), the Cook Mountain formation and Mount Selman formation (lower Claiborne), named in descending order. The Cook Mountain and Mount Selman formations are the subjects of this paper.

Wendlandt and Knebel[8] have recently published an excellent paper on the lower Claiborne of east Texas, based on careful field work carried on over a period of several years. The several stratigraphic units of the lower Claiborne which they described are continuous from east Texas into the Brazos valley, and the names which they applied in that area are used in this paper for the same units in the Brazos River area.

Alva C. Ellisor[10] also has recently published a very instructive paper based largely on micro-lithologic and micro-paleontologic study of the Claiborne of East Texas and Louisiana.

The Sparta, Queen City, and Carrizo sands, as well as the underlying Wilcox, are commercially productive on the Clay Creek salt dome in Washington County. This dome, discovered by W. B. Ferguson for the Sun Oil Company, has recently been described by Heath, Waters, and Ferguson.[11]

MOUNT SELMAN—COOK MOUNTAIN CONTACT

The "Mount Selman Series" and "Cook's Mountain Series" were named and first described by Kennedy,[12] although Johnson[13] had previously described some of the

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8Wendlandt, E. A., and Knebel, G. M., Lower Claiborne of East Texas with special reference to Mount Sylvan dome and salt movements, Bull. Am. Assoc. Petr. Geol., Vol. 13, pp. 1347–1376, 1929.

9"East Texas" as referred to by Wendlandt and Knebel included that part of Texas northeast of the Navasota River.

10Ellisor, Alva C., Correlation of the Claiborne of East Texas with the Claiborne of Louisiana, Bull. Am. Assoc. Petr. Geol., Vol. 13, pp. 1335–1346, 1929.

11Heath, F. E., Waters, J. A., and Ferguson, W. B., Clay Creek Salt Dome, Washington County, Texas, Bull. Am. Assoc. Petr. Geol., Vol. 15, pp. 43–60, 1931.

12Kennedy, William, A section from Terrell, Kaufman County, to Sabine Pass on the Gulf of Mexico, Geol. Surv. Texas, 3d Ann. Rept., pp. 52–54, 1892.

13Johnson, L. C., The iron regions of Northern Louisiana and Eastern Texas, 50th Cong. 1st Sess. H. Ex. Doc. 195, pp. 19–21, 1889.

rocks. These units are now considered formations by the U. S. Geological Survey, and Kennedy's names for them have been retained. They represent the stratigraphic equivalent of the "lower Claiborne" of Harris and Veatch.[14] Kennedy took the name Mount Selman from a town in Cherokee County. His general section ran from Bullard to Jacksonville and showed a glauconitic sand (commonly called greensand) at Jacksonville. The Cook Mountain formation was named for a mountain in Houston County about two and a half miles northwest of Crockett. The glauconitic fossiliferous beds at Alto in Cherokee County were also referred to by Kennedy as Cook Mountain. However, the glauconitic sands at Jacksonville and at Alto are the same.

Wendlandt and Knebel[15] divided the Mount Selman formation into the Carrizo, Reklaw, Queen City, and Weches "formations," and the Cook Mountain formation into the Sparta and Crockett "formations," all named in ascending order. They put the Weches glauconitic sand at the top of the Mount Selman since this glauconitic sand was at Jacksonville in Kennedy's Mount Selman Bullard-to-Jacksonville section, but as pointed out above the same glauconitic sand at Alto was also put in the Cook Mountain by Kennedy. From the original descriptions it is therefore apparent that the Weches might have been put in either the Mount Selman or Cook Mountain.

Tracing the Weches member across Leon and Robertson counties to the Brazos River in Burleson County, it is found that Burleson Bluff at old Collard's ferry site (sometimes called Collier's ferry), exposes the basal fossiliferous Weches above the lignitic sands of the Queen City. Deussen,[16] in his geologic section along the Brazos River, regarded the fossiliferous glauconitic sand at Burleson Bluff and all overlying marine beds as Cook Mountain, and

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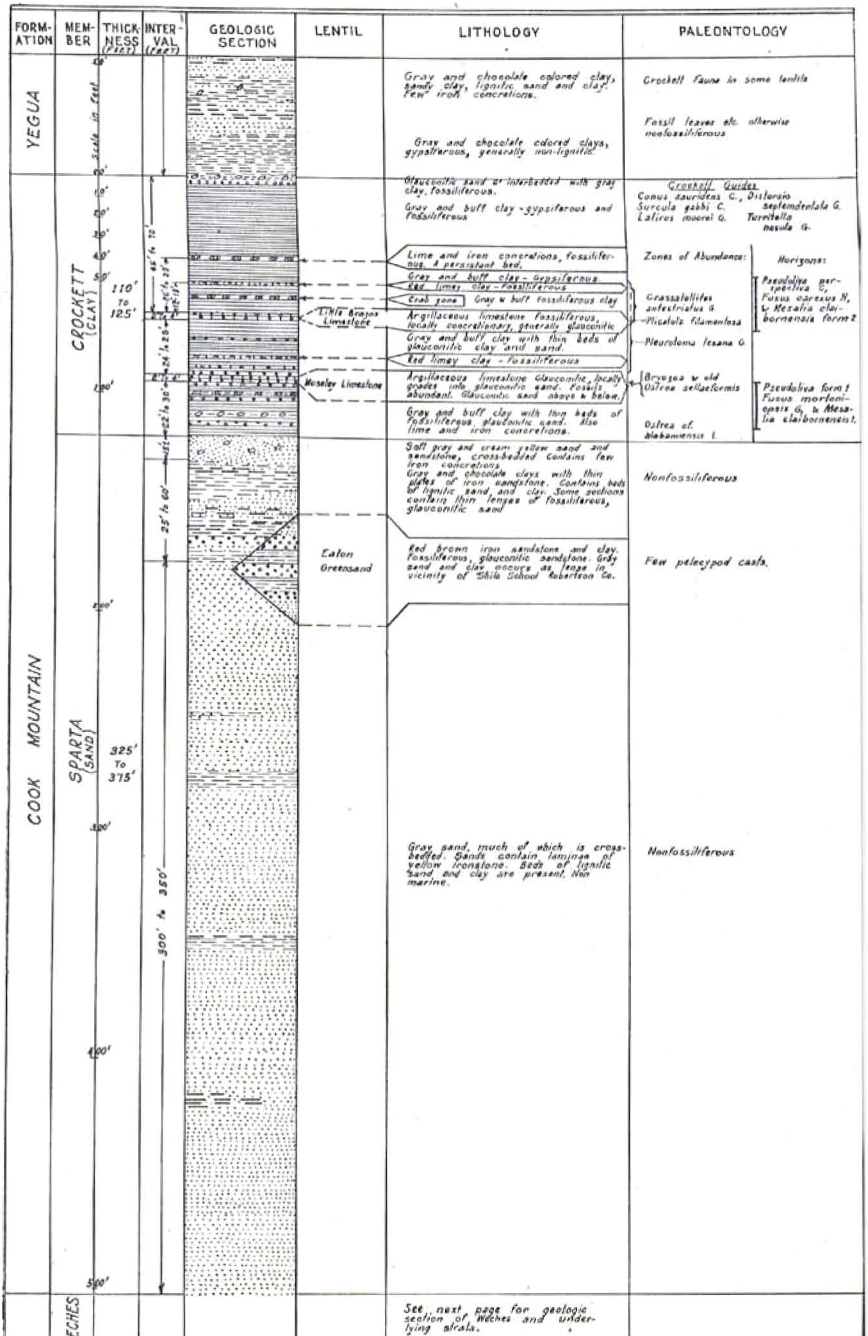
14Harris, G. D., and Veatch, A. C., A preliminary report on the Geology of Louisiana. Rept. Geol. Surv. of La., pp. 73–89, 1899.

15Wendlandt, E. A., and Knebel, G. M., op. cit., p. 1356.

16Deussen, Alexander, Geology and Underground Waters of the Southeastern part of the Texas Coastal Plain, U. S. Geol. Surv., Water Supply Paper 335, p. 57 and Pl. IV, 1914.

Geology of the Coastal Plain of Texas west of Brazos River, U. S. Geol. Surv., Prof. Paper 126, p. 69, and geologic map, Pl. VIII, 1924.


FORMATION
MEMBER
THICKNESS (FEET)
INTERVAL (FEET)
GEOLOGIC SECTION
LENTIL
LITHOLOGY
PALEONTOLOGY
YEGUA
Scale in feet
Gray and chocolate colored clay, sandy clay, lignitic sand and clay. Few iron concretions.
Gray and chocolate colored clays, gypsiferous, generally non-lignitic.
Crockett Fauna in some lentils
Fossil leaves etc. otherwise nonfossiliferous
COOK MOUNTAIN
CROCKETT (CLAY)
110' To 125'
Glauconitic sand or interbedded with gray clay, fossiliferous.
Gray and buff clay - gypsiferous and fossiliferous
Crockett Guides
Conus sauridens C., Distorsio septemdentata G.
Surcula gabbi C.
Latirus moorei G.
Turritella nasuta G.
Lime and iron concretions, fossiliferous. A persistant bed.
Gray and buff clay - Gypsiferous.
Red limey clay - Fossiliferous
Crab zone
Gray & buff fossiliferous clay
Little Brazos Limestone
Argillaceous limestone fossiliferous, locally concretionary, generally glauconitic
Gray and buff clay with thin beds of glauconitic clay and sand.
Red limey clay - Fossiliferous
Moseley Limestone
Argillaceous limestone Glauconitic, locally grades into glauconitic sand. Fossils abundant. Glauconitic sand above & below.
Gray and buff clay with thin beds of fossiliferous glauconitic sand. Also lime and iron concretions.
Zones of Abundance:
Crassatellites antestriatus G.
Plicatula filamentosa
Pleurotoma texana G.
Bryozoa & old Ostrea sellaeformis
Ostrea cf. alabamensis L.
Horizons:
Pseudoliva perspectiva C., Fusus carexus H., & Mesalia claibornensis form 2
Pseudoliva form 1 Fusus mortoniopsis G., & Mesalia clairbornensis 1.
SPARTA (SAND)
325' To 375'
Soft gray and cream yellow sand and sandstone, cross-bedded Contains few iron concretions
Gray and chocolate clays with thin plates of iron sandstone. Contains beds of lignitic sand and clay. Some sections contain thin lenses of fossiliferous, glauconitic sand
Nonfossiliferous
Eaton Greensand
Red brown iron sandstone and clay. Fossiliferous, glauconitic sandstone. Gray sand and clay occurs as lense in vicinity of Shilo School Robertson Co.
Few pelecypod casts.
Gray sand, much of which is cross-bedded. Sands contain laminae of yellow ironstone. Beds of lignitic sand and clay are present. Non marine.
Nonfossiliferous
WECHES
See next page for geologic section of Weches and underlying strata.

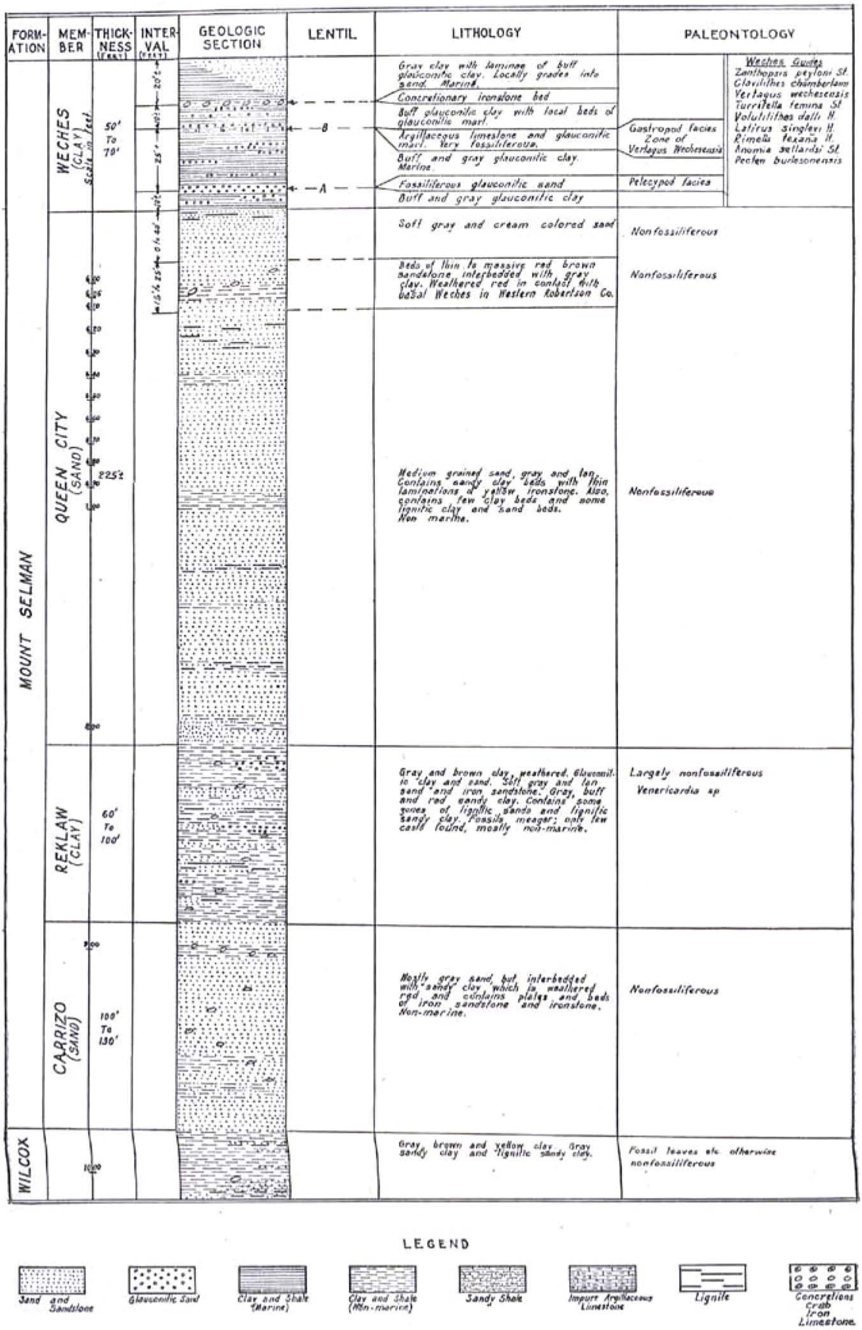


Fig. 10. Columnar section along Brazos River. The Yegua formation is regarded as upper Claiborne mainly, although its basal part contains fossils suggestive of lower Claiborne. The Cook Mountain and Mount Selman formations are lower Claiborne.

the underlying lignitic beds as well as the lower beds upstream as Mount Selman, thus putting the Weches in the Cook Mountain. With this correlation he carried on his mapping southwestward almost to the Rio Grande. Renick[17] also placed this fossiliferous glauconitic sand, which he previously referred to as San Augustine, as the basal member of the Cook Mountain formation.

Dumble [18] on his map of the country east of the Brazos River shows only the "marine," which includes both the Cook Mountain and Mount Selman.

Although, on the basis of Kennedy's original description, the Weches might have been placed in either the Cook Mountain or Mount Selman formation, the authors are following the classification of Wendlandt and Knebel and are placing the Weches in the Mount Selman.

This puts the Weches and the Reklaw in the same formation, which seems a logical classification because in east Texas in Sabine County the Queen City sand disappears and the Reklaw and Weches are in contact and are one stratigraphic unit.

Moody,[19] in a splendid paper on the Sabine uplift, has recently used the name, Mount Selman formation, as representing only the Weches greensand. He also regards the Reklaw, Queen City, and Sparta sand as individual formations, and only the Crockett and overlying beds below the Yegua as belonging to the Cook Mountain formation. The authors of this paper regard the Carrizo, Reklaw, Queen City, and Weches as members of the Mount Selman formation, and the Sparta and Crockett as members of the Cook Mountain formation.

17Renick, B. Coleman, Recently discovered salt domes in East Texas, Bull. Am. Assoc. Petr. Geol., Vol. 12, pp. 527–547, 1928.

18Dumble, E. T., Geology of East Texas, Univ. Texas Bull. 1869, Pl. I, 1918.

19Moody, C. L., Tertiary History of the region of the Sabine Uplift, Louisiana, Bull. Am. Assoc. Petr. Geol., Vol. 15, pp. 531–551, 1931.

WILCOX FORMATION OR GROUP

Lithology and Stratigraphy: The beds in the upper part of the Wilcox are described so that the contact may be recognized, although the Wilcox formation as a whole is not considered in this paper.

The topmost beds of the Wilcox consist of gray, brown, chocolate, yellow, and yellowish-green clays interbedded with soft gray sand, sandy clays, and lignitic sands and clays. These uppermost beds generally form a clay soil and the land is usually at an elevation lower than that of the overlying Carrizo (?), which forms a noticeable sand-covered escarpment southeast of the Wilcox outcrop. Lower in the Wilcox section there are calcareous "boulder" beds.

LOWER CLAIBORNE GROUP

MOUNT SELMAN FORMATION

CARRIZO (?) SAND

Lithology and Stratigraphy: Overlying the Wilcox formation in Robertson and Milam counties there are beds from 100 to 130 feet thick that contain considerable soft gray sand. These give rise to thick sandy soil.

Interbedded with these sands are beds and lenses of glauconitic sandstone and ironstone weathered to a yellow, orange, red, and red-brown color. These ironstones and ferruginous sandstones occur in zones that are as much as 25 feet thick, made up of laminae from a fraction of an inch to beds several inches thick.

Interbedded with the iron sandstones and ironstones is generally some clay and sandy clay weathered red or orange.

The rocks here designated as Carrizo (?) outcrop in a belt across Robertson County north of the Missouri Pacific Railroad (San Antonio to Palestine branch). The Carrizo sandstone is exposed along the Brazos River on the Milam County side in a bluff at the place where the Missouri Pacific Railroad bridge crosses the river. Owing to the presence of ferruginous beds in the Carrizo in Robertson and Milam counties, the contact between the Carrizo and the Reklaw is not definite in most places but is gradational. The contact with the Reklaw is generally placed at the base of the chocolate-colored clays. Below these clays the quantity of sand interbedded with the ferruginous beds increases. The Carrizo (?), which contains weathered glauconitic sand and ferruginous beds, has a decidedly Mount Selman aspect. It is therefore included in the Mount Selman. The predominance of sand and its position in the section suggest that these beds are Carrizo, to which they are here tentatively referred. The coarse-grained sand which occurs in the Carrizo in Lee County and to the southwest was not found in the vicinity of the Brazos River. In adjoining counties to the southwest these beds contain much less ferruginous matter and more resemble the true Carrizo sandstone.

Kennedy,[20] on his map of Robertson County, shows a line at the approximate contact of the Carrizo (?) sandstone and the Wilcox, which he designated "Northern Border of Greensands." Deussen,[21] following the classification of Trowbridge,[22] called the Wilcox a group and separated it into the Indio formation, or basal lignitic part, and Carrizo sandstone, or upper sandy non-lignitic part. The beds here designated as Carrizo (?) were mapped by Deussen as Carrizo sandstone. Dumble[23] regarded these same strata as Wilcox, including both the upper sand phase and the lower lignitic phase. Renick, for the present, following the later classification of Dumble[24] for south Texas, and of Wendlandt and Knebel[25] for east Texas, here designates these beds as Carrizo (?) sandstone and places them

20Kennedy, William, Report on Grimes, Brazos, and Robertson Counties, Geol. Surv. Texas, 4th Ann. Rept., p. 76, 1893.

21Deussen, Alexander, Geology and Underground Waters of the Southeastern part of the Texas Coastal Plain, U. S. Geol. Surv., Water Supply Paper 335, Pl. I, 1914.

Deussen, Alexander, Geology of the Coastal Plain of Texas West of Brazos River, U. S. Geol. Surv., Prof. Paper 126, pp. 48–62 and Pl. VIII, 1924.

22Trowbridge, A. C., A Geologic Reconnaissance in the Gulf Coastal Plain of Texas, near the Rio Grande, U. S. Geol. Surv., Prof. Paper 131, pp. 89–91, 1923.

23Dumble, E. T., Geology of East Texas, Univ. Texas Bull. 1869, Pl. I, 1918.

24Dumble, E. T., A revision of the Texas Tertiary Section with special reference to oil well geology of the Coast Region, Bull. Am. Assoc. Petr. Geol., Vol. 8, p. 428, 1924.

25Wendlandt, E. A., and Knebel, G. M., op. cit., p. 1350.

at the base of the Mount Selman formation. The gradational and interfingering contact into the overlying Reklaw, and the fact that the Carrizo (?) sandstone is more akin lithologically to the Mount Selman than to the Wilcox, are the factors determining this classification.

Paleontology: No fossils were found in the Carrizo (?) sandstone member.

REKLAW CLAY

Lithology and Stratigraphy: This member is essentially a clay unit, but interbedded with the clay are thin beds of sandy clay, ironstone, and lenses of glauconitic iron sandstone. Lignitic sand, lignitic sandy clay, and gray gypsiferous clay are present in the Reklaw in Robertson and Milam counties. The Reklaw is almost entirely non-marine, but a few fossil casts were found associated with lignitic beds. In east Texas the Reklaw is both marine and nonmarine, in some places being fossiliferous, and in other places being non-fossiliferous and lignitic.

The Reklaw usually develops into a gently rolling prairie with a red soil, as contrasted with the more rugged dissected topography of the overlying Queen City sand and underlying Carrizo (?) sands. At many places the sands from the Queen City have washed down on this prairie almost obscuring the Reklaw outcrop. Typical exposures are found near Franklin and New Baden in Robertson County. The contact of the Reklaw and the overlying Queen City is gradational, but the presence of the Reklaw may generally be distinguished by the red color of the soil, even if sand from the Queen City has washed on to it obscuring the actual contact. Where visible, the top of the Reklaw is placed at the top of the red ferruginous sandstones and clays.

Paleontology: The Reklaw in this region contains a few fossil casts. Poorly preserved casts of *Venericardia planicosta* Lam. var. were observed in one of the ferruginous sandstone beds.

Scarcity of fossils and the presence of much lignitic clay-shale seem to indicate brackish water and coastal swamp conditions during Reklaw time in this region.

QUEEN CITY SAND

Lithology and Stratigraphy: Overlying the Reklaw member is the Queen City sand. It consists mostly of gray, cream, and tan sands which at many places are cross-bedded and contain thin laminations of orange-colored ironstone. The Queen City also contains sandy clay and a few clay beds, one of the most important clay beds occurring near the middle of the formation in Robertson County. This clay is mostly gray and tan clay but also contains sandy clay and iron concretions.

The Queen City member also contains several horizons of lignitic sand and clay. Generally about forty feet from the top of this member is a zone which gives the soil a red color. It consists of interbedded ferruginous sandstone plates, thin ironstone laminations, and clay weathered red as a result of the associated iron sandstone.

There are good exposures of the Queen City sand along the Brazos River from Burleson bluff in northeastern Burleson County upstream for several miles.

The Queen City sand generally gives rise to a rough dissected topography. This rugged topography is due in a large part to the presence of a cap of hard massive stream conglomerate on many of the hills. The conglomerate consists of pebbles of quartz, jasper, sandstone, ironstone, and, in some localities, clay pebbles in a matrix of quartz sand cemented by silica and iron.

Paleontology: No invertebrate fossils have been found in the Queen City sand member within this area.

WECHES CLAY

Lithology and Stratigraphy: The Weches member overlies the Queen City sands and consists mostly of glauconitic sand, glauconitic marl, and gray clay. In Robertson County the lower part of this member is made up of buff, brown, and gray clay, containing thin laminae of glauconitic clay and glauconitic sand. In some sections there is a bed of glauconitic iron sandstone at the base of this member, which is about one foot thick and contains a few small fossil casts. However, in Burleson County the basal part of the Weches consists almost entirely of fossiliferous glauconitic sand and glauconitic sandy marl.

The best observed exposure of the lower Weches is along the Brazos River in the J. C. Robertson Survey, northeastern Burleson County. Here there is from 15 to 20 feet of glauconitic sand and clay exposed in a bluff for more than 500 yards along the river. This bluff begins in the southern part of the W. H. Jenkins Est. 41-1/3 acres, and extends downstream about halfway across the J. R. Sadberry Est. 147 acres. This locality, which is known as Burleson Shell Bluff or Collard's ferry (sometimes called Collier's ferry), was first described by Penrose,[26] and later by Kennedy,[27] Deussen,[28] and Dumble.[29]

As previously pointed out, the Burleson Bluff section shows 15 to 20 feet of fossiliferous glauconitic sand resting on gray sand and lignitic sand (lentil A of Fig. 10). The base of the glauconitic sand is the base of the Weches member.

From 15 to 30 feet below the top of the Weches member, is a zone that is especially fossiliferous. In places it consists of about 18 inches of impure, argillaceous, glauconitic, fossiliferous limestone (lentil B of Fig. 10) with fossiliferous glauconitic sand above, and in other places of 4 to 10 feet of glauconitic sand alone. One of the best exposures of the glauconitic sand phase is on Buck McBride's 134 acre tract, Jose Maria Viesca Survey, in eastern Robertson County. The limestone phase is present 0.4 mile north-northeast of Sutton Switch (Southern Pacific Railroad), Antonio Manchaca Survey, Robertson County, along the secondary road which crosses the track

26Penrose, R. A. F., op. cit., p. 27.

27Kennedy, William, The Eocene Tertiary of Texas East of the Brazos River, Proc. Acad. Nat. Sci. Phila., pp. 130–131, 1895.

28Deussen, Alexander, U. S. Geol. Surv., Water Supply Paper 335, p. 57, and Pl. IV, 1914, and U. S. Geol. Surv., Prof. Paper 126, p. 69, 1924.

29Dumble, E. T., Geology of East Texas. Univ. Texas Bull. 1869, p. 98, 1918.

at Sutton. It is also present at many places in Burleson County, especially in the vicinity of Chriesman.

Above the glauconitic sand and limestone lentil (lentil B of Fig. 10) there is about 10 feet of buff and brown clay with glauconitic seams, and at the top of this zone there is in some sections a six-inch iron concretionary bed. Above the latter beds in Robertson County there is locally about 20 feet of clay. This clay grades upward from gray clay with glauconitic seams into pure light gray clay. In some sections this topmost 20 foot clay zone grades laterally into gray sandy clay, and in such localities the contact with the overlying Sparta is difficult to determine.

A good section of the entire Weches member is shown along the Hearne-Wheelock road about 5¼ miles east of Hearne in the eastern part of the L. I. Easterwood 300 acres, Robt. Henry Survey.

The Weches is an easily eroded member, but when not dissected by erosion, it generally produces an open prairie, devoted to farming, and in decided contrast to the rugged, post-oak-covered topography of the Queen City and Sparta sands.

Paleontology: A fairly large number of marine invertebrate fossils were obtained from the Weches. They were found distributed mainly in three levels of the member:

1. Glauconitic sands at the base of the member as exposed on the "Burleson Shell Bluff" of Penrose near the site of old Collier's, or Collard's ferry, Burleson County. This level corresponds with the basal Weches up to and including the lentil A of Fig. 10.

2. Glauconitic sands 15 to 30 feet below the top of the Weches member as exposed at Buck McBride's 134-acre tract, Jose Maria Viesca Survey, in eastern Robertson County, and on the bluff along the Navasota River at the old iron bridge in the E. C. Watson 800-acre tract, Jose Maria Viesca Survey, in southwestern Leon County. This level contains the lentil B of Fig. 10.

3. Red to brown and gray impure limestone as exposed north-northeast of Sutton Switch on the Southern Pacific Railroad, Robertson County. This level corresponds to lentil B of Fig. 10.

The basal glauconitic sands (1. above) are filled with great quantities of *Pecten burlesonensis* Harris and *Ostrea sellaeformis* Conrad var., a variety which is characterized by its very flat upper (right) valve (see Plate VI). Besides these two leading fossils, there are fish teeth and otoliths, a crab finger, a squid *(Belosepia)*, 35 species of gastropods, several species of pelecypods, 1 species of worms, 1 of bryozoa, and 4 of corals,—altogether about 64 species. The predominance of pelecypods, especially of oysters and pectens, is marked, and in comparison with them the other forms are rare. This, together with the fact that many of the shells are broken and worn, indicates conditions of sublittoral marine deposition in the basal part of the member in this region. This facies is not prevalent in this area.

The fauna of the glauconitic sands occurring about 15 to 30 feet from the top of the Weches (2. above) differs greatly from the basal fauna (see fossil lists, Table 2, pp. 105–108). The following gastropods predominate: *Vertagus wechesensis* Stenzel n. sp., *Turritella femina* Stenzel n. sp., *Calyptraphorus velatus* Conrad.[30] Altogether there were found in this level a crab *(Zanthopsis peytoni* Stenzel n. sp.), fish otoliths, 45 species of gastropods, several species of pelecypods (among them *Ostrea sellaeformis* Conrad and *Venericardia planicosta* Lamarck), several bryozoa, worms, and two species of corals. It is therefore essentially a gastropod facies representing a rich and varied assemblage of about 65 forms. The predominance of gastropods as well as the richness in the number of species suggests conditions of sedimentation in a sea of somewhat greater distance from shore than the fauna of the basal glauconitic sands (1. above).

In some parts of the limestone lentil B of the Weches member (see 3. above and Fig. 10), there are many casts of

[30]Descriptions of new species mentioned in this report will appear in a later publication. See Plates VI and VII. *Cerithium vinctum* Harris MS non Whitfield is a synonym of *Vertagus wechesensis* Stenzel n. sp.

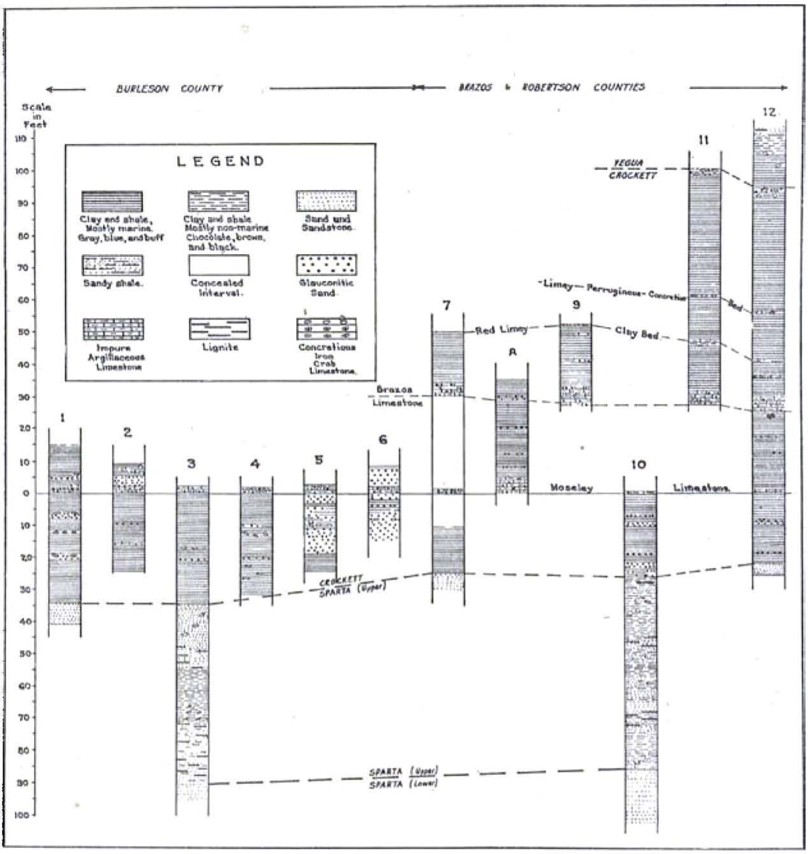


Fig. 11. Geologic sections along Crockett-Sparta contact in the vicinity of the Brazos River. Brazos River limestone in this illustration should read Little Brazos limestone. Following is the location of the sections shown in this figure:

(1) Along Caldwell-Bryan (San Antonio) road, west bank of creek below schoolhouse about 0.4 mile northeast of southwest corner of P. B. Scott Survey, Burleson County;
(2) along Caldwell-Bryan (San Antonio) road at southwest corner of Gabe Jones 130 acre tract, P. W. Scott Survey, Burleson County;
(3) head of ravine near central part of R. E. Clampitt 229.5 acre tract, F. Niebling Survey, Burleson County;
(4) along secondary road along west side of K. Drgac 175 acres, F. Niebling Survey, about 1¼ miles northeast of Cook's Point store, Burleson County;

(5) creek bank about 0.7 mile west of Moseley's Ferry on Irwin Washington place, B. A. Boster Survey, Burleson County;

(6) bluff at Moseley's Ferry or Stone City where Southern Pacific Railroad bridge crosses the Brazos River, Burleson County;

(7) along secondary road across Frank Kopecky 87.2 acres and Joe Kopecky 40 acres, northeast corner of Francisco Ruiz Survey, Brazos County;

(8) along San Antonio road (Brazos-Robertson County line) at southwest corner of Wilson Reed Survey;

(9) along San Antonio road (Brazos-Robertson County line) 0.15 mile southwest of Southern Pacific Railroad on south line of Wilson Reed Survey;

(10) along Bryan-Hearne road (Highway No. 6) near southeast corner and along east line of D. W. Campbell Survey, Robertson County;

(11) along Bryan-Hearne road (Highway No. 6) from Little Brazos limestone in bed of Elm Creek to Yegua contact. Top of section is 4,150 feet along highway southeast of San Antonio road;

(12) along San Antonio road including southeastern part of Skeagh Walker Survey, Robertson County, and northwestern part of Abner Lee Jr. Survey, Brazos County.

Pecten burlesonensis Harris. These parts of the limestone lentil are laterally discontinuous and represent a recurrence of the sublittoral conditions of marine deposition which prevailed during the deposition of the basal parts of the member (1. above).

In summary then, there are two facies present in the Weches member in this region, each characterized by its faunal assemblage. The facies fossils for the pelecypod facies are: *Pecten burlesonensis* Harris and *Ostrea sellaeformis* Conrad var. The facies fossils for the gastropod facies are: *Vertagus wechesensis* Stenzel n. sp., *Turritella femina* Stenzel n. sp., *Latirus singleyi* Harris (see Pl. VI).

Besides these fossils, the following are guides of the Weches member and have not been found in the Crockett member in the vicinity of the Brazos river: *Pseudoliva* n. sp. 4, *Rimella texana* Harris, *Rimella texana* var. *plana* Harris, *Surcula* n. sp. aff. *gabbi* Conrad, *Volutilithes dalli*

Harris, *Clavilithes chamberlaini* Johnson and Grabau, *Anomia sellardsi* Stenzel n. sp. (See Plate VI.)

The gastropod *Vertagus wechesensis* Stenzel n. sp. has been found only near the level of lentil B of the Weches member. It may therefore prove to be a reliable marker for this level in the Weches member of adjoining regions.

COOK MOUNTAIN FORMATION

SPARTA SAND

Lithology and Stratigraphy: The lower 300 to 350 feet of the Sparta consists of soft gray cross-bedded sand, interbedded with lenses of lignitic sandy clay. The sands and clays contain thin flakes of orange-colored ironstone and there are, in places, beds of ferruginous sandstone as much as a foot thick. (See Fig. 10.)

The upper 25 to 60 feet of Sparta sand member consists mostly of dark gray and chocolate-colored clay interbedded with lignitic sandy clay and containing thin beds of ferruginous sandstone.* Thin lenses of ferruginous sandstone containing a little glauconite with a few casts were noted at some places. At the top of this chocolate-colored and lignitic clay zone in eastern Burleson County, there is a 5 to 15 foot bed of soft cross-bedded gray sand containing iron concretions, and this sand is taken as the topmost bed of the Sparta. In northeastern Brazos County there is a gradation from this sand into the overlying marine clays of the Crockett. In Robertson County along Highway No. 6 this topmost soft sand was not observed, and the top of the Sparta is placed at the top of the dark chocolate-colored clays. East of Highway No. 6, at many places, there is a brown cross-bedded sandstone about five feet thick marking the top of the Sparta.

South of Eaton in the vicinity of Shiloh School in southern Robertson County in the A. W. Rowlett, Geo. W. Cox, northwest corner of the Lavina Rollison, and southern part of the Jose Maria Viesca surveys, there are marine beds interlaminated with the Sparta (see Fig. 9 and Fig. 10).

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*This zone is referred to as the upper Sparta. (See fig. 11.)

