THE UNIVERSITY OF TEXAS BULLETIN

No. 3301: January 1, 1933

THE MIDWAY GROUP OF TEXAS

By

JULIA GARDNER

Including a chapter on the coral fauna by
T. Wayland Vaughan and Willis Parkison Popenoe

Bureau of Economic Geology
E. H. Sellards, Director

Prepared in coöperation with the United States
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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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Las Isletas, falls of Presidio de Rio Grande, about 7 miles above the Webb-Maverick county line. Reproduced from steel engraving, Report of the United States and Mexican Boundary Survey, Senate Executive Document No. 108 (House Executive Document No. 135), Vol. I, Pt. I, p. 68, 1857

THE MIDWAY GROUP OF TEXAS

JULIA GARDNER

INTRODUCTION

The purpose of this paper is to assemble the information upon the larger fossils of the Midway group of Texas and to present it against an historical and stratigraphic background.

ACKNOWLEDGMENTS

The difficulty of adequate acknowledgment in a paper such as this is very great. There is in it comparatively little taken directly from an outside source. There is also little which does not carry the impress of the generosity of my fellow workers—of information gained in maps, in records and reports, in correspondence and conversation. In the pattern of the composite fabric it is impossible to trace the threads from which it is woven.

I hold in grateful memory Dr. J. A. Udden, former Director of the Bureau of Economic Geology, for his interest and for the broader outlook which he gave to the entire problem. I particularly wish to thank those who have made the work possible and who have awaited the results so patiently—Dr. E. H. Sellards, Director of the Bureau of Economic Geology, and Dr. L. W. Stephenson, in charge of the Section of Coastal Plain Investigations of the U. S. Geological Survey. Without their constant encouragement and advice this investigation would have been neither begun nor finished.

To practically all of the petroleum companies operating in Texas I am indebted for information either in reports or on maps. I take pleasure in acknowledging an especial obligation to Messrs. Sidney Powers, Frederick B. Plummer, and Albert E. Oldham, formerly with the Amerada Petroleum Corporation; Messrs. Wallace E. Pratt, L. T. Barrow, and F. M. Getzendaner, of the Humble Oil and Refining Company; Mr. Alexander Deussen, formerly of the Marland Oil Company; Messrs. Theron Wasson, Floyd Imbt, Paul Seashore, and E. B. Stiles, all previously associated with the Pure Oil Company; Messrs. Donald C. Barton, Karl Young, and James Gould with the Rycade Oil Corporation; Messrs. Charles Row and A. L. Jones of the Sun Oil Company; and Mr. Robin Willis, formerly with The

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Texas Company. The companies to which these geologists are referred are those with which they were connected at the time the information was given.

Most heartily do I wish to thank those who have worked with me in the field. I recall with keen pleasure my field experience gained with Prof. F. L. Whitney and his class in The University of Texas, on the "Basal Greensands" north and west of Elgin: that with Dr. Gayle Scott of Texas Christian University, in Navarro County: that with Messrs. Karl Young and James Gould in Maverick and Guadalupe counties; that with Mr. E. Manuel Hawtof, formerly with the Bureau of Economic Geology, in Maverick County: with Mr. Hugh Duval of Bastrop, Texas, in Bastrop County: with Mr. Robin Willis in northern Caldwell and southern Bastrop counties: with Mr. Robert Lee Cannon, formerly with the Humble Oil & Refining Company, in Medina and Bexar counties: and with Mr. Carroll E. Cook, formerly with the United North and South Development Company, in Caldwell and Bastrop counties. I am happy to express my sincere appreciation not only for field work and for detailed maps covering the field work, but also for the most generous and complete interpretation of the facts observed and recorded.

The indoor photographs were made by Mr. W. O. Hazard and were retouched by Miss Frances Wieser, both of the U. S. Geological Survey. Mr. Hazard and Miss Wieser merit the sincere appreciation of all of us who have occasion to use these illustrations. I wish to thank Mr. E. A. Shuster, of the Topographic Branch of the Survey, for his interest and coöperation in giving the remarkable air photographs taken in northeast Texas.

HISTORICAL BACKGROUND OF THE MIDWAY GROUP

The early confusions and colorful theories that attended the development of the investigations of the Eastern Gulf and Atlantic Tertiaries had been largely dissipated before scientific interest in the Texas Tertiaries was awakened. During the period dominated by William Maclure all of the formations of the Coastal Plain of the Atlantic seaboard and Gulf, both Mesozoic and Cenozoic, were included under "Alluvial rocks" (2)*. John Finch (3), professor of

*The numbers refer to the bibliographic references.

geology and mineralogy in Birmingham, England, struck the first modern note in 1824, both in his conclusions and the methods by which he arrived. He writes in the American Journal of Science and Arts for 1824:

> In America an immense tract of country, extending from Long Island to the sea of Mexico, and from 30 to 200 miles in width, is called an alluvial formation .... From an examination of fossils brought from that quarter of the United States, from a personal inspection of some of its strata, and the perusal of most of the publications which bear a reference to it, I wish to suggest that what is termed the alluvial formation in the geological maps of Messrs. Maclure and Cleaveland is identical and contemporaneous with the newer secondary and tertiary formations of France, England, Spain, Germany, Italy, Hungary, Poland, Iceland, Egypt, and Hindostan.

This was certainly a brave attempt to correlate the deposits of the Atlantic Coastal Plain of North America with those of most of the rest of the known world, and was adopted by Van Rensselaer though the scientific circles were at that time more occupied with mineralogy than with Coastal Plain stratigraphy. Though Cuvier and Brongniart (1) had successfully demonstrated in 1808 the value of fossils in establishing the geologic succession, the significance of the work was not recognized in this country for 20 years. The year 1829 marked the publication of the first paper of the Philadelphia coterie of paleontologists, Morton (1), Conrad, Say, and Isaac and Henry Lea, a group that laid the sure foundations of Coastal Plain conchology. Morton's concern was primarily with the Cretaceous fauna and that of Conrad, Say and the Leas with the later Eocene and post-Eocene faunas, but interests were more general in those days and many of the descriptions of the more abundant and widely distributed Midway species were first published in the Journal and Proceedings of the Philadelphia Academy of Natural Sciences. In fact, a really comprehensive study of the historical background of the Midway involves on the one hand the review of the work of the earlier paleontologists on the entire Coastal Plain and, on the other hand, of the generalized reports of the early travellers and naturalists on the more restricted area of Texas (6). We are fortunate in having two adequate summaries of these two lines of early investigations. Harris (23) in his "Midway stage" covers all of the work done upon the Midway Mollusca of the Atlantic Coast and Gulf down to 1896.

Robert T. Hill (14) in "The present condition of knowledge of the geology of Texas," published in 1887, has recovered an obscure past. The succession of scientific explorations from the early Spanish, French and Mexican reconnaissances to the established State and Federal surveys is traced and the paper filled with valuable bibliographic references and pertinent comments upon the conclusions of the investigator in question.

According to Harris, G. W. Featherstonhaugh (5, p. 60), a federal geologist, was the first to cite specifically a fossiliferous locality carrying Midway fossils. In relating his Arkansas reconnaissance, Featherstonhaugh notes that "at a very limited locality on the bank (of the Arkansas River) I found a calcareous deposit containing marine fossil shells belonging to the tertiary beds. (*Ostrea, turritella, calyptrea, cerithium*, etc.) Three miles west from Little Rock, this deposit reappears in considerable quantities, and is quarried for the purpose of making lime." The locality cited is doubtless the limestone of the lower Midway which outcrops in the vicinity of Little Rock. The name Midway was not, however, introduced into the literature until more than fifty years later.

Though Roemer's (6a-3) major concern was with the Cretaceous and its contained fauna, no résumé of the early investigations on the Coastal Plain of Texas is complete without a reference to his work.

The German colonization of Texas in the early 40's was organized by the Mainz-verein under the patronage of the German nobility with Prince Carl Solms-Braunfels as the resident agent, and the inducements offered in the hope of stimulating emigration were addressed primarily to the intelligentzia. In order to obtain information which might be of use in meeting the needs of the new German agricultural settlement, a geologist was sent over to make a reconnaissance survey of the new state. Ferdinand Roemer, a student of Leopold von Buch's, only 27 years of age but already a geologist and paleontologist of established reputation, arrived in the United States in 1845 armed with letters of introduction from Alexander von Humboldt. His Texas field work is said to have begun in December, 1845, and to have continued till April, 1847. Two short papers of a general nature were published in the American Journal of Science and others in Germany. The two most pretentious publications and the only reports that touch even indirectly upon the Midway are "Texas," 1849 (7), and "Die Kreidebildungen von

Texas und ihre organischen Einschlüsse," 1852 (8). In his "Texas" map Roemer makes, so far as I know, the first attempt to fix the upper limit of the Cretaceous. He does not, however, recognize the overlying strata as Tertiary but as "Diluvium u. Alluvium" and he limits the Tertiaries to an area including the Wheelock and Caldwell Claiborne outcrops and to that of which Nacogdoches is the center. His contact upon the Rio Grande was placed only a little over a mile above that indicated upon the present map.

The United States and Mexican Boundary Survey (11) doubtless touched upon the Midway outcrop and fauna but the localities are greatly confused and consequently no reliance can be placed upon the deductions based upon the fossils. However, Emory's account of the topographic features of the Lower Rio Bravo del Norte, the Rio Grande of the present day literature, is of great interest and the Cretaceous-Eocene contact at the Border in the map compiled by James Hall, assisted by J. P. Lesley, from the surveys of W. H. Emory and from the Pacific Railroad and other sources, is surprisingly correct even when judged by present day standards. Not only does the Cretaceous-Eocene line coincide almost exactly with that now accepted, but the northward strike of the contact away from the Rio Grande is indicated.

In the second part of the same volume there is a chapter by Arthur Schott (10), the Assistant Surveyor, on the "Substance of the sketch of the geology of the Lower Rio Bravo del Norte." This was written, apparently, quite independently of the map in the same volume. Schott assumed that the lignites occurring north of Eagle Pass and those south of Palafox were of the same age and characterized the "upper belt of green sand." He accordingly placed his contact near the mouth of Las Moras Creek in the northwestern corner of Maverick County and over 50 miles north in an air line of the contact indicated on the Emory map. As a matter of fact, the lignites north of Eagle Pass are now referred to the Upper Cretaceous and those south of Palafox to the Mount Selman formation of the Claiborne group. The Longbridge (12) report is primarily agricultural and on the small map included in the report the line is drawn between the Central Black Prairie Region (Cretaceous) and the Southern and Coast Prairies (Calcareous) which includes not only the Eocene but some of the Upper Cretaceous as well. However, he indicates the contact in the text (pp. 676, 679):

The line marking the eastern limit of the formation passes from Clarksville, Red River County, southwestward to Terrell, where in the railroad cut I observed an outcrop of a hard fossiliferous limestone, resembling in character that of the Ripley group of Mississippi, and with blackened fossil fragments as in the Cretaceous beds north of Lumpkin, in Stewart County, Georgia. Among the fossils recognized were *Turritella, Exogyra, Belemnites,* and *Cardium Ripleyensis.* Farther southward the most easterly Cretaceous outcrops are four miles west of Corsicana, in Navarro County, a few miles east and south of Marlin, in Falls County, at Cameron in Milam County, a mile or two west of Elgin or near the western line of Bastrop County, at Seguin, in Guadalupe, and thence the line passes through the northwest corner of Atascosa, and westward south of the mouth of the Pecos River, on the Rio Grande. . . .

On the Rio Grande the glauconitic sandstones, mentioned by Mr. Schott as occurring along the river from the Cretaceous rocks at the mouth of Las Moras creek, north of Eagle Pass, southward to Roma, near Rio Grande City, are doubtless of Tertiary age.

The following observations (p. 679) are included under the heading *Tertiary*, probably the first recognition of the Midway beds both as a topographic feature and as a stratigraphic group.

The line of low hills at the eastern edge of the black Cretaceous prairie region in Limestone and Falls counties, known as the Tehuacana hills and Blue ridge, are composed of Tertiary rocks, with a few fossils, *Venericardia planicosta*, etc.; while northward, at Corsicana and Wills' point (in Van Zandt County), as well as on the southwest, near Bremond, are soft sandstones, with Tertiary fossil casts overlying lignite beds at 40 feet or more below the surface.

The error in the Cretaceous-Eocene contact on the Rio Grande was further perpetuated by Heilprin (13), who had no first-hand information and accepted the conclusions of Loughridge.

In 1887 Hill (14) brought the "Knowledge of the geology of Texas" up to date and a great forward stride was made by the recognition in Alabama of the Midway "series," by Smith of the Alabama Survey and Johnson of the Federal Survey (15, p. 62). The original description of the type locality may well be repeated:

The bluff at Midway is half a mile or more in length, the dip of the strata quite variable, but very considerable, in places as much as one in thirty, and in some places the beds are nearly horizontal. At the lower end of the bluff appear black clays similar to those at Matthews Landing or Black Bluff, a few feet only showing, and these apparently without fossils. These clays overlie about 10 feet of light colored argillaceous limestone, with projecting hard ledges. This limestone contains the large Nautilus (*Enclimatoceras*) which characterizes the lowermost Tertiary beds about Pine Barren Creek

below mentioned and it is no doubt identical with the Nautilus rock of eastern Wilcox (county).

This Nautilus rock has been recognized in that part of Wilcox County lying west of the Alabama River, and it has been traced thence across Marengo County to Moscow, on the Tombigbee River. Southward of the localities where it forms the surface appears always a strip of black prairie soils, derived from the disintegration of the calcareous clays (of Black Bluff group), which immediately overlie the Nautilus limestone, and southward still of this prairie belt lies the belt of Post Oak Flatwoods, the soils of which come from the disintegration of the non-calcareous clays of the Black Bluff group. The Flatwoods belt, as has already been intimated, does not appear to extend beyond the Alabama River towards the east, while the prairie belt attains to greater and greater importance in that direction.

Midway is some 4 miles down the river from Prairie Bluff, where occurs the first outcrop of Cretaceous rocks on the Alabama.

The Midway was not given formational rank but was placed at the base of the "Lignitic" underlying the Black Bluff section, which in turn underlay the Nahcola and Matthews Landing sections. Due recognition was given to Alexander Winchell, who in 1857 (9) had referred the Midway beds near Allenton, Wilcox County, Alabama, to the Eocene. The work initiated by Smith and Johnson culminated in the "Report on the geology of the Coastal Plain of Alabama," published by the Alabama Survey under Eugene A. Smith and ably assisted by Lawrence Johnson and Daniel W. Langdon, Truman H. Aldrich, and K. M. Cunningham (26), 1894. A Tertiary section was thus established in Alabama which has served as the standard check section for the rest of the Gulf Coastal Plain.

Some Midway was possibly included in Hill's (16) glauconitic beds at the top of the Upper Cretaceous, though his major correlations were sound and based upon a good Upper Cretaceous fauna. It is interesting to note the influence of the European section on the early interpretations of the Atlantic and Gulf Upper Cretaceous and lower Midway sections. The abundance of glauconite in the Upper Cretaceous section in England was doubtless a consideration in the correlation of the sparsely fossiliferous Rancocas and Manasquan marls of New Jersey with the Upper Cretaceous, rather than with the Eocene, an error which was not corrected in print until 1928 (73), though a paper was read by Cooke and Stephenson both before the American Association and the Geological Society in December, 1927. Hill and Penrose suggested that the term "Glauconitic" be applied to this uppermost division of the Upper Cretaceous of the eastern

(Atlantic and Gulf) slopes of the United States, including the Eagle Pass and Anderson County beds of Texas, the "Arenaceous" division of the Arkansas section, the Ripley, "Rotten limestone," and Tombigbee (in part) divisions of the Mississippi-Alabama section, and the "Glauconitic beds" of the New Jersey region below the "Upper Marl beds." The pendulum has of later years perhaps swung too far in the other direction, for there has been too strong a tendency to consider all debatable material carrying a few grains of glauconite as Midway while as a matter of fact glauconite is far from rare in the Upper Cretaceous near the Mexican Border and locally much farther north.

The first attempt to work out the stratigraphy of the Texas Tertiaries is that of Penrose (17) in his "Preliminary report on the geology of the Gulf Tertiary of Texas from Red River to the Rio Grande." The Penrose paper is frankly a reconnaissance report and very incoherent, but it contains the earliest effort to set off the beds now included under the Midway from those above and below. Penrose thus defines his "Basal or Wills Point clays" (17, pp. 19, 20):

> At the base of the Tertiary and immediately overlying the eroded surface of the uppermost Cretaceous strata in East Texas is a great bed of stratified clay, which, on account of its position as the lowermost bed of the Eocene in this region, has been provisionally called the Basal Clays. . . . They consist of a stiff laminated clay, yellow, gray, blue, or bluish-green in color, frequently interbedded with seams and laminae of sand, containing many concretionary masses of gray non-fossiliferous limestone, the latter much cut up by veins of brown crystalline calcite, and varying in size from a few inches to six feet in diameter. They are generally of a flat elliptical shape, and of a gray color. Large quantities of gypsum are also found in places in the clay. . . . Such deposits are found well developed at Wills Point, in Van Zandt County. Going east from this place, they are traceable for two and a half miles, when they finally dip under the overlying sandy strata. West of Wills Point similar strata are seen until we reach Rocky Cedar Creek, a distance of five miles. Here is seen a deposit of shell limestone, composed almost entirely of shells of Lower Eocene fossils. It is traceable up and down Rocky Cedar Creek for seven miles, and underlies the divide between Rocky Cedar and Muddy Cedar Creeks, a distance of four miles. . . . The shell limestone bed is probably of limited extent, occupying no very important stratigraphical position, and appearing at the base of, and as a component part of, the Basal Clays. It is of great importance, however, as showing the geological position of the lowermost Tertiary strata in Northern Texas.

The "Basal clays" were recognized at a number of localities north of the Colorado and the observation was made that they probably become much more sandy south of the Colorado since "the first Tertiary beds found going down the Rio Grande are very sandy, being composed mostly of silicious grains and of glauconite." No attempt at correlation with the Alabama section was made. The thickness of the "Basal clays" was estimated by Penrose to be about 250 to 300 feet.

A very marked advance was made in the development of the East Coast and Gulf stratigraphy in the early 90's, not only in Texas but throughout the Gulf. Mention may well be made of the work of Truman H. Aldrich, who by his excellent determinations and accurate descriptions did great service in the development of the Tertiary section. Kennedy in 1892 (20), Dumble in 1892 (21), and Dumble in 1891 (24), followed Penrose and added only a few details of outcrop without great significance. The second volume of the annual report of the Geological Survey of Arkansas for 1892, but not published till 1891 (25), contained what was for that era a monographic report of the Tertiary geology of southern Arkansas, by Gilbert D. Harris. In that report Harris made the first attempt, so far as I know, at a correlation of the East Coast and Gulf Midway and recognized for the first time the significance and wide distribution of these beds:

> The term "Midway series" was used by Smith and Johnson in 1887 to designate a calcareous formation lying at the base of the Eocene of Alabama, and was classified by them as a subdivision of the "Lignitic." . . . Owing, however, to its persistent nature, occurring, interruptedly to be sure, from Georgia to western Texas, and to its generally marked lithological and paleontological differences from the remainder of "Lignitic" deposits, it seems advisable to make the terms of coördinate rank (p. 8).

Harris also cites several Texas localities from which collections have been made and gives the fossil lists of those collections.

One of the most distinguished contributions of its time or, for that matter, for many years later, was William Kennedy's "The Eocene Tertiary east of the Brazos River" (27). Kennedy considered the "Basal or Wills Point clays" as a sub-stage under the Midway "stage" and correlated them with the Matthews Landing, Black Bluff and Midway sections of Alabama. The greater part of Kennedy's paper was occupied with the lower Claiborne, but he gave sections

with lists of the contained fossils from the Brazos River bluffs and from Tehuacana. The publications of the next two decades that touched upon the lower Eocene of Texas were mainly those of the State and Federal Surveys and the main advance was along the line of the accumulation of detail and the refinement of correlation. The most comprehensive are Veatch's "Geology and underground water resources of northern Louisiana and southern Arkansas," 1906 (30), which includes a plate of characteristic Midway fossils, all of which occur in Texas; Deussen's "Geology and underground waters of the southeastern part of the Texas Coastal Plain," 1914 (33), with good correlations; and Stephenson's "Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain," 1915 (34).

The most significant stratigraphic reports published between 1915 and 1920 were those of the Bureau of Economic Geology of The University of Texas—Dumble's "Geology of East Texas," 1918 (42), a compendium of information on the East Texas Tertiaries; and two county reports, Liddle's "Geology and mineral resources of Medina County," 1918 (43), and Sellards' "Geology and mineral resources of Bexar County," 1919 (44). Dumble had continued his investigations on the Texas Coastal Plain since the early 90's but his major interests were to the east of the Midway outcrop in the later sands. Practically all of the published work upon the Midway had been done by the personnel of the Federal and State Surveys, and dealt with the local stratigraphy, organic contents, areal distribution, correlations within and without the State, but with the exception of the Matson-Hopkins report, which attracted surprisingly little intelligent attention, very little with the structure.

Though shallow oil had been produced near Corsicana since 1895, the occurrence had not aroused any marked geological interest nor had it seriously influenced the course of geologic study. But the opening of the Mexia field, the first to be associated with a fault zone, due possibly in part to the stimulus of war activity and in part to the more intelligent methods and better trained personnel of the commercial world, basically altered the trend of field and laboratory investigations which were dominated during the succeeding years by the search for oil. An immense amount of information on the structure and general tectonics of the Midway, particularly in East Texas, was brought to light and papers of varying degrees of value filled the newly established commercial

publications. Among the more significant of these may be mentioned that of Lahee (49), 1923, on the Currie Field; Julius Fohs and Heath Robinson on the "Structural and stratigraphic data of Northeast Texas petroleum area" (52) and the "Origin of the structure," 1923 (53); Pratt and Lahee (56), 1923, on the "Faulting and petroleum accumulation at Mexia, Texas"; Lahee (65), 1926, "Further notes on the origin and nature of the Currie structure"; Lydon Foley's "Mechanics of the Balcones and Mexia faulting," 1926 (68); and E. W. Bruck's "Geology of the San Marcos quadrangle, Texas" (70) 1927. In the meantime, Deussen's "Geology of the Coastal Plain of Texas west of Brazos River" (62) was published. This was a distinguished contribution to the geology of the time in which it was written, but the delay in publication of almost a decade of rapidly accumulating geologic knowledge had lent an historic interest to a paper distinctly in advance of its time. Trowbridge's "Geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande," (50) begun much later than Deussen's work, was published a year earlier, and completed the areal reconnaissance studies of the Coastal Plain.

The need for a rational interpretation of sub-surface materials stimulated the study of micro-faunas, particularly the foraminifera, and led to a most amazing development in the knowledge of groups which had heretofore aroused only an academic curiosity. The publication of Mrs. Plummer's "The Foraminifera of the Midway formation in Texas," 1926 (69), covers the past history of the foraminiferal researches and establishes a firm foundation on which all future studies must be based. Another line of investigation less directly concerned with the Midway than with formations of more obscure outcrop is the geophysical, a research so comparatively new and so rapidly developing that a new literature will doubtless be produced during the length of time necessary for the publication of this report. One of the most comprehensive articles yet published, Donald C. Barton's (71) "Applied geophysical methods in America," was the direct result of the adoption of geophysical methods of study of the salt domes. The knowledge of the East Texas domes received its greatest advance from Sidney Powers' "Interior salt domes of Texas," 1926 (64). The present trend of all lines of geologic investigations of the Midway is toward the interpretation and coördination of the great mass of scattered incoherent data

that has so rapidly accumulated during the past ten years. The achievement of this difficult end has been epitomized by F. B. Plummer (76). Not only has the published material been coördinated and rationalized but much new material, assembled with modern methods of accuracy and close observation, has been added.

BIBLIOGRAPHY

1. 1808. Cuvier, Georges, and Brongniart, Alexandre, Essai sur la Géographie minéralogique des environs de Paris, vol. 1, pp. 200–203.
2. 1809. Maclure, William, Observations on the geology of the United States, explanatory of a geological map: Am. Philos. Soc., Trans., old ser., vol. 6, pp. 411–428.
3. 1824. Finch, John, Geological Essay on the Tertiary formations in America: Am. Jour. Sci., 1st ser., vol. 7, pp. 31–43.
4. 1829. Morton, S. G., Geological observations on the Secondary, Tertiary, and Alluvial formations of the Atlantic Coast of the United States of America: Acad. Nat. Sci. Philadelphia, Jour., 1st ser., vol. 6, pp. 59–71.
5. 1835. Featherstonhaugh, G. W., Geological report of an examination made in 1834, of the elevated country between the Missouri and Red Rivers, pp. 1–97, Washington.
5a. 1840. Moore, Francis, Jr., Map and description of Texas . . . . 143 pp., Philadelphia; 2d ed., 143 pp., New York, 1844.
6. 1841. Kennedy, William, Texas: The rise, progress, and prospects of the Republic of Texas (2 vols.): vol. 1, 378 pp., 4 maps; vol. 2, 348 pp.
6a. 1846. Roemer, Ferdinand, Sketch of the geology of Texas: Am. Jour. Sci., 2d ser., vol. 2, pp. 358–365.
6b. 1848. ——, ——, Contributions to the geology of Texas: Am. Jour. Sci., 2d ser., vol. 6, pp. 21–28.
7. 1849. ——, ——, Texas, xiv, 464 pp., 1 map, Bonn.
8. 1852. ——, ——, Die Kreidebildungen von Texas und ihre organischen Einschlüsse, pp. 1–100, Bonn.
9. 1857. Winchell, Alexander, Notes on the geology of Middle and Southern Alabama: Am. Assoc. Advancement Sci. Proc., vol. 10, pt. 2, pp. 82–93.
10. 1857. Schott, Arthur, Substance of the sketch of the geology of the lower Rio Bravo del Norte: Report on the United States and Mexican Boundary Survey, U. S., 34th Cong., 1st sess., Senate Ex. Doc. 108 and House Ex. Doc. 135, vol. 1, pt. 2, pp. 23–48, 2 illustrations.
10a. 1857. Conrad, T. A., Description of Cretaceous and Tertiary fossils: Report on the United States and Mexican Boundary Survey, U. S., 34th Cong., 1st sess., Senate Ex. Doc. 108 and House Ex. Doc. 135, vol. 1, pt. 2, pp. 141–174, pls. 1–21.
11. 1857. Emory, W. H., Report on the United States and Mexican Boundary Survey, U. S., 34th Cong., 1st sess., Senate Ex. Doc. 108 and House Ex. Doc. 135, vol. 1, pt. 1, pp. 1–258; 64 steel engravings; 1 geologic section; 1 meteorological diagram; 1 map showing magnetic lines; 12 stone engravings; 20 wood cuts.
11a. 1860. Moore, Francis, Jr., Geological sketch of Texas: Texas Almanac, pp. 91–99, Galveston.
11b. 1871. Hilgard, E. W., Geological history of the Gulf of Mexico: Am. Jour. Sci., 3d ser., vol. 2, pp. 391–404.

11c. 1891. — — , — — , Later Tertiary history of the Gulf of Mexico: Am. Jour. Sci., 3d ser., vol. 22, pp. 58–65.

12. 1894. Loughridge, R. H., Physico-geographical and agricultural features of the State of Texas: Tenth Census United States, vol. 5, pp. 669–713, 2 maps.

13. 1881. Heilprin, Angelo, The Tertiary geology of the eastern and southern United States: Acad. Nat. Sci. Philadelphia, Jour., new ser., vol. 9, pp. 115 154, 1 map.

13a. 1884. — — , — — , Contributions to the Tertiary geology and paleontology of the United States, 117 pp., 1 map, Philadelphia.

13b. 1885. Whitfield, R. P., Brachiopoda and Lamellibranchiata of the Raritan clays and greensand marls of New Jersey: U. S. Geol. Survey Mon. 9, 338 pp., 35 pls., 1 map.

13c. 1885. Koenen, A. von, Über eine Paleocäne fauna von Kopenhagen: Abhandlungen der Königlichen Gesellschaft der Wissenschaft zu Göttingen, Bd. 33, pp. 3–128, pls. 1–5 (Göttingen).

14. 1887. Hill, R. T., The present condition of knowledge of the geology of Texas: U. S. Geol. Survey Bull. 45, pp. 1–95.

15. 1887. Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee and Alabama Rivers: U. S. Geol. Survey Bull. 43, pp. 1–189, pls. 1–21.

16. 1889. Hill, R. T., and Penrose, R. A. F., Jr., Relation of the uppermost Cretaceous beds of the eastern and southern United States, and the Tertiary-Cretaceous parting of Arkansas and Texas: Am. Jour. Sci., 3d ser., vol. 38, pp. 163–173.

16a. 1890. Dall, W. H., Wagner Free Inst. Sci., Trans., vol. 3, pt. 1, pp. 69–74.

17. 1890. 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. Survey Texas, 1st Ann. Rept., pp. 5–101.

17a. 1890. Aldrich, T. H., A new Eocene fossil from Texas (*Omaluxis singleyi*, n. sp.): Nautilus, vol. 4, p. 25, illus.

18. 1891. Clark, W. B., Correlation Papers—Eocene: U. S. Geol. Survey Bull. 83, pp. 1–173, 2 pls.

19. 1891. Heilprin, Angelo, The Eocene Mollusca of the State of Texas: Acad. Nat. Sci. Philadelphia, Proc. for 1890, pp. 393–406, 1 pl.

20. 1892. Kennedy, William, A section from Terrell, Kaufman County, to Sabine Pass on the Gulf of Mexico: Geol. Survey Texas, 3d Ann. Rept., pp. 43–125, text figs. 3–6.

21. 1892. Dumble, E. T., Report on the brown coal and lignite of Texas: Geol. Survey Texas, pp. 1–243, pls. 1–25, 13 text figs.

22. 1893. Kennedy, William, Report on Grimes, Brazos and Robertson Counties: Geol. Survey Texas, 4th Ann. Rept. (for 1892), pp. 1–81, 3 maps, 2 pls. of sections.

23. 1894. Hill, R. T., Geology of parts of Texas, Indian Territory, and Arkansas adjacent to Red River: Bull. Geol. Soc. Am., vol. 5, pp. 297–338, pls. 12, 13, 4 text figs.

24. 1894. Dumble, E. T., The Cenozoic deposits of Texas: Jour. Geol., vol. 2, No. 6, pp. 549–567.

25. 1894. Harris, G. D., The Tertiary geology of southern Arkansas: Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, pp. xiv, 1–207, 34 figs., 7 pls.

26. 1894. Smith, E. A., Johnson, L. C., and Langdon, D. W., Jr., Report on the geology of the Coastal Plain of Alabama: Geol. Survey Alabama, Pt. I, pp. xxiv, 1–445, 29 pls., 1 text fig.

26a. 1895. Harris, G. D., New and otherwise interesting Tertiary Mollusca from Texas: Acad. Nat. Sci. Philadelphia, Proc., pp. 45–83, pls. 1–9.

27. 1895. Kennedy, William, The Eocene Tertiary of Texas east of the Brazos River: Acad. Nat. Sci. Philadelphia, Proc., pp. 89–160.
27a. 1895. Harris, G. D., New or little known Tertiary Molluscs from Alabama and Texas: Bull. Am. Paleontology, No. 2, 31 pp., illus.
28. 1896. — — —, ——. The Midway stage: Bull. Am. Paleontology, vol. 1, No. 4, pp. 1–139, pls. 1–15.
28a. 1897. Aldrich, T. H., Bull. Am. Paleontology, vol. 2, No. 8, p. 130, pl. 1, fig. 2.
29. 1898. Dumble, E. T., Physical geography, geology, and resources of Texas: Chapt. 4, vol. 2, of "A comprehensive history of Texas," published by W. G. Scarff, 1898, pp. 471–516.
29a. 1899. Cossmann, M., Essais de Paléoconchologie Comparée, vol. 3, p. 138.
29aa. 1900. Vaughan, T. W., The Eocene and lower Oligocene coral faunas of the United States: U. S. Geol. Survey Mon. 39, 263 pp., 24 pls.
29b. 1900. — — —, — —. U. S. Geol. Survey Uvalde Folio No. 61, 7 pp., 3 maps.
29c. 1901. Aldrich, T. H., A Texas oil well fossil: Nautilus, vol. 15, p. 71, illus.
29d. 1903. Dall, W. H., Wagner Free Inst. Sci., Trans., Philadelphia, vol. 3, pt. 6, p. 1539, pl. 58, fig. 8.
29e. 1904. Archangelsky, A. D., Dépôts paléocènes de la région Volgienne du gouvernement de Saratov et leur faune: Materialien zur Geologie Russlands, vol. 22, pp. 1–207, 12 pls.
30. 1906. Veatch, A. C., Geology and underground water resources of northern Louisiana and southern Arkansas: U. S. Geol. Survey Prof. Paper 46, pp. 1–422, 51 pls., 33 text figs.
30a. 1906. Dall, W. H., Note on some names in the Volutidae: Nautilus, vol. 19, p. 143.
30b. 1906. Newton, R. B., Note on Swainson's genus *Volutilithes*: Malacological Soc. London, Proc., vol. 7, p. 100–104.
30c. 1906. Smith, Burnett, Phylogeny of the races of *Volutilithes petrosus*: Acad. Nat. Sci. Philadelphia, Proc., vol. 58, pp. 52–76.
30d. 1907. Aldrich, T. H., Nautilus, vol. 21, p. 10, pl. 1, figs. 4, 5.
30dd. 1907. Holst, N. O., and Grönwall, K. A., Paleocen vid Klagshamn: Sveriges Geologiska Undersökning, ser. C, No. 208, pp. 1–27.
31. 1911. DeBoury, Eugene: Jour. de Conchyliologie, vol. 58, p. 218.
31a. 1911. Aldrich, T. H., Bull. Am. Paleontology, vol. 5, No. 22, p. 13, pl. 5, figs. 9, 10.
32. 1911. Gordon, C. H., Geology and underground waters of northeastern Texas: U. S. Geol. Survey Water-Supply Paper 276, pp. 1–78, 2 pls., 6 figs.
33. 1914. Deussen, Alexander, Geology and underground waters of the southeastern part of the Texas Coastal Plain: U. S. Geol. Survey Water-Supply Paper 335, 365 pp., 9 pls.
34. 1915. Stephenson, L. W., The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 90-J, pp. i–iv, 155–182, pls. 11–19, figs. 13–20.
35. 1915. Dumble, E. T., Some events in the Eocene history of the present Coastal area of the Gulf of Mexico in Texas and Mexico: Jour. Geol., vol. 23, No. 6, pp. 481–498, map.
35a. 1915. Oppenheim, Paul, Die eocäne Invertebraten Fauna des Kalksteins in Togo: Beiträge für geologischen Erforschung der deutschen Schutzgebiete, vol. 12, 126 pp., 5 pls.
36. 1916. Dumble, E. T., The geology of Texas: Rice Institute Pamphlet, vol. 3, No. 2, pp. 125–204.
37. 1916. Shaw, E. W., and Matson, G. C., Natural gas resources of part of North Texas: U. S. Geol. Survey Bull. 629, pp. 1–119, 7 pls., 13 text figs.

38. 1916. Udden, J. A., Baker, C. L., and Bose, E., Review of the geology of Texas: Univ. Texas Bull. 44, pp. xi, 1-164, 1 map, 1 correlation table, 10 text figs.
39. 1916. Udden, J. A., and Bybee, H. P., The Thrall oil field: Univ. Texas Bull. 66, pp. vi, 1-78, 7 pls., 7 figs.
40. 1916. Dumble, E. T., Problem of the Texas Tertiary sands: Bull. Geol. Soc. Am., vol. 26, pp. 447-476, pls. 25-27.
41. 1917. Matson, G. C., and Hopkins, O. B., The Corsicana oil and gas field, Texas: U. S. Geol. Survey Bull. 661-F, iii-iv, pp. 211-252, pls. 17-21, figs. 30-32.
42. 1918. Dumble, E. T., The geology of East Texas: Univ. Texas Bull. 1899, 388 pp., 12 pls.
43. 1918. Liddle, R. A., The geology and mineral resources of Medina County: Univ. Texas Bull. 1860, pp. 1-177, 9 pls., 8 figs.
43a. 1919. Cooke, C. W., Contributions to the geology and paleontology of the West Indies: Carnegie Inst. Washington Pub. No. 291, p. 152, pl. 16, figs. 5a-c.
44. 1919. Sellards, E. H., Geology and mineral resources of Bexar County: Univ. Texas Bull. 1932, pp. 1-202, 1 map, 1 pl., 6 figs.
45. 1919. ———, — , Structural conditions in the oil fields of Bexar County, Texas: Bull. Am. Assoc. Petr. Geol., vol. 3, pp. 299-309.
45a. 1920. Brantley, J. E., Petroleum possibilities of Alabama: Geol. Survey Alabama, Bull. 22, pt. 2, p. 149.
45b. 1920. Powers, Sidney, The Butler salt dome, Freestone County, Texas: Am. Jour. Sci., 4th ser., vol. 49, pp. 127-142, figs. 1, 2.
46. 1921. Wrather, W. E., The Mexia pool, Mexia, Texas: Bull. Am. Assoc. Petr. Geol., vol. 5, pp. 419-421.
46a. 1922. Sellards, E. H., Well records in Pamola County including structural contour map: Univ. Texas Bull. 2232, pp. 1-33, 2 figs.
47. 1922. Heald, K. C., Salt domes of northeastern Texas (review of paper by Chas. A. Cheney): Bull. Am. Assoc. Petr. Geol., vol. 6, pp. 58-59.
48. 1922. Thompson, W. C., The Midway limestone of Northeast Texas: Bull. Am. Assoc. Petr. Geol., vol. 6, p. 323-332.
48a. 1922. Vaughan, T. W., Corals from Eocene deposits of Peru: Geology and palaeontology of northwest Peru, Section D, p. 130: MacMillan & Co., Ltd., London, 1922. (Henry Woods and J. A. Cushman, co-authors.)
49. 1923. Lahee, F. H., The Currie field, Navarro County, Texas: Bull. Am. Assoc. Petr. Geol., vol. 7, pp. 25-36.
50. 1923. Trowbridge, A. C., A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131-D, pp. i, ii, 85-107, 1 map.
51. 1923. Gardner, Julia, New species of Mollusca from the Eocene deposits of southwestern Texas: U. S. Geol. Survey Prof. Paper 131-D, pp. 109-115, pls. 29-33.
52. 1923. Fohs, F. J., Structural and stratigraphic data of Northeast Texas petroleum area: Econ. Geol., vol. 18, pp. 709-721, 3 pls., 1 fig.
53. 1923. Robinson, H. M., The origin of the structure (of the northeast Texas petroleum area): Econ. Geol., vol. 18, pp. 722-731.
54. 1923. Jones, J. C., Suggestive evidence on the origin of petroleum and oil shale: Bull. Am. Assoc. Petr. Geol., vol. 7, pp. 67-72.
55. 1923. Huntley, L. G., The Sabine uplift: Bull. Am. Assoc. Petr. Geol., vol. 7, pp. 179-181.
56. 1923. Pratt, W. E., and Lahee, F. H., Faulting and petroleum accumulation at Mexia, Texas: Bull. Am. Assoc. Petr. Geol., vol. 7, pp. 226-236.

57. 1924. Beasley, J. E., Résumé of the geology of the Gulf Coastal Plain: Bull. Am. Assoc. Petr. Geol., vol. 8, pp. 21–28.
58. 1924. Hager, D. S., and Brown, I. O., The Minerva oil field, Milam County, Texas: Bull. Am. Assoc. Petr. Geol., vol. 8, pp. 632–640.
59. 1924. Lahee, F. H., Structural and stratigraphic data of northeast Texas: Econ. Geol., vol. 19, pp. 563–585.
60. 1924. Selland, E. H., The Luling oil field in Caldwell County, Texas: Bull. Am. Assoc. Petr. Geol., vol. 8, pp. 733–738.
61. 1924. Berry, E. W., An early Eocene florule from Central Texas: U. S. Geol. Survey Prof. Paper 132-E, pp. 87–92, pl. 23, text fig. 8.
62. 1924. Deussen, Alexander, Geology of the Coastal Plain of Texas west of Brazos River: U. S. Geol. Survey Prof. Paper 126, pp. 1–139, 36 pls., 38 figs.
62a. 1925. Lahee, F. H., Comparative study of well logs on the Mexia type of structure (with discussion): Trans. Amer. Inst. of Mining and Metallurgical Eng., vol. 71, pp. 1329–1350.
62b. 1925. Gardner, Julia, A new Midway brachiopod, Butler salt dome, Texas: Amer. Jour. Sci., 4th ser., vol. 10, pp. 134–138, figs. 1–8.
63. 1925. Brucks, E. W., The Luling field, Caldwell and Guadalupe counties, Texas: Bull. Am. Assoc. Petr. Geol., vol. 9, pp. 632–654.
64. 1926. Powers, Sidney, Interior salt domes of Texas: Bull. Am. Assoc. Petr. Geol., vol. 10, pp. 1–60, 1 pl., 14 figs.
65. 1926. Lahee, F. H., Further notes on the origin and nature of the Currie structure, Navarro County, Texas: Bull. Am. Assoc. Petr. Geol., vol. 10, pp. 61–71.
66. 1926. Hull, J. P. D., Discovery of Nigger Creek oil pool, Limestone County, Texas: Bull. Am. Assoc. Petr. Geol., vol. 10, pp. 997–998.
67. 1926. Collingwood, D. M., and Rettger, R. E., The Lytton Springs oil Field, Caldwell County, Texas: Bull. Am. Assoc. Petr. Geol., vol. 10, pp. 953–975.
67a. 1926. Stewart, Ralph, Gabb's California fossil type gastropods: Acad. Nat. Sci. Philadelphia, Proc., vol. 78, pp. 287–447, pls. 20–32.
68. 1926. Foley, L. L., Mechanics of the Balcones and Mexia faulting: Bull. Am. Assoc. Petr. Geol., vol. 10, pp. 1261–1269.
69. 1926. Plummer, Helen Jeanne, Foraminifera of the Midway formation in Texas: Univ. Texas Bull. 2644, pp. 1–206, 15 pls., 13 figs., 1 distribution table.
70. 1927. Brucks, E. W., The geology of the San Marcos quadrangle, Texas: Bull. Am. Assoc. Petr. Geol., vol. 11, pp. 825–851, 6 figs.
71. 1927. Barton, D. C., Applied geophysical methods in America: Econ. Geol., vol. 22, pp. 629–668.
72. 1927. Böse, Emil, and Cavins, O. A., The Cretaceous and Tertiary of southern Texas and northern Mexico: Univ. Texas Bull. 2748, pp. 1–142, 1 map.
73. 1928. Cooke, C. W., and Stephenson, L. W., The Eocene age of the supposed late Upper Cretaceous greensand marls of New Jersey: Jour. Geol., vol. 36, No. 2, pp. 139–148, Feb. Mar.
73a. 1929. Morley Davies, A., Faunal migrations since the Cretaceous period: Proc. Geol. Assoc., vol. 40, pp. 307–327, figs. 35, 36.
73b. 1930. Stewart, Ralph, Gabb's California Cretaceous and Tertiary lamellibranchs: Acad. Nat. Sci. Philadelphia, Spec. Pub. No. 3, 314 pp., 17 pls.
73bis, 1930. Carter, W. T., Beck, M. W., Templin, L. H., and Hawker, H. W., Soil survey of Milam County, Texas, 1925: U. S. Dept. Agriculture, Bur. Chemistry and Soils, No. 25, Series 1925.
73c. 1930. Cox, L. R., The fossil fauna of the Samana Range and some neighboring areas: Pt. 3, The Mollusca of the Hangu Shales, Mem.

Geol. Survey of India, Palaeontologia Indica, new ser., vol. 15, pp. 129-222; pls. 17-22.

73d. 1930. Getzendaner, F. M., Geologic section of Rio Grande embayment, Texas, and implied history: Bull. Am. Assoc. Petr. Geol., vol. 14, pp. 1125-1437, map.

73e. 1932. Trowbridge, A. C., Tertiary and Quaternary geology of the lower Rio Grande region, Texas: U. S. Geol. Survey Bull. 837, 260 pp., 45 pls., 76 figs.

74. 1933. Plummer, Helen Jeanne, Foraminiferal evidence of the Midway-Wilcox contact in Texas: Univ. Texas Bull. 3201, pp. 51-62, 1 pl., 1932 (not distributed till 1933).

75. 1933. Claypool, C. B., The Wilcox of Central Texas: Abstract of thesis (Univ. Illinois), 12 pp., Urbana, Ill., May, 1933.

76. 1933. Sellards, E. H., Adkins, W. S., and Plummer, F. B., The geology of Texas, Vol. I, Stratigraphy: Univ. Texas Bull. 3232, 5 pts., pp. 1-819, bibliography (pp. 819-965), 11 pls. (including State geol. map), 54 figs., 1932 (not distributed till July, 1933).

77. 1933. Miller, A. K., and Thompson, M. L., The nautiloid cephalopods of the Midway group: Jour. Paleontology, vol. 7, No. 3, pp. 298-321, pls. 34-38, 4 text figs., September, 1933.

78. 1933. Gardner, Julia, Kincaid formation, name proposed for lower Midway of Texas: Bull. Am. Assoc. Petr. Geol., vol. 17, pp. 744-747.

79. 1934. Morley Davies, A., Tertiary faunas, vol. 2, 252 pp., 1 pl., 28 figs.

STRATIGRAPHIC BACKGROUND

In the early Tertiary, as in the Recent epoch, eastern Texas was the western outpost of the Gulf Province. Texas shares with the other states of the deep South its early Eocene history and the major divisions of the lower Tertiary section have a common nomenclature throughout the Gulf Province. The name Midway, first used by Smith and Johnson (15, p. 62) was taken from Midway Landing on the Alabama River, where the lower Eocene is well exposed. Synchronous deposits were laid down across Alabama into Georgia, while to the west the ocean overflowed northeast Mississippi into Kentucky and Tennessee down through central Arkansas and in a great sigmoidal curve across east and south Texas into Mexico.

The nomenclature adopted in this paper is essentially that proposed by Claypool in May, 1933, and adequately defined and interpreted by Plummer in the Geology of Texas published in July of the same year. Two major divisions of the Midway group are recognized: the lower or Kincaid formation and, above it, the Wills Point formation. It seemed expedient to give member status to the sandy limestone lentils and associated strata in the upper part of the Kincaid although the lenticular nature of the limestone lentils is granted. The Mexia and Kerens members in the Wills Point have been recognized but the Wortham aragonite lentil of

Plummer has been interpreted as an unusually well characterized concretionary bed at the base of the Kerens.

The modifications in the nomenclature may be thus charted:

		Plummer (76)	This report
MIDWAY GROUP	Wills Point formation	Kerens member	Kerens member
		Wortham aragonite lentil	Aragonite bed
		Mexia member	Mexia member
	Kincaid formation	Pisgah member including Tehuacana, Rocky Cedar Creek and Lone Oak limestone lentils	Tehuacana member
			Pisgah member
		Littig glauconite member	Littig glauconitic member

The probable relationship of the Midway section in Texas to the standard Alabama section is expressed in the following table:

MIDWAY GROUP			
		Texas	Alabama
MIDWAY GROUP	Wills Point formation	Kerens member	Barren sands of upper part of Naheola formation
		Mexia member	Fossiliferous beds at base of Naheola formation including beds at Matthews Landing
	Kincaid formation	Tehuacana member	Sucarnoochee clay
		Pisgah member	
		Littig glauconitic member	Clayton formation

Although the formations and members of the Midway are fairly constant in general character, through several hundred linear miles of outcrop in the State of Texas, the lithologic and faunal variations are sufficiently great to preclude the possibility of an unbroken shore line, especially during the lower Midway. The major streams

of the present day were perhaps existent during the Tertiary and formed barriers, possibly of less saline water between the faunal provinces. Throughout the Tertiary a marked change in the sediments and in the contained fauna is coincident with the change in strike south of San Antonio, and is doubtless inherited from the old Central Mineral region which persisted as a positive element while sediments were being deposited to the south and east. The same general conditions of sedimentation probably obtained in South Texas and in Limestone County but there was no direct communication between the embayments. The common species are pelagic forms such as the Bryozoa or those which pass through a pelagic larval stage or they are widely distributed types. None of the heavy-shelled inshore species such as the large *Venericardia* of the Rio Grande fauna have been recognized north of Bexar County. For their nearest kin we must look to the south.

Possibly the South Texas that had been land since the retreat of the Cretaceous sea was near the head of the Rio Grande embayment and was covered only by a tardy invasion from the south and east. Certainly the Midway section on the Mexican side is enormously thickened and includes Midway both lower and higher than any recognized in South Texas. Although the Rio Grande section may be thinned by overlap, the wells on the Farias ranch near the Dimmit-Maverick County line reported about 300 feet of Midway and those drilled along the same structure farther east less than 200 feet, while the Midway of northern Mexico probably exceeds 1500 feet in thickness.

KINCAID FORMATION

The name Kincaid formation was proposed by me in June, 1933, to include the beds in Texas unconformably overlying the Cretaceous and overlain, for the most part unconformably, by the Wills Point. This name was chosen in lieu of the old "Myrick" of Vaughan, which was unfortunately too comprehensive to be acceptable but was of historic interest and a name associated with one of the finest sections of the lower Midway exposed in the State of Texas. It seemed unfortunate that this fine outcrop, which typifies to an unusual degree the development of the lower Midway in South Texas, should not be more widely recognized. The greater part of the commercial exploration in Texas has been north of San Antonio and for that

reason the sections, many of them undistinguished, exposed in North and Central Texas are much better known. The "Myrick" was so called from Myrick's (now Mr. Bob Evans') apiary which stands with a commanding view on the west bank of the Frio River. The exposure from the Cretaceous contact, three-fourths of a mile above the apiary, to the Wills Point contact one-fourth of a mile below it, is almost continuous. The Brazos and the Colorado Rivers offer finer sections of certain horizons but only the Frio offers a scarcely interrupted outcrop of the entire lower Midway from the Escondido to the Wills Point.

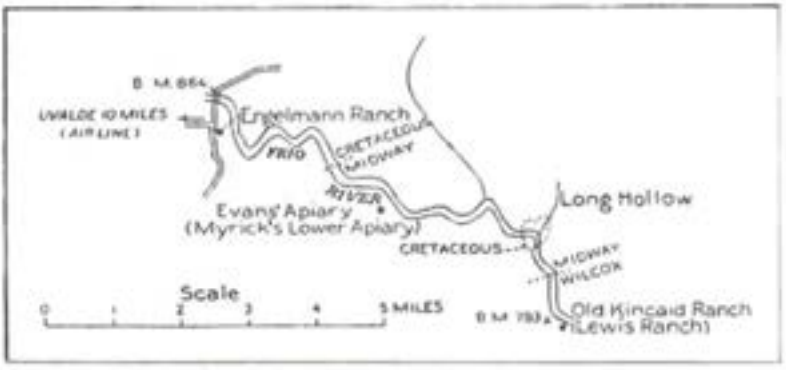


Fig. 1. Type locality of the Kincaid formation, Frio River, Uvalde County.

Three members of the Kincaid formation have been recognized:

Littig glauconitic member.—The basal member, the Littig glauconite member of Plummer (76, p. 536) was thus delimited and defined:

> The Littig glauconite consists of a bed of glauconitic sand from 8 inches to 15 feet or more thick at the base of the Kincaid formation. It is named for the town of Littig in the eastern edge of Travis County. The type locality is the exposure of the sand in the road 1½ miles by road south-southwest of Littig on the south side of Willbarger Creek. The bed consists of greenish-black calcareous glauconite weathering to yellowish-green or buff color and containing phosphate nodules, small pebbles, shark's teeth, casts of fossils, and spherical, calcareous concretions.

Pisgah member.—The middle member, the Pisgah, was also first used by Plummer (76, p. 536), though with a wider meaning than in the present report. The name Pisgah member is here applied to the series of glauconitic and fossiliferous sands and clays between

the Littig glauconitic member and the Tehuacana member. The name is adopted from Pisgah Ridge in Navarro County on the road between Richland and Wortham, 6 miles north of the Limestone County line.

The Pisgah member as restricted consists of clay, glauconitic clay, and sandy calcareous clay underlain conformably by the Littig glauconitic member and overlain conformably by the Tehuacana. The glauconite and sands are not interbedded but occur in pockets and stringers in the clay. The associated concretions are large, with rough surfaces and little structure and are not abundant.

The Tehuacana member was included by Plummer under the Pisgah, but although its lenticular nature is recognized, its prominence both topographically and historically seems to justify its acceptance in the stratigraphic nomenclature of the Midway.

Tehuacana member.—The Tehuacana member, a name here used in a strictly stratigraphic sense, includes the calcareous, glauconitic sands, characteristically indurated with a calcareous cement, the heavy glauconitic, highly fossiliferous, loosely indurated sands with or without phosphatic nodules, and all other equivalent deposits between the top of the Pisgah member and the base of the Wills Point formation. As explained in the chapter on Limestone County, the name Tehuacana "limestone" commonly applied to this unit is largely a misnomer, although it does contain intercalated sandy limestone lenses.

The lower part of the Tehuacana is typically exposed along the western face of the scarp on which the town of Tehuacana stands. The higher horizons are best represented in the quarry one-half mile east of the town. About 72 feet of section are included in the Tehuacana outcrops. Near the base are two oyster beds, the lower about 20 feet above the contact and the equivalent of the oyster bed outcropping on Pisgah Ridge. The second oyster bed is about 10 feet higher than the first and about 10 feet below the horizon rich in turritellas. The venericardias so abundant in central Limestone County are at the top of the Tehuacana. The densely indurated fossiliferous beds are separated by coarse quartz sands of varying thicknesses, some of them loose, some loosely indurated. The resistant, indurated beds of this member produce a prominent topographic feature along an interrupted line of outcrop from Kaufman County to the Rio Grande. The maximum thickness in the outcrop is less than 100 feet but the indicated thickness in the logs

approximates 200 feet. Plummer (76, p. 544) has noted that the limestones of the Tehuacana disappear a few miles down dip.

WILLS POINT FORMATION

The name "Basal or Wills Point clays" was introduced by Penrose (17, pp. 19–22) in 1890 to cover the entire Midway section.

Harris (23, pp. 15, 41), the first to circumscribe the name, considered Wills Point not as a stratigraphic but as a geographic term, analogous to his Rocky Cedar Creek limestone. However, he correlated it quite properly with the upper Midway, and the formation as it is here used is contained within the stratigraphic limits which he imposed upon it. The Wills Point formation thus restricted is a series of bedded sandy clays and clayey sands approximating 600 feet in maximum thickness overlying the Tehuacana member of the Kincaid formation and underlying the sands and laminated clays of the Wilcox. The fauna both micro- and macroscopic is rather meager but the formation is exceptionally well characterized by the abundant concretions which vary in size, color, texture and chemical content with the horizon in which they occur. The formation includes two distinctive members, the Mexia member and the Kerens member.

The terms Mexia member and Kerens member first appeared in print in the abstract of a thesis upon the Wilcox of Central Texas, by Chester Burns Claypool, in May, 1933. He defined the Mexia member (75, p. 5) as "Dark clays, only slightly fossiliferous except for foraminifera." The following description is given by Plummer (76, p. 559): "The Mexia member consists of dark, thinly laminated or compact fossiliferous clays 50 to 75 feet or more thick, of a fairly deep-water, marine facies and having a thin, glauconitic sand layer at its base (*Venericardia bulla* zone). The member is limited at the base by the Kincaid formation and bounded at the top by the Wortham aragonite layer. The type locality is the clay pit at the brick yard in the west edge of the town of Mexia, Limestone County."

The aragonite bed, a thin, concretionary limestone very rarely seen in place, was given member status by Plummer (76, p. 559), but it is considered in this report as a basal precipitate of the Kerens member. The Kerens member was characterized by Claypool (75, p. 5), as "Silts and clays, light gray to blue gray. Some large concretions locally. Much glauconite. Marine with many mollusca and foraminifera."

Plummer (76, p. 559) thus characterized the Kerens member: "The Kerens member consists of dark gray, silty or sandy clay. It occupies the upper two-thirds of the Wills Point formation and is overlain by the basal beds of the Wilcox group. The member is of variable thickness. In Brazos River valley it is about 300 feet thick. In Trinity River valley it is estimated to have a maximum thickness of 450 or possibly 500 feet. The type locality comprises the exposures along Trinity River north of the St. Louis and Southwestern Railroad east of the town of Kerens in Navarro County. An especially good exposure is at the old Humble Oil and Refining Company pumping plant on Trinity River about one mile north of the new highway east from Kerens."

The Wills Point formation has been interpreted as deposits laid down in a slowly shallowing sea. The lower Midway (Kincaid formation) was apparently a period of rather marked diastrophic movement. The streams were rejuvenated and cut rapidly into the Cretaceous sands, possibly to the Woodbine. At the opening of the Wills Point there was a fairly abrupt change in the character of sedimentation. The streams were restricted largely in their activities to formations such as the Navarro and the Taylor. Not only was the source of the coarse sands apparently cut off but also the source of the abundant lime. It is possible that the Wills Point may have been sandy up dip but no record of such a deposit is known. It seems more probable that the Wills Point muds and silts were transported by old sluggish streams meandering through a low hinterland of Navarro and Taylor and were laid down in quiet waters of no considerable depth.

The Wills Point probably represents an appreciable time interval, much more than half of the entire Midway, a period, according to the latest estimates, believed to be in the order of six million years. At the close of the Wills Point the sea was for the most part withdrawn though marine sedimentation was probably continued in the Brazos River embayment, north of the Colorado River in Bastrop County, along the Guadalupe and Medina River basins and in the Rio Grande embayment.

The clays of the Mexia member of the Wills Point are the probable equivalents of the lower fossiliferous part of the Naheola of Alabama and the Kerens member of the barren concretionary sands and clays of the Naheola. The debatable "Coal Bluff beds" of Alabama

(45a, p. 149), a series of 60 to 90 feet of nonmarine sands and clays, with a basal lignite bed of 2 to 7 feet, now referred to the basal Wilcox may be the equivalents of the sands near New Hope and some of the Solomon Branch section south of Elgin.

TOPOGRAPHY

The topography of the Midway group is an expression of the character of the Midway deposits and of the forces of nature acting upon them. Only a single member, the Tehuacana member of the Kincaid formation, is sufficiently thick and sufficiently resistant to be a scenery maker. Along an interrupted line of outcrop from Kaufman County to the Rio Grande this sandy limestone or calcareous sandstone stands out conspicuously between the underlying clays, sandy clays, and greensands of the Pisgah member and the overlying sandy clays and clayey sands of the Wills Point formation. Though the surface outcrops are not comparable in thickness to those recorded in well logs, the scarps in Limestone and Falls counties and in Maverick County dominate the landscape and affect the minor drainage. The climate in Limestone and Falls counties is less arid than in Maverick and the area of outcrop is largely under cultivation. Maverick County, on the other hand, is still a ranching country and the resistant Tehuacana ridge, bare or covered only with sparse chaparral, can be followed from Comanche Creek to the Rio Grande. In north Texas the Tehuacana member is underlain by a varying thickness of greensands, clays and clayey sands. Only the Littig glauconitic member, rarely more than a few inches in thickness, has any resistance. It is relatively harder than the underlying Cretaceous, and this character emphasized by the greenish cast of the soil traces faintly the contact line from Hunt County to Guadalupe. South of Bexar County the Tehuacana member directly overlies the Cretaceous or is separated from it by thin, soft glauconitic sands. The Cretaceous of the Mexican Border is more sandy than that north of Bexar County and carries hard beds which weather into rather high relief, so that on topography alone the Tehuacana and the Escondido are not readily separable. In the extreme northeastern part of the State also, in Franklin, Titus, and Bowie counties, where the Wills Point clays are in contact with Navarro clays, the separation is often difficult, for there is no break in the

topography and very little in the soil. The remarkable flat "prairies" of Bowie, Titus, and Franklin counties are, for the most part, Wills Point, though DeKalb and Wyatt Prairies in Bowie County are of Upper Cretaceous age.

The Wills Point is typically an open prairie country with a dark gray fine sandy or loamy soil. The vegetation is for the most part short grasses and mesquite. The Wilcox topography is much more broken, the soil is coarser and redder, and the buffalo grass and mesquite of the Midway give place abruptly to black jack and an occasional live oak. In the soil and in the vegetation the Wilcox of East and Northeast Texas very closely resembles some of the river terrace deposits.

The curious mounds of Northeast Texas which have been discussed under Titus County give little evidence of being raised by natural forces.

AREAL DISTRIBUTION

The areal distribution of the Midway group is briefly considered in its outcrop from northeast to southwest across the State.

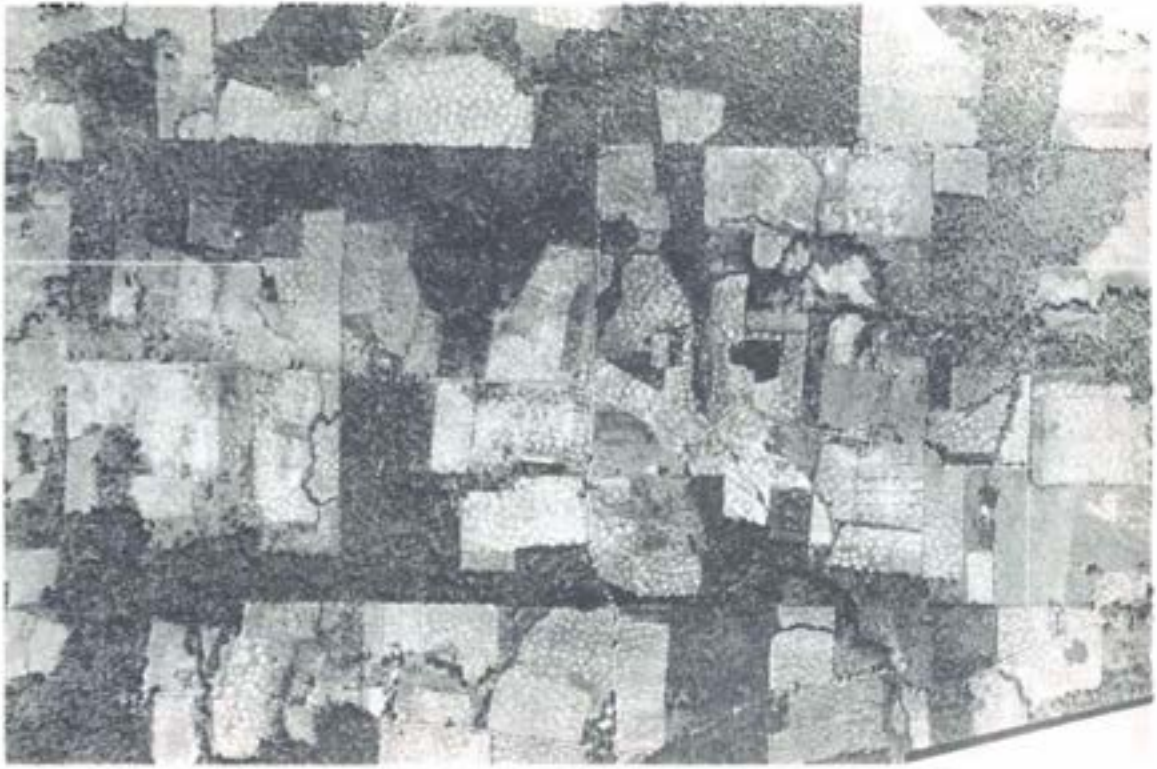
A uniform treatment is not attempted. Many of the counties, particularly in Northeast Texas, are already adequately covered by reports in readily accessible publications. "The Cenozoic Systems in Texas," pt. 3 of The University of Texas Bulletin 3232, not only sketches clearly the broad outlines but in Northeast Texas has filled in many of the significant details. The Midway of South Texas is not so well known and the discussion of that area in this paper is more ambitious.

BOWIE COUNTY

Only the upper part of the Wills Point, the Kerens member, is exposed in Bowie County. A very dense yellow gray clay carrying little or no mica and fretted along the outer surfaces and cleavage faces with ferro-magnesian dendrites outcrops in an east-west belt between the marine and lithologically very fine clays of the Cretaceous and the nonmarine more sandy and often laminated clays and shales of the Wilcox. The Midway clays are, as a rule, obscurely bedded and break with a conchoidal fracture into biscuit-shaped objects. The little mica that is present is biotite and in very small flakes. The clay is reduced by washing to a small residue of rounded

quartz grains and iron pellets and crusts. Fossils are absent or extremely rare. Thin discoidal limonite concretions and cone-in-cone are commonly associated with the clays.

The exposure of the Midway in the faulted section at Buzzards Bluff on the Arkansas side of the Red River is much finer than anything observed in Bowie County. A Midway-Wilcox contact has also been observed in the clay pits of the Texarkana Pipe Works north of Texarkana, secs. 4 and 9, T. 15 S., R. 28 W., Miller County, Arkansas. Leaves determined as Wilcox by E. W. Berry were recovered from the southern pit, while 16 feet of clay similar to that exposed in the Midway section of Buzzards Bluff was exposed in the northern pit in 1924. The Midway-Wilcox contact was established 3½ miles north of Texarkana by the outcropping of Midway clays in a low cut of the Kansas City Southern Railway to the north of a conspicuous Wilcox outcrop. The clays are unusually sandy, but the sand occurs in pockets rather than in layers and large limonite concretions are associated with the clays. On the north side of the Texarkana-New Boston highway, one-half mile east of Hooks, very dense nonmicaceous clays outcrop. These are probably of Midway age, though there is scant evidence in the way of fossils and no associated concretions. Beds lithologically similar to those north of Texarkana outcrop 4 miles east of Antioch School, 2¼ miles south of Hooks. Clays with small discoidal ferruginous concretions are exposed at low water on either side of the bridge over McGee Creek, 1½ miles east of Godley's Prairie Church, 2½ miles west by south of Boston, and concretionary clays on Rice Creek, 1 mile south of Godley's Prairie Church. The shales outcropping to the south along a small north branch of Anderson Creek, between Rice Creek and McGee Creek, are of Wilcox age. Sandy Midway clays and shales with associated limonite concretions and cone-in-cone are well exposed in the roadside ditch, one-half mile west of Pine Lake, 3 miles west of Boston and near Anderson Creek. The contact probably falls between Pine Lake and the sandy shales outcropping 2 miles north of Siloam Church. The shales near the Siloam Church are slightly carbonaceous. Midway clays with associated limonite cores are exposed in dry seasons in the bed of Ward Creek, 4 miles northeast of Dalby Springs. The Midway and Cretaceous outcrops are largely obscured by terrace materials but



Airplane photograph (scale approximately 2½ in. = 1 mi.) of a part of the area between Dalby Springs and the Bowie-Red River county line in Bowie County, showing small mounds.

fossiliferous clays of uppermost Cretaceous age are excellently exposed in Anderson Creek, one-fourth of a mile southeast of the bridge on the road from Oak Grove southwest to Bigwoods School, Bowie County. Well cores indicate a Midway section much thicker than that established by surface outcrops.

The area indicated in Figure 2 is that covered by the airplane photograph reproduced on Plate 2. The key map is cut from the Bassett quadrangle west of Dalby Springs. The scale of the quadrangle map is 1 inch to the mile, that of the air map about 2½ inches to the mile. The curious mounds, so remarkable a topographic feature in the lower Mississippi Valley drainage, stipple much of the surface.



Fig. 2. Key map to Plate 2. The area covered by the photograph is outlined by the black rectangular line.