These marine lenses consist of fossiliferous glauconitic sand, red clay, and ferruginous ironstone, all interbedded with gray sand of Sparta lithology. To these marine beds the name "Eaton lentil" is here applied. The maximum thickness, which is 50 feet, is exposed along the Wheelock-New Baden road, and the interval from the topmost marine bed in the Eaton lentil to the base of the Crockett is from 15 to 50 feet.

The country underlain by the Sparta sand generally bears a considerable growth of post-oak, is hilly and dissected, and not very satisfactory for agriculture. Many of the divides are covered with Pleistocene (?) stream conglomerate and iron sandstone beds similar to those occurring on the Queen City sand outcrop. These conglomerate beds, which are resistant to erosion, tend to increase the relief.

Paleontology: The Sparta sand, with the exception of the Eaton lentil, does not contain any marine fossils. The Eaton lentil shows some poorly preserved casts of a few species of small pelecypods. They are considered as probable brackish water forms.

CROCKETT CLAY

Lithology and Stratigraphy: The Crockett clay is well exposed in Burleson County and southern Robertson County. A number of good exposures of the lower part of the Crockett are found along Highway No. 21 east of Caldwell, as well as along Highway No. 6 between Bryan and Hearne north of Benchley. From 25 to 35 feet above the Sparta sand in Burleson County, and from 15 to 25 feet above the Sparta in Robertson County, there is an argillaceous limestone, sometimes very glauconitic, which is abundantly fossiliferous (see Fig. 10 and Fig. 11). In places this limestone grades into an argillaceous, glauconitic shell marl, and at the old Moseley's ferry site on the Brazos (bridge on the Giddings to Hearne branch of the Southern Pacific R. R.) it is of this latter type. This limestone is persistent across these counties and is here designated the Moseley limestone. The section at Moseley's ferry

(Section 6, Fig. 11) has been described by Roemer,[31] Penrose,[32] Kennedy,[33] Deussen,[34] and Dumble.[35]

Below the Moseley limestone, and above the Sparta sand, the strata consist of sticky blue, gray and buff clays containing beds of fossiliferous glauconitic sand.

Above the Moseley limestone there are 24 to 30 feet of gray and buff clays, the buff color being due to weathered, disseminated glauconite. This interval in places also contains several six-inch to one-foot beds of fossiliferous glauconitic sand.

Overlying these clays is another impure, argillaceous, glauconitic limestone, sometimes occurring as a concretionary bed (see Fig. 10 and Fig. 11). This limestone is called the Little Brazos limestone as it is best exposed and has the best faunal representation along the Little Brazos River, in the neighborhood of the old interurban crossing on the W. T. James Est. 70 acres, W. Matthis Survey, about 1.4 miles northeast of Bryan Junction. It is also exposed at a number of places along the old San Antonio-Nacogdoches road east of the Brazos River in Brazos and Robertson counties and west of the Brazos River in Burleson County.

From 26 to 29 feet above the Little Brazos limestone, there is a concretionary bed consisting of iron concretions slightly calcareous and containing some fossils. This bed is fairly persistent and gives rise to a reddish-brown soil when weathered.

The clays between the Little Brazos limestone and the overlying Yegua are gray and buff, the latter color being due to the presence of weathered glauconite in the clay.

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[31]Roemer, Ferdinand, Contributions to the Geology of Texas, Amer. Jour. Sci. and Arts, Vol. VI, 2d ser., p. 23, 1848.

[32]Penrose, R. A. F., Jr., A Preliminary report on the geology of the Gulf Tertiary of Texas from Red River to the Rio Grande, Geol. Surv. Texas, 1st Ann. Rept., p. 27, 1889.

[33]Kennedy, William, The Eocene Tertiary of Texas East of the Brazos River, Proc. Acad. Nat. Sci. Phila., p. 128, 1895.

[34]Deussen, Alexander, Geology and Underground Waters of the Southeastern part of the Texas Coastal Plain, U. S. Geol. Surv., Water Supply Paper 335, p. 57, and geologic sections Pl. IV, 1914, and Geology of the Coastal Plain of Texas west of Brazos River, U. S. Geol. Surv., Prof. Paper 126, p. 69, 1924.

[35]Dumble, E. T., Geology of East Texas, Univ. Texas Bull. 1869, p. 99, 1918.

In the upper part of the Crockett the clays are gypsiferous, many large crystals of gypsum occurring in the weathered surface. At the top of the Crockett, in some sections, there is a six-inch bed of fossiliferous greensand. At this level also there is generally a zone three or four feet thick containing iron concretions in the clays. The contact with the overlying Yegua is placed at the top of this concretionary zone, since the clays above this point are of a chocolate-brown color and have a non-marine aspect. The typical lignitic sandy clays of the Yegua do not appear in some parts of Brazos County until about 15 feet higher in the section. In parts of Burleson County the lignitic sandy clays and sands of the Yegua rest on this concretionary bed. The Crockett clay is from 110 to 125 feet thick. It is marine throughout and gives rise to an open undulating prairie with a black and brown clay soil.

Paleontology: The glauconitic sands and marls of the Crockett member are very rich both in species and individuals. The fossil lists (see Table 1, pp. 99–105) represent the writers' collection, which includes nearly all species mentioned by the various authors who have described fossils from the Cook Mountain formation of this region. In addition, the lists contain many as yet undescribed forms.

It will be noted that the gastropods have the greatest number of species in this fauna. At the outcrops it was observed that they generally were the most numerous individually as well. The most conspicuous species are the following: *Conus sauridens* Conrad, *Surcula gabbi* Conrad, *Borsonia plenta* Harris and Aldrich, *Latirus moorei* Gabb, *Distorsio septemdentata* Gabb, *Neverita arata* Gabb, *Plejona petrosa* (Conrad) (see Plates VI and VII). These forms, with the exception of *Neverita* and *Plejona,* are characteristic of the Crockett member in this area and are considered guide fossils. One individual of *Conus* was found in lentil B of the Weches member but the others were not found in the Weches member.

The Crockett also contains several species which are distinctly tropical or subtropical, as, for example, the gastropods *Conus sauridens* Conrad, *Distorsio septemdentata*

Gabb, *Cypraea kennedyi* Harris, and the crabs *Harpactocarcinus americanus* Rathbun, *Harpactocarcinus rathbunae* Stenzel n. sp., *Harpactocarcinus* sp. *Conus sauridens, Distorsio septemdentata,* and *Harpactocarcinus americanus* are very numerous. *Conus* is very rare in the Weches and the others seem to be absent. It is probable that the Crockett sea was warmer than the Weches sea in this region, and that the above mentioned forms originated in waters farther south and migrated into this region with the transgression of the Crockett sea.

As a whole, the Crockett fauna is fairly uniform throughout as contrasted with the Weches fauna. Most of the species in the Crockett member may be traced without noticeable change from the bottom almost to the top. There were found fish bones, fish teeth, fish vertebrae, fish earbones, 6 species of crustaceans, several species of squids *(Belosepia)*, a nautiloid *(Hercoglassa* sp.), 154 species of gastropods, 4 species of scaphopods, 44 species of pelecypods, 1 crinoid plate (?), 1 species of brachiopods, several species of bryozoa, 5 species of worms, and 15 species of corals (see pp. 99–105).

The fossiliferous beds of the Crockett member, therefore, include a fauna rich in species and individuals, which are generally of uniform vertical range, and contain some subtropical species. In this fauna gastropods predominate, indicating a warm and somewhat deep shelf sea within the action of the waves, as is indicated by several layers of broken and rolled fossils.

Horizons within the Crockett may be established on two groups of fossils: (1) on species which are present or abundant only within a limited level; (2) on species which show gradual varietal changes from a lower to a higher level.

(1) Species limited to, or abundant in, a certain level:

Harpactocarcinus americanus Rathbun .... from top of Moseley limestone to 15 feet above Little Brazos limestone; most abundant in concretions above the Little

	Brazos limestone (see crab zone of Fig. 10).
Hercoglossa n. sp.	below Moseley limestone.
Pleurotoma texana Gabb	from top of Moseley limestone to 10 feet above Little Brazos limestone.
Borsonia plenta Aldrich and Harris	below Moseley limestone.
Mitra mooreana Gabb	near Little Brazos limestone.
Mitra n. sp. aff. *mooreana* Gabb	near Little Brazos limestone.
Murex (Odontopolys) compsorphytis Gabb	near Little Brazos limestone.
Sphaerella anteproducta Harris	about 1 foot above Little Brazos limestone.
Crassatellites antestriatus Gabb	from top of Moseley limestone to 15 feet above Little Brazos limestone.
Anomia lisbonensis Aldrich	Little Brazos limestone.
Plicatula filamentosa Conrad var.	0 to 2 feet below Little Brazos limestone.
Ostrea cf. *alabamiensis* Lea	5 to 13 feet below Moseley limestone.
Spirorbis (Tubulostium) leptostoma Gabb	0 to 3 feet above Moseley limestone.
Bryozoa of cup shape	0 to 3 feet above Moseley limestone.

Harpactocarcinus, *Crassatellites*, *Spirorbis*, and the cup shaped Bryozoa are more useful as guide fossils than the others, because they are common in their respective levels.

(2) Species showing varietal changes are:

Mesalia claibornensis Conrad	
Slender form	about Little Brazos limestone.
Broad form	below Moseley limestone.

Pseudoliva carinata Conrad
Heavy form *(perspectiva)* .... about Little Brazos limestone.
Slender form .... below Moseley limestone.

Fusus mortoni Lea
var. *carexus* Harris .... about Little Brazos limestone.
var. *mortoniopsis* Gabb .... below Moseley limestone.

Phos texanus Gabb
with coarser and less crowded ornamentation .... about Little Brazos limestone.
with fine and crowded ornamentation .... below Moseley limestone.

These species exhibit very gradual changes, and the different varieties are connected by transitions.

It is recognized that some of the fossil zones established are probably local and will not be identical over a larger area. This can only be determined by additional work in other areas.

UPPER CLAIBORNE GROUP

YEGUA FORMATION

Lithology and Stratigraphy: Although the Yegua formation as a whole is not considered in this paper, the lithologic character of the lower part of the formation is briefly described so that the contact may be recognized.

In Burleson County, 30 to 40 feet above the Crockett member, there is a zone about 60 feet thick which contains marine Yegua beds. These marine beds are generally very fossiliferous and are calcareous; the fossiliferous beds are usually not over a foot thick and are interbedded with non-fossiliferous clays and lignitic sandy clays. The fossils occur in calcareous shale, in thin but hard limy beds, and as casts in concretionary beds.

In eastern Burleson County these marine beds are well exposed in several draws in the northeastern part of the J. H. Giesenschlag 275 acres, J. Reed Survey; also along, and in proximity to, the road beside the Jonas Tarver 40 acres in the southwest part of the A. Kuykendall Survey.

In the western part of Burleson County the marine beds are well shown about one and one-half miles southwest of Deanville along the road which is on the west line of the D. Perry Survey. Along this road, south of the creek, there is near the base of the Yegua about 18 feet of cross-bedded gray sandstone containing some iron flags. Above this sandstone there is about 40 feet of gray and chocolate-colored gypsiferous clay which, in the lower part, contains several beds of fossiliferous concretionary limestone.

In Brazos County, above the fossiliferous glauconitic sand and iron concretions at the top of the Crockett, there is generally about 15 feet of chocolate-brown clay. This clay grades up into sandy clay and sand which is locally lignitic. Iron concretions also occur in the lower part of the Yegua, and the clays are gypsiferous on the weathered surface like those in the upper Crockett. The sandy clay and sand beds above the basal clays of the Yegua form a tree-covered escarpment generally in contrast to the open prairie of the Crockett, which is at a lower elevation.

No unconformity between the Yegua and the underlying Crockett was noted, and though the contact is fairly definite in many places, at other localities it appears to be gradational.

Paleontology: The Yegua formation contains fossil leaves in many levels. These have been described by E. W. Berry and by O. M. Ball.[36] The lentils of marine beds interbedded with the lower Yegua contain a fairly rich fauna. Among species surviving from the Crockett is *Phos texanus* Gabb. The variety of this species found in the lower Yegua shows an accentuation of the characters which had been evolving in the Crockett; its ornamentation is coarser and the spiral lines even broader and flatter than in the variety found at the level of the Little Brazos limestone. The three varieties of *Phos texanus* represent a continuous evolutionary line. The coral *Flabellum cuneiforme* Lonsdale var. *pachyphyllum* Gabb and Horn is more common in the lower Yegua lentils than in the Crockett of this region.

While the entire number of species is less than in the Crockett, it is nevertheless quite an impressive array. The number of individuals is very great in some of the beds. A locality from which there is a good list of lower Yegua

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36Ball, O. M., A Contribution to the Paleobotany of the Eocene of Texas, Bulletin of the Agricultural and Mechanical College of Texas, 4th series, Vol. 2, No. 5, 1931.

Berry, Edward Wilber, The middle and upper Eocene floras of southeastern North America, U. S. Geol. Surv., Prof. Paper 92, 1924.

fossils is 3.25 miles northeast of Edge, Brazos County (see Table 1, pp. 99–105). The fauna may be supplemented by the following additional species found in the lower Yegua lentils of southeastern Burleson County: *Ancilla expansa* Aldrich, *Conus sauridens* Conrad (both from Jonas Tarver 40 acres, near southwest corner of A. Kuykendall Survey), and vertebrae of a cetacean mammal (from the J. H. Giesenschlag 275 acres, southeast corner of J. Reed Survey). The find of this cetacean is of considerable interest as it is the first record of a cetacean from the Claiborne group and the oldest known cetacean of North America.[37]

The most striking feature of the fauna is its great similarity, not to say identity, with the fauna of the Crockett. This may be best seen by consulting the fossil lists. Every species in the lower Yegua is either represented in the faunal lists of the Crockett, or is at least known from the lower Claiborne of other regions. On the other hand, the lower Yegua fauna does not contain any species distinctive of the upper Claiborne. For this reason it is necessary to place the marine lentils of the lower Yegua in the lower Claiborne. Thus part of the Yegua formation, at least up to and including these lentils, apparently belongs to the lower Claiborne. The boundary between the lower and upper Claiborne which is within the Yegua formation, is unknown at present.[38]

The character of the lower Yegua fauna is truly marine in some places, because there are quite a few corals contained in some of the beds. However, this does not exclude the possibility that some of the layers, or perhaps most of them, may represent brackish water conditions. As these lentils overlie beds which were deposited in coastal swamps, it seems justifiable to explain them as local marine ingressions.

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[37]Dr. Remington Kellogg, personal communication.

[38]This conclusion is essentially the same as J. Gardner's. See Gardner, Julia, The correlation of the Marine Yegua of the type sections, Jour. of Pal., Vol. I, pp. 245–251, 1927.

Lists of fossils from selected localities

Table 1

Crockett member and lower part of Yegua formation.

Localities: 1. Moseley's Ferry, at Southern Pacific R.R. bridge over Brazos River, Burleson Co., across the river from Stone City;
Crockett member, below Moseley limestone.

2. Same;
Crockett member, 0 to 3 feet above Moseley limestone.

3. Creek bed adjoining old San Antonio road, north part of George Williams 159-acre tract, northwest part of Abner Lee Jr. Survey, Brazos Co.;
Crockett member, 0 to 3 feet above Moseley limestone.

4. Little Brazos River, at county road bridge, near old interurban crossing on W. T. James Est., 70 acres, W. Mathis Survey, Brazos Co.;
Crockett member, 2 feet below to 20 feet above Little Brazos limestone.

5. Cedar Creek, 3.25 miles northeast of Edge, north of the public road and near the northeast corner of the W. J. McDonald 93-acre tract, W. J. Lewis Survey, Brazos Co.;
Lower part of Yegua formation.

	1	2	3	4	5
Chordata:					
1. Fish bones indet.	*	*	*	*	*
2. Fish otoliths, flat, indet.	*	*	*	*	*
3. Fish vertebrae indet.	*	*			*
4. Fish teeth indet.	*	*	*		*
Arthropoda—Decapoda:					
1. Dactylus of a crab	*	*			
2. Harpactocarcinus americanus Rathbun, emend. Stenzel[39]			*	*	
3. H. rathbunae Stenzel n. sp.				*	
4. H. sp. Stenzel			*		
5. Calappilia diglypta Stenzel n. sp.	*				
6. Callianassa brazoensis Stenzel n. sp.				*	
Mollusca—Cephalopoda:					
1. Belosepia ungula Gabb and related spp.	*	*		*	
2. Hercoglossa n. sp.	*				

[39] New species mentioned in this report will be described subsequently.

	1	2	3	4	5
Mollusca—Gastropoda:					
1. Styliola aff. simplex Meyer	*		*	*	
2. Cylichna kellogii Gabb	*	*	*	*	*
3. Cyl. sp. indet.				*	
4. Volvula conradiana Gabb	*			*	
5. V. minutissima Gabb	*			*	*
6. V. smithvillensis Harris				*	
7. Ringicula trapaquara Harris	*				
8. Acteon pomilius Conrad	*			*	
9. Conus sauridens Conrad	*	*	*	*	
10. Pleurotoma enstricrina Harris	*	*	*	*	*
11. Pl. texana Gabb	*	*		*	
12. Pl. ? childreni Lea	*				
13. Pl. sp. 1 (childreni Lea?)		*	*	*	
14. Pl. sp. 2		*	*	*	
15. Pl. sp. 3				*	
16. Pl. sp. 6				*	
17. Pl. sp. 7				*	
18. Turris cristata Gabb	*	*		*	*
19. T. sp. indet. (near cristata Gabb)		*			
20. Surcula gabbi Conrad	*	*	*	*	
21. S. moorei Gabb, forma 1	*	*	*		
22. S. moorei Gabb, forma 2				*	
23. S. moorei Gabb, forma 3			*	*	
24. S. sp. 4				*	
25. Drillia nodocarinata Gabb	*	*	*	*	*
26. Dr. texacona Harris (=texana Conrad)	*	*	*	*	*
27. Dr. kellogii Gabb				*	
28. Microdrillia insignifica Heilprin					*
29. Glyphostoma harrisi Aldrich (=Mangilia infans Meyer?)	*	*	*	*	*
30. Eucheilodon reticulata Gabb		*	*	*	*
31. Eu. reticulatoides Harris	*	*	*	*	
32. Eu. sp. 1					*
33. Scobinella conradiana Aldrich	*				
34. Sc. sp. 1. aff. conradiana Aldrich				*	
35. Borsonia plenta Aldrich and Harris	*	*			
36. Cryptoconus sp.				*	
37. Terebra houstonia Harris	*		*	*	*
38. T. texagyra Harris	*	*		*	*
49. T. sp.				*	
40. Cancellaria babylonica Lea var. tera de Gregorio	*				
41. Can. babylonica Lea var. nov.				*	
42. Can. bastropensis Harris		*			*
43. Can. penrosei Harris	*				

		1	2	3	4	5
44.	Can. ? tortiplicata Conrad	*	*	*		*
45.	Can. ulmula Harris				*	
46.	Oliva alabamensis Conrad				*	
47.	Olivula punctulifera Gabb	*	*	*	*	
48.	Marginella (Erato) semenoides (Gabb)	*	*	*	*	
49.	Mitra mooreana Gabb				*	
50.	M. mooreana Gabb var.		*			
51.	M. n. sp. aff. mooreana Gabb		*		*	
52.	M. exile Gabb				*	
53.	Conomitra (Turricula) polita Gabb	*	*	*	*	
54.	Con. (Turricula) texana Harris			*	*	
55.	Con. (Turricula) n. sp.			*		
56.	Volutilithes sp. near lisbonensis Aldrich			*		
57.	Vol. sp. indet. 1	*			*	
58.	Plejona (Volutilithes) petrosa (Conrad)	*	*	*	*	*
59.	Caricella subangulata Conrad var. cherokeensis Harris		*		*	
60.	Car. (Scaphella) demissa Conrad var. texana Gabb				*	
61.	Fusus apicalis Johnson				*	
62.	F. ludovicianus Johnson				*	
63.	F. mortoni Lea var. mortoniopsis Gabb	*	*	*	*	
64.	F. mortoni Lea var. carexus Harris				*	
65.	F. mortoni Lea var. 3	*				
66.	F. n. sp. 3				*	
67.	F. n. sp. 3. var.	*				
68.	Clavilithes humerosus Conrad var. texanus Harris				*	
69.	Cl. young (penrosei Heilprin or texanus Harris)		*			
70.	Cl. penrosei Heilprin				*	
71.	Cl. papillatus Conrad				*	
72.	Cl. protextus Conrad				*	
73.	Latirus moorei Gabb	*	*	*	*	*
74.	L. obtusus Johnson				*	
75.	L. n. sp.			*		
76.	Terebrifusus cf. amoenus Conrad	*	*	*	*	
77.	Murex (Odontopolys) compsorhytis Gabb				*	
78.	M. fusates Harris		*			
79.	M. (Phyllonotus) sp. aff. morulus Conrad			*		
80.	M. n. sp. 1				*	
81.	Pseudoliva carinata Gabb, forma 1	*	*			
82.	Ps. carinata Gabb, forma 1 transitional to forma 2 (perspectiva)			*		
83.	Ps. carinata Gabb, forma 2 (perspectiva Conrad)		*		*	

	1	2	3	4	5
84. Ps. carinata Gabb, forma indet.					*
85. Ps. fusiformis Lea	*			*	
86. Ps. linosa Gabb	*				
87. Ps. n. sp. 1				*	
88. Ps. n. sp. 2	*				
89. Ps. n. sp. 3	*				
90. Phos texanus Gabb, forma 1	*				
91. Ph. texanus Gabb, forma 1 transitional to forma 2		*	*		
92. Ph. texanus Gabb, forma 2				*	
93. Ph. texanus Gabb, forma 3					*
94. Cornulina armigera Conrad	*				
95. ? Expleritoma prima Aldrich	*				
96. Neptunea enterogramma Gabb	*				
97. Metula gracilis Johnson				*	
98. "Fusus" whitfieldi Aldrich				*	
99. Hemifusus engonatus Heilprin		*	*	*	
100. Levifusus pagoda Heilprin	*			*	
101. L. trabeatoides Harris	*			*	*
102. L. trabeatoides Harris, old?	*			*	*
103. Distorsio septemdentata Gabb	*	*	*	*	
104. Pyrula penita Conrad ?, variants	*		*		
105. Py. texana Harris ?, variants	*			*	
106. Py. sp. young					*
107. Cassidaria brevidentata Aldrich				*	
108. Rostellaria (Calyptraphorus) trinodifera Conrad	*	*	*		
109. Rimella stephensoni Stenzel n. sp.	*			*	
110. Cerithium sp. indet.	*				
111. Turritella nasuta Gabb	*			*	*
112. T. nasuta Gabb var. houstonia Harris	*			*	
113. T. nasuta Gabb var. houstonia Harris, old ?	*				
114. T. sp. near nasuta Gabb				*	
115. T. dumblei Harris	*			*	
116. T. dumblei Harris var. nov.		*	*		
117. T. cf. mela de Gregorio	*				
118. T. sp. 1	*				
119. T. sp. 2	*				
120. T. sp. 3	*				
121. T. sp. 4				*	
122. T. sp. 5				*	
123. T. sp. 6				*	
124. T. sp. 7				*	
125. Mesalia claibornensis Conrad forma 1 (broad)	*				

	1	2	3	4	5
126. Mes. clairbornensis Conrad forma 2 (slender)		*	*	*	
127. Mes. claibornensis Conrad var.		*	*		
128. Natica semilunata Lea	*	*		*	*
129. Nat. sp. aff. mamma Lea	*	*	*	*	
130. Nat. young of mamma Lea?	*				
131. Nat. sp.				*	
132. Neverita arata Gabb	*	*		*	*
133. Sinum (Sigaretus) bilix Conrad	*			*	
134. S. (Sigaretus) declivus Conrad	*				
135. Hipponyx pygmaea Lea?		*			
136. Calyptraea aperta (Solander)	*	*	*		
137. Solarium bastropensis Harris	*				
138. Sol. elaboratum Conrad	*	*	*	*	*
139. Sol. scrobiculatum Conrad	*				
140. Sol. texanum Gabb	*			*	
141. Sol. sp. 1	*	*		*	
142. Sol. sp. 2	*				
143. Sol. sp. 3	*				
144. Sol. sp.					*
145. Scalaria carinata Lea	*				
146. Scal. sp. indet. 1	*				
147. Tenuiscala trapaquara Harris	*				
148. Pyramidella (Syrnola) bastropensis Harris	*		*	*	
149. Pyr. (Syrnola) trapaquara Harris		*			
150. Pyr. n. sp.	*				
151. Turbonilla sp.	*				
152. Tuba antiquata Conrad	*			*	*
153. Eulima exilis Gabb	*				
154. Eul. texana Gabb	*				*
155. Eul. sp. 1	*				
156. Eul. sp. 2	*				
157. Teinostoma sp.	*				
158. Adeorbis exacua Conrad	*				
159. Delphinula depressa Lea	*				
160. Helcion leanus Gabb				*	
Mollusca—Scaphopoda:					
1. Dentalium minutistriatum Gabb	*	*	*	*	*
2. Cadulus juvenis Meyer	*	*	*	*	
3. Cad. subcoarctatus Gabb		*			
4. Cad. sp. indet.			*	*	*
Mollusca—Pelecypoda:					
1. Corbula alabamiensis Lea	*	*	*	*	
2. Cor. smithvillensis Harris	*	*	*	*	
3. Cor. texana Gabb	*	*	*	*	
4. Cor. cf. conradi Dall					*
5. Cor. cf. deusseni Gardner					*

	1	2	3	4	5
6. Tellina papyria Conrad var. mooreana Gabb	*				
7. Meretrix texacola Harris	*	*	*	*	
8. Mer. trigoniata Lea var. bastropensis Harris	*				*
9. Mer. sp. indet.	*				
10. Protocardia gambrina Gabb	*			*	
11. Diplodonta sp. indet.					*
12. Sphaerella anteproducta Harris				*	
13. Pseudochama harrisi Gardner				*	
14. Venericardia planicosta Lamarck variants	*	*	*	*	
15. Ven. rotunda Lea		*	*		*
16. Ven. rotunda Lea var. flabellum Harris			*		*
17. Ven. n. sp.	*				
18. Crassatellites antestriatus Gabb	*	*		*	
19. Astarte?	*			*	
20. Lirodiscus n. sp. 1			*		
21. Pholadomya harrisi Gardner	*			*	
22. Modiolus houstonius Harris	*				
23. Anomia ephippoides Gabb	*			*	
24. An. lisbonensis Aldrich				*	
25. Spondylus n. sp.				*	
26. Plicatula filamentosa Conrad var.				*	
27. Pecten scintillatus Conrad var. corneoides Harris	*	*	*	*	*
28. Ostrea sellaeformis Conrad var. 1	*	*	*	*	
29. Ostrea sellaeformis Conrad adults		*			
30. Ost. cf. alabamiensis Lea	*				
31. Ost. sp. 1	*			*	
32. Pinna gravida Harris				*	
33. Pinna sp. indet. 1				*	
34. Pinna sp. indet. 2	*				
35. Arca (Barbatia) cuculloides Conrad var. ludoviciana Harris	*	*		*	
36. A. (Barbatia) cuculloides Conrad var. ludoviciana Harris, old?				*	
37. Arca reticulata Gmelin				*	*
38. Glycimeris lisbonensis Harris		*		*	
39. Gl. trigonella Conrad			*		
40. Trinacria decisa Conrad					*
41. Tr. declivis Conrad	*				
42. Tr. pulchra Gabb	*			*	
43. Leda bastropensis Harris?	*				
44. L. houstonia Harris				*	
45. L. opulenta Conrad var. compsa Gabb	*				*
46. L. wautubbeana Harris				*	
47. Yoldia psammotaea Dall	*			*	

	1	2	3	4	5
48. Nucula magnifica Conrad					*
49. N. magnifica Conrad var. mauricensis Harris	*	*	*	*	*
Molluscoidea—Bryozoa:					
1. Numerous indet.	*	*	*	*	
Molluscoidea—Brachiopoda:					
1. Argyrotheca n. sp.		*			
Echinodermata—Crinoidea?:					
1. Crinoid plate?	*				
Annelida—Chaetopoda:					
1. Spirorbis (Tubulostium) leptostoma Gabb		*		*	
2. Sp. (Tubulostium) n. sp.	*	*	*	*	
3. Serpula texana Gabb				*	
4. Ser. sp. indet. 1				*	
5. Ser. sp. indet. 2	*			*	
Cnidaria—Hexacoralla:					
1. Flabellum cuneiforme Lonsdale var. pachyphyllum Gabb and Horn	*	*			*
2. Discotrochus orbignianus Milne-Edwards and Haime		*		*	
3. Turbinolia pharetra Lea	*	*	*	*	*
4. Platytrochus stokesii (Lea)			*		
5. Madracis johnsoni Vaughan	*			*	
6. Oculina singleyi Vaughan	*		*	*	
7. Astrangia aff. expansa Vaughan				*	
8. Astr. n. sp.?	*				
9. Balanophyllia irrorata (Conrad) variants	*	*	*	*	
10. Bal. n. sp.	*				
11. Endopachys maclurii (Lea) var. tenue Vaughan	*	*		*	
12. End. maclurii (Lea) cf. var. triangulare Conrad				*	
13. End. maclurii (Lea) var. 1	*			*	
14. End. ? lonsdalei Vaughan	*				
15. Dendrophyllia lisbonensis Vaughan				*	
Porifera—Spongiae:					
1. Clionidae indet.	*			*	

Table 2

Weches Member

Localities: 6. Collier's Ferry (or Collard's Ferry, or Burleson Shell Bluff) on Brazos River, W. H. Jenkins Est. 41⅓-acre tract, and J. R. Sadberry Est. 147 acres, J. C. Robertson Survey, northeastern Burleson Co.; 0 to 20 feet above base of Weches member.

7. Buck McBride's 134-acre tract, Jose Maria Viesca Survey, eastern Robertson Co.; Level of lentil B of Weches member.
8. Bluff on Navasota River near old iron bridge on E. C. Watson 800 acres, Jose Maria Viesca Survey, southwestern Leon Co.; Lentil B of Weches member.

	6	7	8
Chordata:			
1. Fish teeth, indet.	*		
2. Fish otoliths, flat, indet.	*	*	
3. Fish otoliths, spheroidal, indet.	*		
Arthropoda—Decapoda:			
1. Dactylus of a crab	*		
2. Zanthopsis peytoni Stenzel n. sp.			*
Mollusca—Cephalopoda:			
1. Cylichna kellogii Gabb		*	
2. Ringicula n. sp.		*	
3. Acteon pomilius Conrad		*	
4. Pleurotoma beadata Harris		*	
5. Pl. denticulata Edw.		*	
6. Pl. huppertzi var. penrosei Harris	*	*	
7. Pl. langdoni Aldrich		*	
8. Pl. moniliata Heilprin		*	
9. Pl. sp. 1 (childreni Lea?)	*	*	
10. Pl. sp. 3	*		
11. Pl. sp. 8	*	*	
12. Pl. sp. 9	*		
13. Pl. sp. 10	*		
14. Turris cf. cristata Gabb	*	*	
15. Surcula n. sp. aff. gabbi Conrad	*	*	*
16. Glyphostoma harrisi Aldrich (=Mangilia infans Meyer?)	*		
17. Eucheilodon sp. 2	*		
18. Eu. sp. 3		*	
19. Cancellaria babylonica Lea var. nov. 2		*	
20. Oliva bombylis Conrad	*		
21. Olivula punctulifera Gabb		*	*
22. Cryptochorda (Buccinum) mohri (Aldrich)		*	
23. Mitra cf. dubia (H. Lea)	*	*	
24. Conomitra (Turricula) texana Harris		*	
25. Volutilithes dalli Harris		*	*
26. Vol. sp. 2		*	*
27. Plejona (Volutilithes) petrosa (Conrad)	*	*	*
28. Caricella n. sp. 1		*	
29. Car. n. sp. 2		*	

	6	7	8
30. Fusus interstriatus Heilprin?	*		
31. Clavilithes chamberlaini Grabau and Johnson			*
32. Cl. papillatus Conrad	*		
33. Cl. kennedyanus Harris ? young	*	*	
34. Cl. n. sp. near columbaris Aldrich		*	
35. Latirus singleyi Harris		*	*
36. Murex n. sp. 2	*	*	
37. Pseudoliva n. sp. 4	*	*	
38. Ps. n. sp. 5			*
39. Phos. n. sp.		*	
40. Cornulina armigera Conrad			*
41. Metula brazoensis Johnson	*		
42. Levifusus trabeatoides Harris		*	
43. Pyrula penita Conrad ? variants	*		*
44. Cassidaria brevidentata Aldrich	*		
45. Rostellaria (Calyptraphorus) velata Conrad	*	*	*
46. Rimella texana Harris	*		
47. Rim. texana Harris var. plana Harris	*		
48. Vertagus wechesensis Stenzel n. sp.		*	*
49. Turritella femina Stenzel n. sp.		*	*
50. T. n. sp. 9	*		
51. Xenophora conchyliophora Born	*		
52. Natica semilunata Lea		*	
53. Nat. eminula Conrad ?		*	
54. Nat. limula Conrad ?	*	*	
55. Nat. mamma Lea ?	*	*	
56. Nat. sp. 1	*	*	
57. Neverita arata Gabb	*		
58. Sinum (Sigaretus) bilix Conrad var. 1	*	*	
59. Sinum (Sigaretus) bilix Conrad var. 2		*	
60. Sinum (Sigaretus) bilix Conrad var. 3		*	
61. Calyptraea aperta (Solander)	*	*	
62. Solarium elaboratum Conrad var.		*	
63. Sol. n. sp. 5		*	
64. Pyramidella n. sp.	*	*	
65. Tuba antiquata Conrad var. nov.	*		
66. Adeorbis sp.	*		
Mollusca—Scaphopoda:			
1. Dentalium minutistriatum Gabb	*	*	
Mollusca—Pelecypoda:			
1. Corbula engonatoides Gardner	*	*	
2. Cor. smithvillensis Harris	*	*	
3. Tellina tallicheti Harris var.	*		
4. Tell. sp.		*	
5. Meretrix texacola Harris	*		
6. Cardium claibornense Aldrich	*		

	6	7	8
7. Venericardia planicosta Lamarck variants	*	*	*
8. Ven. trapaquara Harris subsp. texalana Gardner	*		
9. Ven. rotunda Lea var. flabellum Harris		*	
10. Crassatellites trapaquarus Harris		*	
11. Lirodiscus n. sp. 2 (=smithvillensis Harris partim)	*	*	
12. Anomia sellardsi Stenzel n. sp.	*	*	
13. Lima sp.	*		
14. Pecten burlesonensis Harris	*		
15. Ostrea sellaeformis Conrad var. 2	*	*	*
16. Ost. sp. (=alabamiensis Harris non Lea)	*		
17. Pinna sp.	*		
18. Arca deusseni Gardner	*	*	
19. Glycimeris idonea Conrad	*		
20. Trinacria pulchra Gabb		*	
21. Leda jewetti Gardner		*	
22. Leda sp.	*		
23. Nucula magnifica Conrad var. mauricensis Harris		*	
Molluscoidea—Bryozoa:			
1. Many cup-shaped bryozoa, indet.	*	*	
Echinodermata—Echinoidea:			
1. Echinoid plate			*
Annelida—Chaetopoda:			
1. Serpula sp. 3	*	*	
Cnidaria—Hexacoralla:			
1. Flabellum cuneiforme Lonsdale var. pachyphyllum Gabb and Horn			*
2. Turbinolia pharetra Lea	*	*	
3. Platytrochus stokesii (Lea)	*	*	
4. Paracyathus alternatus Vaughan	*		
5. Balanophyllia irrorata (Conrad) variants	*		

SOME CRETACEOUS FORAMINIFERA IN TEXAS

By

Helen Jeanne Plummer

INTRODUCTION

The recent endeavors of the Bureau of Economic Geology to deposit in its museum accurately named Texas fossils for general reference amongst stratigraphic paleontologists has included some concentrated efforts to establish clearly the identity of many Cretaceous foraminifera that have already been treated in the literature. Further data on stratigraphic ranges have been sought to make records more complete. Toward this end Professor F. L. Whitney and Dr. Robert Cuyler of the department of geology in The University of Texas have extended their generous coöperation in lending types and in helping to designate precisely the outcrops from which many of these were originally selected. Dr. W. L. Moreman of the department of geology of Texas Christian University has submitted some of his Eagle Ford types for examination. Mrs. Carsey has kindly checked the identity of several forms and gave from her original samples several metatypes that have aided considerably in assembling the museum collections.

During the recent rapid development of micropaleontology in close relationship to stratigraphy, it is becoming increasingly imperative that all species be very clearly defined both by detailed formal descriptions and by completely adequate illustrations. Toward a better understanding of many forms designated prior to this present period of meticulous presentation of paleontologic data, many new and more satisfactory descriptions and figures have been published as the opportunity for the study of types and of material from type localities has arisen. Fuller records of old type localities have permitted workers to collect and to study first-hand large suites of topotypes. It is only by such vigilance in learning the characteristics of each species at its type locality and also its variations geographically and stratigraphically that the best interests of paleontology are served. It is becoming increasingly important that descriptions be made from as large suites of specimens of any species as is possible to assemble, and it is necessary that each description and accompanying figure cover adequately the ranges in variations that the species exhibits. Such variations can best be observed first where a species is abundant at one locality, thus eliminating the factors of environment and evolution through the geologic section. Possible stratigraphic variations are then valuable records, if material from several parts of the area and of the section can be made available.

The species here presented include not only many forms already designated but also a few new closely associated or similar forms, which for further clarity in specific definitions and distinctions have required careful study. Care has been exercised in choosing for each new species a type locality that furnishes specimens in as great abundance as possible and in an excellent state of preservation.

Until recently only two species of Texas foraminifera have been recognized in the literature, the well-known *"Nodosaria" texana* Conrad (now placed in the genus *Haplostiche)* and *Orbitolina texana* (Roemer). The first record of any comprehensive investigation of Texas Cretaceous foraminifera is the geologic report on Denton County,[1] which offers very clear photographs of numerous microscopic organisms from most of the Lower Cretaceous formations of that area. Only generic determinations were attempted, as no systematic descriptions of species were prepared for this report. The following year some of the common foraminifera of the Cretaceous formations of central Texas were described and figured photographically by Mrs. Dorothy Ogden Carsey.[2] Since many of these are common forms throughout the Gulf Coast and in Mexico,

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1Winton, W. M., et al., The geology of Denton County: Univ. Texas Bull. 2544, pp. 186, text figs. 1–8, pls. 1–27, 1925.

2Carsey, Dorothy Ogden, Foraminifera of the Cretaceous of central Texas: Univ. Texas Bull. 2612, pp. 1–56, pls. 1–8, 1926 (edition exhausted).

the types that comprise the Carsey Collection have been the logical starting point in the present investigations toward building up the museum collections of microfaunas for the Bureau of Economic Geology. As future work on Cretaceous faunas in this state must carefully consider the names assigned in this early study, it is hoped that new figures of many of the holotypes or of newly selected types will help to establish more clearly the diagnostic characters of the species treated in that contribution. In addition it has been deemed advisable to designate specifically some of the commoner species figured and named generically in the Denton County report. Several new forms for purposes of comparison and clearer specific segregation have been introduced to obviate certain confusions that might otherwise arise.

Material from two fossiliferous outcrops in Denton County and from all the Lower Cretaceous formations in the Fort Worth area has been collected in order to replace certain Denton County species, the photographed specimens of which have been lost.

The Carsey Collection, deposited in 1926 in the department of geology, The University of Texas, was very generously lent to the Bureau of Economic Geology to aid in establishing a duplicate set of specimens. Unfortunately, about twenty of the types were found missing or were badly broken. Some of the missing specimens, however, represent species that are sufficiently common at their type localities and sufficiently well figured in the original paper to permit the establishment of unquestionably accurate neotypes of the new species and new plesiotypes of the old species included in the original collection. Toward this end Mrs. Carsey has very generously lent her aid.

The orbitoline forms on record from the Lower Cretaceous strata in Texas are now being more carefully studied and will be presented later.

The form designated as *Globigerina cretacea* var. *del rioensis* has never been figured, and no specimen so labeled has been found in the Carsey Collection. As the name is quadrinomial, it is invalid and must be dropped from further consideration.

The Miliolidae of the Edwards limestone can be observed mainly in thin section of the compact layers, and specific identification of such material is too doubtful to be of value in precise systematic work. The specimen designated as *Quinqueloculina rotunda* Carsey n. sp. (non Roemer, 1838) has been lost. It is so rare in the basal Navarro strata (Sta. 226–T–9) on Onion Creek, that specimens found in this study have been too poor for identification. Inquiry has revealed that the specimen figured was a pyrite cast. As the name assigned is preoccupied, the record is set aside for the present.

The holotype for *Ramulina edwardsensis* Carsey was found shattered to powder. New specimens have been furnished by Mrs. Carsey, but identification has not been possible. The very irregularly formed smooth calcareous tubes are coarsely incrusted by angular calcareous fragments. It is possibly a foraminiferal structure, but complete delineation of the form must await further material.

"ORBULINA ROCK"

The Georgetown limestone of central Texas has for a long time been popularly known as the "Orbulina rock," because thin sections of fragments of its hard layers exhibit minute, thin-walled, globular bodies that appear as circles suggestive of the tests of the foraminifer *Orbulina.* These are scattered sparsely or abundantly through a cryptocrystalline matrix that is rich in various microscopic organic remains, such as *Inoceramus* prisms, ostracods, foraminifera, echinoid spines, and shell fragments. In drilling deep wells this so-called "Orbuline" structure is very successfully employed as a diagnostic feature of the Georgetown limestone, which can otherwise be easily confused with other fine-grained limestones in the geologic section. Rarely the Austin chalk carries traces of similar bodies, but their abundance in the Georgetown and their persistence in almost all thin sections of this limestone makes this feature a very reliable guide in identifying the formation.

That these globular bodies are orbuline tests is highly improbable.

1. The maximum diameter, which can be assumed to represent a section through the center of the body, is not more than .05 of a millimeter, and the thickness of the wall varies from .01 to .02 of a millimeter. From a knowledge of indubitable tests of *Orbulina,* this minute size alone raises considerable question as to the orbuline character of the bodies.
2. The wall of these globular bodies is fine crystalline calcium carbonate that crystallized apparently at a different time from that of the matrix, as it stands out very sharp in the field of the section. This wall of all the bodies is single and exhibits no trace of pores or of any special aperture. Globigerinae in the same sections present fine features of wall structure that one expects in hyaline foraminifera.
3. The soft layers of the Georgetown formation yield the globigerine species frequent in the thin section of the hard layers, *Globigerina cretacea* d'Orbigny, and *G. washitensis* Carsey. No trace of minute globular bodies that can possibly be referred to the genus *Orbulina* have been found. Small solid rotund calcareous bodies occur rarely in these soft layers, but they lack any character of the true foraminiferal hyaline test. That *Orbulina* existed in such great abundance only while the calcareous matter comprising the hard layers was being deposited and was absent from the waters that deposited the thin partings of softer and more argillaceous matter is inconceivable, especially since the other pelagic species persisted throughout the series of alternating layers.
4. No true *Orbulina* has yet been reported in the Texas geologic section. It is difficult to believe that this form thrived in such numbers during a small fraction of the Lower Cretaceous period and was completely exterminated with the cessation of deposition of the limestone characterized by these "orbuline" bodies. The

> accompanying globigerine species persisted in varying abundance throughout Lower Cretaceous seas in the Texas area, and it is reasonable to expect the similar pelagic form, *Orbulina,* likewise to persist. If *Orbulina* had been present in a primitive form during Lower Cretaceous times, it would probably have developed further and in greater abundance during Upper Cretaceous times, as did the *Globigerinae.*

Orbulina has been recorded in strata of many ages from Cambrian to Recent, but all attempts to check the reliability of these records have shown that this identification of material in deposits earlier than Tertiary is erroneous. Cushman[3] has made a careful investigation of many of the records from the Paleozoics and has found only oolitic or concretionary bodies or other highly unconvincing evidence. He has shown that *Orbulina* is undoubtedly as end form[4] in the family Globigerinidae and regards it as present as a fossil in Tertiary strata. It became abundant during the Miocene, and today tests of this genus are being deposited in great numbers in the deeper portions of the oceans. Examination of type material from Gerhardsreut, Bavaria, one of Egger's Cretaceous localities reveals a few very small calcareous spherules, and single globigerine chambers, which that author probably designated[5] as *Orbulina.*

Samples of the hard layers of the uppermost part of the Georgetown formation, the Main Street member, collected on the Austin-Mt. Bonnel road west of Austin, Travis County, have been submitted to several petrographers for opinions on the possible character and origin of these problematical and diagnostic globular bodies. The following reports are worthy of consideration.

Prof. W. H. Twenhofel of the University of Wisconsin has offered the following opinion:

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[3]Cushman, J. A., Foraminifera, their classification and economic use: Cushman Lab. Foram. Res., Spec. Publ. No. 1, p. 43, 1928.

[4]Idem, p. 307.

[5]Egger, J. G., Foraminiferen und Ostrakoden aus den Kreidemergeln der oberayerischen Alpen: Abh. k. bayer. Akad. Wiss., Cl. II, vol. 21, p. 173, 1899.

The rocks contain many small fossils and fragments of larger ones. Each thin section contains the minute globular bodies in greater or less abundance. I see nothing in these globular bodies that permits me to assert that they are of organic origin. Several seem to have the ooltic structure, and these are composed of concentric laminae; others have a nucleus of limonitic material. I do not know what they are, and it may be that organisms were concerned in their making. It is possible that each represents a small bubble, around which a film of calcium carbonate was formed, thus permitting the spherical shape to be retained, infiltration later filling the center and transforming the spherules into solid bodies. I can see no reason for referring these globular bodies to the genus *Orbulina*.

Prof. L. S. Brown of the department of geology, The University of Texas, has presented the following report:

Reporting on the three Georgetown limestones recently submitted, I may say that these are all fine-grained, compact, buff limestones characteristic of the Georgetown in this vicinity. All three contain an abundance of foraminiferal remains, variously imperfect, frequent and well-dispersed particles of limonite, and an abundance of "orbicular" structures, the latter being especially common in one of the three samples. All three contain detrital quartz.

I interpret the "orbs" as microscopic oolites. The evidence supporting this identification is as follows:

1. The practically invariable perfection and the usually sharp outlines of these circular forms as compared with the definitely determinable foraminiferal tests. None of the orbs show evidence of fracture or distortion, as is the case with the determinable tests, and as one would expect where organic remains are being accumulated by gravity and buried under an increasing load of sediment, and the usually sharp outlines of the orbs indicate growth within the sediment after accumulation.

2. The structure of the orbs is commonly radiate, microcrystalline. True oolites show this structure in combination with concentric growth bands, but the particles in this case are extremely minute in comparison with recognized oolites, which may account for the absence of multiple banding.

3. Generally the orbs exhibit a center or nucleus of material of a different character, in most cases a particle of limonite. Occasionally a larger grain of calcite seems to serve this purpose, but detrital quartz does not seem to play

the same rôle. In many instances the nuclear particle can not be distinguished without close observation; also, in many instances no foreign particle can be discerned, but this need cause no embarrassment as the section could easily avoid the minute particle, above or below, and in recognized oolites the nucleus is frequently missing. While limonite particles occur definitely as centers of the orbs, they also occur liberally otherwise through the matrix, but it is interesting to note that few, after close observation, do not show a coarser crystallization immediately about them, apparently the formation of an initial ring.

4. In one instance a quartz grain was observed embedded within the edge of the circle, apparently without influence on the outline or internal structure, and seemed to have been partially surrounded by the encroaching calcite.

Opinions as to the origin of oolites are at some variance, but is more settled as to the essentials of oolitic structure, which agree with the facts observed above. These are well summarized in Twenhofel, p. 533, et seq., and may be mentioned here as a concentric, evidently concretionary form, with micro-crystalline radiate structure growing away from a nucleus of some foreign substance.

For these reasons I would say that the orbicular structures are inorganic in origin. I may add, however, that I distinguish two types. In the first the circles are entirely of clear calcite from the nucleus to the sharp border. These are unquestionably inorganic. They are present in considerable abundance, though they are commonly seen only when the section is feather thin and considerably magnified. The second type may be called annular, most of the center being of fine-grained calcite apparently identical with the matrix. In many of these also a nucleus of limonite may be observed, which would indicate them to be of similar origin as the first. Otherwise, however, they often conform so closely in structure to the test remains, that precise distinction does not seem possible. Being more or less unfamiliar with specific organic forms, it would hardly be proper for me to assign a blanket inorganic origin at all. I am unable to set a sharp line between the organic and inorganic, but there is no doubt as to the first type above, and I believe the bulk of the second type to fall within the same category.

The megafauna of the Georgetown limestone, especially the abundance of *Gryphaea* and *Exogyra* beds, large *Pectens,* echinoids, the common brachiopod *(Kingena waco-*

ensis Roemer), and oysters suggests comparatively shallow-water deposition. The fine-grained, dense texture of the layers suggests chemical precipitation of the calcium carbonite from a saturated solution of the bicarbonate through some reducing agency. It is conceivable that through this calcareous slime bubbles of hydrogen sulphide and other gases arose from decaying organic matter. Many such bubbles were probably large enough to escape at the surface, whereas the smaller ones were held in suspension in the colloidal ooze. The presence of limonite within the globular bodies and disseminated somewhat throughout the matrix suggests decaying matter, since hydrogen sulphide combines with iron to form ferric sulphide, which appears now in the rock as nuclei in many of the spheres. Some chemical reaction between the gas of the bubbles and the surrounding calcium carbonate or the bicarbonate in a saturated solution may have resulted in a rapid precipitation and crystallization of a thin layer of calcium carbonate to form a rigid shell, as suggested by Twenhofel, and it is this outer layer that has been erroneously interpreted as the test of *Orbulina*. Infiltration can possibly have filled these cavities much as geodes are filled.

The typical oolitic structure of many of these bodies makes their designation as oolites highly reasonable. It is perhaps somewhat difficult to explain on the basis of this theory the definite outer "shell" of calcite that characterizes so many of the spheres. This outer coat presents quite a different crystallization from that of the matrix or of the filling of the spherules.

The well-known "spheres" of the English chalk have given rise to much discussion regarding their origin. They are somewhat larger than those of the Georgetown limestone and occur as small calcite balls in the softer parts of the chalk. Similar bodies have been observed in some of the soft Texas Cretaceous strata. Heron-Allen and Earland have suggested "that they (spherical bodies of the English chalk) may be the chitinous tests of flagellate infusoria such as are found in great numbers in the sea of today, of practically the same size and shape." Jour. Quekett Mic. Soc., ser. 2, vol. 12, p. 8, April, 1913.)

DESCRIPTIONS OF OUTCROPS

The Bureau of Economic Geology is designating by a series of station numbers the outcrops represented by its museum collections. The numbers here employed are those officially assigned by this organization to the outcrops from which types figured in this publication have been selected.

Dallas County

Sta. 57–T–2. Middle Taylor formation in roadside bank close to underpass at Missouri Kansas and Texas Railroad on the Dallas-Greenville highway about one mile east of Rowlett. These clays carry a rich fauna, from which tests of *Kyphopyxa christneri* (Carsey) are here figured. This outcrop is the type locality for two species of ostracods, *Paracypris angusta* Alexander and *Krithe cushmani* Alexander (Univ. Texas Bull. 2907, Sta. 49).

Denton County

Sta. 61–T–2. Grayson formation in steep bluff on Denton Creek about three and one-half miles northeast of Roanoke (Univ. Texas Bull. 2544, fig. 8, section 2; Univ. Texas Bull. 2907, Sta. 34). This is the type locality for the foraminifer *Valvulineria asterigerinoides* n. sp. Plesiotypes of *Dentilinopsis excavata* (Reuss) and *Gyroidina nitida* (Reuss) have been chosen from this outcrop. This has been made the type locality for eight species of ostracods, *Cytherella comanchensis* Alexander, *Bairdia parallela* Alexander, *Macrocypris graysonensis* Alexander, *Paracypris alta* Alexander, *Cytheridea washitaensis* Alexander, *C. graysonensis* Alexander, *Cythereis subovata* Alexander, and *C. roanokensis* Alexander.

Limestone County

Sta. 146–T–5. Navarro formation in road ditch on Marlin road .7 of a mile west of Odds in base of low scarp at east end of bridge across the broad valley of Big Creek (sample collected by Prof. Gayle Scott). The compact buff-gray clay is very rich in fresh and well-preserved ostracods, foraminifera, fish remains, and echinoid spines. This outcrop is the type locality for *Hemicristellaria silicula* n. sp.

Milam County

Sta. 165–T–4. Uppermost Navarro formation, in bank of Walker Creek 6 miles north 15 degrees east of Cameron, about one mile upstream from the intersection of Walker Creek and the Cameron-Clarkson road. In this exposure the Navarro clays are in contact with the superjacent Midway (Eocene) glauconitic clays. This richly foraminiferal Navarro outcrop is the type locality for *Siphogenerinoides plummeri* (Cushman), *Vaginulina gracilis* Plummer var. *cretacea* Plummer, and *Ventilabrella carseyae* n. sp. The neoholotype of *Vaginulina simondsi* Carsey has been selected from this outcrop. Plesiotypes of *Gümbelina globifera* (Reuss), *Hemicristellaria ensis* (Reuss), and *Nodosaria radicula* (Linné) are figured in this publication from these strata.

The Midway assemblage of species in this exposure is noteworthy for a species of *Gümbelina*, which can not be regarded as derived, since it is very different from any known Cretaceous form in the Texas section and since it is present in excellent condition despite the extreme tenuity of its coarsely perforate test.

Navarro County

Sta. 174–T–4. Lower Navarro clays in large pit of Corsicana Brick Company about two miles south of Corsicana (Univ. Texas Bull. 2644, fig. 10). This exposure of very pure calcareous clay lies about 60 feet above the Nacatoch sand. Concentrate from this material consists almost wholly of beautifully preserved micro-organisms comprising mainly well-developed foraminifera of many species. This outcrop is the type locality for *Lenticulina navarroensis* (Plummer), *Dentalina crinita* n. sp., *Astacolus dissonus* n. sp., *Pseudopolymorphina cuyleri* n. sp., and *Clavulina insignis* n. sp. Plesiotypes of *Dentalina granti* (Plummer), *D. reussi* Neugeboren, *Vaginulina simondsi* Carsey, and *Frondicularia clarki* Bagg have been selected from this material for illustration in this paper. Cushman and Ozawa have mentioned *Pseudopolymorphina mendezensis* (White) as a frequent form in this clay pit.

This has been made the type locality for eight species of ostracods, *Cytherella tuberculifera* Alexander, *G. navarroensis* Alexander, *C. moremani* Alexander, *C. ovoidea* Alexander, *Cythere parallelopora* Alexander, *Cytheridea globosa* Alexander, *C. micropunctata* Alexander, and *Cytheropteron navarroense* Alexander.

Tarrant County

Sta. 219–T–12. Duck Creek formation in an eight-foot eastward-facing bank on Ammonite Creek in about the center of the Municipal Golf Course and west of Texas Christian University, Fort Worth (Univ. Texas Bull. 2907, fig. 1, Sta. 8). The soft layers of this exposure yield frequent tests of foraminifera and ostracods, and *Tritaxia pyramidata* Reuss is figured in this paper from these strata.

Sta. 219–T–14. Fort Worth formation in a steep eastward-facing eight-foot bank along a small creek (known locally as Dairy Creek from a dairy no longer in operation) about four hundred feet east of Forest Park Boulevard in the 2900-block, Fort Worth (Univ. Texas

Bull. 2907, fig. 1, Sta. 14). These lower beds of the formation consist of alternating hard and soft layers that yield an abundant microfauna. A specimen of *Anomalina falcata* (Reuss) is figured from this exposure.

Travis County

Sta. 226–T–4. Top of Austin chalk close to bridge over Little Walnut Creek on Austin-Manor highway 3.9 miles by road from the corner of East Avenue and Twenty-second Street in Austin (fig. 1). A soft yellowish layer in the top of the exposure is very rich in foraminifera, ostracods, *Inoceramus* prisms, bryozoa, and echinoid and shell fragments. This is the type locality for *Vaginulina regina* n. sp.

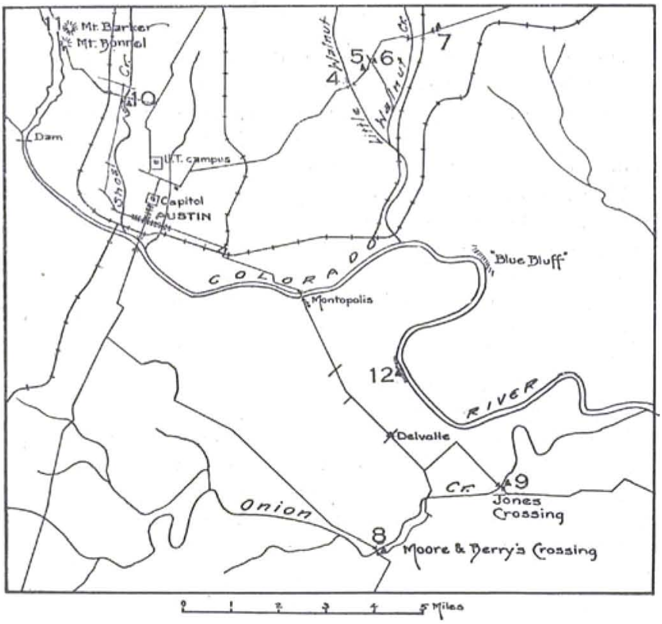

Fig. 12. Map of Austin area showing the Travis County outcrops, Sta. 226–T–4 to Sta. 226–T–12, from which specimens have been figured.

Sta. 226–T–5. Lowermost Taylor formation in ditch on Austin-Manor highway .4 of a mile by road east of the bridge over Little Walnut Creek (fig. 1). Very fresh, compact, fossiliferous clay about 50 feet above the top of the Austin chalk is exposed and yields an abundance of excellently preserved Taylor species. Specimens of *Kyphopyxa christneri* (Carsey) are figured from this outcrop.

Sta. 226–T–6. Lower Taylor clay about 50 feet above the Austin chalk in low banks of a small creek on the Austin-Manor highway .6 of a mile by road northeast of the bridge over Little Walnut Creek (fig. 12). The typical compact, unctuous clays of this formation are rich in well-preserved tests of many species of micro-organisms. *Kyphopyxa christneri* (Carsey) is abundant here, and figures have been made from tests selected from this exposure.

Sta. 226–T–7. Lower Taylor clays about 100 to 150 feet above the top of the Austin chalk at east end of long bridge over Walnut Creek about six miles east-northeast of The University of Texas campus and on the Austin-Manor highway (fig. 12). An excellent 60-foot section of clays below the *Baculites taylorensis* zone, which consists of soft chalky beds at the top of the slope, is exposed in a gully on the north side of the road at this point. From these clays have been selected the neoholotype of *Kyphopyxa christneri* (Carsey) and the plesiotype of *Flabellina rugosa* d'Orbigny.

Sta. 226–T–8. Upper Taylor formation on right bank of Onion Creek near bridge at Moore and Berry's Crossing eight and one-half miles in a straight line southeast of the capitol in Austin (fig. 12). These strata yield excellent specimens of numerous foraminifera and ostracods. Nine species have previously been recorded from this outcrop (Univ. Texas Bull. 2612), and it is the type locality for *Buliminella carseyae* n. sp., *Globotruncana rosetta* (Carsey) [= *G. arca* (Cushman)], *G. fornicata* n. sp., *Flabellina projecta* (Carsey), *Ramulina incidenta* (Carsey) [= *R. globulifera* H. B. Brady], and *Anomalina taylorensis* Carsey. Plesiotypes of *Lenticulina rotulata* (Lamarck), *Globotruncana canaliculata* var. *ventricosa* White, *Rambulina globulifera* H. B. Brady, and *G. arca* (Cushman) have been selected from material from this outcrop. A paratype of *Clavulina insignis* n. sp. is figured from here.

Sta. 226–T–9. Basal Navarro strata exposed in a steep 80-foot slope on the right bank of Onion Creek just east of the bridge (known as Jones' Crossing) on the Austin-Bastrop highway (fig. 12). These compact, dark clays, rich in shells of *Exogyra costata* Say, yield an abundance of foraminifera and ostracods typical of this formation in Texas. Twenty-seven species of foraminifera have been recorded previously from this outcrop, (Univ. Texas Bull. 2612) described as "Navarro near Delvalle on Onion Creek." This is the type locality for *Trochammina diagonis* (Carsey), *Spiroplectammina semicomplanata* (Carsey), *Gümbelina costata* (Carsey) [= *G. excolata* Cushman], *Loxostoma plaitum* (Carsey), *Dorothia bulletta* (Carsey), *Nodosaria larva* Carsey [= *N. radicula* (Linné)], *Vaginulina webbervillensis* Carsey, *V. simondsi* Carsey, *Discorbis correcta* Carsey, *Anomalina pseudopapillosa* Carsey, *Gyroidina cretacea* Carsey [= *G. depressa* (Alth)], and *Nonionella robusta* n. sp. These strata have furnished plesiotypes of *Dentalina obliqua* (Linné), *Guttulina problema* d'Orbigny, *Bulimina pupoides* d'Orbigny, *Uvigerina selegi* Cushman, *Globigerina rugosa* Plummer, *Nodosaria radicula* (Linné), *Lenticulina navarroensis* (Plummer), *Lagena hispida* Reuss, *Frondicularia clarki* Bagg, *Gümbelina excolata* Cushman, *Gyroidina depressa* (Alth), *Anomalina grosserugosa* (Gümbel), *Gaudryina rugosa* d'Orbigny, and *Hemcristellaria ensis* (Reuss). Specimens of a species of *Pseudoglandulina* have been figured from this exposure.

It is interesting to note that *Siphonina prima* Plummer and *Ceratobulimina cretacea* Cushman and Harris are well developed at this locality, the lowest stratigraphic position known to the present author for these species.

Sta. 226–T–10. Del Rio formation on right bank of Shoal Creek in a steep slope just south of the Thirty-fourth Street bridge in Austin (fig. 12). About 40 feet of the upper part of the formation capped by Buda limestone are exposed on the upthrow side of a small fault that cuts across the face of the bank. The dark, compact, gypsiferous clays are rich in micro-organisms typical of this formation in central Texas. Eleven species have already been recorded (Univ. Texas Bull. 2612) from this outcrop designated as "Del Rio, Shoal Creek, Austin." This is the type locality for *Textularia washitensis* Carsey, *T. rioensis* Carsey, *Lenticulina washitensis* (Carsey), *Globigerina washitensis* Carsey, *Anomalina petita* Carsey [= *A. falcata* (Reuss)], *Globorotalia delrioensis* n. sp., and *Gaudryinella delrioensis* Plummer. From this outcrop have been chosen plesiotypes of *Nodosaria obscura* Reuss, *Gaudryina gradata* Berthelin, *Dentalina communis* (d'Orbigny), *Anomalina falcata* (Reuss), and *Lagena sulcata* (Walker and Jacob). *Globigerina cretacea* var. *del rioensis* Carsey has been recorded from these strata but has not been figured. As a quadrinomial the name is invalid.

Sta. 226–T–11. Walnut formation near top of Mt. Barker three and one-half mile northwest of the capitol in Austin (fig. 12). This is the type locality for *Orbitolina walnutensis* Carsey. The yellowish clays of this outcrop are rich in ostracods and foraminifera, of which the following are frequent: *Ammobaculites goodlandensis* Cushman and Alexander, *A. cretacea* Cushman and Alexander, *Vaginulina intumescens* Reuss, *Choffatella* sp., *Flabellammina alexanderi* Cushman, and *Cyclammina* sp.

Sta. 226–T–12. Taylor formation in 40-foot bluff on right bank of Colorado River northeast of Delvalle on Anderson farm (fig. 12). The three-chambered test of *Dentalina raristriata* (Chapman), contributed by Robert Cuyler and herein figured, has come from this outcrop.

Val Verde County

Sta. 232–T–5. Del Rio formation in a low bank at west side of road 20.2 miles by road north of the city limits of Del Rio at a point 6.0 miles by road south of the junction of the Del Rio-Sonora highway and the Del Rio-Junction highway. The soft clays are rich in the megascopic forms, *Exogyra arietina* Roemer and *Haplostiche texana* (Conrad).

Ammobaculites goodlandensis Cushman and Alexander, *A. cretacea* Cushman and Alexander, and *Flabellammina alexanderi* Cushman occur in these strata.

Sta. 232–T–6. Conspicuous cone-shaped outlier of the Del Rio formation near the road to the Mexican cemetery southeast of the city. Typical strata of this formation are exposed on the sides of this prominent topographic feature, and fossils are abundant. The tests of *Haplostiche texana* (Conrad) illustrated in figure 2 have been chosen from the soft clays in this outcrop. The hard thin slabs of limestone carry this species in large numbers.

Williamson County

Sta. 245–T–2. Taylor chalk marl in an abandoned roadside excavation 2.1 miles by road west of Main Street, Taylor, on the Taylor-Austin highway. About 25 feet of very clayey chalk about midway in the Taylor are well exposed and furnish a rich microfauna. From material collected from this outcrop a comparative study of *Flabellina interpunctata* von der Marck and *F. projecta* (Carsey) has been made and illustrations of the plesiotypes presented. Plesiotypes of *Dentalina soluta* Reuss and *D. raristriata* (Chapman) have been selected from these beds.

The ostracod *Bairdia rotunda* Alexander has this exposure for its type locality.

Sta. 245–T–3. Upper part of Taylor formation in a series of gullies on the west side of the Taylor-Coupland road 3.6 miles by road south of the railroad station in Taylor. Typical yellowish-grey, very compact, and highly unctuous clays in these outcrops yield an abundance of foraminifera, ostracods, echinoid remains, shell fragments, and numerous specimens of a species of *Micrabasia*. Seven species of foraminifera have been recorded (Univ. Texas Bull. 2612) from this locality designated as "4 miles SW. of Taylor." This is the type locality for *Bolivina latticea* Carsey [= *B. decorata* Jones], *Dentalina intrasegma* (Carsey) [= *raristriata* (Chapman)], *Nodosaria marla* Carsey [= *N. zippei* Reuss], and "*Truncatulina*" *refulgens* var. *conica* Carsey [= *Eponides micheliniana* (d'Orbigny)]. A plesiotype of *Dentalina alternata* (Jones) and a paratype of *Astacolus taylorensis* n. sp. have been selected from this exposure for illustration in this paper.

Sta. 245–T–4. Upper part of Taylor formation in low roadside bank .5 of a mile south of the railroad station in Taylor near the top of the slope south of a small stream. The compact, unctuous clay yields a rich foraminiferal fauna in excellent preservation. This is the type locality for *Astacolus taylorensis* n. sp.

DESCRIPTIONS OF GENERA AND SPECIES

Family REOPHACIDAE

Genus HAPLOSTICHE Reuss, 1861

HAPLOSTICHE TEXANA (Conrad)

Pl. XV, fig. 1

Nodosaria texana Conrad, 1857, Mexican Boundary Survey, vol. 1, pt. 2, p. 159, pl. 14, fig. 4.
Nodosaria texana Böse, 1910, Inst. Geol. México, Bull. 25, p. 177, pl. 35, figs. 4–6, 9; pl. 45, fig. 3.
Nodosaria texana Christner and Wheeler, 1918, Univ. Texas Bull. 1819, pl. 8.
Nodosaria texana Adkins and Winton, 1920, Univ. Texas Bull. 1945, p. 76, pl. 19, figs. 1, 2; pl. 21.
Nodosaria texana Adkins, 1920, Univ. Texas Bull. 1856, p. 145, pl. 11, fig. 2.
Nodosaria texana Winton, 1925, Univ. Texas Bull. 2544, pl. 15, fig. 4.
Nodosaria texana Scott, 1926, Thèse Univ. Grenoble, pp. 48, 74, 79.
Nodosaria texana Carsey, 1926, Univ. Texas Bull. 2612, p. 36, pl. 6, fig. 10.
"*Nodosaria*" *texana* Adkins, 1927, Univ. Texas Bull. 2738, pp. 47, 54.
"*Nodosaria*" *texana* Adkins, 1928, Univ. Texas Bull. 2838, p. 59.

Test large, straight or arcuate, very coarsely arenaceous with considerable cement insoluble in acid; chambers numerous, as many as fifteen, ventricose, short, stout, strongly overlapping, gradually enlarging from a small blunt aboral extremity in the megalospheric form or from a more acutely pointed initial extremity in the microspheric form; sutures transverse, distinctly but not deeply depressed; shell wall very thick, labyrinthic; aperture typically cribrate at apex of final chamber.

Length up to 12 mm.

In all essential characteristics *Haplostiche texana* (Conrad) is constant throughout the Lower Cretaceous formations. Its variations at any locality where it occurs in abundance are numerous. At some localities straight tests are much more common; at other places slightly arcuate tests predominate. In some places only the megalospheric forms can be found; in a few places the microspheric form is present. In general youthful specimens exhibit but a single, central, terminal orifice, which changes to a more and more complex cribrate opening with advancing age. This single opening persists into early maturity in many tests, but numerous other accompanying tests exhibit the cluster of several openings, which may number as many as fifteen. Observations of material very rich in tests of *H. texana* prove that these differences are insignificant variations of no stratigraphic value.

Sections of specimens filled with calcite present the best detail in labyrinthic structure of the heavy wall of quartz grains. The figured sections (Pl. XV, fig. 1, c, d, e) were obtained by grinding down one side of the test and then applying weak acid at the tip of a brush until the labyrinthic wall stood in relief.

H. texana (Conrad) was originally described from an outcrop of Washita beds "between El Paso and Frontera," which is near the present cement plant about three miles northwest of El Paso. Probably because no true shell material enveloped the tests, Conrad described them as casts, as did Böse several decades later, when he recorded the species as abundant in Zone 5[6] (Duck Creek and Fort Worth) and Zone 6 (Denton, Weno, Pawpaw) in the Cerro de Muleros in northern Mexico.

This species has been recorded from many formations in the Lower Cretaceous section in Texas and Mexico. In the Solitario it has been observed from the Trinity[7] strata. The present author has found frequent specimens in the Glenrose limestone of the Trinity division in an outcrop rich in tests of *Orbitolina* in a roadside bank six miles by road from Fischer's Store on the way to San Marcos. Solu-

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6The occurrence in Zone 5 is regarded by W. S. Adkins as derived from the overlying Zone 6 in steep slopes by slump and wash.

7Adkins, W. S., Geology and mineral resources of the Fort Stockton quadrangle: Univ. Texas Bull. 2738, p. 47, 1927.

tion of samples of Edwards limestone from Bell County has yielded[8] typical tests, and the equivalent Goodland limestone of north Texas carries the species[9] as a very rare form in its fauna. In north Texas the upper part of the Weno formation carries these tests in abundance,[10] and the same horizon in the Fort Stockton area has yielded a few specimens.[11] In west Texas the Del Rio formation is richest in this species, and many thin limestones are composed almost wholly of these tests oriented largely in the same direction, an arrangement that suggests current action. In central Texas *H. texana* is rather rare in the Del Rio; and in north Texas it is rare in its stratigraphic equivalent, the lower Grayson formation.

Plesiotypes, from Del Rio formation, Sta. 232–T–6, in Plummer Collection (S–778, S–779). Specimens in Bureau of Economic Geology.

Family LITUOLIDAE

Genus FLABELLAMMINA Cushman, 1928

FLABELLAMMINA ALEXANDERI Cushman

Flabellammina alexanderi Cushman, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, pl. 1, figs. 3, 4.

Wherever this very thin, coarsely agglutinate, and rather smoothly finished form has been observed in abundance, the outline of the test has been found to be an exceedingly variable feature. The early coil may lie wholly within the contour of the later sagittate chambers, thus forming an even ovate or elliptical test, or it may lie wholly outside the contour of the later chambers and form a short hook at the initial extremity of the test. The microspheric form is more elongate than the megalospheric form as a general rule. In all places where it occurs the shell wall is composed of various kinds of coarse angular mineral fragments

[8]Personal communication from W. S. Adkins.

[9]Scott, Gayle, Études stratigraphiques et paléontologiques sur les terrains crétacé du Texas: Thèse, p. 48, 1926, Grenoble.

[10]Winton, W. M., The geology of Denton County: Univ. Texas Bull. 2544, p. 58, 1925.