TITUS COUNTY

In Titus County, as in Bowie County, probably only the Kercus member of the Wills Point is present. The trend of the Midway across southeastern Red River and northwestern Titus counties is very much obscured by the terrace deposits along Sulphur River,

and in western Titus the outcrop is widened by the repetition of beds due to faulting. The Wills Point is probably the surface formation in the cotton fields of the Blalocks, about 6 miles east of Talco (Goolesboro) but no good outcrops were observed. The Browne wells in the extreme northeastern corner show Wilcox at the surface. The arroyos to the south and east of Daphne offer some very remarkable outcrops of uppermost Wills Point, or possibly basal Wilcox. A trench 9 feet deep extending for probably half a mile cuts laminated shales dipping west at a low angle. The sandy layers are very thin, the clays much less so. The associated concretions are rather small, and discoidal, with hollow centers and show no marked regularity of arrangement. Cone-in-cone and fossil wood are rare. Daphne Prairie in western Titus and eastern Franklin counties is conspicuously flat, suggesting some of the country between Hagansport and Talco. It does not show, however, the curious circular mounds (see pl. 2 and fig. 2) observed in northern Titus, Franklin, and Bowie counties. These mounds, which have been discussed by Stephenson, Veatch and others,[1] have never been adequately explained. An explanation must cover the following remarkable features: (1) Their distribution over wide areas in Oklahoma, Arkansas, Louisiana, and Texas; (2) approximate uniformity of size; (3) symmetry; (4) uniformity in spacing; (5) absence of any remains of former animal habitation; (6) absence of any human artifacts or bones.

They stipple entire counties, are 10 to 100 feet in diameter and 2 to 6 feet in altitude, uniformly and rather closely spaced but only

[1]Buckley, S. B., Mounds formed by the rotting out, *Myrmica fenestrae*: Acad. Nat. Sci. Philadelphia, Proc., vol. 13, p. 9, 1861.

Lockett, S. H., First Ann. Rept. Topographic Survey, La., for 1869, pp. 66-67. 1870.

Foster, J. W., Prehistoric races of the United States, 2d ed., Chicago, pp. 121-122, 1873.

Marquis de Nadaillac, Prehistoric America, translated by N. d'Anvers, p. 152, 1895.

Bushnell, D. I., Jr., American Anthropologist, pp. 291-295, pl. 12, 1901.

Veatch, A. C., The question of the origin of the natural mounds of Louisiana, Arkansas, and Texas: Science, n.s., vol. 21, p. 210, 1905.

Brancer, J. C., Natural mounds or hog wallows: Science, n.s., vol. 21, pp. 511-516, 1905.

Purdue, A. H., Concerning natural mounds: Science, n.s., vol. 21, pp. 821-824, 1905.

Bushnell, D. I., Jr., The small mounds of the United States: Science, n.s., vol. 22, pp. 712-714, 1905.

Veatch, A. C., On the human origin of the small mounds of the lower Mississippi Valley and Texas: Science, n.s., vol. 23, pp. 31-36, 1906.

——, ——, Geology and underground water resources of northern Louisiana and southern Arkansas: U. S. Geol. Survey Prof. Paper 46, pp. 55-59, 1906.

Stephenson, L. W., and Crider, A. F., Geology and ground waters of northwestern Arkansas: U. S. Geol. Survey Water-Supply Paper 209, pp. 30-31, 1916.

rarely in contact. It is not credible that any force of degradation, such as gullying, could have so dotted hundreds of square miles. The force, whatever it was, built up the mounds rather than wore down the intervening areas. Similar mounds are produced in small numbers around the "suck-holes" of the salines, but the mounds in question are independent of the surface formation and there is no reason to suppose that they are associated with any accumulation of gas. The soil is fairly loose and is essentially like that in the intervening areas between the mounds. The mounds are not limited to a single formation or soil so that wind action could not have been the potent factor. Organisms have been suggested, both vertebrate and invertebrate. It is hard to understand how any vertebrate, either a mound-building rodent or a mound-building man, could have colonized to such an extent without leaving some other trace of its former existence. Against the origin by some lower form of life such as the social ants, there is the argument that some trace of the underground passages might reasonably be expected to persist. Nothing of that nature has been observed in those mounds which have been sectioned by the highways. Dr. Robert T. Hill has suggested in conversation, the explanation that seems the most plausible, that the lands stippled by the mounds are the old early American cornfields and that the soil was banked about the roots of the corn to hold the moisture. Whatever the agent, it operated in recent years, geologically speaking, for mounds such as these would not retain their uniformity of size and spacing for any long period of time. In cultivated fields the mounds are being rapidly reduced to the general level of the intervening areas.

FRANKLIN COUNTY

The Midway is the dominant formation in the northern half of Franklin County although the outcrop is greatly obscured by the heavy terrace deposits along White Oak Creek and Sulphur River. West of Mount Vernon the Midway-Wilcox contact runs south of the Cotton Belt Railroad (St. Louis & Southwestern), but east of Mount Vernon it bends rather sharply to the north. As in Titus and Bowie Counties, only the Wills Point formation is certainly present, but the Mexia member of the Wills Point has been recognized in western Franklin County. Faulting, probably *en echelon*, accounts for the repetition of the beds north of White Oak Creek and for the

occurrence of Wills Point along the Sulphur Bluff-Hagansport-Talco (Goolesboro) road.

No Midway-Cretaceous contact was observed, but the Cretaceous is well exposed about 2 miles north of Needmore in the extreme northwest corner of Franklin County. In this vicinity a quite highly fossiliferous resistant limestone forms a high wooded hill descending abruptly to Sulphur Bottom. The limestone weathers to a red soil contrasting strongly with the black lands of the bottom less than half a mile below. About a mile and a half north of Hagansport, the topography suggests that north of Needmore. No limestone boulders were observed, and large "oyster shells" similar to those north of Sulphur Bluff were reported by hunters. In the eastern half of the county no trace of the Cretaceous was found, and it is probable that it disappears beneath the alluvium in South Sulphur Bottom, about 1 mile east of the road leading north from Hagansport. The full thickness of the Midway section is apparently present in some of the wells, but neither the Littig glauconitic member nor the Pisgah member of the Kincaid formation has been recognized in surface outcrops. The very fine sandy, yellow shaly clays outcropping 2 miles southeast of Needmore are referred to the lower part of the Wills Point formation. Associated with them are calcareous nodules, argillaceous concretions and curious flattened concretions of the same yellow sand that makes up the matrix. The inner layer of the flattened concretions is cellular and stained black with limonite, and the center is commonly raised to form a boss. Some of these concretions run as large as dinner plates but they are more commonly 4 inches or 5 inches in diameter. A similar assemblage with a small associated fauna is well exposed in Hopkins County, 1½ to 2 miles north of Mahoney on the Dike road. Similar calcareous nodules are present in great abundance along the roadside half a mile north of the intersection of the highway and the St. Louis & Southwestern Railroad 2 miles west of Mount Vernon. Fossils have been reported from some of these nodules.

The western half of Franklin County is more closely associated structurally with Hopkins County, the eastern half with Titus County. The faulting which brings to the surface the yellow shales southeast of Needmore is probably the broken continuation of the Sulphur Bluff fault. The manganese clays of the Kerens member of the Wills Point, which outcrop at intervals from Hagansport east to

Lavada and the Titus County line, doubtless owe their position to the same faulting which has dropped down the Wills Point and Wilcox near Talco. The absence of the Kincaid north of Hagansport may be due to overlap. The surface trace of the Talco faulting is uncertain, for the contact of the Wilcox north of White Oak Creek is obscured by the terrace deposits.

All of the Midway outcrops are included on those areas mapped on the soil maps of the Department of Agriculture under the Houston clay, the Wilson loam and the Lufkin fine sandy loam. Some Wilcox and some terrace materials are also included under these captions.

HOPKINS AND HUNT COUNTIES

In eastern Hunt and northwestern Hopkins counties, the strike of the Midway swerves from a general east-west direction to a north-northeast and south-southwest trend. The angle of the change of strike was a zone of stress and weakness and is now, in consequence, a zone of faulting. To the eastward the Kincaid formation is rarely recognized; to the southward it outcrops in a narrow but for the most part continuous band to the Guadalupe County line, and from Medina County to the Rio Grande. The Kincaid in eastern Hunt and western Hopkins counties includes a few inches of the Littig glauconitic member frequently with phosphatic nodules and the Pisgah member, a yellow brown foraminiferal clay or clayey sand, a gray foraminiferal sand and sandy clay and either a thin yellow impure limestone or its equivalent. A molluscan fauna, possibly lower than any of which we have adequate knowledge, is indicated in the coarsely glauconitic greensand reported from South Sulphur River (U.S.G.S. Sta. 13352), 5 miles north of Cumby.[2] A meager fauna was also collected from Pisgah foraminiferal sands 2 miles north of Cumby. The most characteristic species is a high, rounded-trigonal *Venericardia* about 1 inch in diameter and with numerous ribs. The species is related to *V. moa* but it is known only from molds and can not be determined with assurance. The Kincaid formation has been reported from south and west of Tira, 4 miles north of Birthright, but east of Tira it has not been recognized. Good outcrops of the faulted Kincaid beds in Hunt County have been recorded by

[2] This collection was made by Ross in 1907 from a vaguely cited locality which has not since been recognized and in an area which is mapped as Cretaceous. The collection has been retained, however, and mention is here made of it because of its unusual character.

Mrs. Plummer (69, p. 45), and adequate though not very striking outcrops occur on the northern edge of Commerce in a roadside ditch along the Paris highway. South and west of Campbell the faulted Kincaid has been traced almost to Cowleech Fork of the Sabine River. A small collection sent in by Mrs. D. A. Saunders of Greenville, from 14 miles southeast of Greenville on the Lone Oak pike, was doubtless made from the same very low Kincaid horizon as that recorded from 5 miles north of Cumby. The species include *Ostrea pulaskensis*, a rather broad and compressed *Venericardia* allied to *V. mon* of South Texas, and a high inflated species of the same genus with 15 to 20 ribs. The belt of Kincaid thus exposed is only a fraction of a mile in width. The Quinlan fault lets down a sliver of basal Kincaid 7 to 10 miles west of the normal belt of outcrop. This has been traced for about a mile southwest of Quinlan and with some interruptions for several miles to the northeast. The fault doubtless extends for some distance beyond the limits of the Midway. The Lone Oak lentil is represented by a sandy yellow limestone exposed in Lone Oak Quarry. Highly fossiliferous Kincaid sands were collected by Stephenson and Cook, about 1½ miles west of Lone Oak and 140 feet above the base.

The Wills Point occupies the greater part of the northern half of Hopkins County and the southeastern corner of Hunt. The Kereus member of the Wills Point, so well developed in Bowie, Titus, and Franklin counties, is also present in Hopkins, but it occupies a position of much lesser importance in the section. The Mexia member of the Wills Point, on the contrary, is very well developed. The best observed exposure of this member is in north-central Hopkins in a ditch on the west side of the Dike-Mahoney road a little more than one mile north of Mahoney, 7 miles northwest of Sulphur Springs. Harsh, sandy clays or shales, dark gray when wet, yellow grayish brown when dry, are exposed with some interruptions along the north slope of Caney Creek. The relatively sandy layers oxidize more rapidly than the gray clays, giving to the materials a streaky gray and yellow brown aspect. Mica is common but the flakes are small. The associated concretions are numerous and of several types. Large dark blue argillaceous concretions with crackled Limonitic centers are common. More characteristic, however, are the sandy discoidal or flattened elliptical concretions, averaging 4 to 5 inches in diameter, though some of them are much larger,

frequently elevated in the center, and cellular within. The interior is commonly stained with a black oxide of iron, and it is probably the iron that is present that makes them very noticeably heavy. Tests for strontium and barite were negative. Calcareous nodules which exhibit the same texture are similar in chemical composition. Compressed calcareous tubes are also present, and a meager fauna which includes *Balanophyllia ponderosa texana* Vaughan and Popenoe, an undetermined *Leda* and *Modiolaria* and a scrap of a nautiloid. The same horizon is probably represented on the Sulphur Springs-Birthright road on the south slope of White Oak Bayou and also about 1½ miles south of Birthright and repeated by faulting about 3 miles south of Sulphur Bluff. The aragonite bed at the base of the Kerens, indicated by the "rosette concretions," is traceable almost to the Franklin County line and has been, all in all, the most dependable criterion in working the faults in the Wills Point of central and eastern Hopkins County.

From Birthright northeast, almost to the Cretaceous contact, large angular quartzite boulders, many of them highly glazed and showing a peculiar pitted surface, which may result from the decomposition of a former constituent, occur at significantly frequent intervals. They are apparently of Wilcox age and similar to those in place at Rock Hill, 5 miles east of Sulphur Springs. Their present distribution cannot be explained by stream action for the drainage is to the east and not the north.

The shales outcropping on the western edge of Brashear are remarkably well bedded and thinly laminated for the Kerens member of the Wills Point. The sand is whiter and finer and better sorted than is usual for even the sandy clays of the Daphne Prairie section. In the course of road construction a 10 to 12-inch layer of indurated sandy shale carrying a few shell fragments and macerated plant remains was exposed half a mile west of Brashear. Boulders, probably derived in large measure from the indurated shales, were associated with them and like them carry a few molluscan and plant remains. It is possible that the Midway fossils reported from the branches of Big Creek 4 miles and more east of Miller Grove are referable to this same horizon. An anomalous outcrop 1 mile north of Peerless on the Cooper road may also be related. A roadside gully leading down to Sulphur Bottom exposes 8 feet of thinly laminated shales with fine sandy layers carrying an unusual amount of mica

and macerated plant remains. No associated concretions were observed. The nearby soil is reddish, and silicious boulders and fossil wood are scattered about. These may, however, have been distributed by South Sulphur, and although suggestive of the Wilcox, too much importance should not be attached to the evidence. The outcrop is very close to the Campbell fault which brings the apex of the faulted Cretaceous wedge east to Peerless.

RAINS AND VAN ZANDT COUNTIES

The contact lines from southern Hunt County to the Brazos River are based largely on data generously furnished by the commercial companies, and from southern Hunt through Limestone County there is little to be added to the already published material.

The western third of Rains County is included within the area of the Midway outcrop, but the Kincaid formation is restricted to a strip for the most part little more than a mile wide, which follows the Hunt-Rains County line and borders the trigonal area of faulted Cretaceous in southeastern Hunt County.

The Midway occupies the northwestern and extreme western part of Van Zandt County. The core drills made in the Sabine River valley indicate a swing in the strike south of the river, in line with the outcrop of the faulted Cretaceous in extreme southern Hunt County.

The type locality of the Wills Point was happily chosen for the town of Wills Point is on the strike of the aragonite bed at the base of the Kerens member, and good outcrops of the Mexia member are to be found to the west and, of the Kerens member, to the northeast and the south-southwest of the village.

KAUFMAN COUNTY

In Kaufman County the general trend of the Cretaceous-Midway contact is almost due north and south from a point less than a mile east of the Texas Midland railroad on the Hunt County line to the Henderson County line, south of Kemp, where the exact contact is obscured by the wash from the tributaries of the Trinity River. The greater part of this area is occupied by the Kincaid formation, though the Wills Point overlaps the Van Zandt County line north and south of Cobb and occupies the southeast corner. The Cretaceous

contact is fringed by a series of northeast-southwest faults approximately parallel. The McCoy fault, which brings up a southwest trending tongue of Cretaceous in the extreme northeast corner, is continued from Hunt County. The others, with the possible exception of the Elmo fault, have not been traced for more than 10 miles. The surface geology has been mapped largely on the Tehuacana member and the repetition of the beds in this well marked horizon. The prevalence of Cedar in the place names of northern Kaufman County – Cedar Grove, Cedar Creek, Rocky Cedar Creek—is indicative of Tehuacana outcrops. Good exposures of the Tehuacana carrying an abundant but poorly preserved fauna, and locally known as the "old sea floor," are to be found below the dam on Rocky Cedar midway between Elmo and Wills Point. Above the dam the water is ponded as far as the Texas & Pacific Railway bridge about half a mile upstream. The limestone in this section, unlike that of Limestone County, weathers black, like the Buda, and exposes the fossils only on the fresh surfaces. In Limestone County, on the contrary, the Turritellas and Venericardias are, as a rule, more resistant than the matrix that contains them, and stand out in high relief upon the weathered surfaces while all attempts to break them out from fresh surfaces result in failure. A low Midway fauna is recorded on the upthrow side of the Ola fault. Collections including a number of well preserved individuals of common species and a few fine rare forms have been made by Stanton, Stephenson, C. E. Cook, and other members of the Federal Survey from the ledge-forming glauconitic sandy limestone which outcrops at a number of localities in the vicinity of Water Hill northeast of Kemp. *Cucullaea* is the most prolific form, but *Callocardia*, *Venericardia* and *Turritella* are conspicuous members of the fine assemblage. The relatively large number of corals is also worthy of note. This is the most northern molluscan fauna in the Texas Midway sufficiently abundant and sufficiently well preserved to serve as a satisfactory basis for comparison. Many of the species are new, but the major characters of the fauna are similar to those of the Tehuacana member in Limestone County and south of San Antonio. The minor differences, recognized in many cases by subspecies, are sufficiently marked to make it improbable that the fauna if contemporaneous lived along a common shore line with the fauna of the Tehuacana of Limestone County. It is quite possible that the

break in the Tehuacana at the Trinity River valley represents an old barrier effective at the close of Kincaid time.

There is very little recorded information on the area southeast of Kemp. The silt is very heavy south of Kings Creek, and no outcrops have been reported south of the Texas & Pacific Railroad.

The Riley No. 1, on the Gregorio Ybarbo Survey, 4 miles southeast of Kemp about a mile north of the railroad, did not reach the Cretaceous at 242 feet.

HENDERSON COUNTY

The areal geology of western Henderson County is so obscured by the thick silts and other terrace deposits from the Trinity River that neither contacts nor fault lines can be traced across from Kaufman to Navarro County. The Tehuacana member has not been detected in either the well logs or in surface outcrops, and there is no certain outcrop of the Kincaid recorded. It is possible that it is faulted out as it is in Navarro County. The Plummers have made classic an excellent section of the Wills Point extending for at least half a mile along the Trinity River at Burton's Bluff, 1½ miles above the Trinity Valley store on the Kerens-Athens road. Discoidal ferruginous concretions are present but at no well defined horizon. The Miller No. 1 well, less than a mile northeast of Tarkenton Ford on the Trinity River, went into the Upper Cretaceous between 152 and 192 feet. No Tehuacana was recorded in the well.

NAVARRO COUNTY

The greatest oil production in the Mexia fault zone is that of southern Navarro and northern Limestone counties. The Midway bibliography during the five years from 1922 to 1927 includes a long list of important papers on the structure of this belt.

The Cretaceous-Midway contact north of Angus is a faulted contact which cuts out the Kincaid formation. One mile northwest of Angus the thin edge of the faulted Kincaid touches the Texas Central Railroad, and from this point the Kincaid strikes almost due south to Tehuacana, in a belt averaging less than 2 miles in width and including such notable outcrops as Richland Quarry and Pisgah Ridge. A small collection from the scarp, 7 miles northwest of

Wortham, was submitted by Deussen. The material is highly fossiliferous but the fossils are very poorly preserved and most of them determinable only generically. As in the so-called limestone at the Richland Quarry, there is a high percentage of sand and a very appreciable amount of glauconite present.

An uncommonly interesting phase of the Tehuacana is exposed in Richland Quarry. The sands which in northeastern Kaufman County underlie the limestone and are more than a hundred feet thick are absent and the limestone rests directly upon the Cretaceous. Lithologically the Richland Quarry outcrop has much in common with the basal greensand as it is developed in Caldwell County. Glauconite is present in very appreciable quantities though it is by no means uniform in its distribution. Rolled phosphatic pebbles, fish teeth, and reworked Cretaceous fossils such as *Baculites* are common. The abundance of calcite, some of it in veins almost 2 inches in width, is, however, peculiar to this area and is related, possibly, to the proximity to a fault zone. The soft marly layers, yellowish brown in color, intercalated between the ledges of resistant limestone, are similar to those in other outcrops at this horizon, and the fauna with the abundant *Conopeum danicornis* and the crab claws is typical of the Tehuacana.

The western margin of the Kincaid belt is the normal Cretaceous-Midway contact; the Tehuacana fault defines the eastern margin. The Corsicana graben, perhaps the most important structural feature of the Midway of Navarro County, is surficially a belt of Wills Point beds striking north-northeast. The Corsicana fault which has brought Wills Point clay down against the Cretaceous on the west, has been traced from the Trinity River almost to Richland Creek. South of Angus the Corsicana fault is offset by the Tehuacana fault, the western boundary of the Corsicana graben through southern Navarro and northern Limestone counties. The eastern and southern margin of the graben in Navarro County is delimited by the East Bazette, the Powell, the Richland, the Currie and the Wortham faults *en echelon*.

The Wills Point-Wilcox contact bends downstream on the Trinity almost to Trinidad; on Rush Creek, to within 2 or 3 miles of the county line and on Richland Creek almost to the Freestone County line. South of Richland Creek it gradually narrows, and at Streetman, which is very close to the contact, the Wills Point is less than

10 miles in width. The Wilcox has not been recognized in Navarro County west of the Trinity and Brazos Valley Railroad, excepting that brought down by the Wortham fault which may touch and overpass the Freestone-Navarro County line.

FREESTONE COUNTY

Although the area occupied by the Midway deposits is restricted to the extreme western corner and a salt dome near the Trinity River, Freestone County offers a few very interesting outcrops. No Kincaid has been recognized. The normal Midway-Wilcox contact crosses the Navarro County line on the edge of Streetman and the Limestone County line almost due east of Mexia. A narrow belt of Wilcox is dropped down along the Wortham fault and there is a small isolated Wilcox area on the Navarro County line. The excellent outcrops in the vicinity of New Hope on one of the head branches of Tehuacana Creek have served as check sections for the Midway-Wilcox border line (69, pp. 52–54, fig. 11). Thin-bedded selenitic shales dusted with sulphur-yellow grains, probably copiapite, becoming increasingly carbonaceous and decreasingly fossiliferous toward the upper part of the section are exposed to a maximum thickness of 10 feet in both the east and the west branches near the New Hope settlement. Ferruginous concretions staining reddish brown, commonly reaching 3 feet in diameter, and usually broader than they are high, occur throughout the section though they are more uniform in occurrence and in arrangement in the lower half. The fossils include fragile and not very well preserved individuals of *Leda*, *Callocardia*, and *Volutocorbis*.

An equivalent section is probably offered in the Daphne Prairie succession of Franklin and Titus counties, and on the Solomon farm, 6 miles south of Elgin in Bastrop county.

The structural relations of the Butler salt dome, the surface geology and the topographic features have been adequately treated by Sidney Powers (45b, pp. 127–142, figs. 1, 2) and certain observations have been made upon the fauna (62b). The outcrop at the salt dome has been thus described by Powers (45b, pp. 134, 135).

> The most readily traced horizon on the southwest side of the dome is found on the east side of the Hollow. Rows of sideritic concretions dipping 70 degrees west are exposed above beds of plastic blue clay at the south side of the

north road to Butler. The larger concretions are about 1 foot wide and 4 feet long. They consist of an outer layer of cone-in-cone structure from 1 inch to 6 inches in thickness with a center 3 to 8 inches thick composed of calcareous, sandy siderite. Small balls ⅛ inch to 1 inch in diameter also occur in the center and represent small siderite concretions. Fossils, especially small corals, are found throughout the larger concretions, but they are practically destroyed in the cone-in-cone rims. They are not found in the smaller concretions, which are almost wholly limonite replacing siderite without cone-in-cone structure. The shales exposed at the side of the road contain a few flat limonite concretions less than a foot in diameter and the shales are occasionally streaked with yellow. Selenite crystals of small size are also present. The shale breaks up into tiny angular fragments. It is a very pure clay, is very different from the typical sandy shales of the Wilcox and is believed to be of Midway age.

Large unfossiliferous concretions similar to some of those associated with the fossils, are exposed north of the Hollow near the bridge and also south of the fossil locality in three places. The latter outcrops show argillaceous sands of white to yellow color . . . .

Another locality where fossils were collected is on the Oakwood road at the top of the hill north of the saline. Other similar concretions, but without fossils, were found between the Bonner's Ferry road and the saline as indicated on the map.

Medium-sized grains of glauconite are locally present in appreciable numbers. This bed of concretionary limestone carries a fauna quite distinct from that of the Tehuacana member. Although the most abundant species are peculiar to the locality, some of the rarer forms have decided Wilcox affinities and if it were not for a few such presumably diagnostic species as *Volutocorbis limopsis*, there would not be sufficient justification for referring the fauna to the Midway. Both in the character of the matrix and of the contained fauna the Butler Dome material recalls the border line bed at Jett Crossing (U.S.G.S. Sta. 6153), at the Palo Alto road crossing on the Medina River in Bexar County and (U.S.G.S.Sta. 6283) on the Guadalupe River near the ferry 3 miles east of Seguin and 2½ miles above the power house south of Seguin, in Guadalupe County. Although the field relations have not been established, these mottled red and green ferruginous and argillaceous concretionary limestones are possibly the time equivalents of the sand near New Hope and a part of the section exposed in the branch of Wilbarger Creek on the Solomon farm south of Elgin.

ANDERSON COUNTY

Wills Point clays, probably the Kerens member, are exposed in Anderson County on the northeastern and southwestern flanks of Keechi salt dome (61, pp. 35–45), 7½ miles northwest of Palestine on the Athens road. At the former locality dark grayish brown sandy clays with associated limonite boulders and cone-in-cone outcrop in a roadside gully. The sand in the clays tends to segregate in layers and small flakes of mica are present. The conchoidal cleavage is very marked and the cleavage faces are commonly chased with manganese dendrites. No macrofossils were observed but an upper Midway foraminiferal fauna has been reported.

LIMESTONE COUNTY

The Mexia field in the area of the Midway outcrop was the first in the State to develop oil production along a fault plane and for that reason the Midway of Limestone County has probably inspired a longer bibliography than that of any other county in Texas. The major features of the structure are widely known. The Corsicana graben is continued from Navarro County through northern and central Limestone County, limited on the west by the Tehuacana fault, on the east by the Mexia and Groesbeck faults. Extensive outcrops of the Tehuacana member of the Kincaid formation are offered on the upthrow side of both the Tehuacana fault and the Mexia-Groesbeck fault. South of McKinzie Creek the Kincaid outcrops on the west side of the graben, and is exposed on the east side in and directly south of the creek, and in one other small area about midway between Thornton and Kosse. The downthrow in the trough involves the Wilcox. The Mexia and Groesbeck producing fields are on the west side of the Mexia and Groesbeck faults; the Nigger Creek and Cedar Creek are small fields on back line faults of the Tehuacana.

Aside from the economic significance, Limestone County offers some of the finest and the most interesting outcrops to be found in the Texas Midway. The Tehuacana member of the Kincaid, first and best known from Limestone County, is sufficiently resistant to give rise to such place names as Honest Ridge, Horn Hill, and Big Hill. Beneath it the Pisgah sand and Littig glauconitic member of the Kincaid are typically developed. The outcrop of the Kincaid formation is extremely irregular, due in part to extensive faulting

and in part to the high resistance of the Tehuacana relative to the overlying clays and sandy clays of the Wills Point formation. The outcrops in the northern half of the county are much more extensive than those in the southern. Roughly, there is a narrow and very irregular outcrop of more or less marked cuesta type along the western margin of the Corsicana graben and even more irregular outcrops on the east side of the graben between McKinzie Creek and Mexia. In the valley of the Navasota River southwest of Mexia and northwest of Groesbeck, the erosion of the Wills Point clays has been locally sufficient to expose the underlying Tehuacana. South of the outcrop on McKinzie Creek a single small exposure of Tehuacana has been recognized on the east side of the graben.

Mrs. Plummer (69, p. 54, fig. 11) reported on a section of the Kincaid clays within half a mile of the Navarro County line, but there is no good exposure of the Tehuacana member north of Tehuacana. The Tehuacana section has long been classic, and none in the Kincaid formation of Texas is more complete or more arresting. The crest of the scarp overlooks a monotonous exposure of Navarro black land. Below the Tehuacana, which in the Richland Quarry, some 15 miles in an air line to the north, rests perhaps directly upon the Cretaceous and carries reworked *Baculites*, fish teeth and phosphatic pebbles, the Tehuacana section exposes, with some interruptions due to slump, over 100 feet of sands and clays belonging to the lower members of the Kincaid formation. The Mexia-Waco highway descending the steep western face of the scarp traverses the section. The contact with the Navarro is best observed along a small branch north of the highway (69, p. 54, fig. 11). However, the Littig glauconitic member, a coarse trashy greensand with phosphatic pebbles 2 inches in diameter, was uncovered in a roadside gully at the base of the scarp. The Navarro flags which outcrop nearby probably support the low hills beyond. Though as old at least as the name of the county, the current Tehuacana "limestone" is largely a misnomer, for at this type section the "limestone" is little more than a coarse quartz sand with a calcareous cement. The contact between the "limestone" and the underlying sand is not sharp, for near the base the "limestone" is only locally indurated and takes the form of fossiliferous masses in a sandy matrix. *Ostrea crenulimarginata* is abundant at this horizon, and

probably records an old reef fauna living in clear but shallow water in which quartz sands were rapidly being laid down. A certain amount of glauconite is present throughout the Tehuacana member but it is increasingly common toward the base. The grains, however, are much smaller than those of the Littig glauconitic member. The higher horizons of the Tehuacana are best represented in the quarry one-half mile east of the town on the Mexia road where a maximum thickness of about 40 feet is exposed. The quarry "limestone" is heavy-bedded, weathering red and in smooth rounded surfaces cross sectioning the abundant fossils. Some of the "limestone" is almost a coquina, so abundant are the organic remains. The eastern rim of the quarry commands an exceptionally fine view of the Mexia fault traceable by the long narrow line of derricks. The *Venericardia* and *Turritella*-bearing beds are well exposed at Comanche Crossing on the Navasota River about 6 miles southwest of Mexia. Honest Ridge, a conspicuous example of the "limestone cuesta," overlooks the Navasota valley from the southwest. Horn Hill, between the southern extension of the Tehuacana fault and the northern extension of the Big Hill fault is the southernmost of the notable limestone outcrops in the graben. Roadside and hillside outcrops of the limestone are common west of Mexia and Groesbeck. The fine exposure on the Confederate Reunion grounds, 2½ miles southwest of Mexia, has frequently been described and figured. Good outcrops are to be seen on the road from Horn Hill through Thelma to Mexia and all of the roads leading west and northwest from Groesbeck cross the limestone brought up on the eastern margin of the graben. One of the best collections from the *Turritella* zone was made from a tank on the south side of the Parker School road on the tract known as the Continental State Bank 69A., 2 miles northwest of Groesbeck. The Littig glauconitic clays carrying an appreciable amount of sand outcrop on the Waco road one-half mile east of Lavendar, a small settlement 2½ miles southwest of Horn Hill. The "limestone" outcropping on the tract known as the Lillian Dustin 140A., 3½ miles southwest of Thornton on the Fairview School road, is an excellent exposure of the narrow lenticular area of Tehuacana on the upthrow side of the Groesbeck fault.

The Wills Point is the usual surface formation in the northeastern part of the county. The Wilcox is dropped down on the west side of the Wortham fault almost to the latitude of Mexia, although the

Wills Point is exposed in the valley of Tehuacana Creek. Wills Point outcrops have been studied by Mrs. Plummer (*69*, pp. 54–57, fig. 11) on the east side of the fault, in the clay pit of the Mexia Brick Works, 1 mile west of Mexia, the type locality of the Mexia member, and in the clay pit at the Groesbeck brick yard. A small molluscan fauna including *Cucullaea macrodonta* was collected by Stephenson and Cook (U.S.G.S. Sta. 10346), 1 mile southwest of the crossing of the Houston & Texas Central Railroad over Tehuacana Creek, presumably 160 to 170 feet above the base of the Midway. A narrow lens of Wills Point outcrops along the west side of the Tehuacana fault south of the Navasota River. It is exposed with some interruptions due to faulting and to erosion throughout the Corsicana graben. Only the Wills Point is involved in the Nigger Creek and Cedar Creek structures, on the western edge of the graben between Thelma and the Navasota. Good exposures of this formation also occur on the Groesbeck-Waco road between the Groesbeck and the Big Hill faults. Dense brownish gray shales breaking with a strong conchoidal cleavage outcrop on the northern margin of the Hearnstadt 33A., 4 miles southwest of Groesbeck. The cleavage faces are chased with manganese dendrites and associated with the shales are discoidal concretions several inches in diameter of sandy calcareous clay with an internal structure suggesting cone-in-cone and a much roughened external surface. A good foraminiferal fauna has been recovered from the shales and *Volutocorbis*, possibly *V. limopsis*, was noted in one of the concretions. Apparently the Mexia member of the Wills Point is represented. Samples from a well drilled on the Moody farm one-half mile northwest of the Thornton railroad station yielded a good Wills Point fauna at 250 to 320 feet.

Big Hill, though commanding the rolling black lands of the Navarro, offers no such striking outcrop of the Tehuacana as might be anticipated from the name. Small exposures occur within a mile to the south, but at the settlement of Big Hill, which on most of the maps is placed too far west by a mile, the surface formation is a sand of the Mexia member of the Wills Point formation splotched with lime and locally indurated. The normal Midway-Wilcox contact falls a little more than a mile to the northwest of Kosse, but due west of Kosse it intersects the Groesbeck fault and the Wilcox replaces the Wills Point along the strike. The Midway area of

outcrop on the Falls County line is thus reduced to less than half its average width in Limestone County.

FALLS COUNTY

The Midway of Falls County is restricted to a belt 3 to 5 miles wide striking almost due north and south across the eastern corner of the county between Reagan and the Houston & Texas Central Railroad. In the northern part of the outcrop the structure though less involved is similar to that of southern Limestone County and the sections are strikingly alike. South of the railroad which runs from Bremond to Marlin, the beds are apparently normal, but the Tehuacana member of the Kincaid formation has disappeared, nor is it seen again north of Medina County. It is possible that the absence of the "Limestones" in the major stream valleys such as the Trinity and the Brazos may be indicative of former deltaic conditions which prevented the deposition of the coarse calcareous sandstones of the Tehuacana.

The Wills Point outcrop follows roughly the Little Brazos River valley. The Tehuacana cuesta is a prominent topographic feature from the county line to the Stranger School, a small community 7 miles west of Kosse, and from the Stranger School the Tehuacana continues, though less prominent topographically, to within about 3 miles of Reagan. One-quarter of a mile north of the Stranger School house, a southwest road descends the 75 or 90-foot hill and offers good exposures along the side gullies. Pisgah clays below the Tehuacana are grayish brown with pockets and stringers of gray, highly fossiliferous sand. The fossils include large numbers of small bivalves and some univalves, preserved for the most part in the form of molds and impressions. About halfway down the hill, a highly calcareous and partially indurated layer with abundant but poorly preserved molluscan remains outcrops as a ledge. The sands below the indurated layer are more harsh than those above it and more glauconitic. The fauna is similar but less varied. The "limestone" that forms the scarp is perhaps a little more dense than that commonly seen at Tehuacana and the brown calcite more rarely developed but otherwise no lithologic differences were observed and none in the contained faunas. The best collection made in the Tehuacana of Falls County was from a roadside outcrop in the northwest corner of the A. Whitaker Survey on the P. Kendall line, 6 miles

northeast of Kosse. *Cucullaea kaufmanensis*, an *Ostrea*, possibly *O. palaskensis*, *Venericardia* and *Callocardia* are the most common forms. The matrix at this locality is a fine-grained gray calcareous sandstone. The most southerly Tehuacana outcrop of importance is probably that on Salt Branch of the Little Brazos at Rocky Crossing on the Bremond-Reagan road. Salt Branch cuts at a low angle across the strike and up the dip, exposing the indurated beds of the Kincaid formation along the banks and, at low water, in the bed of the stream for almost a mile. South of the Bremond-Reagan highway the surface geology is obscured by the terrace deposits from the Brazos and the Little Brazos. The Kincaid sands were, however, observed in a gully along the road to Eloise, 2½ miles northeast of the Eloise-High Bank railroad, and separated from it by a wide stretch of bottom land planted in cotton. There is an elevation of 10 to 15 feet along High Bank Creek, but nothing comparable apparently to the scarp from which the town, High Bank, took its name many years ago. The maps of the Reclamation Department of the State of Texas of the Brazos River, published in 1926, indicate that north of the Josiah Hogan Headright, the Brazos is swinging hard against its eastern bank and that the lower courses of Big Creek, High Bank Creek, and Mussel Run Creek are probably utilizing in large measure the old meanders of the Brazos. The Peacock No. 1 well, drilled 1¾ miles north of High Bank station on the Texas & Gulf Railway, encountered the following section:[3]

	Thickness *Feet*
Surface clay and water sand	0- 40
Mucky gumbo carrying an abundance of fine shells	40- 75
Hard lime rock with sandy streaks	75- 97
Water sand and bed of preserved cottonwood logs	97-105
Gumbo	105-380
Sandy shale; showing gas	380-420
Gumbo	420-550
Mucky shale	550-700
Chalk (upper chalk or Taylor marl)	700-900

et cetera to 3052 ft. In Comanche at 2850 ft.

The Navarro-Midway contact has been recognized upon the Brazos River since the days of Kennedy and Harris. It crosses the Houston &

[3] By courtesy of the Bureau of Economic Geology.
The "gumbo" at 105 feet is doubtless Upper Cretaceous.

Texas Central Railroad, little less than a mile north of Eloise and cuts diagonally along the river to the Milam County line. The shoals between the Milam County line and Eloise are due to Navarro sandstone, and there is a perceptible narrowing of the river channel along the strike of these resistant beds. The Brazos River section of the Midway will be considered as a whole in the observations on the areal distribution.

An interesting section is exposed along a lane leading north from the Bremond-Reagan road about 3½ miles northwest of Bremond. The sandy shales of the uppermost Wills Point are directly overlain by a basal Wilcox greensand, not so coarsely glauconitic, to be sure, as that of the basal Kincaid, but with sufficient glauconite to lend a greenish cast to the gray sand. Three feet above the contact the more usual sandy thin-bedded shales of the lower Wilcox outcrop. Thinly laminated sandy shales more pockety than the usual Wilcox shale with associated concretions of very large size are well exposed a little to the northwest of the Bologna School, 2½ miles northwest of Bremond.

THE BRAZOS RIVER SECTION

The Brazos River offers one of the finest series of exposures to be found in the Midway of Texas, and one of the first to be recognized by the geologist and paleontologist. (See fig. 3.) In the First Annual Report of the Geological Survey of Texas the area of outcrop for the "Basal clays" along the Brazos was indicated by Penrose (17, pp. 25-26), "Descending the Brazos River from Waco, we pass over strata of Upper Cretaceous epoch until we reach the northeast corner of Milam County, where the Basal Clays of the Tertiary period, already described, are met and extend thence for some seven miles to within two miles of Pond Creek." The Cretaceous-Eocene contact has been properly placed for more than 40 years. Kennedy (22, p. 69) wrote in 1893:

> Going still further north into Falls County, the base of these beds is seen in contact with the underlying Cretaceous deposits in section No. 111, on the southeast corner of Josiah Hogan* league:

*The Josiah Hogan league is the league to the north of the Westly Fisher league.

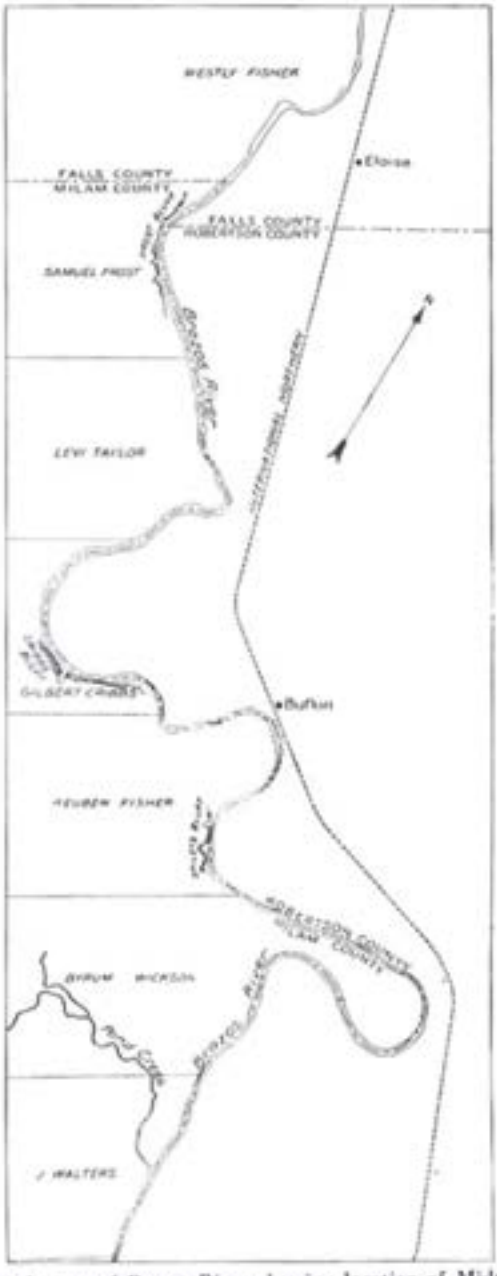


Fig. 3. Sketch map of Brazos River showing location of Midway exposures. Scale: 11/16 inch equals 1 mile approximately.

River alluvium	4 feet
Gravel	1 foot
Blue clay and sand breaking into nodules and conchoidal pieces, weathering to a grayish yellow, and containing in the upper half *Calyptraphorus velatus*, Conrad, *Cucullaea macrodonta*, Whitfield, *Ostrea palaskiensis*, Harris, and others; and *Cardita alticostata*, Conrad, *Pleurotoma*, sp., *Yoldia*, sp., and *Crassatella*, sp., in lower two and half feet	5 feet
Transitional blue clay	1 foot
Massive blue clay, with baculites and other fossils	14 feet

This section is 1½ miles (air line) upstream from the Milam-Falls County line. Harris (28, pp. 1–125, pls. 1–15) reports a similar fauna with the addition of *Enclimatoceras* from one-half mile below, doubtless from the section which now goes by the name of Blue Shoals. Lower fossiliferous Kincaid clays are well exposed on the west bank of the Brazos about half a mile above the Milam County line and also, on the west bank, is an excellent section beginning about half a mile below the Milam County line and extending for almost a mile downstream. There seems to be some confusion in the local usage of the names of the conspicuous bluffs and it is difficult to place sections referred to them. Black Bluff has been used both for the section on the Josiah Hogan Headright, in which the Cretaceous-Eocene contact is so well exposed, and for that just above the county line. Milam Bluff has been used both for the section a little above the county line and for that a little below it. The lower bluff has also been called Cribbs Bluff, although it is not on the Cribbs League but on the Samuel Frost League. The following section was made on the west side of the Brazos River on the Westly Fisher League in Falls County:

	Thickness Ft.	In.
Kincaid formation:		
4. Harsh sandy clay showing jointing but very little trace of lamination; dull blue gray when fresh, weathering yellowish brown; abundantly fossiliferous; *Cucullaea macrodonta, Ostrea palaskensis, Crassatellites* sp. cf. *C. gabbi, Venericardia* sp. cf. *V. moa, Bittium estellensis,* and *Calyptraphorus* sp. abundant	6	6
3. Very dense blue clay, deeper in color and not so sandy as No. 4, breaking with a conchoidal fracture and sparsely fossiliferous	3	6

	Thickness Ft.	In.
2. Thinly laminated yellowish brown sand with an inconstant layer of partially indurated marl with sandy fossiliferous stringers above it; marl often as thick or thicker than the sand bed	1	6
Upper Cretaceous:		
1. Dense dark blue gray shale breaking with a conchoidal fracture, fossiliferous throughout, and, directly below the top, abundantly so; ammonites present and a *Baculites* observed at the extreme top; a 2-inch gypsum seam about midway from the base to the contact	10	

The repetition of the Cretaceous-Midway contact in the downstream section is not due to faulting but to the northeast-southwest strike both of the Midway and the Brazos.

The following section was made at the bluff which extends from about half a mile below the Falls County line along almost the entire frontage of the Samuel Frost League:

	Thickness Ft.	In.
Wills Point formation (Mexia member)?:		
6. Glauconitic sandy marl, medium gray in color, locally with a slight greenish tinge; sparsely fossiliferous; foraminifera, a solitary coral, bivalves, univalves, *Hercoglossa*. Thickness concealed by cover.		
Kincaid formation:		
5. Calcareous, densely packed, fine sand, grayish to yellowish brown and stained with iron; a bed of fossiliferous calcareous boulders about 2 ft. from the top; fossils relatively rare in the matrix and preserved, for the most part, in the form of impressions	4	
4. Clay, dense blue when wet, dark dull gray when thoroughly dry, breaking with a conchoidal fracture, selenitic, chippy and less distinctly bedded than No. 1, evenly but not abundantly fossiliferous; *Leda (Ledina) smirna, Ostrea pulaskensis, Periploma* sp., *Corbula (Caryocorbula) kennedyi, Volutocorbis* sp. cf. *V. texana, Turritella* sp.	25	
3. Highly calcareous sandy marl, light gray in color, breaking readily into angular fragments with pockets of dark greenish black marl disseminated in the form of cylindrical oolites; fossils rare and indeterminate		6
2. Heavily bedded dense bluish gray clay, more resistant than the overlying bed and tending to form a ledge; pockets		

	Thickness Ft.	In.
and stringers of very fine dark gray sand carrying many foraminifera, ostracods, and small Mollusca; the same fauna spar-ely represented in the shale; *Flabellum conoideum, Leda (Ledina) smirna, Amusium (Paramussium) alabamense, Corbula (Caryocorbula)* sp.	1	6
1. Dense bluish gray clay, very chippy and inclined to break along iron-stained joint planes; fossiliferous throughout but with layers one-fourth inch to one-half inch thick packed with fossils in a more or less crumbled state; foraminifera exceedingly abundant especially *Robulus; Flabellum conoideum matthewsense*, echinoid spines in abundance, *Leda (Ledina) smirna, Cucullaea macrodonta, Ostrea paluxyensis, Crassatellites* sp. cf. *C. ioannes, Corbula kennedyi, Falsifusus* sp., *Turritella* sp., *Dentalium* sp. cf. *D. mediaviense*, a reworked *Baculites*, a crab finger, otoliths, fish teeth, and vertebrae	16	

The greensand at the top of this Midway section may mark the base of the Wills Point formation. No satisfactory outcrops of the non-resistant Wills Point were observed for a distance of about 4 miles by river from the lower end of the bluff. The upper part of the Wills Point outcrops, however, on the west bank of the Brazos from one-half mile to a mile above Bufkin and the mouth of Hardin Slough on the east bank. The intermediate banks over a considerable part of the distance are 15 to 20 feet high, but are entirely of terrace material. The abundance of the land gastropods throughout some of these sections is remarkable.

The Wilcox contact is probably close at hand, for the classic Smileys Bluff section, 2 miles above the mouth of Pond Creek, formerly referred to the Midway, occurs a short distance below, on the property of Mrs. Carey Woodhull. The sands and clays in the Smileys Bluff section are thinly laminated and beautifully cross-bedded and carry in the upper third of the section enormous concretions as large as mill stones and similar to them in outline. The indurated fossiliferous sandstone is identical with that outcropping in the branch on Mr. Solomon's land, 6 miles below Elgin in Bastrop County. Smileys Bluff serves as the type locality for many of the species described and figured by Harris in "New and otherwise interesting Tertiary Mollusca from Texas" (26a). These include *Leda milamensis, Fusus ostrarupis, Pseudoliva ostrarupis,* and

Cerithium penrosei. The specific name *ostrarupis* so commonly used was doubtless suggested by the old name *Oyster Bluff* so called because of the abundance of *Ostrea multilirata* at this locality. The same reef outcrops about half a mile north of the Baileyville-Cameron road, and about one mile south of Mr. Carey Woodhull's ranch house near Baileyville.

ROBERTSON COUNTY

Although the Midway is presumably the surface formation in the southwestern corner of Robertson County, neither the Kincaid nor the Wills Point has been observed through the ubiquitous terrace deposits of the Brazos and Little Brazos. In Kennedy's day the wash was not so heavy or the geologist more discerning (22, pp. 67, 68). The following excerpt is from the report upon Robertson County:

"BASAL BEDS.—The deposits assigned to this division occupy but a very small areal extent in the northwestern portion of the county. The territory is generally level, and so covered with surface deposits of gray sand and river alluvium that few exposures of the underlying beds can be seen anywhere. . . . The basal beds as represented in Robertson County comprise a series of thinly stratified yellowish gray sands, and grayish blue laminated clays and sands, with broken strata of grayish blue fossiliferous siliceous limestone, and occasional rounded and flattened boulders of gray calcareous sandstone." It is possible that the description was drawn from the outcrops upon the west bank of the Brazos in Milam County. The lower Wilcox oyster, *Ostrea multilirata* Conrad, was, however, collected in abundance from 3½ miles southwest of Hammond, by H. J. Weeks.

MILAM COUNTY

The remarkably regular area of outcrop of the Midway in Milam County, as mapped, may be due to the simplicity of the structure but probably in part to the rarity of the outcrops and our incomplete knowledge of the areal geology. This is particularly true of the Cretaceous-Midway contact and that between the Kincaid and Wills Point formations. The change in the color and texture of the soils is relatively marked in passing from the Wills Point to the Wilcox. This is well shown in the Soil Survey map (73bb), particularly in the area south of Little River. Between the Brazos and the Little

River there is not much to be seen excepting stream wash. Both the Kincaid and the Wills Point are subnormally sandy in Milam County and it is possible that there is a slight overlap of the Wills Point to account for the restricted width of outcrop of the Kincaid, particularly near Tracy.

No exposures of note were observed between the Brazos and the sharp bend to the east in Little River. Two miles northwest of Cameron, near the bridge crossing a branch of Elm Creek on the property of Mr. Wiffly, there is an outcrop of bluish-gray to brown, dense and rather greasy joint clay carrying a large amount of amorphous calcite, fragments of small indeterminate bivalves and a rather meager foraminiferal fauna, probably of Kincaid age.

Outcrops along the San Gabriel, Little River, and Brushy Creek are exceptionally rare.

The delta between the San Gabriel River and Brushy Creek offers no good outcrops. At a few localities near the mouth of Alligator Creek the dense yellow sandstone so characteristic of the Upper Cretaceous in this part of the country has been used as paving stone around the farm houses, but the source could in every instance be traced to outcrops at some distance up the creek and well within the known Cretaceous limits. This same sandstone was found in a small draw directly north of Turkey Creek, 3 miles north of Thorndale. A meager Cretaceous foraminiferal fauna was washed from the underlying clay.

The development of secondary material along the streams is locally remarkable. Three miles west of the mouth of Brushy Creek and about 1 mile north of the mouth of San Gabriel an indurated gravel conglomerate, apparently a stream deposit, is filled with *Exogyra arietina* Roemer and *Gryphaea mucronata* Roemer reworked from the Comanche deposits.

By far the best exposure of the Wills Point in Milam County is on the south bank of Brushy Creek about 100 feet above the mouth. At this point, the bluff rises to a height of 25 feet and is made up, for the most part, of a dense blue-gray clay broken by layers and pockets of glauconitic sand and weathering yellowish brown above. Four or five ledges of large flattened limonite concretions, fairly regular in arrangement, outcrop along the bank. The jointing in the clay becomes increasingly pronounced toward the western limit

where the outcrop is concealed by slump. The beds are rather sparsely fossiliferous but contain several characteristic upper Midway forms, including echinoid fragments, *Leda* (*Ledina*) *smirna* Dall, *Volutocorbis limopsis* (Conrad), *Triton* (*Ranularia*) n.sp. aff. *T.* (*Ranularia*) *eocense* (Aldrich), *Pyrula* sp. ind., *Turritella* sp. cf. *T. alabamiensis* Whitfield, and *Natica* sp. cf. *N. reversa* Whitfield.

A greensand at the base of the Wilcox similar to that exposed in southern Falls County was recovered from beneath the highway bridge over Little River on the Cameron-Rockdale road, 2 miles east of Cameron. The trend of the Midway-Wilcox contact southward coincides with that of the major drainage channels. In fact, over the greater part of the distance from the Limestone County line to the Williamson County line the Wills Point is occupied by a stream flowing along the strike. In Falls and Robertson counties the Little Brazos found this the easiest way. In Milam County the abrupt change in direction where Little River meets the Wills Point is very conspicuous. San Gabriel River and Brushy Creek are strike tributaries from the southwest. It is noteworthy that all of the major tributaries of Little River and San Gabriel River come from the west. An elaborate drainage system has developed in western Milam County, but east and south of the Wilcox contact, the drainage is restricted to a few branches and to the headwaters of the tributaries of the Yegua.

The Wilcox contact has for the most part been sketched in from the lithology alone. The northeast-southwest line of Little River from Cameron to the mouth of the San Gabriel, of the San Gabriel to the mouth of Brushy Creek, and Brushy Creek to the rather sharp bend to the west follows closely upon the Midway-Wilcox contact. South of the Brushy the Wilcox crosses the Thorndale-Rockdale road about 6 miles east of Thorndale near the head of the eastern branch of the arroyo flowing north into Brushy. There is an abrupt change at this point to a more sandy, redder soil which probably marks the beginning of the Wilcox. Some very good exposures of the Wilcox occur farther along the Thorndale-Rockdale road toward Rockdale. The beds are sandy and closely laminated, with some intercalated clays and iron crusts and, more rarely, concretions of limonite. Mesquite and cactus are uncommon, while the post oak, the characteristic growth of the Wilcox soil, is conspicuously abundant along

the roadsides. The strike of the Midway after crossing the Thorndale-Rockdale road apparently trends more sharply to the west. At the Milam-Williamson County line the area of outcrop is relatively narrow.

WILLIAMSON COUNTY

In Williamson County, as in Milam County, the area of outcrop of the Midway is a northeast-southwest band from 3 to 5 miles wide. In Williamson County this band forms a broad diagonal of the rectangle made by the Lee and Milam County lines and the two railroads which intersect at Taylor. Notwithstanding the proximity of the igneous mass associated with the Thrall oil field, only minor irregularities in the structure of the Midway formations have been observed.

The basal beds of the Midway are soft and have only rarely left a permanent record within the county limits. The underlying upper Navarro beds, on the contrary, include a resistant flaggy sandstone and above it concretionary shales, so that the contact may be closely approximated.

The best of the Midway sections are to be seen in the Dry Brushy and Little Dry Brushy drainage.[4] The Cretaceous-Midway contact was not observed in the Brushy Creek valley below the mouth of Little Dry Brushy Creek, the western of the two branches entering Brushy Creek from the south. These names, together with Boggy Creek, reflect the general character of the topography in this section. The Taylor-Beaukiss road probably intersects the contact near Little Dry Brushy Creek. At the base of the southern slope leading down to Little Dry Brushy there is an excellent exposure of the Littig glauconitic member of the Kincaid formation. The very coarse, structureless, highly calcareous sand carries well rounded quartz pebbles, glauconite grains sufficiently coarse to be held in the 30 and 50 meshes, and a prolific foraminiferal fauna. The Navarro flags outcrop half a mile to the north. To the southwest the contact follows along the south slope of Little Dry Brushy. Five or six miles down the strike the Littig greensand was exposed in the year 1925 in a new road cut at the jog in the Coupland-Elgin road, 1 mile east and 1¼ miles south of Coupland. Only a foot or so of

[4]The rather muddled nomenclature of the streams in the southeastern corner of the county is assumed to be correct on the Rastrop quadrangle of the U. S. Geological Survey.

the marl was exposed and this will soon be concealed by weathering and vegetation. The large residue remaining after washing is made up, for the most part, of glauconite, but fish teeth and foraminifera are common. Reworked Navarro fossils are also present. The contact crosses the county line near the Missouri, Kansas, and Topeka Railroad and the eastern margin of Travis County. The Littig greensand has been observed on the secondary road leading northeast from Lund and on the northern margin of the town of Lund, 1½ miles southwest of the Missouri, Kansas, and Topeka Railroad at the Travis County line. The most striking and characteristic feature of the Midway group in Williamson County is the amazing amount of glauconite that is present throughout the section. This is clearly indicated in the following log from the water well on the Harvey Hanson place, adapted with slight modifications from the copy of the log on file in the Bureau of Economic Geology.

	Thickness *Feet*
Wills Point formation:	
Soft and very sticky yellow clay with boulders and fragments of limonite scattered about, in, and on the surface	0–5
Bluish, dark yellow clay with thin vertical and slanting seams of crystalline lime, gypsum, and small lumps of barite	5–40
Bluish dark joint clay; ironstone layer	40–70
Exact boundary uncertain.	
Kincaid formation:	
Layer of volcanic dust, white and soft with many angular grains of glauconite in it	70–72
Bed of glauconitic greensand, fairly soft with odor and trace of oil	72–108
Layer of clay ironstone, same as very tough and hard layer found in dug well at 40 feet, in valley between hills, 1½ miles farther north	108–110
Dark and dark green marl with softer seams of a sandy material. "Glauconitic marl containing considerable sand. Fragments of pelecypod, echinoid spine, fish teeth and other remains, ostracods, *Cristellaria* sp., *Nodosaria* sp. cf. *N. vertebralis*, *Nodosaria* sp., and *Anomalina*; Eocene Midway"	110–160
Dark green and gray marl with harder ledges between; quite tough and hard	160–200
Dark green marl; ledges of slate and softer seams of sandy material; small showing of oil	200–230

	Thickness *Feet*
Dark bluish slate, thin seams of blue sand between joints; fairly soft ledges of material; wet but no free water	230–249
Dark green rock, very hard and tough; veins of glauconite	249–249½
Dark green slate, grains of phosphate; glauconitic material laminated; bottom of well	249½–252

The line between the Kincaid and the Wills Point formations may be placed too high in the preceding section.

Description of samples from Harvey Hanson's water well, by J. A. Udden and Paul T. Seashore.

	Thickness *Feet*
Dark greenish gray glauconitic clay or marl. Washed material consists mainly of sand, calcite, and glauconite. Foraminifera abundant—*Triloculina, Cristellaria, Anomalina, Lagena, Nodosaria, Spirillina, Globigerina, Polymorphina, Rotalia,* ostracods, gastropods, pelecypods, fish scales and teeth	200
Gray, slightly calcareous silty clay containing some sand. Washed material consists mainly of sand, calcareous fragments of glauconite, *Nodosaria, Lagena, Anomalina,* ostracods and fragments of larger shells	245–248
Dark greenish gray glauconitic calcareous clay or marl, the glauconite making up about one-half of the material. Some calcite and sand present. Many minute nodules of black phosphate occur with the greensand. *Nodosaria, Lagena, Pulvinulina,* ostracods, and several fragments of shells	250
Like preceding sample except that a fish tooth was noted	252

The following section was measured in Dry Brushy Creek, the eastern of the two branches entering Brushy Creek from the south, above the bridge on the Taylor-Beaukiss road, 9 miles southeast of Taylor:

	Thickness *Feet*
Midway group:	
Wills Point formation:	
1. Glauconitic pockety sandy clays, fossiliferous and concretionary; *Balanophyllum,* foraminifera, a sparse molluscan fauna, crab claws and fish remains; associated concretions ferruginous, highly colored, some of them flattened, elliptical, showing a strong septarian structure and calcite seaming, others discoidal or irregularly elongated, shattering readily, and dusty-yellow within	10

	Thickness *Feet*
2. Very dark grayish black tough sandy clays cross-seamed with sand at an angle of about 60° and with stringers and pockets of green-sand; both micro- and macro-fossils but few of them well preserved; associated concretions discoidal, grayish within, with an amorphous calcite coating	3-4

The section is repeated in part in the first road west of the Taylor-Beaukiss road. An interesting variation, however, is the intercalation on the south slope of the branch of a thin bed of almost pure bentonite heavily flecked with large plates of biotite. This is similar to and doubtless of the same origin as the bentonite bed on the Harvey Hanson farm, 5 miles southeast of Coupland.

The finest exposure of the bentonite was observed on the Harvey Hanson farm a little more than one-half mile upstream from the bridge over Dry Brushy, in a 15-foot bluff on the south side of the stream. The bentonite occurs in a well delimited bed and within this bed in pockets 12 inches to 18 inches in thickness. It is exceedingly fine and dense, ringing under the hammer, shelling like an onion, dark jade green in the mass but almost transparent in thin slivers, and flecked with indigenous biotite. There is a large amount of minor faulting and slipping in the section, due probably to the reaction of the bentonite to water. Practically no residue remains after washing. The bentonitic bed is underlain by a coarse, fossiliferous glauconitic clay, the coarse greensand segregated in pockets and stringers in the dark gray clay. The only observed concretion was very dense, light gray in color, coated and seamed with calcite. The micro-fauna is large and *Leda, Amusium, Cucullaea macrodonta, Ringicula, Cadulus,* and possibly *Hercoglossa* are included among the Mollusca. This section is about 15 feet below a well marked cone-in-cone horizon.

The following Wills Point section is exposed on the long hillside of Dry Brushy from 9.5 to 8.9 miles southeast of Taylor on the Beaukiss road:

	Thickness *Ft.*	*In.*
1. Calcareous ferruginous sandstone		8
2. Non-calcareous mottled gray and brown, slightly glauconitic quartz sands with stringers of clay, more argillaceous toward the base	3-4	

	Thickness Ft.	In.
3. Well bedded sandy clays, light gray splotched with reddish brown, with large calcareous concretions, and at the base flattened ferruginous concretions	6	
4. Very fine sandy micaceous clays, gray with yellowish brown iron stains, sparsely fossiliferous; associated concretions very large, very dense, irregularly elliptical, meagerly fossiliferous, occasionally showing septarian structure on the outer surface, concentrically banded, blue within, brown toward the exterior; *Leda smirna?* observed	7	
5. Very fine sandy iron-stained clays, micaceous and well bedded; associated concretions brownish and banded toward the surface; blue within, veined with calcite. Both the clays and concretions fossiliferous; echinoid test, *Leda* sp., *Corbula* sp.; a large log with *Teredo* borings	12	
6. Bedded gray, fine sandy micaceous, iron-stained clays; associated concretions very large, rounded, bright colored, with calcite	18	
7. Heavily bedded clays with discoidal ferruginous concretions about the size of supper plates, vermilion within and veined with calcite, the outer layers reddish to yellowish brown and not reacting to acid	8	
8. Heavily bedded gray sandy micaceous clays stained brown along bedding planes; associated concretions not so large as those higher in the section, highly colored, discoidal or elongated, often suggesting a ham bone in outline with yellow dusty centers; no organic remains observed	15	
Concealed to the open banks of Dry Brushy	50±	

The selenite so abundantly present throughout the surface outcrops of the Midway is probably of secondary origin.

The Midway-Wilcox contact can be closely approximated along the entire line of strike in Williamson County but its sharp definition is rare.

The top of the Midway one-fourth mile south of Structure Giu, 9 miles southeast of Taylor, is marked by yellow-brown calcareous concretions seamed with calcite. Other good outcrops of the uppermost Wills Point may be seen 2 miles in an air line northeast of Lawrence Chapel. Very sandy well-bedded micaceous clays, brownish gray in color, are associated with large calcareous concretions. The overlying sands carry a little glauconite in small grains and may represent the basal Wilcox.

TRAVIS AND BASTROP COUNTIES

The Travis-Bastrop County line roughly bisects the Kincaid outcrop north of the Colorado River. South of the Colorado the outcrop lies almost entirely to the east of the county line. The area of the normal outcrop is narrow, rarely more than 2 miles in width, but in the southwest corner of Bastrop County the beds are repeated by faulting. A long thin half lens of the Kincaid formation parallels the Travis County line from near Mayhard Creek, almost to the Caldwell County line a mile or more to the west of the main outcrop while a lens of Wills Point is faulted into the Wilcox south of Mayhard. The village of Cedar Creek is north and east of the faulted block.

The best exposures of the Kincaid formation are to be found in Bastrop County on Wilbarger Creek and its tributaries and upon the Colorado River: and of the Kincaid and Wills Point formations on Cedar Creek and the draws leading into it. The uppermost Wills Point and basal Wilcox outcrop in a remarkable manner on the Solomon farm, 6 miles south of Elgin. Excepting for the outcrops of the Littig glauconitic member on the northern margin of Lund and in road cuts to the south of Lund, no exposures of fossiliferous strata of Midway age were observed between the Williamson County line and the forks of Elm Creek in Bastrop County. The actual Cretaceous-Midway contact was observed by L. W. Stephenson in a gully 0.3 mile due north of Lund in Travis County. The Cretaceous-Midway contact, though not observed, can be closely approximated to the west of Elgin. The Cretaceous is exposed by faulting in the northwestern branch of Elm Creek about a quarter of a mile downstream from the bridge on the Elgin-Manda road, about two miles west of Elgin.

Exceptionally fine Cretaceous-Midway contacts may be observed along the scarp which parallels Wilbarger Creek about half a mile to the south of it, a scarp which owes its origin to the resistance of the indurated Littig glauconitic member. The following section was measured at the ford on Mr. Frank Goerick's farm 1½ miles south of Littig in Travis County.

	Thickness Ft.	In.
6. Cover	3	
Midway group:		
Kincaid formation: Littig glauconitic member:		
5. Soft, conglomeratic sandy clay carrying glauconite in appreciable quantities, numerous small phosphatic pebbles, casts of small mollusca (*Leda, Area, Ostrea pulaskensis, Venericardia, Borulites*), crab claws, shark teeth, etc. (U.S.G.S.Sta. 11676)	1	8
4. Indurated sandy marl with pockets of coarse glauconitic sand; molds and phosphatic pebbles fairly common	1	8
Navarro group (Upper Cretaceous):		
3. Stiff blue clay drying with a shaly cleavage, obscurely bedded, sparsely fossiliferous; a sandstone dike cutting diagonally across the lower five feet	10	
2. Stiff blue clay drying with a shaly cleavage, not bedded, containing fossils in considerable abundance but usually crushed and very fragile	5	
1. Covered by slump to water's edge	5	

Ostrea pulaskensis and *Venericardia* cf. *V. mon* are the most significant of the indigenous species in bed No. 5 (U.S.G.S.Sta. 11676). The Littig glauconitic member of the Kincaid formation outcrops in the scarp above Manor's store. The usual Navarro flags are found a little to the west. Another much less usual phase of Upper Cretaceous may be observed in the conglomeratic and glauconitic boulders with sandy seams and dense calcareous outer coverings which outcrop in a ravine below this scarp. These have much in common with the glauconitic Cretaceous conglomerate outcropping 2 miles southeast of Mendoza and 6 miles north of Lockhart. An unsuccessful attempt was made to relocate an exposure of basal greensand on the scarp back of Webberville (U.S.G.S.Sta. 2439) from which a collection was made by T. W. Stanton in 1890. This is the only basal Midway that has been recorded on the banks of the Colorado. An excellent Cretaceous-Midway contact is that exposed at the now classic locality on the Austin-Bastrop road, one-half mile east of the Travis County line (U.S.G.S.Stas. 11680 and 11679). In the roadcut, the section does not go below the Navarro flags—which are separated from the fossiliferous basal greensand by about 2 feet of nonfossiliferous, nonglauconitic yellowish-brown

Cretaceous sand. Float of a conglomerate of broken oyster shells, rounded phosphatic pebbles, and small, angular fragments of Cretaceous sandstone with some sharks' teeth and some glauconite were found by Hugh Duval, of Bastrop, in a nearby field, but their origin could not be traced. They are probably similar to those found in place southeast of Mendoza, 15 miles distant in an air line. This is the only outcrop of importance between the Colorado River and Maybard and Cedar Creeks. The barren interval apparently constituted in some way a buffer against the *Venericardia bulla* fauna ubiquitous in the lower part of the Wills Point formation in north and west-central Bastrop County. The Midway outcrops in southwestern Bastrop County share the involved structure of the Lytton Springs area and yield a similar fauna.

Venericardia bulla is peculiarly restricted both vertically and horizontally. In the lower part of the Wills Point formation from Wilbarger Creek to the Colorado it is extraordinarily abundant. It dominates, to the exclusion of almost all other species, the fauna which it characterizes, but it is restricted to a strip less than 10 miles long and less than 2 miles in width. Excellent outcrops of the *Venericardia bulla* zone can be observed at a number of localities along Wilbarger Creek and Dry Creek and the draws leading into them. Good outcrops, too, can be seen on almost every one of the numerous west-northwest roads leading into the county line from the Elgin-Bastrop road. A particularly interesting series of outcrops occur in a branch of Wilbarger Creek, on the properties of Mr. Lawrence Solomon and Mr. Rivers, about 6 miles southwest of Elgin.