[11]Adkins, W. S., Geology and mineral resources of the Fort Stockton quadrangle: Univ. Texas Bull. 2738, pp. 47, 54, 1927.

in a groundmass of fine material, the whole ensemble being rather smoothly finished with much cement. A conspicuous feature of the masonry is the abundance of elongate translucent fragments, many of which are oriented parallel to the sutures and thereby delineate the shape of the chambers. The test is completely soluble in acid and leaves no chitinous matter.

F. alexanderi Cushman was first described from the Goodland formation west of Fort Worth. It has since been observed in Del Rio clays north of Del Rio (Sta. 232–T–5) and from the Walnut clay on Mt. Barker (Sta. 226–T–11). Careful comparison of material from these three localities reveals no fundamental differences in structure or in the character of the shell masonry. The Del Rio form averages slightly smaller than those at its type locality in the Goodland. These widely separated stratigraphic positions in the Lower Cretaceous and the broadly distributed geographic occurrences indicate that *F. alexanderi* is probably a long-range form throughout this system in Texas and northern Mexico, as are so many of the Cretaceous foraminifera.

Specimens from all three outcrops mentioned above are deposited in the Bureau of Economic Geology.

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance, 1824

TEXTULARIA WASHITENSIS Carsey

Pl. VIII, fig. 5

Textularia washitensis Carsey, 1926, Univ. Texas Bull. 2612, p. 24, pl. 7, fig. 6.

Test spatulate, composed of fine and coarse calcareous grains with considerable cement and varying from somewhat smoothly finished to distinctly rough; chambers transverse, polygonal in outline and generally collapsed, leaving sutures as broad and light-colored, blunt, elevated ridges, periphery in early portion of test rather sharp, in later portion narrowly rounded; aperture typically textularian.

Length of neoholotype .81 mm.; greatest breadth .28 mm.

The holotype has been lost, but the original figure illustrates the essential characters of the species that is common and well developed at its type locality. Some tests show strong collapse of the chamber walls, so that the fossil form is strongly compressed laterally; whereas other tests exhibit some of their original rotundity. Solution in weak acid yields a trace of chitinous matter.

In the Del Rio clays in central Texas and in all the formations of the Washita division in north Texas, *T. washitensis* Carsey is frequent and in places abundant.

Neoholotype, from Del Rio formation, Sta. 226–T–10, in Plummer Collection (S–773). Metatypes in Bureau of Economic Geology.

TEXTULARIA RIOENSIS Carsey

Pl. VIII, fig. 6

Textularia sp., Margaret Carpenter, 1925, Univ. Texas Bull. 2544, pl. 17, fig. 15.

Textularia conica Carsey (non d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 23, pl. 7, fig. 1.

Textularia rioensis Carsey, 1926, Idem, p. 24, pl. 7, fig. 2.

Test elongate conical, composed of very fine calcareous particles smoothly finished to slightly rough with considerable cement; chambers low, broad; sutures slightly depressed; periphery very broadly rounded; aperture a low arch at base of septal face.

Length of holotype .47 mm.; greatest breadth .24 mm.

Textularia rioensis Carsey is frequent at its type locality but few tests are so perfect as the holotype. Most specimens show twisting and axial compression giving rise to a short, broad, conical form that has been designated as *T. conica* from these same strata. Some tests are waxy gray and others exhibit a surface of fine grayish-white calcareous particles. In the Lower Cretaceous strata in Texas no other thick rotund textularian form has been observed.

T. rioensis Carsey has been observed not only in the Del Rio formation in central Texas but also in the Walnut clay (Sta. 226–T–11). In north Texas it occurs commonly in the Grayson formation.

Holotype, from Del Rio formation, Sta. 226–T–10, in Carsey Collection, department of geology, The University of Texas. Metatypes in Bureau of Economic Geology.

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA SEMICOMPLANATA (Carsey)

Pl. VIII, figs. 7, 8

Textularia semicomplanata Carsey, 1926, Univ. Texas Bull. 2612, p. 25, pl. 3, fig. 4.
Textularia carinata var. *expansa* Plummer, 1927, Univ. Texas Bull. 2644, p. 67, pl. 3, fig. 3.

Test very finely agglutinate, composed of very minute white calcareous particles smoothly finished, flaring with considerable rapidity from the narrowly rounded initial extremity to the broad oral extremity; periphery sharp; chambers very narrow, earliest ones arranged in a distinct but small coil of a globular proloculum and four or five slowly enlarging chambers in the spiral, later ones biserial and moderately oblique, inflated or concave because of collapse; sutures slightly elevated and by their junction through the center of each side of the test for a distinct but wide lateral angle; aperture a very narrow slit at base of a triangular septal face.

Length of neoholotype .47 mm.; greatest width .32 mm.; greatest thickness .12 mm.

The holotype in the Carsey Collection has been so badly crushed that it has been rendered useless as a model, but the author of the species has furnished from her original slides new specimens for study, and material from the type locality carries these tests in some frequency, though perfect specimens are rare. The similar structure in Midway strata is probably specifically identical, but the chamber walls of these fossil tests are less frequently collapsed. Slow disintegration of tests of *S. semicomplanata* (Carsey) from the type locality yields a chitinous lining that is thickest in its early coiled portion but persists throughout the structure. Considerable variation in the thickness of the tests may be due to changes in an originally plastic shell wall.

No test belonging indubitably to the microspheric generation has been found. The number of specimens is at present too few for any conclusions regarding the dimorphism or trimorphism of the species. The size of the coil varies considerably, and in some specimens this stage is almost negligible. Hofker has shown[12] that the microspheric form of *S. wrightii* (Silvestri) from the Gulf of Naples is biserial throughout its development, whereas tests of the megalospheric generations have initial coils varying in size. Since the microspheric test bears in its earliest stage the primitive characters of its race, the Textularian structure must on the basis of this law have preceded that of *Spiroplectammina.* A very large number of specimens of *S. carinata* (d'Orbigny) from the Vienna Basin bears out the conclusions reached by Hofker.

S. semicomplata (Carsey) occurs as a rare form in the Navarro and Taylor formations of the Texas Cretaceous section.

Neoholotype, from Navarro formation, Sta. 226–T–9, in Plummer Collection (S–772.1), neoparatype[13] (S–772.2). Metatypes in Carsey Collection, department of geology, The University of Texas, and in the Bureau of Economic Geology.

Family VALVULINIDAE

Genus DOROTHIA n. gen.

Dorothia n. gen., March 22, 1931, Program of Soc. Econ. Pal. and Min., San Antonio, Texas.

Test agglutinate, elongate, chambers of initial stage trochoid around the elongate axis of the complete test with more than three in the first one or more convolutions and with gradually decreasing number in successive convolutions till biseriality is attained and continues to the end of development; aperture in trochoid portion a low arch at

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12Hofker, J., Die Fortpflanzung der Foraminiferen: Ann. Prot., vol. 3, p. 29, fig. 3, 1930.

13During the coming meeting (December, 1931) of The Paleontological Society the definition of the new type *neoparatype* will be formally presented by Helen Jeanne Plummer and B. F. Howell. Meanwhile the term is self explanatory.

the base of the septal face and directed into the umbilical depression, in biserial stage typically textularian.

Genotype, *Gaudryina bulletta* Carsey.

The essential feature that distinguishes this new genus *Dorothia*[14] from *Gaudryina* is the youthful trochoid spire composed of more than three chambers in the first whorl. By a gradual lengthening of the successive chambers and a consequent decrease in the number of chambers per whorl, the adult stage of compact biserial chambers is reached and maintained.

The genotype, *Dorothia bulletta* (Carsey), exhibits the diagnostic generic character more strikingly than any of its congeners. In both the megalospheric and microspheric forms the first whorl is composed of five or six very slowly enlarging short chambers, which lengthen through the first three or four whorls till the mature biserial stage is reached.

In 1840 d'Orbigny described *Gaudryina pupoides* from the Craie Blanche (Senonian). Though his description fails to set forth the details in its early structure different from that of a typical gaudryine test, he has presented in illustration a much-enlarged initial extremity of a specimen that clearly possessed more than three chambers in the earliest whorls. No material from these Upper Cretaceous strata at Meudon has been available for study, but in the Taylor formation (Sta. 245–T–2) is a form that exhibits the proportions and detailed structure of d'Orbigny's original figures of *G. pupoides*. This Taylor test shows about four and one-half chambers in the first convolution, whence it merges into the somewhat compressed biserial development by a more rapid lengthening of the successive chambers than does *Dorothia bulletta* (Carsey). Berthelin, in his description of *Gaudryina spissa*, a typical gaudryine structure, distinguishes this species from *G. pupoides* d'Orbigny by its less developed early spire, thus recognizing perhaps the larger number of chambers in the initial coils

[14]This genus has been named for Mrs. Dorothy Ogden Carsey, who was the first to describe and illustrate the genotype.

of the d'Orbigny form, which is here recognized as *Dorothia pupoides* (d'Orbigny).

The family relationships of *Dorothia* have proved puzzling. The mature aperture without any trace of a valvular tooth is significant of the Verneuilinidae. The early coil, however, is more typical of the Valvulinidae, and the simple aperture during this stage lies beneath a slight projection of the septal face. The present author acknowledges the generous aid of Dr. Cushman in this problem of family alliances: "I believe it has been derived from the group which has more than three chambers in the young, as are found in *Arenobulimina* and related groups, which occur abundantly in the Upper Cretaceous of both hemispheres".[15]

DOROTHIA BULLETTA (Carsey)

Pl. VIII, figs. 13–17

Gaudryina bulletta Carsey, 1926, Univ. Texas Bull. 2612, p. 28, pl. 4, fig. 4.

Test stout, subcylindrical with broadly rounded initial extremity, composed of fine calcareous particles with considerable cement and rather smoothly finished; early chambers arranged in a trochoid spire around the axis of the test, the first whorl of which comprises five or six gradually enlarging chambers, which become fewer and fewer in succeeding whorls till biseriality is reached in the fourth or fifth convolution; chambers of biserial stage only very slightly compressed, varying from uninflated to distinctly inflated, especially in advanced maturity; sutures in early part of test smooth, in biserial portion slightly depressed; aperture a low arch at the base of the final chamber under a slight extension of its septal face near the shallow umbilical depression of the initial stage, in the center of the base of the septal face of the mature biserial chambers.

Length of holotype (in Carsey Collection) .54 mm.; greatest breadth .27 mm.

15 Personal communication, March 26th, 1931.

The holotype has been broken once across, and new specimens have been chosen from the same outcrop for refiguring the species. It is very common in these basal Navarro strata (Sta. 226–T–9) and can not be confused with any associated form. The limonitic filling of the early chambers of many tests accentuates its initial structure especially if specimens are dampened. The very slow application of weak acid on the tip of a fine brush to the initial extremity of a test filled with limonite yields a cast that exhibits strikingly the arrangement of its trochoid chambers. Complete solution of a test in acid yields an inner lining of brown chitinous matter that retains the form of the early chambers. Chitinous matter is present only in traces in the biserial chambers.

Dorothia bulletta (Carsey) in the Texas section is most common in the Navarro formation and occurs from base to top. In some places, notably in the pit of the Corsicana Brick Company (Sta. 174–T–4) it is present in abundance. It occurs sparingly in the Taylor formation (Sta. 226–T–7 and Sta. 245–T–2) and in the Austin chalk (outcrops on Dallas-Greenville highway southeast of White Rock Lake).

Holotype, from Navarro formation, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Plesiotypes, from same locality, in Plummer Collection (S–774.1 to 774.5). Metatypes at Bureau of Economic Geology.

Family VERNEUILINIDAE

Genus TRITAXIA Reuss, 1860

TRITAXIA PYRAMIDATA Reuss

Pl. X, figs. 18–21

Tritaxia pyramidata Reuss, 1862, Sitz. k. Akad. Wiss. Wien (Cl. II), vol. 46, p. 32, pl. 1, fig. 9.

Tritaxia pyramidata Berthelin, 1880, Mém. Soc. géol. France, ser. 3, vol. 1, No. 5, p. 25, pl. 1, fig. 4.

Tritaxia pyramidata Chapman, 1892, Jour. Roy. Mic. Soc., p. 750, pl. 11, fig. 2.

Tritaxia pyramidata Egger, 1899, Abh. bayer. Akad. Wiss. (Cl. II), vol. 21, p. 41, pl. 4, figs. 27, 28.

Tritaxia pyramidata Franke, 1925, Abh. Geol.-paleont. Inst. Univ. Greifswald, vol. 6, p. 18, pl. 2, fig. 1.

Tritaxia pyramidata Franke, 1928, Abh. preuss. geol. Landesans., pt. 3, p. 138, pl. 12, fig. 18.

Test sharply tricarinate, pyramidal, composed of agglutinated calcareous particles with considerable cement, surface rather smooth to rough; chambers triserial, sharply carinate, short; sutures smooth; aperture a rounded opening near the base of the septal face during youth, more and more nearly terminal with advancing age.

Average length about .6 mm. up to a maximum of about 1.3 mm.

The young tricarinate tests of *Clavulina* and *Gaudryina* and tests of *Verneuilina* are separated from the species of *Tritaxia* by their low arched aperture at the base of the septal face and lying on the penultimate chamber. In very young tests of *Tritaxia pyramidata* Reuss the aperture is very low, but in early youth it becomes a distinctly rounded orifice above the base of the septal face and rises closer to the apex of the test with advancing development. Some senile chambers lose their carination (Pl. X, fig. 19). A rare development in tests of this species in the Duck Creek formation is the loss of one row of chambers, thus giving rise to a dimorphous form that changes from triserial to biserial. Otherwise no difference in this type of test from the numerous typical structures of this species has been observed, and it must be regarded as an individual abnormality. These agglutinate forms are much more susceptible to such deviations from normal than are the hyaline forms. The species designated as *Clavulina compressa* Cushman and Waters in the Taylor strata, through the loss of one of its carinations, is an abnormal development of the abundant clavuline species in the Taylor strata. In Navarro and Midway strata these same abnormalities accompany their respective tricarinate clavuline species.

Solution of several tests of *Tritaxia pyramidata* Reuss in weak acid has yielded chitinous linings of the earliest chambers. A trace of chitin persists throughout the later chambers, but it is too weakly developed to retain the form of the chambers after the outer wall has been removed.

In the Texas section the genus *Tritaxia* is represented only in the Lower Cretaceous strata. The species here described is especially common in the Duck Creek formation but has been observed very rarely in the Fort Worth formation (Sta. 219–T–14). This species and other very closely related forms have been recorded from the Gault of England, France, and Germany, and from the Turonian of Germany.

Plesiotypes from lower Duck Creek formation, Sta. 219–T–12, in Plummer Collection (S–775.1 to 775.4). Specimens in Bureau of Economic Geology.

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA RUGOSA d'Orbigny

Pl. VIII, fig. 11

Gaudryina rugosa d'Orbigny, 1840, Mém. Soc. géol. France, vol. 4, p. 44, pl. 4, figs. 20, 21.

Gaudryina pupoides Carsey (non d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 27, pl. 4, fig. 5.

Test elongate, stout, tapering rapidly at its initial extremity, blunt orally, slightly lobate, subquadrate in cross-section of the biserial stage, composed of both fine and coarse calcareous particles with considerable cement; early chambers verneuiline and bluntly carinate forming a trihedral initial extremity, later chambers distinctly biserial, compact, broad, transverse, and somewhat inflated; sutures in early portion of test smooth, on biserial portion slightly depressed on the sides and somewhat more depressed peripherally; aperture a highly arched orifice extending from the base of the septal face upward toward the apex.

Average length .7 mm.; breadth .35 mm. The size of the test varies considerably with the outcrop.

The test already figured from Navarro strata in Texas is much more lobate than average, and the triserial early portion is smaller than that of most tests in this same outcrop. At some localities the very late mature development consists of one or two less compact biserial chambers, the apertures of which are slightly above the base of the septal face. The size and angularity of the initial triserial stage is exceedingly variable.

Slow disintegration of tests of *Gaudryina rugosa* d'Orbigny in Navarro strata yields a residue of a little limonitic matter that fills the chambers and the pliable chitinous linings of the triserial chambers. If disintegration proceeds slowly enough this early stage can be seen intact as a compact series of globular chitinous chambers floating in the liquid.

Gaudryina rugosa d'Orbigny is very common in many outcrops of Navarro strata. In the underlying Taylor strata this species averages somewhat larger and is somewhat more sharply carinate.

Plesiotype, from Navarro formation, Sta. 226–T–9, in Plummer Collection (S–776). Plesiotype from same outcrop in Carsey Collection, department of geology, The University of Texas. Specimens in Bureau of Economic Geology.

GUADRYINA GRADATA Berthelin

Pl. VIII, fig. 12

Gaudryina gradata Berthelin, 1880, Mém. Soc. géol. France, ser. 3, No. 5, p. 24, pl. 1, fig. 6.

Gaudryina gradata Egger, 1899, Abh. bayer. Akad. Wiss. (Cl. II), vol. 21, p. 38, pl. 4, figs. 4–6.

Textularia sp., Margaret Carpenter, 1925, Univ. Texas Bull. 2544, pl. 17, fig. 16.

Gaudryina filiformis Carsey (non Berthelin), 1926, Univ. Texas Bull. 2612, p. 28, pl. 7, fig. 7.

This rare form in the Del Rio formation is more robust in its proportions than the typical *G. filiformis* Berthelin, which is better represented in Eagle Ford and Taylor formations in Texas. It is very roughly agglutinate and composed of irregular calcareous grains with much cement.

The very few early triserial chambers are therefore very indistinct. Material from Egger's locality at St. Johann, from which he has recorded this species, has yielded numerous tests of a structure and proportions identical with the species in the Del Rio clays. Like so many other agglutinate tests, distortion is frequent, probably through forces of sedimentation after the death of the protoplasm.

Length of plesiotype .71 mm.; breadth .28 mm.

Gaudryina gradata Berthelin occurs both in the Del Rio formation in central Texas and in the Grayson formation in north Texas, but it is rather rare wherever it has been observed.

Plesiotype from Del Rio formation, Sta. 226–T–10, in Plummer Collection, (S–777). Carsey plesiotype lost. Specimen in Bureau of Economic Geology.

Genus GAUDRYINELLA Plummer, 1931

GAUDRYINELLA DELRIOENSIS Plummer

Pl. IX, fig. 13

Textularia sp., Margaret Carpenter, 1925, Univ. Texas Bull. 2544, pl. 17, fig. 18.

Gaudryinella delrioensis Plummer, 1931, Amer. Midland Naturalist, vol. 12, p. 341, text figure 1.

Test very elongate and slender, rather coarsely agglutinate for its size and composed of large and small calcareous particles with much cement; earliest chambers in a somewhat compact triserial succession, comprising a small and bluntly pyramidal initial extremity; later chambers biserial grading from an early compact structure of a few rounded chambers through numerous chambers that tend rapidly toward a rectilinear series and become bluntly quadrate posteriorly; senile chambers truly uniserial; sutures very distinct throughout growth and deeply incised; aperture a round opening above the base of the septal face throughout its biserial development and becoming more nearly terminal with advancing age, wholly terminal on uniserial chambers of late maturity.

Length up to 1 mm. at type locality; average length about .6 mm.

Gaudryinella delrioensis at its type locality reaches the extreme uniserial development. Wherever it has been observed the test exhibits its characteristic loosely biserial chambers of early maturity with the high, round aperture, which rises gradually toward the apex of the final chamber, as the biserial structure becomes looser.

The Del Rio clays (Sta. 226–T–10) of central Texas and the equivalent Grayson marls (Sta. 61–T–2) in north Texas carry this species as a frequent member of their faunas. It has been observed as a rare form also in the Duck Creek, Weno, and Pawpaw formations in north Texas.

Heautotype, from Del Rio formation, Sta. 226–T–10, in Plummer Collection (S–771). Metatypes in Bureau of Economic Geology.

Genus CLAVULINA d'Orbigny, 1826

CLAVULINA INSIGNIS n. sp.

Pl. VIII, figs. 1–4

Clavulina triquetra Martinotti, pars (non Reuss), 1925, Atti. Soc. Ital. Sci. Nat., vol. 64, p. 177, pl. 4, figs. 8, 9.
Tritaxia tricarinata Carsey (non Reuss), 1926, Univ. Texas Bull. 2612, p. 27, pl. 6, fig. 4.

Test finely agglutinate, composed of minute calcareous particles with much cement, smoothly finished, trilateral with very sharp, and even extended, longitudinal carinae; lateral outline rarely straight to slightly flaring in the megalospheric form and broadly flaring in the microspheric form; sides almost plane or gently concave in the megalospheric form, and deeply concave in the microspheric form; early chambers triserial and rapidly enlarging thus making the initial extremity pyramidal, later chambers uniserial and slightly inflated; sutures distinct in early portion but not depressed as in the uniserial stage; aperture a round opening at the apex of the final uniserial chamber and only slightly protruding.

Average length of megalospheric form about 1.2 mm., but frequent tests attain 1.8 mm.; length of microspheric test about 1.7 mm., but can be much longer.

The specimens of this abundant Upper Cretaceous form previously figured from the upper Taylor strata have been available for study as well as considerable material from the outcrop from which they were chosen. The material studied for the original treatment of this species did not yield the typical sharply carinate tests. Variation from this typical form is frequent, but other material from the same exposure in the upper Taylor has furnished excellent examples that follow closely the types chosen from the Corsicana clay pit in the Navarro formation where the species is more abundant.

The features that distinguish this Cretaceous form from a similar structure already designated[16] as *C. angularis* d'Orbigny in the Midway formation are the very sharp lateral angles and the more smoothly finished surface of finer sand grains. Also the chambers of *C. insignis* are shorter and somewhat more inflated, and the lateral angles persist into the latest development of the largest tests. The microspheric form is very common in material rich in the species and is conspicuous for its broadly flaring outline and its very deeply concave lateral faces. Some of the microspheric tests show a slight constriction between the triserial and uniserial stages; others are evenly curved along the lateral outline.

Clavulina insignis n. sp. is an abundant form in the Navarro formation. It occurs also in the Taylor, where it is very common in places.

Holotype and paratypes, from lower Navarro formation, Sta. 174–T–4, Plummer Collection (S–780.1 to 780.3); paratype from Taylor formation, Sta. 226–T–8, Plummer Collection (S–781). Metatype in Bureau of Economic Geology.

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[16] Plummer, Helen Jeanne, Foraminifera of the Midway formation in Texas: Univ. Texas Bull. 2644, p. 70, pl. 3, figs. 3, 4, 1927.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1860

TROCHAMMINA DIAGONIS (Carsey)

Haplophragmoides diagonis Carsey, 1926, Univ. Texas Bull. 2612, p. 22, pl. 3, fig. 1.

Trochammina diagonis Cushman and Waters, 1926, Contrib. Cushman Lab. Foram. Res., vol. 2, p. 84, pl. 10, fig. 7.

This species originally figured from the basal Navarro strata has since been excellently illustrated from a well core in the same formation. Its tests are commonly distorted, because of the original plasticity of the shell material, and care must be exercised in identification of the species. *T. texana* Cushman and Waters is commonly a companion form in Navarro clays and should generally be readily distinguishable by its very narrowly rounded, or even sharply angular, periphery, its almost flat dorsal face, and its highly elevated ventral face. Though this latter form is also frequently distorted, these salient characteristics are rarely destroyed.

T. diagonis (Carsey) is very common in outcrops of the Navarro formation in all parts of the state, and in many Taylor outcrops it is rare or frequent.

Specimens from fossiliferous Navarro clay on Colorado River at Webberville, Travis County, in Bureau of Economic Geology. Holotype missing from Carsey Collection.

Family LAGENIDAE

The author has adopted as the most consistent basis of subdivision of the cristellarians the fundamental structure of the tests as expressed in the arrangement and relationship of the successive chambers. This plan is more conformable with the general systematic treatment of foraminifera, and it is more practicable as a working basis for fossils, many of which are too highly mineralized for accurate determination of minor apertural details. The minute, and often exceedingly obscure, robuline slit below the radiate aperture is hereby not given generic weight.

According to this plan, the completely involute coil is referred to *Lenticulina.* The looser and somewhat evolute coil, the later chambers of which fail to reach back to the center of the test but embrace the periphery, is referred to *Astacolus. Hemicristellaria* consists of an early cristellarian coil of two or more chambers beyond the proloculum followed by a linear series of several or numerous oblique, compressed (vaginuline) chambers bearing a radiate aperture on the extreme dorsal edge. *Saracenaria* is an elongate test characterized by the triangular cross-section of its linear chambers.

Vaginulina is distinct from *Hemicristellaria* in having no true coil as its initial stage. The early chambers of some species are strongly oblique to a curved axis, but the earliest sutures do not radiate from the proloculum. *Marginulina* differs from *Hemicristellaria* mainly in having a nodosarian, rather than a vaginuline, linear series with its radiate aperture central, or almost central, on the uncompressed mature chambers.

Genus LENTICULINA Lamarck, 1804

LENTICULINA NAVARROENSIS (Plummer)

Cristellaria cultrata Carsey (non Montfort), 1926, Univ. Texas Bull. 2612, p. 38, pl. 6, fig. 3.

Cristellaria navarroensis Plummer, 1927, Univ. Texas Bull. 2644, p. 39, text figure 4.

Cristellaria midwayensis Willard Berry and Kelley (non Plummer), Proc. U. S. Nat. Mus., vol. 76, art. 19, p. 7, pl. 1, fig. 3.

This characteristic and abundant form in Navarro strata has been well illustrated from the lower beds of the formation in the vicinity of Austin (Sta. 226–T–9), where its development is identical with that of the tests at its type locality (Sta. 174–T–4).

In the Texas Upper Cretaceous, this form is abundant in the Navarro formation, but it has been observed rarely in the upper part of the underlying Taylor (Sta. 226–T–8).

Plesiotype, from Navarro formation, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Metatypes in Bureau of Economic Geology.

LENTICULINA ROTULATA (Lamarck)

Pl. XI, fig. 20

Lenticulites rotulata Lamarck, 1804, Ann. Mus., vol. 5, p. 188, No. 3; 1806, vol. 8, pl. 62, fig. 11.
Cristellaria rotulata Carsey, 1926, Univ. Texas Bull. 2612, p. 39, pl. 6, fig. 2.

The previously figured specimen (now in the Carsey Collection) from uppermost Taylor strata is somewhat deformed, but other tests in the same collection, one of which is here figured, exhibit well the characters of the form. Essentially the Taylor species is identical with the type figured by Cushman from the original collection of Defrance (Contrib. Cushman Lab. Foram. Res., vol. 3, p. 142, pl. 28, fig. 7, 1927), except that it is somewhat fuller bodied.

Average diameter .8 mm.; thickness .45 mm.

Plesiotype, from Taylor formation, Sta. 226–T–8, in Carsey Collection, department of geology, The University of Texas. Plesiotype, from same locality, in Plummer Collection (S–782). Specimens in Bureau of Economic Geology.

LENTICULINA WASHITENSIS (Carsey)

Pl. XI, fig. 19

Cristellaria washitensis Carsey, 1926, Univ. Texas Bull. 2612, p. 38, pl. 7, fig. 9.

Test lenticular, slightly elongate and wholly involute, thinly keeled, strongly umbonate, peripheral outline evenly rounded; chambers from ten to thirteen in mature convolution, uninflated; sutures smooth or slightly elevated around the umbonal area, almost straight and somewhat oblique; aperture radiate on periphery.

Greatest diameter of holotype .6 mm.; lesser diameter .5 mm.; thickness through center .25 mm.

The body of this species merges by direct slope from the central umbonal area into the thick sharp flange which on most specimens is unbroken and broad. A few tests bear only a sharp keel without the extended flange. Rare senile tests exhibit a final astacoline chamber that fails to reach back to the central portion of the test.

L. washitensis (Carsey) is very common in Del Rio and Grayson formations. In the material of Taylor age in the excavation west of Taylor (Sta. 245–T–2) is a frequent test so closely similar as to be probably identical.

Holotype, from Del Rio formation, Sta. 226–T–10, in Carsey Collection, department of geology, The University of Texas. Specimens at Bureau of Economic Geology.

Genus ASTACOLUS Montfort, 1808

ASTACOLUS TAYLORENSIS n. sp.

Pl. XI, fig. 16; Pl. XV, figs. 8–11

Cristellaria gibba Carsey (non d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 37, pl. 5, fig. 4.

Test broadly ovate in outline, moderately compressed, smooth, sharply keeled but not flanged, peripheral outline evenly rounded to very faintly angular in its latest development; early chambers involute, but rapidly becoming evolute and gradually thicker and longer, eight or nine in final convolution, last one or two distinctly inflated; sutures moderately oblique from a broad central boss that lies flush with the general rotundity of the test, very gently curved, limbate but not elevated, last one or two depressed; aperture a simple radiate orifice, the successive apertures in fresh tests being visible along the periphery as triangular areas of clear shell matter.

Length of holotype .62 mm.; breadth .45 mm.; thickness .25 mm.; thickness of last chamber .28 mm.

The first figured specimen of this species was chosen from an outcrop of upper Taylor (Sta. 245–T–3) and is typical of the smooth, full-bodied, ovate test with its partially evolute later development and tumid final chamber. An exposure (Sta. 245–T–4) along the same road nearer Taylor has offered a larger suite of specimens for study and is therefore selected as the type locality. For comparison the specimen in the Carsey Collection is refigured (Pl. XV, fig. 11).

In many outcrops of compact unctuous clays of Taylor age tests of *A. taylorensis* n. sp. are found in fresh and unmineralized condition. The very clear translucent central boss permits vision of some of the earliest sutures and of the large megalospheric proloculum. Though in general the sutures and boss are not elevated above the rotund and smooth contour of the test, rare examples present very slight relief on the early part of the coil when placed in light carefully set for this observation. The successive apertures along the periphery only very rarely form faint protuberances, but the last one or two may produce a very slight angulation of the peripheral curve. Associated with this species is a more circular and only slightly evolute and many-chambered test that is characterized by prominent protuberances at these points along the periphery. Senile tests of *A. taylorensis* n. sp. bear one or two chambers that do not reach back to the coil, thereby foreshadowing evolution into *Hemiscristellaria.*

Though the outline of *A. taylorensis* n. sp. simulates that of *Lenticulina gibba* (d'Orbigny), its partially evolute structure makes it generically as well as specifically distinctive. *A. convergens* (Borneman) is structurally similar, but its later chambers gradually grow thinner instead of thicker, so that the turgid, broad final chamber of *A. taylorensis* n. sp. is a diagnostic character. A Jackson form referred[17] to *Cristellaria propinqua* Hantken, but probably not identical with the type from the *Clavulina-szaboi* beds of Hungary, is very similar to *A. taylorensis* n. sp. No Jackson specimens have been available for comparison, but the most obvious difference appears to be in the central area, which on this Cretaceous form is a broad translucent boss, and on the Jackson test is merely a point of radiation for the sutures.

A. taylorensis n. sp. is restricted to the Taylor formation in the outcropping Texas section and is especially common in its upper half.

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[17]Cushman, J. A., and Applin, E. R., Texas Jackson foraminifera: Bull. Amer. Assoc. Pet. Geol., vol. 10, p. 172, pl. 8, fig. 9, 1926.

Holotype and paratypes, from Taylor formation, Sta. 245–T–4, in Plummer Collection (S–783.1 to 783.4). Paratype, from Taylor formation, Sta. 245–T–3, in Carsey Collection, department of geology, The University of Texas. Metatypes in Bureau of Economic Geology.

ASTACOLUS DISSONUS n. sp.

Pl. XI, figs. 17, 18; Pl. XV, figs. 2–7

Cristellaria reniformis Carsey (non d'Orbigny) 1926, Univ. Texas Bull. 2612, p. 37, pl. 3, fig. 2.

Test elongate oval, much compressed, especially in evolute portion, surface smooth or delicately ornamented by long, curved, very fine, and discontinuous low ridges of exogenous shell matter approximately parallel to the peripheral outline of the test; periphery an even, unbroken curve bounded by a blunt, thick, narrow keel, early chambers involute, rapidly becoming evolute in maturity but reaching back on most tests to the early coil, from seven to nine in the last convolution; sutures curved, marked by thickened elevations that merge in a thick central boss on the early coil but gradually becoming depressed or only very slightly elevated between later chambers; aperture a radiate and protruding orifice at apex of a long, narrow, septal face, the successive apertures appearing as translucent triangular marginal areas that merge into the even outline or into the thickened carina.

Length of holotype 1.05 mm.; breadth .58 mm.; thickness through central area .26 mm.; thickness of final chamber .14 mm.

In the lower Navarro beds (Sta. 226–T–9) from which this species was first figured tests are rare. The specimen previously chosen for illustration, now in the Carsey Collection, is typical in all essential characters, and it is refigured for comparison with new material. Because the outcrop of similar stratigraphic position in the Corsicana clay pit (Sta. 174–T–4) offers an abundance of specimens for a comprehensive study of the species, the holotype has been selected from that material.

The range of variability in the contour of *A. dissonus* n. sp. is striking, as shown by the series of paratypes (Pl. XV, figs. 2–7). The fundamental characters are, however, constant and serve to identify without much hesitation almost any single test. The early involute coil bearing the conspicuous central boss and curved elevated sutures is composed of curved chambers that become rapidly longer and straighter and more compressed. Though on most specimens all chambers reach back to the periphery, frequent tests show a curved linear series of one to three very oblique chambers. The fine, curved, and indistinct ridges that sweep over the surface of the test in the direction of coiling are variable in development, and even at the type locality smooth tests can be found. All specimens from the strata on Onion Creek (Sta. 226–T–9) are devoid of these markings, which must be disregarded in strict definition of the species.

The aperture of almost all tests is a simple radiate orifice, but rare examples of the robuline aperture have been observed.

A. dissonus n. sp. in Texas outcrops is restricted to the Navarro formation, where it occurs from base to top and is comparatively rare. The type locality furnishes tests in abundance, but no other locality so rich in this species is known to the author.

Holotype and paratypes, from Navarro formation, Sta. 174–T–4, in Plummer Collection (S–784 and S–785.1 to 785.6). Paratype, from Navarro formation, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Metatypes in Bureau of Economic Geology.

Genus HEMICRISTELLARIA Stache, 1864

HEMICRISTELLARIA ENSIS (Reuss)

Pl. X, figs. 1–4

Marginulina ensis Reuss, 1845–46, Verstein. Böhm Kreidef., pt. 1, p. 29, pl. 12, fig. 13, pl. 13, figs. 26, 27.

Cristellaria lineara Carsey (non *C. linearis* d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 36, pl. 2, fig. 3.

Test elongate, much compressed throughout; first three or four chambers arranged in a distinct coil, later chambers oblique along a linear axis that curves backward from the initial coil; sutures typically depressed and marked laterally by elongate narrow nodes; aperture radiate, protruding, dorsal.

Average length of mature test 1.1 mm.; breadth .3 mm.

The test previously figured from Navarro strata was selected from an outcrop (Sta. 226–T–9) where the sutural thickenings are weakly developed (Pl. X, fig. 1). Vigilant search in material from this same exposure has yielded tests that are more mature and prove specific identity of this form with tests that have been found more abundantly in numerous other outcrops. Some uppermost Navarro strata (Sta. 165–T–4) have furnished three more typical tests for illustration (Pl. X, figs. 2–4) to show development and slight variations. The partial initial coil followed by a linear series of oblique and compressed chambers along a somewhat backward-curving axis and the dorsal aperture throughout growth constitute the salient structural characters of the species. The degree of development of the sutural nodes is variable.

Hemicristellaria ensis (Reuss) differs essentially from *H. silicula* n. sp. in its much smaller size and lack of initial spine. From *H. trilobata* (d'Orbigny) it is distinguished by its swollen sutural limbations instead of conspicuously swollen chambers.

This species is most abundant and best developed in the Navarro formation but has been observed very rarely in the Taylor and Austin formations.

Plesiotype, from lower Navarro, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Plesiotypes, from upper Navarro, Sta. 165–T–4, in Plummer Collection (S–786.1 to 786.3). Specimens in Bureau of Economic Geology.

HEMICRISTELLARIA SILICULA n. sp.

Pl. X, figs. 8, 9

Vaginulina (?) *trilobata* (?) Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 30, pl. 4, fig. 11.

Test very large, very elongate, arcuate, much compressed throughout growth, apiculate; early three or four chambers coiled about the large megalosphere that bears a strong stout spine, later chambers smooth, narrow, oblique, unilinear along an axis that may be curved slightly backward from the early cristellarian coil; sutures strongly limbate but only slightly elevated over the initial cristellarian stage, elevated in the middle of each side of the unilinear portion of the test to form transversely elongate thick nodes; aperture somewhat protruding, radiate, on dorsal margin.

Length up to 4 mm.; length of holotype (incomplete) 3.4 mm.; greatest breadth of mature chambers .6 mm.; diameter of proloculum about .2 mm.

This rather rare but very distinctive form in the Navarro formation in Texas is readily distinguished from *H. ensis* (Reuss) by its large size and the strong apical spine on its proloculum. Some tests broaden more rapidly than others in maturity, the maximum flare being exhibited by the specimen already figured by Cushman. The marked lateral compression of the test prohibits its position in the genus *Marginulina*.

Hemiscritellaria silicula n. sp. is restricted to the Navarro formation in Texas and is a very rare member of the fauna. At very few localities it has been found very frequent and well developed, as at the type locality. In the Corsicana clay pit the species is very rare.

Holotype and paratype, from Navarro formation, Sta. 146–T–5, in Plummer Collection (S–787.1 and 787.2). Metatype in Bureau of Economic Geology.

Genus DENTALINA d'Orbigny, 1826

DENTALINA COMMUNIS (d'Orbigny)

Pl. XI, fig. 4.

Nodosaria (Dentalina) communis d'Orbigny, 1826, Ann. Mag. Nat. Sci., vol. 7, p. 254, No. 35.
Nodosaria communis Carsey, 1926, Univ. Texas Bull. 2612, p. 34, pl. 7, fig. 5.

This well-known species is typically developed in the Del Rio strata from which the Carsey plesiotype was chosen. It occurs very generally with varying frequency throughout the Cretaceous formations in Texas and is rare in some of the Eocene formations.

Length of plesiotype .62 mm.

Plesiotype, from Del Rio formation, Sta. 226–T–10, in Carsey Collection, department of geology, The University of Texas. Other specimens in Bureau of Economic Geology.

DENTALINA GRANTI (Plummer)

Pl. XI, figs. 8, 9

Nodosaria filiformis Carsey (non d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 33, pl. 7, fig. 8.
Nodosaria granti Plummer, 1927, Univ. Texas Bull. 2644, p. 83, pl. 5, fig. 9.

Test very long, slender, arcuate, smooth, with long apical spine; chambers numerous, elongate, varying from cylindrical to distinctly inflated; sutures flush with outline of test between early chambers on some tests or slightly constricted throughout growth on other tests; wall thick; aperture radiate and not protruding beyond end of the final chamber.

Observed length up to 5 mm.; maximum length probably considerably more.

The variations already recorded in the original discussion of this species in the Midway formation in Texas are equally applicable to the form as it occurs in the Upper Cretaceous formations. The long slender test is so easily broken despite its thick wall, that its maximum length has probably not been observed in any single specimen. From

Nodosaria longiscata d'Orbigny it is separated by its less elongate chambers and by the curvature of its test. *Dentalina cocoaensis* (Cushman) is much smaller, thinner walled and has a strongly protruding aperture.

The basal Navarro strata from which a two-chambered fragment of this species has been previously figured is very poor in specimens. Mrs. Carsey has confirmed the identity of the form here figured from the Corsicana clay pit, which occupies about the same stratigraphic position as the outcrop on Onion Creek.

Dentalina granti (Plummer) is frequent in the Navarro fauna and occurs also in Taylor and Austin formations in the Cretaceous section. It is especially abundant in the basal Midway (Eocene) strata and occurs also sparingly in the upper Midway.

Plesiotypes, from lower Navarro clays, Sta. 174–T–4, in Plummer Collection (S–789.1 and 789.2). Specimens in Bureau of Economic Geology.

DENTALINA SOLUTA Reuss

Pl. XI, fig. 14

Dentalina soluta Reuss, Zeit. deutsch. geol. Gesell., vol. 3, p. 60, pl. 3, fig. 4.

Nodosaria farcimen Carsey (non Soldani), 1926 Univ. Texas Bull. 2612, p. 34, pl. 4, fig. 11.

The specimen previously figured from Taylor strata has been lost. The illustration, however, depicts clearly the characteristics of *Dentalina soluta* Reuss, a rather rare form in this fauna but one that is frequent in a few outcrops. Mrs. Carsey has confirmed the selection of the new plesiotype here figured.

Length up to 2.5 mm.; average length 1.8 mm.

The outcrop (Sta. 245–T–3) from which this Taylor form has already been figured has yielded such unsatisfactory fragments, that the roadside excavation west of Taylor (Sta. 245–T–2) has been chosen for the new plesiotype. A suite of several specimens from this material exhibits a variation in the direction of the axis of the test from perfectly straight, like *Nodosaria concinna* Reuss, to distinctly arcuate like the typical *Dentalina soluta* Reuss. All tests bear a very slightly eccentric aperture and thereby show their dentaline affinities, despite the straight axis of many tests. The size of the proloculum varies greatly, but the number of specimens has been insufficient to contribute definite conclusions on the basis of trimorphism.

Plesiotype, from Taylor formation, Sta. 245–T–2, in Plummer Collection (S–788). Specimen in Carsey Collection lost. Other specimens in Bureau of Economic Geology.

DENTALINA REUSSI Neugeboren

Pl. XI, fig. 5

Dentalina reussi Neugeboren, 1856, Denk, k. Akad. Wiss. Wien, vol. 12, p. 85, pl. 3, figs. 6, 7, 17.

Nodosaria reussi Egger, 1899, Abh. k. bayer. Akad. Wiss., vol. 21, p. 57, pl. 6, fig. 34.

Test rather stout, strongly arcuate, smooth; chambers gradually increasing in width from a broadly rounded aboral extremity, short and appressed in youth with little or no tumidity and gradually more elongate and more inflated with age; sutures transverse, thick, dark bands with little or no constriction during youth, increasingly constricted throughout maturity and strongly constricted between the last two or three very rotund chambers; aperture eccentric, radiate, moderately protruding.

Length up to about 2 mm.

This glassy smooth test with its short compact and most commonly uninflated early chambers, followed by rapidly lengthening and increasingly inflated later chambers can not be confused with any other dentaline form in the Navarro formation in Texas.

Dentalina reussi Neugeborn is abundant in the Navarro in some outcrops, and occurs rarely in Taylor strata.

Plesiotype, from lower Navarro formation, Sta. 174–T–4, in Plummer Collection (S–791). Specimens in Bureau of Economic Geology.

DENTALINA RARISTRIATA (Chapman)

Pl. XI, figs. 10, 11

Nodosaria (D.) raristriata Chapman, 1893, Jour. Roy. Mic. Soc., p. 591, pl. 9, fig. 4.

Nodosaria intrasegma Carsey, 1926, Univ. Texas Bull. 2612, p. 33, pl. 4, fig. 10.

Test slender, arcuate, tapering gradually toward the apical extremity; chambers elongate, gradually more tumid with age, smooth or delicately ornamented by irregularly developed longitudinal costae that are more numerous and stronger across the sutural constrictions; sutures somewhat oblique, moderately constricted to deeply constricted, crossed by coarse striae or fine costae; aperture elongate and protruding eccentrically from the final chamber.

Length probably as much as 2 mm. or more.

The two-chambered fragment originally figured from heavy Taylor clays has been lost, but the last three chambers of a test here figured (Pl. XI, fig. 10) exhibits the same characteristics as the holotype. In somewhat calcareous deposits of this same formation, the characteristic sutural costae are more strongly developed and extend over part of, or across, the chambers themselves with irregular distribution (fig. 11). The essential characters of the two forms are the same, and the degree of ornamentation must be regarded as a response to the amount of calcareous matter present in the sea during growth. The holotype of *D. raristriata* (Chapman) came from highly calcareous strata, and its markings are closely similar to the test figured from the chalky clays of Taylor age (Pl. XI, fig. 11).

D. raristratia (Chapman) is very rare in Taylor strata and has not been observed in any other part of the section.

Plesiotypes, from Taylor clay, Sta. 226–T–12, and from Taylor chalky clay, Sta. 245–T–2, in Plummer Collection (S–794 and S–795). Specimen in Bureau of Economic Geology.

DENTALINA OBLIQUA (Linné)

Pl. XI, fig. 6

Nautilus obliquus Linné, 1758, Syst. Nat., ed. 10, p. 711; ed. 13 (Gmelin's), p. 3372.
Nodosaria obliqua Carsey, 1926, Univ. Texas Bull. 2612, p. 35, pl. 2, fig. 6.

This long, graceful, arcuate test with numerous narrowly rounded costae crowded over all the chambers and across the sutures and extending somewhat obliquely to the axis of the test is rare in the lower Navarro strata from which it has been recorded. The Carsey plesiotype has been lost, but the new plesiotype here figured is from the same outcrop, where no other similar species occurs.

Length of last three chambers figured .85 mm.

Dentalina obliqua (Linné) is rare in the Navarro fauna. It has not been observed by the present author in the outcrop of any other formation.

Plesiotype, from lower Navarro formation, Sta. 226–T–9, in Plummer Collection (S–792). Specimen in Bureau of Economic Geology.

DENTALINA ALTERNATA (Jones)

Pl. XI, fig. 7

Nodosaria zippei var. *alternata* Jones, 1884–1885, in Wright, Proc. Belfast Nat. Field Club, p. 330, pl. 27, fig. 10.
Nodosaria alternata Carsey (n. sp.), 1926, Univ. Texas Bull. 2612, p. 35, pl. 4, fig. 7.

It is a remarkable coincidence that the Taylor form figured and named *Nodosaria alternata* Carsey n. sp. has since been found identical with a previously figured species of the same name by Jones. The alternating types of longitudinal costae are obviously the impressive feature of both these tests. The original figure published in a paper by Wright on the Cretaceous foraminifera of Keady Hill is almost precisely the same broken test as that in the Carsey Collection. Jones' figure is strongly suggestive of a broken apical spine, which is present on well-preserved tests of the species in the Taylor strata. The species in the Taylor clays is very distinctive and can not be confused with any other costate form, as the few long, thin, continuous ribs alternate with lower short ribs that do not cross the sutures. The test is cylindrical and almost straight during youth, but the sutural constrictions gradually grow deeper with advancing age, and the test becomes slightly arcuate. The final chamber is strongly bulbous and consequently is easily broken during the cleaning process. The aperture is radiate at the end of a short prolongation of the final chamber.

Length of plesiotype 1.85 mm.

Dentalina alternata (Jones) is frequent in the Taylor and upper Austin formations in Texas. It has been observed as a very rare and minute form in the lower Navarro strata (Sta. 146–T–5), the only occurrence known to the author above the Nacatoch sand.

Plesiotype, from Taylor formation, Sta. 245–T–3, in Carsey Collection, department of geology, The University of Texas. Plesiotype, from same locality, in Plummer Collection (S–793). Specimens in Bureau of Economic Geology.

DENTALINA CRINITA n. sp.

Pl. XI, figs. 12, 13

Nodosaria consobrina Carsey (non d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 32, pl. 2, fig. 5.

Test very elongate, arcuate, only slightly tapering, without apical spine; chambers slowly enlarging in youth, but of about equal breadth through maturity, short, appressed throughout most of the test but slightly longer and more inflated in late maturity, typically ornamented by faint and discontinuous striae that bear irregularly distributed minute nodes giving the chambers a hirsute appearance; sutures flush to markedly constricted between the later chambers, transverse; aperture a radiate protruding orifice, somewhat eccentric.

Length up to 2.5 mm.

This form in Navarro strata has been described as smooth. The specimen originally figured from lower Navarro strata (Sta. 226–T–9) has been lost, but supplementary specimens in the Carsey Collection from the same outcrop show that a surface roughened by irregularly developed and discontinuous fine striations constitutes a consistent character of the species. Rare tests are almost smooth, but even these lack the glassy smoothness of truly unornamented tests. Material from the outcrop that has furnished the specimen previously figured is poor in this species, and new material has, therefore, been selected from the very richly foraminifral strata of the Corsicana clay pit.

D. crinita n. sp. has been observed most frequently in the Navarro fauna, where it is not common. It occurs very rarely also in the Taylor formation.

Holotype and paratype, from Navarro formation, Sta. 174–T–4, in Plummer Collection (S–790.1 and 790.2). Metatypes in department of geology, The University of Texas; and in the Bureau of Economic Geology.

Genus NODOSARIA Lamarck, 1812

NODOSARIA RADICULA (Linné)

Pl. XI, figs. 1, 2

Nautilus radicula Linné, 1758, Syst. Nat. ed. 10, p. 711, Gmelin's ed. 13, 1788, vol. 1, pt. 6, p. 3373, No. 18.

Glandulina manifesta Reuss, 1851, Haid. Naturw. Abh., vol. 4, p. 22, pl. 1, fig. 4.

Glandulina elongata Reuss, 1860, Sitz. k. Akad. Wiss. Wien, vol. 40, p. 190, pl. 4, fig. 2.

Nodosaria lepida Reuss, 1860, Idem, p. 178, pl. 1, fig. 2.

Glandulina aperta Stache, 1864, Novara Exped., Geol. Theil, vol. 1, p. 188, pl. 22, fig. 11.

Glandulina erecta Stache, 1864, Idem, p. 189, pl. 22, fig. 12.

Nodosaria radicula H. B. Brady, 1884, Challenger, vol. 9 (Zool.), p. 495, pl. 61, figs. 28–31.

Glandulina manifesta Egger, 1899, Abh. k. bayer. Akad. Wiss., vol. 21, p. 82, pl. 5, figs. 27, 28.

Nodosaria larva Carsey, 1926, Univ. Texas Bull. 2612, p. 31, pl. 2, fig. 2.

Nodosaria radicula Plummer, 1927, Univ. Texas Bull. 2644, p. 77, pl. 4, fig. 9.

This cosmopolitan species has been observed and figured under various names by many authors both as a fossil and as a form in present oceans. The specimen in the Carsey Collection is typical of this form.

Length up to .8 mm.; breadth .2 mm.

In Texas strata *N. radicula* (Linné) exhibits considerable variation in the sutural constrictions. Some tests are almost glanduline, yet the fully mature tests with two or three less embracing and more inflated chambers shows its true nodosarian structure. Where it is rare, the tests are likely to be short, but in outcrops where it is abundant the longer tests are very common.

Nodosaria radicula (Linné) is frequent in Upper Cretaceous strata in Texas, especially in the Navarro formation. It is frequent also in Midway clays. The form designated as *Glandulina manifesta* by Egger has been found to be very common in material from his type locality at Gerhardsreut and is identical with the Cretaceous tests here referred to *N. radicula.*

Plesiotype, from lower Navarro strata, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Plesiotype, from uppermost Navarro strata, Sta. 165–T–4, in Plummer Collection (S–796). Specimens in the Bureau of Economic Geology.

NODOSARIA OBSCURA Reuss

Pl. XI, fig. 3

Nodosaria obscura Reuss, 1845–46, Verstein. böhm., Kreidef., pt. 1, p. 26, pl. 13, figs. 7–9.

Nodosaria obscura Chapman, 1893, Jour. Roy. Mic. Soc., p. 593, pl. 9, fig. 16 (erroneously fig. 15 on plate).

Nodosaria fragilis (Carsey (non Defrance), 1926, Univ. Texas Bull. 2612, p. 35, pl. 4, fig. 1.

Nodosaria raphanus var. *obscura* Franke, 1928, Abh. preuss. geol. Landesan., pt. 3, p. 48, pl. 4, fig. 5.

Test straight, short, stout, composed of a few cylindrical to very slightly inflated chambers ornamented by seven to nine very thin and highly elevated longitudinal ribs that extend from a sharp apical spine to the oral extremity of the test; aperture at end of a prominent slender tube that projects from the end of the final chamber.

Length of plesiotype .67 mm.; breadth .19 mm.

The form previously figured from the Del Rio strata is no longer extant, but type material from the same outcrop has yielded numerous specimens that are indubitably identical with the costate form recorded. The few costae are very thin and fragile and are highly elevated above the chambers and across the sutures, consequently in fossil condition they are characteristically ragged. One salient feature of this short, straight, ribbed test is the long tubular apertural extension that is similar to that of many well-known species of *Lagena* but much more rare amongst the *Nodosariae*. This delicate feature is naturally broken from most of the tests, but even the hole at the end of the last chamber with its ragged rim is diagnostic.

N. obscura Reuss is well developed and frequent in the Del Rio formation in central Texas and in its stratigraphic equivalent, the Grayson formation, in north Texas. It is very rare in the Fort Worth limestone and may occur rarely throughout several Lower Cretaceous formations. It has been recorded from the Gault of England and the Continent.

Plesiotype, from Del Rio formation, Sta. 226–T–10, in Plummer Collection (S–797). Specimens in the Bureau of Economic Geology.

NODOSARIA ZIPPEI Reuss

Nodosaria zippei Reuss, 1844, Geogn. Skizze aus Böhmen, p. 210.
Nodosaria zippei Reuss, 1845, Verstein. böhm. Kreidef., pt., 1, p. 25, pl. 8, figs. 1–3.
Nodosaria veretebralis var. *austinensis* Carsey, 1926, Univ. Texas Bull. 2612, p. 31, pl. 7, fig. 12.
Nodosaria marla Carsey, 1926, Idem, p. 34, pl. 4, fig. 6.

The specimen figured as *Nodosaria vertebralis* var. *austinensis* from a core at some unknown depth in a well at Lytton Springs and presumably from the Austin chalk is clearly the microspheric form of the very common and coarsely ribbed species that is present in several variations throughout the Upper Cretaceous strata in Texas. The specimen designated as *N. marla* from Taylor strata has been lost, but the illustration exhibits well the typical characteristics of a young megalospheric form of the same species. Tests show all variations in degree of curvature from perfectly straight, which is most common, to slightly arcuate. Some tests are constricted between the successive chambers throughout growth; others show a short succession of unconstricted chambers beyond the proloculum, which is marked by a strong basal spine.

Length up to 10 mm.

Specimens from Taylor formation, Sta. 245–T–4, in the Bureau of Economic Geology.

Genus PSEUDOGLANDULINA Cushman, 1929

PSEUDOGLANDULINA sp.

Pl. X, figs. 16, 17

Nodosaria laevigata Carsey, 1926, Univ. Texas Bull. 2612, p. 32, pl. 4, fig. 13.

This smooth, very small, spiculate test is composed of a short uniserial succession of chambers in both its megalospheric and microspheric forms. With the loss of *Glandulina laevigata* d'Orbigny to the family Polymorphinidae no attempt is here made to choose from the long list of names that have been assigned to tests of this form and structure. No doubt a long and arduous study of much old type material will be necessary to ascertain the first name assigned to this test in the Lagenidae.

Average length .3 mm.; greatest thickness .15 mm.

This form occurs very rarely in the Upper Cretaceous and Tertiary strata of the Gulf Coast of the United States.

Specimens figured, from Navarro strata, Sta. 226–T–9, in Plummer Collection (S–798). Specimens in the Bureau of Economic Geology.

Genus LAGENA Walker and Jacob, 1798

LAGENA HISPIDA Reuss

Pl. X, fig. 12

Lagena hispida Reuss, 1858, Zeit. deutsch. geol. Gesell., vol. 10, p. 434.
Lagena hispida Reuss, 1862, Sitz. k. Akad. Wiss. Wien, vol. 46, p. 335, pl. 6, figs. 77–79.
Lagena hispida Carsey, 1926, Univ. Texas Bull. 2612, p. 30, pl. 4, fig. 8.

Test globular and covered by short delicate spines that are evenly distributed over the test; aperture at end of long tube.

Length of globular body of test .18 mm.; breadth .17 mm.; length of test including apertural tube .27 mm.

This minute and delicate test is rather rare in lower Navarro strata, and it occurs sparingly in both Lower and Upper Cretaceous formations in Texas.

Plesiotype, from Navarro formation, Sta. 226–T–9, in Plummer Collection (S–803). Specimen in the Bureau of Economic Geology.

LAGENA SULCATA (Walker and Jacob)

Pl. X, fig. 11

Serpula (Lagena) sulcata Walker and Jacob, 1798, Adam's Essays, Kannmacher's ed., p. 634, pl. 14, fig. 5.
Lagena sulcata Carsey, 1926, Univ. Texas Bull. 2612, p. 31, pl. 7, fig. 4.

Test flask-shaped, body somewhat elongate and ornamented by ten to twelve sharp coarse costae that merge anteriorly and posteriorly into the curvature of the test; aperture radiate at end of long neck; apical spine missing on all specimens observed but broken stump proves its original existence.

Length of body of test .17 mm.; thickness .12 mm.; length of test to end of neck .24 mm.

In the Del Rio formation and the equivalent Grayson marls of north Texas *Lagena sulcata* (Walker and Jacob) is frequent. It has been observed as a rare form in the Upper Cretaceous strata of this state.

Plesiotype, from Del Rio formation, Sta. 226–T–10, in Plummer Collection (S–802). Specimen in the Bureau of Economic Geology.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA WEBBERVILLENSIS Carsey

Vaginulina webbervillensis Carsey, 1926, Univ. Texas Bull. 2612, p. 39, pl. 2, fig. 7.
Vaginulina webbervillensis Moreman, 1927, Jour. Paleont., vol. 1, p. 98, pl. 16, fig. 2.
Vaginulina webbervillensis Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 27, pl. 4, fig. 14.

This conspicuous, large (up to 8 mm. in length), very strongly compressed, wing-shaped form has already been so well figured and described that further repetition of descriptive details is needless. The typical test of this species is smooth beyond the somewhat costate megalosphere and minute smooth microsphere. Frequent tests bear several short costae along the ventral edge of the first two of three chambers, and rare tests exhibit a rather marked costation over the youthful portion of the test. The stronger outward curvature of the ventral edge of the early part of the test serves as the most useful diagnostic character to separate *V. webbervillensis* Carsey from the wedge-shaped and typically more costate *V. simondsi* Carsey, two forms that occur commonly together.

V. webbervillensis Carsey is most abundant in the Navarro strata throughout Texas. The Eagle Ford plesiotype has been examined and is found to conform well to many of the variations that characterize the species at any locality in the Navarro where it is abundant. The present author has not observed it in the Austin and Taylor formations.

Holotype, from Navarro formation, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Metatypes in the Bureau of Economic Geology.

VAGINULINA SIMONDSI Carsey

Pl. X, figs. 13–15

Vaginulina simondsi Carsey, 1926, Univ. Texas Bull. 2612, p. 40, pl. 2, fig. 4.
Vaginulina simondsi Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 27, pl. 4, figs. 6–8.

Test moderately large in its full development, very strongly compressed, narrowly V-shaped with a somewhat lobate and bicarinate to multicarinate periphery, flaring gradually from a globular costate and apiculate proloculum, typically ornamented by longitudinal obsolescent costae that extend from the proloculum forward over the early chambers but are present, if at all, on the later portion of the test as short longitudinal costae across the elevated sutures; chambers strongly oblique, slightly curved at ventral edge, short, gradually widening; sutures oblique, somewhat elevated near dorsal edge, somewhat depressed along opposite edge; aperture somewhat protruding, radiate, on dorsal border.

Length of neoholotype 3.8 mm.; average length about 2 mm.

As the holotype has been lost, the neoholotype has been selected with the aid of Mrs. Carsey from uppermost Navarro strata north of Cameron (Sta. 165–T–4). The original type locality has yielded a few immature tests, but no specimen so typical as the holotype has been found in this material to take its place.

V. simondsi Carsey is found commonly associated with *V. webbervillensis* Carsey, which at all localities has been found to be the much more common form. *V. simondsi* is consistently more evenly wedge-shaped in peripheral outline, characteristically ornamented over the earlier chambers by several distinct costae that are stronger along the dorsal and ventral edges. On some weakly developed tests the costae extend only over two or three chambers beyond the proloculum, whereas on well-developed tests, like the neoholotype (Pl. X, fig. 14), these costae continue over much of the test and are especially represented by short longitudinal elevations that cross the thickened sutures obliquely.

The evenly flaring edges of the test, due to a regular rate of widening of the chambers, constitutes a persistent character that separates this species from *V. webbervillensis,* in which the chambers during youth widen very rapidly and throughout maturity widen more gradually, thus producing a ventral edge that is strongly curved. Some specimens of *V. webbervillensis* bear a few short costae along the ventral edge of the first two or three chambers, and rare tests exhibit considerable costation over much of the test. The respective outlines of these two somewhat similar and associated forms have proved the best clues to their identity in Navarro strata.

V. simondsi occurs frequently in richly foraminiferal Navarro clay and is very rare in the underlying Taylor strata.

Neoholotype and neoparatype (Pl. X, figs. 13, 14), from uppermost Navarro formation, Sta. 165–T–4, and neoparatype (Pl. X, fig. 15) from lower Navarro, Sta. 174–T–4, in Plummer Collection (S–799.1, S–799.2, and S–800). Specimens in Bureau of Economic Geology.

VAGINULINA REGINA n. sp.

Pl. X, fig. 22

Vaginulina sp. (?) Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 30, pl. 4, figs. 12, 13.

Vaginulina simondsi Moreman (non Carsey), 1927, Jour. Paleont., vol. 1, p. 98, pl. 16, fig. 1.

Test rather large, compressed, flaring gradually from a compressed or globular apiculate proloculum toward the oral extremity, strikingly ornamented over sides and peripheral margins of the chambers by thin, highly elevated, longitudinal and somewhat anastamosing costae; chambers strongly oblique, narrow; sutures oblique, faintly visible on somewhat weakly costate test but obscured by well-developed ornamentation; general contour of both peripheries broadly rounded; aperture radiate, protruding on dorsal edge.

Length of holotype 3.3 mm.; attains a length of as much as 5 mm.

This striking form is especially characterized by its longitudinal, anastamosing thin costae, by its strongly compressed test, and by the bluntly rounded peripheral margins. The holotype shows the average degree of flaring of the dorsal and ventral edges, but narrower tests are frequent. The fragments previously figured as *Vaginulina* sp. are typical of tests in the Austin chalk, where complete specimens are rather rare.

Vaginulina regina n. sp. is frequent in the Austin chalk and lower chalky layers of the Taylor formation. The form figured from the Eagle Ford by Moreman is typical in its essential characters, but exhibits one or two later chambers almost devoid of the longitudinal costae except across the thickened sutures. Such weakening of the ornamentation is characteristic of forms in less calcareous strata.

Holotype, from uppermost soft chalky layers of Austin formation, Sta. 226–T–4, in Plummer Collection (S–801). Metatypes in the Bureau of Economic Geology.

Genus FLABELLINA d'Orbigny, 1839

FLABELLINA INTERPUNCTATA von der Marck

Pl. XII, figs. 1–3

Flabellina interpunctata von der Marck, 1858, Verh. Nat. Ver. preuss. Rheinlands, vol. 15, p. 53, pl. 1, fig. 5.
Flabellina interpunctata Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 30, pl. 4, figs. 16, 17.

Test rhomboid in peripheral outline, equally compressed, periphery truncate or slightly bicarinate; chambers strongly coiled in early stage and sagittate during maturity, surfaces characteristically marked by conspicuous pustules; sutures marked by distinct elevations that vary from broad continuous curves to somewhat broken or slightly wavy fine ridges, which at the apices of a few of the sagittate chambers develop characteristic loops; aperture projecting.

Length of average specimen (Pl. XII, fig. 1) 1.15 mm.; breadth .95 mm.; thickness at periphery .1 mm.

In size, outline, and thickness *F. interpunctata* von der Marck closely resembles *F. rugosa* d'Orbigny but is distinguished by its characteristic pustulate surface, which on some specimens is weakly developed. An examination of several specimens usually reveals the tendency to develop apical loops on the sagittate sutures (Pl. XII, fig. 2). This is not so constant a feature as to be absolutely diagnostic. In the Upper Cretaceous strata in Texas the sutural elevations of *F. rugosa* d'Orbigny are likely to be much higher and thinner than those of *F. interpunctata*, and in general they are more continuous.

Together in some highly calcareous strata of the Taylor formation (Sta. 245–T–2) occur both *F. interpunctata* von der Marck and *F. projecta* (Carsey), which are so similar in their surface markings that they can readily be confused. Mature tests of *F. interpunctata* are larger and thicker and are more rhomboid in peripheral outline, it exhibits far less tendency to develop apical loops on the sagittate sutures, and its sutural curves on the average specimen are more constant and continuous. In a large assemblage of specimens of this species only very rare tests exhibit sutural ridges almost as broken and erratic as those of *F. projecta.* The dominant distinctions, therefore, are greater size and thickness of test and its more rhomboid outline with its less embracing sagittate chambers.

F. interpunctata von der Marck in Texas occurs most commonly in the Taylor formation. It is rare in the Austin chalk, and it has been observed as a very rare but well-developed form in the uppermost Navarro strata (Sta. 165–T–4).

Plesiotypes, from Taylor formation, Sta. 245–T–2, in Plummer Collection (S–804.1 to 804.3). Specimens in the Bureau of Economic Geology.

FLABELLINA PROJECTA (Carsey)

Pl. XII, figs. 5–8

Frondicularia projecta Carsey, 1926, Univ. Texas Bull. 2612, p. 41, pl. 6, fig. 5.

Test broadly ovate with sharply pointed oral extremity, thin equally compressed; early chambers arranged in a coil, later chambers sagittate and embracing; sutures marked by sharp ridges that tend to be broken and slightly wavy and develop conspicuous apical loops; wall characteristically pustulate; aperture protruding and radiate.

Length of holotype .87 mm.; breadth .63 mm.; thickness at periphery .05 mm.

The name originally assigned to the specimen chosen as the holotype has been retained to define a combination of characters that marks this form from a similarly pustulate species described as *F. interpunctata* von der Marck. Material from an abandoned excavation west of Taylor (Sta. 245–T–2) has furnished numerous specimens of both these species, thus eliminating the factor of environment as the possible fundamental cause of seemingly slight differences in test structure and markings. Like the holotype, which is an excellent example of *F. projecta,* mature specimens of this species are smaller, much thinner, and more broadly rounded across their aboral extremities, and the later chambers are consistently more strongly embracing than are those of the associated *F. interpunctata.* The coiled portion of *F. projecta* only rarely lies adjacent to the peripheral outline of the test, whereas in *F. interpunctata* it is only rarely enclosed within this outline by the later chambers. In most tests of *F. projecta* the coiled stage is embraced completely by only one of the early sagittate chambers; the later chambers curve strongly downward toward the early coil. The sutural ridges of two forms are closely similar in elevation, but a study of numerous tests of both forms reveals distinctive characteristics in development. The sutural elevations of *F. projecta* are on the whole much more broken and less continuous than those of *F. interpunctata;* the apical loops are strongly developed and are present even between some of the coiled chambers, whereas on tests of *F. interpunctata* they are frequent and present, if at all, only between the sagittate chambers.

The upper Midway form designated as *F. delicatissima* (Plummer) is similar to *F. projecta* in size and development, but most tests are less embracing in the curvature of their mature chambers. The holotype of this Midway form is almost identical with that of *F. projecta* in shape and structure, but unfortunately it was not well chosen to represent the average Midway test. Without doubt the Midway form should be regarded merely as a variety of *F. projecta.*

The present author has observed *F. projecta* only in Taylor outcrops and regards it as a diagnostic form of this formation.

Holotype, from upper Taylor strata, Sta. 226–T–8, in Carsey Collection, department of geology, The University of Texas. Plesiotypes, from middle Taylor strata, Sta. 245–T–2, in Plummer Collection (S–805.1 –.3). Specimens in the Bureau of Economic Geology.

FLABELLINA RUGOSA d'Orbigny

Pl. XII, fig. 4

Flabellina rugosa d'Orbigny, 1840, Mém. soc. géol. France, ser. 1, vol. 4, p. 23, pl. 2, figs. 4, 5, 7.

Frondicularia rugosa Plummer, 1927, Univ. Texas Bull. 2644, p. 118, pl. 5, fig. 1, text fig. 13.

Fabellina rugosa Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 32, pl. 4, fig. 15.

In the Texas geological section this form is especially frequent in the clayey Taylor strata, where it is well developed and can be observed in large numbers at many localities. Its outline varies from broadly subtriangular (Pl. XII, fig. 4) to more rhomboid; its chambers are typically smooth and the early coiled portion in most specimens is not embraced by the later sagittate chambers; and its sutures are marked by conspicuous high, thin elevations that swing across the surface of the test in broad continuous curves.

Length of plesiotype 1.15 mm.; breadth .9 mm.; thickness of periphery .1 mm.

In size, in outline, in thickness, and in arrangement of the chambers *F. rugosa* d'Orbigny most closely resembles *F. interpunctata* von der Marck, which is also frequent in the Taylor formation but especially in the highly calcareous strata. The main difference between the forms lies in the character of the chamber surfaces, which in *F. rugosa* are smooth and in *F. interpunctata* are covered with small irregularly distributed pustules. Gradations from one species into the other can be followed by the degree of pustulation. Some specimens are so weakly pustulate that the protuberances of the chamber surfaces occur mainly on the coiled portion of the test (Pl. XII, fig. 3). Whereas the sutural elevations of *F. rugosa* are very thin high ridges that sweep in broad curves over the test, those of *F. interpunctata* are less elevated, are more likely to be slightly broken or faintly wavy, and on some specimens develop a loop at one or more apices of the sagittate chambers.

The typical *F. rugosa* d'Orbigny is common in a few exposures of basal Midway in northeast Texas, where it can not be regarded as reworked from lower strata during Midway deposition. In each of these Midway outcrops the tests have been found in perfect condition and in the same state of shell preservation as the accompanying tests, of which none resemble any of the other typical Cretaceous forms.

In the Texas Cretaceous section *F. rugosa* d'Orbigny is most abundant in the heavy clays of the lower part of the Taylor formation.

Plesiotype, from Taylor formation, Sta. 226–T–7, in Plummer Collection (S–806). Specimens in the Bureau of Economic Geology.

Genus KYPHOPYXA Cushman, 1929

KYPHOPYXA CHRISTNERI (Carsey)

Pl. XII, figs. 9–19

Frondicularia christneri Carsey, 1926, Univ. Texas Bull. 2612, p. 41, pl. 6, fig. 7.

Kyphopyxa christneri Cushman, 1929, Contrib. Cushman Lab. Foram. Res., vol. 5, p. 1, pl. 1, figs. 1–7.

Kyphopyxa christneri Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 33, pl. 4, fig. 20.

Kyphopyxa christneri Cushman, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, pp. 65, 85, pl. 9, fig. 5, pl. 12, fig. 2.

Test broadly rounded aborally and sharply pointed toward the aperture, thickest in the central area to thin along the slightly rounded to truncate periphery; early chambers from loosely coiled to typically cristellarian, adolescent chambers biserial, in the same plane and strongly embracing, mature chambers typically frondicularian and broadly curved downward around the early portion of the test; sutures marked through the central area by strong, high, thin, continuous elevations; surface of chambers perfectly smooth; aperture projecting, radiate.

Length of neoholotype 1.9 mm.; breadth 1.4 mm.; greatest thickness (through center) .5 mm.; thickness of peripheral edge .04 mm.

The holotype was selected from a core from a well at Lytton Springs, Caldwell County, and has since been lost. It has been made the genotype for *Kyphopyxa* Cushman on the basis of the biserial stage between the coiled initial stage and the sagittate mature stage.

Many outcrops of lower Taylor strata yield numerous well-developed specimens of *K. christneri* (Carsey), and any one of these permits a study of the broad range of variability of the species in a stable environment. The peripheral outline of the test is almost persistently broadly rounded below and sharply pointed orally, though rare tests exhibit greater angularity. The conspicuous external expression of structure in the sutural elevations renders the biserial adolescent stage and the sagittate mature stage very prominent on all tests regardless of general condition of preservation or mineralization. The initial stage is clearly revealed by thin section or even in dampened limonite-filled tests of unmineralized megalospheric tests that are common in the heavy unctuous clays of the lower Taylor. Most megalospheric tests show three or four rapidly lengthening coiled chambers beyond the proloculum, from five to seven strongly curved biserial chambers, and a succession of strongly curved sagittate chambers to the end of the development of the test.

Variations in the initial stage of megalospheric tests are common, as have been revealed by ground sections. On some tests the proloculum is followed by only two chambers so loosely coiled and so nearly erect as to be almost biserial (Pl. XII, figs. 14, 17). In others the point of convergence of the first few sutures is so far from the proloculum as to be vaginuline (Pl. XII, fig. 18). The opposite extreme even in the megalospheric form consists of a very tight coil of six or seven narrow chambers, the sutures between which converge within, or tangent to, the proloculum (Pl. XII, fig. 13). This extreme is very rare. So unstable is the early development of this species that the normal initial coil may be followed by two chambers coiled in the opposite direction before regular biseriality is attained (Pl. XII, fig. 16). The change in direction of the two series of coiled chambers marks fundamentally a change to biseriality, but emphasizes the instability of equilibrium in its potentialities during this stage in its ontogeny.