The section of the Midway along the Colorado River, though incomplete, is an exceptionally fine collecting ground. The outcrop of the Upper Cretaceous at Webberville has long been classic. Between Webberville and the first recognizable Midway the bank has slumped, concealing the section and the Cretaceous-Midway contact. The Midway is first exposed on the south bank of the Colorado around the big bend downstream from Webberville and 1½ to 2 miles beyond the Travis-Bastrop County line.

The following is a generalized section at fairly low water:

	Thickness Ft.	In.
Wilcox group:		
7. Red sand well bedded, separated from the underlying bed by a faulted contact		
Midway group:		
Wills Point formation:		
6. Chippy shales, iron-stained along the bedding planes, for the most part barren	1±	
5. Glauconitic sandy clay, fossiliferous, becoming increasingly less glauconitic toward the top. Foraminifera, corals, Mollusca, especially gastropods, *Hercoglossa* fragments (U.S.G.S.Sta. 10,527, 11,890, 12,113)	25–30	
4. *Venericardia bulla* zone—locally indurated and ledge-forming, glauconitic. Fossils other than *V. bulla* rare (U.S.G.S.Sta. 5281)	2	6
Kincaid formation:		
3. Dark gray, brownish, sandy micaceous clays, more argillaceous toward the base and somewhat greasy, resistant and ledge-forming; glauconite present in considerable quantities but very irregularly distributed. *Calyptraphorus*, *Turritella*, *Natica*, *Hercoglossa* (U.S.G.S.Sta. 10,526, 11,696, 11,914, and 12,112)	12	
2. Ferruginous and calcareous concretions, rather evenly spaced	1	
1. Dark gray chippy clays (U.S.G.S.Sta. 11,915) Species mostly of small size.	12–15	

The dip is low, but a series of limonitic concretions about one foot in the greatest diameter and elliptical in outline cuts across at an angle of 3° 30'. The rather abundant fossils in No. 3 weather out of the marl and rest in an almost perfect state of preservation upon the top of the bed, which extends as a ledge 15 feet above the base for a distance of 50 to 100 feet. The most conspicuously abundant forms are perhaps *Crassatellites*, *Calyptraphorus*, and *Turritella*. The overlying bed is packed with *Venericardia bulla* Dall to the exclusion of nearly all other organisms. The shells have been partially dissolved and redeposited as a cementing material, so that the stratum is firmly indurated and persists as a well defined ledge for a distance of more than half a mile. Above the bed bearing *Venericardia bulla* is a loose, dark gray, sandy, glauconitic clay carrying a diversified fauna. The barren chippy sandy shales at the top may be synchronous with the sand at New Hope in Freestone County. The throw involved in the contact fault is doubtless very

slight. The Wilcox sandstone at Miller Riffles, the next bend downstream in the Colorado (5 miles by the river below the Travis County line) was referred by Deussen to the basal Wilcox.

The Midway has not been successfully followed between the Colorado River and Cedar Creek. Dall's type locality of *Venericardia bulla* is "Brown sandstone of the Midway horizon, east of the first small creek on the road to Bastrop, Texas, from old Garfield in the Austin quadrangle." The creek in question must have been Dry Creek. Mr. Duval reports a poor exposure about 2 miles from the county line, and L. W. Stephenson collected *Venericardia bulla* from the hill slope near old Garfield, possibly Dall's original locality.

In the southwestern part of Bastrop County, south of Mayhard Creek, excellent outcrops are offered by Cedar Creek and its tributaries. Only the Kincaid formation and the basal part of the overlying Wills Point are exposed along the unfaulted line of contact. The Navarro-Kincaid contact in a small gully head near Half-Mile Creek, one-half to three-fourths mile above Cedar Creek road (U.S. G.S.Sta. 11678) is exceptionally good. The indurated ledge of the Littig glauconitic member carries not only reworked Cretaceous fossils, but also clays and angular blocks of Cretaceous sandstone. *Ostrea palaskensis* and *Venericardia* sp. cf. *V. aroa* are the most characteristic species of the indigenous fauna. The well known outcrop at the bridge over Cedar Creek on the Austin-Red River road is very close to the base of the Wills Point formation. The sliver of Midway which parallels the Travis County line, at a distance of little more than a mile from it, outcrops rather poorly in a tank just northwest of Williams' store on the Austin quadrangle. By a confusing error in the Austin quadrangle map, Williams' store is placed at the crossroads, one-half mile northwest of Cedar Creek instead of the next crossroads to the northwest, a little over a mile from the point where Mayhard Creek crosses the Travis County line. As a matter of fact the name is now known only to the oldest inhabitant.

Wills Point sands and clays outcrop to the east of a northeast trending fault which extends from Cedar Creek southwestward far beyond the Caldwell County line. A good fauna was recovered from the gully below a tank on the Cedar Creek-Lytton Springs road (U.S.G.S. Sta. 11903). It is older than the faunas from a tank on

the Austin-Red Rock road, 1½ miles southwest of Cedar Creek bridge and from a gully, one-half mile to the east. There are pearl-gray tenacious clays, carrying echinoid impressions, a small *Leda* (*Sacella*) and *Ringicula*. Though none of the species is determinable, they form an association which is remarkably characteristic of the high Wills Point. Clays outcropping in a branch one-fourth mile east of the Lytton Springs-Cedar Creek road at Cedar Creek Crossing carry echinoid impressions and a few shell fragments. Nothing can be determined even generically, but the lithology and the echinoid impressions speak for an upper Wills Point age.

CALDWELL COUNTY

My hearty thanks are due to Carroll E. Cook of Austin, Texas, for his most cordial coöperation during my work in Caldwell County. He not only acted as a guide to the most significant outcrops, but he gave most generously of the results of his investigation and careful study of a rather involved area. The section is one of unusual interest for the beds are well characterized both lithologically and faunally and can be followed, for the most part with confidence, over a badly faulted area. The following is a generalized section of the Kincaid formation in the vicinity of Lockhart. All of the thicknesses are measured from field outcrops and run conspicuously lower than they do in wells.

Generalized section in the vicinity of Lockhart, Texas.

	Thickness Ft.	In.
Midway group:		
Kincaid formation:		
8. Brownish gray sandy joint clays usually fossiliferous	5-15	
7. Highly fossiliferous glauconitic sand with yellow cone-in-cone concretions, *Hercoglossa*, *Ostrea pulaskensis*, *Crassatellites* sp.	1-4	
6. Light yellow calcareous sands	25-30	
5. Mottled brownish yellow and bluish gray sandy clays with splashes of white	5-12	
4. Light gray calcareous marl often specked with glauconite	6	8
3. Basal greensand	4	
Navarro group (Upper Cretaceous):		
2. Very fine sands and slick clays	4	
1. Flaggy sandstone usually very fine and homogeneous, barren; rarely conglomeratic, fossiliferous and glauconitic		10-12

The Midway occupies roughly the north-central portion of Caldwell County and roughly parallels the northwestern boundary. A wedge of down-faulted Wilcox is driven into the Midway north of Lockhart, and southwest of Lockhart the Kincaid forks to receive a wedge of upthrown Cretaceous. There are also two small half lenses of Midway downthrown near the Hays County line between Mendoza and Maxwell, and Midway fossils were recovered from a shallow well 2 miles southwest of Joliet, 7¾ miles due south of Lockhart, probably on the upthrow side of the Luling fault. The basal Midway is sharply defined but the upper boundary is more difficult to follow. The geology of Caldwell County is common knowledge and mention is made only of the more notable outcrops.

Faulted Kincaid shale is exposed in an arroyo to the east and much better to the west of the Austin-Lockhart road, 1½–2 miles south of Mendoza (U.S.G.S. Sta. 11681) and half a mile to a mile northwest of the normal line of outcrop. *Ostrea pulaskensis, Venericardia* sp. cf. *V. mea*, molds of small species of *Leda, Turritella*, and other gastropods together with fish teeth and reworked *Baculites* characterize the outcrop. A conglomeratic-glauconitic phase of the underlying Upper Cretaceous is remarkably well displayed. Another interesting outcrop of Upper Cretaceous is that at the normal contact in an air line about a mile to the south of the preceding in a draw, 6 miles due north of Lockhart and about half a mile west of the Austin-Lockhart road (U.S.G.S.Sta. 11682). Very fine dense sandstone Navarro flags are locally filled with pebbles and other shoreline trash, a little greensand, and, in one locality, a 4-inch seam of *Micrabacia*, probably the most characteristic Upper Cretaceous coral. A curious weathering phase was observed in some of the Navarro flags, a blue gray medial band with oxidized portions of equal width on the upper and lower surfaces. These flags are probably less than 25 feet below the top of the Cretaceous. The characteristic basal greensand fauna of the Kincaid formation includes *Ostrea pulaskensis*, molds of small transversely produced species of *Leda* (possibly reworked), *Turritella*, and numerous molds of a *Cerithium*-like form also possibly reworked, together with fish teeth and reworked *Baculites*. A basal greensand suggesting the greensand near Leon Creek, north of the San Antonio-Castroville road in Bexar County, but much more usual both in the character of the glauconite grains and of the binder, occurs just south of the

Bastrop County line, 2½ miles southeast of Travis County (U.S.G.S. Sta. 11690). The glauconite does not occur in polished oolites as in Bexar County, nor is the matrix such a pure crystalline calcite, but there is a tendency toward an oolitic structure, and a yellow crystalline calcite makes up the greater part of the impure matrix. This greensand carries reworked *Gryphaeostrea vomer* and *Baculites* in very considerable numbers, and phosphatic pebbles are commonly associated.

An interesting outcrop (U.S.G.S.Sta. 11634), which includes the basal greensand, occurs below a farmhouse on the hill overlooking Elm Creek, 4 miles northwest of Lockhart near the intersection of Elm Creek and the Rogers Ranch School-Lockhart road. The creek probably cuts into the Cretaceous. The lower part of a rounded hill nearby is Kincaid. Yellow and red concretions may be observed on the side slope and Wilcox caps the top, its presence revealed in part by an abrupt change in the character of the vegetation. The greensand on the bank above Elm Creek is unusually coarse and the matrix highly calcareous. Two miles north of Lockhart, on the C. W. Cardwell farm, W. C. Williams Survey (U.S.G.S.Stas. 11635 and 11636) an arroyo offers an excellent exposure of the contact.

	Thickness Ft.	In.
Midway group:		
Kincaid formation:		
6. Mottled gray and blue sandy marl, carrying an abundance of micro-fossils and a small number of Mollusca: *Leda, Ostrea pulaskensis, Volutocorbis* sp. (U.S.G.S.Sta. 11,683) to top		
5. A soft but not crumbly, dense, dirty, gray chalk, peppered with glauconite carrying a micro-fauna and a few molluscan impressions (U.S.G.S.Sta. 11,687)	6	8
4. Greensand similar to that below but less glauconitic and less fossiliferous; comparatively few reworked fossils, *Volutocorbis* sp., *Tubulostium* sp. (U.S.G.S.Sta. 11,685)	2	
3. Ledge-forming, coarse, highly calcareous greensand, the glauconite making up the greater part of the marl; *Ostrea pulaskensis, Cucullaea*, and a large number of reworked fossils (U.S.G.S.Sta. 11,636)	2	
Navarro group (Upper Cretaceous):		
2. Fine, densely compacted, yellowish noncalcareous sand	3	
1. Flaggy sandstone	1–1½	

The chalk overlying the Littig glauconitic member is fairly persistent in the Kincaid section in Caldwell County and indicates a return to quiet waters after the troublous period of the basal greensand when the old Cretaceous beach was being pounded by the invading Midway sea. Fine, loosely compacted, marly, clayey sands, mottled yellowish brown and bluish gray in color, succeed the chalk (U.S.G.S.Sta. 11688). They carry a rich microfauna but comparatively few Mollusca, among them *Ostrea pulaskensis* molds and impressions of *Volutocorbis*. The average thickness of the marly sands and sandy clays is about 8 feet. They grade upward into a light yellow sand, which is richly fossiliferous. On the Martindale farm, 4 miles southwest of Lockhart (U.S.G.S.Sta. 11689), the Littig glauconitic member is repeated by faulting. The crystalline and yellowish brown calcite so characteristic a feature of the facies that has been called the "Squirrel Creek formation" is common at this locality.

The Littig glauconitic member outcrops along the north tongue of Kincaid which crosses the San Marcos near Staples and persists possibly to York Creek. Exogyras have been found, presumably in place, in a small branch on the southern edge of Staples. On the bank above the San Marcos, at the end of the first secondary road about 1 mile north of Staples (U.S.G.S.Sta. 11695), a coarse greensand with a highly calcarreous matrix outcrops rather widely but not conspicuously. The calcite in the matrix is finely crystalline and of the same color as that in the more coarsely crystalline facies of the so-called "Squirrel Creek formation." The micro-fauna includes foraminifera and ostracods. The Mollusca are reworked or not specifically determinable. No exposures of Littig were observed along the normal line of contact north of Fentress.

The upper Kincaid in Caldwell County is well characterized and carries a richer molluscan fauna than the basal greensand. One of the finest outcrops observed in the county is in a draw, one-half mile northwest of the Simms Oil Company's derrick on the G. A. Moser farm, Isaac Jackson Survey, 5½ miles due north of Lockhart (U.S.G.S.Sta. 11707). The highly glauconitic matrix carries *Ostrea pulaskensis* and, among the characteristic fossils of the upper part of the Kincaid formation, *Venericardia smithii*, *Volutocorbis texana*, *Turritella alabamiensis*, and abundant *Hercoglossa*. The greensand below the *Hercoglossa*-bearing ledge carries *Ostrea pulaskensis* but

no other common fosssils excepting foraminifera. The 8 to 10 feet of sandy clay above the *Hercoglossa* zone carried smaller foraminifera but no Mollusca were observed. Red concretions, probably a disintegrating ledge, cap the hill.

The same fauna, even to *Turritella nerinexa*, restricted in its known Caldwell County distribution to these two localities, outcrops on the Martindale farm, 5½ miles southwest of Lockhart (U.S.G.S.Sta. 11706). Yellow cone-in-cone concretions are commonly associated with the *Hercoglossa*-bearing greensand.

One of the best horizon markers in Caldwell County is that of the so-called "red concretions," the oxidized and calcareous cobbles, dirty yellowish brown in color and specked with polished dark brown, noncrystalline grains which are probably altered glauconite. A concretionary structure may be detected but is by no means marked and it is highly probable that these "concretions" are remnants of a continuous resistant stratum rather than a discontinuous series, indicating apparently the base of the Wills Point formation. The relation between the "red concretions" and the yellow cone-in-cone concretions commonly associated with the upper fossiliferous greensand and the clays directly above them is established locally by an outcrop on the south side of the J. L. Pruitt farm about 6 miles northeast of Lockhart. Red and yellow concretions separated by 5 to 8 feet of slightly glauconitic marl outcrop conspicuously along a deep cut, probably made by an old road. The intervening distance between the two series of concretions is usually much greater—about 25 or 30 feet.

Clays of the Mexia member of the Wills Point formation bearing *Volutocorbis limopsis* were collected from Town Branch on the Dale road on the western margin of Lockhart in 1925 but the locality is no longer accessible.

Similar clays are exceptionally well exposed on the Austin-Lockhart road along the south side of Plum Creek and 4.6 miles northwest of Lockhart at a jog in the secondary road leading north from the road to Maxwell.

The dome of the Lytton Springs structure is encircled by red "concretions" and before the development of the field, yellow cone-in-cone concretions and *Hercoglossa* were found within the circle.

GUADALUPE COUNTY

Excepting for a slender faulted tongue of the Kincaid southwest of Staples, the Wills Point occupies by far the greater part of the section in the narrow strip which extends across the north-central part of Guadalupe County roughly parallel to the northern boundary. No Kincaid has been recognized in surface outcrops between Geronimo Creek and the Bexar County line. On the San Marcos River, the eastern boundary of Guadalupe County, the outcrop of both the Kincaid and Wills Point is about 1½ miles wide.

Kincaid clays, fossiliferous, glauconitic, slightly phosphatic, and brownish rather than gray in color, are well exposed in a small break of the San Marcos, 1½ miles southwest of Fentress. A few inches of shale outcrop beneath the greensand, and both the field relations and the fauna indicate the higher glauconitic sand and not the Littig glauconitic member. In fact, excepting in the faulted tongue southwest of Staples, no outcrop of the Littig glauconitic member has been observed in Guadalupe County. The southern extension of the Staples fault is indicated by fossils recovered from a gully exposure 2.3 miles southwest of Staples by L. W. Stephenson. No good outcrops of Wills Point were noted near the San Marcos but the lower Wilcox outcrops a little to the south of the crossroads, 2 miles southwest of Fentress, and the oyster bed within a mile of the crossroads. Fossiliferous Kincaid shale with associated brownish septarian concretions seamed with calcite were thrown out in digging a tank, 3½ miles southwest of Fentress. Geodic concretions filled with selenite crystals and often brilliantly colored are associated with the Wills Point clays exposed in a roadside ditch 9 miles or more southwest of Seguin, on both the north and east sides of the R. E. Brown 300 acres. In the northeast corner of the adjoining Martinez Survey basal Kincaid has been reported from a depth of 190 feet. The flood plain of Cibolo Creek is very wide and offers no outcrops but the clays and associated concretions exposed in the west bank of Cibolo are probably all of Wills Point age.

Cucullaea macrodonta? was collected by Deussen at Zuehl. The lithology is that of the Wills Point, and the associated concretions are banded in shades of red and brown with yellow centers. It is possible that the Midway is brought to the surface in the faulted

area southwest of New Berlin, but the width of the normal outcrop on Cibolo Creek does not exceed 4 miles.

A very high Wills Point horizon, the probable equivalent of that represented at Jett Crossing on Medina River, is indicated by a ferruginous and fossiliferous glauconitic sandstone outcropping on the Guadalupe River near the ferry 3 miles west of Seguin and also 2½ miles above the power house south of Seguin.

An oxidized calcareous sandstone riddled with *Teredo* tubes, collected by Stephenson, from the north-facing slope of the San Marcos, 1½ miles west of Fentress, is probably of Midway age and lower than the sandstone at Jett Crossing. Guadalupe and Bexar counties must have been synclinal during the early Eocene, for marine conditions apparently persisted, at least intermittently, well into Wilcox time.

The waters were, for the most part, shallow, for *Ostrea* and *Cerithium* are the most common species at many of the outcrops but they record the continuance of the general marine conditions that attended the close of the Midway, and indicate a nearby retreat for the very considerable number of Midway species which persisted into the Wilcox.

BEXAR COUNTY

The surface geology of Bexar County is adequately covered by Nelson A. Sayre in a report soon to be published by the Division of Ground Water of the U. S. Geological Survey. The Kincaid, which makes up practically the entire Midway section in Medina and Uvalde counties and by far the greater part of it in Maverick County, has not been certainly recognized in surface outcrops in Bexar County.

As in Guadalupe County, the Kincaid formation is for the most part absent and east of San Antonio probably concealed by overlap. Greensands referred questionably to the basal Wills Point outcrop, however, at a number of localities along the Cretaceous-Midway contact. The most striking of these are along the scarp on the west side of Leon Creek and particularly in a small west branch of Leon Creek on the north side of the San Antonio-Castroville road. The greensand is oolitic, the grains are small and polished, elliptical, averaging about 2 millimeters in length and 1 in breadth, and the brittle matrix is a yellow, highly crystalline calcite. No fossils were recovered except possibly fruit of a species of *Chara*. The basal

greensand of the Kincaid formation is much coarser as a rule, not oolitic and not homogeneous and usually carries some trace of organic remains. Calcareous boulders which may carry a little glauconite and which suggest in texture the matrix of the greensand north of the Castroville road were observed in a small draw, 1½ miles north of Martinez.

The Cibolo Creek section has been described by Deussen (62, pp. 13-14). The greater part of the section at Zuehl, including that which carries *Cucullaea macrodonta*, is of Wills Point age. The clays are micaceous and vermilion concretions are associated with them.

The Midway-Indio contact is obscured on Cibolo Creek by flood plain deposits but it probably crosses the stream a little less than a mile below the mouth of Santa Clara Creek on the Guadalupe County side.

The jointed clays of the Wills Point formation are well exposed in the Missouri, Kansas & Topeka Railroad cut in southeastern San Antonio and in Salado Creek and are reported from time to time in gravel and brick pits in the vicinity of southern San Antonio. The San Antonio River valley offers very few good outcrops but there are some excellent cuts made by the Medina River. A few hundred feet upstream from the north bank of Garza Crossing, 3 miles above Jett Crossing, there is an exceptional section of the Wills Point concretionary clays. The clays are bedded, chippy, and stained with manganese. The included concretions are of boulder dimensions, gray and argillaceous, and are giving rise to large numbers of smaller banded, highly colored concretions, all with a strong tendency toward septarian structure.

A collection was made by Deussen from the ferruginous sandstone concretions at Jett Crossing on the Palo Alto road. The fauna is on the border line between the Midway and the Wilcox.

No Midway is known from surface outcrops in Bexar County west of Medina River, excepting for a small area near the mouth of Elm Creek.

MEDINA COUNTY

East of the big bend in the Southern Pacific Railroad, south of Castroville in Medina County, the Midway seems to be cut out entirely. Between Dunlay and Noonan and the Hondo River the

areal geology indicates a series of parallel faults trending east-northeast; the northernmost and southernmost of these faults are downthrown to the south, and the other three to the north. The southeast dips on the first north-south road east of the Hondo River near the farmhouse on the Tom Neuman 213 acres run as high as 45°. Both to the east and west of the Elstone structure, which brings the Cretaceous to the surface in the Hondo River valley, the Midway scarp is a conspicuous topographic feature. The Cretaceous at Elstone is best exposed in the bend of the Hondo to the east near the power house of the Central Power and Light Company. The *Ostrea cortex* reef forms the bed rock for some little distance and extends at some points entirely across the river. *Sphenodiscus* is associated with *O. cortex* but is much less abundant. The Midway exposures below the Elstone Crossing are mostly in the form of large, fossiliferous, calcareous sandstone boulders derived from a section some 8 feet in thickness outcropping in the bed of the Hondo about 1 mile below the Graff farmhouse and about half a mile above the crossing. Some 3 feet of very massive sandy limestone weathering smooth with slight smooth depressions overlies about 5 feet of sandy limestone with brown calcite. Liddle's formational terms "Squirrel Creek" and "Elstone" describe lithologic facies which do not apparently maintain a uniform stratigraphic position. The "Squirrel Creek" facies, which is characterized by the abundance of large crystals of brown calcite, can be followed to the Rio Grande, where it caps the Cretaceous at White Bluff. Thick-bedded Indio sandstone fills the bed of the stream about halfway between the Midway outcrops in the Hondo and the Graff farmhouse. No Midway was observed in the Hondo River section between this Wilcox and the Cretaceous to the north. It is present, however, in the hill south of the bend in the railroad between Dunlay and the Hondo.

Midway boulders of the facies that has been called "Elstone formation" by Liddle were observed on the south side of Live Oak Creek to the west of the road running due south from the eastern edge of Hondo. Cannon reports 153 feet of Wilcox from a well on the south line of the H. Castro Survey and lignite at 100 feet. This is less than a mile in an air line to the northwest of the Midway and less than a mile to the southwest from a roadside outcrop of Cretaceous flags. The Butts Gin-Hondo road follows roughly the

Midway-Wilcox contact between Live Oak and Butts Gin, 4.3 miles (air line) northwest of Yancey. Rounded boulders of fossiliferous Midway of the "Elstone" facies, with *Venericardia* and *Turritella*, too large to be transported in any usual manner, are strewn about the abandoned gin yard. The fact that smaller boulders of Wilcox sandstone are associated with them casts some doubt upon their origin. The Indio caps the hills between Butts Gin and the Seco. From Live Oak to the Seco the northern boundary of the Midway is marked by a conspicuous scarp with Fohn Hill as probably the highest point. The contact described by Stephenson in his "Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain," U. S. Geological Survey Professional Paper 90-J, from 7½ miles southeast of D'Hanis on the Yancey road, is along this front. The limestone at this locality, which is not far from Liddle's type "Squirrel Creek formation," contains small balls of clay about half an inch in diameter. These are similar to those in the basal limestone at White Bluff on the Rio Grande. The trend of the Cretaceous boundary is strongly to the south, that of the Midway-Wilcox to the west, so that along the Seco the areal extent of the Midway is reduced to a little more than a mile. North of the Southern Pacific Railroad there are two, possibly three, notable areas of outcrop of the limestone, one along the scarp overlooking Quihi on the Castroville road, the other in the bed of Verde Creek, 1 mile northwest of New Fountain. The third is reported by Cannon from the stream bed about 3½ miles north of Quihi.

Membranipora, crab claws, and the tubes of either worms or gastropods are the most characteristic fossils of the "Elstone" facies, whereas the "Squirrel Creek" facies carries *Venericardia crenaca*, *Limopsis quihi*, *Callocardia pteleina*, and other relatively large bivalves in considerable abundance. No outcrops of Wills Point age have been definitely recognized in surface deposits in Medina County.

UVALDE COUNTY

Excepting for a single obscure locality on the eastern terrace above the Nueces River, about 1 mile north of the Zavala County line, the Midway outcrops in Uvalde County are restricted to isolated exposures along the major streams in the southeastern part of the county.

One and one-half miles north of the Pulliam ranch house, which is about 300 yards southeast of the San Antonio, Uvalde & Gulf Railroad bridge over the Nueces River, on the road to the Widow Cook ranch, 0.3 mile due east of the Nueces River, along the face of the west-facing mesa, L. W. Stephenson made the following section:

	Thickness *Feet*
Indio formation:	
Gray, soft, cross-bedded sandstone with some interbedded clay lenses. Glauconitic at base	10–15
Kincaid formation:	
Dark clay, somewhat shaly	4
Gray argillaceous sand	2
Light gray, calcareous glauconitic sandstone becoming conglomeratic in the lower 1 or 2 feet. Contains some phosphatic nodules and casts, fragments of oysters, and *Sphenodiscus*, gastropod casts, some of which are reworked from the underlying Escondido. Also *Ostrea pulaskensis?*	2–3
Unconformity.	
Escondido formation (Upper Cretaceous):	
Argillaceous sand and sandy clay with one indurated layer; contains Cretaceous fossils	20

The Frio River above and below Evans' (Myrick's) apiary, 4 miles east of the Englemann ranch, has furnished the classic section of the lower Midway in Uvalde County. The downstream outcrops are on the well known Kincaid ranch and for that reason the lower formation of the Midway group was named the Kincaid formation. The section was first described in 1900 in U. S. Geological Survey Uvalde Folio No. 64, by T. Wayland Vaughan (29b).

Excellent outcrops of the Kincaid formation occur with interruptions and irregularities from about three-fourths of a mile above the Evans' apiary to about a mile above the old Kincaid ranch house some 5 to 6 miles below. The contact between the Midway and Cretaceous is exposed on the northeast bank of the Frio. Fucoidal sandstone forms the bed of the stream and the base of the bank. The section directly above the fucoidal sandstone is concealed, but about 2½ feet above is another 2½ feet of partially indurated yellow sand stained with manganese and packed with *Ostrea cortex*. Above this are fossiliferous glauconitic boulders, irregular in size and shape, apparently a disintegrating ledge of Kincaid conglomerate.

The conglomerate grades upward into a yellow sand with little glauconite and very few fossils. The contact on the west bank slightly downstream from that on the east is not so obvious, but 30 to 35 feet of alternating sands and limestones are exposed above it. The sands are for the most part fine and yellowish brown and carry a few disseminated grains of glauconite. The greater part of the relatively thin Midway section on the Frio is occupied by the fine yellow calcareous sands in which glauconite is a more or less constant but rarely abundant constituent and occasional beds of arenaceous limestone, also glauconitic and fossiliferous, at some localities abundantly so. Three limestone beds, each of them about 5 feet in thickness and separated by approximately equal intervals of less calcareous and less indurated sands, the lowest of the three usually 10 to 15 feet above the basal limestone, can be followed for very considerable distances both above and below the apiary. The sand is very fine, fairly homogeneous, slightly calcareous and carries small fragments of shell but nothing which makes even a generic determination possible. Concretions a foot or so long and pointed at either end occur most commonly toward the top of the section and are usually oriented with the long axis vertical. Capping the sandstone on the south bank is a very sandy, light yellowish gray limestone carrying *Cucullaea texana*, *Venericardia* and *Callocardia pteleina*. Just above the trail leading up to the Evans' apiary, a dense gray limestone outcrops as a well defined ledge a foot or more above the bed of the stream. It carries *Volutocorbis* sp. cf. *V. limopsis*, but the general ensemble of the fauna is that of the Tehuacana member. The ledge can be followed downstream for an eighth to a quarter of a mile where it forms the base of a bluff of about 50 feet at its highest. In this bluff the limestone is overlain by gray sands and sandy clays carrying rounded concretions, some of them 2 feet in diameter. Fairly well developed ferruginous layers may be traced for short distances and ferruginous concretionary nuclei are quite common. These sands, varying in thickness from 10 to 20 feet, are referable to the Wills Point formation, and are the only beds so determined in Uvalde County. They are overlain with marked unconformity by heavy cross-bedded sands of Indio age.

Downstream the section is repeated, and a quarter to a half mile above the mouth of Long Hollow the Navarro is brought to the surface and persists as a ridge on the east side of the channel for

a distance of 100 to 150 feet. It is also present in the east bank of the Nueces. The best Cretaceous-Midway contact is that exposed by the upthrow of the Cretaceous and Kincaid formations in the break designated "Long Hollow" on the topographic map, though there is no stream draining through it, and the indentation does not persist for more than an eighth of a mile. I have Mr. Getzendaner's generous interest to thank for information on this excellent exposure. The following section was measured on the southeast bank:

	Thickness Ft.	In.
Eocene:		
Midway group:		
Kincaid formation:		
8. Indurated limestone	6	0
7. Yellow sand	4	6
6. Indurated limestone	1	8
5. Fine yellow sand	1	6
4. Indurated highly calcareous sandstone resistant and ledge-forming	1	0
3. Fine yellow, slightly glauconitic sand	2½-3	
2. Basal conglomerate forming a discontinuous series of boulders, very hard, pebbly, with abundant glauconite. *Hercoglossa*, 2 feet above the base	2	
Upper Cretaceous:		
Escondido formation:		
1. Yellow fucoidal sandstone, no *Ostrea cortex* observed, *Sphenodiscus* worked out from clays at bottom of hollow	10	

The 6 feet of arenaceous limestone at the top is apparently the most resistant bed in the Frio Midway section. It is the equivalent in part of that designated "Squirrel Creek formation" by Liddle in his Medina County report, and is commonly characterized by the brown calcite of the large but poorly preserved bivalves such as *Cucullaea* and *Venericardia*. At the outcrop on the west bank, about half a mile below the Indio outcrop, the limestone beds lose their identity, becoming more arenaceous, less indurated and tending to fuse not only with one another but with the intermediate sands. Farther downstream on the east bank and at the final outcrop about 1 mile above the Kincaid ranch house, there is at least one limestone and usually two or three sufficiently resistant to stand out as a ledge. The irregularity of outcrop is accompanied by irregularity in dip.

The following section of the Kincaid formation was taken 1 mile above the old Kincaid ranch house:

	Thickness *Feet*
Kincaid formation:	
5. Glauconitic calcareous sand, with two indurated zones about 1 to 2 feet thick and 5 feet apart	15–20
4. Sandy fossiliferous limestone of the "Squirrel Creek" facies, the heavy shells of the large bivalves indicated by strongly crystalline brown calcite	5
3. Fine yellow sand with an ill-defined concretionary bed about 4 feet from the top	7
2. Very dense limestone suggesting that outcropping near the foot of the apiary trail, made up of two layers, both of them weathering with uneven surfaces	2
1. Glauconitic sandy clay to water's edge	1

Thanks to the courtesy of Mr. Frank Getzendaner of Uvalde, an outcrop of highly fossiliferous Midway was observed on Blanco Creek almost due west from the Schuddemagen ranch house. The boulders are scattered across the bed of the creek and along the west bank for perhaps an eighth of a mile. Slabs of Cretaceous sandstone outcrop a quarter of a mile above, and about three-quarters of a mile below there is a change to a reddish sandy soil.

The northwest slope of Elm Creek below the Schuddemagen ranch house, 11 miles south of Sabinal, offers a striking outcrop of 10 feet of massive limestone overlying the calcareous sand of the Escondido formation and overlain by sands and sandstone of possibly Wilcox age. The *Ostrea* collected from the pockets in the upper surface of the limestone is probably a sub-species of the Wilcox oyster, *Ostrea multilirata*. The brown calcite characteristic of the "Squirrel Creek" facies is abundant in the limestone, and the glauconitic grains are not sufficiently common to tint the rock. *Limopsis quihi* and *Venericardia crenaea*, so common around Quihi and New Fountain, are present and crab remains are very common. *Sphenodiscus* was collected from the base of the bluff. Apparently the Midway is reduced, probably by overlap, to little more than 10 feet. Not only are the Wills Point sands entirely absent, but the glauconitic conglomerate of the Frio River section and the yellow pack sand between the conglomerate and the limestone are without representatives on Elm Creek. At Irishman Hill, on the Uvalde and Medina County line, and

between 9 and 10 miles above the Zavala County line, the Tehuacana can be followed as a discontinuous series of boulders, fossiliferous and sparsely glauconitic, yellowish to dove-gray within, weathering blackish gray. *Ostrea cortex* is present from 12 to 20 feet below the crest. The capping is of gravel from 5 to 10 feet in thickness.

MAVERICK COUNTY

Areal mapping in Maverick County is seriously hampered by the lack of adequate base maps. The outcrops are good and the Rio Grande and several of the arroyos traverse the entire Midway section. Confusion in mapping arises much more readily from difficulty in placing the outcrop than in the interpretation of it.

The Tehuacana member of the Kincaid formation is one of the most prominent topographic features in Maverick County and is clearly traceable across the southern half of the county, with notable outcrops along Comanche Creek on the Farias ranch, at Bibora tank, all along the scarp on which the Indio wells were drilled, in the arroyo leading from Tobar tank to the river on the road from the Windmill (Jacal) ranch house to Las Isletas, and for several miles along the Rio Grande. A short distance north of Comanche Creek and in northeastern Maverick, northwestern Zavala, and south-central Uvalde counties the Midway is, for the most part, concealed by the overlapping Indio and Carrizo formations.

The Mexican Border "limestone," like that in the Tehuacana scarp, is more properly a calcareous sandstone, light gray to creamy white in color and highly fossiliferous. The shells occur, for the most part, firmly embedded in the matrix, and the shell substance, as in the "Squirrel Creek" facies of Medina County, occurs as a brown, highly crystalline calcite. Fossils though common are restricted in the number of species. The fauna is dominantly that of a few groups of rather large bivalves, notably *Cucullaea* and *Venericardia*. *Cucullaea texana* is widely distributed and usually abundant. Several species of *Venericardia* are present in considerable numbers, notably *V. smithii*, *V. jewelli*, of the *planicosta* group, and *V. moa* of the *V. alticostata* group. *Callocardia hanetofi* is also common and, like *Venericardia jewelli* and *V. moa*, is characteristic of the basal limestone of the Rio Grande embayment. Turritellas of the *humerosa*

and *mortoni* type are present though they are probably not specifically identical with these common eastern forms. The estimated thickness of the limestone is 25 feet.



Fig. 4. Upper Midway (Wills Point formation) and basal Wilcox section, Rio Grande about 3 miles above the Webb-Maverick County line.

The section on the Rio Grande is almost complete. The Midway exposures along the river are most readily accessible by the road leading down from the Windmill (Jacal) ranch house to the old crossing at the deserted Blessé ranch house on the Mexican side, an interesting example of Spanish architecture now falling in ruins but still an excellent landmark. At the northern end of the bluffs which extend from half a mile to a mile upstream from the Blessé ranch on the Texas side is a remarkably fine Cretaceous-Midway contact. At a slightly greater distance downstream from the Blessé ranch on the north side of the sharp bend in the river is an equally fine exposure of the Midway-Wilcox contact. The Midway outcrop is interrupted for only about three-quarters of a mile at the Blessé Crossing. The contact of the Cretaceous and Midway is already classic. The bluff in which it is exposed was formerly known as White Bluff, though the present occupants of the Indio ranch are not familiar with that name. The section has been described by Deussen and, more fully, by Stephenson. White Bluff of the literature is the most northern of the series that extends for half a mile downstream, and its commanding elevation is due to the Tehuacana member which caps it. West of White Bluff the Cretaceous shales, unprotected by the limestone, are readily eroded, and the landscape abruptly flattens. A turn to the west in the strike and the eastward trend of the Rio Grande bring the limestone very close to the river near Las Islas crossing. The following local section was made.

	Thickness *Feet*
6. Caliche capping	1-2
Eocene:	
Kincaid formation:	
5. Yellowish gray (3-21-e)[1] sandy but very highly crystalline limestone, resistant under the hammer, very fossiliferous, the calcite glistening white when fresh, weathering brown; casts of *Cucullaea texana, Venericardia mon,* and *Callocardia hantoft* common	3
4. Yellow gray (2-21-6) noncalcareous sand carrying a few reworked fragments of *O. cortex* and a few scattered grains of glauconite	0-2
3. Grayish tan (2-21-h, but not so green), very sandy massive limestone; the lower 2 or 3 inches packed with glauconite, with occasional sharks' teeth, pebbles, and fragments of *Ostrea cortex;* the upper 18 inches sparsely glauconitic and fossiliferous, the fossils weathering out on the upper surface and frequently with the shell substance preserved, the most common among them being *Cucullaea texana, Limopsis* cf. *L. quihi, Venericardia mon;* a persistent ledge-forming bed of fairly uniform thickness	3
2. Clay conglomerate with layers and pockets of glauconite with irregular and wavy bedding, the clay, apparently reworked from the Cretaceous, the glauconitic pockets with fragmentary and reworked Cretaceous fossils, seed cases, and probably with *Venericardia*	0-2
Cretaceous:	
1. Very compact greenish gray shale (nearest to 3-21-a but not so dark) with abundant dendritic markings of manganese; *Sphenodiscus* very near top, *Ostrea cortex* about 35 to 40 feet down	75-100

The *Ostrea cortex* horizon of the Cretaceous is a prominent clay bed for a considerable distance downstream. Good outcrops of the fossiliferous Tehuacana member are exposed for a quarter to half a mile downstream. The break through which the road passes to the Blessé Crossing offers nothing but terrace material and river sands and clays with a thin shingle of very coarse dark-colored gravel. An eighth to a quarter of a mile south of the Blessé Crossing the upper part of the limestone appears interbedded with greenish, yellowish gray sands. One arroyo section offers 3 to 4 feet of these sands

[1]These numbers refer to the Goldman Color Chart, issued under the auspices of the National Research Council, Washington, D. C.

overlying a limestone platform and overlain by 15 to 18 inches of massive gray crystalline limestone weathering grayish black. The sands are relatively soft but firmly packed and bedded in layers about 1 inch in thickness and forming a natural bridge between the limestones. At low water a limestone floor extends for some distance into the Rio Grande and great slabs are piled up upon the Mexican bank. Potholes cover the upper surface and the fossils, though numerous, are presented in cross section only. The associated sands carry scattered grains of glauconite and locally abundant *Turritella*. The calcareous sands become increasingly important downstream and up the section and about a quarter of a mile below the Blessé ranch, though still sparsely glauconitic and fossiliferous, they are concretionary. The concretions are of the argillaceous calcareous ironstone type and run up to two feet or more in diameter. This bed extends across the channel of the river at low water; the uneven upper surface forms a series of stepping stones. The following section was taken along the bluffs extending from three-fourths mile to a mile downstream from the Blessé ranch and forming the strong east-west bend in the Rio Grande.

	Thickness *Feet*
Indio formation:	
6. Fine quartzitic, noncalcareous sand carrying some glauconite at the base, streaked and mottled grayish brown and reddish in color, light gray within 2 feet of the base and spattered with macerated leaf fragments. A conglomerate with ferruginous pebbles up to several inches in diameter derived doubtless from Midway concretions, locally developed within 10 to 15 feet of the base. The 15 to 20 feet of heavy, often cross-bedded indiscriminately massed sands overlain by much darker colored paper-thin and regularly-bedded sands and clays. Composite section	40
Midway group:	
Wills Point formation:	
5. Grayish yellow, chippy argillaceous sands and sandy clays and shales, glauconitic and calcareous at the base (rather deeper than 3-18-2), gradually losing the glauconite and most of the lime and altering upward into a gray clay (7-15-0); a thin-bedded shale probably with some copiapite and possibly at the extreme top, nonmarine. No well defined concretionary bed but a few rather small reddish but not vermilion concretions at the top	20

	Thickness *Feet*
4. Highly calcareous, glauconitic, concretionary sandstone in dull shades of grayish purple and reddish brown, forming a continuous ledge	1
Kincaid formation:	
3. Dull grayish brown to greenish and purplish (3 1/8-a to 3-1 2), rather coarse highly glauconitic and calcareous sand, conglomeratic at the base and carrying *Venericardia smithii* in abundance; in the lower 3 feet, less glauconitic and less fossiliferous than above, weathering reddish, especially toward the base	6-7
2. Dark gray, glauconitic, laminated, sandy shale, cut by joint planes at 60° and with a bed of concretions at the top. Concretions dense, rather thick oval, with gray, sparsely glauconitic rims and reddish centers seamed with calcite, weathering out into purple-red cores	5
1. Brownish yellow, sparsely glauconitic and calcareous sand, very fine, crudely bedded, tending to be concretionary. A well defined series of argillaceous concretions, about 15 inches in diameter and half as thick, seamed with calcite about 2½ feet above the base of the sands; another series of similar concretions crowning the sands; concretions and numerous joint planes weathering brownish red	8

The section is more uniform in character than the sections farther north and the line between the glauconitic sandy limestone and the glauconitic calcareous sandstone is less sharp than the terminology implies. Glauconite is present in varying amounts throughout almost the entire section of the Rio Grande Midway. It is possible that the base of the Wills Point formation is indicated in the conglomerate at the base of bed No. 3 in the section below the Blessé ranch, though *Hercoglossa vaughani* and other fossils commonly associated with the upper part of the Kincaid formation are present. The 25 or 30 feet which overlie the conglomerate indicate a single depositional series and the clays at the top may be nonmarine. The break between them and the Indio above, is, however, very sharp.

The structure so prominent in the Cretaceous of Maverick County and in the Indio and Carrizo formations in the Winter Garden area is reflected in the swing of the Tehuacana member of the Kincaid formation to the east along Comanche Creek and south of Comanche to the headwaters of Pendencia Creek.

The following list includes the determinable Midway species cited and discussed in the taxonomic section:

DISTRIBUTION OF SPECIES

	Kincaid formation	Wills Point formation
Linthia mavericken-is		x
Conopeum damicornis	x	
Argyrotheca powersi		?
Leda saffordana	x	
Leda eoa	x	
Leda smirna	x	x
Limopsis quihi	x	
Cucullaea macrodonta	x	x
Cucullaea texana	x	
Cucullaea kanfmanensis	x	
Breviarca stearnsii	x	
Pteria dennseni	x	
Gryphaeostrea vomer	x	
Ostrea pulaskensis	x	
Ostrea crenulimarginata	x	
Ostrea kochae	x	
Ostrea multilirata sabinalensis		?
Amusium alabamense	x	x
Modiolus saffordi	x	
Crassatellites gabbi	x	
Crassatellites ioannes	x	?
Corbicula texana	x	
Venericardia jewelli	x	
Venericardia smithii	x	x
Venericardia alticostata		x
Venericardia bulla		x
Venericardia hesperia	x	
Venericardia whitei	x	
Venericardia crenaea	x	
Venericardia moa	x	
Venericardia eva	x	
Pharoides albaripa	x	
Pharoides mesakia	x	
Kelliella? evansi	x	
Kelliella aldrichi	x	x
Protocardia quihi	x	
Protocardia actia		x
Callocardia hawtofi	x	
Callocardia pteleina	x	
Callocardia biloraensis	x	
Callocardia kempae	x	
Tellina quihi	x	
Corbula milium	x	x
Corbula kennedyi	x	
Corbula coloradoensis	x	x
Teredo ringens		x
Teredo mavericken-is	x	
Dentalium mediaviense	x	x
Cadulus turgidus	x	?
Cadulus phoenicea	x	
Cadulus aldrichi		x
Tornatellaea texana	x	x
Actaeocina leai	?	
Cylichnina emoryi		x
Gilbertina texana	x	x
Orthosurcula longipersa		x
Orthosurcula longipersa tobar		x
Orthosurcula francescae	x	x
Orthosurcula phoenicea	x	
Mangelia schotti	x	
Exilia pergracilis	x	x
Levifusus lithae		x
Olivella mediavia	x	x
Volutocorbis rugata	?	
Volutocorbis texana	x	x
Volutocorbis limopsis		x
Volutocorbis kerensensis		x
Latirus? stephensoni	x	
Fasciolaria? plummeri	x	
Falsifusus ottonis	?	

	Kincaid formation	Wills Point formation
Falsifusus tolsar		x
Laevibuccinum constrictum	?	?
Tritaria? emoryi	x	
Murex mansfieldi	x	x
Ranularia hula		x
Tritonium cedri		x
Cypraea estellensis	?	
Calyptraphorus compressus	x	
Calyptraphorus aldrichi	x	
Calyptraphorus popenoe		x
Bittium estellensis	x	x
Epitonium cookii	x	
Epitonium dolosum	x	x
Lemintina? goniodes	x	
Tubulostium tolsar	x	x
Turritella alabamiensis s.l.	x	
Turritella kincaidensis	x	
Turritella mortoni s.l.	x	
Turritella humerosa s.l.	x	x
Turritella biloxiensis	x	
Turritella ola	x	
Turritella nerinexa	x	
Turritella hilli	x	
Mesalia mavericki		x
Architectonica phoenicea	x	x
Natica reversa	x	x
Natica perspecta	x	x
Natica saffordia	x	
Polinices harrisii	x	?
Lacunaria lithae		x
Teinostoma coa		x
Solariorbis gyrus	x	
Hercoglossa ulrichi	x	
Hercoglossa vaughani	x	x

GENERAL CHARACTER OF THE MIDWAY FAUNA AND CORRELATION WITHIN THE GULF REGION

At the opening of the Midway, in the Littig glauconitic member of the Kincaid formation, there are included among the significant genera and species *Breviarca stearnsii, Cucullaea macrodonta* s.l., *Ostrea pulaskensis, Crassatellites gabbi,* small venericards, *Calyptraphorus velatus,* a few small turritellas, and *Hercoglossa.* It is notable that the bivalves are the more numerous in species and individuals and, with the exception of *Hercoglossa,* that all of the forms are relatively small for the groups they represent. *Cucullaea* and *Calytraphorus* are of world-wide distribution and probably have a certain value in the broader correlations (73a, pp. 308–314). *Ostrea pulaskensis* is perhaps the closest check with the Eocene of the Gulf for it is the most characteristic species of the Sucarnoochee clay of Alabama, is equally characteristic of the lower Midway of Mississippi, Tennessee, and Arkansas, and has not been recorded from fossiliferous beds of upper Midway age. The common occurrence of this species in the higher greensands of the Texas Midway is the strongest single bit of evidence against their correlation with the Naheola of Alabama. *Hercoglossa* is a group of world-wide distribution which in Texas is abundant only in the lower

Midway, not at the base, but within the upper third of the Kincaid. It is present but rare in the upper Midway.

The Littig fauna, though sparse, is more cosmopolitan than the later Kincaid faunas. There are relatively few new species and many of the forms, such as the *Crassatellites*, venericards, and *Calyptraphorus*, are widely distributed in the Gulf province. *Ostrea pulaskensis* has an even wider distribution. In the later Kincaid, particularly in the Tehuacana member, the faunas are much more local, indicating apparently a series of embayments in which provincial development was accomplished.

The Pisgah macro-fauna is not so well characterized as either the Littig fauna or that of the Tehuacana. Bottom conditions were possibly less favorable to the majority of species as the sediments were finer and not so hard. Burrowing forms such as *Modiolus* are common locally and the small Ledas and *Amusium* are rather widely distributed.

In the Tehuacana, hard bottom conditions again prevailed and in the clear shallow waters, oysters and other large heavy-shelled bivalves must have been prolific both in species and individuals.

A number of faunules, some of them cut off from one another by barriers of land or unfavorable waters, others possibly reflecting only local bottom conditions, may be discriminated. The faunas of Kaufman and Limestone counties, though showing the same general characters, were probably separated by some manner of barrier at the present Trinity River. The fauna developed along the Colorado River in Bastrop County differs conspicuously from the synchronous Caldwell County fauna, 25 miles to the south. In the Border faunas of Medina, Uvalde, and particularly of Maverick County, the majority of the species are peculiar to the province. This diversity of the molluscan faunas of the Tehuacana member can not be entirely due to unusually variable bottom conditions, for the general ecology was probably rather uniform. The bottom was for the most part sandy from Hopkins County to Maverick County and the waters in which the Tehuacana faunas lived were uniformly shallow, but the widely distributed species are generalized or pelagic types.

The bryozoan *Conopeum danicornis* is one of the few forms specifically identical from both the Limestone County and the

Frio River Tehuacana faunas. In Alabama it has been identified from the Clayton formation, at the base of the Midway.

One of the most striking features of the Kincaid faunas is the explosive appearance of *Venericardia*. Only feebly foreshadowed in the late Cretaceous, the two major groups of probably the dominant genus in the Eocene are represented in the Kincaid by 7 described species and a number of other species too imperfectly represented to describe. Among these, 4 are peculiar to the Tehuacana of the Rio Grande embayment, all of them coarse, heavy-shelled forms suggesting inshore waters. The efflorescence of *Callocardia* is almost equally remarkable but they are a less striking group and more difficult to use; however, each horizon and many of the faunal provinces have their own peculiar *Callocardia* faunas. *Cucullaea macrodonta*, an abundant Naheola species, presents some interesting variations that can be utilized stratigraphically. *Crassatellites* is locally common in the Tehuacana but less widely distributed than in the Pisgah and Littig. The gastropods are relatively less numerous than the pelecypods both in the number of species and of individuals. The prominent groups are those peculiarly characteristic of the Eocene—*Volutocorbis*, *Calyptraphorus*, and *Turritella* of the *mortoni* and *humerosa* groups. Though nothing is known of the habits of *Calyptraphorus*, it is probable that it was unsuited to the coarse sandy bottoms which prevailed during Tehuacana time and for that reason is restricted largely to the finer sands. *Turritella mortoni* is exceedingly abundant at a horizon between the *Ostrea crenulimarginata* and *Venericardia* zones in Limestone County. The turritellas of the *humerosa* group are peculiarly characteristic of the Rio Grande embayment. Naticoids are common and ubiquitous but of little value to the stratigrapher.

The Wills Point macro-fauna reflects the ecologic change from sandy bottoms and probably disturbed waters to softer bottom conditions and more quiet waters. The *Venericardia bulla* zone at the base of the Wills Point formation (base of Mexia member) on the Colorado River in Bastrop County is an anomalous bed packed with a single species similar to *Venericardia wilcoxensis* of the Naheola of Alabama and isolated in some unexplained manner from all its known contemporaries and from those which precede and follow it.

The overlying beds of the Mexia member carry a diversified fauna with no conspicuously abundant species. The comparative absence of the larger coarser bivalves which thrived during the Kincaid is notable. Scaphopods and gastropods are relatively much more common than in the Kincaid, particularly the smaller forms such as *Cadulus*, the turretids and the opisthobranchs. *Volutocorbis limopsis* was described from the Naheola and its distribution in Texas is restricted exclusively to the Wills Point formation. However, a related but coarser species, *Volutocorbis texana*, is widespread through the Kincaid.

The upper beds of the Wills Point are conspicuously barren and in part nonmarine. At the extreme top of the Kerens member, however, at a few localities, notably in Freestone County near Good Hope and in Bastrop County south of Elgin, a meager fauna has been recovered. Because of the presence of *Volutocorbis limopsis*, these beds have been referred to the Midway rather than to the lower Wilcox, which they strongly resemble lithologically.

THE RELATION OF THE MIDWAY FAUNA OF TEXAS TO THE FOREIGN FAUNAS

The widespread orogenic movements which marked the close of the Mesozoic raised most of the present land masses above the level of the sea. Marine deposits at the close of the Cretaceous and the beginning of the Tertiary are rare, localized, and, for the most part, thin. In the Eastern Hemisphere, at the close of the Cretaceous, two faunal provinces were already defined, and continued to exist during most of the Tertiary: (1) a north temperate and boreal province and (2) a warm-water Tethys which included northern India, the Mediterranean region, and northern Africa, and which extended westward in the Cretaceous to Mexico, and in the Eocene apparently to Jamaica.

In the northern province the late Cretaceous deposits, the Senonian and Danian, are chiefly calcareous, with bands of dark flint. The base of the Eocene is very generally marked by a conglomerate of rolled pebbles and fossils from the underlying or nearby chalk. Both the pebbles and the fossils are commonly scarred by the attacks of boring organisms and are stained with glauconite.

TENTATIVE CORRELATION OF MIDWAY FAUNA OF TEXAS AND OTHER REGIONS

	Texas	Denmark	Belgium	England	France	Germany	Russia	Sind	Persia	Egypt	West Africa	Trinidad	Brazil
										Mokattam			
Basal Eocene	Upper Midway (Wills Point)		Upper Landenian	Oldhaven and Blackheath Woolwich and Reading beds	Soissons lignite and plastic clay	Glauconitic and ferruginous sands and marls of Kressenberg	Upper Syzranian	Upper Ranikot	Impure limestones	Upper Libyan?	Fossiliferous limestones of basal Eocene age in the Soudan, northern Nigeria, Senegal, Togo, and Landana, and possibly Angola	Soldado formation (Bed No. 2)	Pernambuco beds
		Kjerteminde clay	Lower Landenian	Thanet sands	Bracheux sands								
	Lower Midway (Kincaid)	Seelandian	Montian		Meudon marl Pisolitic chalk	Well-bores and erratics in north Germany	Lower Syzranian	Lower Ranikot		Lower Libyan?			
Upper Cretaceous		Hiatus	Tuffeau de Ciply	Hiatus	Lithothamnium chalk			Deccan trap					
								Cardita beaumonti beds	Cardita beaumonti beds				
		Danian chalk	Hiatus		Hiatus	Hiatus	Hiatus						
		Hiatus											
		White chalk	Tuffeau de Saint Symphorien	Trimminghan chalk	White chalk	Mucronaten beds	White chalk	Arriaboo					

The basal Eocene deposits, the Paleocene[6] of the European section, in marked contrast to the deposits of the underlying Danian, are chiefly sand and clay. In the Tethys province the lithologic contrast is much less marked, and both the Upper Cretaceous and the basal Eocene are represented by impure limestones. The deposits of recognized Danian age are fewer than those of the basal Eocene, and none of them was deposited during environmental conditions very closely approximating the conditions which prevailed during the deposition of the Midway of Texas. Faunally the only comparable species in the north European Danian and the Midway sections are *Hercoglossa danica* and *Hercoglossa vaughani* and *ulrichi*. They are members of a group of species of very similar aspect, which was widespread at the close of the Cretaceous and the beginning of the Eocene.

The Tethyan fauna of Danian age best known and best comparable with that of the Midway is that from the *Cardita beaumonti* beds of India, described by Douvillé and referred by him to the upper Danian. These and equivalent beds have a considerable area of outcrop not only in the Sind, but also across the border in Baluchistan and Afghanistan and westward into Persia and northern Africa. In India they are overlain by the Deccan trap, and their reference to the Cretaceous is unquestioned. The fauna is of uncommon interest, because it seemingly contains several ancestral types of species and genera of importance and wide distribution in the Tertiary, among them a species similar in general aspect to *Venericardia bulla*. The latest Cretaceous beds in the Gulf Coast area contain none of the conspicuously precursal forms. In the Sind, however, the hiatus between the Cretaceous and the Eocene

[6] Paleocene was introduced by Schimper in 1874 (Paléontologie végétale, vol. 3, p. 680), to include the Heathen sands and the lignitic beds of Soissons. It is now generally accepted by European geologists to include all Tertiary deposits in the London-Paris basin below the London clay and the Cuisien and their time equivalents elsewhere. It is generally distinct lithologically from the later Eocene, and the flora and the fauna, both vertebrate and invertebrate, have their own characters. The lithology records the struggle between the old beaches and the invading sea. The flora indicates on the whole a warm climate, not as dry as that of the later Eocene. The fauna, both the marine and the nonmarine, retains some archaic characteristics which disappear at or before the close of the Paleocene. Many European geologists consider the differences which separate the Paleocene from the later Eocene as significant as those which separate the Eocene from the Oligocene, and give the Paleocene equal rank with the Eocene and the other divisions of the Tertiary. In this country it is in common use by the vertebrate paleontologists to cover the beds between the top of the Cretaceous and those in which the earliest remains of the horse have been found.

is more less marked. There are not only the *Cardita beaumonti* beds, presumably of upper Danian age, but separated from them by an unconformity is a section of Hangu shale, with a maximum thickness of 2300 feet, described by Cox and referred by him to the Paleocene. The faunas of the Midway and the Hangu shale are, however, not closely allied, for the Hangu shale fauna is typically Tethyan, containing *Campanile* and *Gisortia*, and the Midway sea was evidently open both to the *Calyptraphorus* fauna of the south and to the *Cucullaea* fauna of the north, and the facies is not tropical but warm temperate. Furthermore, the Hangu sea and the Midway sea were separated by half the circumference of the earth.

On the evidence of the Mollusca alone it seems that the Tertiary fauna originated in the Indian Ocean and migrated westward. Cox (73c, p. 137) has indicated that this theory is not supported by the distribution of the nummulites. However, the Danian fauna of the Tethyan province contains several ancestral types, descendants of which migrated widely and flourished in the Paleocene of the Tethyan province and in the Midway of the Gulf region of the Western Hemisphere.

The so-called Paleocene deposits of the Eastern Hemisphere are classed, as are the Danian, in two distinct faunal provinces: (1) the Tethyan, extending westward probably to Jamaica, and (2) a northern Euro-Asiatic province. This north temperate or boreal province was less extensive than the Tethyan and included several isolated basins, which, during their short existence, were filled with deposits of rapidly changing character.

The northernmost European early Eocene basin from which a fauna has been recovered and studied is the basin in Denmark. The extent of this early boreal sea is not well known. It certainly invaded Denmark and southern Sweden, possibly northern Germany, and may have been connected for a short period with the Volga Basin. The fauna recovered from the excavations made for the Vestre Gasvaerk in Copenhagen and studied by von Koenen (13c) has served as the check fauna for the boreal province. A thin deposit of glauconitic sand and conglomerate, less than 20 feet thick, containing a fauna similar to that from Copenhagen, was found at a single locality at Klagshamn, Skania (30dd), in south Sweden, but erratics of similar material are common in south Sweden and north

Germany. The fauna of the lower Syzranian (29e) of the Volga Basin has elements in common with that of the Copenhagen fauna and some direct intercommunication has been postulated, though the exact migrational route has not been traced. Inasmuch as it also contains a nautiloid of the *Hercoglossa danica* group, it was first correlated with the Danian. The lithology of the Seelandian is typical of the north European basal Eocene, namely, a coarse, glauconitic sand, ordinarily with a basal conglomerate of rolled Cretaceous fossils and chalk. Though the Seelandian fauna includes *Cucullaea, Admete, Aporrhais, Lunatia,* and *Beloptera,* all northern forms, it includes also several species of *Cancellaria* and two of *Murex,* indicating conditions probably somewhat warmer than conditions of the East Sea of today but colder than the Midway waters. The occurrence of *Cucullaea, Pseudoliva,* and *Propeamussium* in the Copenhagen fauna is also of interest. The Seelandian may, however, have been deposited in a basin with a very small outlet on the west but opening on the east into the East Sea of the early Eocene. The general similarity between the Vestre Gasvaerk fauna and the fauna of the Midway, though not remarkable, is certainly more marked than the similarity between the present south Atlantic and Gulf Coast faunas and the fauna of the East Sea.

The Montian fauna of Belgium, known only from wells, is believed to be the approximate equivalent in time of the Seelandian, possibly a little older. It was deposited in another basin of sedimentation probably separated by a barrier from the fauna of Copenhagen and occupied the valley of the Haine, a narrow gulf opening near the French border and extending eastward to the vicinity of Mons. East of Mons the deposits are continental, and the Montian fauna itself is less marine than the fauna of Copenhagen or the succeeding Ypresian. It is rich in the smaller gastropods, in brackish water forms such as *Hydrobia,* in the trochoids and limpets, but in spite of the warmer water facies it has less in common with the Midway fauna than does the fauna of Copenhagen. The pelecypods, however, *Crassatellites* of the *Scambula* type, a *Venericardia* of the *planicosta* group, some of the plentiful and diversified lucinoids, and the venerids, sugest the Midway; and *Corbis* may be cited as evidence that the middle Eocene molluscan fauna of the Paris basin was chiefly derived from the Montian. The most definite connections are

Venericardia, *Volutocorbis elevata* Sowerby, a species of the *Volutocorbis texana* group, and *Calyptraphorus*, a widespread and characteristic Eocene genus, presumably excluded from the Copenhagen basin by the low temperature of the water.

A fauna which has much in common with the Montian has been determined from the Garumian of southwest France. It is probable that in early Eocene time the Aquitanian basin and the Pyrenean formed a gulf opening westward. The deposits in the western part of the basin are truly marine; those of the east are nonmarine. Almost no record of the molluscan life of the Mediterranean region has been discovered, though some of the limestones are rich in foraminifera.

No deposits so old as the Montian have been observed in England. The Anglo-Franco-Belgian basin in which the Eocene was laid down included all of south England and Belgium and northwestern France. The Landenian, the earliest Eocene of the London basin, includes glauconitic sands unconformably overlying the chalk. The upper Landenian is characterized by a silting-up of the shallow seas, and on the Isle of Thanet is the only locality in which the entire Landenian is marine. The fauna of the Thanet sands is boreal and, in contrast to the Montian fauna and that from Copenhagen, it includes the larger bivalves in conspicuous number. The predominance of the bivalves over the univalves is cited by Morley Davies (73a, p. 313) as a characteristic of the boreal and temperate faunas from Cretaceous time to the Recent. The differences which distinguish the Thanetian fauna from the Midway are due not only to latitude but also to time. Though the base of the Thanetian is marked by rolled flints stained with glauconite from the chalk beneath, the hiatus is greater than in the Danish and Belgian Cretaceous-Eocene contacts, for in Belgium the Thanetian has been found overlying the Montian.

At some time during the early Eocene, probably the Thanetian, the boreal sea transgressed as far as Kressenberg in Bavaria, leaving a deposit of coarse, fossiliferous, and very glauconitic sand. This fauna contains a nautiloid closely allied to *Hercoglossa danica*. The outcrop is of great interest, inasmuch as in the lowest beds only the boreal fauna occurs, but higher in the section the gradual invasion of the Tethyan fauna can be traced in the increasingly common occurrence of *Gisortia gigantia*, a typical Tethyan species

and genus. *Gisortia* is, however, not represented in the cooler Midway sea, and the later Kressenberg fauna furnishes no direct information about the fauna of the Midway.

The Tethyan fauna lived in the seas of the Indian, north African, and south European provinces, and probably extended as far west as Jamaica. In consideration of the thickness of the formation and of the fauna contained, the most significant outcrop is that of the Hangu shale of the western Sind in north India. The basal Eocene which L. R. Cox of the British Museum has so adequately treated in the "Palaeontologia Indica" far exceeds in thickness any yet observed, and the fauna of his monograph is the most significant yet described.

At no locality in the boreal province does the combined Danian-basal Eocene section greatly exceed 600 feet, and though the two series are in every observed occurrence separated by an unconformity, the significance of the break has been questioned. In India, on the contrary, a maximum thickness of 2300 feet of beds, referred by Cox to the Paleocene, has been determined. These beds unconformably overlie 90 feet of Deccan trap, which in turn covers 300–400 feet of *Cardita beaumonti* beds of upper Danian age. Most of the fossils, however, are from a very thin layer of shale 2 to 15 feet thick, approximately 500 feet above the trap. Although exact correlation of the Hangu shale with the faunas of the boreal province is not possible, Cox believes that the fauna is of Landenian, or possibly Montian, age.

In Persia, Arabia, and northern Africa the basal Eocene is represented chiefly by impure limestones, many of them foraminiferal. Tethyan Mollusca of early Eocene age have, however, been recovered in Persia and Arabia. The age of the Libyan series of Egypt has not yet been established. The foraminiferal and the molluscan evidence do not seem to be in accord, but a part, at least, of the basal Eocene is probably included in the Libyan. The Landana and Senegalese limestones are foraminiferal and contain a good echinoid fauna. They evidently represent much of the basal Eocene, but the Mollusca are not well known.

A fauna from the Belgian Congo which has much in common with the fauna of the Midway of Texas has been described. Among the allied forms are a small *Calyptraphorus*, *Clinuropsis diderrichi*, which suggests *Levifusus trabeatus*, and which is compared

by Vincent with *Pleurotoma ampla* from the Montian and *Fusus mörchi* from Copenhagen, *Venericardia landanensis*, of the group of *Cardita beaumonti*, *Nautilus landanensis*, and *Hercoglossa didericki*, of the *Hercoglossa danica* group.

A relation between the possibly later Eocene fauna of Togo (35a) and that of the Midway of south Texas is indicated by the Togo species, *Turritella adabienensis*, *Volulithes cumeri*, which differs from *Volutocorbis limopsis* chiefly in the more slender outline and the closer spacing of the stronger spirals, *Calytraphorus* and small Carditas of the general type of *C. beaumonti*, but less inflated. A *Hercoglossa* of the *danica* group, occurring in the basal Eocene both in Landana and the Sokoto beds of Nigeria, earlier caused confusion in correlation. However, in spite of the lithologic similarity of the late Cretaceous and early Eocene limestones, in north Africa, wherever detailed work has been done, a hiatus between the Cretaceous and the Eocene has been established.

The extension of the Tethyan sea westward to Jamaica during Lutetian time is postulated chiefly because of the reported occurrence of *Velates schmideliana* Chemnitz, which in the Paris basin characterizes the Sables de Cuises, and at Kressenberg and in South Madagascar characterizes the Lutetian horizon. Other significant genera include *Campanile*, *Clavilithes*, two species of *Gisortia*, *Carolia*, and *Corbis*. The middle and South American earliest Eocene faunas, however, are more closely allied to those of the North American Gulf faunas than to the north African. The fauna of the Soldado formation of Trinidad, which includes *Ostrea pulaskensis*, *Ostrea crenulimarginata*, *Cucullaea harttii*, *Calyptraphorus compressus*, and *Turritella nerinexa*, is definitely not only of Midway but of lower Midway age. *Mesalia pumila nettoana* is a link not only with the Midway of Alabama and Texas but also with the Pernambuco beds of Brazil, from which it was first described, and through *Mesalia fasciata*, a similar species ubiquitous in the Tethyan province, possibly with the basal Eocene of northern Africa and India.

The Pernambuco beds of Brazil contain a more pronounced Tethyan element than the Soldado. They are notable as the southernmost limit of *Cucullaea*, which is commonly associated with the boreal province. The genus is unknown in the Afrieo-Asiatic province and is not found in Europe south of Kressenberg. The

Harpa dechordata of White is a *Pseudoliva; Fusus (Serrifusus) mariae* is a *Levifusus* of the *trabeatus* group; and *Calyptraphorus? chelonitis* is closely related to *C. compressus*. *"Nerinaea" inaugurata, sagittaria* and *buarquiana* are *Campanile*, one of the most characteristic genera of the Tethyan province. The Turritellas indicate a relation with the Gulf Coast faunas, and the Mesalias are widespread in the Tethyan province. There is no evidence of any Pacific element in either the middle or the South American basal Eocene faunas.

The Midway fauna of Texas is unmistakably a part of the homogeneous biota which lived on the warm and warm temperate shores of the Gulf of Mexico and as far south as Brazil, and is less definitely a part of the more heterogeneous biota orginating in the inshore waters of the old Tethyan sea.

The existence of marine deposits of Danian age in either of the Americas has not been established.

SYSTEMATIC PALEONTOLOGY

FOSSIL LOCALITIES

583. 18 miles southeast of Eagle Pass, Maverick County, C. A. White, collector. Kincaid formation.

2061. Neakenny Hills, Limestone County, F. L. Yoakum, collector. Kincaid formation.

2439. 1 mile east of Webberville, Travis County, T. W. Stanton, collector. Kincaid formation.