The biserial portion of the test is very regular from test to test in its development and structural expression. This intermediate stage is conspicuous and prolonged through five to seven gradually widening chambers before the final series of sagittate chambers is added. In general the early portion of the test is wholly embraced by a late pair of biserial chambers, the ends of which may overlap (Pl. XII, figs. 10, 11, 14) or merely meet (Pl. XII, figs. 12, 15). Many specimens, however, show the proloculum tangent to the periphery with the ends of a pair of biserial chambers abutting the proloculum on each side and within the rounded aboral outline (Pl. XII, fig. 17). Very frequent in material rich in this species are tests that show the early coiled stage extending beyond the broadly rounded outline formed by the strongly curved later chambers and forming a blunt or even sharp point at this end of the structure (Pl. XII, figs. 13, 16, 18).

The microspheric form is typical of this generation in its development from a minute proloculum through several very small but gradually lengthening coiled chambers to the biserial stage, from which point in its growth development is like that of the megalospheric form. This condition can only rarely be detected externally, as the sutures during this initial stage are not elevated, and the shell is generally too thick to permit transmission of sufficient light through the test to reveal structure so delicate. Many exceptionally large forms have been examined in the expectation that size might be a clue to tests of this microspheric generation, but in this species size is evidently not a factor of generation. The two microspheric tests caught by chance in the sections made were of average size as compared with the abundant megalospheric material in the same sample. It is perhaps a fallacy too commonly entertained that the microspheric form in full development must necessarily be larger than the megalospheric form of equal development. Characteristically small microspheric forms of some species have been carefully studied[18] and described, and size is undoubtedly a character to be considered for each separate species.

Amongst the exceedingly varied forms that comprise the large family Lagenidae the ontogeny of *K. christneri* (Carsey) may constitute striking preservation of the ancestral record of this very plastic group. The biserial stage intermediate between the initial coiled stage and the sagittate stage may be the exaggerated structural expression of an inherent potentiality in typically flabelline forms that pass

[18]Heron-Allen E., and Earland, Arthur, An experimental study of the foraminiferal species *Verneuilina polystropha* (Reuss), and some others, being a contribution to a discussion "On the origin, evolution, and transmission of biological characters": Proc. Roy. Irish Acad., vol. 35, Sec. B, No. 8, p. 172, figs. 49, 50, 1920.

through this stage too rapidly to reflect this period of development in the arrangement of chambers. In rare flabelline tests, however, single strongly unsymmetrical sagittate chambers immediately succeeding the coiled stage suggest this biserial adolescent stage. According to the general application of the law of recapitulation, such a form as *K. christneri* should occur in the geologic records prior to the more accelerated forms of *Flabellina*. Whether such a form does occur yet undiscovered in the early Mesozoic strata remains for further searches to reveal. The phylogenetic records as interpreted from ontogeny would be very simple, if conflicting elements were not introduced to change the normal sequence, and frequently too much is claimed for the law of tachygenesis, or perhaps it is generally too rigidly applied.

In the Texas section *K. christneri* (Carsey) occurs in the upper Austin formation and in the lower Taylor, particularly below the zone of *Baculites taylorensis* Adkins, that lies about 150 feet above the compact Austin chalk in Travis County. This series of beds is well exposed along the Austin-Manor highway, and a few of these exposures have herein been recorded.

Neoholotype, from Taylor formation, Sta. 226–T–7, in Plummer Collection (S–807) ; neoparatypes, from same locality (S–808.1 to 808.3). Neoparatypes, from Taylor formation, Sta. 226–T–5 (S–810), Sta. 226–T–6 (S–809.1 and 809.2), and Sta. 57–T–2 (S–811). Specimens in the Bureau of Economic Geology.

Genus FRONDICULARIA Defrance, 1824

FRONDICULARIA CLARKI Bagg

Pl. IX, figs. 16, 17

Frondicularia clarki Bagg, 1895, Johns Hopkins Univ. Circ. 121, p. 2 (list).

Frondicularia clarki Bagg, 1898, U. S. Geol. Survey Bull. 88, p. 48, pl. 3, fig. 4.

Frondicularia alata Carsey (non d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 40, pl. 2, fig. 1.

Frondicularia clarki Bagg, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, p. 34, pl. 5, figs. 1, 2.

The test previously figured from Navarro strata has been closely compared with suites of similar tests from several Upper Cretaceous outcrops in central Texas, and it is found to be clearly the youthful stage of the frequent *F. clarki* Bagg, which is characteristically elongate oval to elliptical in outline in maturity at a length of about 2.5 mm. The angular outline of this youthful test is variable in this species but is very common in the early stage of this form in Navarro material. Though examination of considerable clay from Jones Crossing on Onion Creek (Sta. 226–T–9) has yielded no mature tests of this form, several perfect and well developed tests and accompanying young tests in the lower Navarro strata at Corsicana (Sta. 174–T–4) exhibit clearly the ontogenic features of the species.

The megalospheric proloculum is strongly bulbous and carries at least one central longitudinal ridge. Other specimens bear in addition a less elevated but distinct ridge on each side of the central ridge. The chambers of this species are perfectly smooth and very finely perforate, and they show no tendency to embrace the earliest portion of the test. Though this form has been described as having perfectly smooth sutures, all the specimens studied from the Texas strata possess sutures marked by very low, blunt elevations that are evident under strong magnification and in light thrown across the test at a very low angle.

Another closely allied, but rather rare and somewhat stouter, form in the Taylor strata exhibits lateral angularity of outline through growth, and in light at a low angle across its tests, the sutures are clearly marked by shallow depressions.

Plesiotype (youthful), from lower Navarro formation, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Plesiotype (adult), from lower Navarro formation, Sta. 174–T–4, in Plummer Collection (S–812). Specimen in the Bureau of Economic Geology.

Family POLYMORPHINIDAE

Genus GUTTULINA d'Orbigny, 1826

GUTTULINA PROBLEMA d'Orbigny

Pl. XIII, fig. 1

Guttulina problema d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 266, No. 14.

Polymorphina communis Carsey, 1926, Univ. Texas Bull. 2612, p. 42, pl. 1, fig. 5.

The specimen figured from the lowermost Navarro strata (Sta. 226–T–9) is well developed for this form as it occurs in this outcrop. Compared with a typical test of *G. problema* this specimen appears to be somewhat underdeveloped.

Plesiotype, from Navarro formation, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Specimen in the Bureau of Economic Geology.

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, 1928

PSEUDOPOLYMORPHINA CUYLERI n. sp.

Pl. IX, figs. 18–21

Test large, broadly elliptical or ovate, compressed, generally lobate, ornamented by thickening of shell matter over the successive apertures on each side; periphery rather narrowly rounded, early chambers triloculine, later chambers biserial; sutures on most tests slightly depressed near the periphery, thickened toward the central portion of the test on each side; aperture radiate, protruding.

Length of holotype 2.4 mm.; breadth 1.6 mm.

The plane of biseriality in *Pseudopolymorphina cuyleri* n. sp. is established by the fourth chamber, and the typical outline and ornamentation develops very early in its biserial stage. The study of over fifty mature tests reveals a variation in the degree of elevation of the shell matter over the successive apertures, and a few tests are quite smooth. The periphery of some tests is almost an even and unbroken curve; whereas others are deeply lobate.

From the same outcrop Cushman and Ozawa have recorded[19] a form that they have referred to *P. mendezensis* (White). This is much less regular in its outline, has fewer biserial chambers, and is a smaller test.

P. cuyleri[20] n. sp. is restricted to the Navarro formation, where it is rather rare, though at its type locality it is common. The only other polymorphine test of similar size in the Texas strata is *Polymorphina cushmani* Plummer of the Midway formation (Eocene). *Pseudopolymorphina cuyleri* n. sp. has been observed as a rare form in the Navarro strata at Sta. 146–T–5 and in the uppermost Navarro at Sta. 165–T–4.

Holotype and paratype, from lower Navarro strata, Sta. 174–T–4, in Plummer Collection (S–813, S–814.1 to S–814.3). Metatypes in the Bureau of Economic Geology.

Genus RAMULINA Rupert Jones, 1875

RAMULINA GLOBULIFERA H. B. Brady

Pl. XI, fig. 15

Ramulina globulifera H. B. Brady, 1879, Quart. Jour. Mic. Soc., vol. 19, p. 272, pl. 8, figs. 32, 33.

Lagena incidenta Carsey, 1926, Univ. Texas Bull. 2612, p. 30, pl. 4, fig. 12.

Ramulina gobulifera White, 1928, Jour. Paleont., vol. 2, p. 214, pl. 29, fig. 2.

This common Cretaceous species is well represented by the specimen previously figured from the Taylor formation. The globular segment is somewhat hispid and bears the characteristic slender stolon tubes. This species occurs commonly throughout the Lower and Upper Cretaceous strata in Texas and somewhat rarely in Tertiary formations.

Plesiotype (holotype of *Lagena incidenta* Carsey), from Taylor formation, Sta. 226–T–8, in Carsey Collection, department of geology, The University of Texas. Plesiotype,

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19Cushman, J. A., and Ozawa, Y., A monograph of the foraminiferal family Polymorphinidae recent and fossil: Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 109, pl. 28, figs. 7–9, 1930.

20This species has been named for Robert Cuyler, instructor in micropaleontology, department of geology, The University of Texas.

from same outcrop, in Plummer Collection (S–815). Specimens in the Bureau of Economic Geology.

Family NONIONIDAE

Genus NONIONELLA Cushman, 1926

NONIONELLA ROBUSTA n. sp.

Pl. XIV, fig. 12

Nonionina scapha Carsey (non Fichtel and Moll), 1926, Univ. Texas Bull. 2612, p. 49, pl. 1, fig. 2.

Test very small, moderately compressed, about equally biconvex but unsymmetrically developed; periphery narrowly rounded and bluntly angular in maturity, only slightly lobate in later portion of some tests but an even curve on most tests; chambers about eight in the final convolution, rapidly legthening, gently inflated on most specimens, distinctly but not coarsely punctate; sutures slightly depressed or flush with the contour of the test, somewhat curved; umbilicus on dorsal side small, narrow, depressed, shallow, showing minute chambers of inner whorl; on ventral side umbilical depression filled with the successive short extensions of the chambers filling the depression irregularly; aperture a low slit on the periphery at base of final chamber.

Length of holotype .30 mm.; greatest breadth .22 mm.; thickness across septal face .14 mm.

The specimen chosen for the holotype shows the average proportions for the test that is very common in the Navarro strata (Sta. 226–T–9) from which a test has already been figured. The asymmetrical development of the chambers is not strong but very distinct. The chambers on the ventral side develop short thin extensions that fill the umbilical area irregularly and compactly. The outline and proportions are similar to those of forms referred to *Nonion scapha* (Fichtel and Moll), but the inequilateral development of the chambers now requires generic differentiation. The test described as a variety of *Nonion scapha* (Fichtel and Moll) in the Jackson formation is similarly developed, but its tests are somewhat longer and more compressed than this Cretaceous form, which presents in edge view a very broad septal face.

Throughout the Navarro formation this species is very frequent. It is rare in the Taylor and very rare in the Austin.

Holotype, from lower Navarro strata, Sta. 226–T–9, in Plummer Collection (S–816). Metatype in Carsey Collection, department of geology, The University of Texas. Specimens in the Bureau of Economic Geology.

Family HETEROHELICIDAE

Genus GÜMBELINA Egger, 1899

GÜMBELINA EXCOLATA Cushman

Pl. VIII, fig. 10

Gümbelina excolata Cushman, 1926, Contrib. Cushman Lab. Foram. Res., vol. 2, p. 20, pl. 2, fig. 9.

Textularia costata Carsey, 1926, Univ. Texas Bull. 2612, p. 26, pl. 1, fig. 4.

Gümbelina excolata Cushman, 1927, Jour. Paleont., vol. 1, p. 157, pl. 28, fig. 13.

Gümbelina excolata White, 1928, Jour. Paleont., vol. 3, p. 34, pl. 4, fig. 7.

Test small, considerably compressed, enlarging from a pointed initial extremity to a broadly rounded oral extremity; chambers distinct, somewhat turgid, increasing gradually with age, ornamented by coarse, curved, longitudinal costae, which are for the most part not confluent; sutures sharply but not deeply depressed, strongly oblique to the axis of the test; aperture a narrow arched opening across a restricted septal face, which in full maturity on many specimens lies above the apex of the penultimate chamber.

Length of average specimen .35 mm.; breadth .22 mm.

The specimen previously figured, and here refigured, from lower Navarro strata (Sta. 226–T–9) bears all the characters of the form at its type locality in the Mendez formation in Mexico. The outcrop of the Navarro on

Walker Creek (Sta. 165–T–4) offers many beautiful empty tests in their original state. This small, much-compressed, coarsely costate form is so distinct from its accompanying congeners in Texas Cretaceous strata that confusion is unlikely.

Plesiotype (holotype of *Textularia costata* Carsey), from lower Navarro strata, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Specimens in the Bureau of Economic Geology.

GÜMBELINA GLOBIFERA (Reuss)

Pl. IX, fig. 14

Textularia globifera Reuss, 1860, Sitz. k. Akad. Wiss. Wien, vol. 40, p. 232, pl. 13, figs. 7, 8.

Test very small, moderately compressed, smooth, periphery lobate, broadly rounded; chambers rapidly enlarging during youth but only very gradually enlarging through maturity, moderately appressed; sutures strongly depressed; aperture a strongly arched opening at base of last chamber.

Average length .2 mm.; width .1 mm.

This small smooth form is distinguished from *G. globulosa* (Ehrenberg) by its somewhat more appressed chambers and the less flaring peripheral outline of the mature portion of the test. The form previously recorded (but missing from the Carsey Collection) by this name from lower Navarro strata is described as finely striate and can not, therefore, be included here.

G. globifera (Reuss) is very frequent in Upper Cretaceous strata in Texas. *G. globulosa* (Ehrenberg) occurs in the Washita division of the Lower Cretaceous formations in north Texas as well as in some of the Upper Cretaceous strata.

Plesiotype, from uppermost Navarro strata, Sta. 165–T–4, in Plummer Collection (S–818). Specimens in the Bureau of Economic Geology.

Genus VENTILABRELLA Cushman, 1928

VENTILABRELLA CARSEYAE n. sp.

Pl. IX, figs. 7–9

Textularia globulosa Carsey (non Ehrenberg), 1926, Univ. Texas Bull. 2612, p. 25, pl. 5, fig. 2.

Test V-shaped, laterally somewhat compressed, composed throughout much of its development of appressed, well-inflated, distinctly striate biserial chambers that increase rapidly in size with growth, later chambers arranged irregularly in the plane of biseriality forming a fully mature test that is somewhat fan-shaped in peripheral outline; sutures deeply incised; aperture a broad lunate opening at base of septal face of biserial portion of test and a similar opening on each side of many of the later chambers.

Length of holotype .48 mm.; breadth .40 mm.; thickness .25 mm.

All the microspheric tests observed are biserial throughout, this biserial development being larger than only the biserial series of chambers of most megalospheric tests. The specimen figured shows the early small but very distinct coil of about five chambers. The last chamber bears a supplementary aperture on its periphery, but no test clearly referable to the microspheric generation shows further development of the irregular late chambers characteristic of the megalospheric form. This late stage in *V. carseyae* n. sp. consists of but very few chambers across the top of the biserial series. An abundant accompanying congener at the type locality for this species is more coarsely striate, has fewer biserial chambers, and numerous later irregularly arranged chambers.

The specimen "*Textularia globulosa* Ehrenberg" in the Carsey Collection is refigured for comparison with *Ventilabrella carseyae* n. sp. This specimen is completely mineralized and the aperture is obscured by mineral deposit. Though the test is somewhat deformed, it exhibits the shape and ornamentation of this new species.

V. carseyae n. sp. is very common in the Navarro formation and occurs also in the Taylor.

Holotype and paratypes, from uppermost Navarro formation, Sta. 165–T–4, in Plummer Collection (S–819.1 to 819.3). Metatypes in the Bureau of Economic Geology.

Family BULIMINIDAE

Genus BULIMINELLA Cushman, 1911

BULIMINELLA CARSEYAE n. sp.

Pl. VIII, fig. 9

Bulimina compressa Carsey (non Bailey, 1851), 1926, Univ. Texas Bull. 2612, p. 29, pl. 4, fig. 14.

Test ovate, about twice as long as broad, initial extremity bluntly pointed; chambers about four in each mature whorl, turgid, smooth; sutures distinctly depressed, disposed at a strong angle to the elongate axis of the test; aperture small, comma-shaped, in a strong depression on the septal face and overhung by a sharp projection of the apex of the last chamber and marked by a minute and very narrow apertural flap extending down the long side of the septal face.

Length of holotype .39 mm.; breadth .22 mm.

The holotype of *Bulimina compressa* Carsey (non Bailey) is almost completely covered by a rough deposit of calcite but sufficient of the test is visible to identify the form, which is abundant at its type locality. A typical triserial bulimine test of about the same size occurs in some outcrops with *Buliminella carseyae* n. sp.

This form is diagnostic of the Taylor formation and occurs from base to top.

Holotype, from Taylor strata, Sta. 226–T–8, in Plummer Collection (S–820). Metatypes in the Bureau of Economic Geology.

Genus BULIMINA d'Orbigny, 1826

BULIMINA PUPOIDES d'Orbigny

Pl. IX, fig. 15

Bulimina pupoides d'Orbigny, 1846, Foram. Foss. Vienne, p. 185, pl. 11, figs. 11, 12.
Bulimina pupoides Carsey, 1926, Univ. Texas Bull. 2612, p. 29, pl. 4, fig. 3.
Bulimina pupoides Plummer, 1927, Univ. Texas Bull. 2644, pl. 2, fig. 11.

Test broadly ovate, broadest toward the oral extremity, some specimens with a very short minute apical spine, initial end narrowly to broadly rounded on megalospheric tests and pointed on microspheric tests; chambers inflated, smooth; sutures depressed slightly on early portion of test and more deeply depressed between the later chambers; aperture a long narrow loop-shaped orifice extending from the base of the septal face upward toward the apex, some unusually well-preserved tests being provided with a tiny tooth.

Average length .45 mm.; breadth .25 mm.

This species is somewhat variable in shape, some tests being evenly ovate and compact, whereas others are more elongate and attain almost the development and curvature of *B. elongata* d'Orbigny. At a few localities the early chambers bear exceedingly fine and indistinct striae distinguishable only under high magnification.

Bulimina pupoides d'Orbigny is very frequent in the Navarro formation. In the underlying Taylor it is common in a few places, but in general the form is infrequent in this fauna.

Plesiotypes, from lower Navarro strata, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas, and in Plummer Collection (S–821). Specimens in the Bureau of Economic Geology.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA DECORATA Jones

Pl. X, fig. 10

Bolivina decorata Jones, 1886, in Wright, Proc. Belfast Nat. Field Club, App. No. 9, p. 330, pl. 27, figs. 7, 8.
Bolivina decorata Cushman, 1926, Bull. Amer. Assoc. Pet. Geol., vol. 10, p. 586, pl. 15, fig. 11.
Bolivina latticea Carsey, 1926, Univ. Texas Bull. 2612, p. 27, pl. 4, fig. 9.
Bolivinoides decorata var. *delicatula* Cushman, 1927, Contrib. Cushman Lab. Foram. Res., vol. 2, p. 90, pl. 12, fig. 8.
Bolivinoides decorata var. *delicatula* Cushman, 1927, Jour. Paleont., vol. 1 p. 158, pl. 28, fig. 7.
Bolivinoides decorata var. *delicatula* Cushman, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 99, pl. 14, fig. 9.
Bolivina decorata White, 1929, Jour. Paleont., vol. 3, p. 43, pl. 5, fig. 1.

Test elongate oval in outline with the broadest portion near the oral extremity; chambers oblique, narrow, bearing bluntly rounded longitudinal ridges that rise on the upper half of each chamber and extend downward to the suture or even across the sutural depression; sutures slightly depressed and on many specimens much obscured by the surface markings, strongly oblique; aperture a typical bolivine orifice on the septal face extending from the base upward almost to the apex.

Length of figured specimen .50 mm.; greatest breadth .24 mm.

The Taylor specimen figured as *B. latticea* Carsey, here refigured, bears none of the salient characteristics of *Bolivinoides* Cushman, such as the thickening of the shell material along the oral extremity of the test and a nearly terminal aperture that does not reach down to the penultimate chamber. The holotype is typical of the form as it occurs throughout the Taylor marls. It may be somewhat irregular in outline as is the test figured, or it may be perfectly symmetrical. In some outcrops the tests average shorter than at others, but the essential characters such as proportions and surface markings persist. Wherever it is common, tests show considerable variation in all details, and in the Texas section no specific or varietal divisions seem advisable.

Bolivina decorata Jones is diagnostic of the Taylor formation in the Texas section.

Plesiotype (holotype of *B. latticea* Carsey), from Taylor formation, Sta. 245–T–3, in Carsey Collection, department of geology, The University of Texas. Specimens in the Bureau of Economic Geology.

Genus LOXOSTOMA Ehrenberg, 1854

LOXOSTOMA PLAITUM (Carsey)

Pl. X, figs. 5–7

Bolivina plaita Carsey, 1926, Univ. Texas Bull. 2612, p. 26, pl. 4, fig. 2.

Proroporus plaita Cushman, 1927, Contrib. Cushman Lab. Foram, Res., vol. 2, p. 89, pl. 12, fig. 7.

Loxostomum plaitum Cushman, 1928, Foram. Class Econ. Use, Cushman Lab. Foram. Res., Special Pub. No. 1, pl. 37, fig. 9.

Test very elongate, compressed, slender, unornamented in typical form but bearing a beadlike limbation on each of the sutures in especially calcareous clays; chambers smooth, somewhat turgid, typically bolivine in arrangement throughout most of the test but tending toward uniseriality in advanced maturity; sutures simple and depressed in typical form but somewhat limbate in center of test on each side of some tests, at an angle of 38 to 40 degrees to the axis of the test; aperture bolivine and narrowly comma-shaped throughout most of its growth but located higher on the final chambers in old age.

Length of neoholotype .58 mm.; breadth .13 mm. The length of some very large specimens is .8 mm.

Though the holotype has been lost, the features originally illustrated and described readily identify the species that is very common at its type locality. The clays throughout most of the 90 feet of exposure (Sta. 226–T–9) are highly calcareous, and the varietal form with the limbate and beaded sutures is the more common. This is the type of test represented by metatypes found in the Carsey Collection (Pl. X, fig. 7). Following the original description and figure that shows simple depressed sutures, the neoholotype has been chosen to fit these requirements. Such tests are more common in a few slightly ferruginous strata in the outcrop. All gradations from the typical form to the more ornate variety can easily be found in almost any sample of this material, and other outcrops of this same age yield similar suites of specimens. The angle between the axis of the test and the direction of the sutures is sufficiently constant to prohibit specific distinction. The present author prefers not to erect a new variety.

Loxostoma plaitum (Carsey) is very common in the Navarro formation and occurs rarely in the Taylor clays. It has been reported from the upper Ripley of Mississippi and occurs also in similar beds of Alabama.

Neoholotype, from Navarro strata, Sta. 226–T–9, in Plummer Collection (S–823); varietal form from same outcrop (S–824). Neoparatype, from same outcrop, in Carsey Collection, department of geology, The University of Texas. Specimens in the Bureau of Economic Geology.

Genus SIPHOGENERINOIDES Cushman, 1927

SIPHOGENERINOIDES PLUMMERI (Cushman)

Pl. IX, figs. 1–6

Siphogenerina plummeri Cushman, 1926, Proc. U. S. Nat. Mus., vol. 67, art. 25, p. 18.

Siphogenerina plummeri Cushman, 1926, Contrib. Cushman Lab. Foram. Res., vol. 2, p. 15, pl. 1, fig. 7.

Siphogenerinoides plummeri Cushman, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, pl. 13, fig. 16.

Siphogenerinoides plummeri Cushman, 1928, Cushman Lab. Foram. Res., Spec. Pub. No. 1, pl. 33, fig. 27, pl. 34, fig. 16.

Siphogenerinoides plummeri Cushman, 1929, Contrib. Cushman Lab. Foram. Res., vol. 5, p. 55.

Test elongate, subcylindrical, slowly increasing in breadth with advancing age toward a broadly rounded oral extremity; initial end bluntly rounded in megalospheric form and on some specimens slightly spinose, very attenuate in microspheric form; early chambers biserial, laterally somewhat compressed in the megalospheric form, much compressed in microspheric form and slightly twisted, later chambers uniserial and uncompressed, somewhat inflated, coarsely punctate; sutures faintly depressed between early chambers, increasingly depressed toward last-formed chamber; surface conspicuously ornamented by eight to thirteen sharp longitudinal major costae that may continue unbroken across the sutures or may be broken into minute downward-pointing, short, sharp, posterior spines, and also by less distinct short minor costae on the uniserial chambers between the major ribs; aperture a central terminal, elliptical orifice bounded by a short rolled collar, the end of which is elevated above the general level of the collar and curved inward; internal tube, which connects the foramina throughout the test and projects above the apex of the last chamber to form the apertural collar, well developed and curved slightly in opposite directions in successive chambers.

Length from an average of about .7 mm. up to 1.0 mm.

The first description of this species was made from observations on only three or four tests obtained from a very small lump of clay. Later collections from the same outcrop show these beds very rich in beautifully preserved tests of both megalospheric and microspheric forms of the species. A small and well-washed concentrate has yielded several hundred perfect specimens of which more than fifty are microspheric. Only two of the microspheric tests found are as large as the average mature megalospheric test. Because the early chambers of most specimens are filled with pyrite or limonite, canada-balsam mounts of the much-compressed early chambers of microspheric tests reveal with exquisite clarity the perfect bolivine biserial arrangement throughout a series of twelve to fourteen gradually enlarging chambers before uniseriality is attained. The megalospheric form usually exhibits but four or five true bolivine chambers beyond the proloculum. Between the compactly interlocking biserial chambers and the perfect uniserial chambers of tests of both generations are from two to four transition loosely biserial chambers that extend across the entire width of the test but are symmetrical to the plane of biseriality and are separated by sutures that zigzag at a low angle across this plane similar to the later chambers of *Loxostoma.*

The stoloniferous internal tube is well developed, but in canada-balsam mounts the tenuity of its shell wall makes it only faintly visible, and the prominence of the external costae further obscure its outline. Direct observation of this feature was obtained by dissolving a portion of the outer wall of a large test by applying weak acid at the tip of a fine brush. A test on which this delicate operation was performed is shown on Pl. IX, fig. 6. It is the extension of this tube through the end of the last chamber that forms the short collar that almost encircles the orifice.

The genotype of *Siphogenerinoides* is here placed in the family Buliminidae Cushman, of which the internal tube is a fundamental character. Whereas *Siphogenerina,* characterized by its triserial initial stage, has probably evolved from *Bulimina* through *Uvigerinella* with its collared aperture and *Uvigerina* with its aperture bounded by a neck and phialine lip, *Siphogenerinoides* has probably arisen through bolivine stock. The frequent twisting of the earliest biserial chambers of the microspheric test is possibly an inheritance from *Virgulina* and *Bolivina.* The basic characters that differentiate *Siphogenerinoides* from *Siphogenerina* are, therefore, the biserial arrangement of numerous early chambers of the microspheric form.

S. plummeri (Cushman) has been observed by the present author only in Navarro strata immediately subjacent to basal Midway beds. At the type locality (Sta. 165–T–4) the form occurs throughout about ten feet of uppermost Navarro in contact with basal Midway greensand. On the west bank of Brazos River in Milam County almost on the Falls County line is an excellent exposure of the Cretaceous-Eocene contact, and the upper ten feet of the Navarro beds yield this species somewhat sparingly but in well-developed tests. In Hopkins County in a small gully about one mile in a direct line south-southwest of Peerless the upper ten feet of the Navarro below typical basal Midway glauconitic clay yield numerous tests of this form. Material from a dug water well about one mile southeast of Kemp is rich in tests of *S. plummeri*, but a large fault just south of this location makes determination of the precise stratigraphic position somewhat uncertain, though it is obvious that these beds lie high in the Navarro. These field data show that this species has a wide geographic distribution in uppermost Navarro strata, yet its occurrences are scattered. It is possible that the beds bearing these tests represent a very late Navarro deposition that was eroded almost entirely during the period of elevation of the area prior to Eocene deposition, so that we find only remnants here and there below the Midway formation.

Plesiotypes from type locality, uppermost Navarro formation, Sta. 165–T–4, in Plummer Collection (S–825.1 to S–825.4, S–826). Specimens in the Bureau of Economic Geology.

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA SELIGI Cushman

Pl. XIV, fig. 10

Uvigerina seligi Cushman, 1925, Contrib. Cushman Lab. Foram. Res., vol. 1, p. 1, pl. 4, fig. 1.

Uvigerina tenuistriata Carsey (non Reuss), 1926, Univ. Texas Bull. 2612, p. 42, p. 1, fig. 1.

Test very small, average specimen about twice as long as broad, the last two whorls comprising most of the test; chambers strongly marked by two prominent longitudinal and faintly beaded costae that give the appearance of bicarination to each of the three longitudinal series of chambers, which strongly overlap; sutures between later mature chambers depressed, giving a distinctly lobate outline to the test; aperture a short cylindrical neck with phialine lip.

Length of plesiotype .26 mm.; thickness .12 mm.

The specimen figured from the basal Navarro strata on Onion Creek has become so badly crushed that a new plesiotype from the same outcrop has been chosen for refiguring. In these lowermost Navarro beds *U. seligi* Cushman is very abundant, and the average test is strongly costate throughout growth. A few exceptionally well-developed tests bear a smooth or almost smooth final chamber, a probable sign of senility in the individual form.

The species was originally named from some well sample in Bossier Parish, Louisiana, and recorded as Upper Cretaceous. The form is very common in the Navarro formation in Texas in numerous outcrops and in well material from this zone. In uppermost Ripley strata on Owl Creek, near Ripley, Mississippi, it is a rather rare but well-developed species in the faunal assemblage.

Plesiotype, from lower Navarro strata, Sta. 226–T–9, in Plummer Collection (S–827). Specimens in the Bureau of Economic Geology.

Genus DENTILINOPSIS Reuss, 1860

DENTILINOPSIS EXCAVATA (Reuss)

Pl. IX, figs. 11, 12

Rhabdogonium excavatum Reuss, 1862, Sitz. k. Akad. Wiss. Wien, vol. 46, p. 91, pl. 12, fig. 8.

Rhabdogonium excavatum Berthelin, 1880, Mém. Soc. géol. France, ser. 3, vol. 1, Mém. 5, p. 47.

Rhabdogonium excavatum Egger, 1899, Abh. k. bayer. Akad. Wiss. (Cl. II), vol. 21, p. 92, pl. 17, figs. 23, 24.

Rhabdogonium minutum (?) Burrows, Sherborn, and Bailey, 1890, Jour. Roy. Mic. Soc., p. 559, pl. 10, fig. 8.

Rhabdogonium excavatum Chapman, 1894, Jour. Roy. Mic. Soc., p. 160, pl. 4, fig. 9.

Rhabdogonium excavatum Franke, 1925, Abh. Geol.-Paleont. Inst. Univ. Griefswald, vol. 6, p. 53, pl. 4, fig. 20.

Clavulina sp. Margaret Carpenter, 1925, Univ. Texas Bull. 2544, pl. 16, fig. 4.

Rhabdognium excavatum Franke, 1928, Abh. preuss. geol. Landesan., n. s., vol. 3, p. 73, pl. 6, fig. 22.

Test elongate, tricarinate, straight to slightly arcuate; chambers uniserial from a globular proloculum, short, triangular in cross-section with concave lateral faces, curved downward, lobate along lateral edges with an occasional posterior projection in the form of a blunt spine; sutures excavated; aperture a terminal round opening.

Average length .45 mm.; breadth .18 mm.

Most tests of this species in the Texas strata are straight, but some unusually well-developed and unusually long tests show a slight curvature. The degree of lateral excavation and the degree of angularity of the lateral angles vary amongst specimens from the same sample. The form is very distinctive in the faunas in which it occurs and invites no confusion in identification.

Dentilinopsis excavata (Reuss) is very frequent in the Grayson marl (Sta. 61–T–2) in Denton and Tarrant counties, north Texas. In the Del Rio formation (Sta. 226–T–10) of central Texas it also occurs. So far as present data show this species is diagnostic of these two equivalent formations at the top of the Lower Cretaceous section. It has been widely reported from Cenomanian strata of England, France, and Germany, and from Turonian of Germany.

Plesiotypes, from Grayson formation, Sta. 61–T–2, in Plummer Collection (S–829.1 and 829.2). Specimen in the Bureau of Economic Geology.

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

DISCORBIS CORRECTA Carsey

Pl. XIV, figs. 1–4

Discorbis correcta Carsey, 1926, Univ. Texas Bull. 2612, p. 45, pl. 3, fig. 5.

Test plano-convex, with dorsal face gently rounded and ventral face flat or slightly concave; periphery very narrowly rounded, lobate; chambers moderately curved, from five to seven in final whorl, distinctly but not very coarsely punctate; sutures depressed, curved; umbilicus broad, shallow, in perfect condition covered by the successive umbilical flaps from the chambers of the final whorl; aperture a low opening into the umbilicus under the flap.

Average diameter .35 mm.; thickness about .12 mm.

The holotype was well selected to represent the average tests of this species, which is very common at its type locality. The original photograph, however, has exaggerated by its relations of lights and shadows some very faint angulations in the periphery and some slight mineralization at these points. The new figure of this same specimen presents faithfully the true outline, which is typical of this form. In number of chambers considerable range of variation is exhibited in the suite of specimens studied. Five or six constitute the average number, but as many as seven or even eight have been observed, as shown by the series of figures. Tests of very similar structure have been figured under various names, such as *D. bertheloti* (d'Orbigny), *D. vilardebouana* (d'Orbigny) and *D. rosacea* (d'Orbigny), but many of these have not followed closely the types for the names assigned, or those that have followed the types display very sharp and thin peripheral margins or characteristic limbations. *D. correcta* Carsey is characteristically very narrowly rounded along the margin, and no thickening of shell matter is present on any part of the test wherever the test has been observed. The delicate umbilical flaps can very rarely be observed in good condition, but the ragged edges of the chambers around the umbilicus and rare tests of unusual presentation prove the original structure of this area (Pl. XIV, fig. 2).

The species has been observed in the Texas Upper Cretaceous most commonly in the Navarro strata. It is rare in the Taylor, and very rare in the Austin.

Holotype, from lower Navarro strata, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Plesiotypes, from same outcrop, in Plummer Collection (S–830.1 to 830.3). Metatypes in the Bureau of Economic Geology.

Genus VALVULINERIA Cushman, 1926

VALVULINERIA ASTERIGERINOIDES n. sp.

Pl. XIV, fig. 6

Anomalina sp. Carpenter, 1925, Univ. Texas Bull. 2544, pl. 17, figs. 9, 10.

Test small, round to somewhat elliptical in outline, slightly lobate; periphery broadly rounded; dorsal face somewhat depressed; ventral face gently convex with a broadly excavated umbilicus that is surrounded by a star-shaped pattern formed by the overlap of successive umbilical flaps; chambers seven to eight in mature convolution, last two or three slightly turgid; sutures almost radiate on both sides, slightly depressed between last few chambers; aperture near umbilical area under a broad conspicuous flap that marks the posterior side of each chamber.

Longest diameter of holotype .34 mm.; shortest diameter .26 mm.; thickness through last chamber .15 mm.

The most striking characteristic of this new species is the ventral stellar pattern formed by the overlapping successive broad umbilical flaps. The general structure of the trochoid coil is typical of the genus *Valvulineria* with the early convolution depressed beneath the level of the last convolution on the dorsal side and with its almost radiate sutures.

In Texas *V. asterigerinoides* n. sp. has so far been found only in the Del Rio formation of central Texas and in the equivalent lower Grayson formation of north Texas. It is one of the very few Washita species that has been found stratigraphically restricted.

Holotype, from Grayson formation, Sta. 61–T–2, in Plummer Collection (S–831). Metatypes in the Bureau of Economic Geology.