2440. 4 miles northeast of Kemp, Kaufman County, T. W. Stanton, collector. Kincaid formation.

3178. Three-fourths mile northwest of Bob Evans' (Myrick's) apiary, north of Frio River, Uvalde quadrangle, Uvalde County, T. W. Vaughan, collector. Kincaid formation.

3179. Bluff on Frio River, one-half mile northwest of Bob Evans' (Myrick's) apiary, Uvalde County, T. W. Vaughan, collector. Kincaid formation.

3180. Bluff on Frio River, one-half mile below Bob Evans' (Myrick's) apiary, Uvalde County, T. W. Vaughan, collector. Kincaid formation.

3181. Frio River, just above waterhole opposite apiary, below Englemann's ranch, Uvalde County, T. W. Vaughan, collector. Kincaid formation.

3184. About 1 mile above Bob Evans' (Myrick's) apiary on Frio River, Uvalde County, T. W. Vaughan, collector. Kincaid formation.

3185. Just above Bob Evans' (Myrick's) lower apiary, west side of Frio River, Uvalde County, T. W. Vaughan, collector. Kincaid formation.

3186. About 4 mile above Webb-Maverick County line inside of Indio ranch pasture, Maverick County, T. W. Vaughan, collector. Kincaid formation?

3187. East side of the Rio Grande about 3½ miles above the mouth of San Ambrosia Creek, Maverick County, T. W. Vaughan, collector. Kincaid formation.

3309. East of first small creek going from old Garfield to Bastrop, Austin quadrangle, Bastrop County. Type locality of *Venericardia bulla* Ball. T. W. Vaughan, collector. Wills Point formation.

4398. 18 miles south and east of Eagle Pass, Maverick County. J. A. Udden, collector. Kincaid formation.

4795. 3½ miles north of the mouth of Pond Creek on the Brazos River, Milam County. Alexander Deussen, collector. Kincaid formation.

5280. Fossiliferous shale on right bank of Colorado River, 4 miles below Webberville, Bastrop County. Alexander Deussen, collector. Kincaid formation.

5281. Colorado River, 5 miles below Webberville, Bastrop County. Alexander Deussen, collector. Wills Point formation.

5282. Clay from bluff at Webberville, Travis County. Alexander Deussen, collector. Kincaid formation.

6100. From a depth of 2145 feet in well at Sulphur Springs, Hopkins County. Alexander Deussen, collector. Formation?

6136. Dump from well in bottom of Salado Creek, 2 miles north of Dullings well, Bexar County. Alexander Deussen, collector. Wills Point formation.

6153. Jett Crossing, Palo Alto road and Medina River, 3 miles below Garza Crossing, Bexar County. Alexander Deussen, collector. Wills Point formation.

6225. About 2 miles below Merkel, midway between Merkel and New Berlin on Cibolo Creek, Bexar County. Alexander Deussen, collector. Wills Point formation.

6226. Fossils from shale at Merkel on Cibolo Creek, Bexar County. Alexander Deussen, collector. Wills Point formation?

6277. North-facing slope of the San Marcos River valley, 1½ miles west of Fentress, Guadalupe County. L. W. Stephenson, collector. Wills Point formation?

6278. 11 miles south of Sabinal, a few hundred yards south of the junction of Elm Creek with Sabinal Creek. North-facing slope, base of layer No. 5 of section. Uvalde County. L. W. Stephenson, collector.

6279. Same locality as 6278. Layer No. 4 of section. Uvalde County. L. W. Stephenson, collector. Kincaid formation.

6280. Hondo Creek. Loose boulder in bed of creek, one-eighth mile below the road crossing due east of Elstone, Medina County. The boulder came from a ledge of Eocene rock in place one-fourth mile above the same crossing. L. W. Stephenson. Kincaid formation.

6281. Hondo Creek. Left bank of creek, one-fourth mile above the road crossing due east of Elstone, Medina County. L. W. Stephenson, collector. Kincaid formation.

6282. Guadalupe River at a ferry 3 miles west of Seguin, Guadalupe County. L. W. Stephenson, collector. Wills Point formation.

6283. Guadalupe River just below small falls, about 2½ miles by the river above the power house south of Seguin, and about 2 miles below the ferry which is 3 miles west of Seguin, Guadalupe County. L. W. Stephenson, collector. Wills Point formation.

6558. Limestone forming scarp on the T. H. Plunkett place, 7 miles northwest of Wortham, Navarro County. Alexander Deussen, collector. Kincaid formation.

6559. Comanche Crossing on Navasota Creek about 6 miles west of Mexia, Limestone County. Alexander Deussen, collector. Kincaid formation.

6560. Near Horn Hill, Limestone County. Alexander Deussen, collector. Kincaid formation.

6561. On the face of scarp about one-fourth mile west of Tehuacana College at Tehuacana, Limestone County. Alexander Deussen, collector. Kincaid formation.

6561. About three-fourths mile north of Bob Evans' (Myrick's) lower apiary on Frio River. About 300 yards above so-called Cretaceous-Eocene

contact, Uvalde County. Alexander Deussen, collector. Kincaid formation.

6575. White Bluff, 4½ miles west of south of Windmill (Jacal) ranch house, on Rio Grande. From Eocene limestone layer No. 3 of section. Land of Indio Cattle Company in southeast part of Maverick County. L. W. Stephenson, collector. Kincaid formation.

6576. Rio Grande. From Eocene glauconitic sand at water's edge. Land of Indio Cattle Company, 1⅝ miles below White Bluff, which is about 4½ miles west of south of Windmill (Jacal) ranch house, Maverick County. L. W. Stephenson, collector. Kincaid formation.

6577. Rio Grande. From about 35 feet below top of Eocene gray marine sand. Land of Indio Cattle Company about 2 miles below White Bluff, which is about 4½ miles west of south of Windmill (Jacal) ranch house, Maverick County. L. W. Stephenson, collector. Kincaid formation.

6578. Road leading a little west of north from Windmill (Jacal) ranch house. Land of Indio Cattle Company, about 11 miles from the ranch house, Maverick County. L. W. Stephenson, collector.

6583. Bibora Creek, just below Bibora tank about 13 miles southeast of Eagle Pass. From ledges of Eocene sandstone and limestone in valley slopes below dam, Maverick County. L. W. Stephenson, collector. Kincaid formation.

6584. From basal Eocene limestone on Yancey road, about 7½ miles east of south of D'Hanis, Medina County. L. W. Stephenson, collector. Kincaid formation.

8245. Well, left bank Salado Creek, 5.3 miles southeast of San Antonio, Bexar County. L. W. Stephenson, collector. Wills Point formation.

8246. Salado Creek, 1 mile east of San Antonio, Bexar County. L. W. Stephenson, collector. Wills Point formation.

8656. Smith well, Somerset field, Bexar County, 721 feet to 917 feet. Wills Point formation.

8792. Texas side of Rio Grande, 1 mile below Cerrito Prieto ranch house on Mexican side, Maverick County. A. C. Trowbridge and A. G. Maddren, collectors. Kincaid formation.

8797. Texas side of Rio Grande, 1 mile below Cerrito Prieto ranch house on Mexican side, Maverick County. A. C. Trowbridge and A. G. Maddren, collectors. Kincaid formation.

9172. Long new cut of Missouri, Kansas & Texas Railway in the southeastern part of San Antonio, Bexar County. Basal part of section. L. W. Stephenson, collector. Wills Point formation.

10128. Bed of Verde Creek, 4½ miles (air line) northeast of Hondo, 1¾ miles northwest of New Fountain, Medina County. L. W. Stephenson, collector. Kincaid formation.

10264. Some 14 miles southeast of Greenville on the Lone Oak pike, about 50 yards from the pike on the east side of Coulcech Fork just as the road is climbing the hill on the northeast side of the pike. It is easily distinguished at a distance as a small naked white area, Hunt County. Mr. and Mrs. D. A. Saunders, collectors. Kincaid formation.

10277. Rio Grande, about 40 ft. below the Midway-Wilcox contact, Maverick County. L. W. Stephenson, collector. Kincaid formation.

10420. Lower bed on Dry Brushy Creek, 6 miles south of Thrall on Taylor-Bradkiss road, Williamson County. Julia Gardner, collector. Wills Point formation.

10519. Mouth of Brushy Creek at San Gabriel River, Milam County. Julia Gardner, collector. Wills Point formation.

10522. Boulder in place directly below foot bridge, branch of Wilbarger Creek on Mr. Lawrence Solomon's farm, 6 miles southwest of Elgin, Bastrop County. Julia Gardner, collector. Wills Point formation.

10523. 150 yards above mouth of branch of Wilbarger Creek, on Mr. Lawrence Solomon's farm, 6 miles southwest of Elgin, Bastrop County. Julia Gardner, collector. Wills Point formation.

10526. Colorado River, one-half mile above the mouth of Dry Creek; 3½ to 4 miles downstream from Webberville, Bastrop County. Julia Gardner, collector. Kincaid formation.

10527. Colorado River, one-fourth mile above the mouth of Dry Creek, 1¼ to 4½ miles downstream from Webberville, above *Venericardia bulla* zone, Bastrop County. Julia Gardner, collector. Wills Point formation.

10718. Butler Dome, one-fourth mile northwest of Gin Lake, 2½ miles east of Butler, Freestone County. Julia Gardner, collector. Wills Point formation?

10744. Northeast corner of the J. W. Boyce 120 acres in the W. F. Butler Survey, about 2½ miles northeast of Kemp on public road. Just above indurated glauconitic sand, Kaufman County. L. W. Stephenson and C. E. Cook, collectors. Kincaid formation.

10786. 3± miles above bridge over Cedar Creek on Austin-Red Rock road, Bastrop County. Julia Gardner and Paul Seashore, collectors. Kincaid formation.

10790. Main road in center of J. A. F. McCasland Survey, W. H. Ellingston 158-acre tract, 2 miles northeast of Quinlan, Hunt County. L. W. Stephenson and C. E. Cook, collectors. Kincaid formation.

10791. 15 to 20 feet higher in section than 10790. Main road in center of J. A. F. McCasland Survey, W. H. Ellingston 158-acre tract, 2 miles northeast of Quinlan, Hunt County. L. W. Stephenson and C. E. Cook, collectors. Kincaid formation.

10792. Wilbarger Creek, one-half mile downstream from Travis-Bastrop County line; one-eighth mile west of bridge on road west to county line, Bastrop County. Julia Gardner, collector. Kincaid formation.

10793. Northwest bank of Plum Creek, 1.9 miles north of Lockhart on road to Austin, Caldwell County. Julia Gardner and E. H. Sellards, collectors. Wills Point formation.

10794. 4.6 miles west and a little north of Lockhart in gully at jog in secondary road, Caldwell County. Julia Gardner and E. H. Sellards, collectors. Wills Point formation.

10796. Upper bed on Dry Brushy Creek, 6 miles south of Thrall, on Taylor-Beaukiss road, Williamson County. Julia Gardner, collector. Wills Point formation.

10797. Foraminifera-bearing Midway on the west or downthrow side of fault, 2 miles northwest of Lone Oak, Hunt County. L. W. Stephenson and C. E. Cook, collectors. Kincaid formation.

10799. Butler salt dome, 1200 feet northwest of Lakeport store, Freestone County. L. W. Stephenson, collector. Wills Point formation?

10800. Butler salt dome, 1500 or 1600 feet southeast of Lakeport store, Freestone County. L. W. Stephenson, collector. Wills Point formation?

10801. Brazos River, just above the Falls County line, Falls County. H. J. Weeks, collector. Kincaid formation.

10815. 2 miles north of Mabones, roadside cut, Hopkins County. Julia Gardner, collector. Wills Point formation.

10816. From right bank of a small tributary of Tehuacana Creek, a mile southwest of the Houston & Texas Central Railroad crossing and 3½ to 4 miles south of Wortham; 160 to 170 feet above base of Midway, Limestone County. L. W. Stephenson and C. E. Cook, collectors. Wills Point formation.

10849. Butler Dome, one-fourth mile northwest of Gin Lake; 2½ miles east of Butler, Freestone County. Sidney Powers, collector. Wills Point formation?

11665. Water Hill, 5 miles northeast of Kemp, Kaufman County. Julia Gardner, collector. Kincaid formation.
11674. 1 mile east of Coupland and 1¼ miles south in roadside cut at jog in road, Williamson County. Julia Gardner, collector. Kincaid formation.
11675. 1 mile north of Littig (air line), Travis County. Julia Gardner, collector. Kincaid formation.
11676. Ford over Wilbarger Creek on F. Goerick's farm, 1½ miles southwest of Littig. E. H. Sellards, Paul Seashore, and Julia Gardner, collectors. Kincaid formation.
11678. One-half to three-fourths mile above Cedar Creek road on Half Mile Creek. Austin quadrangle, Bastrop County. Julia Gardner, collector. Kincaid formation.
11679. Indurated ledge above reworked greensands, half a mile east of Elysium on Bastrop-Austin road, Bastrop County. Julia Gardner, collector. Kincaid formation.
11680. One-half mile east of Elysium on Bastrop-Austin road. Julia Gardner, collector. Kincaid formation.
11681. 1½ to 2 miles south of Mendoza, Caldwell County. Julia Gardner, collector. Kincaid formation.
11682. 6 miles north of Lockhart in draw one-half mile west of Austin-Lockhart road, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11683. About 4 miles south of Lytton Springs, to east of Lockhart-Lytton Springs highway, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11684. About 4 miles north and a little west of Lockhart, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11685. 2 miles (air line) north of Lockhart on G. W. Cardwell farm, W. C. Williams Survey, Caldwell County. C. E. Cook and Julia Gardner, collectors. Upper 2 feet of basal greensand, Kincaid formation.
11686. 2 miles (air line) north of Lockhart on G. W. Cardwell farm, W. C. Williams Survey, Caldwell County. C. E. Cook and Julia Gardner, collectors. Lower 2 feet of basal greensand. Kincaid formation.
11687. Chalk layer above the greensand, 2 miles (air line) north of Lockhart on G. W. Cardwell farm, W. C. Williams Survey, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11688. Same locality as 11687. Gray and blue sand overlying the chalk.
11689. 4 miles southwest of Lockhart on the Martindale farm, Caldwell County. Julia Gardner, collector. Kincaid formation.
11690. 5 miles northwest of Lytton Springs, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11691. 5 miles northeast of Staples, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11692. 3 miles northeast of Staples, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11693. 1 mile northeast of Staples, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11694. 1 mile northeast of Staples, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11695. 1 mile north of Staples, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.
11696. Colorado River, 1½ miles below the Travis-Bastrop County line. Bastrop County. Julia Gardner, collector. Kincaid formation.
11697. Gully 1 mile south of Cedar Creek and south of Cedar Creek-Lytton Springs road, 3 miles southwest of Cedar Creek Post Office, Bastrop County. Robin Willis and Julia Gardner, collectors. Wills Point formation.

11698. Deep gully south of Cedar Creek-Lytton Springs road, 1 mile south of Cedar Creek, 3 miles southwest of Cedar Creek Post Office, Bastrop County. Julia Gardner and Robin Willis, collectors. Wills Point formation.

11699. William Mercer well, 2 miles southwest of Joliet; 0 10 ft.; 8 miles (air line) due south of Lockhart, Caldwell County. Collector unknown. Wills Point formation.

11700. 1.9 miles north of Lockhart on the Austin road, Caldwell County. E. H. Sellards and Julia Gardner, collectors. Wills Point formation.

11702. 1½ miles southwest of Fentress in small break of Guadalupe River, Guadalupe County. Julia Gardner, collector. Kincaid formation.

11703. 1 mile west and a little south of Fentress, Guadalupe County. Julia Gardner and C. E. Cook, collectors. Wills Point formation?

11704. 3 miles (air line) north of Lytton Springs, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.

11705. 2 to 2½ miles north and a little west of Lockhart, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.

11706. 5½ miles southwest of Lockhart on the Martindale farm, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.

11707. 5½ miles due north of Lockhart on the E. A. Moser farm, Isaac Jackson Survey, about one-half mile northwest of Simms Oil Company derrick, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.

11708. 4 miles north-northeast of Staples, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.

11752. Comanche Creek Crossing on west road to Farias ranch, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11753. Bibora tank, 7 miles (air line) east of new Indio ranch house, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11754. 6 miles below the McFarland sheep pens and 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road. Surface shingle of "Red Beds." Maverick County. Julia Gardner and E. M. Hawtof, collectors. Wills Point formation.

11755. 3 miles north of Media tank. Indio ranch. Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11756. Media tank, 26 miles southeast of Eagle Pass on Windmill (Jacal) ranch road, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11757. Hillside above a small tank 2 miles west of Lorez tank, about 29 miles southeast of Eagle Pass, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11758. Limestone scarp near the Indio Wells, about 29 miles southeast of Eagle Pass, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11759. West side of Indio Wells scarp about 29 miles southeast of Eagle Pass, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11760. Tobar Arroyo about 2¼ miles southwest of Tobar tank and about 35 miles southeast of Eagle Pass. Directly above the second greensand. Maverick County. Julia Gardner and E. M. Hawtof, collectors. Wills Point formation.

11761. Tobar Arroyo, Maverick County. Same as 11760. Julia Gardner, James Gould, and Karl Young, collectors. Wills Point formation.

11762. Tobar Arroyo about 3½ miles southwest of Tobar tank and about 36 miles southeast of Eagle Pass, Maverick County. Julia Gardner, E. M. Hawtof, James Gould, and Karl Young, collectors. Kincaid formation.

11763. 3½ to 4 miles southwest of Windmill (Jacal) ranch house on Las Islas Crossing road, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11764. Three-fourths mile upstream from crossing of small branch, 4½ miles southwest of Windmill (Jacal) ranch on Las Islas Crossing road, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11765. Schuddemagen ranch, south bank of Elm Creek, 11 miles south of Sabinal, Uvalde County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11766. South bank of Elm Creek, about one-fourth mile east of ford on Schuddemagen ranch, Uvalde County. Julia Gardner and E. M. Hawtof, collectors.

11767. Ledge a foot or more above the Frio River bed just above trail leading down from Bob Evans' (Myrick's) apiary, Uvalde County. Julia Gardner, collector. Kincaid formation.

11768. Bed of Frio River, about 4 miles above Kincaid ranch, Uvalde County. Julia Gardner, collector. Kincaid formation.

11769. 5.7 miles northwest of Castroville on the Quihi road, Medina County. Julia Gardner, collector. Kincaid formation.

11770. Bed of Hondo River, 1 mile northwest of New Fountain, Medina County. Julia Gardner, collector. Kincaid formation.

11771. 5 miles southeast of Elstone, on the Pearsall road, Medina County. E. H. Sellards and Julia Gardner, collectors. Kincaid formation.

11772. 3 miles north of Squirrel Creek School House and about 7½ miles south of D'Hanis, Medina County. Julia Gardner, collector. Kincaid formation.

11867. Tobar Arroyo, about 2½ miles southwest of Tobar tank and about 35 miles southeast of Eagle Pass, one-half mile below "Red Beds" outcrop, Maverick County. Julia Gardner, James Stearns, and Karl Young, collectors. Wills Point formation.

11869. Tobar Arroyo, about 3½ miles southwest of Tobar tank, Indio ranch, and about 35 miles southeast of Eagle Pass; Tehuacana member, one-eighth of a mile below the greensand, Maverick County. Julia Gardner, James Stearns, and Karl Young, collectors. Kincaid formation.

11871. Railroad cut 5.2 miles southeast of Dunlay on Nooman road, Medina County. Julia Gardner and E. H. Sellards, collectors. Kincaid formation.

11872. 6.6 miles south of Dunlay just south of the Nooman road. Soft glauconitic marls from the side of a 75-100-foot scarp. Julia Gardner, collector. Kincaid formation.

11873. 4 miles northwest of the Burke ranch house and 3.3 miles southeast of Chilipitin tank, Maverick County. Julia Gardner and E. M. Hawtof, collectors. Wills Point formation?

11874. Frio River, just above Bob Evans' (Myrick's) apiary, Uvalde County. Julia Gardner, collector. Kincaid formation.

11876. South-facing slope on the Saathoff place, 1 mile east of the church at Quihi, Medina County. L. W. Stephenson, collector. Kincaid formation.

11877. One-fourth to one-half mile above Bob Evans' (Myrick's) apiary, south bank of Frio River, Uvalde County. Julia Gardner, collector. Kincaid formation.

11878. Frio River at foot of trail leading down from Bob Evans' (Myrick's) apiary, Uvalde County. Julia Gardner, collector. Kincaid formation.

11883. 9.5 miles northeast of Seguin, Guadalupe County. Julia Gardner, collector. Kincaid formation.

11884. Town Branch, Dale road, Lockhart, Caldwell County. Julia Gardner and Tom Banks, collectors. Wills Point formation.

11890. Colorado River, 1½ to 2 miles below Travis-Bastrop County line, Bastrop County. Wills Point formation.

11891. 2 miles east of Mendoza, Caldwell County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.

11892. West slope of Plum Creek on Austin-Lockhart road about 2 miles northwest of Lockhart, Caldwell County. C. E. Cook and Julia Gardner, collectors. Wills Point formation.

11893. 1½ miles south of bridge over Cedar Creek on Austin-Red Rock road, Bastrop County. Julia Gardner and Robin Willis, collectors. Wills Point formation.

11894. 1¾ miles southeast of bridge over Cedar Creek on Austin-Red Rock road, Bastrop County. Julia Gardner and Robin Willis, collectors. Wills Point formation.

11895. Hillside above branch, 2 miles southwest of Cedar Creek Post Office (ferruginous concretions), Bastrop County. Julia Gardner and Robin Willis, collectors. Wills Point formation.

11896. About 2½ miles southwest of Cedar Creek Post Office. Gully a little less than one-half mile south of the Lytton Springs-Cedar Creek road and about 1 mile south of Cedar Creek, Bastrop County. Julia Gardner and Robin Willis, collectors. Wills Point formation.

11897. Elm Creek, 2½ miles west of Elgin, east bank of East Fork, in stream bed, a little more than one-half mile back from road, Bastrop County. Julia Gardner, collector. Kincaid formation.

11898. One-fourth mile east of Lytton Springs-Cedar Creek road at Cedar Creek Crossing, Bastrop County. Julia Gardner and Robin Willis, collectors. Wills Point formation.

11899. 50 to 60 feet west of bridge over Cedar Creek on Austin-Red Rock road, Bastrop County. Hugh Duval, collector. Wills Point formation?

11900. Williams' store. Sandy fossiliferous shales exposed in tank to the west of the store, Bastrop County. Julia Gardner and Robin Willis, collectors. Kincaid formation.

11901. North branch, Wilbarger Creek, at first road crossing east of Travis-Bastrop County line, Bastrop County. Julia Gardner and Grady Kirby, collectors. Wills Point formation.

11902. Wilbarger Creek, one-half mile below Travis-Bastrop County line, Bastrop County. Julia Gardner and Grady Kirby, collectors. Wills Point formation.

11903. Dry Brushy Creek on Harvey Hanson farm about 5 miles southeast of Coupland (below and in bentonite bed), Williamson County. Julia Gardner and C. E. Cook, collectors. Kincaid formation.

11904. Indurated ledge below the second greensand on Brazos River, 1 mile below the Falls County line, Milam County. Julia Gardner, collector. Kincaid formation.

11905. Brazos River (bed No. 5: 4 ft. calcareous marl carrying fossiliferous calcareous boulders and, near the top, some glauconite), 1 mile below the Falls County line, Milam County. Julia Gardner, collector. Kincaid formation.

11906. Brazos River (second greensand), 1 mile below Falls County line, Milam County. Julia Gardner, collector. Kincaid formation.

11908. Cedar Creek, one-half mile northeast of crossing on Austin-Red Rock road, small branch below tank on Cedar Creek-Lytton Springs road, Bastrop County. Julia Gardner and Robin Willis, collectors. Wills Point formation.

11909. Cedar Creek, 3¾ miles (air line) southeast of Williams' store. Upper indurated ledge, Bastrop County. Julia Gardner and Hugh Duval, collectors. Kincaid formation.

11910. Cedar Creek, 3± miles (air line) southeast of Williams' store. Loose sandy marl beneath the indurated greensand ledge of 11909. Julia Gardner and Hugh Duval, collectors. Kincaid formation.

11911. One-half mile east of Williams' store, Austin quadrangle, roadside gully, Bastrop County. Julia Gardner and Hugh Duval, collectors. Kincaid formation.

11912. Dry Creek, 7½± miles (air line) southwest of Elgin. Middle bed in bluff about one-half mile above first bridge east of the county line. Bastrop County. Julia Gardner, collector. Wills Point formation.

11913. Colorado River, 2 miles below the Travis-Bastrop County line (above the *Venericardia bulla* bed), Bastrop County. Wills Point formation.

11914. Colorado River section, 1½ miles below Travis-Bastrop County line, Bastrop County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11915. Colorado River, 1½ miles below the Travis-Bastrop County line (bed No. 7), Bastrop County. Julia Gardner and E. M. Hawtof, collectors. Kincaid formation.

11916. Brazos River (bed No. 1), 1 mile below Falls County line, Milam County. Julia Gardner, collector. Kincaid formation.

11917. Brazos River, 1 mile below the Falls County line (bed No. 2), Milam County. Julia Gardner, collector. Kincaid formation.

11918. Brazos River (bed No. 3), 1 mile below the Falls County line, Milam County. Julia Gardner, collector. Kincaid formation.

11919. Brazos River, 1 mile below the Falls County line (bed No. 4), Milam County. Julia Gardner, collector. Kincaid formation.

11920. Brazos River, one-eighth mile below Milam Bluff (bed No. 5, Volcanic ash?), Milam County. Julia Gardner, collector. Kincaid formation.

11921. Brazos River, 1 mile below the Falls County line, Milam County. Julia Gardner, collector. Kincaid formation.

11922. One-eighth to one-fourth mile below Milam Bluff (uppermost part of bed No. 6), Brazos River, Milam County. Julia Gardner, collector. Kincaid formation.

11923. Brazos River, 1 mile below Falls County (uppermost part of bed No. 6), Milam County. Julia Gardner, collector. Kincaid formation.

11924. Brazos River, 1 mile below Falls County line (directly below the second greensand), Milam County. Julia Gardner, collector. Kincaid formation.

11925. Black Bluff, Brazos River (bed No. 3), 1½ miles above the Milam-Falls County line, Falls County. Julia Gardner, collector. Kincaid formation.

11926. Milam Bluff, Brazos River, 0 to one-fourth mile below the Falls County line (bed No. 4), Milam County. Julia Gardner, collector. Kincaid formation.

11929. Little Brazos (fossiliferous boulders), a little less than one-fourth mile upstream from Rocky Crossing on Kosse road. Julia Gardner, collector. Kincaid formation.

11931. Whitaker Survey, about 6 miles northwest of Kosse (Kosse roadside outcrop), Falls County. Julia Gardner, collector. Kincaid formation.

11932. One-fourth mile northwest of Stranger School. Shales below the Tehuacana member, in roadside gully, Falls County. Julia Gardner, collector. Kincaid formation.

11933. Tehuacana Quarry on Mexia road, Tehuacana, Limestone County. Julia Gardner, collector. Kincaid formation.

11934. Three-fourths of a mile west of Tehuacana on the Waco road. Shales below the Tehuacana, about 15 to 20 feet above the contact, Limestone County. Julia Gardner, collector. Kincaid formation.

11935. 7½ miles northwest of Groesbeck on the Thelma road, Limestone County. Julia Gardner, collector. Kincaid formation.

11936. 2½ miles northwest of Groesbeck, Limestone County. Julia Gardner, collector. Kincaid formation.
11937. Rocky Crossing, Little Brazos, just below bridge on Kosse road, Falls County. Julia Gardner, collector. Kincaid formation.
11938. 7 miles northwest of Kosse; roadside outcrop of highly fossiliferous limestone, Limestone County. Julia Gardner and E. H. Sellards, collectors. Kincaid formation.
11939. 5 miles southwest of Thornton; limestone boulders in small branch crossing road on Lillian Dustin farm, Limestone County. Julia Gardner, collector. Kincaid formation.
11940. Stranger School, 7½ miles northwest of Kosse. Julia Gardner and E. H. Sellards, collectors. Kincaid formation.
11941. One-fourth mile northwest of Stranger School. Shales below the Tehuacana member and 50 ft. to 75 ft. below 11922, Falls County. Julia Gardner, collector. Kincaid formation.
11942. One-fourth mile south of Big Hill. Roadside ditch exposing fossiliferous shales, Limestone County. Julia Gardner, collector. Kincaid formation.
11943. 2 miles southeast of Big Hill. Micaceous shales with vermilion concretions, Limestone County. Julia Gardner, collector. Wills Point formation.
11944. 7 miles northwest of Thornton; shales; Limestone County. Julia Gardner and E. H. Sellards, collectors. Wills Point formation.
11948. Tehuacana horizon, Mexia, Limestone County. E. T. Dumble, collector. Kincaid formation.
12108. Directly above bridge over Cedar Creek on Austin-Red Rock road, Bastrop County. Wills Point formation.
12109. Glauconitic red sand below rock ledge. Directly above bridge over Cedar Creek on Austin-Red Rock road, Bastrop County. Julia Gardner, collector, June 28, 1930. Wills Point formation.
12110. Upper rock ledge. Directly above bridge over Cedar Creek on Austin-Red Rock road, Bastrop County. Julia Gardner, collector. Wills Point formation.
12111. Colorado River, one-eighth to one-fourth mile above the mouth of Dry Creek-*Venericardia bulla* ledge, Bastrop County. Julia Gardner, collector. Wills Point formation.
12112. Colorado River, one-half to three-fourths mile above mouth of Dry Creek, below *V. bulla* bed, Bastrop County. Julia Gardner, collector. Kincaid formation.
12113. Same locality as 12112, above *V. bulla* bed. Julia Gardner, collector. Wills Point formation.
12128. B. K. Smith No. 1 well (Simms Oil Co.), depth 506 ft., A. Lytton Survey, Bastrop County. Collector unknown. Kincaid formation.
13241. Small branch, 2.8 miles southwest of Staples, 5 miles east by south of Zorn, Guadalupe County. L. W. Stephenson, collector. Kincaid formation.
13245. 2½ miles north, 20 east from Dunlay, Medina County (Gulf Production Co.). Collector unknown. Kincaid formation.
13246. 3½ miles N. 25° W. of Dunlay, Medina County. Grady Kirby (Gulf Production Co.), collector. Kincaid formation.
13247. From glauconitic concretions in east-facing slope of San Marcos River valley, one-half mile north of Staples, Guadalupe County. L. W. Stephenson, collector. Kincaid formation.
13248. Northeast corner of sec. 19, F. B. Flowers ranch, 4 miles west by north of the ranch house; 1.7 miles due south of the Eagle Pass-Uvalde road crossing over Turkey Creek, Zavala County. L. W. Stephenson and E. H. Finch, collectors. Kincaid formation.
13249. Gullies in east-facing slope of Leon Creek valley, 1000-2000 feet upstream from the Southern Pacific (Galveston, Harrisburg & San

Antonio) Railway bridge, Bexar County, Texas. L. W. Stephenson, collector.

13352. 5 miles north of Cumby, Hopkins County, Russ, collector, June 3, 1907. Kincaid formation.

13353. 2 miles north of Cumby, from hard ledge of sand which underlies prairie. Russ, collector, June 3, 1907. Kincaid formation.

DESCRIPTION OF SPECIES

Phylum ECHINODERMATA
Class ECHINOIDEA
Order EXOCYCLOIDA Jackson
Suborder SPATANGINA Jackson
Family SPATANGIDAE
Genus LINTHIA Desor

1853. *Linthia* Desor. Notice sur les Échinides du terrain nummulitique des Alpes, avec les diagnoses de plusieurs espèces et genres nouveaux, Soc. Helvétique Sci. Naturelles, Actes 38 session, p. 278.

Type—*Linthia insignis* Merian (Eocene of the Alps).

Oursins de grande taille à sommet ambulacraire central ou à peu près. Ambulacres pairs grands et profonds. Ambulacre impair logé dans un large et profond sillon. Un faisceau périnéal entourant les ambulacres de près comme chez les *Brissus*, plus un faisceau latéral qui part de l'ambulacre pair postérieur pour se diriger en arrière sous l'anus comme chez les *Schizaster*. Granulation tuberculeuse très-serrée. Diffère des *Schizaster* et des *Prenaster* par ses ambulacres à peu près égaux et son sommet central, et de tous les autres genres par la disposition de ses faisceaux. Ce genre comprend, outre les espèces nouvelles que nous allons décrire, plusieurs autres que l'on a rangées jusqu'ici dans les *Hemiaster*. Dédié à M. A. Escher de la Linth. (Desor, 1853.)

The single well preserved representative of the genus in the Midway of Texas is very small for the genus.

The characteristics of the genus include relatively long and divergent anterolateral ambulacra, a sunken anterior ambulacrum, and closely granulated and tuberculated interambulacral areas. It is this portion of the test which is most frequently recorded in the Wills Point formation.

LINTHIA ALABAMENSIS Clark?

1915. *Linthia alabamensis* Clark, U. S. Geol. Survey, Mon. 54, p. 153, pl. 71, figs. 1 a-d, 2 a d.

Determinative characters.—Test small, nearly round, except for groove on anterior margin and slight truncation posteriorly, low, somewhat depressed, the upper surface sloping gradually toward the apex. Ambulacra narrow, not deeply sunken, the posterolateral petals much shorter than the anterolateral. Peristome near anterior margin. Peripetal relatively high on narrow truncated posterior margin.

Dimensions.—Large specimen: length, 34 millimeters; width, 35 millimeters; height, 19 millimeters. Small specimen: length, 22 millimeters; width, 22 millimeters; height, 14 millimeters.

Description.—The test of this species is small, low, somewhat depressed, nearly round in ambital outline, except for the rather shallow groove on the anterior margin and the slight, narrow truncation on the posterior margin. The upper surface slopes gradually from the anterior margin posteriorly.

The ambulacra are narrow and not deeply sunken. The single anterior ambulacrum is situated in a narrow, rather shallow groove. The anterolateral paired ambulacra have long, narrow, rather shallow petals, and the posterolateral pair are short and shallow.

The interambulacral plates are covered with small perforate tubercles. The peripetalous and lateral fascioles are not easily traced.

The peristome is in a shallow depression near the anterior margin. The periproct is situated relatively high on the narrow truncated posterior margin.

Localities.—Prairie Creek, Wilcox County, Ala.; near Grand Glaise, Jackson County, Ark.

Geologic horizon.—Midway group (lower Eocene).

Collection.—U. S. National Museum (166483, 137371). (Clark, 1915.)

Indeterminate impressions of a closely tuberculated test are common through the Wills Point formation of Texas. Such impressions can not be separated from *Linthia alabamensis* and though too imperfect for certain identification, they form one of the best horizon markers of the upper Midway.

LINTHIA MAVERICKENSIS Gardner new species

Pl. 1, figs. 13, 14

Test very small, ovoid, expanded posteriorly, the maximum latitude a little behind the median horizontal, the maximum altitude decidedly posterior. Posterior margin broadly rounded or obscurely truncate, the anterior margin reëntrant at the ambulacral groove. Upper surface elevated, obliquely descending toward the anterior extremity, rounding smoothly into the flattened lower surface. Apical disk eccentric. Anterior ambulacrum petaloid, much longer than any of the others, the groove broad and moderately deep and reflected in the marginal outline; posterolateral grooves much shorter than the anterolateral; area between the anterior and anterolateral areas narrow and high, between the antero and posterolateral areas relatively broad and little or not at all elevated. Ambulacral plates very narrow, the relation of the pores to the plates obscure.

Peristome semi-elliptical, labiate, near the anterior margin. Periproct very close to the posterior margin.

Dimensions.—Altitude, 7.5 millimeters; latitude, 11.0 millimeters; longitude, 11.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370904.

Type locality.—Surface shingle, Wills Point(?) formation, Maverick County: U.S.G.S. Sta. 11754, 6 miles below the McFarland sheep pens on the Windmill (Jacal) ranch road, Indio ranch.

The species is so unlike anything known that it has been described even though the state of preservation of all of the fossils in the area is very imperfect.

Linthia alabamensis Clark from the Midway group of Alabama and Arkansas is treble the dimensions of the south Texas species. Like *L. maverickensis*, however, it is apparently associated with *Volutocorbis limopsis* (Conrad).

Occurrence.—Wills Point(?) formation. *Maverick County:* U.S. G.S. Sta. 11754, Indio ranch, 6 miles below the McFarland sheep pens on the Windmill (Jacal) ranch road.

Phylum	MOLLUSCOIDEA
Class	BRYOZOA
Subclass	ECTOPROCTA
Superorder	GYMNOLAEMATA
Order	CHEILOSTOMATA Busk
Suborder	ANASCA Levinson
Division	MALACOSTEGA Levinson
Group	MEMBRANIPORAE Canu and Bassler
Genus	CONOPEUM Norman

1903. *Conopeum* Norman, Natural history of East Finmark, Annals and Mag. Nat. Hist., ser. 7, vol. 11, p. 386 (1848, Gray, J. E., List British Animals, British Museum, Centroniae, pp. 108, 146).

1920. *Conopeum* Canu and Bassler, U. S. Nat. Mus., Bull. 106, p. 86.

No ovicell, no dictellae, no avicularia. The margins of the mural rim are wholly granulated. A distal multiporous septula; two or three lateral septulae. Triangular, interopesial hollows having special walls.

Genotype. *Membranipora hartoisii* Auctores.

Range. Cenomanian–Recent.

The granulations of the mural rim are often very fine and attenuated on the fossil forms. In these also the distal septulae often unite into a very large pore. The hollows of the surface are not interzooecial, as Levinson has described them, but are only interopesial; they are not deep and are situated between the mural rims; rarely they contain an avicularium; their purpose is unknown. In living specimens Waters has described two lucid spots on the dorsal side. These are replaced on the fossils by two hollow impressions in

the dorsal olocyst. We are ignorant of their use, for they have no connection with the operculum.

The type of this genus is very common on the coasts of France and England, and Osborn has noted its occurrence in American waters. However, no naturalist has made a study of its embryology and anatomy. (Canu and Bassler, 1920.)

CONOPEUM DAMICORNIS Canu and Bassler

Pl. 5, figs. 9–11

1920. *Conopeum damicornis* Canu and Bassler, North American early Tertiary Bryozoa, U. S. Nat. Mus., Bull. 106, p. 87, pl. 3, figs. 3–8.

The zoarium is free, formed of two lamellae growing back to back, irregularly bifurcated; the fronds are distorted. The zooecia are distinct, irregular, polygonal, or elliptical; the mural rim is very thin, regular, projecting but little, convex. The opesium has the same form as the zooecium. The interopesial cavities are polygonal and of a very great irregularity.

Measurements. Opesia { ho = 0.32 mm. / lo = 0.20 mm. } Zooecia { Lz = 0.35 mm. / lz = 0.23 mm. }

Variations and affinities.—This species has zooecia of a disconcerting irregularity; it is absolutely impossible to discover among them a form the least constant. The same holds true with the interopesial cavities which disappear following the irregularities of the zoarium.

The structure of the zooecial walls is quite remarkable. In tangential sections (fig. 6) these walls appear normal but in transversal thin sections, they are thickened, crenulated on the inside, and composed of tissue not very dense (fig. 5). In the median thin sections obtained by rubbing away both sides of the fronds, a structure may be noted identical with the zooecial walls; the olocystal elements grouped around the mural rim appear to be chambered (fig. 7). Finally, a section taken perpendicularly to the plane of the fronds (fig. 8) shows that the zoarium is formed of two lamellae placed back to back and separable.

The false chambering of the mural rim is not analogous to the formation of dietellae in *Periporosella;* we find in reality in every species chambered in this way some large, scattered, unoriented olocystal elements (figs. 4, 6).

The zoarium itself is quite constant and characteristic; it often assumes, although rather vaguely, among other shapes, the form of the horns of a deer, hence our specific name. As its zoarial dimensions exceed two centimeters, we may consider this species as an easily recognized, characteristic fossil. Unfortunately, the species has not yet been discovered in many of the localities of the Midwayan.

Occurrence.—Midway group (Clayton limestone): Owl Creek, 2¾ miles northeast of Ripley, Mississippi (common); Mabelvale, near Little Rock, Arkansas (very rare).

Cotypes. Cat. No. 63789, U.S.N.M. (Canu and Bassler, 1920.)

The specimens were referred to R. S. Bassler, who kindly determined them. The identity of the mode of occurrence in the Tehuacana member of the Kincaid formation of Limestone and Medina counties is significant. In each locality in both counties in which *Conopeum damicornis* Cann and Bassler occurs it is for the most part abundant and associated with crab claws. The foraminiferal and molluscan faunas of these localities are meager.

Occurrence.—Kincaid formation, Tehuacana member. *Limestone County:* U.S.G.S. Sta. 11933, Tehuacana Quarry, Tehuacana; U.S. G.S. Sta. 11938, 7 miles northwest of Kosse. *Medina County:* U.S. G.S. Sta. 6281, left bank of Hondo Creek, one-fourth mile above road crossing due east of Elstone; U.S.G.S. Sta. 11772, 7½ miles south of D'Hanis. *Uvalde County:* U.S.G.S. Sta. 11765, Schuddemagen ranch, 11 miles south of Sabinal.

Class	BRACHIOPODA
Order	TELOTREMATA
Superfamily	TEREBRATULACEA
Family	TEREBRATELLIDAE
Subfamily	MEGATHYRINAE
Genus	ARGYROTHECA *Dall*

1900. *Argyrotheca* Dall, Nautilus, vol. 14, p. 44.
= *Cistella* Gray, 1853, Catalogue British Museum, p. 114.
Not *Cistella* Gistel, 1848. (Insecta.)

Type.—*Terebratula cuneata* Risso (Recent in the Mediterranean).

ARGYROTHECA POWERSI Gardner

Pl. 5, fig. 1–8

1925. *Argyrotheca powersi* Gardner, Am. Jour. Sci., col. 10, p. 134, figs. 1–8.

Shell large for the genus, wider than long, rather thick and heavy, strongly punctate, punctae relatively large and widely spaced. Dorsal valve flattened, anteriorly sulcate, postero-lateral margins sulcate; ventral valve moderately convex. Outline varying from semi-elliptical to subrectangular; cardinal extremities nearly a right angle; the anterior margin nearly horizontal medially, curving broadly and smoothly posteriorly at the distal extremities. External surface rarely preserved, feebly plicate, concentrically rugose toward the outer margin. Cardinal area rather low. Deltidial opening large, rudely trigonal, much eroded. Deltidial plates small, widely separated. Median septum in dorsal valve very high, reaching its apex a

little posterior to the mid-line of the valves. Dental sockets moderately deep. Septum in ventral valve low and apparently uniform in elevation from the beak nearly to the anterior margin. Hinge teeth not observed.

Dimensions.—Dorsal valve (holotype): length, 4.0 millimeters; width, 6.0 millimeters. Ventral valve of another individual: length, 4.0 millimeters; width, 4.0 millimeters. Fragments of other shells indicate dimensions half as large again as those attained by the type.

Holotype.—U. S. Nat. Mus. No. 353033.

Type locality.—U. S. G. S. Sta. 10349, Butler Dome, one-fourth mile northwest of Gin Lake, 2½ miles east of Butler, Freestone County, Texas. Conglomeratic ferruginous limestone, probably from the Wills Point formation.

The species is named in honor of the discoverer, Sidney Powers, formerly of the U. S. Geological Survey, through whose interest and generosity the Federal collections have been greatly enriched.

Argyrotheca powersi, though very imperfectly preserved, is abundantly represented in the conglomeratic boulders at the single locality from which it has been collected. The apparently restricted distribution of a form so prolific locally is very difficult to understand. The punctate surface of the brachiopod is quite distinct from anything exhibited by any of the mollusca so that when present it can scarcely be confused with any other form.

Evidence of the extraordinarily local distribution of *Argyrotheca powersi* was advanced by material collected later by L. W. Stephenson of the U. S. Geological Survey. The collection was made 1500 to 1600 feet southeast of the Lakeport store, approximately half a mile from the type locality of *A. powersi*. There is no appreciable difference in the matrix nor in the mode and state of preservation of the contained fauna but not a single trace of the brachiopod could be found in perhaps 15 to 20 pounds of fossiliferous conglomerate. *Pteria* and *Volutocorbis*, like *Argyrotheca*, are apparently absent, while crustacean remains which were not recognized in any of the earlier collections are fairly common in the Stephenson material.

Argyrotheca powersi is the fourth of the genus to be cited in the fossil state from the American faunas and the third to be reported from the American Eocene. *Argyrotheca schucherti* was described by Dall (29d) in 1903 from the upper Miocene of Jackson Bluff, Florida. *Argyrotheca dalli* by Aldrich (31a), 1911, from the

upper Wilcox of Alabama and *Argyrotheca gardneri* Cooke, 1934—*Argyrotheca dalli* Cooke (43a) 1919, from the upper Eocene of Saint Bartholomew. There are four or five Recent species, all of them, with the exception of *A. lutea* Dall, smaller than *A. powersi*. They are, for the most part, deep water forms and tropical or subtropical in distribution. Only one of them ventures so far north as Hatteras. In Europe, *Argyrotheca* has been recognized from the Cenomanian to the Recent, and the Recent species are, in the main, Mediterranean.

The Floridian Miocene species bears a certain resemblance to some of the Recent forms but the Eocene species are far removed from the later Tertiary and Recent types and from each other. *A. dalli* and *A. aldrichi* are closely plicate radially; *A. schucherti* and most of the Recent species develop a fairly strong and regular fluting, while in *A. powersi* the radii are irregular and ill-defined.

The discovery of a possible progenitor of this small, warm-water group flourishing in the midst of a diversified early Eocene molluscan fauna raises some very interesting distributional problems. The character of the matrix and of the associated fauna precludes the possibility of accounting for *Argyrotheca* by an extreme depth of water.

Occurrence.—Wills Point formation(?). *Freestone County:* U. S. G. S. Sta. 10349, Butler Dome, one-fourth mile northwest of Gin Lake.

Phylum	MOLLUSCA
Class	PELECYPODA
Order	PRIONODESMACEA
Section	TAXODONTA
Superfamily	NUCULACEA
Family	NUCULIDAE
Genus	NUCULA Lamarck

1799. *Nucula* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 87.

Type.—*Arca nucleus* Linnaeus. (Recent off the European coast from the Faroe Island- to the Aegean Sea; Pliocene of England and southern Europe.)

Shell nacreous, small, trigonal to subcircular or elliptical; umbones subcentral or posterior; two series of transverse, numerous and close-set hinge teeth, separated by a triangular chondrophore; surface generally smooth or concentrically striated; margins simple

or crenulate; adductor impressions subequal, two in number; pallial line simple.

The genus has survived from the middle Paleozoic, possibly because of its remarkable adaptability. It is found in both shallow and deep water and on both sandy and muddy bottoms. Though characteristic of the boreal and temperate oceans the group has also a meager representation in the tropical seas.

Indeterminate fragments of *Nucula* are not uncommon in the fossiliferous Midway but determinable individuals are very rare and apparently without stratigraphic significance.

NUCULA MEDIAVIA Harris

1896. *Nucula mediavia* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 53, pl. 4, fig. 4.

1896. *Nucula magnifica* Aldrich, Geol. Survey Alabama, Bull. 1, p. 60 (name only).

Not *Nucula magnifica* Conrad, 1833, Fossil shells Tertiary formations North America, p. 37.

Size and general form about as figured; surface showing besides lines of growth, many radiating striae; lunule large, deeply depressed, and sometimes traversed by a faint radiating ridge; within, strongly crenulate at margin; posterior as well as anterior row of teeth well developed, each tooth angulate in the middle; angle formed at the junction of the two rows of teeth about 130 degrees.

The sharp posterior, deeply sunken and sharply defined lunule, great angle formed by the junction of the two rows of teeth, and coarsely crenulated margin, serve to distinguish the species. (Harris, 1896.)

Nucula mediavia may be the forerunner of *Nucula magnifica* of the Claiborne fauna from which it differs in the higher posterior dorsal margin, the more pronounced lunule and the stronger radial sculpture. The Texas specimens are all young but are probably referable to this species. *Nucula ovula* Lea described from the Claiborne of Alabama has been reported from the Texas Midway but the occurrence has not been verified.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 11915? and 12112. Colorado River, 1½ miles below the Travis-Bastrop County line.

NUCULA species

Indeterminate fragments are widespread in both the Kincaid and Wills Point formations, notably at Butler Dome in Freestone County.

at Cribbs Bluff on the Brazos River, both above and below the *Venericardia bulla* zone on the Colorado River, and in the Tehuacana member of the Kincaid formation in Medina and Maverick counties. They are apparently without stratigraphic significance.

Family LEDIDAE
Genus LEDA Schumacher

1817. *Leda* Schumacher, Essai d'un nouveau système des habitations des vers testacés, pp. 55, 172.

Type.—*Arca rostrata* Chemnitz = *Mya pernula* Müller. (Recent in the North Atlantic.)

Shell solid, porcellaneous, transversely elongate, rounded anteriorly; beaks proximate, commonly tumid, feebly opisthogyrate; exterior surface concentrically sculptured; hinge armature taxodont, the teeth arranged in an anterior and a posterior series; chondrophore subumbonal, trigonal; pallial line interrupted by a shallow sinus corresponding to the short siphons of the animal; inner ventral margins simple.

This genus also originated in the Paleozoic but in the Silurian, one period later than *Nucula*. The more than 30 living species have a wide geographic and bathymetric distribution.

Many of the Ledas found in the basal Midway are casts of the *gabbana* type, probably reworked from the Cretaceous.

LEDA SAFFORDANA Harris?

1860. *Leda protexta* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 397, pl. 68, fig. 36.

Not *Leda protexta* Gabb, 1860, *ibid.*, p. 303, pl. 48, fig. 23.

1896. *Leda saffordana* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 55, pl. 4, fig. 9.

Very wide transversely; beaks small, incurved; posterior end acuminate, curved slightly upwards; anterior and basal margins regularly rounded; surface marked by numerous transverse ribs.

Dimensions of the most perfect specimen. Length, .5 in.; width, .25 in.; diameter, .2 in.

Locality. Hardeman Co., Tenn. (Gabb, 1860.)

Harris in 1896, ignoring Whitfield's attempt (13b) to give the name *gabbana* to the Tennessee species, renamed the Tennessee shell which Gabb had confused with that he had formerly described from Burlington County, New Jersey. Whitfield, though he cited Gabb's description and figure of the Hardeman County shell, described at

some length and figured a cast from the Cretaceous marls of Freehold, New Jersey, considering it identical with the Tennessee species and renaming it *Nuculana Gabbana*. Since 1885, the Cretaceous species has commonly appeared in the literature under the name *gabbana* and in view of the fact that the Cretaceous species was described and figured by Whitfield, it seems not only highly desirable but legitimate to continue to restrict *gabbana* to the Cretaceous shell and to adopt Harris's *saffordana* for the Eocene shell.

The species, though fragile, is abundant and well preserved in the micaceous, slightly glauconitic sands of Middleton, Hardeman County, Tennessee. It is characterized by the relatively large and compressed valves and by the abrupt disappearance of the concentric sculpture upon the rostrum.

It is quite probable that the Tennessee species is fairly well represented in the lower Midway (Kincaid formation) of Texas but the material is too imperfect for an assured determination.

Occurrence.—Kincaid formation. *Falls County:* U.S.G.S. Sta. 11929, Litle Brazos above Rocky Crossing on Kosse road.

LEDA EOA Gardner new species

Pl. 6, figs. 1, 2

Shell small, moderately compressed, transversely elongate, much produced posteriorly, and sharply rostrate. Anterior extremity broadly and smoothly rounded, the tip of the produced posterior rostrum unfortunately broken away. Umbones anterior, low, broadly rounded, the tips incurved and turned slightly backward. Lunule sharply defined, little more than linear; escutcheon much wider than the lunule, the outer and posterior portion set off by a faint secondary ray; concentric lineation developed upon it; smooth inner area symmetrically lenticular. Entire surface excepting for the lunule and escutcheon sharply threaded concentrically.

Dimensions.—Height, 6.5 millimeters; length (of incomplete specimen), 11.5 millimeters; diameter of double valves, 5.0 millimeters.

Holotype. U. S. Nat. Mus. No. 132604.

Type locality.—U.S.G.S. Sta. 2439, 1 mile east of Webberville, Travis County, Texas. Littig glauconitic member of Kincaid formation.

The small transversely elongated casts that are found so commonly in the basal greensand of Bastrop and Caldwell counties are probably referable to this species. They are particularly abundant in the greensand at the Cretaceous-Eocene contact on the Austin-Bastrop road, half a mile east of Elysium, Bastrop County.

Both *Leda saffordana* and *Leda eoa* represent a horizon fairly low in the Midway but *L. eoa* is a smaller, more inflated shell upon which the concentric threading is continuous across the keel to the very margin of the escutcheon. It is also more produced posteriorly than *L. saffordana*, so much so that molds, probably of this species, suggest *Perrisonota*.

Occurrence.—Kincaid formation, Littig glauconitic member. *Travis County:* U.S.G.S. Sta. 2439, 1 mile east of Webberville.

LEDA new species

Pl. 6, figs. 3, 4

A *Leda*, imperfectly preserved, but retaining unusual and characteristic features, was collected from the Tehuacana member in Medina County, 5 miles southeast of Elstone on the Pearsall road. The shell is of moderately large dimensions for the group, inflated broadly and rather strongly from the umbones to the ventral margin but constricted and contracted posteriorly. The anterior extremity is broadly rounded, the posterior produced and obtusely rostrate. The concentric cording is strong and regularly but rather distantly spaced, most prominent upon the disk but continuous across the rostrum to the margin of the escutcheon. It is a much larger and more inflated species than *Leda* (*Saccella?*) from Falls County and not so sharply nor so closely sculptured.

Figured specimen.—U. S. Nat. Mus. No. 370953.

Locality.—Tehuacana member of Kincaid formation. *Medina County:* U.S.G.S. Sta. 11771, 5 miles southeast of Elstone.

A similar but probably not identical species is present in the Tehuacana member on the Schuddemagen ranch on the south bank of Elm Creek, 11 miles south of Sabinal, Uvalde County (U.S.G.S. Sta. 11765), and at White Bluff on the Rio Grande (U.S.G.S. Sta. 6575).

Subgenus SACCELLA Woodring

1898. *Ledina* Sacco, I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 26, p. 53, December, 1898.

Not *Ledina* Dall, April, 1898, Wagner Free Inst. Sci., Trans., vol. 3, pt. 1, p. 580.

1925. *Saccella* Woodring, Miocene Mollusks from Bowden, Jamaica, Carnegie Inst. Washington, Pub. 366, p. 15.

Type.—*Arca fragilis* Chemnitz = *Leda commutata* Philippi (Miocene to Recent in the Mediterranean Sea).

Shell small, high, slightly inequilateral, posterior end rostrate, rostrum sharply pointed and unicarinate; a shallow groove extends from the umbo to the ventral margin at both ends of the valve; sculpture consisting of strong concentric rugae; hinge like *Leda* s.s., but the anterior and posterior series of teeth are approximately equal in length; apex of pallial sinus broadly U-shaped. (Woodring, 1925.)

The group, which becomes increasingly prominent through the later Tertiaries to the Recent, has a meager representation in the Midway. Molds of forms possibly referable to *Saccella* are common in the Littig glauconitic member of the Kincaid formation, especially in Travis County, and in the Littig glauconitic member at the contact on the Austin-Bastrop road, one-half mile east of Elysium, Bastrop County.

LEDA (SACCELLA?) new species

A *Leda* apparently new but too imperfectly preserved to describe and figure is common in the Kincaid formation one-fourth mile west of the Stranger School in Falls County (U.S.G.S. Sta. 11932). The rostrum is pronounced and apparently much more produced in the adults than in the juveniles. The most characteristic feature is the coarse, but sharp, distant, but regular, concentric threading.

Another species, small, rather compressed, ovate-trigonal in outline, and finely striated upon the disk but smooth distally, is represented by abundant impressions in the Wills Point formation. Like the echinoids with which it is commonly associated, the species is sufficiently well characterized to serve as a horizon marker, though the material is too imperfect to describe and figure. *Leda milamensis* Harris from the lower Wilcox is a very similar form but apparently larger.

LEDA (SACCELLA) MILAMENSIS Harris

1895. *Leda milamensis* Harris, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 47, pl. 1, fig. 4.

1896. *Leda milamensis* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 54, pl. 4, fig. 8.

General form as figured; surface covered with fine concentric striae except near the anterior margin where it is smooth and polished; diameter from beak to base great and the shell here much inflated; posterior remarkably narrow and flattened.

Locality.—Smiley's Bluff, Brazos River, 2 miles above the mouth of Pond Creek. (Harris, 1895.)

Harris's figures published in the Proceedings of the Philadelphia Academy and in the Bulletin of American Paleontology differ appreciably, the original indicating a species much more produced posteriorly and seemingly less inflated. The length of the original, taken from the figure, is 11 millimeters; of the figure published in the Bulletin of American Paleontology, 9 millimeters, a difference so slight that no marked age variation can be postulated. Perhaps the numerous *Saccella* impressions in the Wills Point sands and clays should be referred to *L. milamensis* though their average length does not exceed 5 or 6 millimeters.

The outcrop at Smiley's Bluff is now referred to the lower Wilcox.

Subgenus LEDINA Dall

1898. *Ledina* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, p. 580.

Type.—*Leda smirna* Dall = *Leda eborea* Conrad, 1860, not *Nucula eborea* Conrad, 1836. (Midway of the southern United States.)

Shell solid, strong, arcuate below, both ends evenly rounded, valves nearly equilateral, smooth.

This section has been frequently placed with *Yoldia*. (Dall, 1898.)

LEDA (LEDINA) SMIRNA Dall

Pl. 6, fig. 11

1860. *Leda eborea* Conrad, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 295, pl. 47, fig. 26.

Not *Nucula eborea* Conrad, 1836, Acad. Nat. Sci. Philadelphia, Proc., p. 21. (= *Leda concentrica* (Say) 1824).

1890. *Leda (Yoldia) eborea* Conrad, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 187, pl. 22, fig. 37.

1891. *Leda (Yoldia) eborea?* Conrad, Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 42.

1896. *Yoldia eborea* Conrad, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 56, pl. 4, fig. 7.

1898. *Leda (Ledina) smirna* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, pp. 578, 580.

Conrad, in 1860, gave to the Eocene species a name which he had already used in describing a Recent shell off the west coast of Florida. Dall's *smirna* merely replaces the preoccupied *eborea*.

Triangular, equilateral, ventricose smooth polished; lunules of equal length and defined by carinated lines; anterior lunule widely elliptical; dorsal margin when the valves are together defined by a slight carina; a slight furrow near the posterior dorsal margin and parallel with it; posterior end acutely rounded and the submargin slightly contracted; base regularly rounded.

Length ⅝ inch. (Conrad, 1860.)

Type locality.—Conrad's only clue to a type locality is the statement that "Dr. Showalter of Uniontown, Alabama, has sent me some Eocene shells which appear to be new, and are from a locality further north in Alabama than any Mr. Tuomey had explored." The late Truman H. Aldrich, of Birmingham, Alabama, who was most familiar with the early collecting and collections in Alabama, informed me that some, possibly all, of Doctor Showalter's collection came from the Matthews Landing horizon, but after Showalter's death his collection, which he had kept in his residence, was thrown out and the labels destroyed so that the loss is final.

Leda smirna is ovate in outline, well rounded, polished and often showing color bands that may be the remnant of the original pattern. The incised lines upon the medial portion of the shell are regular and sharp but they are less distinct anteriorly and completely disappear in the majority of individuals in front of the rounded posterior keel. *Leda smirna* is a smaller, more inflated shell than *Leda saffordana* Harris from the lower Midway of Hardeman County, Tennessee. The posterior keel of *saffordana* is upcurved and much more pronounced than in *L. smirna* and the concentric sculpture stronger, though like that of *smirna* it is obsolete upon the rostrum.

In Alabama *Leda smirna* Dall is restricted to the lower part of the Naheola formation (Matthews Landing horizon), but is foretold in the lower Midway Sucarnoochee clay by a larger, less trigonal species. The *Leda smirna* material in the lower Midway Kincaid formation in Texas is mostly juvenile or imperfect, so that it has

been impossible to separate it with any degree of assurance from the well preserved *Leda smirna* of the higher Midway (Wills Point formation). It is probable, however, that a distinction exists. The species has never been recognized in the basal Midway.

Leda smirna is not notably abundant but it is widespread in the middle Midway. *Leda sucfiana* Rathbun from Maria Farinha, Pernambuco, Brazil, is a possible analogue and *L. corpulentoides* Aldrich from the lower Wilcox is a probable descendant; in any case, a very closely related species.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Stas. 11901?, 11916, 11917?, 11919, and 11924, Brazos River, 1 mile below the Falls County line. *Bastrop County:* U.S.G.S. Stas. 11696, 11914, and 12112, Colorado River, 1½ miles below the Travis-Bastrop County line; U.S.G.S. Stas. 5230 and 11915, right bank of Colorado River, 4 miles below Webberville.

Wills Point formation. *Williamson County:* U.S.G.S. Sta. 10120, Dry Brushy Creek, 6 miles south of Thrall on Taylor-Beaukiss road. *Milam County:* U.S.G.S. Sta. 10519, mouth of Brushy Creek at San Gabriel River. *Bastrop County:* U.S.G.S. Stas. 10527, 11390, and 12113, Colorado River, 4¼ to 4¾ miles downstream from Webberville. *Caldwell County:* U.S.G.S. Sta. 11700, 1.9 miles north of Lockhart on the Austin road: Bureau of Economic Geology Sta. 12, 4.6 miles north of Lockhart.

Subgenus PERRISONOTA Conrad

1869. *Perrisonota* Conrad, Am. Jour. Conchology, vol. 5, p. 98.

Type.—*Perrisonota protexta* Conrad (Upper Cretaceous, Matawan group of New Jersey).

Equivalved, elongated; posterior hinge line long, curved, linear, with numerous close, transverse teeth, extending nearly to the end margin; anterior hinge area broad, oblique and somewhat distant from the hinge margin. No fosset under the apex? (Conrad, 1869.)

Molds suggesting *Perrisonota* and probably reworked from the Cretaceous are not uncommon in the Littig glauconitic member.

Superfamily ARCACEA
Family LIMOPSIDAE
Genus LIMOPSIS Sassi

1827. *Limopsis* Sassi, Giornale ligustico di scienze, lettere ed arti, year 1, p. 476.

Type.—*Arca aurita* Brocchi. (Miocene and Pliocene of Italy.)

Shell medium sized, subcircular to obliquely ovate, inflated, broadly rounded anteriorly, obliquely truncate posteriorly; beaks full, sub-central; ornamentation not very strong, usually reticulate; dentition taxodont, the teeth not very numerous and rather coarse, vertical medially, oblique or horizontal distally; inner margin of valves smooth in *Limopsis* s. s., fluted in the subgenus *Pectunculina*; ligament fossette small, trigonal, subumbonal.

The group is long-ranging. Species have been reported from the early Mesozoic and their recent distribution is typical of age-old genera. The Recent species are relatively few in number but almost world-wide in distribution, many of them taking refuge in the deeper waters.

LIMOPSIS QUIHI Gardner new species

Pl. 6, figs. 5-8

Shell of moderate dimensions, rather strongly inflated, subcircular to ovate trigonal in outline; the anterior end broadly rounded; the posterior a little shorter than the anterior, obtusely truncate in the obtusely rostrate individuals, broadly rounded in those individuals in which the keel is obsolete. Umbones gibbous, the tips incurved, proximate and very slightly opisthogyrate. External surface radially lirate, the lirae very fine and regular and tending to group in threes or fours; a few pronounced resting stages toward the base. Hinge characters very imperfectly preserved; apparently a small, trigonal, asymmetric ligament pit; the anterior teeth coarse, oblique and about 8 in number; the posterior teeth slightly more numerous and, toward the umbones, almost at right angles to the hinge. Inner margins simple.

Dimensions.—Double valves: height, 24.5 millimeters; length, 23.0 millimeters; convexity, 13.7 millimeters.

Holotype and 3 paratypes.—U. S. Nat. Mus. No. 370905.

Type locality.—U.S.G.S. Sta. 11376, 1 mile east of Quihi, Medina County, Texas. Tehuacana member of Kincaid formation.

Occurrence.—Tehuacana member of Kincaid formation. *Medina County:* U.S.G.S. Sta. 11376, 1 mile east of church at Quihi; and U.S.G.S. Sta. 11770, Hondo River bed, 1 mile northwest of New Fountain. *Uvalde County:* U.S.G.S. Stas. 6279 and 11765, 11 miles south of Sabinal, and a few hundred yards south of junction of Elm Creek with Sabinal Creek on the Schuddemagen ranch.

LIMOPSIS species

A right and a left valve of an indeterminate juvenile were collected from the glauconitic sand below the indurated ledge directly above the bridge over Cedar Creek on the Austin-Red Rock road (U.S.G.S. Sta. 12109). These small valves are beautifully preserved and the recovery of the adults is highly desirable.

Another valve apparently of the same species was recovered from U.S.G.S. Sta. 5280 on the Colorado River below the *Venericardia bulla* zone.

Family PARALLELODONTIDAE
Genus CUCULLAEA Lamarck

1801. *Cucullaea* Lamarck, Système des animaux sans vertèbres, p. 116.
Type.—*Arca concamerata* Martini = *Cucullaea auriculifera* Lamarck. (Recent in the Indian Ocean and the China Sea.)

Shell large, heavy, inflated, rhomboidal or cordiform, equi- or subequi-valve. Umbones prominent, incurved, separated by a rather wide cardinal area with divergent ligament grooves. Sculpture dominantly radial, often discrepant on the two valves. Hinge taxodont; medial teeth transverse or slightly oblique to the hinge margin; distal teeth sub-parallel to it. Posterior adductor supported by a buttress. Inner ventral margins crenate.

Cucullaea is one of the most conspicuous genera in the bivalve faunas of the Mesozoic particularly toward the close of the era. Though much reduced in species, it is still abundantly represented by individuals in many of the lower Eocene faunas. Only three species survive to the present day, all of them relicts in the Indian Ocean or the China Sea. *Cucullaea* is one of the most prominent groups in the Midway of Texas, and one of the most characteristic groups of the Paleocene faunas of the boreal and temperate provinces in Europe and Asia.

CUCULLAEA MACRODONTA Whitfield

Pl. 7, fig. 5

1865. *Cucullaea macrodonta* Whitfield, Am. Jour. Conchology, vol. 1, p. 267, pl. 27, fig. 17.
1890. *Arca (Cucullaearca) macrodonta* Whitfield, De Gregorio, Mon. Faune Eocénique de l'Alabama, p. 197, pl. 24, fig. 30.
1894. *Cucullaea macrodonta* Whitfield, Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 41.

1896. *Cucullaea macrodonta* Whitfield, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 51, pl. 3, figs. 10, 10a.

Shell of medium size, sub-rhomboidal in outline, broad heart-shaped in profile; hinge line nearly as long as the greatest length of the shell; hinge area broad, corrugated; valves deep; beaks distant, slightly incurved; surface marked by from forty-five to fifty low, radiating ribs, which are finely corrugated by concentric lines; ribs indistinct on the posterior part; a rather deep, narrow sulcus extends from the beak to the posterior basal angle, leaving a prominent umbonal ridge; hinge line with sixteen teeth, the right valve having four at each extremity, parallel to it; muscular scars sub-quadrangular, the posterior much the largest; muscular ridges faint or obsolete; pallial line crenulate; inner margin of shell smooth.

This species is remarkable for the very transverse lateral teeth, a feature not often noticed in fossil species of the genus.

Locality.—Nine miles below Prairie Bluff, Alabama. (Whitfield, 1865.)