Genus GYROIDINA d'Orbigny

GYROIDINA DEPRESSA (Alth)

Pl. XIII, fig. 3

Rotalina depressa Alth, 1850, Haid. Nat. Abh., vol. 3, p. 266, pl. 13, fig. 21.

Rotalia cretacea Carsey, 1926, Univ. Texas Bull. 2612, p. 48, pl. 5, fig. 1.

Gyroidina depressa Cushman and Church, 1929, Proc. Calif. Acad. Sci., vol. 18, No. 16, p. 515, pl. 41, figs. 4–6.

Test biconvex, much compressed, with narrowly rounded peripheral margin, dorsal face only slightly convex, ventral face somewhat more convex, umbilicus small and open; chambers numerous, narrow, only last three or four turgid, from 11 to 12½ in the mature whorl; sutures depressed only between later chambers, faintly limbate in earlier portion of coil on dorsal face but not elevated, curved on dorsal face, almost radiate on ventral face; aperture a very narrow slit at base of septal face on ventral side.

Longest diameter of figured specimen .28 mm.; thickness .1 mm.

The test that was previously figured from Navarro strata has been crushed, but the illustration shows clearly the characters of the form common in the outcrop that constitutes the type locality for *G. cretacea* (Carsey), here referred to *G. depressa* (Alth).

This species is common in the richly foraminiferal beds of Navarro age and is rare in the Taylor. It has been observed in the Cretaceous strata in California and in the Colon shale of Venezuela.

Plesiotype, from lower Navarro strata, Sta. 226–T–9, in Plummer Collection (S–832). Specimens in the Bureau of Economic Geology.

GYROIDINA NITIDA (Reuss)

Pl. XIV, fig. 5

Rotalina nitida Reuss, 1844, Geogn. Skizze Böhmen, vol. 2, pt. 1, p. 214.

Rotalina nitida Reuss, 1845–1846, Verstein. böhm. Kreidef., pt. 1, p. 35, pl. 8, fig. 52, pl. 12, figs. 8, 20.

Placentula nitida Berthelin, 1880, Mém. Soc. géol. France, ser. 3, vol. 1, No. 5, p. 69, pl. 4, fig. 11.

Rotalia soldanii var. *nitida* Chapman, 1898, Jour. Roy. Mic. Soc., p. 9, pl. 2, fig. 2.

Pulvinulina sp. Margaret Carpenter, 1925, Univ. Texas Bull. 2544, pl. 17, figs. 11, 12.

Test small, circular to very slightly elliptical in peripheral outline, composed of about two and one-half convolutions; periphery broadly rounded; dorsal face gently excavated, ventral face more strongly convex; umbilicus small, excavated, but on perfectly preserved specimens obscured by the posterior extension of the last chamber into a broad thin flap; chambers six to seven in final whorl, smooth, last few slightly turgid; dorsal sutures smooth on early part of test but somewhat incised between last few chambers; ventral sutures radiate, very little incised; aperture a narrow slit at base of septal face extending toward the umbilicus.

Average diameter about .28 mm.; thickness .14 mm.

This small and subglobular test is especially distinctive for its umbilical flap which is the strongly exaggerated development of a small posterior point of the final chamber of many of its congeners in other Texas strata. Because it fits very closely the body of the coil, it is well preserved on most tests.

In the Texas Cretaceous section *G. nitida* (Reuss) is abundant in the Del Rio and Grayson formations and occurs also in the other Washita formations in north Texas. Material from the Gault of Folkestone has yielded this same structure with the same umbilical flap. From this classic section Chapman has reported the species as very common in the upper part of the series and rare or frequent in the lower part. It is well known from the equivalent Cenomanian beds of France and Germany and Reuss has reported it also from the lower Turonian strata.

Plesiotype, from Grayson formation, Sta. 61–T–2, in Plummer Collection (S–833). Specimens in the Bureau of Economic Geology.

Genus EPONIDES Montfort, 1808

EPONIDES MICHELINIANA (d'Orbigny)

Pl. XIV, fig. 11

Rotalina micheliniana d'Orbigny, 1840, Mém. Soc. géol. France, vol. 4, pt. 1, p. 31, pl. 3, figs. 1–3.

Truncatulina refulgens var. *conica* Carsey, 1926, Univ. Texas Bull. 2612, p. 46, pl. 4, fig. 15.

Test conical, dorsal face being almost perfectly flat, ventral face strongly convex with sides sloping steeply into the deep umbilical area, very sharply carinate, somewhat lobate; chambers about six in final convolution; sutures strongly oblique and straight or faintly curved on dorsal face, a few being slightly elevated, radiate and somewhat depressed on ventral side; wall very finely punctate; umbilicus a deep narrow excavation; aperture a very low long slit at base of septal face between periphery and umbilicus.

Diameter of figured test .6 mm.; height of convexity on ventral side .3 mm.

In the Taylor formation *E. micheliniana* (d'Orbigny) is very frequent but somewhat variable in the degree of convexity. It is doubtful whether any of these variations are sufficiently constant to define other species of varieties. In the Senonian strata in France, Germany and England this is a common form.

Plesiotype (holotype of *Truncatulina refulgens* var. *conica* Carsey), from Taylor strata, Sta. 245–T–3, in Carsey Collection, department of geology, The University of Texas. Specimens in Bureau of Economic Geology.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA WASHITENSIS Carsey

Pl. XIII, fig. 12

Globigerina sp. Margaret Carpenter, 1925, Univ. Texas Bull. 2544, pl. 17, fig. 5.

Globigerina washitensis Carsey, 1926, Univ. Texas Bull. 2612, p. 44, pl. 7, fig. 10, pl. 8, fig. 2.

Test compact, with moderately appressed globular chambers in a low trochoid spire of two or two and one-half convolutions; chambers from three and one-half to as many as six in the whorl; surface coarsely and conspicuously marked into rather regular polygonal areas by exogenous ridges that form a honeycomb pattern over the whole test; aperture at base of final chamber opening into a deep umbilical excavation.

Longest diameter of neoholotype .42 mm., shortest diameter .32 mm.; thickness through spire .22 mm.

The holotype has been lost, but the original description identifies the very frequent coarsely reticulate globigerine species at its type locality. Almost any single sample yields tests that present a wide range of variation in arrangement and number of chambers. Most tests show a rather high trochoid spire, and the larger the number of chambers in the whorl, the higher the spire. The dominant and diagnostic feature of this species that separates it from all other globigerine forms in the Texas section is the striking surface pattern.

In the Washita division of the Lower Cretaceous *Globigerina washitensis* Carsey has been recorded from the Del Rio clay in central Texas and from the Grayson and Main Street formations of Denton and Tarrant counties. In three sections of Georgetown limestone, it is frequent and rare tests exhibit the spines projecting from the polygonal surface depressions. It is a common form throughout the series of formations that comprise this division. It occurs also in the Goodland and Kiamitia formations of the Fredericksburg division in north Texas and in the Walnut formation of central Texas.

Neoholotype, from Del Rio formation, Sta. 226–T–10, in Plummer Collection (S–835). Metatypes in Bureau of Economic Geology.

GLOBIGERINA RUGOSA Plummer

Globigerina cretacea Carsey (non d'Orbigny), 1926, Univ. Texas Bull. 2612, p. 43, pl. 5, fig. 5.

Globigerina rugosa Plummer, 1927, Univ. Texas Bull. 2644, p. 38, pl. 2, fig. 10.

The specimen figured from the lowermost Navarro strata is found to bear the characteristic surface markings of *G. rugosa* Plummer. The early spire is somewhat more elevated than that of the holotype, but this feature is somewhat variable, and typical tests are common in material from this outcrop.

Plesiotype, from lower Navarro strata, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Specimens from same outcrop in the Bureau of Economic Geology.

Family GLOBOROTALIIDAE

Genus GLOBOTRUNCANA Cushman, 1927

GLOBOTRUNCANA ARCA (Cushman)

Pl. XIII, figs. 7–9, 11

Globigerina canaliculata Egger (non Reuss), 1899, Abh. k. bayer. Akad. Wiss. (Cl. II), vol. 21, p. 172, pl. 21, figs. 24–26.

Pulvinulina arca Cushman, 1926, Contrib. Cushman Lab. Foram. Res., vol. 2, p. 23, pl. 3, fig. 1.

Globigerina rosetta Carsey, 1926, Univ. Texas Bull. 2612, p. 44, pl. 5, fig. 3.

Globigerina rosetta Plummer, 1926, Univ. Texas Bull. 2644, pl. 2, fig. 9.

Globotruncana arca Moreman, 1927, Jour. Paleont., vol. 1, p. 100, pl. 16, figs. 16, 17.

Globotruncana arca Cushman, 1927, Jour. Paleont., vol. 1, p. 169, pl. 28, fig. 15.

Globotruncana rosetta White, 1928, Jour. Paleont., vol. 2, p. 286, pl. 39, fig. 1.

Globotruncana arca Cushman and Church, 1929, Proc. Calif. Acad. Sci., vol. 18, No. 16, p. 518, pl. 41, figs. 1–3.

A study of abundant material for this species in Mexico has revealed some interesting stages in development that must be recognized in order fully to define this form. The holotype shows a strongly bicarinate test moderately and about equally biconvex, characters that mark many specimens in Mendez strata that yielded material for its original description. Many other tests in the same material closely resemble the form described in the shape and number of chambers in the whorl, but these have a stronger ventral convexity and a single carination. The clue to the relationship of the two groups lies in tests that exhibit a gradual development from bicarination and low ventral convexity to single carination and stronger ventral convexity in the final whorl. Young tests show bicarination, which in a large suite of specimens studied is obviously a character of early development. The subordinate carination close to the periphery on the ventral side is evanescent during early maturity, and in advanced maturity the final whorl is almost or completely unicarinate. This change on most tests of *G. arca* (Cushman) at its type locality is accompanied by a rapid increase in convexity of the ventral face of the test.

The original description claims seven chambers in the whorl, but type material available for these observations show six to be much more common. Possibly the holotype is microspheric.

Because this change in peripheral character and biconvexity in most Upper Cretaceous material of Mexico takes place much earlier in the growth of the shell than at its type locality, White has reported *G. arca* (Cushman) as very rare and has recognized as the abundant species the singly carinate *G. rosetta* (Carsey).

At the type locality for *G. rosetta* (Carsey) tests are very common in all their stages of growth and are in an excellent state of preservation. The same developmental features that characterize *G. arca* at its type locality in the Mendez are exhibited by these upper Taylor tests. The bicarination of youth, (Pl. XIII, fig. 7) persists in many tests into early maturity (fig. 8), but in general from late youth the change is rapid toward the singly carinate periphery and the stronger ventral convexity of full maturity (fig. 9). A very few old tests are singly carinate throughout the final whorl, and the ventral side is markedly conical, a condition expressed by the holotype of *G. rosetta* (Carsey) (fig. 11). Most fully mature tests in this Taylor outcrop (Sta. 226–T–8), however, bear a faint subordinate keel on the early portion of the final whorl.

In most Upper Cretaceous material in Texas *G. arca* (Cushman) passes through the youthful bicarinate stage early in its development, as in equivalent strata in Mexico. The form in which it is best known is unicarinate with only slightly convex or even a flat dorsal face and a strongly convex ventral face. This more normal development marks the species in the uppermost Navarro outcrop north of

Cameron (Sta. 165–T–4), from which a test has previously been figured (Univ. Texas Bull. 2644, pl. 2, fig. 9). This relationship of peripheral characters and relative biconvexity to individual development is broadly applicable in this species, but in most material it is possible to find tests at variance with this simple statement of the ontogeny in the form.

The fundamental and diagnostic character of *G. arca* (Cushman) is the shape of its chambers as outlined by the beaded sutures. On the dorsal face the sutures are strongly oblique and slightly curved, and in extreme maturity they may be nearly straight and tangent to the penultimate whorl. The intervening chamber walls are only a little, if at all, inflated. Ventrally the sutures are curved sharply forward between the periphery and the wide and open umbilicus, and most of these are marked by narrow and rather smooth ridges. The degree of rugosity of the test varies. In some material the exogenous shell matter is limited to the sutures and the margin. In the upper Taylor clays on Onion Creek (Sta. 226–T–8) the sutures and margins are heavily beaded, and the ventral side of the chambers are also marked by thick blunt protuberances. The holotype for *G. rosetta* (Carsey) is unusually smooth for tests in this exposure.

From *G. fornicata* n. sp., which occurs in abundance in the same strata, *G. arca* (Cushman) is distinguished fundamentally by the broader and somewhat more triangular shape of the chambers on the dorsal side. *G. canaliculata* var. *ventricosa*, which is frequent in the outcrop, bears broader and distinctly inflated chambers separated by sutures which on the dorsal face are more nearly radial.

In Texas *G. arca* (Cushman) as here defined is very common, and in places abundant, in the Austin, Taylor, and Navarro formations, and it is rare in the Eagle Ford. No member of this genus has been observed in any Lower Cretaceous strata in Texas.

Plesiotypes, from Taylor formation, Sta. 226–T–8, in Plummer Collection (S–837.1 to 837.3). Plesiotype (holotype of *Globigerina rosetta* Carsey), from same outcrop, in Carsey Collection, department of geology, The University of Texas. Specimens in the Bureau of Economic Geology.

GLOBOTRUNCANA FORNICATA n. sp.

Pl. XIII, figs. 4–6

Test biconvex, periphery truncate and lobate; chambers seven in final convolution, long, narrow, strongly curved, smooth; dorsal sutures finely beaded, very strongly oblique and slightly curved; ventral sutures elevated and curved strongly forward in maturity, depressed and more nearly radial in youth; umbilicus broad and open; apertures from last three or four chambers of the final whorl into the umbilicus.

Average diameter .4 mm.; commonly up to .5 mm.

This species at its type locality in the Taylor formation (Sta. 226–T–8) is easily distinguished from its congeners by its narrow and strongly arched chambers that sweep in strong curves on the dorsal face. The chambers of the microspheric form are even more strongly curved than those of the megalospheric. Its dorsal sutures and margin are finely delineated by narrow and delicately beaded elevations which show a tendency to merge into sharp depressions from the periphery inward toward the earlier whorl. The center of each test is occupied by a globigerine spire of globular chambers, and this inflation persists in many tests in the strongly inflated inner extremities of the more mature chambers on the dorsal side. The dorsal convexity of the test varies from moderate to very high, especially in the microspheric form. The double carination is very characteristic of this species, but the secondary keel in some specimens weakens in late maturity.

The chambers of G. *fornicata* n. sp. are dorsally much more strongly curved than are those of *G. arca* (Cushman), its bicarination is much more persistent throughout development, and the beaded bands are finer and more delicate.

In Taylor and Navarro strata, this species is very common, and in many places it is abundant.

Holotype and paratypes, from Taylor formation, Sta. 226–T–8, in Plummer Collection (S–838, 839.1, and 839.2). Metatypes in the Bureau of Economic Geology.

GLOBOTRUNCANA CANALICULATA (Reuss) var. VENTRICOSA White

Pl. XIII, fig. 10

Globotruncana canaliculata (Reuss) var. *ventricosa* White, 1928, Jour. Paleont., vol. 2, p. 284, pl. 38, fig. 5.

Associated with *G. arca* (Cushman) and *G. fornicata* n. sp. in many Upper Cretaceous strata is a very strongly bicarinate form that possesses the typical shape of the chambers exhibited by *G. canaliculata* (Reuss). The ventral side, however, instead of being flat is distinctly inflated, and the varietal named assigned to a similar test in the Mexican Upper Cretaceous is equally applicable in the Texas section. This form is in most places not common, and the typical *G. canaliculata* (Reuss) is also infrequent. The chalky facies of the Texas section are more likely to carry the species in its typically compressed and widely truncate form. The ventrally ventricose variety is more frequent in clayey strata.

Average diameter about .45 mm.

Plesiotype, from upper Taylor strata, Sta. 226–T–8, in Plummer Collection (S–840). Specimens in the Bureau of Economic Geology.

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA DELRIOENSIS n. sp.

Pl. XIII, fig. 2

Test broadly elliptical to round in peripheral outline, strongly lobate, singly carinate, about equally biconvex, periphery marked by short, conspicuous, spinose processes; chambers five or six in each convolution, roughened somewhat by small blunt beadlike elevations of shell matter especially toward the peripheral margin on each side; dorsal sutures marked by beaded shell material, moderately curved; ventral sutures depressed and radiate; umbilicus distinct, small, shallow, closed; aperture a narrow slit on the inner edge of the base of the septal face under a narrow extended rim.

Average diameter about .3 mm.

The exogenous shell material is rather well developed on tests at its type locality, but variation in the degree of roughness of the surface includes some tests that are only weakly marked. This must therefore be regarded as a secondary character of the species, the structure and proportions of the test itself being fundamental. The shape of the chambers, the number per whorl, and the convexity of the dorsal face combine to make the Del Rio form almost identical with *G. crassata* (Cushman) as it occurs at its type locality in the Eocene of Mexico. The much lower convexity of the ventral face of this Lower Cretaceous form, however, serves to distinguish it.

This species has already been mentioned (Univ. Texas Bull. 2612, p. 45) as occurring in the Del Rio formation and was identified with *Globotruncana rosetta* (Carsey) [= *G. arca* (Cushman)] of the Upper Cretaceous formations. The general plan of arrangement of chambers in the two forms is similar, but the definite single carination, the more compressed test, and the character of the aperture combine to make the form both generically and specifically different. No true *Globotruncana* has been found in the Texas section earlier than the Eagle Ford formation.

Globorotalia delrioensis n. sp. occurs rarely in the Del Rio clays of central Texas and also in the synchronous Grayson marl of north Texas.

Holotype, from Del Rio formation, Sta. 226–T–10, in Plummer Collection (S–841). Metatypes in the Bureau of Economic Geology.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA PSEUDOPAPILLOSA Carsey

Pl. XIV, fig. 13

Anomalina pseudopapillosa Carsey, 1926, Univ. Texas Bull. 2612, p. 47, pl. 1, fig. 6.

Anomalina navarroensis Plummer, 1927, Univ. Texas Bull. 2644, p. 38, pl. 2, fig. 6.

A tightly coiled, much-compressed test that is almost equally biconvex and about equally embracing on its dorsal and ventral faces. The tiny thickened ends of the sutures on the ventral face present a beaded appearance to the central area and make it distinct from any other form in the Upper Cretaceous strata in Texas. It is confined to the Navarro formation and ranges from base to top.

Diameter of holotype .35 mm.; thickness .12 mm.

Holotype, from lower Navarro strata, Sta. 226–T–9, in Carsey Collection, department of geology, The University of Texas. Specimens in the Bureau of Economic Geology.

ANOMALINA GROSSERUGOSA (Gümbel)

Pl. XIV, fig. 9

Truncatulina grosserugosa Gümbel, 1868, Abh. k. bayer. Akad. Wiss. (m.-ph. Cl.), vol. 10, p. 660, pl. 2, fig. 104.

Anomalina grosse-rugosa Burrows, Sherborn, and Bailey, 1890, Jour. Roy. Mic. Soc., p. 563, pl. 11, fig. 25.

Truncatulina grosserugosa Carsey, 1926, Univ. Texas Bull. 2612, p. 46, pl. 3, fig. 3.

Test round in peripheral outline, biconvex with the ventral face slightly more elevated, very coarsely punctate, involute on both sides, broadly rounded peripherally in maturity, bluntly angular in youth; chambers eight to nine in mature convolution, later chambers distinctly inflated; sutures depressed between last few chambers, somewhat thickened and elevated between earlier chambers, slightly curved on both sides; aperture an arched orifice at base of septal face over the periphery.

Average diameter .45 mm.; thickness .25 mm.

This coarsely punctate involute coil is unlike any other form with which it occurs. It is frequent in the Taylor, but common in the Navarro formation throughout Texas. The Carsey plesiotype is imperfect and another test from the same outcrop has been chosen for illustration here.

Plesiotypes, from Navarro formation, Sta. 266–T–9, in Carsey Collection, department of geology, The University of Texas, and in Plummer Collection (S–843). Specimens in Bureau of Economic Geology.

ANOMALINA TAYLORENSIS Carsey

Anomalina taylorensis Carsey, 1926, Univ. Texas Bull. 2612, p. 47, pl. 6, fig. 1.

This greatly compressed, thin, discoid test has been well illustrated and described in the original publication. It occurs as a rather small form in the Austin formation, though in a few places it attains the average size for this species as it occurs in the overlying Taylor formation, where it is abundant.

Holotype, from Taylor formation, Sta. 226–T–8, in Carsey Collection, department of geology, The University of Texas. Metatypes in the Bureau of Economic Geology.

ANOMALINA FALCATA (Reuss)

Pl. XIV, figs. 7, 8

Truncatulina falcata Reuss, 1869, Sitz. k. Akad. Wiss. Wien, vol. 59. pt. 1, p. 461, pl. 2, fig. 1.

Truncatulina falcata Chapman, 1894, Quart. Jour. Geol. Soc., vol. 1, p. 721, pl. 34, fig. 15.

Anomalina petita Carsey (nom. nud.), 1926, Univ. Texas Bull. 2612, p. 48 (through error a cristellarian test represents this species, pl. 7, fig. 31).

Test somewhat elongate, elliptical, much compressed, biconvex, periphery bluntly acute, central portion of dorsal face marked by a conspicuous boss that obscures the inner whorl; chambers nine to ten in final whorl, last few slightly turgid; sutures thick but not elevated on dorsal side, slightly elevated on ventral side, distinctly curved across whorl; aperture a small arch over the periphery and extending down slightly on the ventral side.

Average longest diameter .45 mm.; shortest diameter .35 mm.; thickness through central boss .15 mm.

Though *A. petita* Carsey has never been figured, a rather poorly preserved anomaline form so labeled is in the Carsey Collection (Pl. XIV, fig. 7). This species is present at its type locality in the Del Rio formation in a less perfectly preserved condition than in the Fort Worth limestone (Pl. XIV, fig. 8). Its much compressed test and the prominent boss of shell matter lying in the central portion of the dorsal face over the earliest coil make this species, here identified as *A. falcata* (Reuss) distinct from any forms with which it occurs.

In the Texas section *A. falcata* (Reuss) is frequent in most of the formations of the Washita division in north Texas (Duck Creek, Fort Worth, Weno, Pawpaw, Grayson) and in the Del Rio formation of central Texas. In a richly foraminiferal sample of Austin chalk it has been found to be common. It has been reported by Chapman from the Bargate beds of Surrey.

Plesiotype (holotype of *A. petita* Carsey) from the Del Rio formation, Sta. 226–T–10, in Carsey Collection, department of geology, The University of Texas. Plesiotypes, from Fort Worth limestone, Sta. 219–T–14, in Plummer Collection (S–846). Specimens in the Bureau of Economic Geology.

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PLATE I

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8–15. *Fusulina primaeva* (Skinner) 32
Magnification × 14, except figure 10, which is × 9. Figure 8 is a chert specimen.

Note.—In a few figures lines have been drawn around the photographs to show the general shape. They may incorrectly suggest an extra outside wall which is not present.

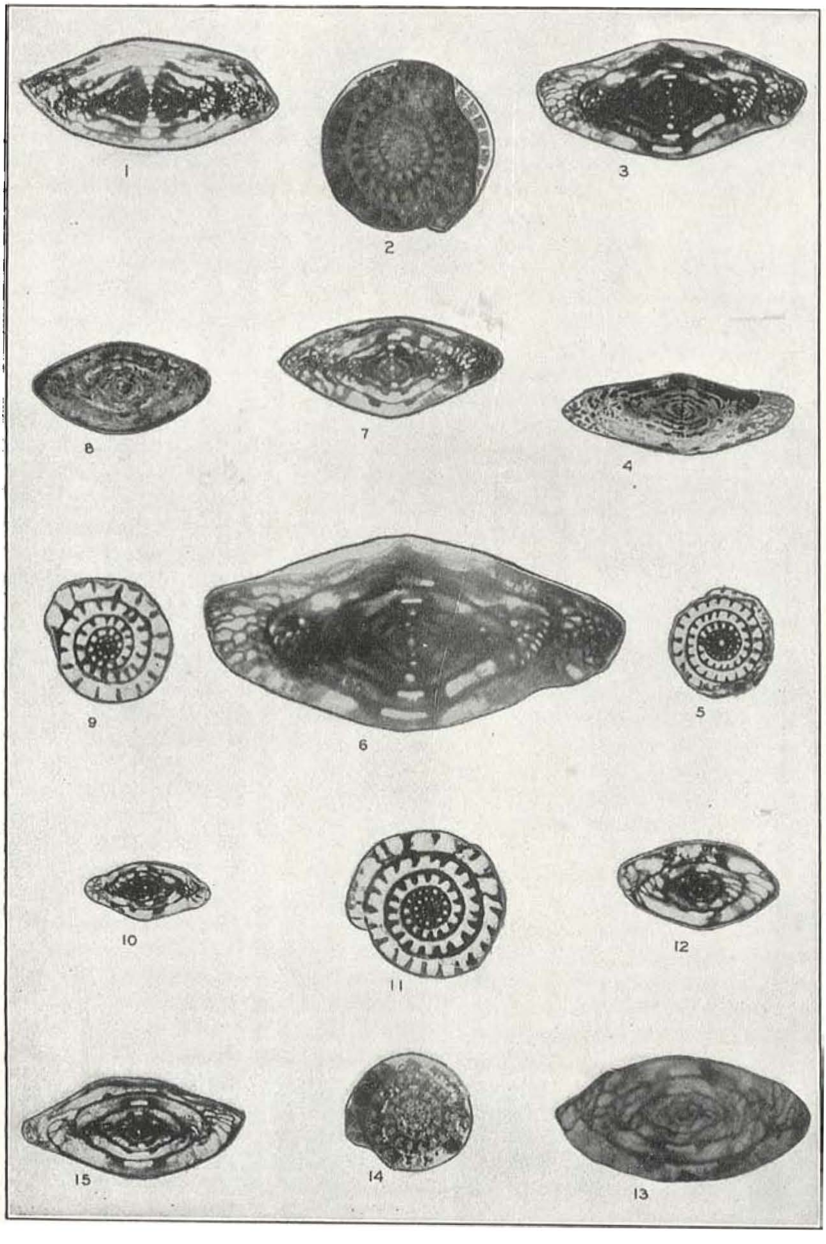
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PLATE II

Unless otherwise stated, all fossils are from the Eagle Ford equivalents. All figured material is in the collections of the Bureau of Economic Geology.

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21. Romaniceras loboense, n. sp. 44
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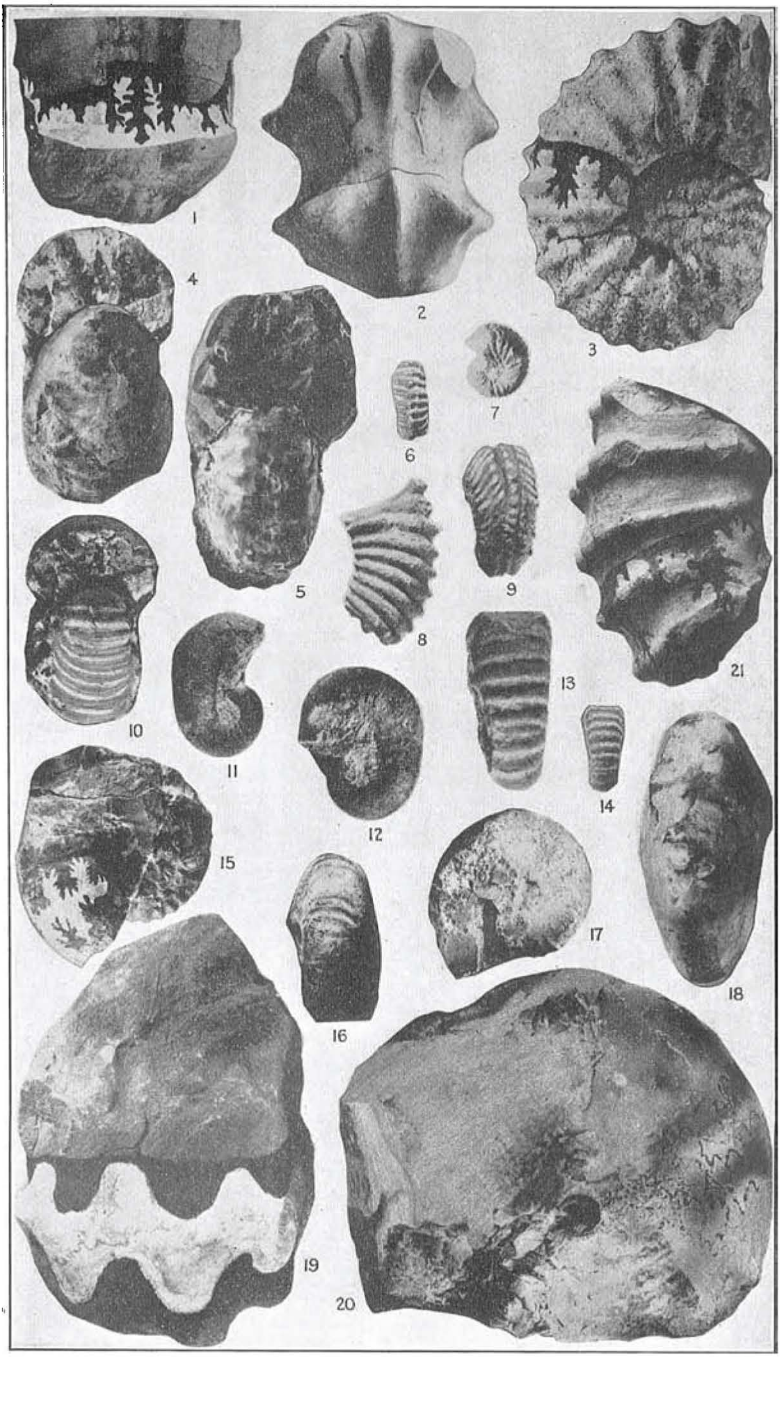
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3–4. Pseudaspidoceras (?) n. sp. A. 53
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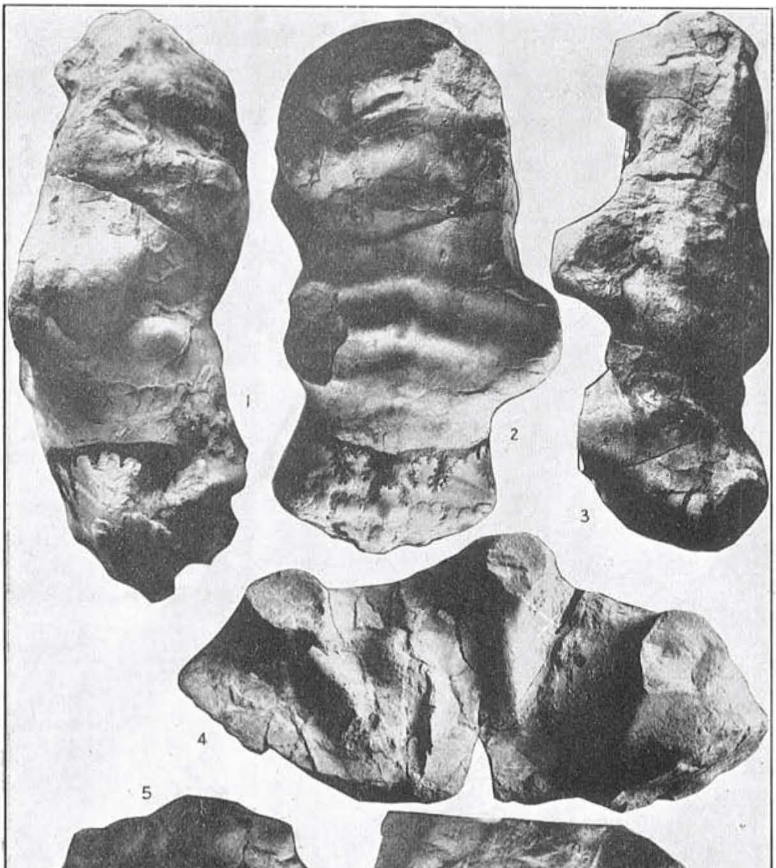
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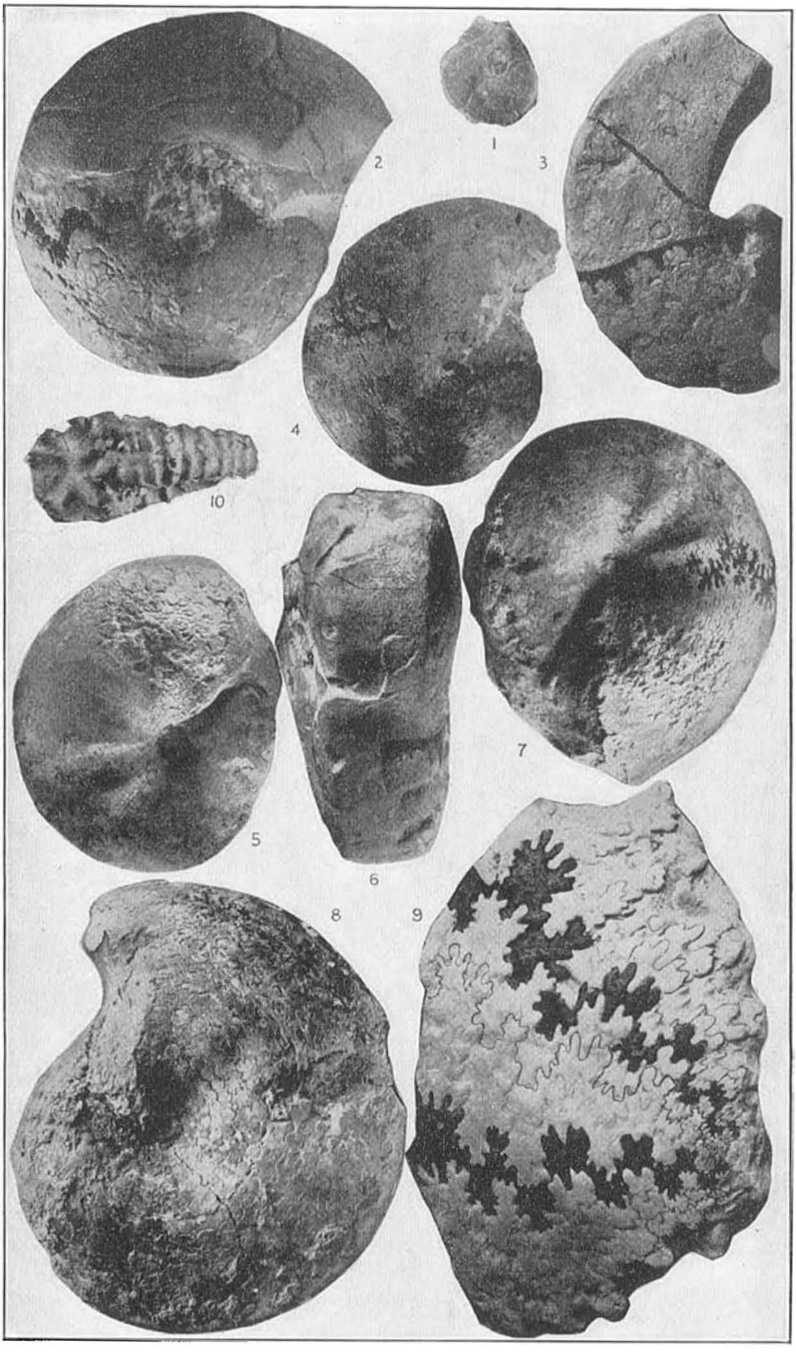
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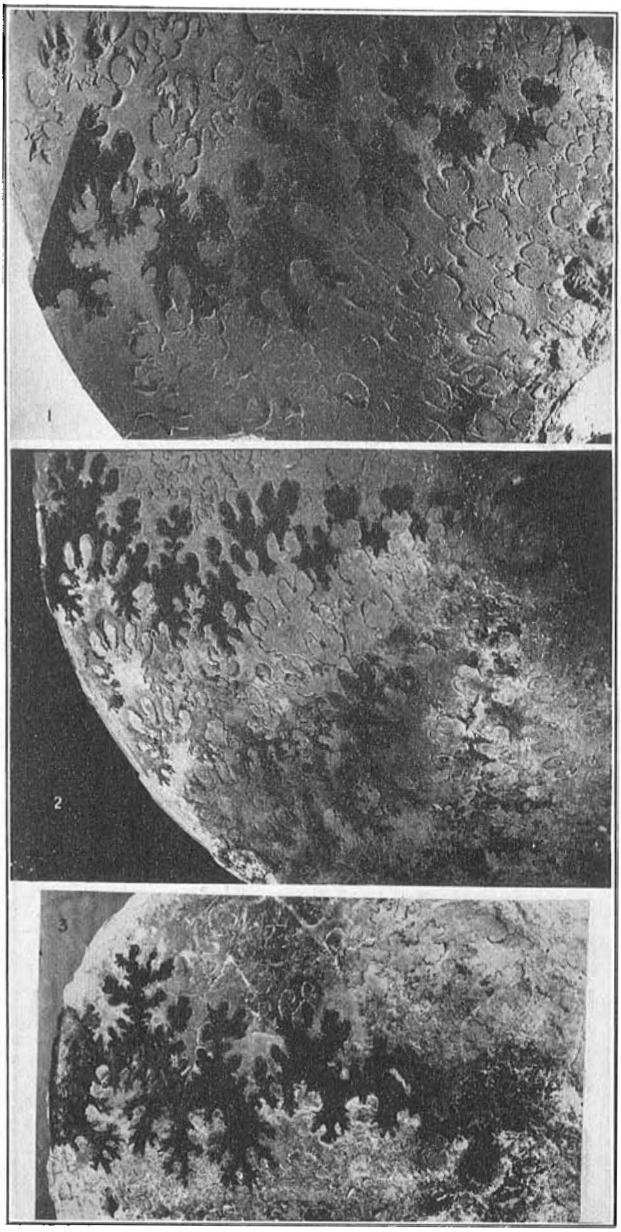
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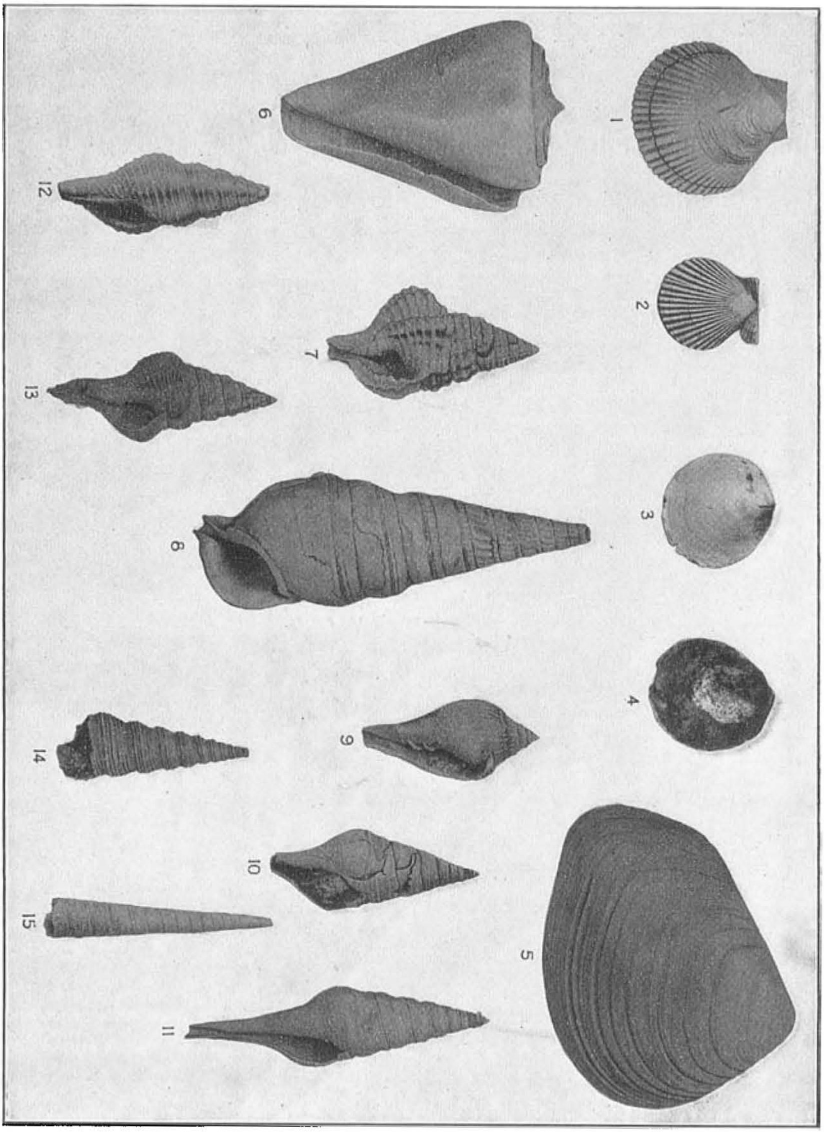
PLATE VI