The *Cucullaea macrodonta* group is one of the most prominent in the Midway of Texas particularly in the Tehuacana member of the Kincaid formation. True *macrodonta* is apparently present in the central part of the Midway area while the coarser, more uniformly sculptured *texana* is developed in the Border basin and the more transversely elongate, more delicately sculptured *kaufmanensis* occurs in northeast Texas.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Sta. 11926?, Milam Bluff, Brazos River, 0 to one-fourth mile below the Falls County line; U.S.G.S. Stas. 11916? and 11921?, Brazos River, 1 mile below Falls County line. *Bastrop County:* U.S.G.S. Stas. 5230 and 10526?, right bank of Colorado River, 4 miles below Webberville. *Caldwell County:* U.S.G.S. Sta. 11707, 5½ miles north of Lockhart on E. A. Moser farm.

Wills Point formation. *Limestone County:* U.S.G.S. Sta. 10346, right bank of a small tributary of Tehuacana Creek, 1 mile southwest of the Houston & Texas Central Railroad crossing. *Williamson County:* U.S.G.S. Sta. 10120?, Dry Brushy Creek, 6 miles south of Thrall on Taylor-Beaukiss road. *Bastrop County:* U.S.G.S. Stas. 11913? and 12113?, Colorado River, 2 miles below the Travis-Bastrop County line; U.S.G.S. Sta. 11908, Cedar Creek, one-half mile northeast of crossing on Austin-Red Rock road. *Caldwell County:* U.S.G.S. Sta. 11700?, 1.9 miles north of Lockhart on the Austin road; Bureau of Economic Geology Sta. 12, 4.6 miles northwest of Lockhart; U.S.G.S. Sta. 11699?, William Mercer well, 2

miles southwest of Joliet. *Bexar County:* U.S.G.S. Sta. 6225, Merkel, Cibolo Creek.

CUCULLAEA TEXANA Gardner

Pl. 7, figs. 6-7

1923. *Cucullaea (macrodonta* subsp.?) *texana* Gardner, U. S. Geol. Survey, Prof. Paper 131-D, p. 111, pl. 29, figs. 4, 5.

Shell large, heavy, inflated, the single valves rudely quadrate in outline, the double valves cordate in cross section through the umbones. Umbones prominent, inflated, overhanging the cardinal area, the tips incurved and prosogyrate, slightly in advance of the median vertical. Length of hinge approximately five-sixths that of the shell. Anterior extremity angulated dorsally, rounding broadly into the ventral margin. Base line approximately horizontal medially. Posterior extremity obliquely truncate; posterior area flattened, delimited by a narrow but obtuse ridge with a shallow sulcus behind it. Valves differentially sculptured, the right valve exhibiting about 30 low, broad radials separated by linear interspaces and persisting to the posterior keel, where they abruptly disappear; a very fine, close, and uniform radial cording developed upon the posterior area in some individuals, but commonly absent, as in the type, or evanescent toward the margin. Left valve exhibiting only about 24 radials distributed over the medial and anterior portions of the shell but absent upon the posterior third, narrower than those upon the right valve and separated by interspaces of a width almost equal to the radials; sculpture of posterior area similar in the two valves; incremental sculpture pronounced, particularly toward the base. Hinge area of moderate width for the genus, obliquely grooved; hinge very imperfectly preserved; very narrow medially with short vertical teeth, abruptly widening near the extremities; distal teeth coarse, few in number, and rudely parallel to the hinge margin. Characters of interior not known.

Dimensions.—Height, 42.0 millimeters; length of hinge, 39.0 millimeters; maximum length, 47.5 millimeters; convexity, 40.0± millimeters.

Holotype.—U. S. Nat. Mus. No. 352267.

Type locality. U.S.G.S. Sta. 6575, White Bluff, Rio Grande, Maverick County, Texas. Kincaid formation.

Cucullaea texana varies widely in outline and to a lesser degree in detail of sculpture. The shell runs larger and heavier than the typical *C. macrodonta* Whitfield, and the sculpture of the left valve, though discrepant, is regular and differs from that of the right only in the narrower ribs, wider interspaces, and in its development over a more restricted portion of the shell. These differences, though slight, are fairly constant in the imperfect material in hand. *Cucullaea saffordi* Gabb was described from a shell 0.2 inch in latitude. This type, according to Harris, has been lost. Until the young have been correlated with adults at the type locality and the species adequately described from such material, the characters of *C. saffordi* Gabb must be open to question. There is need for uncommon caution in Hardeman County, as the Upper Cretaceous and Eocene outcrops are very near to one another and were confused in some of the earlier collections.

Cucullaea texana is the Border representative of the *C. macrodonta* group.

Occurrence.—Kincaid formation. *Medina County:* U.S.G.S. Sta. 6584, D'Hanis-Yancey road about 7½ miles east of south of D'Hanis; U.S.G.S. Sta. 11772, 3 miles north of Squirrel Creek School House, and about 7½ miles south of D'Hanis. *Uvalde County:* U.S.G.S. Sta. 11765?, Schuddemagen ranch, south bank of Elm Creek, 11 miles south of Sabinal; U.S.G.S. Sta. 3178?, three-fourths mile northwest of Evans' (Myrick's) apiary, north of Frio River; U.S.G.S. Sta. 3179, bluff on Frio River, one-half mile northwest of Evans' (Myrick's) apiary; U.S.G.S. Sta. 11877, south bank Frio River, one-fourth to one-half mile above Evans' (Myrick's) apiary; U.S.G.S. Stas. 3185 and 11874, Frio River, just above Evans' (Myrick's) apiary; U.S.G.S. Sta. 11873, Frio River, foot of trail leading down from Evans' (Myrick's) apiary; U.S.G.S. Sta. 3181?, Frio River, just above waterhole opposite apiary, below Englemann's ranch; and U.S.G.S. Sta. 3180, Frio River one-half mile below Evans' (Myrick's) apiary. *Maverick County:* U.S.G.S. Stas. 533?, 4396, 6583, and 11753, Bilsora tank, 18 miles southeast of Eagle Pass; U.S.G.S. Sta. 11757, hillside above a small tank, 2 miles west of Lopez tank, about 29 miles southeast of Eagle Pass; U.S.G.S Sta. 11758, scarp near the Indio Wells about 29 miles southeast of Eagle Pass; U.S.G.S. Sta. 11763?, 3½ to 4 miles southwest of Windmill (Jacal) ranch house on Las Islas Crossing road; and U.S.G.S.

Sta. 6575, White Bluff on Rio Grande River, 1½ miles west of south of Windmill (Jacal) ranch house.

CUCULLAEA KAUFMANENSIS Gardner new species

Pl. 7, figs. 1–4

Shell rather small for the genus, not very heavy, moderately inflated, elongated transversely. Umbones prominent, inflated, overhanging the cardinal area, the tips incurved and prosogyrate, anterior in position. Anterior extremity angulated dorsally, rounding broadly and obliquely into the ventral margin. Posterior extremity obliquely truncate. Base line feebly arcuate. Posterior area flattened, delimited by a narrow but obtuse ridge with a shallow sulcus behind it and by the very much finer ornamentation. Difference in sculpture upon the two valves less than in other members of the genus represented in the Texas Midway; right valve sculptured upon the anterior and medial portions with numerous radials (38 in the type), very low and flat and separated by linear interspaces, the broadest of the radials medially sulcate; posterior area crowded with linear radials and evenly granulated by the incremental. Radials upon the left valve slightly more numerous than upon the right, less regular and with relatively wider interspaces; not mesially sulcate; sculpture upon the posterior area of the left valve similar to that upon the right though the groove behind the obtuse keel is apparently less pronounced. Hinge area rather narrow for the genus, strongly and obliquely grooved. Hinge very imperfectly preserved; very narrow medially with short vertical teeth, abruptly widening toward the extremities; distal teeth coarse, three in number in the single individual in which they are preserved and rudely parallel to the hinge margin. Characters of interior known only from casts which preserve the impression of a not very conspicuous posterior buttress.

Dimensions.—Holotype: height, 25.0 millimeters; length of hinge, 30.5 millimeters; length, 36.8 millimeters; convexity, 13.2 millimeters.

Holotype. U. S. Nat. Mus. No. 370959; paratypes, U. S. Nat. Mus. Nos. 370960 and 370961.

Type locality.—Holotype and smaller paratype, U.S.G.S. Sta. 10744, northeast corner of the J. W. Boyce 120 acres in the W. F.

Butler Survey, on the public road about 2½ miles northeast of Kemp, Kaufman County, Texas. Larger paratype, U.S.G.S. Sta. 11665, 5 miles northeast of Kemp, Kaufman County, Texas. Kincaid formation.

The type specimen is more elongated transversely than most of the individuals.

Cucullaea kaufmanensis is obviously of the *macrodonta-texana* group but the differences are sufficiently great to be recognized taxonomically. It is the smallest, the most finely sculptured, and the most elongated transversely of any member of the group. The radial lineation upon the posterior area is more uniformly developed than in the other species and the medial sulcation more generally developed upon the right valve.

Occurrence.—Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665, Water Hill, 5 miles northeast of Kemp; U.S.G.S. Sta. 2446, 4 miles northeast of Kemp; and U.S.G.S. Sta. 10744, about 2½ miles northeast of Kemp on public road. *Falls County:* U.S. G.S. Sta. 11931, 6 miles northwest of Kosse; and U.S.G.S. Sta. 11932, one-fourth mile northwest of Stranger School.

Family ARCIDAE
Genus BREVIARCA Conrad

1872. *Breviarca* Conrad, Acad. Nat. Sci. Philadelphia, Proc., p. 55.

Shell short; hinge area minutely striated across; hinge line descending at the ends; cardinal plates minute, crowded. *Trigonarca perovalis*, Plate II, fig. 4, *T. safordii*, Gabb, Plate II, fig. 3. (Conrad, 1872.)

1876. *Breviarca* Conrad, Meek, U. S. Geol. Survey of the Territories, vol. 9, Rept. Invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country, p. 91.

Shell small, suborbicular or suboval, more or less rounded at the extremities, or rarely truncated obliquely behind; surface nearly smooth, or finely radiately-striated; hinge-area with minute cross-striae; hinge denticles very fine and crowded. *T. perovalis*, Conrad. (Meek, 1876.)

In 1930, Stewart (73b, footnote, p. 86) made the following contribution: "*Breviarca* Conrad, Pr. Ac. Nat. Sc. Phila. 1872, p. 55. Proposed for two species, of which *Trigonarca safordi* (Gabb) Conrad, ibid., pl. 2, fig. 3, is here designated the type species."

BREVIARCA STEARNSII Gardner new species

Pl. 6, figs. 9, 10

Shell small, rather heavy, inflated, transversely elongate, obscurely rostrate posteriorly; hinge line horizontal, more than two-thirds the width of the entire shell; anterior lateral margin rounding smoothly into the arcuate base; posterior lateral margin produced at the ventral extremity and rather sharply rounded. Umbones broad, flattened, prominent, separated by a wide cardinal area, slightly anterior. Outer surface sculptured with a very fine but not very closely spaced concentric grooving regular upon the medial portion of the disk but interrupted toward the ventral margin by strong resting stages; surface overridden by an exceedingly fine radial lineation, least feeble anteriorly and upon the posterior slope. Cardinal area wide, rhombic in the double valves, microscopically lineated parallel to the hinge margin. Ligament area exceedingly narrow, subumbonal, amphidetic. Hinge teeth short, relatively heavy, set at right angles to the margin, the distal teeth oblique. Muscle scars very large. Pallial line simple following rather closely the simple inner margin of the valve.

Dimensions.- Height, 3.5 millimeters; length, 4.9 millimeters; semi-diameter, 1.7 millimeters.

Holotype.—U. S. Nat. Mus. No. 373167.

Type locality.- U.S.G.S. Sta. No. 5282, clay from bluff at Wellerville. Kincaid formation of Midway group.

Breviarca stearnsii is one of the few Midway species reminiscent of the Cretaceous. The fauna with which it is associated is one of the oldest known from the Eocene.

I have the pleasure of naming the species in honor of Stearns MacNeil, a Geologic Aid on the Federal Survey. He has for some time past been particularly interested in the superspecific groups of the taxodonts and he will later have something of interest to say upon the relationships of the breviarcas.

Genus ARCA (Linnaeus) Lamarck

1758. *Arca* Linnaeus, Systema naturae, 10th ed., p. 693.

1799. *Arca* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 87.

Type.- *Arca noae* Linnaeus. (Recent in the Mediterranean.)

Shell equivalve, oval or subquadrate. Valves closed or gaping ventrally. Sculpture generally heavy and radial. Hinge line long, straight, furnished with numerous transverse teeth. Umbones prominent, incurved, prosogyrate, separated by a rhomboidal ligamental area scarred with cartilage grooves. Margins smooth or crenulate. Pallial line simple. Adductor impressions subequal, strongly marked.

A genus represented by about 500 fossil species, which range from the Silurian onward, and by about 150 Recent species which are widely distributed in the warmer seas from between tides to abyssal depths.

The abundance of the representatives of this genus, their wide range in time and place, together with their rather more than normal sensitiveness to environmental conditions, make them of peculiar importance in stratigraphic work.

Though *Arca* is doubtless present in the Midway deposits in Texas, *Cucullaea* had not yet lost the prominence which it maintained during the Mesozoic, and continued to be the dominant representative of the Arcacea.

ARCA sensu lato species

A mold of a rather small, inflated valve rudely rectangular and with strongly anterior umbones, sculptured with some 20 fairly coarse ribs, occurs in the Littig glauconitic member of the Kincaid formation on Wilbarger Creek near Littig in Travis County (U.S.G.S. Sta. 11676), and probably also in the basal Kincaid (U.S.G.S. Sta. 11678) one-half to three-fourths of a mile above Cedar Creek road on Half Mile Creek, Austin quadrangle, Bastrop County.

Molds of other Littig species, probably referable to *Arca* sensu lato, occur in Caldwell County, 1½ to 2 miles south of Mendoza (U.S.G.S. Sta. 11681) and on the Martindale farm, 4 miles southwest of Lockhart (U.S.G.S. Sta. 11639).

There is no obvious reason why *Arca* should not be recovered from the higher horizons of the Midway, but its observed occurrence is practically confined to the basal greensand.

ARCA species indeterminate

The genus is clearly indicated by fragmentary and juvenile material from Butler Dome, one-fourth mile northwest of Gin Lake.

The general outline of the Midway species is similar to that of *A. hatchetigbeensis* Harris from the upper Wilcox but the Midway form is higher and more closely reticulated. The umbones are relatively high and narrow and there is a single pair of divergent grooves beneath the umbones. This is the only true *Arca* which has been reported from the Midway and it is unfortunate that the material is not more satisfactory.

Fragments have been collected from a number of localities in the Wills Point formation exposed on Butler Dome, Freestone County (U.S.G.S. Sta. 10718).

Genus GLYCYMERIS Da Costa

1778. *Glycymeris* Da Costa, British Conchology, p. 168.

Type. *Glycymeris orbicularis* Da Costa = *Arca glycymeris* Linnaeus. (Recent off the British Isles and the coast of Europe.)

Shell heavy, equivalve, equilateral or subequilateral, suborbicular. Beaks almost straight, only very slightly incurved. Hinge margin arcuate, set with two series of strong transverse teeth which are progressively obliterated during growth by the subsidence of the cardinal area. Exterior surface of valves concentrically or radially striate. Margins crenulate within. Adductor scars subequal. Pallial line simple or very slightly sinuous.

The genus originated in the Cretaceous, culminated in the Miocene, and is represented today by about 30 species, widely distributed in the shallower waters of the warm and temperate seas.

GLYCYMERIS species

A mold of a moderately compressed form about 2 centimeters in height and diameter was collected from the Tehuacana member of the Kincaid formation 3 miles west of the Farias ranch house on the south ranch road, eastern Maverick County.

A mold of a second species, about 3½ centimeters in height and width, also compressed with narrow, pointed sub-central beaks, distinct but not conspicuous muscle scars and a pallial line very close to the ventral margin is associated with *Volutocorbis limopsis* in the weathered glauconitic sands at the base of the Wills Point formation, U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass.

A worn exterior possibly of the same species was recovered from the outcrop of the Tehuacana at White Bluff. This valve is about 3

centimeters wide and retains traces of regular radials about 1 millimeter wide at the ventral margin of the disk and separated by linear grooves.

Superfamily PTERIACEA
Family PTERIIDAE
Genus PTERIA Scopoli

1777. *Pteria* Scopoli, Introductio ad historiam naturalem, p. 397.

Type.—*Mytilus hirundo* Linnaeus. (Recent off the coast of England and southward through the Mediterranean.)

Shell inequivalve, inequilateral, auriculate. Anterior ear comparatively small, posterior aliform. Byssal sinus under anterior auricle of right valve. Exterior surface almost smooth, lamellar or striated. Interior nacreous. Umbones low but sharp. Hinge line elongated, straight. A single cardinal tooth placed under the umbone of each valve, commonly supplemented by a laminar lateral tooth. Ligament marginal, partly internal, partly external. Pallial line entire. Adductor impression subcentral.

The genus has a vast stratigraphic range—from the Silurian onward. The Recent species number about 120 and live chiefly in tropical and subtropical waters. Among them may be mentioned the Antillean pearl oyster, *Pteria radiata* Leach.

The picturesque name of the type species was doubtless suggested by the outline of the shell, which is not unlike that of a swallow on the wing.

PTERIA DEUSSENI Gardner new species

Pl. 7, fig. 8

Shell small, obliquely semi-elliptical in outline, the straight dorsal margin equalling in length the maximum latitude. Umbones very small, acute, terminal, set about a third of the way back from the anterior margin. Posterior area about twice as great as the anterior—neither of them sharply delimited. Outer surface decorticated, but apparently marked with a very strong growth sculpture. Interior not accessible.

Dimensions.—Height, 4.5 millimeters; length, 4.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 370964.

Type locality.—U.S.G.S. Sta. 6559, Comanche Crossing on Navasota Creek about 6 miles west of Mexia, Limestone County, Texas. Tehuacana member of Kincaid formation.

The species is named in honor of the collector, Alexander Deussen, whose name is so intimately associated with the intelligent investigations on the Tertiary Coastal Plain of Texas during the decade from 1915 to 1925.

So imperfect a form would not be described if there were much hope of getting anything better in the near future but it is the first established record of the genus in the Midway of Texas and the characteristic outline and slight depression of the auricles should be sufficient to characterize it.

Occurrence.—Kincaid formation, Tehuacana member. *Limestone County:* U.S.G.S. Sta. 6559, Comanche Crossing on Navasota Creek, about 6 miles west of Mexia.

Fragments of a related and possibly though not probably identical species occur rather commonly in association with *Argyrotheca* at Butler Dome in Freestone County (U.S.G.S. Sta. 10713).

Superfamily OSTRACEA
Family OSTREIDAE
Genus GRYPHAEA Lamarck
Subgenus GRYPHAEOSTREA Conrad

1865. *Gryphaeostrea* Conrad, Am. Jour. Conchology, vol. 1, p. 15 (name only). Type.—*Ostrea subrotunda* Conrad = *Gryphaea vomer* Morton.

GRYPHAEOSTREA VOMER (Morton)

1828. *Gryphaea vomer* Morton, Acad. Nat. Sci. Philadelphia, Jour., 1st ser., vol. 6, p. 83.

Shell of moderate size, elongate, rudely ovate or elliptical, strongly inequivalve; attached left valve strongly convex, often irregular in outline over the area of attachment in the umbonal region. Left umbone inflated, tip prosogyrate and acutely pointed, when not flattened against the supporting surface; anterior and posterior dorsal margins of perfect and typically developed individuals produced into long, slender, auricular extensions somewhat similar to those of *Gryphaea convexa* Say. External surface of left valve smooth excepting for growth striations. Right cover-valve regularly sulcate, flattened, often a little sinuous and with a slight forward twist in the flattened umbonal region; external surface sculptured with conspicuous, fine-edged concentric laminae, 5 to 11 in number, regularly spaced, parallel to the outer margin and delimiting the outline of the shell during former stages of growth; hinge

area small, low, flattened as a rule, irregular in outline; submargins auriculately produced in the left valve, somewhat thickened but not produced in the right valve, not sculptured; muscle impressions elongated, rudely semi-elliptical, concentrically striated.

The characters of the attached valve of *G. vomer* are variable, the inflated umbones and smooth external surface constituting perhaps the best diagnostic of indifferently preserved individuals. The ovate outline and the elevated concentric laminae are sufficient to determine even a fragment of the right valve.

Gryphaeostrea vomer, a widespread and prolific species of the Upper Cretaceous, occurs, probably reworked, in the Littig glauconitic member of the Kincaid formation at the ford on Wilbarger Creek south of Littig in Travis County (U.S.G.S. Sta. 11676), and one-half mile east of the Travis-Bastrop County line, on the Austin-Bastrop road (U.S.G.S. Sta. 11620); 5 miles northwest of Lytton Springs in Caldwell County (U.S.G.S. Sta. 11690); and on an east-facing slope of the San Marcos River valley, one-half mile north of Staples in Guadalupe County (U.S.G.S. Sta. 13247).

Genus OSTREA (Linnaeus) Lamarck

1758. *Ostrea* Linnaeus, Systema naturae, 10th ed., p. 696.

1799. *Ostrea* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 81.

Type.—*Ostrea edulis* Linnaeus. (Recent off the European shores from Iceland to the Adriatic.)

Ostrea, the common oyster, is doubtless by reason of its great economic value the most widely known of the molluscan genera. The shell is inequivalve, generally irregular and more or less inequilateral. Except in the larval stages it is attached by the convex left valve. The right valve, which is flattened or slightly concave, serves as a cover. The hinge is edentulous. There is a single muscle scar, the posterior, and this is subcentral. The pallial line is simple but not well defined.

The genus has been prominent in all the molluscan faunas from the Mesozoic onward. Two hundred and forty species have been recognized in the Cretaceous alone, and throughout the Tertiary *Ostrea* forms one of the most conspicuous elements of nearly every fauna.

As in all attached forms, the variation is great but the Eocene oysters are many of them remarkably well characterized, widely dispersed, and of limited stratigraphic range and consequently of great service in correlation.

OSTREA PULASKENSIS Harris

Pl. 11, figs. 7, 8

1869. *Gryphaea vomer* Morton, Safford, Geol. Tennessee, p. 419 (name only). Not *Gryphaea vomer* Morton, 1828, Acad. Nat. Sci. Philadelphia, Jour., vol. 6, p. 83.

1881. *Gryphaea pitcheri* Morton?, White, U. S. Nat. Mus., Proc., vol. 4, p. 137. Not *Gryphaea pitcheri* Morton, 1834, Synopsis Organic Remains, Cretaceous Group U. S., p. 55.

1894, March. *Ostrea pulaskensis* Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 40, pl. 1, figs. 3 a–d.

1894, March. *Gryphaea vomer* Langdon, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 416.

1896. *Ostrea pulaskensis* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 46, pl. 1, figs. 2, 2a–c, 3, 3a.

1898. *Ostrea pulaskensis* Harris, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, p. 677.

1912. *Ostrea pulaskensis* Harris, Maury, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 15, p. 38, pl. 7, fig. 2.

Outline of the larger valve right angle-triangular; a carination from the umbo to the posterior basal margin forming the hypoteneuse, the basal margin the base, and the shorter margin from umbo to base the perpendicular with proportional lengths of 8, 7 and 5 respectively; beak generally very incurving; carination often very pronounced; between it and the margin of the valve are one or two more or less distinct sulci; surface comparatively smooth, though possessing a few slight concentric undulations which curving upwards in the middle of the valve, form a very shallow sulcus extending from beak to base; muscular impression not distinctly marked; lesser valve thin, flat, circular; marked exteriorly by lines of growth; smooth within with an oval muscular impression which is submarginally located.

This description and the figures referred to, show the most *Gryphaea*-like phase of this species. Other forms are less distinctly sulcate and carinate. (Harris, 1894.)

Dimensions.—Cotypes: height of figured left valve, 21.0 millimeters; unfigured left valve, 16.5 millimeters. Length of figured left valve, 17.5 millimeters; unfigured left valve, 15.0 millimeters.

Cotypes (2).—U. S. Nat. Mus. No. 135138.

Type locality.—Pulaski County, Arkansas.

Ostrea pulaskensis Harris is one of the most common and characteristic species of both the basal greensand and the lower part of the second greensand. Though the attached valve suggests *Ostrea vomer*, the cover valve lacks the strong concentric sculpture of that species. It is the characteristic species of the Sucarnoochee clay of Alabama.

Occurrence.—Kincaid formation. *Hopkins County:* U.S.G.S. Sta. 13353, 2 miles north of Cumby. *Hunt County:* U.S.G.S. Sta. 10264, 14 miles southeast of Greenville. *Kaufman County:* U.S.G.S. Sta. 11665, Water Hill, 5 miles northeast of Kemp. *Falls County:* U.S.G.S. Sta. 11931?, about 6 miles northwest of Kosse; and U.S.G.S. Sta. 10691, Brazos River just above the Falls County line. *Milam County:* U.S.G.S. Sta. 11926?, Milam Bluff, Brazos River, 0 to one-fourth mile below Falls County line; U.S.G.S. Stas. 11916? and 11924, Brazos River, 1 mile below Falls County line. *Travis County:* U.S.G.S. Sta. 11676, Wilbarger Creek, 1½ miles southwest of Littig. *Bastrop County:* U.S.G.S. Sta. 11897, 2½ miles west of Elgin, Elm Creek, east bank of East Fork, one-half mile back from road; U.S.G.S. Sta. 11678, one-half to three-fourths mile above Cedar Creek road on Half Mile Creek, Austin quadrangle, and U.S.G.S. Sta. 11909?, Cedar Creek, 3± miles southeast of Williams' store. *Caldwell County:* U.S.G.S. Sta. 11681, 1½ to 2 miles south of Mendoza; U.S.G.S. Sta. 11682, 6 miles due north of Lockhart in draw about one-half mile west of Austin-Lockhart road; U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart on the E. A. Moser farm, about one-half mile northwest of Simms Oil Company derrick; U.S.G.S. Stas. 11686 and 11683, 2 miles north of Lockhart. *Uvalde County:* U.S.G.S. Sta. 3131, Frio River, above waterhole opposite Evans' (Myrick's) apiary, below Englemann's ranch; and U.S.G.S. Sta. 11767, bed of Frio River above trail from Bob Evans' (Myrick's) apiary. *Zavala County:* U.S.G.S. Sta. 13218, northeast corner of sec. 19, E. B. Flowers' ranch, 4 miles west of north of the ranch house, 1.7 miles due south of Eagle Pass-Uvalde road crossing over Turkey Creek.

OSTREA species

A single cover-valve, sculptured only with the growth lines, thin-shelled, 3 by 1 centimeters, and with a small hinge area, was col-

lected from the Kincaid formation, 5½ miles north of Lockhart, Caldwell County (U.S.G.S. Sta. 11707).

OSTREA CRENULIMARGINATA Gabb

Pl. 10, fig. 2; Pl. 11, fig. 9

1860. *Ostrea crenulimarginata* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 393, pl. 68, figs. 40, 41.

1891. *Ostrea prae-compressirostra* Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 39.

1894. *Ostrea tumidula* Aldrich, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 242, pl. 14, figs. 1, 2; pl. 15, figs. 1, 2.

1891. *Ostrea compressirostra* Say, Langdon, *ibid.*, p. 413.
Not *Ostrea compressirostra* Say, 1824, Acad. Nat. Sci. Philadelphia, Jour., 1st ser., vol. 4, p. 132, pl. 8, fig. 2.

1896. *Ostrea crenulimarginata* Gabb, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 45, pl. 1, figs. 1, 1a; pl. 2, figs. 1, 1a; pl. 3, fig. 1.

1912. *Ostrea crenulimarginata* Gabb, Maury, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 15, p. 36, pl. 5, fig. 11; pl. 6, figs. 1–4.

Subtriangular, sometimes elongated oval; attached; portion of the outside of the shell not attached is very squamose; hinge about an equilateral triangle, central groove of the hinge deep; internal margin strongly crenate, muscular impression large; upper valve?

Dimensions.—Length, 2.2 in.; greatest width about 2 in.

Locality.—Found in a marl bank, two miles east of Middleton, Tenn. Rather common and associated with *O. denticulifera*, Con. (Gabb, 1860.)

The associated *Ostrea* is certainly not *O. denticulifera* and is probably the missing valve of the species which Gabb is describing.

Ostrea crenulimarginata Gabb is characterized by its broadly plicate lower valve and the concentrically lirate upper valve. The lower valve is frequently quite deep though it suffers the usual wide range in variation in outline of attached valves. The absence of radial plications upon the upper valve serves to separate it at once from the otherwise similar *Ostrea multilirata* Conrad. *Ostrea duvali* from the Wilcox of Bastrop and Guadalupe counties shares with *O. crenulimarginata* the radially plicate left valve and the concentrically sculptured right valve but the radials of *O. duvali* are characteristically finer, sharper, and more numerous.

A species which may be a variant of *Ostrea crenulimarginata* Gabb is rather common near the Cretaceous-Midway contact 7½ miles southeast of D'Hanis on the Yancey road (U.S.G.S. Sta. 6504). The left valve is strongly and evenly convex and apparently without radial fluting though the surface is decorticated and the characters

of the outer surface lost. The right valve is flattened and strongly laminated concentrically.

In Texas *Ostrea crenulimarginata* is most commonly found in the Tehuacana member of the Kincaid formation, especially in Limestone County.

Occurrence.—Tehuacana member of Kincaid formation. *Limestone County:* U.S.G.S. Sta. 6561, one-fourth mile west of Tehuacana; U.S.G.S. Sta. 11933, Tehuacana Quarry on Mexia road, Tehuacana. *Medina County:* U.S.G.S. Sta. 11770?, Hondo River bed, 1 mile northwest of New Fountain; and U.S.G.S. Sta. 6230?, Hondo Creek, one-eighth mile below road crossing due east of Elstone. *Uvalde County:* U.S.G.S. Sta. 11874, Frio River, just above Bob Evans' (Myrick's) apiary; and U.S.G.S. Sta. 11878, at the foot of trail leading down from Bob Evans' (Myrick's) apiary.

OSTREA KOCHAE Gardner new species

Pl. 8, figs. 1-5

Shell small for the genus, not very heavy, the left valve quite strongly convex, the right valve much less so and tending to thicken toward the beaks. Outline ovate-trigonal, the left valve much more pinched toward the umbones than the right. Surface concentrically sculptured by the free edges of the overlapping lamellae and more foliaceous in the left valve than in the right; no radical plications on either valve. Umbones and ligament area narrow and trigonal in the left valve, broad but not high in the right. Submargins strongly punctate in the left valve, feebly in the right. Ligament scar rather large but not impressed, crescentic in outline.

Dimensions.—Cotypes: height of right valve, 51.0 millimeters; left valve, 50.0 ± millimeters. Length of right valve, 41.5 millimeters; left valve, 39.0 millimeters.

Cotypes (2).—U. S. Nat. Mus. No. 370962.

Paratype.—U. S. Nat. Mus. No. 370963.

Type locality.—U.S.G.S. Sta. 6594, 7½ miles southeast of D'Hanis, Medina County, Texas. Tehuacana member of Kincaid formation.

I have the pleasure of naming this species in honor of Mrs. Koch of D'Hanis, Medina County, to whose kindness I owe much of the pleasure of my field work in that area.

The species is remarkable for the absence of any tendency toward a radial plication. It is a smaller and thinner shell than *Ostrea cyathiae* Maury from Soldado Rock, Trinidad. It is fairly common at the single locality but has not been recognized elsewhere.

Occurrence. Kincaid formation. *Medina County:* U.S.G.S. Sta. 6534, D'Hanis-Yancey road, 7½ miles east by south of D'Hanis.

OSTREA MULTILIRATA Conrad

1857. *Ostrea multilirata* Conrad, U. S. and Mex. Boundary Survey Rept., vol. 1, pt. 2, p. 157, pl. 12, figs. 1a–d.

1923. *Ostrea texex* Gardner, in Trowbridge, U. S. Geol. Survey, Prof. Paper 131-D, p. 109, pl. 29, figs. 6, 7; pl. 31, figs. 1–4.

1926. *Ostrea multilirata* Conrad, Gardner, Washington Acad. Sci. Jour., vol. 16, no. 19, pp. 513–514.

Subtriangular, thick and ponderous, somewhat curved; both valves flattened, irregularly undulated concentrically, and having numerous radiating interrupted folds; umbo flat, very thick; cardinal fosset long and somewhat curved, deep, cavity very shallow.

This is a remarkable species, very variable in form. I know of no cretaceous species like this or the preceding (*Ostrea cortex* Conrad), and as no other fossil was obtained with these, their geological age is uncertain; possibly they may belong to strata of earlier date than the cretaceous rocks of Texas.

Locality. Dry Creek, Mexico. (Conrad, 1857.)

Cotypes (a right and a left valve).—U. S. Nat. Mus. No. 9895.

Shell of only moderate dimensions for the genus, subequivalve, ovate-trigonal in outline, generally somewhat produced anteriorly; surface layer decorticated; both the right and left valves radiately sculptured with 15 to 20 fine, approximately uniform, rippling riblets, similar to those developed upon the attached valve of *O. crenulimarginata* Gabb; ligament area moderately large, somewhat flattened in the right valve, the medial depression relatively wide, broadly but not deeply excavated; growth striae obvious; lateral margins very finely crenate, the crenae persistent in some individuals around the entire inner margin; basal margin often fluted in harmony with the external sculpture; adductor scar crescentic, lying below the median horizontal, moderately large, not very deeply excavated; pedal scar obscure.

Dimensions. Right valve: altitude, 80 millimeters; latitude, 65 millimeters; left valve: altitude, 90 millimeters; latitude, 72 millimeters.

Type locality. Station 3925, a quarter of a mile northwest of Glass ranch headquarters, Uvalde County, Texas.

Ostrea texex is the analogue in southwestern Texas of *Ostrea crenulimarginata* of the Midway of Alabama. In the Alabama species, however, the right valve is smooth, but in those found along the Rio Grande the two valves are similarly sculptured. Toward the umbones the radials are sharply elevated, though they tone down into an even fluting toward the outer margin.

Ostrea tasex is probably identical with *Ostrea multilirata* Conrad, collected from the so-called Cretaceous of "Dry Creek, Mexico." Conrad's types are in the National Museum and are fairly well preserved. Nothing of the kind has been reported from the Cretaceous by later investigators who have collected extensively in the Rio Grande area. However, *Ostrea cortex*, collected at the same locality, is certainly a Cretaceous species, and until "Dry Creek" can be definitely located and the confusion in the stratigraphic relations cleared, the Wilcox form may well be kept apart. (Gardner, 1923.)

The name *tasex* was later rejected in favor of Conrad's *multilirata* because of the strong circumstantial evidence that Conrad had the Wilcox species in mind and hand and that he merely failed to recognize that its association with *O. cortex* was accidental. The two species are associated by the drainage both on the Texas and the Mexican side of the Rio Grande.

Ostrea multilirata is restricted to the Wilcox group, but a closely related form is scattered about in pockets at the top of the Tehuacana member of the Kincaid formation. These, too, may be Wilcox but there is no other evidence of Wilcox nearby.

OSTREA MULTILIRATA SABINALENSIS new subspecies

Pl. 9, figs. 1, 2

Shell rather small for the genus, subequivalve, falcate or spatulate, commonly with a large attachment area; epidermis decorticated; valves similarly sculptured with 25 to 40 radials, sharply elevated and in many individuals acutely ridged, and crenulated upon the margin and at the intersection with the concentric laminae. Shell built up of overlapping concentric layers so that it thins toward the ventral margin, and is very heavy toward the umbones. Ligament area moderately large, relatively flat in the right valve, medially depressed in the left, both valves with a slight posterior twist to the umbones. Lateral margins finely pitted. Adductor scars of moderate dimensions, semi-elliptical to crescentic, posterior and below the median horizontal. Pedal scar obscure.

Dimensions.—Right valve: height, 50.0 millimeters: length, 33.0 millimeters. Left valve: height, 60.0 millimeters; length, 37.0 millimeters.

Cotypes (2).—U. S. Nat. Mus. No. 370906.

Type locality.—U.S.G.S. Sta. 6273. Schuddemagen ranch, 11 miles south of Sabinal. In pockets at top of the Tehuacana member of Kincaid formation.

The subspecies *sabinalensis* is very close to *multilirata* Conrad and was included under it in the reconnaissance report upon the Gulf Coastal Plain (51). It has thus far been recognized only from the type locality. It is smaller than *Ostrea multilirata* Conrad and is, as a rule, more finely and sharply sculptured though the differences are all of degree rather than kind.

Occurrence.—Indio formation(?). *Uvalde County:* U.S.G.S. Stas. 6273 and 11766, Schuddemagen ranch, south bank of Elm Creek, 11 miles south of Sabinal.

It is possible that these oysters may be of appreciably later age than the Tehuacana on which they rest. They are loose and segregated in slight depressions in the limestone. There is a heavy cover of Reynosa gravel, but no evidence of Wilcox other than the *Ostrea* which so closely resembles *multilirata* has been observed.

OSTREA species

A small form, scarcely 20 millimeters in altitude, the left valve fluted with 7 or 8 strong radials, which do not persist to the umbones, the right valve closely laminated concentrically was collected at a number of localities in Medina County. This may be identical with or a varietal form of *Ostrea crenulimarginata*. Palmate Bryozoa are frequently associated with the *Ostrea*.

Occurrence.—Kincaid formation. *Medina County:* U.S.G.S. Sta. 6231, Hondo Creek, left bank, one-fourth mile above road crossing due east of Elstone; U.S.G.S. Sta. 6230, loose boulder, bed of Hondo Creek, one-eighth mile below the road crossing due east of Elstone.

Superfamily PECTINACEA
Family PECTINIDAE
Genus AMUSIUM ("Bolten") Roeding

1798. *Amusium* ("Bolten") Roeding, Museum Boltenianum, 1st ed., pt. 2, p. 165.

Type.—*Ostrea pleuronectes* Linnaeus. (Recent in the Indo-Pacific.)

The valves are commonly large, thin, and feebly convex and like those of the true Pectens are not attached by a byssus. Radial sculpture is sometimes suggested by the color pattern but is rarely developed and is never strong. A concentric imbrication may be observed in some species, particularly toward the ventral margin. The discrepancy in ornamentation so common in *Pseudamussium* is reflected in the discrepant coloring in *Amusium* s.s. In *Amusium*

papyraceum, the Recent Antillean shell, the right valve is white or bordered with pale yellow, but the left is a deep reddish or purplish brown. This general type of color holds throughout *Amusium* s. s. The lirae developed upon the inner surface of the disk are perhaps the most constant diagnostic of the genus.

Like *Pecten*, *Amusium* may be traced back to the Mesozoic. The thin, internally lirate shells of *Amusium* require a much more specialized habitat than the heavy, externally ribbed shells of most of the Pecten group, and perhaps for this reason the genus is relatively rare.

Subgenus PARVAMUSSIUM Sacco

1897. *Parvamussium* Sacco, I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 24, p. 48.
= *Propamussium* Dall, 1898, Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, p. 698 (in part).
Not *Propamussium* De Gregorio, 1881, Naturalista Siciliana, vol. 3, Nota intorno ad alcune nuove conchiglie mioceniche di Sicilia, p. 119. Type, *Pecten (Propamussium) Cecilioe* De Gregorio (Miocene of Italy).
= *Parvamussium* Woodring, 1925, Miocene Mollusks from Bowden, Jamaica, Carnegie Inst. Washington, Pub. 366, p. 74.

Type by original designation.—*Pecten duodecim-lamellatus* Bronn (Miocene and Pliocene of Italy).

The subgenus is characterized by the small, delicate valves, the small, subequal auricles, the fine concentric imbrication, and the distant internal radials which do not persist to the ventral margin.

The representatives of this small group are not abundant but they are widely distributed both in time and space.

AMUSIUM (PARVAMUSSIUM) ALABAMENSE (Aldrich)

1886. *Pecten (Pleuronectia) alabamensis* Aldrich, Geol. Survey Alabama, Bull. 1, p. 40, pl. 4, fig. 8.

1890. *Pecten (Amussium) alabamiensis* Aldrich, De Gregorio, Annales Géol. et Pal., vol. 8, p. 183, pl. 21, fig. 26 (after Aldrich).

1894. *Pecten alabamensis* Aldrich, Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 41.

1896. *Pecten alabamensis* Aldrich, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 48, pl. 2, fig. 3.

1898. *Pecten (Propamussium) alabamensis* Aldrich, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, p. 757.

Shell small, suborbicular; upper valve covered with equidistant concentric lines which run over upon the anterior ear; a few raised radial lines upon the center and anterior side; ears small; right valve nearly smooth; within both valves eight raised prominent rounded ribs, becoming obsolete as they approach the beak.

Locality.—Matthews' Landing, Ala.

Seems to unite *Pleuronectia* and *Pecten*. One specimen shows concentric striae and ribs in the younger part of the shell, these becoming obsolete toward the ventral margin. (Aldrich, 1886.)

Dimensions.—Height, 3.6 millimeters; length, 3.5 millimeters.

Holotype.—Aldrich Collection, Johns Hopkins University, Baltimore, Maryland.

These small discrepantly sculptured valves are quite unlike any co-existing Midway form.

There is a considerable range of variation in the sharpness of both the radial and concentric sculpture in the left valve. This is true not only of the Texas individuals but also of those from Alabama.

Harris considered *A. alabamense* a probable subspecies of the Wilcox (Bashi) form which he referred to *A. squamulum* Lamarck of the Paris Basin. Though the specific lines are now more sharply drawn, the similarities are sufficiently great to be a factor in correlation.

Occurrence.—Kincaid formation. *Falls County:* U.S.G.S. Sta. 11942?, one-fourth mile southeast of Big Hill. *Milam County:* U.S.G.S. Sta. 11926?, Brazos River, Milam Bluff, 0 to one-fourth mile below Falls County line; U.S.G.S. Sta. 11920?, Brazos River, one-eighth mile below Milam Bluff; and U.S.G.S. Stas. 11917? and 11921, Brazos River, 1 mile below the Falls County line. *Bastrop County:* U.S.G.S. Stas. 11914, 11915, and 12112, Colorado River, 4 to 5 miles below Webberville.

Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11697, 3 miles southwest of Cedar Creek Post Office. *Bexar County:* U.S.G.S. Sta. 8215, 5.3 miles southeast of San Antonio Post Office Building.

Superfamily MYTILACEA
Family MYTILIDAE
Genus MODIOLUS Lamarck

1799. *Modiolus* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 87.

Type.—*Mytilus modiolus* Linnaeus. (Recent in the Arctic Ocean and the North Atlantic.)

Shell equivalve, inequilateral, transversely or obliquely ovate in outline; ligament marginal, opisthodetic; hinge edentulous; anterior muscle impression atrophied; pallial line simple.

The genus is separated from *Mytilus* by the character of the beaks, which are nonterminal, wider, and rounded anteriorly. It has a long geologic range, at least from the beginning of the Mesozoic and possibly from the Devonian. The Recent species are about 70 in number and are most abundant in the tropical seas. Unlike *Mytilus*, the representatives of *Modiolus* are nest-builders and burrow or spin a woven structure from stones and fragments of shells.

Subgenus BRACHIDONTES Swainson

1840. *Brachidontes* Swainson, Treatise on malacology, p. 384.
Type.—*Modiola salenta* Lamarck. (Recent in the Indian Ocean.)

Brachidontes is characterized by the radially sculptured surface and the non-hirsute epidermis.

MODIOLUS (BRACHIDONTES) SAFFORDI (Gabb)

Pl. 8, figs. 8, 9

1860. *Modiola safordi* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 395, pl. 68, fig. 30.
1869. *Modiola safordi* Gabb, Safford, Geol. Tennessee, p. 419 (name only).
1896. *Modiola safordi* Gabb, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 49, pl. 3, figs. 4, 5.

Gibbous, widened posteriorly; beaks small, anterior; umbones very large; umbonal ridge prominent, rounded, with a rounded furrow anterior to it; cardinal margin nearly straight, posterior margin rounded, anterior wide and regularly rounded, basal sinuous; surface marked by regular radiating ribs, except a small space between the umbonal ridge and the beak, leaving a little more than one-third of the basal portion plain, or only marked by lines of growth.

Dimensions.—Length .3 in., width .6 in., greatest height of valve .2 in.

Locality.—From the marls and alternating limestone of the Ripley Group, Hardeman Co., Tenn. (Gabb, 1860.)

The type has been lost.

Figured specimens.—U. S. Nat. Mus. Nos. 370907 and 370908.

The shell is thin and fragile and slightly nacreous; the umbones almost but not quite terminal. The radials are, for the most part, simple but occasionally anastomosing, and fairly uniform in size and spacing. In front of the umbonal ridge toward the umbones,

the radials are confined to the exceedingly thin epidermis which is easily decorticated, revealing an apparently fresh surface beneath sculptured only with prominent growth lines. On the small expanded portion directly in front of the beaks, the radials are sufficiently strong to flute the margin. The minute taxodont denticulations upon the inner margin probably represent an impingement of the radial sculpture. The provinculum is present in all of the few individuals observed but no true teeth are developed.

Although determinable specimens have been recovered only from the Kincaid, fragments of a similar species are present in the Wills Point (U.S.G.S. Sta. 12113) directly above the *Venericardia bulla* zone on the Colorado River.

The small size of *M. saffordi* and the character of the subcutaneous sculpture suggest *Modiolaria*.

Occurrence.—Kincaid formation. *Limestone County:* U.S.G.S. Sta. 11935, 7½ miles northwest of Groesbeck on the Thelma road. *Bastrop County:* U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line. *Medina County:* U.S.G.S. Sta. 6230, Hondo Creek, one-eighth mile below road crossing due east of Elstone. *Maverick County:* U.S.G.S. Sta. 11753, Bibora tank, 7 miles east of new Indio ranch house; and U.S.G.S. Sta. 11753?, near the Indio Wells, about 29 miles southeast of Eagle Pass.

Genus LITHOPHAGA ("Bolten") Roeding

1798. *Lithophaga* ("Bolten") Roeding, Museum Boltenianum, pt. 2, p. 156.
Type. *Mytilus lithophagus* Linnaeus. (Recent in the Mediterranean.)

Shell thin, nacreous, equivalve, strongly inequilateral, transversely elongated, more or less cylindrical in outline. Umbones strongly anterior, but not terminal. Anterior extremity rounded. Posterior extremity rostrate or cuneiform. External surface smooth or feebly sculptured concentrically. Ligament submarginal. Hinge edentulous. Muscle impressions unequal, indistinct.

The genus has been reported from strata as far back as the Carboniferous. The Recent species number less than 50 and are confined to tropical and subtropical waters.

The young are attached by a byssus but in the later stages usually perforate coral colonies, the shells of larger bivalves, or even the solid rock. Two of the five subgenera into which the group has been divided are incrusted with a dense calcareous covering in the

adult stages. The cavities which they excavate are characteristically flask-shaped in outline. The perforations in the columns of the temple of Serapis, which served Lyell for his classic illustration of changes in the level of the sea, were made by Lithophagae.

LITHOPHAGA species

Elongate ovate bodies some 25 to 30 millimeters long and 10 to 15 millimeters in maximum diameter occur in the bluff on the Frio River, one-half mile above the Evans' (Myrick's) apiary. They are probably *Lithophaga* burrows.

Occurrence.—Kincaid formation, Tehuacana member. *Uvalde County:* U.S.G.S. Sta. 3178, three-fourths of a mile northwest of the Evans' (Myrick's) apiary, north of the Frio River; and U.S.G.S. Sta. 3179, bluff on Frio River, one-half mile northwest of the Evans' (Myrick's) apiary.

Superfamily ANOMIACEA
Family ANOMIIDAE
Genus ANOMIA (Linnaeus) Müller

1758. *Anomia* Linnaeus, Systema naturae, 10th ed., p. 700 (part).
1776. *Anomia* Müller, Zoologiae danicae, prodromus seu animalium, p. 248.

Type.—*Anomia ephippium* Linnaeus. (Recent from the Arctic Ocean, off the European shores, to the Aegean archipelago; fossil in the Pliocene of England and Italy and the Pleistocene of Scandinavia.)

Shell inequivalve, adherent, generally subcircular or oblong. Left valve more or less convex, right valve flattened. Hinge margin of left valve commonly incurved and slightly thickened. Ligament scar found directly beneath left umbone. Interior of disk of left valve scarred with an adductor and a major and minor byssal impression, the major byssal scar being the largest of the three and dorsal to the adductor and minor byssal scars, which are usually subequal; interior of right valve containing foraminal opening and, ventral to it, the impression of the adductor muscle; posterior dorsal margin of right valve carrying an inconspicuous ligamental process. Pallial line simple.

Ancestral forms of this genus have been recognized in rocks as ancient as the Devonian. The Recent species number about 40 and are widely distributed along the shores from low-water mark to 100 fathoms.

An indeterminate specimen of *Anomia* was collected from the bluff at Webberville on the Colorado River, Travis County. It may possibly be reworked from the underlying Cretaceous.

Order ANOMALODESMACEA Dall
Superfamily ANATINACEA
Family PERIPLOMATIDAE
Genus PERIPLOMA Schumacher

1817. *Periploma* Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 115.

Type.—*Periploma inaequicostis* Schumacher. (Recent in the West Indies.)

Shell subnacreous, inequivalve, nearly closed, oval or rounded; umbones opisthogyrate; ligament internal, supported by two vertically or anteriorly directed chondrophores; hinge edentulous; muscle impressions unequal; pallial sinus broad and shallow.

The genus is rare in the Tertiary and the Recent forms are for the most part restricted to the eastern coast of the Americas.

PERIPLOMA species

A species uncommonly well characterized by a prominently and acutely elevated ridge delimiting the posterior area is unfortunately represented only by fragments of the umbonal portion. These were recovered from Wills Point clays above the *Venericardia bulla* zone on the Colorado River (U.S.G.S. Sta. 12113).

PERIPLOMA species

Fragments of a compressed, ovate trigonal concentrically sculptured bivalve apparently referable to *Periploma* occur at a number of localities in the Kincaid formation.

Occurrence.—Kincaid formation. *Limestone County:* U.S.G.S. Sta. 11942, one-fourth mile south of Big Hill, in roadside ditch. *Falls County:* U.S.G.S. Sta. 11932, one-fourth mile northwest of Stranger School. *Milam County:* U.S.G.S. Sta. 11916, Brazos River, 1 mile below Falls County line, bed No. 1, and U.S.G.S. Sta. 11921, Brazos River, 1 mile below Falls County line.

Order TELEODESMACEA
Superfamily ASTARTACEA
Family ASTARTIDAE
Genus ASTARTE Sowerby

1816. *Astarte* Sowerby, Mineral conchology of Great Britain, vol. 2, p. 85 (81 in index), pl. 137.

Type.—*Venus scotica* Maton = *Pectunculus sulcatus* Da Costa. (Recent off the British coast.)

Shell small or of medium size, heavy, compressed trigonal, the umbones often flattened and at the apex of the obliquely truncate dorsal margins; ventral margin broadly rounded. Lunule impressed, the escutcheon less clearly defined. Outer surface concentrically corrugated, rarely reticulate; ligament external; right anterior and posterior cardinals commonly atrophied, the medial cardinal very heavy and deltoid; left anterior and medial cardinals strong, the posterior cardinal fused with the ligament nymph; muscle scars distinct; pallial line simple; inner margins usually dentate.

Astarte differs from *Crassatellites* chiefly in the more trigonal outline, usually smaller size, and in the external rather than internal ligament.

A single individual, quite certainly referable to this characteristically cold water genus, was collected by Deussen from the lower Midway clays of the Kincaid formation in the bluff at Webberville, Travis County (U.S.G.S. Sta. 5232), a locality that it has not been possible to find during the later field seasons. The *Astarte* in question is small, less than 4 millimeters in altitude, compressed, concentrically wrinkled, the furrows increasingly strong toward the ventral margin and cut into beads by radial grooves.

Family CRASSATELLITIDAE
Genus CRASSATELLITES Krüger

1823. *Crassatellites* Krüger, Geschichte der Urwelt, vol. 2, p. 466.

Type.—*Crassatellites sinuatus* Krüger = *Crassatella gibbosula* Lamarck. (Eocene of the Paris Basin.)

Shell slightly inequivalve, inequilateral, subquadrate or subtrigonal in outline, the umbones anterior, and usually prominent; lunule and escutcheon distinctly depressed; surface sculpture feeble, as a rule, concentric and commonly confined to the umbonal area; ligament and resilium internal; dentition vigorous; three cardinals in the right valve, the posterior frequently effaced by the resilium and two cardinals in the left; anterior margin of the right valve and the posterior margin of left grooved to receive the beveled edge of the opposite valve; muscle scars distinct, impressed; pallial line simple; ventral inner margins dentate.

The genus apparently originated in the Cretaceous, culminated in the Tertiary, and is represented in the Recent faunas by about 40

species, which are confined chiefly to the tropical seas. The Midway *Crassatellites* are not abundant excepting in the Colorado River section but they are widely distributed both in the vertical section and through the area of outcrop.

CRASSATELLITES GABBI (Safford)

1860, November. *Crassatella pteropsis* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 395, pl. 68, fig. 28.

Not *Crassatella pteropsis* Conrad, February, 1860, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 279, pl. 46, fig. 9.

1864. *Crassatella gabbi* Safford, Am. Jour. Sci., 2d ser., vol. 37, p. 368. (Change of name only.)

1869. *Crassatella gabbi* Safford, Geol. Tennessee, p. 419 (name only).

1894. *Crassatella tumidula* Whitfield, Aldrich in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 242.

1894. *Crassatella* sp. Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 43.

1896. *Crassatella gabbi* Safford, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 63, pl. 5, figs. 7–9.

Subtriangular, flattened; beaks very small; in some specimens a slight depression in advance of the umbonal ridge, which is rounded; surface marked by heavy transverse ribs, which become faint on and behind the umbonal ridge; hinge rather small; muscular scars deeply impressed; cardinal margin straight, anterior margin regularly rounded, basal margin slightly sinuous, posterior subangular.

Dimensions.– Length, .9 in.; width, 1.4 in.; height of valve, 2 in.

Locality.–Ripley group, Hardeman Co., Tenn., Prof. Safford; and from the same formation at Eufala, Ala. Collection of the Smithsonian Institution, No. 553. (Gabb, 1860.)

The nomenclature of the Midway species has been very much confused. In February, 1860, Conrad described from the Ripley formation of Tippah County, Mississippi, a form which he called *Crassatella pteropsis*. In November of the same year Gabb described under the same name another form from Hardeman County, Tennessee, from greensand which he at that time considered Cretaceous but which has later proved to be Midway. This he figured but the species which he labelled *Cotype* from Eufala, Alabama, is distinct from the Hardeman County species and has been referred to the true *C. pteropsis* by the Cretaceous geologists. The dimensions are those of No. 553 of the Smithsonian Institution from Eufala. The Cretaceous species was later renamed *C. cuneata* by Gabb (1861), the Midway species, *C. gabbi* by Safford.

Crassatellites gabbi from the lower Midway differs from the slightly higher *ioannes* in the more obtuse and more distant umbonal sculpture developed over a greater part of the shell. The relative dimensions vary quite widely in both species. Well preserved material, both juvenile and adult, is needed for the satisfactory determination of this group.

Occurrence.—Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665?, Water Hill, 5 miles northeast of Kemp; and U.S.G.S. Sta. 10744?, 2½ miles northeast of Kemp on public road. *Falls County:* U.S.G.S. Sta. 11932?, one-fourth mile northwest of Stranger School. *Bastrop County:* U.S.G.S. Sta. 11678?, one-fourth to three-fourths mile above Cedar Creek road on Half Mile Creek. *Caldwell County:* U.S.G.S. Sta. 11633, about 4 miles south of Lytton Springs, east of Lockhart-Lytton Springs highway. *Guadalupe County:* U.S.G.S. 13247, east-facing slope of San Marcos River valley, one-half mile north of Staples. *Medina County:* U.S.G.S. Sta. 11876?, 1 mile east of church at Quihi. *Maverick County:* U.S.G.S. Sta. 6575?, White Bluff on Rio Grande River, 4½ miles west of south of Windmill (Jacal) ranch house.

CRASSATELLITES species

1896. *Crassatella gabbi* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 63, pl. 5, figs. 10, 11. (Text and figs. 7–9 excluded.)

1861. *Not Crassatellites gabbi* Safford, Am. Jour. Sci., 2d ser., vol. 37, p. 368.

The forms from the Kincaid section on the Brazos River possibly represent a distinct species allied to *Crassatellites gabbi*. The outline is higher than that of the usual *C. gabbi*, and the entire outer surface with the exception of the posterior and ventral areas is rather closely rippled. Near the ventral margin the sculpture flattens into prominent growth lines and on the posterior area it becomes obsolete. Molds are abundant at Milam Bluff (U.S.G.S. Sta. 11926) just below the Falls County line and juveniles apparently referable to this species at the upper end of Cribbs Bluff (U.S.G.S. Stas. 11916 and 11921) but there is no adequate adult material. The concentric sculpture is closer than that of the average *C. gabbi* and seems to be much more regular upon the adult disk.

CRASSATELLITES IOANNES Gardner new species

Pl. 11, fig. 1-6

Shell of moderate dimensions, rather thick and heavy. Outline ovate-trigonal, more inflated than most of the genus. Umbones prominent by reason of their position at the apex of an angle of more than 90°, flattened upon their summits, incurved, prosogyrate, placed within the anterior third. Anterior extremity short, broadly rounded. Posterior extremity produced, but not angulated. Posterior ridge increasingly obtuse toward the basal margin, defined by the direction of the incrementals as well as by the outline of the valve. Lunule cordate, wider in the left valve than in the right. Escutcheon narrow, lanceolate, sharply defined, wider in the right valve than in the left. Umbones sculptured with prominent, closely and regularly spaced concentric ridges, acute at the tips, subacute away from the tips, giving place abruptly to an incremental sculpture more pronounced toward the extremities than that upon the medial portion of the disk; linear radials corresponding to the crenae of the inner margins often obscurely developed near the basal margin. Resilifer cuneate, relatively very large, apparently crowding and distorting the cardinals. Anterior cardinal of right valve much reduced, merged with the lunular margin; medial cardinal cuneate, rather thin for the genus. Margin of resilial pit sharply elevated but no true posterior cardinal developed; the two cardinals of the left valve short and not very heavy. Interior of shell thickened over the surface of the adherent mantle, throwing into prominence the relatively small adductor scars and the simple pallial line. Inner margins finely and sharply crenate.

Dimensions.—Holotype: height, 27.0 millimeters; length, 44.0 millimeters; diameter of double valves, 23.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370909; paratype, U. S. Nat. Mus. No. 370910.

Type locality.—U.S.G.S. Sta. 5230, Colorado River, 4 miles below Webberville. Stratigraphically below the *Venericardia hulla* zone of Kincaid formation.

Crassatellites ioannes is usually a little more produced posteriorly than *C. gabbi* Safford, but the outlines of both species vary within rather wide limits. The umbonal sculpture seems to be a more constant character. In *C. ioannes*, it is finer and more regular than in

C. gabbi, usually persistent across the posterior area, but unlike *C. gabbi* and the Brazos River *Crassatellites* is restricted, as a rule to the umbonal region. It has not been certainly recognized excepting upon the Colorado.

I have the sincere pleasure of naming this species in honor of Mrs. Helen Jeanne Plummer. For her cordial interest and the graciousness with which she has shared her intimate knowledge of the Texas Tertiary section I am greatly indebted.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 5290 and 10526, 4 miles below Webberville; and U.S.G.S. Stas. 11696, 11914, and 12112, 1½ miles below the Travis-Bastrop County line.

Wills Point formation. *Bastrop County:* U.S.G.S. Stas. 10527? and 12113?, 4½ to 4¾ miles below Webberville.

Superfamily CYRENACEA
Family CYRENIDAE
Genus CORBICULA Megerle von Mühlfeldt

1811. *Corbicula* Megerle von Mühlfeldt, Entwurf eines neuen System's der Schalthiergehäuse, Magazin der Gesellschaft Naturforschender Freunde, 5ter Jahrgang, Berlin, p. 56.

Type.—*Tellina fluminalis* Müller. (Recent in the Euphrates River.)

Shell usually heavy, sub-trigonal or cordate; not markedly inequilateral; umbones sub-central, high and prominent; lunule and escutcheon not defined; external surface smooth or concentrically furrowed; epidermis polished; cardinals three in each valve, diverging fan-like beneath the umbones; both anterior and posterior laterals developed, finely striate transversely; pallial line little or not at all sinuated.

Corbicula is abundantly represented in the non-marine Cretaceous and lower Tertiaries of the Western Interior, at a few restricted localities in the marine Tertiaries of the East Coast and Gulf and in the Eocene of the Paris Basin. The Recent species are confined exclusively to the rivers and lakes of the Eastern world.

CORBICULA TEXANA Gardner new species

Pl. 8, fig. 6, 7

Shell of moderate dimensions, high and rounded trigonal, broadly inflated in the umbonal area. Umbones very prominent, slightly anterior, the tips incurved and prosogyrate. Lunule and escutcheon

not defined. Outer surface coarsely wrinkled concentrically, but no regular sculpture developed. Hinge known only from a fragment of the left valve. Three divergent cardinals, the medial bifid, slender and not greatly produced, finely striate transversely.

Dimensions.—Height, 26.0 ± millimeters; length, 28.9 millimeters.

Holotype.—U. S. Nat. Mus. No. 370930.

Type locality.—U.S.G.S. Sta. 6279, Schuddemagen ranch, 11 miles south of Sabinal, a few hundred yards south of the junction of Elm Creek with Sabinal Creek, Uvalde County, Texas. Kincaid formation, Tehuacana member.

Corbicula has not been previously recorded from the Midway.

Occurrence.—Kincaid formation, Tehuacana member. *Medina County:* U.S.G.S. Sta. 6534, D'Hanis-Yancey road about 7½ miles east of south of D'Hanis. *Uvalde County:* U.S.G.S. Stas. 6279 and 11765, 11 miles south of Sabinal on Elm Creek.

Superfamily CARDITACEA
Family CARDITIDAE
Genus VENERICARDIA Lamarck

1801. Lamarck, Système des animaux sans vertèbres, p. 123.

Type by subsequent designation.—*Venericardia imbricata* Lamarck = *Venus imbricata* Gmelin (Schmidt, Chr. Fr., Versuch über die beste Einricht. zur. Aufstell., Benhandl. und Aufbewahr. der ver-chied. Naturkörper und Gegenstände der Kunst, vorzüglich der Conchyliensammlungen; nebst kurzer Beurtheil. der conchyliolog. Systeme . . . 1818, pp. 57, 176.)

Shell of moderate dimensions, from 25 to 40 millimeters high and slightly wider; diameter more than two-thirds the height; shell not very heavy, evenly but not strongly inflated. Umbones anterior, not conspicuously prominent, but well rounded to their tips which are turned inward and forward and are almost in contact, the right umbone slightly higher than the left. Lunule exceedingly small, subumbonal, slightly less narrow in the right valve than in the left. Escutcheon not defined. Anterior extremity short, rounding smoothly into the arcuate base line. Posterior extremity obtusely truncate. Posterior area indicated only by the obscure truncation, a slight flattening of the shell and a slightly closer spacing of the radials. Sculpture of 30 to 33 narrow /\-shaped radials, sharply crenate near the tips of the umbones, outlined on the adolescent and adult stages by a heavy, sharply noded cord. Ligament opisthodetic, deeply inset,

produced for more than half the length of the dorsal margin. A short thin laminar anterior cardinal, an obliquely produced cuneate medial and a much produced laminar posterior cardinal in the right valve: a moderately heavy anterior and a produced laminar posterior cardinal in the left valve, a faint grooving barely perceptible on the lateral surfaces of the heavier teeth; no true laterals developed but a slight pucker in the shell at the extremity of the lunular groove possibly analogous to an anterior lateral. Pedal scar small but deeply impressed, close to the margin just above the dorsal extremity of the deeply impressed pyriform anterior adductor scar. Posterior adductor less deeply impressed, semi-elliptical. Pallial line obscure, simple. Inner margins deeply crenate.

The description is based upon genotypes from the Paris Basin.

The type is one of a rather large group of closely related species abundantly represented in the Paris Basin. *Venericardia rotunda* from the Gulf Eocene, especially the larger individuals from the Claiborne sand, has very much the same general aspect, and more closely resembles *V. imbricata* than does the coarser, more inflated *V. alticostata* with which *imbricata* has been commonly compared.

Venericardia is separated from *Cardita* by the dentition of the right valve. In *Cardita* there is a heavy, more or less cuneate, subumbonal cardinal, and behind it an obliquely produced, often laminar posterior cardinal; in *Venericardia*, there is in addition to these two teeth, a third right cardinal, which is short and thin, and anterior to the heavy subumbonal tooth.

Venericardia is one of the most prominent genera of the Mollusca of the Midway fauna. Its interest, however, is derived less from its local distribution than from the world-wide dispersion not merely of the genus but of restricted groups within the genus. Conrad characterized the *Venericardia planicosta* as "the finger post of the Eocene" and as such it has served in the major correlations on two hemispheres. A large number of the Texas venericardias have not been recognized elsewhere. Of those remaining, *Venericardia alticostata*, first described from the Claiborne, is a wide-ranging, long-lived type and its occurrence is without great significance. The striking resemblance and abundant occurrence of *V. bulla* Dall at the base of the Wills Point formation in Texas, and *V. wilcoxensis* Dall of the Naheola formation of Alabama is highly significant.

Both the *planicosta* and *alticostata* groups are represented in the Midway Eocene faunas of Soldado Rock, off the southwest corner of Trinidad, and it was largely on the basis of the *Venericardia* faunas that the correlation with the Midway of the Gulf was founded. This, according to the present records, is the southern outpost of *V. planicosta*, sensu lato, and Miss Maury has estimated the known east and west range of the single group, including *V. hornii* from the Tejon formation of California, as over 6000 miles; the north and south range as 2650 miles.

Radials simple.
  Outline ovate trigonal; length exceeding 40 millimeters.
    Radials low, broad, not exceeding 25. *Venericardia (Venericor) jewetti* Gardner n. sp.
    Radials narrow, elevated, exceeding 25. *Venericardia (Venericor) smithii* Aldrich.

Radials tripartite.
  Valves highly inflated.
    Shell transversely elongated; length exceeding 50 millimeters. *Venericardia (Glyptoactis) alticostata* (Conrad).
    Shell almost as high or higher than it is long; length not exceeding 50 mm.
      Radials exceeding 25. *Venericardia (Glyptoactis?) bulla* Dall.
      Radials not exceeding 25. *Venericardia (Glyptoactis?) hesperia* Gardner.
  Valves not highly inflated.
    Length exceeding the height.
      Radials usually exceeding 25, crowded medially. *Venericardia (Glyptoactis) crenora* Gardner n.sp.
      Radials not exceeding 25, not crowded medially. *Venericardia (Glyptoactis) moa* Gardner n.sp.
    Length approximately equal to the height. *Venericardia (Glyptoactis) moa* Gardner n.sp.

Subgenus VENERICOR Stewart

1930. *Venericor* Stewart, Ralph, Gabb's California Cretaceous and Tertiary type Lamellibranchs, Acad. Nat. Sci. Philadelphia, Special Pub. 3, p. 153.

Type by original designation. *Venericardia planicosta* Lamarck (Eocene of the Paris Basin and of the Bracklesham Beds of England).

Shell large, heavy, its apparent inflation increased by the thickness of the shell. Outline trigonocordate, strikingly cordate in the profile of the double valves. Umbones inflated, turned inward and forward, that of the right valve a little higher and fuller than the left,

placed well forward. Lunule narrow, deep, slightly wider in the right valve than in the left and deeper in the left valve than in the right, delimited by a groove that strongly dents the inner margin. Escutcheon not defined. Anterior extremity short, rounding obliquely into the upcurved base; posterior lateral margin obscurely truncate. Posterior area indicated by the obtuse flattening of the shell and a change in the character of the radial sculpture. Radials 26 on the antero-medial portion of the left valve, possibly one more on the right and 7 on the posterior area of each, the earliest ribbing very narrow, sharply crested and finely crenate, the adolescent and early adult ribs on the antero-medial portion simple, flat-topped and slightly wider than the U-shaped channels which separate them, the ribs upon the posterior area narrow, cordate and crowded; radial sculpture overrun by the incremental toward the margins of the adult shell, most persistent anteriorly; no trace of lateral cording but a slight tendency toward an undercutting of the ribs discernable. Ligament deeply inset, marginal, mounted on heavy nymphs. Hinge plate, high, trigonal. A short thin laminar anterior cardinal, a heavy, somewhat scimitar-shaped medial cardinal and a laminar posterior cardinal produced along the inner margin of the nymph in the right valve; a short anterior and produced posterior cardinal, both of them moderately heavy and separated by a deep and obliquely produced dental socket in the left valve. Inner surface thickened over the area of the adherent mantle. Pedal pit very deep. Anterior adductor scar also very deep and obliquely produced; posterior scar, broader, not quite so deep. Pallial line ragged and rather far removed from the deeply crenate inner margins.

The description is made from the subgenotype U. S. Nat. Mus. No. 12704, from Grignon in the Paris Basin, the locality from which Lamarck received his type material for the species.

Specimens in our collections from the Bracklesham beds of Selsey, Sussex, differ from those from the Paris Basin in the higher, more anterior beaks, and higher hinge plates, the slightly lower rib count and the less persistent ribbing.

VENERICARDIA JEWELLI Gardner new species

Pl. 12, figs. 1, 2

Shell large, heavy, transversely ovate trigonal in outline, rather strongly inflated in the umbonal region, but flattening toward the

margins, especially toward the posterior ventral margin. Posterior area defined less by the angulation of the shell than by the abrupt change from the coarse ribbing to a fine threading which tends to become obsolete away from the umbones. Umbones prominent, broad and full, the tips incurved, proximate and prosogyrate. Lunule small, cordate. Costal sculpture very strong, the ribs exclusive of the fine posterior threading, 13 to 14 in number in the types, separated by deep and squarely channeled interspaces which shallow a little toward the ventral margin; surface not preserved but ribs apparently simple excepting for the strong concentric imbrication. Posterior threads 5 or 6 in number in the types, evanescent toward the ventral margin. Characters of the interior not known.

Dimensions.—Double valves: height, 65.0 ± millimeters; length, 65.0 millimeters; convexity, 45.0 millimeters. Right valve: height, 65.0 ± millimeters; length, 70.0 millimeters.

Cotypes.—U. S. Nat. Mus. No. 370914.

Type locality.—U.S.G.S. Sta. 11758, limestone scarp near the Indio Wells tank, about 29 miles southeast of Eagle Pass, Maverick County, Kincaid formation, Tehuacana member.

Venericardia jewelli is remarkable for the flattening of the shell toward the ventral margin, the few broad, simple radials and the absence of any well defined sculpture upon the posterior area.

Poorly preserved specimens of a closely allied but apparently more inflated form occur at Bibora tank, in Maverick County.

This fine *Venericardia* is named in honor of William R. Jewell, who located the Indio Wells. We are indebted to him not only for the most interesting Wilcox fauna that we have from Maverick County but also for his generous interest, and his death was a great loss to all of us who are working in the Border country.

Occurrence.—Kincaid formation, Tehuacana member. *Maverick County:* U.S.G.S. Sta. 11752, Comanche Creek Crossing on west road to Farias ranch; U.S.G.S. Sta. 11753?, Bibora tank, 7 miles east of new Indio ranch house; U.S.G.S. Sta. 11755, 3 miles north of Media tank; and U.S.G.S. Sta. 11758, near Indio Wells, about 29 miles southeast of Eagle Pass.

VENERICARDIA SMITHII Aldrich

Pl. 12, figs. 3, 4

1891. *Venericardia planicosta* Lamarck, Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 42.

1894. *Venericardia smithii* Aldrich, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 243, pl. 12, figs. 1a-b.

1896. *Venericardia planicosta* var. *smithi* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 59, pl. 4, fig. 11; pl. 5, figs. 1, 2.

1903. *Venericardia smithii* Aldrich, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, p. 1422.

1933. *Venericardia smithii* Aldrich, Plummer, Univ. Texas Bull. 3232, pp. 811, 812, pl. 8, figs. 4a, 4b.

Shell large, solid, slightly transverse, inflated, inequilateral, strongly ribbed, beaks strongly recurved, elevated; ribs 32-35 on specimens figured, flat in central part, strongly tuberculated, both on the anterior and posterior, more faintly marked on the central part; teeth nearly transverse, cavity of shell deep, margin crenulate, cicatrices slightly impressed.

The drawings are slightly larger than the shells. The general outline of this species is like *V. planicosta*, Lam., with which it is associated, and of which a figure is also given.

Differs from *V. alticostata*, Con., (*transversa*, Lea.,) in the flatness of the ribs. Fig. 1 is from a specimen in my collection, the other (1b.) is in the state collection. Rather abundant. Named in honor of Dr. Eug. A. Smith (Aldrich, 1894.)

Type locality.—*Turritella* rock, near Allenton, Wilcox County, Alabama.

Mr. Aldrich's collection was purchased by the Johns Hopkins University and the cotype figured in this paper is now in the Paleontologic Laboratory in Baltimore.

Venericardia smithii is widespread though not conspicuously abundant in Alabama and in Texas. No other member of the *Venericardia planicosta* group is so well represented in the Texas Midway. Its large inflated valves and the numerous high, narrow costals without lateral terraces or intercalaries characterize the species.

The Maverick County material is all very poor but the forms present no characters by which they may be separated from the Alabama species except that the ribs are less numerous and in consequence more distantly spaced upon the disk. The individuals from the upper Midway run much smaller than those from the lower.

Molds from Maverick County strongly suggesting *Venericardia smithii* are frequently distorted so that they closely simulate *Cardium* and the species of *Cardium* which is so abundant in the Escondido.

Occurrence. Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665, Water Hill, 5 miles northeast of Kemp; U.S.G.S. Sta. 2110, 4 miles northeast of Kemp; and U.S.G.S. Sta. 10711, 2½ miles northeast of Kemp on public road. *Limestone County:* U.S.G.S. Sta. 11935?, 7½ miles northwest of Groesbeck on the Thelma road; and U.S.G.S. Sta. 11939, 3 miles southwest of Thornton. *Falls County:* U.S.G.S. Sta. 11931?, about 6 miles northwest of Kosse. *Bastrop County:* U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line; and U.S.G.S. Sta. 11909, Cedar Creek, 3± miles southeast of Williams' store. *Caldwell County:* U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart; and U.S.G.S. Sta. 11706, 5½ miles southwest of Lockhart. *Guadalupe County:* U.S.G.S. Sta. 13244, 2.3 miles southwest of Staples; and U.S.G.S. Sta. 11223, 9½ miles northeast of Seguin. *Medina County:* U.S.G.S. Sta. 6280?, Hondo Creek, one-eighth mile below road crossing east of Elstone. *Uvalde County:* U.S.G.S. Sta. 3130?, bluff on Frio River, one-half mile below Evans' (Myrick's) apiary; and U.S.G.S. Sta. 6279?, 11 miles south of Sabinal, south of junction of Elm Creek with Sabinal Creek. *Maverick County:* U.S.G.S. Sta. 11752?, Comanche Creek Crossing on west road to Farias ranch; U.S.G.S. Sta. 11758, Indio Wells, about 29 miles southeast of Eagle Pass; U.S.G.S. Sta. 6575, White Bluff on Rio Grande River, 4½ miles west of south of Windmill (Jacal) ranch house; U.S.G.S. Sta. 8792, Rio Grande, Texas side, 1 mile below Cerrito Prieto ranch house on Mexican side; and U.S.G.S. Sta. 6577, Rio Grande River, 2 miles below White Bluff, 4½ miles southwest of the Windmill (Jacal) ranch house.

Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11761, Tobar Arroyo, 2¼ miles southwest of Tobar tank, about 35 miles southeast of Eagle Pass; U.S.G.S. Sta. 11754?, 6 miles below the McFarland sheep pens, 27 miles southeast of Eagle Pass on Windmill (Jacal) ranch road.

Subgenus GLYPTOACTIS Stewart

1930. Stewart, Ralph, Gabb's California Cretaceous and Tertiary type Lamellibranchs, Acad. Nat. Sci. Philadelphia, Special Pub. 3, pp. 151–152.

Type by original designation. *Venericardia hadra* Dall. Lower Miocene (Chipola formation) of Florida.

The American Miocene *Venericardia* are not so high as the typical or *Venericor* or *Leuroctis*. For this group the new subgeneric name *Glyptoactis* is proposed with *V. hadra* Dall as the type species (Dall, 1903, p. 1129, pl. 53, figs. 11, 13-Chipola). The species differ from the typical in having a curved elongate right cardinal and a small anterior pustule or lateral. The right hinge of a closely related species has been figured by Dall (1903, p. 1130, pl. 53, fig. 12) and his figures of both species have been reproduced by Gardner (U. S. Geol. Survey Prof. Pap. 142-B, 1926, p. 90, pl. 17, figs. 11–13). The group is known from the Eocene *V. alticostata* (Harris, Bull. Am. Pal. v. 6, 1919, p. 82, pl. 30, figs. 1-5, Claiborne) and is still living on the West Central American coast as *V. cumingi* Broderip (Reeve, Conch. Iconica, v. 1, 1843, pl. 5, fig. 24—*Cardita*). Judging from the figures *V. acuticostata* from the French Eocene is another member of this group (Cossmann and Pissarro, 1906, pl. 31, fig. 97-7, Lutetien-Bartonien). *"Cardita" sandiegoensis* from the Eocene of California may also be a *Glyptoactis* (Hanna, Univ. Cal. Bull. Geol., v. 16, 1927, p. 283, pl. 37, figs. 1-2, 8-9).

The hinge of *Glyptoactis* suggests the minute Mediterranean *Glans* Megerle 1811 (Bucquoy, Dautzenberg and Dollfus, Moll. Roussillon, v. 2, 1892, p. 231, pl. 38, fig. 21-25) which has more distinct laterals and a shorter right cardinal enlarged anteriorly. Were it not for the similarity of *Glyptoactis* with some of the species of *Venericardia* s.s. I should place *Glyptoactis* under *Glans* but the resemblance may be fortuitous, and temporarily at least *Glyptoactis* is better left under *Venericardia* since it is difficult if not impossible at the present time to recognize the two groups among immature Eocene specimens. These specimens may actually show the development of a subgenus but such an interesting conclusion could only be accepted after a much more exhaustive study of them has been made. (Stewart, 1930.)

VENERICARDIA ALTICOSTATA (Conrad)

1833. *Cardita alticostata* Conrad, Am. Jour. Sci., 1st ser., vol. 23, p. 342.
1896. *Venericardia alticostata* Conrad, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 57 (*ex parte*).
1919. *Venericardia alticostata* Conrad, Harris, Bull. Am. Paleontology, vol. 6, p. 82, pl. 30, figs. 1–5, 12.

Shell subcordate, convex, with about twenty-two profoundly elevated nodulous ribs, which on the interior side are laterally carinated. Length, two inches.

Locality.—Claiborne, Ala. London clay. Extremely abundant and very variable in outline. (Conrad, 1833.)

A fairly well preserved individual from Tobar Arroyo about 3 miles northwest of Windmill (Jacal) ranch house, exhibits no characters by which it can be separated from the typical *Venericardia alticostata* of the Claiborne group (Gosport sand) at the type locality in Alabama.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11367, Tobar Arroyo, 2¼ miles southwest of Tobar tank and about 35 miles southeast of Eagle Pass.

VENERICARDIA BULLA Dall

Pl. 13, figs. 1-4; Pl. 14, figs. 4-6

1903. *Venericardia bulla* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, p. 1424, pl. 56, figs. 13, 14.

1933. *Venericardia bulla* Dall, Plummer, Univ. Texas Bull. 3232, pp. 811, 812, pl. 8, figs. 2a, 2b.

Shell subovate, very much inflated, inequilateral, the beaks nearly anterior, decurved, low; surface sculptured with about thirty subequal, rough riblets, separated by subequal channelled inter-spaces; the ribs are crossed by numerous, somewhat irregular emphatic lines of growth, between which they are more or less imbricate; the ribs are sometimes squarish and towards the base more rounded or even obsolete, closer and finer behind; the lunule is deep and small; the outline of the shell varies, some of the specimens being shorter and higher than others; the inner margin is sharply and closely crenulate. Length 32, height 30, diameter 32 mm.

The fossils of this horizon are poorly preserved, but no other species known from our Tertiary approaches this in inflation. The interior is inaccessible, but the specimens, such as they are, apparently abundant.

Type.—U. S. Nat. Mus. No. 164556.

Type locality.—Brown sandstone of the Midway horizon, east of the first small creek on the road to Bastrop, Texas, from Old Garfield in the Austin quadrangle. (Dall, 1903.)

Figured specimen.—U. S. Nat. Mus. No. 370913.

Several unsuccessful attempts were made to find this locality. The closest approach to it is represented in a collection made in 1932 by L. W. Stephenson and C. E. Cook from 2.5 miles southeast of the Travis-Bastrop County line. Beautifully preserved specimens of *Venericardia bulla* pack the glauconitic marls of the Colorado River below the Caldwell ranch house. The shells are commonly removed and the matrix indurated, forming a ledge which may be followed for a considerable distance. It is extraordinary that a species locally so prolific should be restricted in its known areal distribution to a single county.

Venericardia bulla Dall bears a striking resemblance to *Venericardia wilcoxensis* Dall (Pl. 14, figs. 1-3), a name which has a geographic rather than a stratigraphic significance for it refers to Wilcox County, Alabama, where the material was collected and where

the Nanafalia formation of the Midway group is exceptionally well developed. The individual reproduced from Plate 54 of volume 3, part 6 of the Transactions of the Wagner Free Institute of Science, is higher relatively and more rounded trigonal in outline than the usual individual which is, like *V. bulla*, subovate to subquadrate in outline. *Venericardia bulla* has broader, fuller umbones than its Alabama analogue and slightly more numerous ribs, especially upon the posterior area, but otherwise it would be hazardous to attempt to separate the two species. Their striking similarity offers an excellent basis for the correlation of the Texas and Alabama sections for they are both abundant within the restricted area in which they are developed. The possibility of confusion of the Alabama species with *Venericardia alticostata* offers the only explanation of the delay of the description of the form until 1903. A specimen from Dale's Branch, 1 mile northwest of Oak Hill, Wilcox County, Alabama, is figured on Plate 14, figure 1. The specimen from Matthews Landing in Figures 2 and 3 resemble those given the subspecific name *tripla* by Dall because of the unusually fine sharp ribbing and the deeply serrate costal crests.

Occurrence.—Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11901?, North Branch, Wilbarger Creek, first road crossing east of Travis-Bastrop County line; U.S.G.S. Sta. 11902, Wilbarger Creek, one-half mile below Travis-Bastrop County line; U.S.G.S. Sta. 11912?, Dry Creek, 7½ miles southwest of Elgin; U.S.G.S. Stas. 11913 and 12113, Colorado River, 2 miles below the Travis-Bastrop County line; U.S.G.S. Sta. 5231, Colorado River, 5 miles below Webberville; Bureau of Economic Geology Sta., 3 miles above Cedar Creek bridge on Austin-Red Rock road.

VENERICARDIA HESPERIA Gardner

1396. *Venericardia alticostata* Conrad, Harris (*ex parte*), Bull. Am. Paleontology, vol. 1, No. 4, p. 57.

Not *Cardita alticostata* Conrad, Am. Jour. Sci., 1st ser., vol. 23, p. 342, 1833.

1923. *Venericardia alticostata* subsp. *hesperia* Gardner, U. S. Geol. Survey, Prof. Paper 131-D, p. 112, pl. 32, figs. 1, 2.

Shell of moderate dimensions, thick, porcellaneous, inflated-cordate in cross-section; umbones prominent, well rounded, slightly anterior in position; lunule very small, deep; anterior extremity strongly and evenly bowed in front of the lunule; posterior dorsal margin gently sloping, the posterior lateral

margin obliquely truncate; base line feebly arcuate, strongly upcurved anteriorly, abruptly rounded posteriorly; general character of surface sculpture similar to that of *V. alticostata* s.s.; radials not far from 20 in number, normally tripartite on the anterior and medial portions of the shell as in *V. alticostata;* crest of radials narrow, and sharply serrate; lateral "terraces" well defined; inter-radial channels broadly U-shaped; incremental sculpture very fine and sharp; heavy growth stages rarely developed; hinge and ligament characters poorly preserved; hinge plate thick, heavy; adductor scars impressed, the anterior excavated; pallial line simple; inner margins deeply crenate.

Dimensions.—Altitude, 38 millimeters; latitude, 44 millimeters; diameter, 37 millimeters. (Gardner, 1923.)

Holotype.—U. S. Nat. Mus. No. 352268.

Type locality.—U.S.G.S. Sta. 3130, bluff on Frio River half a mile below Evans' (Myrick's) apiary, Uvalde County, Texas. Tehuacana member of Kincaid formation.

Venericardia hesperia is shorter and wider than the similarly sculptured *V. alticostata* and more inflated in the umbonal region. *Venericardia crenaea* from Medina County is smaller, is much less inflated, and is sculptured with more numerous but less elevated radials.

Venericardia bulla Dall is smaller and relatively higher and has a higher and relatively heavier hinge plate and less numerous radials. In *V. smithii* Aldrich, the radials are simple.

The higher, shorter, and more inflated individuals of *V. moa* may readily be confused with *V. hesperia* particularly in the imperfect state of preservation which is usual in the Border fauna. The normal *V. moa* is a smaller, decidedly less inflated shell than *V. hesperia* with 7 or 8 coarse radials upon the disk.

The specimen shown on Plate 15, figure 6, U. S. Nat. Mus. No. 370922, presumably from U.S.G.S. Sta. 2439, 1 mile east of Webberville, Travis County, may be referable to *V. hesperia.*

Occurrence.—Kincaid formation. *Medina County:* U.S.G.S. Sta. 10123?, Verde Creek, 1½ miles northeast of Hondo, 1¾ miles northwest of New Fountain; U.S.G.S. Sta. 6534, D'Hanis-Yancey road, about 7½ miles southeast of D'Hanis. *Uvalde County:* U.S.G.S. Sta. 3131, Frio River, just above waterhole opposite apiary below Englemann's ranch; and U.S.G.S. Sta. 3130, bluff on Frio River, half a mile below Evans' (Myrick's) apiary.

VENERICARDIA WHITEI Gardner

1896. *Venericardia alticostata* Harris (*ex parte*), Bull. Am. Paleontology, vol. 1, No. 4, p. 57, pl. 5, fig. 3.

Not Cardita alticostata, Conrad, Am. Jour. Sci., 1st ser., vol. 23, p. 342, 1833.

Not Venericardia perantiqua Conrad, Am. Jour. Conchology, vol. 1, p. 8, 1865.

1923. *Venericardia (alticostata* subsp.?) *whitei* Gardner, U. S. Geol. Survey, Prof. Paper 131-D, p. 112, pl. 32, fig. 3.

Shell small but thick and heavy, transversely elongated in outline, rather compressed; umbones low, broadly rounded, for the most part strongly anterior in position; lunule minute; anterior extremity bowed in front of the lunule; posterior extremity obliquely produced and broadly rounded; base line feebly arcuate; surface coarsely sculptured radially; radials usually 19 to 21 in number, broad, crowded and heavily corrugated upon the anterior and medial portions of the shell; narrow, and less closely spaced posteriorly; ligament characters not known; dentition apparently normal, very poorly preserved in all the material available for study; adductor scars very distinct; pallial line simple; inner margins very coarsely crenate.

Dimensions. Altitude, 32 millimeters; latitude, 31 millimeters; semidiameter, 13.5 millimeters. (Gardner, 1923.)

Holotype.—U. S. Nat. Mus. No. 352269.

Type locality.—U.S.G.S. Sta. 3130, bluff on Frio River, half a mile below Evans' (Myrick's) apiary, Uvalde County, Texas. Tehuacana member of Kincaid formation.

Venericardia whitei is similar to *Venericardia moa* in general dimensions and outline but the radials are more numerous in *V. whitei*.

Occurrence.—Kincaid formation. *Uvalde County:* U.S.G.S. Sta. 6279?, 11 miles south of Sabinal, a few hundred yards south of the junction of Elm Creek with Sabinal Creek; and U.S.G.S. Sta. 3130, bluff on Frio River, one-half mile below Evans' (Myrick's) apiary.

VENERICARDIA species

Poorly preserved specimens of a species allied to *Venericardia hesperia* but higher relatively and more trigonal and with a sparser ribbing, particularly upon the posterior area, were collected by L. W. Stephenson in the Tehuacana member of the Kincaid formation in the bed of Verde Creek, 1½ miles (air line) northeast of Hondo, Medina County (U.S.G.S. Sta. 10123). The surface is so badly decorticated that the lateral terraces upon the ribs are almost obliterated

and the species in its general outline, degree of inflation, and spacing of the ribs assumes the aspect of *V. jewelli*, from which it is readily separable, however, by the terraced medial and anterior ribs and the development of radials upon the posterior area.

VENERICARDIA CRENAEA Gardner new species

Pl. 15, figs. 1, 2

Shell rather small, not strongly inflated, moderately heavy, subrotund to transversely ovate in outline. Posterior area obtusely carinated, defined rather by the finer, closer ribbing than by the angulation of the shell. Umbones anterior, not prominent, prosogyrate. Lunule very small and deeply impressed. Radial costae usually 25 to 30 in number (30 in the types), broad and squarely terraced anteriorly, with sharply elevated serrate crests and separated by linear interspaces; the ribs much narrower posteriorly without lateral tabulae, but crested as on the anterior portion of the shell. External ligament lodged securely on a heavy nymph extending over half the length of the posterior margin. Hinge very imperfectly preserved and only in the right valve. Medial right cardinal obliquely deltoid and very heavy. Inner margins coarsely crenate.

Dimensions. Right valve: height, 22.5 millimeters; length, 25.0 millimeters. Left valve: height, 27.5 millimeters; length, 27.3 millimeters.

Cotypes. U. S. Nat. Mus. No. 370911.

Type locality.—U.S.G.S. Sta. 11770, bed of Hondo River, 1 mile northwest of New Fountain, Medina County, Texas. Kincaid formation, Tehuacana member.

Venericardia crenaea is doubtless related rather closely to *V. hesperia* Gardner but it is smaller and not nearly so full, and the radials are more numerous, more closely spaced, and not so prominent.

Two worn individuals with a primary sculpture similar to that of *V. crenaea* were collected from the Kincaid formation at U.S.G.S. Sta. 10711, 2½ miles northeast of Kemp, Kaufman County, and another from the Littig glauconitic member at U.S.G.S. Sta. 13247, on an east-facing slope of the San Marcos valley, one-half mile north of Staples in Guadalupe County.

Occurrence.—Kincaid formation, Tehuacana member. *Medina County:* U.S.G.S. Sta. 11876, 1 mile east of the church at Quihi;

U.S.G.S. Sta. 13246, 3¼ miles N. 25° W. of Dunlay; U.S.G.S. Sta. 10128, Verde Creek, 4½ miles northeast of Hondo, 1¾ miles northwest of New Fountain; U.S.G.S. Sta. 11770, bed of Hondo River, 1 mile northwest of New Fountain; and U.S.G.S. Sta. 6581?, D'Hanis-Yancey road, 7½ miles southeast of D'Hanis. *Uvalde County:* U.S.G.S. Sta. 6279, 11 miles south of Sabinal, a few hundred yards south of the junction of Elm Creek with Sabinal Creek; and U.S.G.S. Sta. 3130, half-mile below Bob Evans' (Myrick's) apiary.

VENERICARDIA species

Molds of an inflated species of moderate dimensions of the *V. alticostata* type of sculpture occur in considerable abundance in Limestone and Falls counties. The ribbing is rather sparse, suggesting *V. crenaea* from the limestones of Medina County, but the outline is less elongated transversely and the umbones more inflated.

VENERICARDIA MOA Gardner new species

Pl. 10, fig. 1

Shell rather small for the genus, transversely ovate in outline, not strongly inflated. Umbones anterior, the tips incurved and proximate. Characters of the lunule and escutcheon not preserved. Anterior margin bowed in front of the lunule. Posterior extremity obliquely produced and broadly rounded. Sculpture vigorous. Radials 19 in number on the type- the 7 on the posterior slope are less elevated than those upon the disk and much more crowded; the 5 anterior radials also crowded; the 7 radials upon the disk prominent, and laterally terraced with serrate crests. Characters of the hinge and muscle scars obscured by the mode of preservation. Inner ventral margins crenate.

Dimensions.--Double valves of holotype from which a part of the shell has been removed: height, 30.0 millimeters; length, 34.0 millimeters; convexity, 20.0 millimeters.

Holotype.--U. S. Nat. Mus. No. 370922.

Type locality.—Holotype, U.S.G.S. Sta. 4393, 13 miles south and east of Eagle Pass, Maverick County, Texas. Kincaid formation.

Venericardia moa closely approaches in some of its higher variants *V. hesperia* so common on the Frio River in Uvalde County. It runs decidedly smaller, however, than *V. hesperia*, is normally much less inflated, and is more produced posteriorly. In general

dimensions and outline it closely approaches *V. whitei*, but the radials are less crowded upon the disk. The unnamed species from the basal greensands of north and central Texas is doubtless closely related and may prove to be specifically identical, though the Mexican Border form runs a little larger, is more produced posteriorly, and apparently develops more radials upon the posterior and possibly the anterior area.

It is unfortunate that the collections offer no better type material, but the species is so common and so characteristic in the Tehuacana of the Mexican Border that even though the state of preservation is so uniformly poor, its recognition seems desirable without further delay.

Occurrence.—Kincaid formation, Tehuacana member. *Maverick County:* U.S.G.S. Stas. 4393, 6583?, and 11753, Bibora Creek just below Bibora tank, about 18 miles southeast of Eagle Pass; U.S.G.S. Sta. 11755, 3 miles north of Media tank; U.S.G.S. Sta. 11757, hillside above small tank 2 miles west of Lopez tank, about 29 miles southeast of Eagle Pass; U.S.G.S. Sta. 11360, 3½ miles southwest of Tobar Tank; and U.S.G.S. Sta. 6575?, White Bluff on Rio Grande, about 4½ miles west of south of Windmill (Jacal) ranch house.

VENERICARDIA MOA new subspecies?

A *Venericardia* recalling *Venericardia moa* from the Tehuacana member of the Kincaid formation of Maverick County is rather widely distributed in the basal greensand of the Kincaid, apparently from Hunt County to Caldwell, though the species is represented largely by casts and many of the individuals are not definitely determinable. The shells are similar in outline to those of *V. moa* but the average dimensions are lower and they are uniformly compressed. The radials are normally 7 in number upon the disk, as in *V. moa*, but the anterior and posterior areas may be less closely ribbed than those of the Border species.

It is unfortunate that the material is so poor for the species seems to have stratigraphic significance. In its known distribution it is restricted to the basal greensand.

Occurrence.—Kincaid formation, Littig glauconitic member. *Hunt County:* U.S.G.S. Sta. 10261, about 11 miles southeast of Greenville on Lone Oak Pike, 50 yards from pike on east side of Cowleech Fork. *Travis County:* U.S.G.S. Sta. 11676?, ford over Wilbarger Creek on

F. Goerick's farm, 1½ miles southwest of Littig. *Bastrop County:* U.S.G.S. Sta. 11679, one-half mile east of Elysium on Bastrop-Austin road; and U.S.G.S. Sta. 11678, one-half to three-fourths mile above Cedar Creek road on Half Mile Creek. *Caldwell County:* U.S.G.S. Sta. 11681, 1½ to 2 miles south of Mendoza.

The common species in the lower but not the basal part of the Kincaid formation in Falls County (U.S.G.S. Sta. 11931) and on the Brazos River, at Milam Bluff (U.S.G.S. Sta. 11926), and 1 mile below the Falls County line (U.S.G.S. Sta. 11924) runs a little more than 2 centimeters in altitude and latitude and is more inflated than *Venericardia moa*. The general character of the ribbing is similar to that of *V. moa* but there are usually 8 instead of 7 ribs upon the disk and the posterior and anterior portions of the shell are rather more closely sculptured.

VENERICARDIA new species

Molds of a small, subcircular, highly inflated species sculptured with 16 strong ribs, occur in the basal greensand of the Kincaid formation associated with *Venericardia moa* subspecies?, 11 miles southeast of Greenville, Hunt County (U.S.G.S. Sta. 10264). The height of the best preserved of the three individuals is 14.0 millimeters, the length, 15.5 millimeters.

VENERICARDIA EOA Gardner new species

Pl. 15, figs. 3-5

1933. *Venericardia eoa* Gardner MS., Plummer, Univ. Texas Bull. 3232, pp. 811, 812, pl. 8, fig. 1.

The specimen figured in Bulletin 3232 of The University of Texas was recovered from a roadside exposure 2 miles northeast of Cedar Grove and 5 miles due north of Cobbs, about one-half mile west of the Kaufman-Van Zandt County line, Kaufman County.

Shell small for the genus, moderately heavy and porcellanous, subcircular in outline, not strongly inflated. Umbones rather full, slightly anterior, the tips proximate and prosogyrate. Lunule small, deeply impressed, cordate. Escutcheon absent. Sculpture vigorous; radials 22 to 25 in number, narrow, crenate upon their summits, flanked by secondaries which merge into the lateral "terraces" of the *Venericardia alticostata* group; interradials broader than the radials,

strongly concave, finely striated by the crowded growth laminae. Ligament lodged in a deep marginal groove, well buttressed ventrally. Hinge heavy; the atrophied anterior cardinal of the right valve separated from the obliquely cuneate medial cardinal by a deep pit; posterior right cardinal merely a modification of the dorsal margin; left anterior cardinal heavy, trigonal, cross striated; posterior left cardinal produced. Adductor and pedal scars distinct and, in the heavier shells, impressed. Pallial line simple. Inner margins crenate from the lunule to the escutcheon.

Dimensions.—Height, 22.0 millimeters; length, 23.0 ± millimeters; convexity, 8.0 millimeters. The other figured specimen from the same locality measures approximately 26.0 millimeters in height and length and 11.5 millimeters in convexity.

Holotype and paratype.—U. S. Nat. Mus. No. 370918.

Type locality.—U.S.G.S. Sta. 11914, south bank of Colorado River, 1½ miles below the Travis-Bastrop County line; below the *Venericardia bulla* zone. Kincaid formation.

In dimensions and general outline and appearance, *Venericardia eoa* suggests *V. rotunda* of the Claiborne group. The Midway species is heavier, however, the radials more sharply serrate, and the crests not overhanging as in the Claiborne species. The sculpture of *V. eoa* is an interesting link between the simple costals such as those of *V. planicosta* and the terraced costals of *V. alticostata* Conrad.

*Occurrence.**—Kincaid formation. The species is known only from the environs of the type locality. *Bastrop County:* U.S.G.S. Sta. 11915, 4 to 5 miles below Webberville, Colorado River; U.S.G.S. Stas. 11914 and 12112, Colorado River, 1½ miles below the Travis-Bastrop County line.

VENERICARDIA species

A small *Venericardia,* rarely 20 millimeters in length, is extremely abundant at Jett Crossing, 3 miles below Garza Crossing on the Medina River, and on the Guadalupe River, 2½ miles above the Seguin power house. It suggests a miniature *V. smithii.* In almost all the many individuals, the surface is decorticated and the true outline of the costals lost. Apparently they are simple as in *V. smithii,* but casts of a few individuals which may be referable to another species, suggest a terracing similar to that of *V. eoa.*

*Collections of the U. S. National Museum.

The matrix at both localities is an indurated greensand.

Molds which may well represent the same species are common in the clays on the east bank of Rosilla Creek, 0.1 mile north of Corpus Christi road in Bexar County.

Occurrence.—Wills Point formation. *Guadalupe County:* U.S. G.S. Sta. 6283, Guadalupe River, 2½ miles above the power house south of Seguin; and U.S.G.S. Sta. 6153, Jett Crossing, Palo Alto road, 3 miles below Garza Crossing on the Medina River.

Superfamily LUCINACEA
Family LUCINIDAE
Genus PHACOIDES Blainville

1825. *Phacoides* Blainville, Manuel de malacologie, vol. 1, p. 550.
Type.—*Lucina jamaicensis* Lamarck. (Recent in the West Indies.)

Shell more or less lenticular; compressed, as a rule, or slightly tumid; umbones low, subcentral, erect or prosogyrate; sculpture dominantly concentric; anterior and posterior dorsal areas usually differentiated; lunule commonly profound; escutcheon obsolete; ligament external, in many specimens deeply sunken; normal dentition of right valve consisting of a simple anterior cardinal, a bifid posterior cardinal and anterior and posterior laterals; normal dentition of left valve consisting of a bifid anterior cardinal, a simple posterior cardinal, and anterior and posterior lateral grooves; laterals in many species and the cardinals in some species obsolete; muscle impressions strongly marked, the anterior elongate, the posterior oval; inner margins smooth or crenulated; pallial line entire.

The genus is abundantly represented in the Tertiary, the Mesozoic, and, if it be made to include the *Prolucina* of Dall, may be traced as far back as the Silurian. The living species number more than a hundred, and though they are most prolific in the Tropics, they are present in the temperate seas as well.

Subgenus MILTHA H. & A. Adams

1857. *Miltha* H. and A. Adams, The genera of Recent Mollusca, vol. 2, p. 468.
Type. *Lucina childreni* Gray. (Recent off the coast of Brazil.)

Shell relatively large, heavy, compressed; ovate to subcircular in outline; umbones not conspicuous, narrow, acute; lunule small, deeply impressed; anterior and posterior dorsal areas not sharply

defined; sculpture feeble, consisting, for the most part, of exaggerated incrementals; ligament and resilium external, long and deeply inset; two cardinals in each valve, the inner pair bifid; anterior adductor scar much produced.

The group is well established in the Eocene and is abundant throughout the Tertiaries. But four Recent species persist—the type from the Brazilian coast, two on the Pacific coast of Central America and Mexico, and one in the Indian Ocean.

PHACOIDES (MILTHA?) ALBARIPA *Gardner new species*

Pl. 16, figs. 1, 2

Shell small, compressed, subcircular in outline. Anterior lateral and ventral margins forming a broad continuous curve; posterior lateral margin vertically truncate; dorsal margins oblique, the posterior a little higher than the anterior. Umbones subcentral, full, rising only a little above the dorsal margins, the tips turned forward and proximate. Anterior dorsal area narrow but produced the length of the anterior dorsal margin, its extremity apparently indicated by a notch in the margin of the shell, delimited by the flattening of the shell but not by any incised line. Lunule minute, cordate, sunken, indicated by the depression of the shell and the obsolescence of the concentric sculpture. Escutcheon not defined. Outer surface of shell closely threaded concentrically—the lirations very fine, sharp, and regular; resting stages developed at uniform intervals toward the ventral margin. Interior not accessible.

Dimensions.—Height, 17.0 millimeters; length, 20.0 millimeters; convexity, 8.4 millimeters.

Holotype.—U. S. Nat. Mus. No. 370865.

Type locality.—U.S.G.S. Sta. 6575, White Bluff, Rio Grande, 4½ miles southwest of Windmill (Jacal) ranch house, Maverick County; layer No. 3 of Stephenson section, Kincaid formation.

Phacoides albaripa has the external aspect of *Miltha* but without knowledge of the hinge, the reference is uncertain.

Occurrence. Kincaid formation, Tehuacana member, *Uvalde County:* U.S.G.S. Sta. 3181, Frio River, just above waterhole opposite apiary below Englemann's ranch. *Maverick County:* U.S.G.S. Sta. 6583, Bibora Creek just below Bibora tank, about 18 miles southeast of Eagle Pass; and U.S.G.S. Sta. 6575, White Bluff on Rio Grande, 4½ miles southwest of Windmill (Jacal) ranch house.

Subgenus LUCINISCA Dall

1901. *Lucinisca* Dall, U. S. Nat. Mus., Proc., vol. 23, p. 805.
1903. *Lucinisca* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, p. 1361.

Type.—*Lucina nassula* Conrad. (Recent off the southeastern coast of the United States.)

Shell lentiform, white, with well marked dorsal areas, the sculpture reticulate and muricate, the right anterior cardinal obsolete. (Dall, 1901.)

The group is not typically developed in the lower Eocene of Texas but the general character of the dentition and the form and configuration of the shell ally *P. mesakta* with *Lucinisca* rather than with any other described subgenus.

PHACOIDES (LUCINISCA) MESAKTA Gardner new species

Pl. 16, figs. 3, 4

Shell small, compressed, not so high as it is wide. Umbones nearly central, small, pointed at the tips, elevated slightly above the gently sloping dorsal margins. Anterior dorsal margin a little lower than the posterior; anterior lateral margin obliquely truncate at the anterior area, broadly rounded in front of it, the posterior margin obtusely truncate vertically; base line broad and gently arcuate. Lunule and escutcheon clearly defined by the depression of the shell and the abrupt disappearance of the sculpture, the escutcheon linear, the lunule slightly expanded beneath the beaks. Anterior and posterior dorsal areas indicated by the flattening of the shell and the truncation of the margins. Outer surface adorned with strong, regularly spaced concentric lamellae the interlammellar spaces shagreened both concentrically, and toward the umbones, radially. Dentition delicate but clean cut; only that of the left valve known. Anterior cardinal, small, trigonal, the posterior short and laminar; anterior and posterior lateral sockets short but deep, set close to the extremities of the dorsal margins. Muscle scars sunken, the anterior elongated, the posterior reniform. Pallial line simple, obvious. Inner margin finely crenate.

Dimensions.—Height, 6.0 millimeters; length, 7.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370966.

Type locality.—U.S.G.S. Sta. 5232, clay from bluff at Webberville, Travis County, Texas. Kincaid formation.

Four more or less complete left valves referable to this species appear in the collections.

Occurrence.—Kincaid formation. *Travis County:* U.S.G.S. Sta. 5232. clay from bluff at Webberville.

PHACOIDES (LUCINISCA) species

A specimen 20 millimeters in height and with an almost equal length suggests in general characters "*Lucina*" *fortidentalis* Harris (Bulletin American Paleontology, vol. 1, no. 4, p. 69, pl. 6, figs. 11 and 11a). Harris' species was reported from the Clayton formation of Alabama and in the basal clay on the Chattahoochee River, Georgia. The Texas individual is from the second greensand in the Kincaid formation, 5½ miles north of Lockhart, Caldwell County (U.S.G.S. Sta. 11707). It is a much compressed species with a very strong, sharp, concentric sculpture closer than that of *fortidentalis* and with a fine radial lineation.

Another species of *Lucinisca* is probably represented by a less compressed and rather closely but not very strongly sculptured individual from the Kincaid formation of Falls County, 6 miles northwest of Kosse (U.S.G.S. Sta. 11931). The dimensions are similar to those of the Caldwell County individual, namely, about 20 millimeters in altitude and latitude.

A fragment, but sufficient to establish the presence of the group, was recovered from U.S.G.S. Sta. 5230, on the Colorado River, 4 miles below Webberville.

Subgenus PARVILUCINA Dall

1901. *Parvilucina* Dall, U. S. Nat. Mus., Proc., vol. 23, p. 906.
1903. *Parvilucina* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, p. 1362.
Type.—*Lucina tenuisculpta* Carpenter. (Recent on the west coast from Bering Sea to the Coronado Islands.)

Dall described *Parvilucina* as follows: "Shell small, plump, often inequilateral; sculpture more or less reticulate, but not muricate, teeth small, but all usually present."

The group apparently has a representation in the lower Midway sandy clays (Kincaid formation) one-fourth mile northwest of the Stranger School in Falls County, about 7 miles northwest of Kosse (U.S.G.S. Sta. 11941).

A compressed species, probably referable to *Parvilucina*, has been detected in the sandy clays in Limestone County, one-fourth mile south of Big Hill (U.S.G.S. Sta. 11942) and at Milam Bluff on the Brazos River just below the Falls County line (U.S.G.S. Sta. 11926).

The height and length slightly exceed 5 millimeters. The concentric lineation is very fine, regular, and rather close.

Small, concentrically sculptured bivalves, apparently referable to this subgenus are not uncommon in the firmly indurated oxidized greensand of the Wills Point formation on Guadalupe River, $2\frac{1}{2}$ miles above the power house south of Seguin (U.S.G.S. Sta. 6253).

Family DIPLODONTIDAE
Genus DIPLODONTA Bronn

1831. *Diplodonta* Bronn, Italiens Tertiär-Gebilde, p. xii.

Type.—*Venus lupina* Brocchi. (Miocene and Pliocene of the Piedmont of Italy.)

Shell suborbicular, inequilateral; external surface smooth or concentrically sculptured: lunule and escutcheon not clearly delimited; ligament chiefly external; hinge of right valve armed with a simple anterior and a bifid posterior cardinal; hinge of left valve armed with a bifid anterior and a simple posterior cardinal; laterals absent; adductor impressions oval; pallial line entire; inner margins of valves smooth.

The genus is first noted in the Cretaceous; from that time on it has constituted one of the less conspicuous elements in the bivalve faunas. The forty odd Recent species have a wide distribution in the warmer waters of the globe.

DIPLODONTA species

A rather heavy little shell suggesting *Diplodonta* and measuring some 9.0 millimeters in height and length was collected from the Tehuacana member of the Kincaid formation, 5.7 miles northwest of Castroville on the Quihi road (U.S.G.S. Sta. 11769). The lunule and escutcheon are not defined. The outer surface is etched with linear grooves with an occasional heavy resting stage. The characters of the interior are not accessible.

Diplodonta is doubtless represented at other localities but the material is too poor for certain determination even of the genus.

Superfamily LEPTONACEA
Family KELLIELLIDAE
Genus KELLIELLA Sars

1869. *Kelliella* Sars, Forhandlinger i Videnskabs-Selskabet i Christiania, p. 257.

Type by monotypy. *Kelliella abbyssicola* Sars (living off the Norway coast at 150 fathoms).

Shell minute, subcircular, moderately inflated; surface concentrically sculptured with closely spaced rugae; umbones subcentral, slightly anterior; lunule relatively large, cordate, defined by a sharply incised groove; escutcheon not differentiated; ligament attachment obscure; cardinal platform clearly defined; right valve with 2 minute cardinal lamellae diverging beneath the tips of the umbones and the margin of the hinge plate elevated to oppose the anterior cardinal; left valve with a more or less sigmoidal anterior cardinal and a lamellar posterior cardinal; no laterals; pallial line obscure but apparenty simple.

This seems to be one of the groups with rather a wide Tertiary distribution which has retired in Recent times to the deeper waters.

KELLIELLA? EVANSI Gardner new species

Pl. 16, figs. 5, 6

Shell minute, subcircular, rather compressed. Umbonal region feebly arched, the umbones subcentral, the tips acute and prosogyrate. Lunule relatively large, defined by a clearly incised line. External surface regularly sculptured from the umbones to the rounded ventral margin by fine lirae, separated by linear interspaces. Interior not accessible.

Dimensions.—Right valve: height, 2.55 millimeters; length, 2.55 millimeters.

Cotypes (2).—U. S. Nat. Mus. No. 370915.

Type locality.—U.S.G.S. Sta. 11767, ledge a foot or more above the bed of Frio River just above the trail leading up to the Bob Evans' (Myrick's) apiary, Uvalde County. Kincaid formation, Tehuacana member.

This small species is abundant in the hard gray limestone but the specimens can not be removed from the resistant matrix and without the hinge it is not possible to separate *Kelliella* from *Lutetia*. Both generally occur in the Gulf Eocene but neither of them has been reported from beds so low as the Midway.

Occurrence.—Kincaid formation, Tehuacana member. *Uvalde County:* U.S.G.S. Sta. 11767, about 1 foot above bed of the Frio River just above trail from Bob Evans' (Myrick's) apiary.

KELLIELLA? ALDRICHI Gardner new species

Pl. 16, figs. 7, 8

Shell minute, subcircular, the umbones tumid, prosogyrate and a little in front of the median vertical. Prodissoconch smooth and shining. Conch sharply and evenly lirate concentrically from the lunule to the dorsal margin. Lunule large, cordate, cut out by a sharply impressed groove. Dorsal area slightly flattened but no escutcheon defined. Ligament attachment very obscure, apparently marginal and opisthodetic. Hinge frail; cardinal platform clearly defined, cleft in the middle. Right valve with two minute cardinal lamellae diverging beneath the tips of the umbones; anterior dorsal margin of the hinge plate elevated to form with the opposing cardinal lamella a well defined socket for the reception of the anterior lamella of the left valve; right posterior cardinal lamella obliquely produced and continuous with the slightly elevated dorsal margin. Anterior cardinal lamella of left valve minutely arcuate with a tubercle at the distal extremity which is almost cut off from the rest of the lamella; left posterior cardinal lamella very thin and inconspicuous; a very thin laminar posterior ridge developed in the left valve, continuous across the cardinal platform and fusing with the sharp margin of the valve. Muscle scars distinct and large for so small a shell. Pallial line feebly and obtusely indented posteriorly.

Dimensions.—Height, 1.3 millimeters; length, 2.0± millimeters.

Holotype.—U. S. Nat. Mus. No. 370993.

Type locality.—U.S.G.S. Sta. 10420, Dry Brushy Creek, 6 miles south of Thrall, Williamson County, Wills Point formation.

The hinge plate is perceptibly wider in the fossil species of *Kelliella* than in the Recent.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11911, Colorado River, 4 miles below Webberville.

Wills Point formation. *Williamson County:* U.S.G.S. Sta. 10420, Dry Brushy Creek, 6 miles south of Thrall. *Bastrop County:* U.S. G.S. Sta. 12109, directly above bridge over Cedar Creek on Austin-Red Rock road. *Caldwell County:* Bureau of Economic Geology Sta. 12, 1.6 miles northwest of Lockhart; U.S.G.S. Sta. 11709, 1.9 miles north of Lockhart.

Superfamily CARDIACEA
Family CARDIIDAE
Genus CARDIUM Linnaeus

1758. *Cardium* Linnaeus, Systema naturae, 10th ed., p. 678.

Type.—*Cardium costatum* Linnaeus; designated by Children, 1823. (Recent in the Indo-Pacific.)

Shell usually subequilateral, closed or slightly gaping, globose, the united valves subcordate laterally. Umbones prominent, almost straight or with a slight anterior twist. True lunule and escutcheon absent. Sculpture dominantly radial. Ribs commonly granulose, spinose, or imbricated. Ornamentation of lateral areas, particularly of the posterior, commonly differing from that of the disk. Ligament external, opisthodetic. Hinge characterized, with a few exceptions, by two cardinals, of which the ventral is the stronger, and one or two posterior and one or two anterior lateral lamellae in each valve; cardinals more or less twisted. Muscle impressions subequal. Pallial line simple or slightly sinuous posteriorly. Internal basal margins serrate.

The genus Cardium forms a conspicuous element in the faunas from the Mesozoic onward. They are generally rather fragile, and not well adapted to preservation. The external sculpture is commonly formed from a superficial shelly layer, which readily breaks away, leaving no scar upon the polished surface below. For this reason it is difficult to tell a perfectly fresh specimen. The Recent representatives, the so-called cockles, number about 200 species and are most abundant in the warmer waters.

CARDIUM species

A small individual, less than 5 millimeters in height, a mold with a bit of decorticated shell adhering, shows about 8 ribs on the well defined posterior area and about 21 on the anterior and medial portions. This *Cardium* was collected directly below the second greensand of the Kincaid formation at the southeastern end of Cribbs Bluff on the Brazos River, a little more than a mile below the Falls County line (U.S.G.S. Sta. 11924).

Indeterminate molds are also present in the Kincaid, one-fourth mile west and a little north of the Stranger School, Falls County.

Genus PROTOCARDIA Beyrich

1845. *Protocardia* Beyrich, Zeitschrift für Malacologie, p. 17.
Type.—*Cardium hillanum* Sowerby. (Cenomanian of Europe.)

Shell thin, inflated, orbicular-quadrate; radial sculpture upon the posterior area sharply differentiated from that upon the medial and anterior portions of the shell; a small anterior and larger posterior cardinal in the right valve, a large anterior and smaller posterior cardinal in the left valve; both anterior and posterior laterals developed in each valve; posterior muscle scar prominent; an incipient pallial sinus frequently present; inner margin finely fluted, at least upon the posterior area.

PROTOCARDIA QUIHI Gardner new species

Pl. 16, figs. 9, 10

Shell small, orbicular-quadrate, highly inflated. Umbones subcentral, full to their tips. Posterior area flattened, very finely and sharply threaded with radials. Medial and anterior portions of shell more finely but less sharply sculptured, the radials intersected at fairly regular intervals by exceedingly fine concentric threadlets. Characters of interior not accessible.

Dimensions of holotype.—Height, 7.2 millimeters; length, 7.5± millimeters.

Holotype and paratype.—U. S. Nat. Mus. No. 370916.

Type locality.—U.S.G.S. Sta. 11769, 5.7 miles northwest of Castroville, on the Quihi road, Medina County. Tehuacana member of Kincaid formation.

Occurrence.—Tehuacana member of Kincaid formation. *Medina County:* U.S.G.S. Sta. 11769, 5.7 miles northwest of Castroville on the Quihi road; U.S.G.S. Sta. 13245, 2¼ miles N. 20° E. from Dunlay; and U.S.G.S. Sta. 6230, bed of Hondo Creek, loose boulder, one-eighth mile below road crossing due east of Elstone.

PROTOCARDIA species

Molds of a small indeterminate species of *Protocardia* are abundant in the "red beds," a name given locally to the oxidized shingle of Wills Point in southern Maverick County.

Subgenus NEMOCARDIUM Meek

1876. *Nemocardium Meek*, U. S. Geol. Survey of the Territories, Rept., vol. 9, p. 167.

Type.—*Cardium semiasperum* Deshayes. (Eocene of the Paris Basin.)

Shell closely resembling the typical forms of *Protocardia*, but thinner, with two-thirds to three-fourths of surface in front of the stronger posterior, usually echinate, radiating costae, occupied by fine, crowded, radiating striae, and the free margins crenate within all around; cardinal and lateral teeth generally rather slender; pallial line faintly sinuous, irregularly serrated, or nearly simple behind. (Meek, 1876.)

PROTOCARDIA ACTIA Gardner new species

Pl. 16, fig. 11

Shell small, very thin and fragile, strongly and smoothly inflated, subquadrate. Anterior extremity broadly rounded; base line almost horizontal; posterior third of shell flattened and the margin obliquely truncate. Umbones prominent, inflated, an obtuse ridge extending from the tips of the umbones to the posterior ventral margin. Tips of umbones acute, incurved, and feebly prosogyrate. A false lunule indicated by the evanescence of the radial sculpture. Anterior and medial portions of shell closely threaded with subcutaneous *Nucula*-like radials finely reticulated by the growth lines; rostrum and posterior area less finely threaded with about 25 radials which were probably spinose when fresh. Characters of interior not accessible.

Dimensions.—Height, 7.5 millimeters; length, 8.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 370917.

Type locality.—U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line; above the *Venericardia bulla* zone. Wills Point formation.

Fragments of a species closely related but less strongly convex occur at U.S.G.S. Sta. 10120, Dry Brushy Creek, 6 miles south of Thrall on the Taylor-Beaukiss road, Williamson County.

Protocardia actia is quite certainly the precursor of *Protocardia nicoletti*, so conspicuous in the late Eocene faunas.

Occurrence.—Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line.

PROTOCARDIA? species indeterminate

A cast about 20 millimeters in altitude and 25 millimeters in length, probably of *Protocardia*, was collected from the second greensand of the Kincaid formation, U.S.G.S. Sta. 11707, 5½ miles north of Lockhart, Caldwell County.

The genus is also represented by an indeterminate species from the *Venericardia bulla* zone in the Colorado River section (U.S.G.S. Sta. 12111).

Superfamily VENERACEA
Family VENERIDAE
Subfamily MERETRICINAE Dall
Genus CALLOCARDIA A. Adams

1864. *Callocardia* A. Adams, Annals and Mag. Nat. Hist., 3d ser., vol. 13, p. 307.

Type.—*Callocardia guttata* A. Adams. (Recent in the China Sea.)

Shell ovate to subtriangular; umbones anterior, involute; lunule circumscribed by a faintly incised line; escutcheon not delimited; ligament external, lodged in a deep groove; nymphs prominent; exterior sculpture concentric; three more or less discrepant cardinals in each valve, commonly bifid or cuspid; two lateral lamellae in right valve which receive between them the anterior lateral tooth of the left valve; pallial sinus varying widely within the limits of the genus, angular and sharply defined to almost obsolete; inner margins of valves entire.

The group is first recognized in the Eocene; since that time, it has formed a fairly conspicuous and widely distributed factor in the molluscan faunas of the warmer seas.

CALLOCARDIA HAWTOFI Gardner new species

Pl. 17, figs. 1, 2

Shell ovate trigonal in outline, moderately inflated, and like most of the other early Eocene representatives, running rather small for the genus. Umbones well rounded, prosogyrate, slightly anterior. Anterior margin strongly bowed in front of the lunule; the posterior dorsal margin obscurely truncate. Lunule small, the characters hidden by the matrix; outer surface finely and regularly grooved concentrically from the umbones to the ventral margin. Interior not accessible.

Dimensions.—Height, 23.2 millimeters; length, 25.2 millimeters; diameter, 15.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370923.

Type locality.—U.S.G.S. Sta. 11753, limestone scarp near the Oil Lease Development Company's Well No. 1 on the Indio ranch about 29 miles southeast of Eagle Pass, Maverick County. Tehuacana member of Kincaid formation.

Callocardia hawtofi is the possible analogue of *Callocardia pteleina* of Medina County but it differs in the finer and more regular concentric sculpture. In this character it approaches more closely to *Callocardia ripleyana* of the basal Midway of Tennessee, but it is a larger, coarser shell with higher and more inflated umbones.

The species apparently exhibits great variability in outline, the larger forms, as a rule, running decidedly higher relatively than the smaller.

It gives me great pleasure to name this species in honor of E. Manuel Hawtof, formerly of the Texas Bureau of Economic Geology, who was of great assistance to me in the field work in Maverick County.

Occurrence.—Kincaid formation, Tehuacana member. *Maverick County:* U.S.G.S. Sta. 11752, Comanche Creek Crossing on west road to Farias ranch; U.S.G.S. Sta. 4396, 13 miles south and east of Eagle Pass; U.S.G.S. Sta. 6583, Bibora tank, about 18 miles southeast of Eagle Pass; U.S.G.S. Sta. 11753, Bibora tank, 7 miles east of new Indio ranch house; U.S.G.S. Sta. 11758, Indio Wells, about 29 miles southeast of Eagle Pass; and U.S.G.S. Sta. 6575?, White Bluff, Rio Grande, about 4½ miles west of south of Windmill (Jacal) ranch house.

CALLOCARDIA PTELEINA Gardner new species

Pl. 17, fig. 3; Pl. 19, figs. 1–3

Shell rather small for the genus, obliquely ovate in outline, moderately inflated. Umbones well rounded, prosogyrate, a little in front of the median vertical. Lunule small, cordate, deeply impressed, delimited by a linear groove and by the abrupt change in the sculpture or its disappearance. Escutcheon obscured by the matrix.

Surface sculpture restricted to exaggerated growth lines, strongest and most regular near the anterior ventral margin. Hinge not accessible.

Dimensions.—Height, 16.0 millimeters; length, 21.5 millimeters; diameter, 13.0 millimeters.

Holotype and paratype.—U. S. Nat. Mus. No. 370921.

Type locality.—U.S.G.S. Sta. 11765, Schuddemagen ranch, 11 miles south of Sabinal, a few hundred yards south of the junction of Elm Creek with Sabinal Creek (south bank), Uvalde County, Texas. Tehuacana member of Kincaid formation.

Callocardia ptcleina is possibly the analogue in the south Texas Midway of *Callocardia ripleyana* (Gabb) of the basal Midway of Tennessee. The species resemble one another in general dimensions and outline but the Texas form is relatively higher and fuller with a less regular and decided concentric wrinkling and with a more deeply impressed lunule.

A species similar in general outline but larger by a third is common in the Tehuacana member at Comanche Crossing, 6 miles west of Mexia, Limestone County (U.S.G.S. Sta. 6559). The form is doubtless distinct and probably new but it is known only from molds with a few fragments of adherent shell.

Occurrence.—Kincaid formation, Tehuacana member. *Medina County:* U.S.G.S. Sta. 6230, Hondo Creek, one-eighth mile below Elstone Crossing; U.S.G.S. Sta. 11769, 5.7 miles northwest of Castroville on the Quihi road; and U.S.G.S. Sta. 6581, 7½ miles southeast of D'Hanis. *Uvalde County:* U.S.G.S. Stations 6279 and 11765, Schuddemagen ranch, 11 miles south of Sabinal, a few hundred yards south of the junction of Elm Creek with Sabinal Creek (south bank); U.S.G.S. Sta. 11377, Frio River, one-fourth to one-half mile above the Evans' (Myrick's) apiary; U.S.G.S. Sta. 11378, Frio River at foot of trail leading down from the Evans' (Myrick's) apiary; and U.S.G.S. Sta. 3130, Frio River, one-half mile below the Evans' (Myrick's) apiary.

CALLOCARDIA BIBORAENSIS Gardner new species

Pl. 18, figs. 1, 2

Shell large and heavy for the lower Eocene group, inflated, cordate in outline. Umbones prominent, slightly anterior. Lunule fairly large. Anterior extremity strongly bowed in front of the lunule.

the posterior obliquely truncate; ventral margin strongly upcurved in front. Outer surface rather finely and regularly grooved concentrically, the sculpture strongest toward the ventral margin. Interior not accessible.

Dimensions.—Height, 38.2 millimeters; length, 44.0 millimeters; diameter, 29.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370967.

Type locality.—U.S.G.S. Sta. 6583, Bibora tank on the Indio ranch, 18 miles southeast of Eagle Pass, Maverick County, Texas. Kincaid formation.

Callocardia biboraensis is a larger coarser shell than *Callocardia hawtofi* and not so common. *Callocardia kempae* from northeast Texas is much more evenly rounded, both in marginal outline and in the tumidity of the valves.

Occurrence.—Kincaid formation. *Maverick County:* U.S.G.S. Sta. 6583, Bibora tank on the Indio ranch, 18 miles southeast of Eagle Pass.

CALLOCARDIA KEMPAE Gardner new species

Pl. 17, figs. 4-6; Pl. 18, fig. 3

Shell large for the Gulf Eocene callocardias, subcircular to rounded trigonal in outline, broadly inflated. The anterior lateral and ventral margins forming a continuous broad, smooth curve, the posterior lateral margin obscurely truncate. Umbones subcentral, not very prominent, the tips proximate and prosogyrate. Lunule indicated by a cordate depression in front of the umbones but not sharply delimited. Escutcheon not defined. Ornamentation restricted to an incremental sculpture which on the ventral half of the shell develops well marked resting stages. Ligament external, the groove deeply cut and produced almost half the length of the posterior lateral margin. Dentition strong and normal for the genus: three cardinals in the right valve, the posterior slender, cuneate and with a shallow medial groove; anterior and medial cardinals with their inner faces flattened and closely proximate; left cardinals worn down and very obscure but a slender posterior, a more robust medial, and a very slender anterior cardinal indicated; double lateral socket of right valve deep and very close to the anterior cardinal; anterior lateral tooth of left valve not preserved;

posterior laterals not developed. Characters of interior concealed by the matrix.

Dimensions of smaller cotype.– Height, 26.3 millimeters; length, 30.0± millimeters.

Cotypes (2).—U. S. Nat. Mus. No. 370968.

Paratype.—U. S. Nat. Mus. No. 370969.

Type locality.—U.S.G.S. Sta. 10744, 2½ miles northeast of Kemp, Kaufman County, Texas. Kincaid formation.

The specific name has a double meaning for this fine *Callocardia* is called *kempae* in honor of Mrs. John Kemp of Seymour, Texas, and it was collected from near the town of Kemp, Kaufman County.

Callocardia kempae is the largest of any of the described callocardias from the Midway of Texas with the exception of *C. biboraensis*, a larger, more ovate trigonal shell, not so uniformly tumid and with more inflated umbones.

Occurrence.—Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665, Water Hill, 5 miles northeast of Kemp; and U.S.G.S. Sta. 10744, 2½ miles northeast of Kemp on public road.

CALLOCARDIA species indeterminate

Molds of a species similar to but apparently smaller than *C. harctoft* are common in the "red beds," the shingle of oxidized Wills Point at U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

Other indeterminate *Callocardia*, apparently new, were collected from Comanche Crossing in Limestone County (U.S.G.S. Sta. 6559), from the limestone on the Whitaker Survey, 6± miles northwest of Kosse in Falls County (U.S.G.S. Sta. 11931), from directly below the second greensand of the Kincaid formation at Cribbs Bluff on the Brazos River, a little over a mile below the Falls County line, and at Wilbarger Creek, one-half mile below the Travis-Bastrop line, and above the *Venericardia bulla* zone on the Colorado River.

Superfamily TELLINACEA
Family TELLINIDAE
Genus TELLINA (Linnaeus) Lamarck

1758. *Tellina* Linnaeus, Systema naturae, 10th ed., p. 674.

1799. *Tellina* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 84.

Type.—*Tellina radiata* Linnaeus. (Recent in the West Indies.)

Shell transversely ovate to ovate-trigonal in outline, compressed; usually rostrate and flexed to the right posteriorly and broadly depressed in front of the rostrum. Umbones low, subcentral or posterior, often opisthogyrate. External surface rarely smooth; dominant sculpture concentric, regular, and, as a rule, more or less incremental in character; radial ornamentation commonly suggested by the color pattern and by the reinforcing internal rays, rarely by the sculpture; oblique sculpture developed in one group. Ligament external, opisthodetic. Two cardinals, one of them bifid, developed in each valve, interlocking in the closed valves so that the bifid teeth are flanked on either side by a simple laminar tooth. Anterior and posterior laterals developed in some groups in both valves; in others, reduced to a single right anterior lateral. Sinus free or coalescent ventrally with the pallial line, often discrepant in the two valves, the dorsal margin of the sinus commonly uniting the anterior and posterior adductors.

The Tellinas are essentially a modern group, though they have their roots in the Mesozoic.

TELLINA QUIHI Gardner new species

Pl. 16, fig. 12

Shell thin, flexuous, transversely ovate in outline. Umbones subcentral. Anterior end of shell broadly rounded; the posterior obscurely rostrate. Concentric threading upon the outer surface exceedingly fine and sharp, not quite so fine and more regular toward the ventral margin. Interior of shell not accessible.

Dimensions.—Height, 9.0 millimeters; length, 13.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 370924.

Type locality.—U.S.G.S. Sta. 11769, 5.7 miles northwest of Castroville on the Quihi road, Medina County, Texas. Tehuacana member of Kincaid formation.

Occurrence.—Tehuacana member of Kincaid formation. *Medina County:* U.S.G.S. Sta. 11769, on the Quihi road, 5.7 miles northwest of Castroville.

TELLINA species

Tellina is represented at U.S.G.S. Sta. 11769, 5.7 miles northwest of Castroville, Medina County, by at least two other species, neither one of them preserved sufficiently well to be described. One of them

is more than double the size of *T. quihi* but lacks the fine sharp sculpture, the other is a heavier shell with a fine concentric sculpture and something of the aspect of *Callocardia*.

Other species of *Tellina* are doubtless present in both the Kincaid formation and the Wills Point formation throughout the extent of outcrop but the shells are fragile and the determinative characters are not retained in molds.

TELLINA species

A compressed, transversely elliptical bivalve, probably *Tellina*, occurs in a fragmentary state at U.S.G.S. Sta. 6283, 2½ miles above the power house south of Seguin, Guadalupe County. The beaks are submedial, the anterior extremity symmetrical, the posterior slightly compressed, the height not far from 14.0 millimeters, the length about 32.0 millimeters.

The horizon is near the top of the Wills Point formation.

Superfamily SOLENACEA
Family SOLENIDAE
Genus SILIQUA Megerle von Mühlfeldt

1811. *Siliqua* Megerle von Mühlfeldt, Entwurf eines neuen System's der Schalthiergehäuse, Magazin der Gesellschaft Naturforschender Freunde, 5 Jahrgang, p. 44.

Type. *Solen radiatus* Linnaeus. (Recent in the Indo-Pacific.)

Shell transversely ovate-elliptical, compressed; hinge line approaching the horizontal; umbones anterior but by no means terminal; two cardinals in the right valve and three in the left; the anterior and medial cardinals vertical, the posterior oblique or nearly horizontal; hinge armature strengthened by a clavicle dropped from the beaks to the ventral margin; pallial sinus deep.

The genus has a reputed range from the Cretaceous to the Recent.

SILIQUA? species indeterminate

An impression of the interior of a transversely elliptical form with a strong rib dropped vertically from the beaks occurs in the Mexia member of the Wills Point formation of Little Dry Brushy Creek on the Taylor-Beaukiss road, 6 miles south of Thrall, Williamson County, Texas (U.S.G.S. Sta. 10796).

Superfamily MYACEA
Family CORBULIDAE Fleming
Genus CORBULA (Bruguière) Lamarck

1798. *Corbula* Bruguière, Tableau encyclopédique et méthodique des trois règnes de la nature, vol. 1, pl. 230. (Figures only; no names.)

1799. *Corbula* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 89. (No species cited.)

1801. *Corbula* Lamarck, Système des animaux sans vertèbres, p. 137.

Type.—*Corbula gibba* (Olivi). (Recent off the west coast of Europe and in the Mediterranean; Tertiary of southern Europe.)

Shell small, thick, ovate, more or less rostrate; valves unequal, the left usually smaller and flatter; umbones prominent, prosogyrate or erect, the right usually higher than the left; hinge line of right valve fitted with a single prominent tooth in front of the resilial pit; lateral laminae absent; left valve with a chondrophore and a deep cardinal socket; surface sculpture variable, commonly discrepant on the two valves of the same individual, usually concentric, never strongly radial; adductor scars distinct; pallial line indistinct; sinus feeble or obsolete.

A prominent genus among the small bivalves since the beginning of the Mesozoic. The recent Corbulas include some 70 species of almost universal distribution but more prolific in the warmer waters, particularly of the China seas.

CORBULA MILIUM Dall

Pl. 19, fig. 4

1898. *Corbula (Aloidis) milium* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, p. 845.

1900. *Corbula (Aloidis) milium* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 5, p. 1192, pl. 36, fig. 19 (figure only).

Shell minute, rounded, inflated, with prominent beaks a little in advance of the middle line of the valves; right valve larger, sculptured with fine, even, concentric threads separated by narrower interspaces; there is no radial striation, but near the posterior cardinal margin a well-marked sulcus extends from the beak to the upper posterior margin, the surface above it and next to the cardinal margin turgid; in front of the strongly prosocoelous beaks the valve is impressed, though without any defined lunule; left valve smaller, less inflated, nearly smooth or with faint incremental lines; a strong radial rib close to the posterior hinge-margin; interior and internal margins of the valves polished; a small ridge near the hinge reflects the posterior external sulcus of

the right valve; cardinal tooth small, conical, rather prominent, the chondrophore hidden under the cardinal margin; left valve with the chondrophore flat, squarish, projecting, and a socket for the point of the right cardinal. Lon., 2.2; alt., 2.3; diam., 1.6 mm.

This interesting little species recalls *C. laqueata* Conrad on a smaller scale and with proportionately finer sculpture. Though so small, there is no reason to doubt that it is an adult form. (Dall, 1898.)

Type.—U. S. Nat. Mus. No. 107313.

Type locality.—U.S.G.S. collection 3100, Thomasville, Clarke County, Alabama. Bashi formation (upper Wilcox).

The known distribution of this small species is remarkable. It was first described from the "Woods Bluff" (Bashi) formation of the Wilcox. In Alabama it is "extremely common," according to Aldrich, in the Sucarnoochee clay of the lower Midway, and it is locally common in Texas at a slightly higher horizon.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11914, Colorado River section, 1½ miles below the Travis-Bastrop County line.

Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11908?, one-half mile northeast of Cedar Creek Crossing on Austin-Red Rock road; U.S.G.S. Sta. 11899, 50 to 60 feet west of Cedar Creek bridge on Austin-Red Rock road; and U.S.G.S.Sta. 12109, directly above bridge over Cedar Creek in Austin-Red Rock road.

Subgenus CARYOCORBULA Gardner

1926. *Caryocorbula* Gardner, Nautilus, vol. 40, p. 46.
Cuneocorbula Dall and authors [not *Cuneocorbula* Cossmann, 1886].