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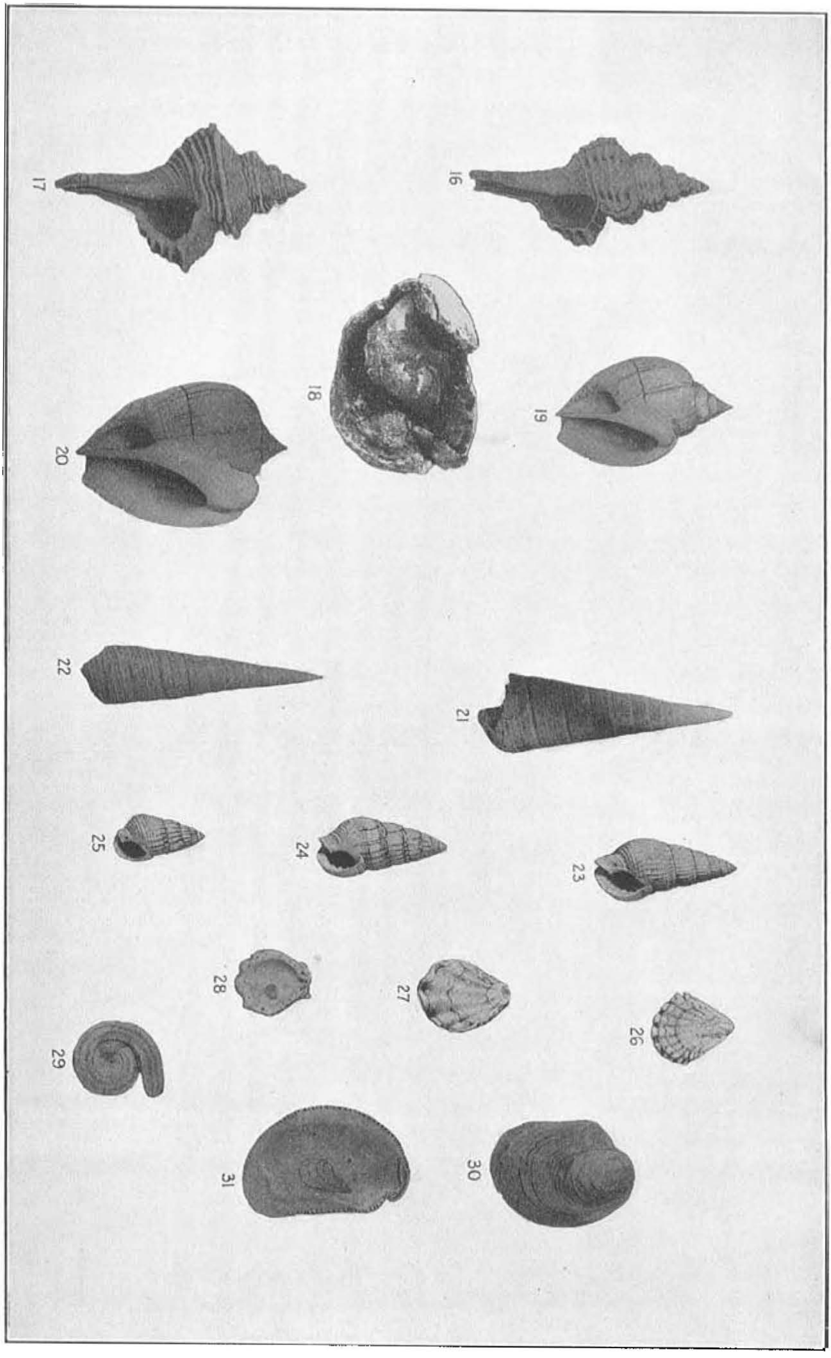
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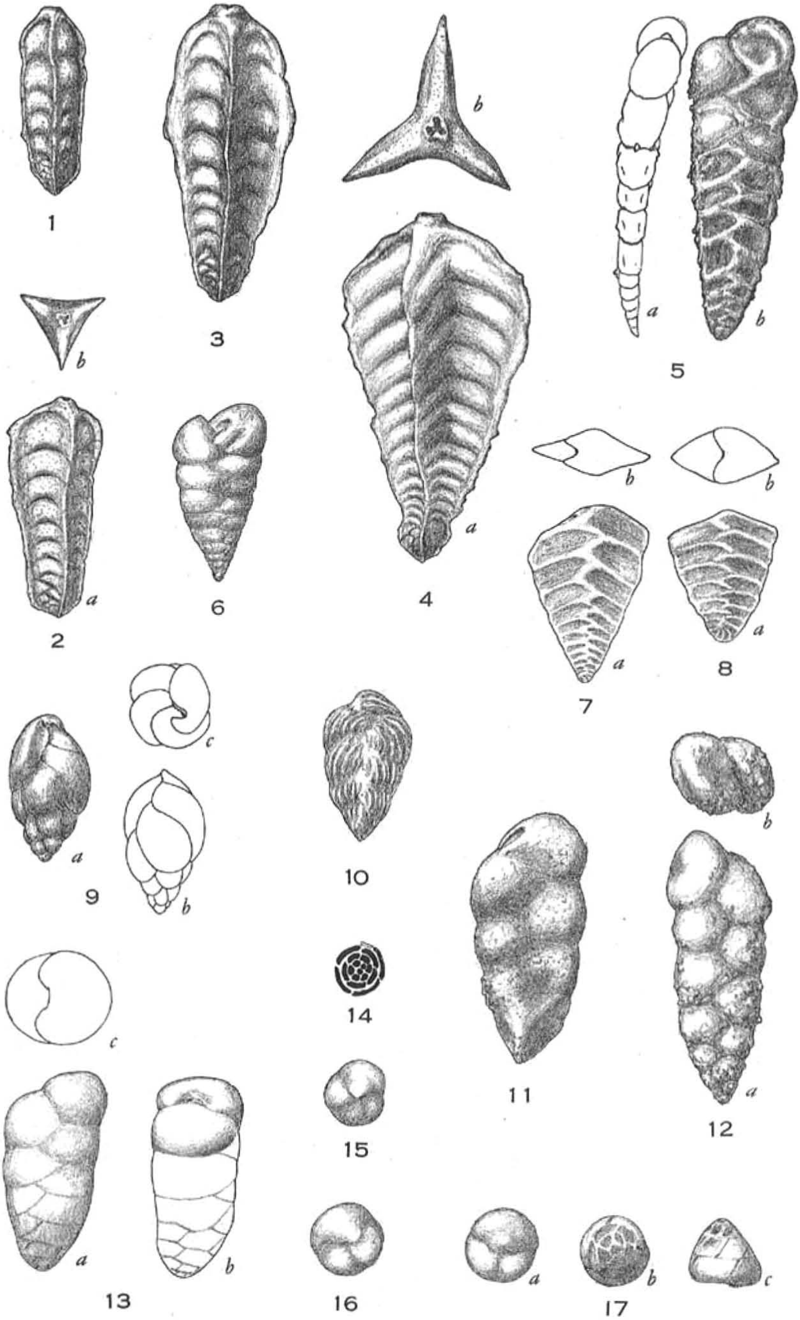
PLATE VIII



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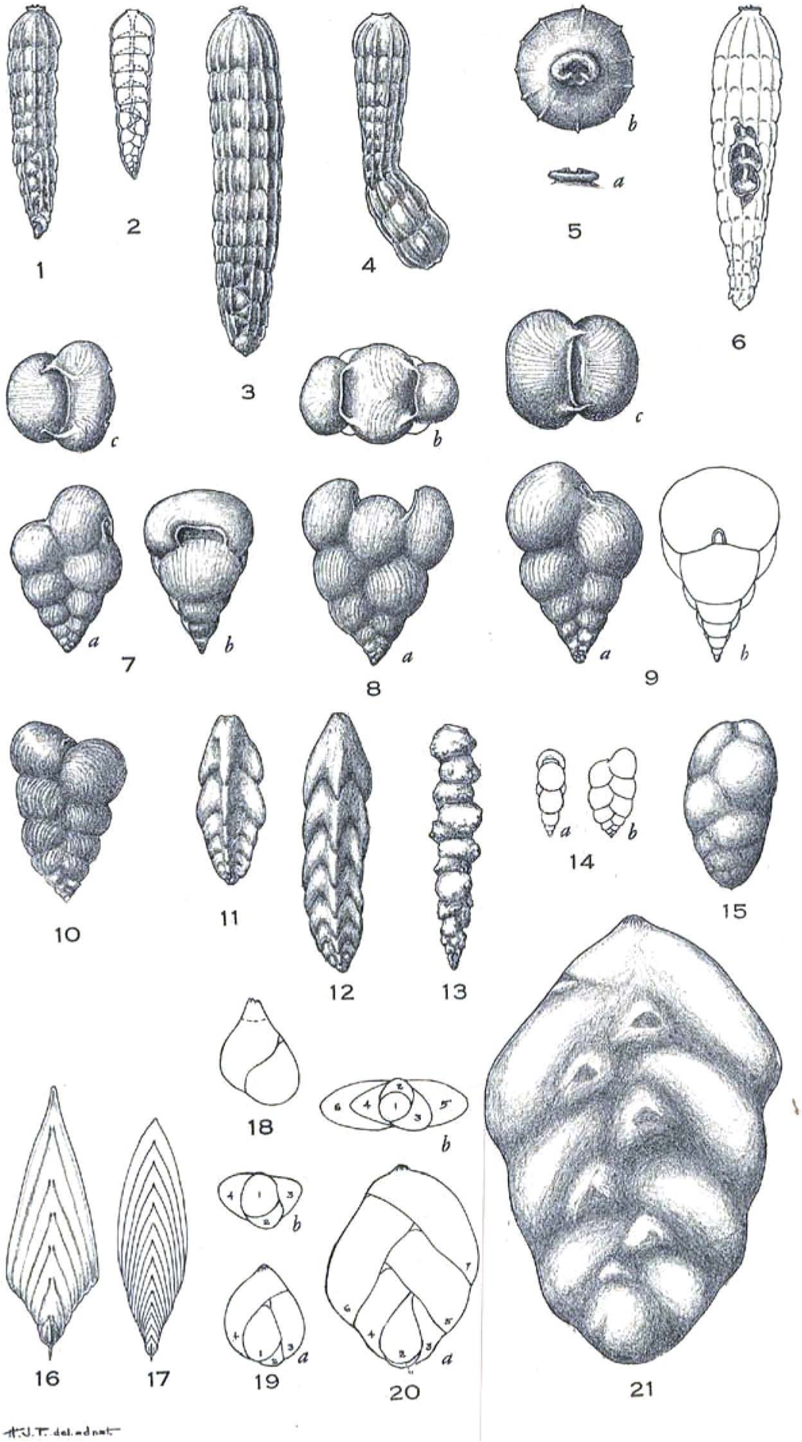
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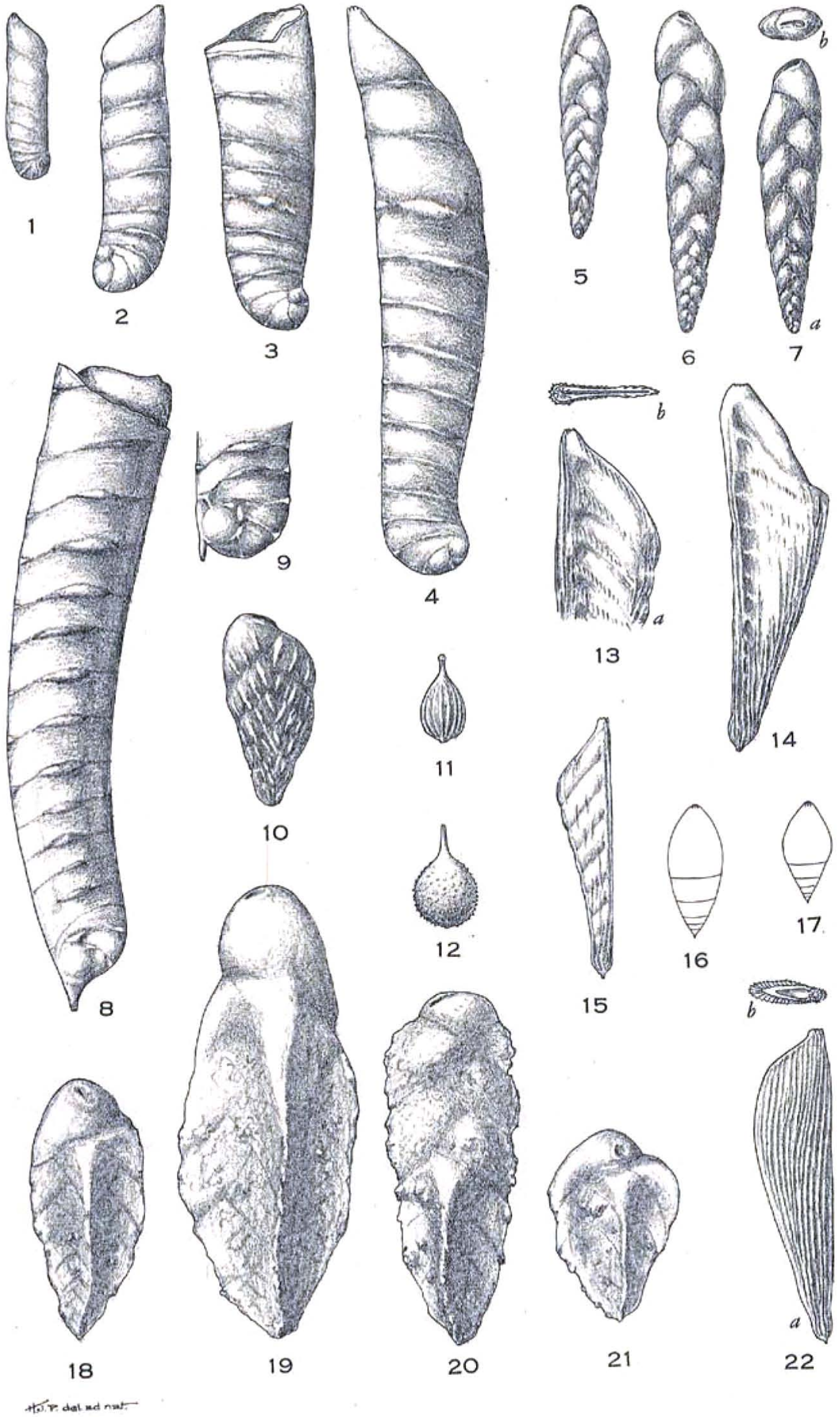
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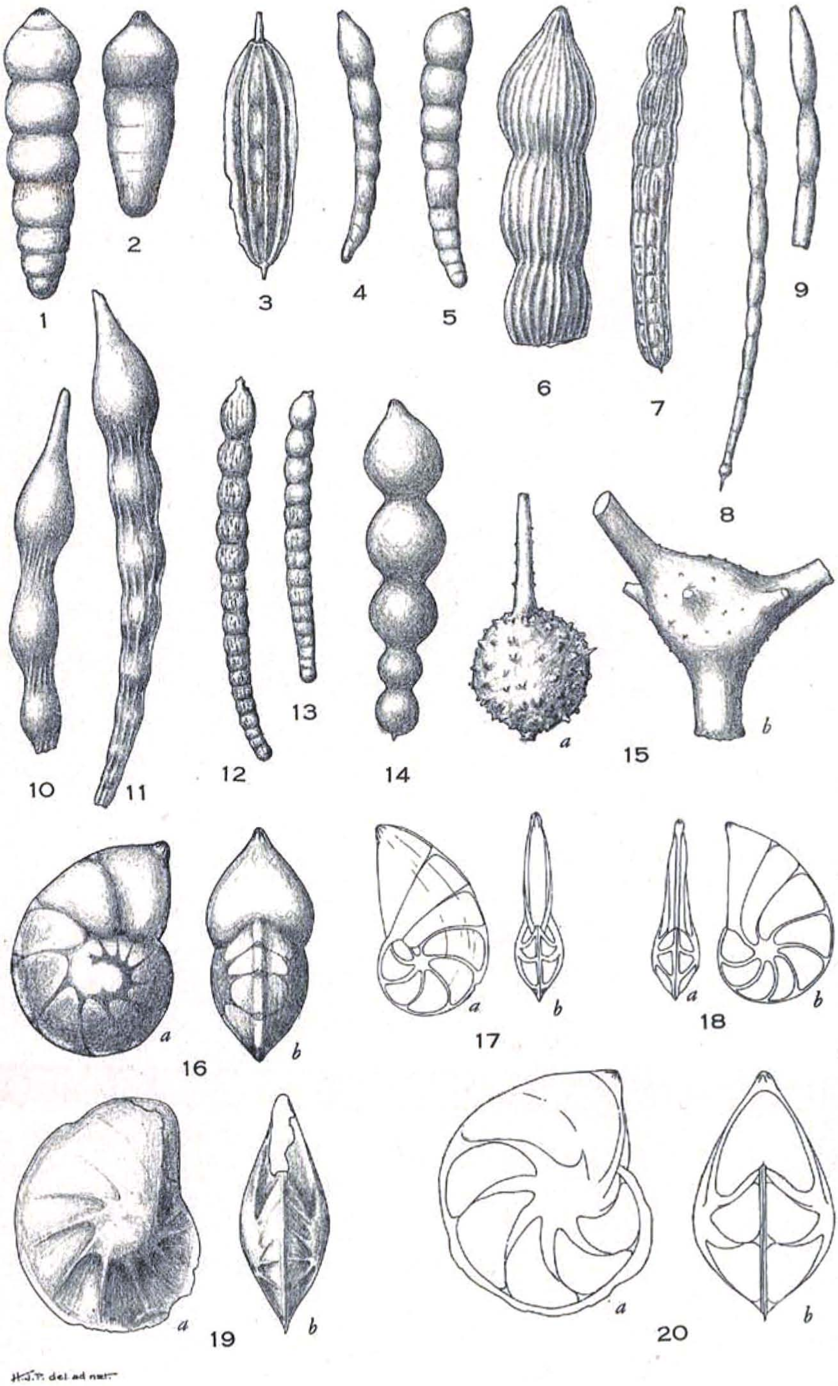

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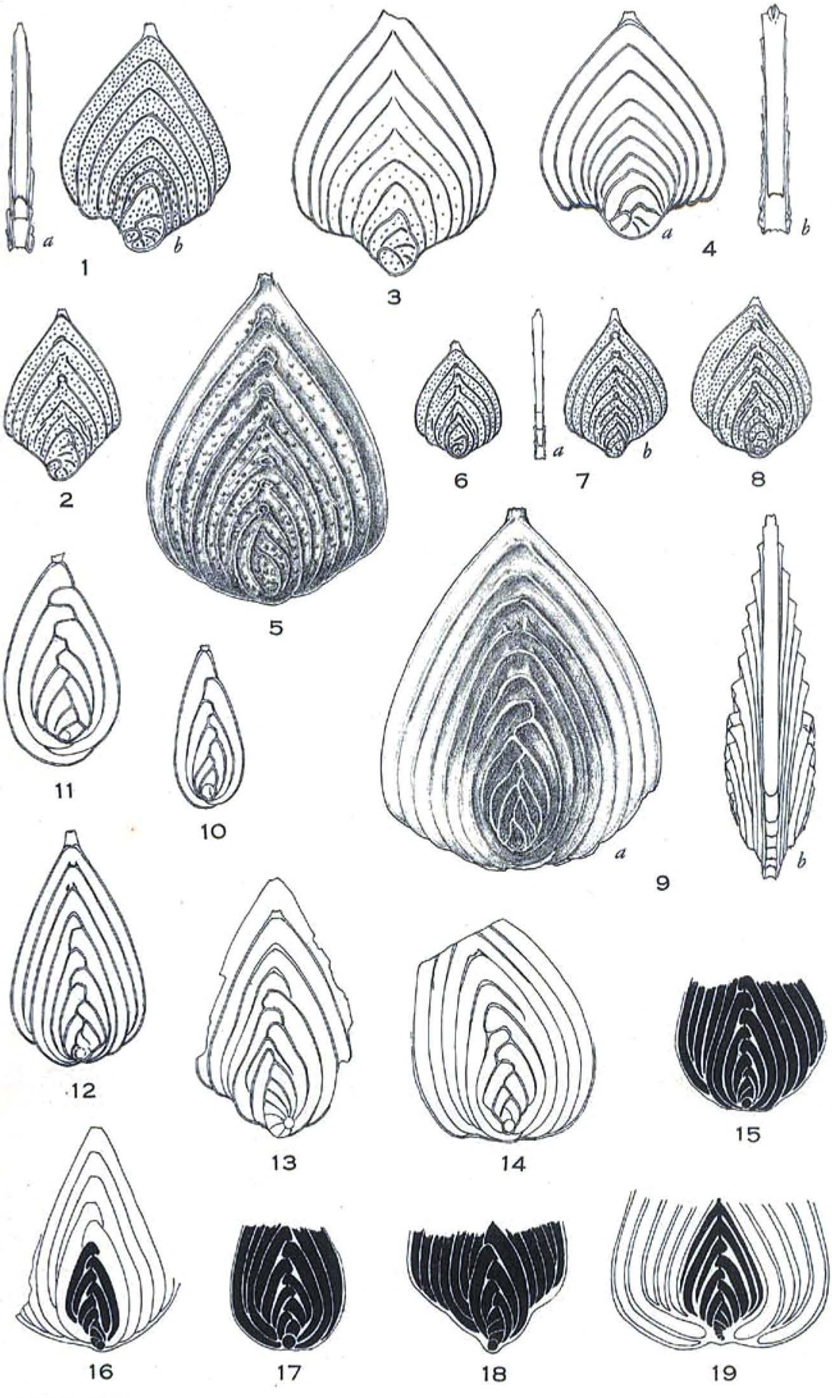
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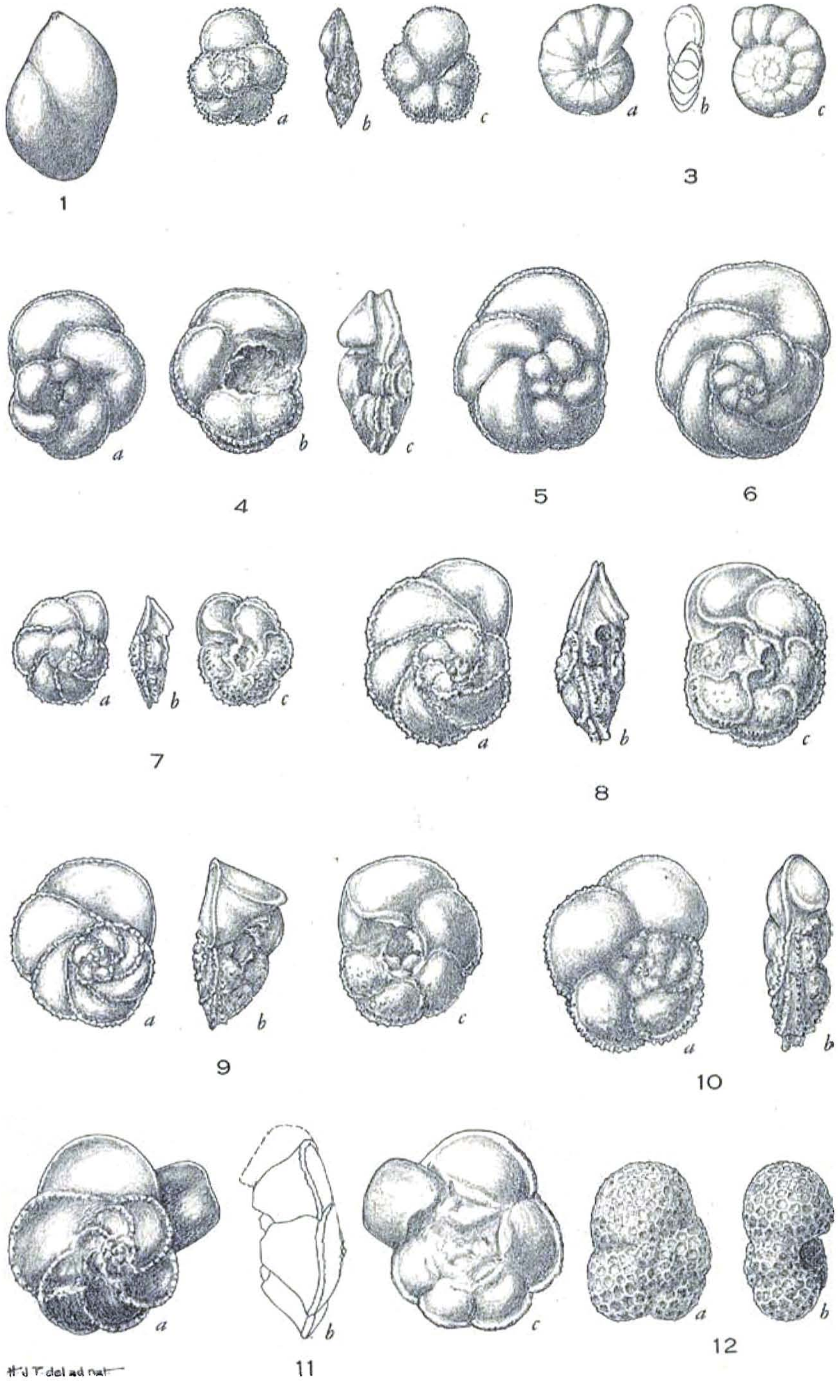
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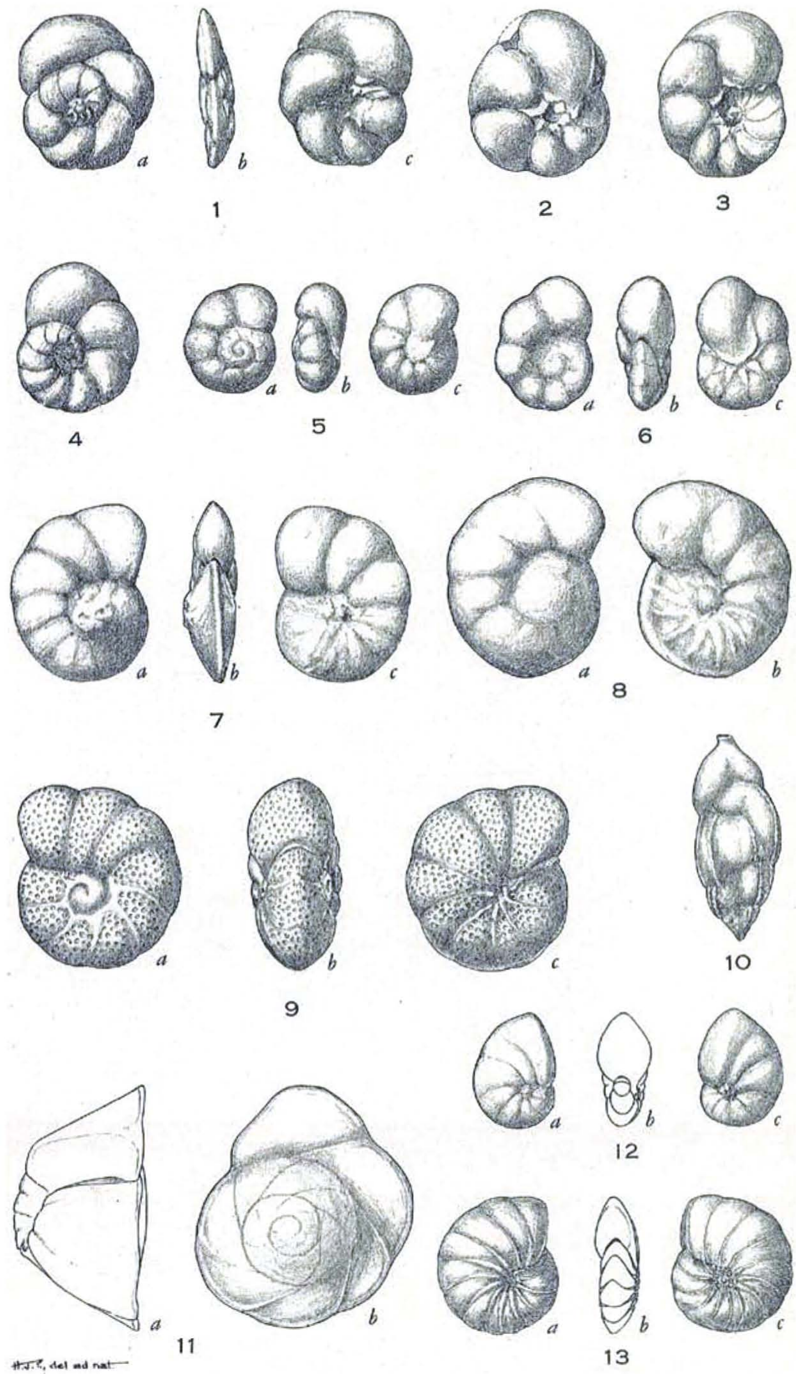
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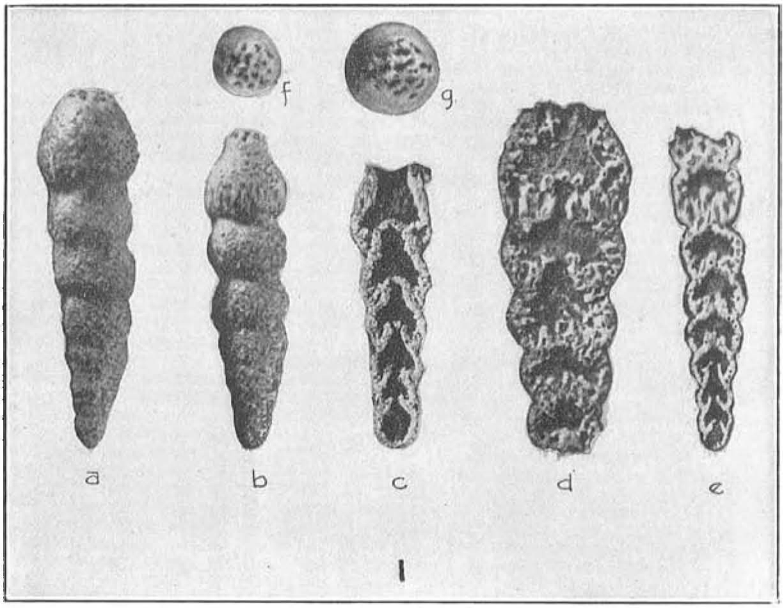
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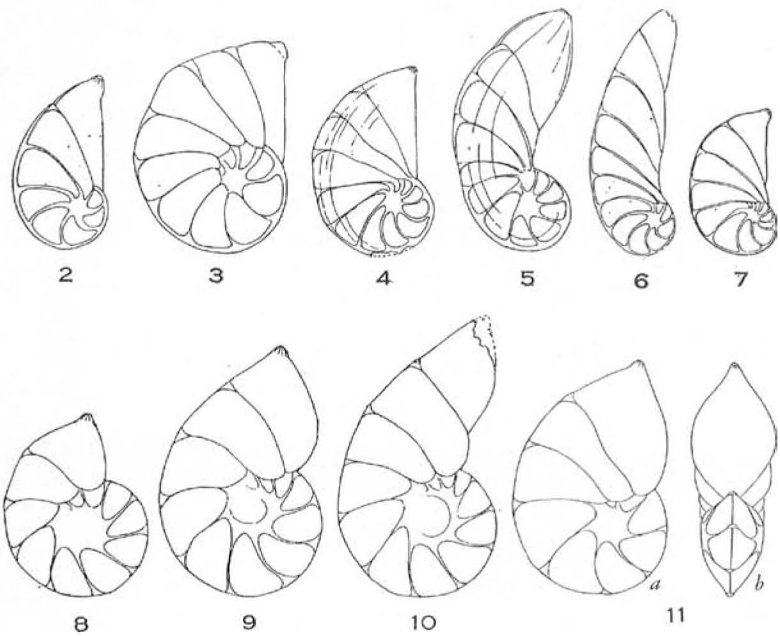
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