Type.—*Corbula alabamiensis* Isaac Lea. (Claiborne Eocene of the east coast and Gulf from South Carolina to the Rio Grande.)

Shell small or of moderate dimensions; acutely keeled, posteriorly; slightly inequivalve; right valve a little larger and a little higher relatively than the left; both valves concentrically rugose, the sculpture upon the right valve in some species stronger and more regular than upon the left; a microscopically fine radial lineation developed in some of the later species, particularly upon the posterior keel; ligament, dental, muscle and sinal characters similar to those of *Corbula* sensu stricto.

Caryocorbula includes most of the American species hitherto assigned to *Cuneocorbula*. *Caryocorbula* differs from the Paris Basin

group in that the shell is less trigonal, not so produced posteriorly, usually heavier, unirostrate rather than birostrate and more strongly sculptured. *Caryocorbula* is abundantly represented in the Tertiary and Pleistocene deposits of the east coast and Gulf and in the Recent east American waters.

CORBULA (CARYOCORBULA) KENNEDYI Gardner new species

Pl. 19, fig. 5

Shell very small, slightly inequivalve. Acutely rostrate posteriorly, the rostrum persistent almost to the tips of the umbones. Umbonal area flattened, the tips acute and twisted forward, subcentral in position. Shell broadly rounded anteriorly, truncate posteriorly and slightly flexuous ventrally in front of the keel. The right valve only known. Interior not accessible.

Dimensions. Height, 3.3 millimeters; length, 1.6 millimeters.

Holotype.– U. S. Nat. Mus. No. 370926.

Type locality.– U.S.G.S. Sta. 11767. Limestone ledge just above trail leading down from Evans' (Myrick's) apiary, Frio River, Uvalde County. Tehuacana member of Kincaid formation.

The species is named in honor of William Kennedy, one of the earliest to interest himself in the physical features of Texas.

Corbula kennedyi has much in common with *C. coloradoensis*, best developed in the Wills Point formation, and may be identical with it. The right valve figured, apparently an adult, is smaller than the Colorado River species, the posterior portion of the valve is more sinuous and not so sharply keeled and no subcutaneous radial sculpture was observed. The relation to the left valve figured from the same locality is doubtful. The scultpure is so discrepant on the two valves of *Corbula* that they may conceivably represent the same species. The figured left valve is very similar to the left valve of *C. coloradoensis* but more compressed than the few imperfect lefts recovered from the Colorado River.

Occurrence.—Kincaid formation. *Falls County:* U.S.G.S. Sta. 11931?, Whitaker Survey, 6± miles northwest of Kosse; and U.S.G.S. Sta. 11929?, Little Brazos River, less than one-fourth mile upstream from Rocky Crossing on the Kosse road. *Milam County:* Brazos River, 1 mile below the Falls County line, U.S.G.S. Sta. 11916, bed No. 1; U.S.G.S. Sta. 11917, bed No. 2; U.S.G.S. Sta. 11919, bed No. 4. *Medina County:* U.S.G.S. Sta. 6230, bed of Hondo

Creek, one-eighth mile below road crossing due east of Elstone, and on Irishman Hill, 10 feet above the *Ostrea cortex* zone. *Uvalde County:* U.S.G.S. Sta. 11767, limestone ledge just above trail leading down from Evans' (Myrick's) apiary, Frio River.

CORBULA (CARYOCORBULA) species indeterminate

Double valves running about one centimeter wide with fragments of shell still adhering indicate a highly inflated, strongly sculptured species of *Caryocorbula* fairly common at U.S.G.S. Sta. 11665, at Water Hill, 5 miles northeast of Kemp in Kaufman County.

CORBULA (CARYOCORBULA) species

Pl. 19, figs. 11, 12

Two valves, U. S. Nat. Mus. No. 370927, probably referable to the same species, were partially uncovered from a bit of a limestone boulder one-eighth mile below Elstone Crossing. The valves are small, transversely ovate-trigonal, and obtusely rostrate posteriorly. The concentric sculpture of fine wrinkles is absent upon the umbones. A microscopically fine radial shagreening is discernible on both valves. The characters of the interior are not known.

The specimens are both left valves, though the high light on the photograph of Figure 12 suggests a right valve. Although they are closely related to *C. kennedyi* from the Frio River and to *C. coloradoensis* from the Colorado River, they seem to be lower relatively than either and they are less flexuous. The radial sculpture unlike that of the Colorado River specimens can be seen only under high magnification. Further material is necessary to determine the relationships of these small corbulas.

CORBULA (CARYOCORBULA) COLORADOENSIS Gardner new species

Pl. 19, figs. 7–10

Shell small but solid, moderately inflated, inequivalve but not conspicuously so, the ventral margin of the right valve slightly overlapping the left; rudely trigonal in outline. Umbones rather high, slightly anterior and prosogyrate. Anterior extremity rounded, the posterior rostrate; base line slightly flexuous. Concentric sculpture developed only in the form of growth lines which are strongest near the ventral margin; radial lineation distinct and regular upon the disk, subcutaneous and suggesting that of *Nucula*. Resilifer of

right valve deep, undercutting the dorsal margin. Cardinal tooth of right valve short, horizontally compressed, upcurved at the pointed tip, not very prominent. Chondrophore and cardinal socket in left valve known only from imperfect material.

Dimensions.—Right valve (cotype): height, 4.5 millimeters; length, 6.5 millimeters. Left valve of another individual (cotype): height, 4.2 millimeters; length, 5.5 millimeters.

Cotypes (2).—U. S. Nat. Mus. No. 370970; paratype, U. S. Nat. Mus. No. 370992.

Type locality—U.S.G.S. Sta. 11890, Colorado River, 1½ to 2 miles below the Travis-Bastrop County line; gray shales above the *Venericardia bulla* zone. Wills Point formation.

Corbula coloradoensis is remarkable for the subcutaneous radial sculpture and the compactness of its small form.

This may prove to be synonymous with *Corbula (Caryocorbula) kennedyi* from the Tehuacana member of the Kincaid formation of the Frio River, in Uvalde County, but it runs a little larger and seems to be consistently sculptured radially. The left valve from the same limestone on the Frio is more compressed than those observed on the Colorado. This may be an individual variation or possibly this less inflated species is characteristic of the Kincaid. This is further indicated by the few valves collected from the Colorado River, one of them in contact with the right valve so that their relationship is beyond doubt. The right valves from the Kincaid formation on the Brazos and Colorado rivers are also a little more inflated than those from the upper part of the same section, but the material is too poor to justify their reference to *C. kennedyi* from the Tehuacana of Uvalde County.

A very similar, possibly identical, species occurs rather commonly in the indurated and oxidized glauconitic sandstone at U.S.G.S. Sta. 6283 on Guadalupe River, 2½ miles above the power house south of Seguin, Guadalupe County.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Sta. 11916?, Brazos River, bed No. 1, 1 mile below Falls County line. *Bastrop County:* U.S.G.S. Sta. 5230, right bank of Colorado River, 4 miles below Webberville; U.S.G.S. Stas. 11696, 11914, 11915, and 12112, Colorado River, 1½ miles below the Travis-Bastrop County line; below the *Venericardia bulla* zone.

Wills Point formation. *Williamson County:* U.S.G.S. Sta. 10420, lower bed, Dry Brushy Creek, 6 miles south of Thrall on the Taylor-Beaukiss road. *Bastrop County:* U.S.G.S. Stas. 10527, 11390, and 12113, Colorado River, 1½ to 2 miles below the Travis-Bastrop County line; above *Venericardia bulla* zone; and U.S.G.S. Sta. 12103, glauconitic red sands forming stream bed directly above bridge over Cedar Creek on Austin-Red Rock road. *Guadalupe County:* U.S.G.S. Sta. 6283, 2½ miles above power house south of Seguin. *Bexar County:* U.S.G.S. Sta. 6153, Jett Crossing, Palo Alto road and Medina River.

CORBULA (CARYOCORBULA) species indeterminate

Pl. 19, fig. 6

The compressed left valve of a species very closely resembling *C. (Caryocorbula) kennedyi* and *C. (Caryocorbula) coloradoensis* was collected from the Tehuacana member of the Kincaid formation on the Frio River. It is possibly identical with one or both of them for they may, with the aid of better material, be proven synonymous. The left valve from the Frio River section is, however, more compressed than the imperfect few left valves now in the Wills Point collections from the Colorado River, and in a group so discrepantly sculptured as the Corbulas it is hazardous to establish definite relationships without material showing the valves in contact.

The locality is the limestone a foot or more above the bed of Frio River just above the trail leading down from the Evans' (Myrick's) apiary (U.S.G.S. Sta. 11767), Uvalde County.

Superfamily ADESMACEA
Family PHOLADIDAE
Genus MARTESIA Leach

1825. *Martesia* Leach, in Blainville, Manuel de Malacologie et de Conchyliologie, p. 632.

Type. *Pholas clavata* Lamarck. (Recent in the European waters.)

Shell thin ovate-oblong, cuneiform, strengthened by three accessory plates; gaping posteriorly; valves closed in front at the completion of the burrow with a calcareous septa or "callum"; surface deeply sculptured by a single radial sulcus; myophore long, slender, curved. Burrows flask-shaped.

The genus has been reported from deposits as early as the Carboniferous. The customary habitat of the present day species is in burrows excavated in the floating timber and driftwood of the warm and temperate seas.

MARTESIA? species

Certain small flask-shaped molds from the Kincaid formation (Littig glauconitic member) 6 miles due north of Lockhart (U.S.G.S. Sta. 11682) Caldwell County, suggest *Martesia* but the characters preserved are not sufficient to make the generic determination possible.

Similar molds have been recovered from the Littig glauconitic member in Bastrop County on the Austin-Bastrop road (U.S.G.S. Sta. 11680) one-half mile east of Elysium and at the same horizon in Caldwell County, 2 miles south of Mendoza (U.S.G.S. Sta. 11681).

Family TEREDIDAE
Genus TEREDO Linnaeus

1758. *Teredo* Linnaeus, Systema naturae, 10th ed., p. 651.

Type.—*Teredo navalis* Linnaeus. (Recent in unprotected wood exposed for a length of time to the salt water of the European shores.)

Shell reduced to spatulate or spoon-shaped pallets, the animal depending for its protection upon the burrow which it excavates in unprotected wood exposed for a length of time to salt water, and which is lined with a calcareous tube secreted by the mantle. The great majority of fossil species are known from the tubes alone so that their systematic position is clouded.

TEREDO? RINGENS Aldrich

1921. *Teredo ringens* Aldrich, Bull. Am. Paleontology, vol. 9, No. 37, p. 17, pl. 2, fig. 12.

Shell substance thin, closed at the larger end like *Kaphas;* body of shell with raised, rather acute rings parallel to each other, and virtually at right angles to the longer diameter. Other fragments are not so strongly marked. Length of type specimen 37 mm. Average breadth 5 mm.

Locality. Sucarnoochee clay bed, 3 miles south of Estelle, Ala.

Type. Alabama Museum, University, Ala. (Aldrich, 1921.)

Fragment of tubes ringed like the Alabama form have been found in the oxidized greensands which shingle the surface 1 to 2 miles west of the Windmill (Jacal) ranch tank, Maverick County, and in

an oxidized sandstone possibly of upper Midway age in Caldwell County.

Occurrence.—Wills Point formation. *Guadalupe County:* U.S.G.S. Sta. 6277, 1½ miles west of Fentress. *Maverick County:* U.S.G.S. Sta. 11751, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

Teredo? ringens differs from *T. maverickensis* in the sharp, more distant, and more regular annulations.

TEREDO MAVERICKENSIS Gardner

1923. *Teredo maverickensis* Gardner, U. S. Geol. Survey, Prof. Paper 131-D, p. 114, pl. 32, fig. 11.

Tubes of moderate dimensions, somewhat irregular in growth habit though tending to follow the grain of the wood; closely and quite sharply rugose; characters of valves not known.

Dimensions.—Diameter, 6.0 millimeters; thickness of shell, 0.6 millimeters.

Holotype. U. S. Nat. Mus. No. 352274.

Type locality.—U.S.G.S. Sta. 10277, Rio Grande, lower end of Maverick County, about 40 feet below Midway-Wilcox contact.

Teredo maverickensis is less regularly and less distantly wrinkled than *T.? ringens* Aldrich. These differences may be due in part to differences in habitat for *T. maverickensis* is found in fossil wood while *T.? ringens* has been observed only in the sandstone.

Occurrence.—Kincaid formation. *Maverick County:* U.S.G.S. Sta. 10277, Rio Grande, lower end of Maverick County, about 40 feet below the Midway-Wilcox contact.

Class SCAPHOPODA
Family DENTALIIDAE
Genus DENTALIUM Linnaeus

1758. *Dentalium* Linnaeus, Systema naturae, 10th ed., p. 785.
1920. *Dentalium* Linnaeus, Henderson, U. S. Nat. Mus., Bull. 111, p. 8.

Type.—*Dentalium elephantinum* Linnaeus. (Recent in the China Sea.)

Shell an elongate tube open at both ends, increasing in diameter from the apex to the aperture, the section of maximum diameter being coincident with the peristome; almost straight to strongly curved; usually sculptured with longitudinal (lengthwise as from tip to aperture) riblets or engraved lines, especially near the tip or on the posterior portion. The sculptural features may vary in degree from faint indications to strong heavy ribs and these may vary in number from 6 to 60 or more. The original number of ribs or riblets

is the apical portion is often increased later by the addition of others intercalated between them so that as the animal grows its shell increases in the number of its ribs. Frequently all sculptural features present in the posterior or middle portion of the shell disappear in the anterior portion, the senile stage showing a smooth surface. The sculpture is sometimes further modified by fine transverse lirae occupying the spaces between the longitudinal ribs or even crossing them. Again, the intercostal surface may present a fine reticulated plan of excessively minute sculptural elements. In some groups there are no sculptural features whatever. The embryonic portion of the apex is very minute and fragile, and is always lost, save rarely, in very young specimens. The apical section remaining may be round or angular in section, in which latter case the angles become the beginnings of the primary ribs or ribdets. The apical opening is usually modified by a slit or notch of varying width or depth and variously placed in different groups; or the opening may be simple without either notch or slit. The shell varies in size from minute needle-like forms to those of 4 or 5 inches in length, in thickness from fragile to heavy and solid; in texture from soft and chalky to hard porcellaneous or glassy; in color from occasional greenish, reddish, or yellowish species to pure white, the latter greatly predominating. The shells may be transparent, translucent to opaque, dull lusterless to the most highly polished and glistening surface. (Henderson, 1920.)

DENTALIUM MEDIAVIENSE Harris

1892. *Dentalium minutistriatum* Gabb, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, p. 438 (*ex parte*).

Not *Dentalium minustriatum* Gabb, 1860, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 386, pl. 67, fig. 46.

1896. *Dentalium mediaviense* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 73, pl. 7, figs. 1, 1a.

Size and general form as shown by the figures; surface nearly smooth near the greater extremity, though showing some irregular slight annulations; above, becoming longitudinally striate with alternating fine and coarse lines, annulations plainly visible and very regular; shell, about larger aperture very thin, but becoming very thick within half an inch of this extremity . . .

. . . The Midway species are large, sometimes quite large and attaining a maximum diameter of ½ inch; their striation is very plainly alternate and sometimes becomes quite strong towards the apex; they have clearly defined and regular annulations; they are much more tapering than *minutistriatum*. (Harris, 1896.)

Dimensions.—Height of figured fragment about 14.0 millimeters.

Type locality.—One-half mile west of Graveyard Hill, Wilcox County, Alabama.

Type.—Paleontological Museum, Cornell University, Ithaca, New York.

Better material may prove the Texas *Dentalium* distinct. The shell seems thinner and more delicately sculptured than that of the Alabama species.

A specimen from the lower part of the fossiliferous section on the Colorado River (U.S.G.S. Sta. 11915) is feebly annulated and shows only the faintest traces of an axial sculpture.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Stas. 11916? (bed No. 1) and 11919 (bed No. 4), Brazos River, 1 mile below Falls County line. *Bastrop County:* U.S.G.S. Stas. 5230 and 10526, Colorado River, right bank, 4 miles below Webberville; U.S.G.S. Stas. 11696, 11914, and 12112, Colorado River, 1½ miles below the Travis-Bastrop County line. *Medina County:* U.S.G.S. Sta. 11769?, 5.7 miles northwest of Castroville on the Quihi road; and U.S.G.S. Sta. 6230, bed of Hondo Creek, one-eighth mile below road crossing east of Elstone.

Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 12113, one-half to three-fourths mile above mouth of Dry Creek; above *Venericardia bulla* zone; U.S.G.S. Sta. 11697?, 1 mile south of Cedar Creek and south of Cedar Creek-Lytton Springs road.

Family SIPHONODENTALIIDAE
Genus CADULUS Philippi

1844. *Cadulus* Philippi, Enumeratio Molluscorum Siciliae, vol. 2, p. 209.
Type.—*Dentalium orulum* Philippi. (Recent in the Mediterranean.)

Shell tubular, more or less inflated medially or anteriorly and contracted near the aperture; maximum diameter often sharply defined by the so-called cingulum; outline somewhat arcuate, especially along the outer, convex, or ventral margin and toward the posterior extremity; external surface usually polished, smooth or faintly striated concentrically; posterior orifice simple or cut up into two or more lobes; anterior orifice circular, oval, or ovate, usually oblique to the axis.

The genus though of much more modern origin than *Dentalium* can trace its ancestry back into the Cretaceous. The Recent species are about 70 in number and are quite abundantly represented in the warmer waters.

CADULUS TURGIDUS Meyer

1886. *Cadulus turgidus* Meyer, Geol. Survey Alabama, Bull. 1, p. 65, pl. 1, fig. 10.

1896. *Cadulus turgidus* Meyer, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 73, pl. 7, fig. 2.

Width of the shell rapidly increasing for about two-thirds of the entire length, and then more rapidly decreasing; section circular.

Locality.—Matthews' Landing, Ala.

Rather common; I received this shell from Mr. Aldrich. It differs by its very strong inflation from all the other species of *Cadulus* of the Southern Tertiary which I know of. (Meyer, 1886.)

The height of the figured type is 4.9 millimeters, the maximum diameter, 1.25 millimeters. The type is in the Aldrich Collection, Johns Hopkins University. The maximum diameter falls about one-third of the distance from the anterior to the posterior extremity. The inflation is more abrupt than in *Cadulus phoenicea* and the shell is not so small.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 11696 and 11914, Colorado River, 4 miles below Webberville and about 1½ miles below the Travis County line.

Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11690?, Colorado River, 2 miles below the Travis County line.

CADULUS PHOENICEA Gardner new species

Pl. 20, fig. 2

Shell minute, flattened along the inner margin, broadly arched along the outer, constricted more gradually toward the anterior orifice than toward the posterior. Maximum inflation medial or slightly anterior. Anterior orifice nearly circular, the posterior slightly compressed.

Dimensions.—Height, 3.0 millimeters; greatest diameter, 1.0 millimeter.

Holotype.—U. S. Nat. Mus. No. 370996.

Type locality.—U.S.G.S. Sta. 5282, clay from bluff at Webberville. Kincaid formation.

This small shell seems to be something more than an immature *C. turgidus* with possibly the posterior tip broken away. It is more decidedly flattened along the inner surface and the inflation is more nearly symmetrical and the maximum not so far forward. The type is unfortunately unique.

Occurrence.—Kincaid formation. *Travis County:* U.S.G.S. Sta. 5232, clay from bluff at Webberville.

CADULUS ALDRICHI Gardner new species

Pl. 20, fig. 1

1895. *Cadulus subcoarctatus* Gabb, Aldrich, Bull. Am. Paleontology, vol. 1, No. 2, p. 4, pl. 1, fig. 4.

Not *Ditrupa subcoarctata* Gabb, 1860, Acad. Nat. Sci. Philadelphia, Jour., vol. 4, 2d ser., p. 386, pl. 67, fig. 47.

1899. *Cadulus abruptus* Meyer and Aldrich, Harris, Bull. Am. Paleontology, vol. 3, p. 5 (*ex parte*).

Not *Cadulus abruptus* Meyer and Aldrich, 1886, Soc. Nat. Hist., Cincinnati, Jour., vol. 9, No. 2, p. 104 (40), pl. 2, fig. 2.

Shell scimitar-shaped, slender and gradually tapering. Inner margin more strongly arcuate than the outer. Maximum diameter within the anterior fourth. Anterior orifice oblique to the axis, broadly elliptical in outline. Posterior orifice compressed.

Dimensions.—Height, 10.0 millimeters; greatest diameter, 1.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 373066.

Type locality.—U.S.G.S. Sta. 8245, Salado Creek, 5.3 miles southeast of San Antonio. Wills Point formation.

The individual which is referred to this species is much the most slender of the Texas Midway *Caduli* and the maximum diameter falls farther forward than in any of the other known species.

Occurrence.—Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11697?, 3 miles southwest of Cedar Creek Post Office. *Bexar County:* U.S.G.S. Sta. 8245, Salado Creek, 5.3 miles southeast of San Antonio.

Class	GASTROPODA
Subclass	EUTHYNEURA
Order	OPISTHOBRANCHIATA
Suborder	TECTIBRANCHIATA

The state of confusion of the Tectibranchs is notorious, and until the soft parts of the constituent groups have been examined it is well nigh hopeless. Pilsbry in the fifteenth volume of the Manual of Conchology emphasizes again and again the absolute necessity for detailed dissections before definite relationships can be established between some of the best known genera. The hard parts are apparently less intimately concerned with the soft parts than in

the majority of the univalves doubtless because of the relatively small size of the shell. In many groups it is not sufficient to cover the animal, and in still others it has degenerated into a thin, often membranous, internal skeleton.

Family ACTAEONIDAE
Genus TORNATELLAEA Conrad

1860. *Tornatellaea* Conrad, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 294.

Type.—*Tornatellaea bella* Conrad (lower Eocene of the Gulf).

Ovate ventricose; columella with two slender, prominent folds, the lower fold not distinctly continuous with the margin of the base. (Conrad, 1860.)

The genus shares with *Actaeon* a heterostrophous nucleus and a dominantly spiral, often punctate sculpture. The shell is characteristically heavier, however; the labrum is lirate within; the columella bears two folds instead of one, and the anterior extremity of the aperture is constricted into an incipient canal.

The genus has been reported from various horizons from the Lower Jurassic to the early Miocene. In North America it is restricted to the Eocene, Oligocene, and Miocene, and it is quite probable that the reference of some of the European forms to the lower Mesozoic horizons is incorrect.

TORNATELLAEA BELLA Conrad

1860. *Tornatellaea bella* Conrad, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 294, pl. 47, fig. 23.

1890. *Tornatellaea bella* Conrad, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 166, pl. 16, fig. 19.

1896. *Actaeon (Tornatellaea) bella* Conrad, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 74, pl. 7, fig. 3.

Ovate; spire conical; revolving lines numerous, impressed, punctate-striate. (Conrad, 1860.)

Tornatellaea bella is relatively large and solid and decidedly more inflated than *T. quercollis* of Alabama or *T. texana* of Texas.

None of the occurrences cited in the older check lists have been verified and there is no good reason to suppose that *Tornatellaea bella* is to be found in Texas. A species not unlike *T. bella* in outline but with a much finer spiral sculpture is found in a poorly preserved state at a number of localities at or near the top of the Kincaid formation.

Tornatellaea bella is one of a considerable number of species common to the Midway and Wilcox groups.

TORNATELLAEA QUERCOLLIS Harris

Pl. 20, fig. 1

1896. *Actaeon (Tornatellaea) quercollis* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 74, pl. 7, fig. 4.

General form as shown by the figure; spire usually broken at apex, remaining whorls slightly shouldered above but becoming more rectilinear below, traces of lines of growth sometimes present, spiral striae rather faint; body whorl somewhat shouldered, sides rather straight, spiral striae fainter above and stronger below; columella in adult specimens with two well marked folds; aperture truncated anteriorly; labrum thin at margin, strongly lirate and varicose within. (Harris, 1896.)

Dimensions.—Height, 7.4 millimeters; greatest diameter, 3.4 millimeters.

Holotype.—U. S. Nat. Mus. No. 129607.

Type locality.—U.S.G.S. Sta. 264, Prairie Creek, Wilcox County, Alabama. Midway group. Clayton formation.

The Texas species *T. texana* Gardner is similar to that from Alabama in altitude and sculpture, even to the suggestion of a very fine axial sculpture upon the anterior half of the early whorls, but it runs a little stouter and has been considered distinct taxonomically. *Tornatellaea quercollis* has been reported from Texas but its occurrence has not been verified.

TORNATELLAEA TEXANA Gardner new species

Pl. 20, fig. 5

Shell rather small for the genus, very fragile, trigonal ovate in outline. Adult conch probably made up of five post-nuclear and one smooth, partially immersed nuclear whorl. Post-nuclear whorls narrowly tabulated posteriorly, broadly but not strongly inflated medially. Surface of conch spirally grooved with straight-sided sulci microscopically grilled by the incrementals which are uniform in size and spacing. Sulci 6 to 12 in number on the whorls of the spire, the spaces between, wider than the sulci, low and flattened; a tendency toward an axial puckering on the anterior portion of the early whorls. Aperture pyriform, angulated posteriorly, the outer lip convex, the inner excavated at the base of the body. Columella

calloused and biplicate, the anterior of the two folds marginal. A suggestion of a siphonal fasciole in the character and disposition of the spirals.

Dimensions.—Height, 7.1 millimeters; greatest diameter, 4.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370931.

Type locality.—U.S.G.S. Sta. 10527, Colorado River, about 5 miles below Webberville; above the *Venericardia bulla* zone, Bastrop County, Texas, in the Wills Point formation.

Tornatellaea texana is closely related to *Tornatellaea quercollis* Harris from Prairie Creek, Wilcox County, Alabama, but it is consistently broader and more inflated. In the convexity of the whorls and in the relative dimensions, it stands midway between *T. quercollis* and *T. bella* but in the delicacy of the shell and of the surface sculpture, it is much more closely allied to Harris' species than to Conrad's.

Specimens from below the *Venericardia bulla* zone in the Colorado River section are slightly more inflated in front of the shoulder. Whether or not this slight but seemingly constant difference is of taxonomic value cannot be determined from the material under observation.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 10525, 11915, 11911 and 12112, Colorado River, 4 miles below Webberville.

Wills Point formation. *Bastrop County:* U.S.G.S. Stas. 10527, 11913, and 12113, Colorado River, 1½ to 2 miles below the Travis-Bastrop County line; above the *Venericardia bulla* zone.

A poorly preserved individual from the Windmill (Jacal) ranch, 27 miles southeast of Eagle Pass (U.S.G.S. Sta. 11754), Wills Point formation, is more inflated and more coarsely sculptured than the Colorado River individuals.

TORNATELLAEA species

A larger, stouter species with a shorter spire, very narrow spirals and relatively wide interspirals occurs in the Kincaid formation, but the specimens are all in a fragmentary state and too imperfect to furnish type material. Those from bed No. 4 at Milam Bluff, Brazos River (U.S.G.S. Sta. 11926), have a much shorter spire than those from Bastrop and Caldwell counties, a difference which may

be of taxonomic importance. The specimen from the lower bed on Dry Brushy Creek, Wills Point formation, 6 miles south of Thrall, Williamson County (U.S.G.S. Sta. 10420), is perhaps more closely allied to those from the Brazos River than to the higher-spired race from Cedar Creek, 300 feet above the bridge on the Austin-Red Rock road (Bureau of Economic Geology), from 5 miles northeast of Staples, Caldwell County (U.S.G.S. Sta. 11691), and from 5½ miles due north of Lockhart (U.S.G.S. Sta. 11707).

The same species may be represented in Bexar County in the glauconitic concretions on the east-facing slope of Leon Creek, 1000 feet to 2000 feet upstream from the Southern Pacific Railroad crossing.

Family ACTEOCINIDAE
Genus ACTEOCINA Gray

1847. *Acteocina* Gray, Zool. Soc. London, Proc., p. 160.
= *Tornatina* Arthur Adams, 1850, in Sowerby, Thesaurus Conchyliorum, Vol. 2, p. 554.

Type.—*Acteon wetherilli* Lea. (Miocene of New Jersey.)

The name *Acteocina* was used by Gray in 1847 as a possible subgenus of *Actaeon*. He gave no description, but he chose as his type "*Acteon wetherilli* Lea," which is not an *Actaeon* but a member of the group more commonly known under Adams' name *Tornatina*.

Shell small, cylindrical or fusiform, thin, inflated; protoconch papillate and heterostrophous, evolute, coiled at right angles to the axis of the conch; sutures channeled; sculpture absent or feeble; aperture narrow, often sub-linear; outer lip simple; columella reinforced, monoplicate.

The Recent species of *Acteocina* are for the most part denizens of the warmer waters ranging in depth from the littoral zone to more than 200 fathoms.

ACTEOCINA? species

Pl. 20, fig. 3

Though *Acteocina* has not been recognized in strata older than the late Oligocene, two individuals seemingly of this genus are present in the material under observation. A juvenile with the nucleus still beautifully preserved, from the glauconitic sands above the *Venericardia bulla* zone in the Colorado River section (U.S.G.S.

Sta. 10527), has developed no characters by which it can be separated from the *Acteocina* of the later Tertiary and Recent faunas. It is figured as an interesting indication of the presence of the genus in the early Eocene. The height is 1.7 millimeters.

Figured specimen.— U. S. Nat. Mus. No. 370982.

This juvenile is apparently distinct from the *Acteocina* represented also by two individuals which occur even lower in the section and are related to *Acteocina leai* (Aldrich) of the lower Wilcox.

ACTEOCINA LEAI (Aldrich)?

1895. *Bullina leai* Aldrich, Bull. Am. Paleontology, vol. 1, No. 2, p. 7, pl. 2, fig. 6.

1895. *Tornatina leai* (Aldrich) Cossmann, Rev. Annuaire Geol. Universel, p. 34.

1899. *Tornatina leai* (Aldrich) Harris, Bull. Am. Paleontology, vol. 3, No. 11, p. 7, pl. 1, fig. 8.

Shell cylindrical, whorls five, spire depressed; suture deeply impressed; shell rounded, marked by a series of raised longitudinal lines at base that correspond to lines of growth; body whorl shouldered and bordered on upper part with a large number of very fine spiral lines which are crossed by lines of growth, the whole forming a band, shell slightly constricted just below this band; main part of body whorl nearly smooth; at the base the spiral lines again appear; columella with one fold; outer lip recurved, smooth and rounded; aperture narrow, widest at base.

Locality.—Bell's Landing, Ala. (Aldrich, 1895.)

Type.—Aldrich Collection, Geological Laboratory, Johns Hopkins University, Baltimore, Maryland.

The type measures 4.7 millimeters in height and 1.8 millimeters in greatest diameter.

The single individual from the Kincaid formation, U.S.G.S. Sta. 5290, Colorado River section, 4 miles below Webberville, is not fully mature but it shows the slightly swollen posterior band and other characteristic features of the lower Wilcox form.

An adult from the same fossiliferous section (U.S.G.S. Sta. 12112) is apparently more strongly lineated. The posterior edge of the whorl is very sharp and the outer lip thin. The heterostrophous nucleus is preserved but the spire is decorticated. Faint traces of a spiral lineation are visible under magnification over the entire body but the sculpture strengthens toward the anterior extremity.

Genus CYLICHNINA Monterosato

1881. *Cylichnina* Monterosato, Nomenclatura Generica e Specifica di Alcune Conchiglie Mediterranee, Palermo, p. 143.

Type. *Bulla umbilicata* Montagu. (Recent on the European shores from the Shetland Islands to the Mediterranean Sea.)

Shell small, involute, subcylindrical, the body whorl of the adult more or less conoidal, as a rule, tapering posteriorly; external surface smooth or axially striated, more rarely spirally lineated; aperture longer than the body, more or less produced behind and patulous anteriorly; columella non-plicate; apex perforate; umbilicus imperforate.

CYLICHNINA EMORYI Gardner new species

Pl. 20, figs. 6, 7

Shell very small, involute, ovate cylindrical. Apex perforate. Body obliquely flattened in the rear view, feebly inflated in the front. A very fine and regular spiral sculpture of flattened lirae with linear interspaces developed over the entire outer surface of the shell. Aperture narrow behind, broadening anteriorly. Outer lip, thin, sharp, produced posteriorly, patulous anteriorly. Aperture filled with matrix obscuring the characters of the columella.

Dimensions.—Height, 3.5 millimeters; greatest diameter, 5.0 millimeters.

Holotype. U. S. Nat. Mus. No. 370923.

Type locality.—U.S.G.S. Sta. 11754, 6 miles below the McFarland sheep pens and 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road. Wills Point formation.

Cylichnina emoryi is named in honor of William H. Emory, Major in the First Cavalry and United States Commissioner at the time that the United States and Mexican Boundary report was made. His personal narrative of the country traversed, the steel engravings which accompany it, and the difficulties, necessary and unnecessary, under which the work was done, are both informative and entertaining.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

Family SCAPHANDRIDAE
Genus SCAPHANDER Montfort

1810. *Scaphander* Montfort, Conchyliologie Systématique, vol. 2, p. 334.
Type.—*Bulla lignaria* Linnaeus. (Recent off the west coast of Europe.)

Shell entirely external, involute, subcylindrical or ovate in outline; large for the group; spire concealed, imperforate; external surface covered with an epidermis, usually ornamented with a fine spiral grooving; aperture relatively very large, narrow, produced, and sinuated, posteriorly dilated and patulous anteriorly; outer lip thin, sharp; columella revolving around a hollow axis; columellar lip simple in the typical form, broadly concave, the margin reflexed and closely appressed; parietal wall thinly glazed.

The genus may have been initiated as early as the Cretaceous. At least it was present throughout the Tertiary. The Recent species are few in number, but they have a very wide latitudinal and bathymetric range. *Scaphander punctostriatus* Mighels has been reported from off the west coast of Norway and from the Azores in 1000 fathoms. It has also been reported along the east coast of North America from Maine to the Gulf of Mexico and the Barbados at depths ranging from 46 to 1467 fathoms.

SCAPHANDER LIGNITICUS Aldrich?

1897. *Scaphander lignitica* Aldrich, Bull. Am. Paleontology, vol. 2, No. 8, p. 11, pl. 2, fig. 4.
1899. *Scaphander lignitica* Aldrich, Harris, Bull. Am. Paleontology, vol. 3, No. 11, p. 8, pl. 1, fig. 10.

Shell thin, cylindrical, narrowing posteriorly; outer lip rising above the shell; surface finely striated.

Differs from *S. alabamensis* Ald. in its being narrower posteriorly and longer, and from *S. primus* Ald. by its more regularly cylindrical shape. A specimen is in the National Museum, Washington.

Locality.—Alabama: Wood's Bluff horizon at Choctaw Corner. (Aldrich, 1897.)

Fragments suggesting *Scaphander lignitica* in general dimensions and type of sculpture are widespread but not common in the Midway of Texas and cannot be specifically or even generically determined with assurance.

SCAPHANDER new species

Crushed and imperfect specimens suggesting *Scaphander* in size, shape and character of the sculpture occur at a few localities in the

greensand of the Kincaid and Wills Point formations. The Midway species is apparently less inflated than *Scaphander lignitica* Aldrich from the "Woods Bluff horizon" (Bashi formation) of the Wilcox group of Alabama. The anterior two-thirds of the shell is wound with quite deeply incised grooves running 3 or 4 to the millimeter and shagreened by the incrementals. The posterior third of the shell is very faintly incised except for 2 or 3 deeper grooves near the extremity. The characters of the apex and of the aperture are not revealed.

The largest and most perfect specimen was collected from a small branch of Cedar Creek, one-half mile northeast of the crossing on the Austin-Red Rock road in Bastrop County (U.S.G.S. Sta. 11906). Other specimens possibly referable to *Scaphander* occur at U.S. G.S. Sta. 5280, the Colorado River, 4 miles below Webberville, Bastrop County.

Genus ATYS Montfort

1810. *Atys* Montfort, Conchyliologie Systématique, vol. 2, p. 342.
Type.—*Atys cymbulus* Montfort = *Bulla naucum* Linnaeus. (Recent in the Indo-Pacific.)

Shell very thin, inflated, often globose, ovate or cylindrical in outline; spire involute, occulted; external surface spirally sulcate, as a rule, toward the extremities, free from sculpture medially; aperture arcuate, more produced than the body both anteriorly and posteriorly, sharply constricted behind the vertex and in the true *Atys* twisted or plicate upon its inner margin; outer lip thin, sharp, expanded, patulous anteriorly; inner lip short, usually obliquely plicate or truncate; umbilicus in the typical forms narrowly perforate.

Subgenus ALICULASTRUM Pilsbry

1896. *Aliculastrum* Pilsbry, Manual of Conchology, ser. 1, vol. 16, p. 237.
1831. *Alicula* Ehrenberg, Symbolae Physicae, seu icones et descriptiones Mammalium Avium, Insectorum et animal. evertebrates, Insecti- (no pagination p. II of Moll.).
Not *Alicula* Eichwald, 1829. Naturhistorische Skizze von Lithauen, Volhynien u. Podolien, p. 214.
Type.—*Bulla cylindrica* Helding. (Recent in the Indo-Pacific.)

Aliculastrum is separated from the typical *Atys* by the less inflated, more cylindrical outline and the obscure or obsolete plication of the

columella. It shares with *Atys*, however, the characteristic twist of the lip behind the vertex.

The subgenus is present in the Tertiaries, but it has not been previously reported from so early a horizon. In the Recent seas it is much the best represented of the subdivisions of *Atys*.

ATYS (ALICULASTRUM?) new species

Shell very small, subcylindrical; the diameter slightly greater medially than at the extremities but with no marked equatorial inflation. Apical end grooved with a half dozen or more sulci, the posterior sulci, slightly more numerous and more regular in size and spacing than the anterior. Sculpture obsolete medially except for microscopically fine and faint linear grooves. Apical extremity slightly excavated but not perforate. Outer lip obviously longer than the altitude of the body but the other characters of the aperture obscured by the matrix.

Dimensions.—Height, 4.1 millimeters; greatest diameter, 1.5 millimeters.

The specimen described is U. S. Nat. Mus. No. 370984, from U.S.G.S. Sta. 11916, Brazos River, 1 mile below the Falls County line, Milam County, Texas. Kincaid formation.

The characters preserved are not sufficient to make the generic and subgeneric determinations with absolute assurance. Fragmentary material is fairly common and eventually adequate type material should be recovered.

Cylichna meyeri Aldrich, 1895, Bulletin of American Paleontology, vol. 1, No. 2, p. 6, pl. 2, fig. 5, from Matthews Landing, Alabama, is apparently in *Atys*, and related to the Texas individual. The growth sculpture so distinctly developed posteriorly in *meyeri* has not been observed in the Texas form. The intensive study of the early Tertiary warm water faunas will doubtless reveal representatives of a number of groups which like *Aliculastrum* have not been previously reported from strata older than the Miocene.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Sta. 11916, Brazos River, Cribbs Bluff, 1 mile below the Falls County line.

A crushed individual probably of the same group but more evenly cylindrical, smaller and more faintly lineated, was recovered from

the Kincaid formation of the Colorado River section, 4 miles below Webberville (U.S.G.S. Sta. 11914).

ATYS (ALICULASTRUM)? species

A poorly preserved specimen from the lower fossiliferous bed of the Colorado River section (U.S.G.S. Sta. 11915) indicated a relatively large species, less strongly lineated both in front and posteriorly.

Family RINGICULIDAE
Genus RINGICULA Deshayes

1838. *Ringicula* Deshayes, Histoire naturelle des animaux sans vertèbres, 2d ed., 1838, vol. 8, p. 342.

Type. *Auricula ringens* Lamarck. (Eocene of the Paris Basin.)

Shell small, ventricose, spire relatively short; nucleus heterostrophous; surface of shell smooth or spirally striate; aperture narrow parallel to the axis of the shell, dilated and more or less emarginate anteriorly; outer lip thickened and reflected, smooth or finely plicate within; columella excavated, calloused, furnished posteriorly as a rule with a strong tubercular denticle and anteriorly with two prominent, transverse plaits.

The genus has been noted in the Cretaceous deposits of Europe and India as well as in those of North America. Some seventy species are reported from the various Tertiary horizons, and about thirty-five from the temperate and tropical waters of today.

The Recent members of the genus occur for the most part in waters over 50 fathoms in depth.

RINGICULA ALABAMENSIS Aldrich

1897. *Ringicula alabamensis* Aldrich, Bull. Am. Paleontology, vol. 2, No. 8, p. 9, pl. 2, figs. 8, 8a.

Shell small, spire blunt; whorls five, first two smooth, the others spirally striated; the striae are exceedingly fine and closely set; aperture long and narrow, the border of the posterior notch reaching beyond the suture; outer lip reflexed and flattened, faintly striated anteriorly; inner callus strong posteriorly, with two moderate plaits very angular to each other.

This species is of medium size and is peculiar in having the longest aperture of any species known in our Eocene. The surface is much more finely marked than other forms. It approaches *R. trapezoura* Harris, but differs, as above stated, from it. It is much closer to *R. dalli* Clark, and while the plaits on the

inner lip are more angular to each other, and the aperture a little longer, yet other specimens may be found to unite the two forms.

Locality.—Alabama: Matthews' Landing. (Aldrich, 1897.)

Ringicula trapaquara Harris was described from the Cook Mountain formation of Mosley's Ferry, Brazos River, Texas, and *Ringicula dalli* Clark from Woodstock, Virginia, from the Woodstock member of the Nanjemoy formation, the possible equivalent of the Claiborne of Alabama. There is no question of a probable specific identity of the Claiborne with the Midway species. They are certainly distinct. There is some doubt, however, about the specific identity of the Alabama and the Texas individuals. Those from the Smith tract in the Sutherland Field, Bexar County, at a depth of 659 to 680 feet are smaller, relatively stouter, and more sharply sculptured than the type from Matthews Landing, Alabama.

A similar form occurs in the Wills Point formation (U.S.G.S. Sta. 11697) 3 miles southwest of Cedar Creek Post Office, Bastrop County.

RINGICULA species

A single individual from Jett Crossing on the Medina River (U.S.G.S. Sta. 6153), 3 miles below Garza Crossing in Bexar County, exhibits a relatively higher spire and lower and broader spirals than either the Alabama species or those from the Smith well. The significance of these differences cannot be determined without further material but as the Jett Crossing horizon is higher than that from which the other ringiculas have been uncovered, it may be well to isolate the form in question for the present.

Genus GILBERTINA Morlet

1888. *Gilbertina* Morlet, L., Journal de Conchyliologie, vol. 36, p. 220.

Type.—*Gilbertina inopinata* Morlet. (Thanetian of the Paris Basin.)

Cossmann in the Catalogue Illustré des Coquilles Fossiles de l'Éocène des environs de Paris, 4th volume, page 351, changed the name *Gilbertina* to *Gilbertia* on the ground that *Gilbertia* was the proper form for a genus dedicated to Captain Gilbert. However, if the author wished to use the diminutive, it was certainly his privilege to do so.

Shell imperforate, depressed, rather heavy; somewhat naticoid in outline, the spire very short, the body whorl relatively large and

inflated; spirals feeble or obsolete; aperture subpyriform, angulated and feebly emarginate posteriorly, expanded and entire anteriorly, partially choked with the heavy callous, the two strong columellar folds and the denticle upon the inner margin of the outer lip opposite the posterior fold: outer lip reinforced by a broad flat band of callous, denticulate within.

The distribution of this rare and minute form is extremely suggestive. The type has a meager representation in the Bracheux sands at the base of the Eocene section of the Paris Basin. The genus is present also in the Paleocene at Copenhagen. Aldrich in 1921 in the Bulletin of American Paleontology, vol. 9, No. 37, described the new species *Gilbertia estellensis* from the Sucarnoochee clay (lower Midway) of Estelle, Alabama. *Gilbertina texana* is known only from the fossiliferous section on the Colorado River, and from Cedar Creek in southwestern Bastrop County.

GILBERTINA TEXANA Gardner new species

Pl. 20, figs. 8, 9

Shell minute, relatively heavy, naticoid. Protoconch not preserved, certainly exceedingly small. Conch of three rapidly enlarging whorls, the two that make up the spire rising only slightly above the broadly inflated body. Surface smooth, except for a very faint shagreening visible under high magnification and a slight puckering at the posterior suture of the whorls of the spire. Aperture minutely pyriform, obtusely angulated and feebly emarginate posteriorly, heavily reinforced; a broad flat band of callous along the outer margin of the outer lip, produced backward upon the preceding whorl; inner margin of the aperture convex heavily enamelled especially toward the suture, completely concealing the umbilicus and continuous with the heavy callous of the outer lip. Two very sharp and prominent folds projecting almost horizontally into the aperture at the base of the body; inner margin of outer lip much thickened and feebly denticulate, the most prominent denticle opposite the columellar folds. Anterior extremity of aperture slightly patulous.

Dimensions.—Height, 2.3 millimeters; greatest diameter, 2.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 370933.

Type locality.—U.S.G.S. Sta. 11915, Colorado River, 1½ miles below the Travis-Bastrop County line. Bed No. 7. Kincaid formation.

Gilbertina texana is very close to the *Gilbertina estellensis* of Aldrich and may prove to be identical. The spire of the Alabama species seems, however, to be more depressed though the altitude of the shell is relatively greater than that of *G. texana.*

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11915, 1½ miles below the Travis-Bastrop County line, and U.S.G.S. Sta. 12112, 1½ miles below the Travis-Bastrop County line. Bed No. 7.

Wills Point formation. *Bastrop County:* U.S.G.S. Stas. 11890 and 12113, Colorado River, 4 to 5 miles below Webberville and 1½ to 2 miles below the Travis County line. Above the *Venericardia bulla* zone. U.S.G.S. Sta. 12110, directly above bridge over Cedar Creek on Austin-Red Rock road (upper ledge).

Subclass STREPTONEURA
Order PECTINIBRANCHIATA
Suborder STENOGLOSSA
Family TURRITIDAE

The old group of the Pleurotomidae is a source of embarrassment to every systematic paleontologist. Even the family name—whether they shall be called the Turridae or the Turritidae—is a subject for discussion. Practically all of the old generic names such as *Pleurotoma* and *Surcula* with types from the Indo-Pacific have been discarded, and the present tendency is toward a rather bewildering multiplication of generic names. Certainly the turretids exhibit decided group tendencies, both geographic and geologic and it is highly desirable to recognize such relationships in the nomenclature. For that reason, names such as De Gregorio's *Coronia* and Casey's *Orthosurcula* have been utilized rather than the better known *Pleurotoma* and *Surcula* which have come to mean little more than operculate turretids with long anterior canals and the siphonal notch upon the periphery, and operculate turretids with long anterior canals and the siphonal notch upon the shoulder. In forms imperfectly preserved referable, apparently, to undescribed groups, the old generalized names have been retained.

Genus CORONIA De Gregorio

1890. *Coronia* De Gregorio, Monographie de la Faune Éocénique de l'Alabama, Ann. Géol. and Pal., vol. 7, p. 23.

Type: *Pleurotoma childreni* Lea. (Claiborne Eocene of the Gulf States.)

Shell small, turriculate; the whorls angular, the periphery in many species outlined by a double spiral; protoconch of 2 or more smooth rapidly enlarging whorls succeeded by one or more convex whorls adorned with numerous obliquely arcuate costae. Both axial and spiral sculpture upon the conch, the axial tending to be oblique, the spiral most prominent upon the periphery and in front of it; body constricted rather abruptly into a narrow straight and fairly short broad canal; aperture narrow; siphonal fasciole rather shallow, following the periphery.

Coronia has been considered a synonym of *Hemipleurotoma* by Cossmann and others but the type of *Hemipleurotoma* is *Pleurotoma archimedis* Bellardi from the Miocene of northern Italy. No specimens are available for comparison and the tip is broken away in the figured individual, but apparently in the Italian Miocene species, the fasciole is more constricted and deeper, and in the Italian forms related to *P. archimedis* in their conchal characters, the protoconch is smaller and more obtuse than in the Gulf Eocene group. The acute, multispiral protoconch of *Coronia* bars it also from *Eopleurotoma*, a Paris Basin Eocene group of similar aspect.

Coronia includes the compact assemblage of Gulf Eocene turretids characterized by the rather large, conic, multispiral protoconch in which the earlier whorls are smooth, the later costate; by the slender fusoid conch, with both the axial and spiral sculpture strongest upon the periphery, and by a siphonal notch, broad and not remarkably deep, following the periphery of the whorl as in true *Pleurotoma*.

CORONIA MEDIAVIA (Harris) ?

1896. *Pleurotoma mediavia* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 79, pl. 7, fig. 16.

General outline as shown by the figure; two embryonic whorls smooth, a third and a part of the fourth are longitudinally costate, finely so at first but becoming coarser below; on the four subembryonic spiral whorls there is a submedial carina traversed by fine costations not so sharply triangular as in *Pl. denticula* or *Pl. alternata*, but recalling those in *Pl. waterkeynii* as shown on Pl. 30 of Edwards' Eocene Mollusca of England, 1860; spiral and longitudinal lines fine, though just beneath the carina the spirals are apt to be

coarser; costations traversed by four fine spiral lines; costae nearly obsolete on the body whorl.

A very closely related but larger form from Wood's Bluff has three lines traversing the costae, while *Pl. alternata* and *Pl. childreni* have but two.

Locality.—Alabama: 1 mi. W. of Oak Hill P. O., Wilcox Co.

Type.—Paleontological Museum, Cornell Univ. (Harris, 1896.)

The Texas species is probably distinct but the material is too imperfect for certain identification or for description.

Most of the specimens are juveniles and they are characterized by a relatively large protoconch, the earlier nuclear whorls smooth and polished, the later axially costate, the periphery of the whorls of the conch emphasized by the relatively strong spirals and the numerous axials, oblique or slightly arcuate in harmony with the periphery. Juveniles apparently referable to a closely related but stouter species occur in the Colorado River section at U.S.G.S. Stas. 11696, 11914, 11915, and on Cibolo Creek midway between Merkel and New Berlin in Guadalupe County (U.S.G.S. Sta. 6225).

Genus ORTHOSURCULA Casey

1904. *Orthosurcula* Casey, Acad. Sci. St. Louis, Trans., vol. 14, p. 151.

Type.—*Pleurotoma longiforma* Aldrich. (Vicksburg Oligocene of Mississippi.)

The species are large, moderately stout, completely devoid of ribbing and have the beak elongate, tapering, relatively slender and straight. The spirals are close-set, moderate or small in size, sometimes granulose, and the whorls are more or less broadly inflated below and feeble concave posteriorly. The outer lip projects in the middle as a broad rounded lobe beyond the juxtasutural part, with the sinus large and posterior, as in *Surcula*, and the embryo is pauci-spiral. (Casey, 1904.)

The lower Eocene species retain a feeble retractive axial sculpture upon the earlier whorls of the conch and though this character is pushed farther back in the Oligocene, it is still manifest in many individuals of the type species as a shallow undulation of the periphery. The protoconch of the type includes 3 to 3½ smooth, polished whorls rapidly increasing in size and about three-fourths of a whorl with sharp obliquely arcuate costae.

Orthosurcula Casey covers a group formerly included under *Surcula*, characterized by a fusoid outline, multispiral protoconch, moderately long anterior canal and a broad, rather deep siphonal notch set squarely upon the shoulder.

ORTHOSURCULA ADEONA (Whitfield)?

Pl. 20, fig. 20

1865. *Pleurotoma adeona* Whitfield. Am. Jour. Conchology, vol. 1, p. 262.

1896. *Pleurotoma (Surculus) adeona* Whitfield, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 76, pl. 7, figs. 9, 10.

Shell fusiform; spire moderately high; volutions five, deeply concave on the upper side, carinate in the middle, and rounded below; ornamented on the carina by strong oblique nodes, about fifteen on the body whorl; columella long, straight, and, with the aperture, forming more than half the length of the shell; entire surface marked by fine revolving striae, and crossed by lines of growth having a deep retral curvature on the concave portion of the volution.

Locality.—Nine miles below Prairie Bluff, Alabama. (Whitfield, 1865.)

Type.—Apparently lost.

The figured specimen, probably a topotype, is from the Naheola formation, Matthews Landing, Alabama River, Wilcox County, Alabama (U.S.G.S. Sta. 2671).

The height of the figured specimen is 15.3 millimeters; the diameter, 6.7 millimeters.

The early whorls of a species apparently related to *O. adeona* (Whitfield) were recovered from clays of the Wills Point formation at U.S.G.S. Sta. 11697, 3 miles southwest of Cedar Creek Post Office, Bastrop County, and another fragmentary species probably distinct but related from the Kincaid of the Colorado River section (U.S.G.S. Stas. 11914 and 12112).

Two individuals from the Wills Point formation (U.S.G.S. Sta. 12113) approach even more closely to the Alabama species. They are larger and coarser shells, however, with a smaller apical angle and are so wound that the anterior suture does not fall so near to the periphery of the whorl as it does in *O. adeona* s.s.

ORTHOSURCULA LONGIPERSA (Harris)

1896. *Pleurotoma longipersa* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 78, pl. 7, fig. 15.

General form as indicated by the figure; spire of about seven whorls; 1, 2, and 3 smooth, 4 costate, these are embryonic; remaining spiral whorls with a subsutural band traversed by a revolving line, below with fine lines of growth and alternating spiral lines; carinations of 5 and 6 obliquely and faintly costate.

This species resembles *P. perse* and *P. gabbi*; from the former it is distinguished by its much more constricted sutures and the subsutural band;

from the latter it differs in having more constricted sutures, by having a tendency to costation in the upper spiral whorls, not embryonic.

Locality.—Alabama: Matthews' Landing.

Type.—Paleontological Museum, Cornell Univ. (Harris, 1896.)

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

ORTHOSURCULA LONGIPERSA TOBAR Gardner new subspecies

Pl. 20, fig. 15

Shell small and exceedingly slender. Spire very high but made up of comparatively few high obtusely shouldered straight sided whorls which diminish gradually in diameter. Body obliquely tabulated, the sides smoothly converging into the slender anterior canal the extremity of which is broken away. Protoconch and earliest whorls of conch not preserved. Shoulder occupying more than a third of the whorl, feebly and obliquely convex, with only the faintest traces of an axial sculpture still preserved upon the earliest whorls. A very fine close spiral liration developed over the entire shell, the spirals upon the shoulder approximately 9 in number, the two directly in front of the suture slightly less feeble than the rest: spirals on the sides of the whorl also 8 or 9 in number but not so fine as those behind the periphery: body spirals similar to those upon the sides of the spire: secondaries fortuitously introduced; all of the spirals microscopically beaded by the growth striae. Siphonal notch U-shaped, behind the periphery but nearer to the periphery than to the posterior suture. Columella straight, probably quite long.

Dimensions.—Height (of incomplete specimen), 19.5 millimeters; greatest diameter, 6.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370929.

Type locality.—U.S.G.S. Sta. 11754, 6 miles below the McFarland sheep pens and 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road. Wills Point formation.

The subspecies is much more slender than any *longipersa* observed elsewhere and the axial sculpture more evanescent.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

ORTHOSURCULA SPECIES cf. O. LONGIPERSA (Harris)

Specimens closely allied to *Orthosurcula longipersa* (Harris), but with more persistent axials, occur in weathered beds of the Wills Point formation (U.S.G.S. Sta. 11754) 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass. They are all too imperfect to describe or to determine with any degree of accuracy.

A similar or possibly identical species occurs in the weathered glauconitic concretions on the east-facing slope of Leon Creek in Bexar County 1000 to 2000 feet above the Southern Pacific Railroad bridge (U.S.G.S. Sta. 13249).

ORTHOSURCULA FRANCESCAE Gardner new species

Pl. 20, fig. 21

Shell small, very slender, the aperture more than half as long as the entire shell. Spire slender, turreted. Whorls of conch, 5; of the protoconch, 4. First three whorls of protoconch smooth, trapezoidal, evenly increasing in diameter; final whorl of protoconch axially ribbed, the earliest riblets scarcely perceptible but growing less feeble and sharper toward the close of the whorl. Beginning of conch indicated by the initiation of the spiral sculpture; established pattern on early whorls of conch consisting of about 15 nodose peripheral riblets to the whorl, a sharply beaded spiral directly in front of the suture, another not so strong and 2 or 3 very faint spirals between the suture and the periphery and, in front of the periphery, 5 sharp and uniformly strong and regularly spaced lirae; on the later whorls of the spire, the shoulder becoming increasingly broad, the periphery increasingly well defined and the axial sculpture entirely obsolete; shoulder of body whorl broad, gently concave, with a strong beaded spiral directly in front of the suture and between that and the periphery 4 faintly beaded spirals, 2 very fine simple spirals and directly behind the peripheral, 2 stronger simple spirals; periphery outlined by 2 simple threads of almost equal width; base of body and canal finely and regularly threaded, with a few secondaries introduced on the base of the body; threading upon the anterior fasciole slightly coarser but of the same general character. Posterior siphonal notch indicated by the broadly U-shaped growth lines symmetrically placed upon the shoulder. Aperture

narrow, both the outer and inner lips simple. Anterior canal long and straight.

Dimensions.—Height, 15.6 millimeters; diameter, 4.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 373057.

Type locality.—U.S.G.S. Sta. 12112, Colorado River, one-half to three-fourths mile above the mouth of Dry Creek, Bastrop County, Texas. Below the *Venericardia bulla* zone. Kincaid formation of the Midway group.

Orthosurcula francescae is the probable analogue in the Texas fauna of *Orthosurcula longipersa* in the Naheola of Alabama, and is closely related to *Orthosurcula longipersa tobar* of the Midway of Maverick County. The axial riblets are more persistent and more nodular on the Colorado River species than on either of the other two and less numerous on the Texas than on the Alabama form. On neither the Alabama species nor on that from Maverick County is the periphery so prominent as in *francescae* nor is the characteristically beaded sutural spiral developed.

I have the pleasure of naming this delicate and interesting species in honor of Miss Frances Wieser who has so faithfully retouched this and many other photographs of our fossil shells.

Occurrence. Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 12112. Colorado River, one-half to three-fourths mile above the mouth of Dry Creek.

Wills Point formation. *Caldwell County:* U.S.G.S. Sta. 11609, Mercer well, 2 miles southwest of Joliet.

ORTHOSURCULA PHOENICEA Gardner new species

Pl. 20, figs. 11, 12

Shell small, fusoid, the aperture a little more than half as long as the entire shell; the spire slender and turreted. Whorls of conch about 2½ in number; of the protoconch, probably 4. First two whorls of protoconch smooth, trapezoidal, evenly increasing in diameter; axial riblets introduced upon the third whorl of the protoconch, the first riblets exceedingly faint, becoming gradually stronger and on the final whorl of the protoconch, strong, sharp, and arcuate, persistent from suture to suture and numbering 14; faint spiral striation visible under high magnification on the later whorls of the protoconch. Beginning of conch clearly defined by

the strengthening of the spiral sculpture and the restriction of the axials to the peripheral and anterior portion of the whorl. Adult axials numbering 25 or more to the whorl, narrow, slanting obliquely forward from the periphery to the aperture, strongest upon the periphery, disappearing rather abruptly behind it, but persisting in front of it almost halfway to the anterior suture; the 3 or 4 peripheral spirals the strongest, flattened and dashed at fairly regular intervals by the growth lines which cut completely through them; a band of relatively feeble spiral sculpture a little in front of the periphery of the body whorl; base of body and canal finely and uniformly lirate; shoulder broad, gently concave, threaded with 10 or 12 very fine lirations and directly in front of the suture, puckered by the growth lines which are continued across the shoulder in broad, symmetrically placed U's, the former margins of the posterior siphonal notch. Aperture narrow, the margins imperfectly preserved. Anterior canal long and straight.

Dimensions.—Height, 10.3 millimeters; diameter, 3.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 373058.

Type locality.—U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line, Bastrop County, Texas. Below the *Venericardia bulla* zone. Kincaid formation of the Midway group.

The type is unique. No specimen of Harris's "*Pleurotoma mediavia*" described from 1 mile west of Oak Hill, Wilcox County, Alabama, has been available for comparison. The superficial resemblance of the Alabama form to *O. phoenicea* is marked but the Alabama species seems to differ in the less oblique axial sculpture and in the absence of a band of relatively finer sculpture upon the base of the body such as that developed upon the Colorado River specimen. It is probable that Harris's species is a *Coronia* and that the posterior siphonal notch is on the periphery rather than the shoulder. The cutting of the peripheral spirals by the growth sculpture gives to the flattened lirae of *O. phoenicea* a dash-dot-dash appearance that is very characteristic and of which there is no suggestion in the Alabama *O. mediavia*.

Genus SURCULITES Conrad

1865. *Surculites* Conrad, Am. Jour. Conchology, vol. 1, p. 213.

1909 *Surculites* Conrad, Whitfield, U. S. Geol. Survey, Mon. 18, p. 217.

1926. *Surculites* Conrad, Stewart, Acad. Nat. Sci. Philadelphia, Proc., vol. 78, p. 420.

Monotype.—*Surculites annosus* Conrad. (Eocene of New Jersey.)

Conrad did not characterize his genus but merely assigned to it the single species, *S. annosus*, which he described and badly figured. Whitfield in monographing the Gastropoda of the "Raritan clays and greensand marls of New Jersey," made the following observations:

> The type specimen used by Mr. Conrad in his description and figured on Plate 20, Fig. 9, of the volume cited above, is now in my hands, together with several other specimens of the same, and another much more slender species. They differ but little generically from *Surcula* proper as typified by *S. nodifera* Lam., except in the notch in the lip, and straighter anterior beak, which, from the evidence afforded by the specimens before me, does not seem to be bent or twisted to any extent . . . . The upper surface of the volutions is nearly rectangular and the sinus scarcely marked; in fact, in most specimens the lines of growth indicating are nearly direct, but below the angle the line is directed forward in a broad curved extension, occupying nearly the entire length of the aperture. (Whitfield, 1892.)

Stewart in 1926 referred to *Surculites* two species from the Tejon formation of California and noted the similarity of one of them to *Surculites errans* (Solander) from the upper Eocene of Barton, England.

The most obvious diagnostics of the genus are the angular whorls, strongly carinated at the periphery, the biconical outline, the broad but feeble siphonal notch placed well back toward the posterior suture and the crowded spirals finely tesselated by the incrementals.

"*Fusus engonatus* Heilprin," 1880, Acad. Nat. Sci. Philadelphia, Proc., p. 372, pl. 20, fig. 8, is doubtless referable to *Surculites*, but whether the Matthews Landing, Alabama, species is identical with that from Woods Bluff, Alabama, Heilprin's type locality, is questionable. The Midway species seems to be a finer, more delicately sculptured shell than the Wilcox. In any case, a representative of the genus is present in the greensand of the Kincaid formation, 2½ miles northeast of Kemp, Kaufman County (U.S.G.S. Sta. 10744), in the form of a mold.

Genus MANGELIA Risso

1826. *Mangelia* Risso, Histoire naturelle des principales productions de l'Europe méridionale, vol. 4, p. 219.

Type.—*Mangelia striolata* Risso (living in the Gulf of Lyon).

The genus as defined by Fischer includes the small Turritidae which do not possess opercula. The species are all of small size and usually thin shells. The Midway species referred to *Mangelia* sensu lato is not intimately allied with any described group but the type is unique and not perfect and generic grouping is reserved for more adequate material.

"MANGELIA" species

A single individual, not fully mature, is remarkably modern in general aspect and may be referable to the group of *Cryoturris* Woodring (Miocene Mollusks from Bowden, Jamaica, Part II, Carnegie Institution of Washington, Publication 385, p. 173, 1928): Type, *Cryoturris engonia* Woodring from the upper Miocene beds of Bowden, Jamaica. However, the spire is less elevated relatively than in the Bowden species and the characteristic frosted appearance of the spirals is not so marked. The Midway species shares with the type of the subtropical Miocene group the nuclear characters, the shouldered whorls of the spire, the general sculpture pattern, and the shallow siphonal notch. The nucleus of the Midway species is slightly larger relatively than that of the Miocene forms; of the 3½ whorls, the first 2½ are smooth but the final whorl of the protoconch is sculptured with arcuate axial riblets, strongest on the rounded periphery. The whorls of the conch are angulated at the periphery and sculptured with narrow axials about 14 to the whorl, overridden by narrow flattened spirals, 3 in front of the periphery and 2 or 3 finer lirae behind it; secondaries are introduced upon the final whorl. The incremental sculpture is sharp and crowded. The siphonal notch is exceedingly shallow, the aperture narrow, the anterior canal short, twisted slightly at its extremity and emarginate. The columella is washed with a thin callous but the outer lip is sharp and simple, a character which may be youthful or possibly specific. A single individual was recovered from the fossiliferous section of the Colorado River, U.S.G.S. Sta. 11390, 1½ to 2 miles below the Travis-Bastrop County line. The horizon is low in the Wills Point formation but above the *Venericardia bulla* zone.

MANGELIA SCHOTTI Gardner new species

Pl. 20, figs. 13, 14

Shell small, slender, acutely tapering posteriorly, the maximum diameter falling in front of the median horizontal. Whorls 7 in

number, the early coils trapezoidal or slightly convex, the later with a slightly concave shoulder occupying almost the entire posterior half of the whorl. Body smoothly tapering to a short and slender canal. Apex of spire decorticated so that the line between the conch and protoconch is obscured. Protoconch small, smooth and probably paucispiral. Conch closely and evenly threaded with fine spiral lirae. Axial sculpture much more prominent than the spiral; axials broadly rounded, not persistent across the fasciole, about 12 in number to each of the later whorls. Posterior fasciole broad, spirally threaded, very feebly undulated by the evanescing axials; sinus obscure, probably close to the appressed posterior margin. Sutures distinct. Characters of aperture not well preserved. Aperture pyriform, the anterior canal slender and not preserved in its entirety.

Dimensions.—Height, 5.5± millimeters; greatest diameter, 2.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370997.

Type locality.—U.S.G.S. Sta. 6279, a few hundred yards south of the junction of Elm Creek with Sabinal Creek, Schuddemagen ranch, 11 miles south of Sabinal, Uvalde County, Texas. Tehuacana member of Kincaid formation.

The species is named in honor of Arthur Schott, Assistant Surveyor, who accompanied Major Emory on the Mexican Boundary Survey and reported upon the geological features of the country adjoining the Rio Bravo del Norte.

Occurrence.—Tehuacana member of Kincaid formation. *Uvalde County:* U.S.G.S. Sta. 6279, Schuddemagen ranch, 11 miles south of Sabinal.

Genus EXILIA Conrad

1860. *Exilia* Conrad, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 291. (No description.)

1918. *Exilia* Dall, U. S. Nat. Mus., Proc., No. 2134, vol. 54, p. 221.

1926. *Exilia* Stewart, Acad. Nat. Sci. Philadelphia, Proc., vol. 78, p. 418.

Type. *Exilia pergracilis* Conrad. (Lower Eocene of the Gulf.)

Shell tall and very slender; spire high, many whorled, gradually tapering; body much elongated, merging into the long straight canal; nucleus smooth, paucispiral, the normal adult sculpture abruptly initiated at the close of the last nuclear whorl; adult sculpture of

numerous flexuous axials and spiral lirae: not nodulated at their intersection: aperture narrow; outer lip thin, sharp, not lirate within: inner lip and pillar smooth.

Exilia is placed in the Turridae because of the faint notch in the outer lip of the type species which is probably a shallow anal sulcus. (Stewart, 1926.)

EXILIA PERGRACILIS Conrad?

Pl. 20, figs. 18, 19

1860. *Exilia pergracilis* Conrad, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 291, pl. 47, fig. 34.

1890. *Fusus (Exilia) pergracilis* Conrad, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 80, pl. 6, fig. 10.

1896. *Exilia pergracilis* Conrad, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 90, pl. 9, fig. 1.

Narrow-fusiform; volutions twelve, convex, with slightly curved, numerous, narrow ribs, and fine closely-arranged revolving lines; spire rather longer than aperture; first two whorls smooth; beak perfectly straight, minutely striated to the extremity.

Locality.—Alabama. Dr. Showalter. (Conrad, 1860.)

Type.—Probably lost.

The Texas individuals are in all probability distinct from the *Exilia pergracilis* of Alabama, but the shells are exceedingly fragile, and though fragments are by no means uncommon, no good type material has been preserved. The Texas species is taller than the Alabama but equally slender and adorned with more numerous axials and finer, more crowded spirals.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Sta. 11926, Brazos River, 0 to one-fourth mile below the Falls County line, bed No. 4; U.S.G.S. Stas. 11916 and 11919?, Brazos River, 1 mile below the Falls County line. *Bastrop County:* U.S.G.S. Sta. 11914, Colorado River, 1½ miles below the Travis-Bastrop County line; and U.S.G.S. Stas. 11696 and 11915, 1½ miles to 2 miles below the Travis-Bastrop County line.

Wills Point formation (upper Midway). *Bastrop County:* U.S. G.S. Stas. 10527 and 12113, 4½ to 4¾ miles downstream from Webberville; above the *Venericardia bulla* zone.

Genus LEVIFUSUS Conrad

1865. *Levifusus* Conrad, Am. Jour. Conchology, vol. 1, p. 17.

Type by subsequent designation.—*Levifusus trabeatus* Conrad (Eocene of the southern United States).

Shell moderately large and rather thin; pyriform in outline; protoconch small, smooth, paucispiral, papillate, merging without a decided break into the conch; spire short, the whorls broadly tabulated; body large, broadly shouldered, constricted rather abruptly into the broad anterior canal; axial sculpture indicated by the nodose or crenulate shoulder, occasionally persistent to the anterior and more rarely to the posterior suture; shoulder keel outlined by a strong spiral; a second keel and strong spiral frequently developed at the base of the body; spirals, usually low and flattened, quite generally present, especially upon the base of the body and in front of the keel; aperture broad, pyriform; inner lip sigmoidal; columella smooth; parietal wall calloused.

In the character of the protoconch, *Levifusus* is more closely allied to the turretids than to *Fusus*.

LEVIFUSUS LITHAE Gardner new species

Pl. 20, fig. 10

Shell small for the genus, short, broadly spindle-shaped, the maximum diameter when viewed from the front not far from the median horizontal. Spire rather high for the genus, the whorls few in number and rapidly increasing in size. Shoulder very broad, covering fully two-thirds of the whorl, obliquely concave. Periphery evenly crenulated by the axials which number 9 upon the body and undulate the sides of the whorls and the base of the body. Three strong spiral cords in front of the periphery, the whorls of the spire wound upon the posterior of the three. No other spiral sculpture developed. Growth lines distinct, those upon the shoulder indicating a broad siphonal notch set a little closer to the periphery than to the posterior suture. Body whorl abruptly constricted into the broad canal which was undoubtedly short though the extremity is broken away.

Dimensions.—Height (of incomplete individual), 13.0 millimeters; greatest diameter, 13.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 370931.

Type locality.—U.S.G.S. Sta. 11751, 6 miles below McFarland sheep pens, 27 miles southeast of Eagle Pass, Maverick County, Wills Point formation.

Levifusus lithae is closely allied to specimens labelled *Levifusus pagoda* Heilprin from Matthews Landing, Alabama. Both the Maverick County and the Matthews Landing forms are probably distinct from the Wilcox species.

The Matthews Landing individuals have a higher spire than that from Texas and more numerous axials. The affinities of the genus with the turretids is indicated by the backward curve of the growth lines upon the shoulder, evidence of a former siphonal notch.

An affiliated species is known from the last whorl of the spire and the shoulder of the body. The axials are reduced to peripheral nodes about 9 in number, but the entire surface is finely threaded spirally. The shoulder is obliquely concave and so closely appressed that the suture line is undulated by the peripheral nodes. The insinuated growth lines upon the shoulder indicate a rather pronounced siphonal notch. The single battered specimen was collected from the glauconitic sand of Water Hill, 5 miles northeast of Kemp, Kaufman County (U.S.G.S. Sta. 11665).

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

LEVIFUSUS species

Another indeterminate mold 15 millimeters in diameter was collected in association with *Venericardia smithii* and *Hercoglossa* at U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart. The spire is relatively low, the whorls of the conch not more than 4, the shoulder broad and gently sloping, and the suture line well in front of the noded periphery. The peripheral nodes are 12 to 15 in number and traces of an even spiral liration are still preserved upon the body.

INCERTA SEDIS

A species apparently affiliated with *"Fulgur?" dallianum* Harris (Bull. Am. Paleontology, vol. 1, No. 4, p. 96, pl. 9, fig. 13, 1896) is represented in the glauconitic sands at Water Hill in Kemp County. It is known only from the battered and flattened apical portion of the shell. The axials are reduced to peripheral scallops about 9 or 10 in number and there are faint traces of a secondary keel in front of the shoulder. The shoulder is gently sloping and so closely

appressed that the suture line is undulated by the periphery of the preceding whorl. The growth lines upon the shoulder indicate a scarcely perceptible siphonal notch on the peripheral keel. The single specimen was collected from Water Hill, 5 miles northeast of Kemp, Kaufman County (U.S.G.S. Sta. 11665). The source of the species described by Harris is not surely known, for Harris (*ibid.*, p. 97) relates that "This specimen (the only one known) belongs to the collection of the U. S. Nat. Museum and is marked "264a, Wilcox Co., Ala., L. C. Johnson," collector. The nature of the matrix in which this specimen was embedded renders it safe to say that it came from bed 13, sect. p. 31, a mile or two south or southwest of Palmer's mill."

The matrix of the specimen in question carries the large rounded quartz grains which are characteristic of the matrix at Prairie Bluff, Ala. Possibly the resemblance to the matrix in the fossiliferous bed at Palmer's Mill is even closer but the differences from the limy sands at Prairie Bluff seem unessential.

LEVIFUSUS species

A fragmentary individual, possibly referable to *Levifusus*, was collected from a greensand, probably of Kincaid age, in Tobar Arroyo on the Indio ranch about 36 miles southeast of Eagle Pass (U.S.G.S. Sta. 11762). The spire was probably low, the whorls few in number and rapidly increasing in diameter. The shoulder is broad, acutely angulated at the periphery, and sharply threaded with about a dozen fine spirals. Secondaries are introduced in front of the periphery where the spiral threads are not so fine but they are not intercalated upon the base of the body. About 15 axials ripple the shoulder but evanesce toward the base of the body.

LEVIFUSUS species

Fragments of a species sculptured with 10 to 12 peripheral nodes and 4 subequal spirals in front of the shoulder occur rather commonly in the Kincaid section on the Brazos River, 1 mile below the Falls County line (U.S.G.S. Sta. 11921).

LEVIFUSUS species indeterminate

Two individuals, probably not specifically identical, were collected from the second greensand of the Kincaid formation, 3½ miles north of Lockhart, Caldwell County (U.S.G.S. Sta. 11707).

They both have numerous axials (18 to 20) but the spire of one is much higher than that of the other and the spires of both are higher than that of *Levifusus dalei* Harris from Dale's Branch near Oak Hill, Wilcox County, Alabama, the species which they most closely resemble.

LEVIFUSUS? species

Small, stout, spindle-shaped forms, sculptured with 9 or 10 peripheral nodes and a fine spiral threading, which apparently covers the entire conch, occur in the Kincaid formation of Milam Bluff near the Falls County line (U.S.G.S. Sta. 11926).

Family CANCELLARIDAE
Genus CANCELLARIA Lamarck

1799. *Cancellaria* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 71.
Type.—*Voluta reticulata* Linnaeus (Recent off Florida and the West Indies).

Shell of moderate dimensions, usually rather heavy and quite stout, ovate-conic, or rarely fusoid or oliviform in outline; spire usually low, often scalar; protoconch smooth, naticoid, paucispiral; whorls of conch rarely exceeding 6 in number, most frequently only 3 or 4; sculpture normally cancellate, the axial sculpture rarely obsolete, the axials usually narrow and inclined to be irregular in size and spacing, the spirals very often low and flattened upon their summits; sutures impressed; aperture obliquely lenticular; outer lip thickened, lirate within; parietal wall more or less thickly glazed; columella heavily plicate, the folds, 2 or 3 in number, placed about midway between the extremities of the aperture; the posterior as a rule usually the most prominent and the most nearly horizontal, that in front of it less elevated and more oblique in its external aspect; margin of pillar usually elevated into a relatively feeble plication which may persist within the aperture or may, as in *C. reticulata*, be restricted to the apertural face of the pillar; anterior canal typically narrow, short, twisted, nasute in aspect; umbilicus perforate or imperforate, most frequently with a narrow chink between the reverted labium and the arched anterior fasciole, which functions as an umbilical keel.

No true cancellarias have been found in strata older than the Tertiaries, although the genus is well differentiated early in the Tertiaries. The Recent species probably number between 150 and

200. They are for the most part denizens of the inshore waters of the warm temperate and tropical seas.

CANCELLARIA SILVAERUPIS Harris?

1896. *Cancellaria silvaerupis* Harris, Acad. Nat. Sci. Philadelphia, Proc., vol. 48, p. 476, pl. 20, fig. 11.

1899. *Cancellaria sylvaerupis* Harris, Bull. Am. Paleontology, vol. 3, p. 25, pl. 3, fig. 5.

General form and size as indicated by the figure; whorls about 6; 3 embryonic smooth; others with about 8 strong spiral lines between the suture above and the suture below; incremental lines especially prominent between the strong raised spirals; labrum sharp at edge but abruptly thickening and varicose a slight distance within; columella concave, two plaits on its subcentral portion and one marginal below.

This species reminds one of *C. quadrata* of England and *C. alnula* from Texas.

Locality.—Ala.: Woods Bluff.

Type specimen figured.—Lea Memorial collection, Acad. Nat. Sci. Phila. (Harris, 1896.)

A juvenile more finely sculptured than the Wilcox species but obviously very closely related genetically, was recovered from the Mexia member of the Wills Point formation in Dry Brushy Creek, 6 miles south of Thrall, Williamson County (U.S.G.S. Sta. 10420), and others from the Kincaid in Bastrop County, on the Colorado River, at U.S.G.S. Stas. 5280, 11696, 11914, and 11915.

CANCELLARIA species

Juveniles referable to at least two and probably three species were recovered from the sandy clays of the Colorado River section in Bastrop County, 4 to 5 miles below Webberville (U.S.G.S. Stas. 11914, Kincaid formation, and 10527, Wills Point formation). They have in common, however, a squat outline, strongly tabulated shoulder and reticulate sculpture.

Family OLIVIDAE
Genus OLIVELLA Swainson

1831. *Olivella* Swainson, Zoological Illustrations, 2nd ser., vol. 2, Pl. 58 and text.

Type.—*Olivella purpurata* Swainson = *Olivella dama* Mawe (Recent off the West Coast from Southern California to the Gulf of California).

Small polished, cylindrical shells, produced into tapering spires; sutures channeled; aperture narrow posteriorly, dilated anteriorly;

outer lip simple, sharp; inner lip calloused near the suture, obliquely plicate in front; anterior extremity emarginate.

Olivella is separated from *Oliva* by the smaller size of the former, the less oblique, more shallow basal notch, the higher spire and, in the living shells, by the presence of an operculum, and the absence of eyes.

The genus has not been recorded from strata older than the Eocene.

The distribution of the Recent species is similar to that of *Oliva*.

OLIVELLA MEDIAVIA Harris

1896. *Olivella mediavia* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 80, pl. 7, fig. 19.

General form and size as indicated by the figure; whorls about 7; the first extremely small, the second much larger, and the third still greater, producing a blunt appearance; remaining spiral whorls nearly or quite covered by the sutural callosity; body whorl smooth, but the direction of the lines of growth can be traced with a glass; growth lines slightly geniculated about three-fourths of the way from the suture to the anterior folds at a faint depression which produces a faint tooth on the margin of the outer lip; columella well twisted below where it is 7-8 striate; above on the columella there is often a large obtuse fold which marks a former position of the upper margin of the slit for the anterior canal. (Harris, 1896.)

Type locality.—1 mile west of Oak Hill, Wilcox County, Alabama, in beds of upper Midway age.

Type.—Paleontological Museum, Cornell University, Ithaca, New York.

Olivella mediavia is widespread and fairly common. No other species has been certainly recognized. Harris reports the same form from Bells Landing and Woods Bluff in the lower Wilcox of Alabama. The list of occurrences includes only those localities from which well preserved specimens have been recovered.

The variation in size in forms otherwise similar is very puzzling. Harris's figure indicates a height of 10 millimeters. Apparently the infant mortality was very great among the Texas species for most of the individuals run between 3 and 4 millimeters and exhibit certain youthful characters. Poorly preserved specimens, mostly in the form of molds, from the Kincaid formation, 5 miles northeast of Kemp, Kaufman County (U.S.G.S. Sta. 11665), are fairly common and run about 15 millimeters in height. No other characters

by which they may be separated from *Olivella mediavia* have been preserved. One specimen, however, from the glauconitic marls below the *Venericardia bulla* zone in the Colorado River section (U.S.G.S Sta. 11696), is similar to *Olivella mediavia* in general outline but measures 20 millimeters in height. It also exhibits an exceedingly fine spiral shagreen, unlike anything observed in any other member of the group. More material is needed to clarify the relationship between these similar shells of unsimilar dimensions.

Occurrence.—Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665?, Water Hill, 5 miles northeast of Kemp. *Milam County:* U.S.G.S. Sta. 11921, Brazos River, 1 mile below the Falls County line. *Bastrop County:* U.S.G.S. Stas. 11696?, 11914, and 12112, Colorado River, 4± miles below Webberville, bed No. 3.

Wills Point formation, *Williamson County:* U.S.G.S. Sta. 10420, lower bed, Dry Brushy Creek, 6 miles south of Thrall on Taylor-Beaukiss road. *Bastrop County:* U.S.G.S. Stas. 11890, 10527, and 12113, Colorado River, 4⅓–4⅔ miles below Webberville; above *Venericardia bulla* zone. *Bexar County:* U.S.G.S. Sta. 8656, Smith Tract, Somerset field, 659 to 680 feet and 769 to 782 feet.

Family MARGINELLIDAE
Genus MARGINELLA Lamarck

1799. *Marginella* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, *Mémoires de la Société d'Histoire Naturelle de Paris*, p. 70.

Type.—*Voluta glabella* Linnaeus. (Recent off the West Coast of Africa.)

Shell small, usually rather thick and heavy, ovate, fusiform or subcylindrical in outline; spire low and in one subgenus almost or entirely concealed; external surface smooth and as a rule quite highly polished; sutures generally obscured; aperture narrow or sublinear, often equalling or approximating the altitude of the entire shell, truncate or emarginate anteriorly, angulated or emarginate posteriorly; outer lip usually reinforced, smooth, or denticulate within; columella plicate.

The presence of the genus in the Cretaceous has not been established, but it was certainly abundant in the early Tertiary.

MARGINELLA? new species

A species possibly referable to *Marginella* is represented by three individuals from the limestone 5 miles southeast of Elstone (U.S.G.S.

Sta. 11771), Medina County. The best specimen is one centimeter high and a little more than half as broad. The spire is about half as high as the entire shell and the sutures are thinly washed with callous. There is no sculpture. The characters of the aperture are, unfortunately, very imperfectly preserved. The outer lip is flaring and may be slightly thickened. The suggestion of folds upon the columellar lip is so vague that their presence is by no means established. The anterior extremity is not retained but, apparently, there were no lirae such as those commonly developed on the anterior canal of *Mitra*.

Family VOLUTIDAE

The volutes, as a family, are separated from the Marginellidae, on the one hand, by the larger size, the unpolished surface, the greater prominence of the anterior canal, and the columella slightly recurved toward the axis of the shell. From the Mitridae, on the other hand, the volutes differ, as a rule, in the decreasing prominence of the columellar folds anteriorly instead of posteriorly as in the mitras.

Genus VOLUTOCORBIS Dall

1890. *Volutocorbis* Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 1, p. 75.
Holotype.—*Volutocorbis (Volutilithes) limopsis* Conrad (Midway of the Gulf from Alabama to Texas).

Dall introduced the name as a subgenus under *Volutilithes*.

Shell resembling *Volutilithes*, but more slender and without a coronated shoulder; the sculpture is reticulate and nodose or prickly at the intersections; the sutural sinus is less evident than in *Volutilithes* and the suture is sometimes channelled. (Dall, 1890.)

The nomenclature of this old and world-wide distributed group is extremely involved. *Volutilithes* Swainson, 1831, was commonly accepted for many years, and to it Conrad referred the two characteristic Midway species, *limopsis* and *rugatus*. Dall (16a) retained the name *Volutilithes* for species such as those of the *V. petrosus* group in this country and *V. spinosus* Lamarck in Europe. He erected the subgenus *Volutocorbis* to accommodate the two common Gulf Midway forms, *rugata* and *limopsis*, a few species from the European faunas, and the Recent *V. abyssicola* Adams and Reeve. Harris in his Midway monograph, used only the generic name *Volutilithes*,

but Cossman (29a) recognized *Volutocorbis* and raised it to generic rank. Dall (30a) in 1906 stressed the necessity of a thorough revision of the nomenclature of the volutes and suggested that "the shells typified by *Voluta spinosa*, and which are usually called *Volutilithes*, will probably take the name of *Plejona* Bolten, 1798." A little later in the same year R. Bullen Newton (30b) carefully discriminated *Volutilithes* Swainson, 1831, from that of Swainson, 1840, and rejected *Plejona* because of the confusion in the type and proposed the name *Volutospina* to include *Plejona* Bolten pars and *Volutilithes* Swainson, 1840, non Swainson, 1831. He retained *Volutocorbis* Dall, however. The question was fully reviewed in 1926 by Stewart (67a) who also retains *Volutocorbis*.

In the same year in which Dall and Bullen Newton were publishing on the nomenclature of the group, Burnett Smith's paper on the "Phylogeny of the Races of *Volutilithes petrosus*" (30c) appeared. The greater part of his material came from the Eocene of the Alabama and Tombigbee rivers and ranged in time from the Midway at Matthews Landing to the Jackson formation. The Midway and Wilcox representatives of the group probably lived in a shallow sea, intermittently cut off from the open ocean in which normal development was very slowly taking place. Successive invasions of the sea brought with them new forms which, when subjected to the less favorable, partially lagunal conditions underwent a very rapid senile development. *Volutocorbis limopsis* is considered the ancestral type not only because of its primitive character but also because of its stability and lack of individual variation. *Volutocorbis rugata* is considered by Smith as a short, senile offshoot of *V. limopsis*. There is only one living member of the group, *V. abyssicola* Adams and Reeve, a cancellated form bearing a remarkable resemblance to its possible progenitor of the early Eocene. *V. abyssicola* was collected by the Samarang off the Cape of Good Hope in 132 fathoms. In the comparatively deep waters, with little competition and little necessity for development, it apparently had survived with little change through the ages.

VOLUTOCORBIS RUGATA (Conrad)?

Pl. 21, figs. 3, 4

1860. *Volutilithes rugata* Conrad, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 1, p. 292, pl. 47, fig. 32.

1890. *Voluta rugata* Conrad, De Gregorio, Monographie Faune Éocénique Alabama, Annales de Géologie et de Palèontologie, vol. 7, p. 65.

1896. *Volutilithes rugatus* Conrad, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 83, pl. 8, fig. 1.

1906. *Volutilithes rugatus* Conrad, Veatch, U. S. Geol. Survey, Prof. Paper 46, pl. 16, fig. 5.

1906. *Volutilithes rugatus* Conrad, Burnett Smith, Acad. Nat. Sci. Philadelphia, Proc., vol. 58, p. 57, text fig. 3, pl. 2, fig. 2.

1914. *Plejona rugata* (Conrad), Deussen, U. S. Geol. Survey, Water-Supply Paper 335, p. 32, pl. 3, fig. 5.

1924. *Plejona rugata* (Conrad), Deussen, U. S. Geol. Survey, Prof. Paper 126, pl. 14, fig. 5.

1926. *Plejona rugata* (Conrad), Cooke, in Geol. Survey Alabama, Special Rept. 14, pl. 93, figs. 3 a-b.

1933. *Volutocorbis rugatus* (Conrad), Plummer, Univ. Texas Bull. 3232, pp. 813, 814, pl. 9, fig. 9.

Fusiform; spire somewhat elevated; volutions eight, convex, with minute, reticulated lines, the revolving lines microscopic; larger revolving lines prominent; ribs on the body whirl irregular, wanting near the base; an impressed line revolves below the suture, giving that part of the shell between this line and the suture an obscurely or obtusely carinated character; revolving lines on the body whirl distinct; a deposit on the inner lip (doubtless a typographical error for *lip*); columella with three approximate, obtuse folds, the middle one obsolete; aperture narrow.

Length, 2 inches. (Conrad, 1860.)

Type locality.—Not definitely known but certainly in Alabama and probably Matthews Landing.

Burnett Smith's detailed description made for his phylogenetic study is:

Whorls 1, 2, 3—Smooth and rounded.

Whorl 4—Smooth and rounded, except near the end, where in many individuals the curved rib stage begins.

Whorl 5—The curved rib stage usually occupies the latter part of four and early part of five. Its ribs are wide apart and it persists for about a quarter of a whorl. It is followed by the straight, tubercled ribs of the cancellated stage. The two upper tubercles are the largest, those below becoming fainter anteriorly. The ribs die away anteriorly on the branchial siphon. Each tubercle is connected with the corresponding one of the next whorl by a spiral.

Whorls 6, 7, 8—All characterized by the cancellated stage. Changes, however, take place during these whorls. At first the ornamentation is much like that of the cancellated stage in *V. limopsis*, but later the ribs become relatively farther apart and broader (in a spiral direction). At the same time many fine riblets are introduced between the primary ribs. The tubercles are largest

near the suture and become smaller as the ribs die away anteriorly. There is never a distinct shoulder angle. The whorls are covered with spirals.

Whorl 9—Individual variation now sets in. In some specimens the whorl is much as in eight. In others the rib is swollen into a very rounded, transversely long angle which hardly occupies the position of the shoulder angle of later forms, and in addition the shells become thick. In all individuals the mantle protrudes in the region of the anal siphon, and tends to smooth the preceding whorl with a shelly overgrowth. This latter is never extreme.

Whorl 10—Much as in nine, though here the forms with swollen ribs predominate. In some specimens the shells become thick, the growth lines irregular, and the smoothing of the preceding whorl by the shelly overgrowth is quite well marked, though it never becomes extreme as in some forms of later time.

Remarks.—This species in its earlier stages of growth closely resembles *V. limopsis*. It differs radically, however, from that form with the progress of its ontogeny. Though its individuals vary greatly, it is nevertheless entitled, in the opinion of the author, to rank as a distinct species. In its later whorls there is great individual variation, accompanied by senile features. These latter, though never extreme, are well marked. They comprise protrusion of the mantle in the region of the anal siphon, producing a smoothing of the preceding whorl by a shelly overgrowth; thickening of the shell, and irregularity of growth lines. There is no spiny stage. *V. rugatus* is considered to be a short senile offshoot from *V. limopsis*. In the absence of intermediate forms this evolution must have taken place either at some other locality or at some geologically earlier date. (Burnett Smith, 1906.)

Indeterminate molds suggesting *V. rugata* occur in the second greensand in the Kincaid formation, 5½ miles southwest of Lockhart, Caldwell County (U.S.G.S. Sta. 11706).

The height of the largest of these molds is between 45 and 50 millimeters.

VOLUTOCORBIS TEXANA Gardner new species

Pl. 21, figs. 1, 2

1933. *Volutocorbis texana* Gardner MS., Plummer, Univ. Texas Bull. 3232, pp. 813, 814, pl. 9, figs. 1–5.

Shell small and thin for the group; rudely biconic, the maximum diameter a little behind the medium horizontal. Protoconch small, smooth, thrice-coiled, the whorls rapidly enlarging. Whorls of conch 4 or 5 in number, those of the spire rudely trapezoidal, minutely tabulated. Body whorl broadly inflated at the periphery, smoothly constricted into a rather slender pillar. Axials narrow, 12 to 14 in number, dying out upon the base of the body, sharply

elevated, their prominence increased by the overriding spirals; inter-axials wider than the axials, broadly rounded, microscopically netted by the incrementals and exceedingly fine spiral filaments. Spirals narrow fillets, 3 or rarely only 2 in number on each whorl of the spire, 15 to 20 upon the body and pillar; posterior spiral the most prominent, forming at the intersection with the axials flattened tubercles; its prominence further increased by the relatively wide space in front of it; spirals less widely spaced and more rounded toward the base of the pillar. Fasciole finely lirate. Aperture narrow, acutely angulated posteriorly. Inner margin of pillar loosely sigmoidal. Two oblique rather feeble folds, the anterior the less feeble, placed a little in front of the base of the body. Anterior siphonal fasciole slightly recurved, truncate.

Dimensions.—Height, 23.0 millimeters; greatest diameter, 12.5 millimeters.

Other less perfect individuals doubtless reached dimensions half as large again.

Holotype.—U. S. Nat. Mus. No. 370993.

Type locality.—U.S.G.S. Sta. 11698, Colorado River, 1½ miles below the Travis-Bastrop County line, Bastrop County. Kincaid formation below the *Venericardia bulla* zone.

Volutocorbis texana is closely related to *Volutocorbis rugatus* and to *Volutocorbis limopsis*, and, in the general character of the sculpture, is intermediate between them. *Volutocorbis rugatus* is a larger shell than *V. texana*. The spire is higher and the component whorls less flattened and trapezoidal in outline. Both the axial and the spiral sculpture are less pronounced and the columellar folds stronger. In *Volutocorbis limopsis* the axials and the spirals are both of them much more numerous and more inclined to be spinose. The columellar folds, however, are very similar in position and prominence in the two species.

Volutocorbis quercollis Harris from Black Bluff, on the Tombigbee River, Alabama, bears a superficial resemblance to *V. texana* but the spire of the Texas species is a low broad cone while that of the Alabama form is higher and more turreted. Then, too, both the axials and the spirals are less numerous in *V. texana*.

Volutocorbis texana is one of the most characteristic species of the upper part of the Kincaid formation. Fragments and molds which are with little doubt referable to this species have been found

at almost every fossiliferous locality in this part of the Midway section in Texas, but only the forms determinable with assurance have been noted. The species also occurs in the lower part of the Wills Point formation but it is rare. It is perhaps the ancestral form of *V. limopsis* (Conrad) the characteristic species of the upper Midway.

Occurrence.—Kincaid formation. *Limestone County:* U.S.G.S. Sta. 11936?, 2½ miles northwest of Groesbeck. *Falls County:* U.S.G.S. Sta. 11929, Little Brazos, above Rocky Crossing on Kosse road; U.S.G.S. Sta. 11931?, Whitaker Survey; roadside outcrop about 6 miles northwest of Kosse. *Milam County:* U.S.G.S. Sta. 11919, Brazos River, 1 mile below the Falls County line. *Bastrop County:* U.S.G.S. Stas. 11914, 5230, 10526, 11915, 11696 and 12112, Colorado River, 1± miles below Webberville; below the *Venericardia bulla* zone; and U.S.G.S. Sta. 11909, Cedar Creek, 3½ miles southeast of Williams' store. *Caldwell County:* U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart; second greensand of Kincaid formation; U.S.G.S. Sta. 11706?, 5½ miles southwest of Lockhart on the Martindale farm. *Uvalde County:* U.S.G.S. Sta. 11767, Frio River just above the trail leading down from the Evans' (Myrick's) apiary.

Wills Point formation. *Bastrop County:* U.S.G.S. Stas. 10527 and 12113, Colorado River, one-fourth mile above the mouth of Dry Creek, 4¼–4¾ miles downstream from Webberville. Above the *Venericardia bulla* zone; U.S.G.S. Sta. 11908, Cedar Creek, one-half mile northeast of bridge on Austin-Red Rock road. *Caldwell County:* U.S.G.S. Sta. 11699, William Mercer well, 2 miles southwest of Joliet.

VOLUTOCORBIS? species

Univalves between 45 and 50 millimeters in height and coarsely sculptured with 6 to 8 broad, evenly rounded ribs, were collected near Cedar Creek, one-half mile northeast of the bridge on the Austin-Red Rock road (U.S.G.S. Sta. 11908). They are probably referable to *Volutocorbis* though the shells are too imperfectly preserved to show the columellar folds. The contour of the shell and the general type of sculpture, however, certainly suggest the volutidae rather than any other group. A spiral liration was probably developed though only the faintest traces remain.

VOLUTOCORBIS species

Impressions of *Volutocorbis* more closely resembling *V. texana* than *V. rugatus* were observed in the Littig glauconitic member of the Kincaid formation 2 miles north of Lockhart, Caldwell County (U.S.G.S. Sta. 11685).

VOLUTOCORBIS LIMOPSIS (Conrad)

Pl. 21, fig. 7

1860. *Volutilithes limopsis* Conrad, Acad. Nat. Sci. Philadelphia, 2d. ser., vol. 4, p. 292, pl. 47, fig. 24.

1890. *Voluta (Volutilithes) limopsis* Conrad, De Gregorio, Mon. Faune Eocénique de l'Alabama, Annales de Géologie et de Paléontologie, vol. 7, p. 69, pl. 5, fig. 23 (erroneously cited as 22).

1894. *Volutilithes limopsis?* Conrad, Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 45.

1896. *Volutilithes limopsis* Conrad, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 84, pl. 8, fig. 3.

1906. *Volutilithes limopsis* Conrad, Veatch, U. S. Geol. Survey, Prof. Paper 46, p. 33, pl. 16, fig. 4.

1906. *Volutilithes limopsis* Conrad, Burnett Smith, Acad. Nat. Sci. Philadelphia, Proc., vol. 58, p. 56, text fig. 2, pl. 2, fig. 1.

1914. *Plejona limopsis* (Conrad), Deussen, U. S. Geol. Survey, Water-Supply Paper 335, p. 32, pl. 3, fig. 4.

1924. *Plejona limopsis* (Conrad), Deussen, U. S. Geol. Survey, Prof. Paper 126, pl. 14, fig. 4.

1926. *Plejona limopsis* (Conrad), Cooke, in Geol. Survey Alabama, Special Rept. 14, pl. 93, fig. 2.

1933. *Volutocorbis limopsis* (Conrad), Plummer, Univ. Texas Bull. 3232, pp. 813, 814, pl. 9, figs. 6, 7.

Subfusiform; volutions seven; body whirl longitudinally ribbed: ribs angular, acutely tubercular on the upper part; revolving lines prominent, acute, more salient where they cross the ribs, about twenty-seven in number; whirls of spire slightly convex, five series of tubercles on last volution; aperture narrow elliptical; inner lip with a thin, wide deposit; columella with three plaits, the superior one obsolete or very small.

Length, 1⅝ inches. Diameter, ⅝ inch.

A beautiful species resembling *V. crenulata* Lam., or more nearly *V. ambigua*, but it has a more fusiform shape than either, a narrower aperture and dissimilar folds on the columella. (Conrad, 1860.)

Type locality.—Not definitely known, but certainly in Alabama, and probably at Matthews Landing.

Burnett Smith's detailed description made for his phylogenetic study is well worth repeating:

Whorls 1, 2, 3 Smooth and rounded.

Whorl 4—Smooth and rounded, except toward the end, where the curved rib stage may start.

Whorl 5—The curved rib stage often commences early in five, persisting as a rule for about a quarter of a whorl. The cancellated stage follows abruptly with its straight tubercled ribs. These tubercles are largest at the suture, decreasing regularly in size anteriorly on each rib. Each tubercle is connected with the corresponding tubercle of the next rib by a faint spiral. A shoulder angle is never developed.

Whorls 6, 7—Characterized by the cancellated stage and much like the latter part of five.

Whorl 8 Characterized by the cancellated stage and much like six and seven. The tubercles nearest the suture are the strongest, and they diminish in size regularly as the rib is followed anteriorly. The ribs are also less prominent anteriorly, disappearing entirely on the branchial siphon. Spirals cover the entire whorl.

Whorls 9, 10—Much as in eight, the cancellated stage still persisting. The tubercles are a little sharp, and the protruded mantle shows a very slight tendency to smooth the preceding whorl a tendency which in later forms results in a senile feature.

Remarks.—This form possesses no stage later than the cancellated stage and never has a shoulder angle. The suture tubercle is throughout life the dominant one. The specimens are remarkably uniform, no perceptible individual variation occurring. The smooth stage is very long. From its primitive characteristics, and its geological position near the base of the Eocene, the writer has no hesitation in assigning to it an ancestral position among the races and species dealt with in this paper. (Burnett Smith, 1906.)

Both in Alabama and in Texas the true *Volutocorbis limopsis* is apparently the hall mark of the upper Midway. It is never so abundant as *V. texana* of the Kincaid formation but it is widespread and its relative rarity is due in part to the poor state of preservation of most of the upper Midway fossils in the Texas section.

An impression of *Volutocorbis* from 4 miles northeast of Lockhart, on the Dale road, is more closely sculptured than *V. texana* and most closely resembles typical *V. limopsis*. The same species was collected from Town Branch, on the Dale road on the edge of Lockhart, Caldwell County (U.S.G.S. Sta. 11384). These localities are very close to the top of the Midway. Fragments of an apparently similar species occurs in Midway clays 3 miles southwest of Cedar Creek Post Office, Bastrop County (U.S.G.S. Sta. 11697).

This is possibly the species so abundant in the late Midway sandstone on the Guadalupe River, 2½ miles above the power house south of Seguin (U.S.G.S. Sta. 6243) and in equivalent beds in

Bexar County at Jett Crossing on the Medina River (U.S.G.S. Sta. 6153).

Volutocorbis limopsis is the most common species in the shingle of the "red beds" of the Wills Point formation on the Windmill (Jacal) ranch road, 27 miles southeast of Eagle Pass (U.S.G.S. Sta. 11754). Some of the individuals are remarkably stout, suggesting when the anterior portion of the shell is broken away, as it frequently is, *Cancellaria* rather than *Volutocorbis*. The species was also collected in Tobar Arroyo (U.S.G.S. Sta. 11761) about 5 feet below an *Ostrea multilirata* ledge. A similar individual, probably *V. limopsis* was recovered from the 5 feet of gray sandy, slightly glauconitic shale, directly underlying the *Ostrea multilirata* zone in Tobar Arroyo (U.S.G.S. Sta. 11760).

Poorly preserved individuals apparently more delicately sculptured but otherwise similar to *V. limopsis* are abundant in the *Cerithium penrosei* horizon of the lower Wilcox on Solomon's Branch, 4 miles south of Elgin.

Occurrence.—Wills Point formation. *Limestone County:* U.S.G.S. Sta. 11943?, 2 miles southeast of Big Hill. *Bastrop County:* U.S.G.S. Sta. 11906?, near Cedar Creek, one-half mile northeast of bridge on Austin-Red Rock road; U.S.G.S. Sta. 11697, gully 1 mile south of Cedar Creek and south of Cedar Creek-Lytton Springs road. *Caldwell County:* U.S.G.S. Sta. 11934, Town Branch, Dale road on edge of Lockhart. *Guadalupe County:* U.S.G.S. Sta. 6233, 2½ miles above the power house south of Seguin. *Bexar County:* U.S.G.S. Sta. 8246, Salado Creek, 1 mile east of San Antonio; U.S.G.S. Sta. 8245, Salado Creek, 5.3 miles southeast of San Antonio; and U.S.G.S. Sta. 6153, Jett Crossing, Medina River on Palo Alto road. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road; and U.S.G.S. Stas. 11760? and 11761?, Tobar Arroyo, about 2½ miles southwest of Tobar tank and about 35 miles southeast of Eagle Pass.

VOLUTOCORBIS KERENSENSIS Plummer

1933. *Volutocorbis kerensensis* Plummer, Univ. Texas Bull. 3232, pp. 813, 814, pl. 9, fig. 8.

Apical angle 41°–48°; altitude 24.5 mm.; maximum diameter 10 mm.; No. longitudinal ribs next to last whorl, 26–30. No. transverse ribs last whorl, 5 or 6. Transverse ribs much larger than longitudinal ribs. First 3 smooth, 4th and 5th ribbed; others cancellate.

Holotype.—Coll. Bureau of Economic Geology, Austin, Texas.

Type locality. Bluff on Trinity River near old Humble pumping station, about 5½ miles east-northeast of Kerens, Navarro County; Kerens member of Wills Point formation. (Plummer, 1933.)

This species has not been recognized in our collections though it is possible that some of the fragmentary material from the upper Wills Point sands near New Hope may be referable to it.

LYRIA Gray

1847. *Lyria* Gray, Zool. Soc. London, Proc., p. 141.
1907. *Lyria* Dall, Smithsonian Misc. Coll., vol. 48, p. 350.
Type.—*Voluta nucleus* Lamarck. (Recent off north coast of Australia.)

Shell heavy, fusiform or strombiform in outline; spire more or less elevated as a rule and turriculated; nucleus shelly, varying in outline and dimensions; external surface axially costate, the costae usually numerous and obtuse upon their summits; sutures appressed or channeled; aperture ovate or lenticular, angulated at the posterior commissure; outer lip thickened marginally, simple within; columella multiplicate, the anterior folds the most prominent; parietal wall also plicated, the folds similar in general aspect to those upon the pillar but not persisting within the aperture; anterior canal usually short and broad, emarginate at its extremity.

Lyria is quite similar in general character to the more prolific Eocene genus *Volutocorbis* Swainson. However, the axial sculpture of *Volutocorbis* is usually sharper and the labrum is lirate within. *Lyria* is not conspicuously abundant at any horizon, but it persists throughout the Tertiaries and is widely distributed in the tropical seas of today. The Recent species are separated from the volutes mainly upon anatomical characters not available in the fossil forms, but it is probable that the Eocene species are all of them referable to *Lyria* and that the true *Voluta* was not initiated until the Pliocene.

LYRIA? species

Molds and impressions of an uncommonly fine volute are not rare in the greensand of the upper Kincaid at U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart on the A. F. Moser farm and about one-half mile northwest of the Simms Oil Company Moser No. 1. The largest specimen must have been 90 millimeters or more in height with a maximum diameter of 30 millimeters falling near

the median horizontal. The aperture is perhaps a little more than half as high as the entire shell. The whorls of the spire are wide and probably not more than 5 excluding the nuclear turns. The ribs are narrow and pinched with broadly concave interspaces and tend to be irregular or obsolete upon the final half turn. On the spire, they terminate abruptly a little in front of the posterior suture but are uniformly strong on the middle and anterior portions of the whorl and well down upon the base of the body. No traces of a spiral sculpture have been preserved. The aperture is narrow and lenticular in outline, the outer lip somewhat varicose, the inner excavated at the base of the body and the canal, probably rather long for the genus, twisted slightly backward and emarginate. The number and disposition of the columellar folds is not known. Though rather common at this single locality, this well characterized species has not been recognized elsewhere.

LYRIA species

Several imperfectly preserved specimens of a new *Lyria* were collected by L. W. Stephenson from the Littig glauconitic member exposed in a small branch 2.3 miles southwest of Staples, 5 miles east by south of Zorn, Guadalupe County (U.S.G.S. Sta. 13244). The forms are biconic, the height of an average individual is about 45 millimeters, and the diameter about half the height. The whorls are relatively few, not more than 5 exclusive of the nuclear turns and they taper rapidly. The body whorl is conic in outline. The strong, narrow ribs run about 8 to the later whorls and about 10 to the earlier. They terminate abruptly a little in front of the posterior suture and on the later whorls the ends of the ribs are expanded into nodes which coronate the whorl. The interspaces are broadly and rather deeply concave. A fine wavy spiral liration is faintly perceptible under magnification over the entire shell. The suture is closely appressed and undulated by the axials of the preceding volution. The characters of the aperture are not preserved but it was doubtless narrow and the canal short.

INCERTA SEDIS

A coarse shell from Kaufman County (U.S.G.S. Sta. 10711), 2½ miles northeast of Kemp, was possibly 75.0 millimeters in height in its perfect state and suggests one of the volutes in its general

outline and prominent narrow but rounded axial ribs. No attempt at a generic determination is feasible.

LYRIA species

Another species of uncertain generic affinities is a thick-shelled *Lyria*-like individual about 20 millimeters high, from the Tehuacana member of the Kincaid formation, 2½ miles northwest of Groesbeck (U.S.G.S. Sta. 11936). A part of the body and of the two anterior whorls of the spire are preserved. The whorls of the spire are trapezoidal in outline and the body is smoothly rounded. The surface is rippled with heavy axials running about 12 to the whorl. The characters of the aperture are not known.

Genus MACULOPEPLUM Dall 1906

1832. *Scaphella* Swainson, Zoological Illustrations, 2d ser., vol. 2, pl. 87 with text.
1840. *Scaphella* Swainson, Treatise on malacology, p. 318.
1889. *Scaphella* Swainson, Dall, Bull. Mus. Comp. Zool., Harvard Univ., vol. 18, p. 147.
1906. *Maculopeplum* Dall, Nautilus, vol. 19, p. 143.
1907. *Maculopeplum* Dall, Smithsonian Misc. Coll., vol. 48, pt. 3, p. 370.

Type.—*Voluta junonia* Hwass. (Recent from North Carolina to the Barbados.)

Shell of medium size or large, elongate oval, or fusiform. Protoconch smooth, turbinate, usually with a pointed tip in line with the axis of the membranous larval shell. Spire relatively low, usually nodose at the periphery. Aperture not greatly expanded medially, relatively broad anteriorly. Columella carrying 4 obliquely flattened plaits, the two anterior stronger than those behind them.

Maculopeplum is widely distributed but not abundant in the warmer water deposits of the Tertiary and in the Recent seas.

MACULOPEPLUM SHOWALTERI (Aldrich)?

1886. *Voluta showalteri* Aldrich, Geol. Survey of Alabama, Bull. 1, p. 28, pl. 3, fig. 14.
1890. *Scaphella showalteri* Aldrich, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 1, p. 80.
1896. *Scaphella showalteri* Aldrich, Harris, Bull. Am. Paleontology, vol. 1, No. 1, p. 31, pl. 7, fig. 21.

Shell oval, oblong; whorls five; spire blunted; surface smooth and shining; lines of growth hardly perceptible; suture moderately impressed.

Body whorl and next succeeding shouldered, bearing thereon numerous small tubercles; above the shoulder they are concave.

Aperture two-thirds the length of the shell; columella 4 plated- the upper one transverse, the middle one- oblique and larger. Outer lip smooth.

Locality.—Matthew's Landing, Alabama.

This species is a true Volute, and belongs to the section *Vespertilio* Klein —Rare.

Named in honor of Dr. E. R. Showalter, of Point Clear, Alabama. (Aldrich, 1886.)

A juvenile from the lower part of the fossiliferous section on the Colorado River (U.S.G.S. Sta. 11914) is allied to this species but probably not specifically identical with it.

Maculopeplum showalteri (Aldrich) is the earliest known species of *Maculopeplum* and it is interesting to find a related form in the Kincaid formation of Texas.

Family FASCIOLARIIDAE
Genus LATIRUS Montfort

1810. *Latirus* Montfort, Conchyliologie Systématique, vol. 2, p. 531.

Type.—*Latirus aurantiacus* Montfort = *Murex filosus* Lamarck = *Murex gibbulus* Gmelin. (Recent in Australian waters.)

Shell small or of moderate dimensions, turreted, fusiform. Protoconch small, the early whorls smooth and polished increasing rapidly in size; at least a part of the final nuclear whorl axially costate. Conch adorned with broad prominent axials and strong spirals. Body whorl abruptly constricted at the base. Aperture obliquely lenticular, terminating anteriorly in a narrow canal. Outer lip thickened and lirate within. Columella straight with low, slightly oblique folds just behind the entrance to the canal. Parietal wall glazed; an umbilical opening included between the reverted inner lip and the narrow, elevated, strongly lirate siphonal fasciole.

Latirus is a widespread but not prolific genus from the Cretaceous onward.

Subgenus POLYGONA Schumacher

1817. *Polygona* Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 241.

Type.—*Polygona fusiformis* Schumacher = *Murex infundibulum* Gmelin. (Recent in the West Indies.)

The subgenus *Polygona* is characterized by the long, narrow, straight or slightly oblique canal.

The East Coast Recent and Tertiary species of *Latirus* are all of them referable to *Polygona*.

LATIRUS? (POLYGONA) STEPHENSONI Gardner new species

Pl. 21, fig. 11

Shell, from which the tip and the anterior canal are broken away, of only moderate dimensions. Spire elevated, the remaining whorls 4 in number, the earlier convex, the medial and later obliquely shouldered. Axials vigorous, 10 to each of the later whorls, rather narrow but rounded upon their summits, inclined to expand at the periphery, and rather abruptly evanescent behind the periphery, separated by somewhat wider interradials; surface scabrous with the crowded incrementals. Entire surface spirally striate, the primary spirals 4 or 5 in number in front of the periphery with occasional secondaries; shoulder closely threaded with about 8 spirals; incrementals slightly retractive upon the shoulder, crowding the entire surface, over-riding the spirals and their free edges minutely crimped at their intersection. Whorls closely appressed, the sutures undulated by the axials of the preceding volution. Body whorl abruptly constricted at the base. Aperture obliquely pyriform, acutely angulated posteriorly. Outer lip widely expanded, obtusely angulated at the periphery. Columella excavated, smoothly coated with enamel. Canal broken away, and all evidence of the diagnostic folds of *Latirus* lost.

Dimensions.—Height of spire, 25.0+ millimeters; greatest diameter, 20 millimeters.

Holotype. U. S. Nat. Mus. No. 370936.

Type locality.—U.S.G.S. Sta. 11665, Water Hill, 5 miles northeast of Kemp, Kaufman County, Texas. Kincaid formation.

I have the honor to dedicate this fine species to the Chief of the Section of Coastal Plain Investigations of the U. S. Geological Survey, Dr. Lloyd W. Stephenson.

A closely related, possibly identical, species is fairly common at U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart near the top of the Kincaid. The spires of the Caldwell County forms seem lower and more rapidly tapering but they are known only from molds.

Occurrence.—Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665, 5 miles northeast of Kemp.

Genus FASCIOLARIA Lamarck

1799. *Fasciolaria* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 73. Type.—*Murex tulipa* Linnaeus. (Recent on the East Coast from Hatteras to Cartagena.)

Shell often very large, stout, fusiform; spire elevated; apex acute; nucleus smooth, paucispiral; post-nuclear whorls strongly sculptured both axially and spirally; aperture oval-elongate, terminating in an open, more or less twisted, feebly emarginate canal; columella concave, furnished with oblique, diminishing folds, the anterior, as in the volutes, being the most prominent; parietal wall glazed; inner lip finely lirate; anterior fasciole narrow and inconspicuous; umbilicus closed.

FASCIOLARIA? PLUMMERI Gardner new species

Pl. 22, figs. 1–3

Shell large, heavy, fusoid in outline, the maximum diameter falling near the median vertical and approximating half the altitude. Spire turreted, the whorls rapidly diminishing in size. Only 3 whorls remaining, probably as many more conchal whorls broken away with the protoconch. Sculpture ornate. Axials 10 to 12 in number, prominent, rounded, expanded at their posterior extremities into tubercles which crown the periphery of the whorl and disappear abruptly leaving a concave shoulder between the periphery and the posterior suture. Spiral sculpture coarse, persistent alike on the axial and interaxial areas, 4 in number on the sides of the body and 5 or 6 upon the base. Sides of the body obtusely truncate, the base smoothly concave and merging gradually into the rather broad anterior canal. Aperture obliquely ovate, filled with matrix concealing the characters of the columella. Anterior extremity of canal broken away.

Dimensions of holotype.—Height, 93.0 millimeters (incomplete specimen); greatest diameter, 50.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370931; adolescent?, U.S. Nat. Mus. No. 370985.

Type locality.—U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart on the E. A. Moser farm, Isaac Jackson Survey, about one-half mile northwest of Simms Oil Company derrick. Kincaid formation.

I have the pleasure of naming this exceptionally fine species in honor of Frederick B. Plummer, to whom I am deeply indebted for his hearty coöperation and his timely courtesies.

It is probable that *Fusus hubbardianus* Harris from the Midway of Mississippi is related, though certainly there is no question of a possible identity.

Smaller forms, apparently less coarsely sculptured both axially and spirally, are associated with *Fasciolaria? plummeri*. One of these, Figure 3, has been figured. The relationship of these individuals to the type of *F. plummeri* is not clear.

Fasciolaria? plummeri is one of the few elements in the Midway fauna that is reminiscent of the Cretaceous. Large univalves of this general aspect are rare in the Eocene faunas but are widespread in the Upper Cretaceous.

Occurrence.—Kincaid formation. *Caldwell County:* U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart, about one-half mile northwest of Simms Oil Company derrick.

FASCIOLARIA new species

Pl. 22, fig. 4

The broken body of an exceptionally fine species, probably referable to *Fasciolaria*, was collected from the limestone scarp near the Indio Wells in Maverick County (U. S. Nat. Mus. No. 370932). The greatest diameter of the shell is between 55 and 60 millimeters. A row of prominent tubercles, elongated axially and probably about 15 in number decorated the body, directly in front of the suture. A coarse and regular spiral sculpture is developed upon the sides and probably upon the base of the body. The basal constriction is abrupt and the canal moderately broad.

This species exhibits the general features of *Fasciolaria plummeri* but the tuberculated shoulder is not so broad, the tubercles more numerous and more prominent, the spirals 10 or 11 upon the sides of the body instead of 4 or 5, and the constriction at the base of the body more abrupt.

FASCIOLARIA species

Fragments of a large species, probably more closely allied to *Fasciolaria hubbardi* than to *F. plummeri*, occur in the lower part of the Midway fossiliferous section on the Colorado River (U.S.G.S. Sta. 10526).

Family FUSINIDAE
Genus FALSIFUSUS Grabau

1904. *Falsifusus* Grabau, Phylogeny of *Fusus* and its Allies, Smithsonian Misc. Coll., No. 1417, vol. 44, p. 80.

Type.—*Fusus ottonis* Aldrich = *Fusus meyeri* Aldrich, 1886, non *Fusus meyeri* Dunker, 1871. (Midway of Alabama.)

Shells fusiform, with a long and slender spire, and a canal of about the same length. Protoconch merging into the whorls of the conch, no sharp line of demarkation being apparent. The first two whorls of the protoconch are generally smooth, the apical one minute, gradually increasing in size. The three to four whorls which constitute the apical series form a rather narrow cone. Third whorl with fine closely crowded, more or less oblique riblets, which in part are gently concave forward. These after the completion of the third, or sometimes an additional whorl, quickly merge into the normal whorls of the conch. A basal carina usually marks the ribbed whorls of the apical series, this carina appearing just above the suture. Whorls of the conch as in *Fusus*. (Grabau, 1904.)

The similarity of the early stages of *Falsifusus* and of the turretids has suggested a genetic relationship.

FALSIFUSUS OTTONIS (Aldrich)?

Pl. 21, fig. 5

1886. *Fusus meyeri* Aldrich, Geol. Survey Alabama, Bull. 1, p. 21, pl. 3, fig. 12.

Not *Fusus meyeri* Dunker, 1871, Novitates Conchologicae, p. 127, pl. 43, figs. 1–2. (Recent off Ceylon.)

1896. *Fusus meyeri* Aldrich var. Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 87, pl. 8, fig. 12.

1897. *Fusus ottonis* Aldrich, Bull. Am. Paleontology, vol. 2, No. 8, p. 6, (replacing *F. meyeri* Aldrich non *F. meyeri* Dunker, 1871).

1899. *Fusus ottonis* Aldrich, Harris, Bull. Am. Paleontology, vol. 3, No. 11, p. 42, pl. 5, fig. 5.

1904. *Falsifusus meyeri* (Aldrich), Grabau, Smithsonian Misc. Coll., No. 1417, vol. 44, p. 81, pl. 17, fig. 9, and text fig. 4.

Shell elongate fusiform; spire slender, acute; whorls fourteen, surface of the spire and body whorl with seven longitudinal broadly rounded folds, which are spirally arranged, crossed by raised rounded striae, generally seven in

number, rather distant, the central one making a sharp carina on the center of each whorl, with erect longitudinal tubercles at the intersections; spaces between striae showing only lines of growth: canal very long, spirally striated with alternate raised lines; lines of growth very numerous and almost obsolete; mouth small, oblong-ovate; outer lip incurved, smooth.

Locality.—Lower bed, Woods' Bluff, Ala.; Matthews' Landing, Ala.

The figured type retains four embryonic whorls; three are smooth, the fourth longitudinally striate. The Matthews' Landing form is smaller and even more beautiful. One specimen has the ribs obsolete on the upper half of the whorls and the periphery armed with erect longitudinal spines, giving the shell a very strongly carinate form. *Fusus Mississippiensis* Con., from Vicksburg, resembles this form, but this is more carinate, with longer canal and spire; the latter species has many more revolving lines, and the outer lip is striate internally. Named in honor of Dr. Otto Meyer. (Aldrich, 1886.)

Harris in 1896 doubted the identity of the species from Woods Bluff and Matthews Landing, but gave no name to the Midway species. He noted the following differences:

The body whorls are not so widely different as are the spires. In the Matthews Landing—Oak Hill type there are as high as 18 costae on some of the whorls. They are sharp, well defined, direct from the suture to the sharp carina. In the Wood's Bluff forms the costae on the spire number the same as on the body whorl, about 7 or 8; they are also of the same form. Again in the Wood's Bluff forms there is no tendency for the third line below the keel to become very prominent as it does in the Matthews' Landing specimens. It is possible the two may be united by intermediate forms, but there is reason certainly for doubting it.

The species or group of species is certainly represented in Texas but by fragmentary material only, which is apparently very close to the Matthews Landing form but throws no light upon the taxonomic relationship of the Wilcox and Midway races.

Grabau has used Aldrich's first name. *F. meyeri* "since the present species is not a *Fusus* and Dunker's *Fusus meyeri* is," (Grabau, *op. cit.*). The danger of confusion is not eliminated, however, and *ottonis*, the name which Aldrich himself suggested to replace his preoccupied *meyeri* seems the better choice. Grabau described in minute detail the protoconch of *Falsifusus ottonis*, the type of his genus.

A crushed specimen from marls of the Brazos River just above the Falls County line (U.S.G.S. Sta. 10891) has preserved no characters by which it may be separated from *Falsifusus ottonis* of the Midway of Alabama.

A strongly turreted spire of a related species with the crenulated periphery emphasized by a prominent spiral thread was recovered from the lower part of the fossiliferous section on the Colorado River (U.S.G.S. Sta. 11696). In this form, however, only a single spiral intervenes between the periphery and the anterior suture.

FALSIFUSUS species

Another species, probably of the *ottonis* group, is represented in the lower part of the fossiliferous section on the Colorado River (U.S.G.S. Stas. 11915 and 12112) between 4 and 5 miles below Webberville. The outline is not so slender as that of *F. ottonis* and whorls are more rounded, although the undulated periphery is clearly defined by a strong spiral.

FALSIFUSUS? species

Fragments of a mold from Cribbs Bluff, Brazos River (U.S.G.S. Sta. 11924) indicate a slender species sculptured with 12 to 15 axials which abruptly evanesce on the base of the slender body and spirals which abruptly strengthen and grow more distinct with the evanescence of the axials.

FALSIFUSUS TOBAR Gardner new species

Pl. 21, fig. 8

Shell small, exceedingly slender. Spire very high and made up of numerous slender whorls which taper very slowly toward the apex. Protoconch and earliest whorls of conch broken away. Remaining whorls of conch with a broad, steeply sloping, slightly convex shoulder, a periphery crowned with rounded tubercles, and straight or slightly constricted sides in front of the periphery. Axials 11 to the later whorls, most prominent in the peripheral nodes, though persistent for a short interval in front of the periphery. The entire whorl spirally threaded, the shoulder more finely than the sides and the strongest spirals, the two that follow the periphery; spiral directly in front of the suture also more prominent than any of the other shoulder spirals. Anterior portion of shell broken away.

Dimensions.—Height of incomplete specimen, which is little more than half the entire shell, 13.0 millimeters; greatest diameter, 7.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 370933.

Type locality.—U.S.G.S. Sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass, Maverick County, Texas. Wills Point formation.

Falsifusus tobar is based upon very imperfect material but it is of interest to establish the existence of a member of the *Falsifusus ottonis* group in the upper Midway of Maverick County. The axial sculpture of *F. ottonis* is more conspicuous than that of *F. tobar* and the spiral sculpture much coarser. It is interesting to note that this is another of the many affinities of this fauna with Matthews Landing species which persist into the Wilcox.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

Family BUCCINIDAE
Genus NEPTUNEA ("Bolten") Roeding

1798. *Neptunea* ("Bolten") Roeding, Museum Boltenianum, pt. 2, Conchylia, p. 115.

Type.—*Fusus antiquus* Linnaeus. (Recent in the North Atlantic and Arctic seas.)

Shell large or at least of moderate dimensions, stout fusoidal in outline, the whorls inflated or trapezoidal; body whorl relatively large, inflated; spiral sculpture dominant, often fine and evenly developed over the entire shell to the exclusion of all other ornamentation; aperture pyriform with a slight posterior channel; outer lip thickened but not lirate within; inner margin of aperture sigmoidal, the parietal wall and pillar heavily washed with callous; anterior canal short, broad, slightly recurved, the extremity emarginate.

The group has been recognized in strata from the Cretaceous on to the Recent. The Recent species are largely boreal.

NEPTUNEA IMPRESSA Gabb?

1860. *Neptunea impressa* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 389, pl. 68, fig. 5.

1896. *Mazzolina impressa* Gabb, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 92, pl. 9, figs. 5, 6.

Fusiform, whorls six, rounded; spire sharp, but not very high; mouth ovate, canal moderately long, outer lip simple, inner lip coated with a somewhat heavy layer of enamel, a very small sinus between the two lips posteriorly,

not an emargination but rather a continuation of the suture, lined with enamel; surface in some specimens nearly smooth, in others closely marked by fine impressed, revolving lines.

Dimensions. Length, .8 in.; width of body whorl, .5 in.; length of mouth, .55 in.

Locality.—Hardeman Co., Tenn. (Gabb, 1860.)

The specimen from the bluff near Webberville, Travis County (U.S.G.S. Sta. 5232) is incomplete but it exhibits the characteristic features of the genus and many of the marks of the species. Both the Tennessee and the Texas forms retain traces of an axial sculpture on the early whorls.

A specimen from the upper part of the fossiliferous section on the Colorado River (U.S.G.S. Sta. 10527), exhibits the same general dimensions and outline as those of the type species but the sculpture is finer and sharper. No trace of the columellar plaits which characterize *Mazzalina* have been observed and the species has been referred back to the genus under which it was originally placed.

NEPTUNEA species

A fragment from Salado Creek, 5.3 miles southeast of the San Antonio Post Office (U.S.G.S. Sta. 8245) indicates a species with a high spire and numerous narrowly tabulated whorls.

Genus LAEVIBUCCINUM Conrad

1865. *Laevibuccinum* Conrad, Am. Jour. Conchology, vol. 1, p. 21.

Type by monotypy.—*Buccinum prorsum* Conrad. (Claiborne, Eocene of Alabama.)

Shell of medium dimensions, spindle-shaped, the aperture about two-thirds the height of the entire shell; protoconch small; whorls of the conch feebly inflated, increasing rather rapidly in diameter. Axial sculpture not developed. Spirals not very regular nor very prominent, least feeble on the posterior portion of the whorl. Aperture obliquely lenticular, acutely angulated posteriorly. Columella broadly concave, non-plicate. Parietal wall thinly glazed. Outer lip broadly arcuate, lirate within. Anterior canal broad, truncate, and feebly emarginate at the extremity.

The genus, in the United States at least, is restricted in its distribution to the Eocene.

LAEVIBUCCINUM CONSTRICTUM (Aldrich)?

Pl. 21, fig. 6

1895. *Neptunea constricta* Aldrich, Geol. Survey Alabama, Bull. 1, p. 21, pl. 3, fig. 13.

1896. *Neptunea constricta* Aldrich, Harris, Bull. Am. Paleontology, vol. 1, No. 1, p. 97, pl. 9, fig. 11.

Shell broadly fusiform, whorls eight, spire high; suture distinct, whorls concave and compressed just below the suture; covered at this point with fine transverse lines, remaining space smooth. Body whorl large, smooth below the above-mentioned sutural area, narrowed below into a short, stout canal which is marked by fine revolving lines. Aperture about two-thirds the length of the shell; outer lip sharp, thickened and crenulate within; inner lip concave above, straight below; callus not heavy.

Locality.—Matthews' Landing, Ala. (Aldrich, 1896.)

Fragments of a species closely allied to or identical with *Laevibuccinum constrictum* occur in the Tehuacana member of the Kincaid formation at the foot of the trail leading down from the Evans' (Myrick's) apiary.

A decorticated specimen from the Wills Point formation one-half mile northeast of Cedar Creek Crossing on the Austin-Red Rock road, Bastrop County (U.S.G.S. Sta. 11908), presents no characters by which it may be separated from Aldrich's *N. constricta* from Matthews Landing, Alabama.

INCERTA SEDIS

Numerous molds between 25 and 30 millimeters in height and 15 to 20 millimeters in diameter, with short spires, inflated bodies, and short recurved canals, have been recovered from the calcareous sandstone of the Kincaid formation on the Whitaker Survey (U.S.G.S. Sta. 11931), 6 miles northwest of Kosse. The outline and general dimensions suggest *Neptunea* and so do the traces of a uniform spiral liration, but the margin of the outer lip is pulled back upon the preceding whorl in a manner suggesting the stromboids and Apporhaidae and quite unlike anything observed in the buccinoids.

Similar and possibly identical forms, also represented by molds alone, are not rare in the upper greensand of the Kincaid formation, 5½ miles due north of Lockhart in Caldwell County (U.S.G.S. Sta. 11707). The Caldwell County forms are larger, by a half. It is

possible that more than one species is present for the range in the relative height of the spire is very great.

Genus PSEUDOLIVA Swainson

1840. *Pseudoliva* Swainson, Treatise on malacology, p. 32, fig. 3a, p. 306.

Type.—*Baccinum plumbeum* Chemnitz. (Recent off the west coast of Africa.)

Shell thick, oval, oliviform, ventricose; spire very short, acute; base with two parallel grooves, one of which forms a notch at the base of the outer lip; suture slightly channelled; inner lip very thick, and turning inwards; aperture with an internal canal. Connects the Turbinellidae with the Volutidae.

P. plumbea. Chem. 188. f. 1806, 1807. (Swainson, 1840.)

Few genera are so well characterized as is *Pseudoliva* by the deeply incised groove at the base of the body.

PSEUDOLIVA species

The lower part of the body of a very fine specimen of *Pseudoliva* was collected on the south bank of Elm Creek, on the Schuddemagen ranch, 11 miles south of Sabinal, Uvalde County (U.S.G.S. Sta. 6279). The species may easily have attained an altitude of 30.0 millimeters. The axials are ∧-shaped and persist almost to the pseudolivar groove. The area in front of the groove is sculptured with some half a dozen coarse spirals.

A very much smaller species with similar sculpture occurs in the Tehuacana member of the Kincaid formation, 2½ miles northwest of Groesbeck, Limestone County (U.S.G.S. Sta. 11936). This has much in common with the form figured by Harris (Bull. Am. Paleontology, vol. 1, No. 4, p. 100, pl. 9, fig. 21) under the name of *Pseudoliva scalina* Heilprin, a Bashi species.

A smaller species, apparently without axial sculpture, was collected from the Tehuacana member of the Kincaid formation at Comanche Crossing, Navasota Creek, 6 miles west of Mexia, Limestone County (U.S.G.S Sta. 6559).

A *Pseudoliva* of the same general type was collected from U.S. G.S. Sta. 11665, 5 miles northeast of Kemp, Kaufman County.

Family ALECTRIONIDAE
Genus TRITARIA Conrad

1865. *Tritaria* Conrad, Am. Jour. Conchology, vol. 1, p. 21.

1928. *Tritaria* Woodring, Miocene Mollusks from Bowden, Jamaica, Carnegie Inst. Washington, Pub. 385, p. 259.

Type: by monotypy. -*Buccinum mississippiensis* Conrad. (Vicksburg Oligocene of Mississippi.)

Shell operculate, of moderate dimensions and thickness, conic or turrito-conic in outline; whorls closely appressed, feebly convex or shouldered; protoconch for the most part smooth, polished, acuminate, performing a moderate number of turns; external surface both axially and spirally ornamented, as a rule, the axial sculpture dominant; aperture obliquely lenticular or elliptical in outline; labrum more or less thickened and lirate within; labium excavated at the base of the body; parietal wall and pillar heavily glazed; margin of pillar elevated into a more or less prominent fold outlined posteriorly by a sulcus which is usually quite deep; denticles occasionally developed upon the reverted labium; anterior canal very short, recurved at its extremity, the margins parallel; anterior fasciole arched, well differentiated, cut off from the base of the body by a more or less sharply defined sulcus; terminal notch usually deep and obliquely directed; umbilicus imperforate or narrowly perforate.

Tritaria has not been recognized in strata older than the Tertiary.

The recent representatives of the genus have a world-wide distribution along the shores of the tropical and subtropical seas.

TRITARIA? EMORYI Gardner new species

Pl. 20, figs. 16, 17

Shell small, rather stout, the maximum diameter falling a little in front of the medium horizontal. Whorls 5 in all, those of the small, smooth protoconch not sharply differentiated from the reticulately sculptured conch, those of the spire trapezoidal in outline, or broadly and feebly inflated; body rather abruptly constricted into a slender canal. Axial sculpture dominating the spiral; axials narrow, rounded, about 25 to the later whorls, persistent from suture to suture though disappearing rather abruptly at the base of the body. Spirals feeble, low, flat, overriding the axials, about 6 in number on the later whorls of the spire and twice as many upon the body; the posterior spiral beading the axials and set off from the spiral in front of it by an interspace wider than the others. Characters of aperture not well preserved; probably rather narrow for the group and constricted posteriorly into a slender canal.

Dimensions.—Height, 4.3± millimeters; greatest diameter, 2.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370994.

Type locality.—U.S.G.S. Sta. 6279, a few hundred yards south of the junction of Elm Creek with Sabinal Creek, Schuddemagen ranch, 11 miles south of Sabinal, Uvalde County, Texas. Kincaid formation, Tehuacana member.

The species is named in honor of William H. Emory, Major First Cavalry and United States Commissioner in charge of the United States and Mexican Boundary Survey, 1854–1855.

The generic affinities of this small shell are not very clear. The buccinoid outline and the isolation of the posterior spiral, together with the absence of any trace of a siphonal notch apparently ally the form with the nassoids rather than the turretids.

Occurrence.—Tehuacana member of Kincaid formation. *Uvalde County:* U.S.G.S. Sta. 6279, 11 miles south of Sabinal, south of the junction of Elm Creek with Sabinal Creek.

The type is not unique but the species has been recognized only at the type locality.

Genus ALECTRION Montfort

1810. *Alectrion* Montfort, Conchyliologie Systématique, vol. II, p. 566.
Type, *Buccinum papillosum* Linnaeus. (Recent in the South Pacific.)

The name *Alectrion* is in disfavor, but in view of the present confusion it is retained until the nomenclature of the group becomes a little more static.

Shell small, imperforate, solid, buccciniform or conic in outline; spire elevated; apex acute; whorls heavily sculptured, usually cancellated; aperture ovate, terminating in a short, recurved canal, emarginate at its base; labrum heavy, arcuate, furrowed or dentate within; labium smooth, enameled, with a posterior callous or blunt, dentiform plait.

Alectrion is represented in sediments as old as the Cretaceous although it does not occur in any abundance until the middle Tertiary. The Recent species or "dog-whelks," as they are popularly called, exceed 200 in number and occur in the greatest abundance near the shores of the warm temperate seas.

Small nassoids very similar to the young of *Alectrion exilis* (Conrad) from the Greggs Landing horizon of the Alabama Wilcox are

fairly common and widespread in the lower Wilcox of east-central Texas, in the sand near New Hope and possibly in the middle part of the Wills Point formation. Most of the specimens present juvenile characters and the species has not been described.

Family MURICIDAE
Genus MUREX Linnaeus

1758. *Murex* Linnaeus, Systema naturae, 10th ed., p. 746.

Type.—*Murex tribulus* Linnaeus. (Recent in the South Pacific and Indian Ocean.)

Shell oblong, oval, pyriform or fusiform in outline; spire usually elevated, acutely tapering; protoconch rather small, smooth, often somewhat turbinate, for the most part, paucispiral; ornamentation elaborate; axial varices 3 or more in number, usually continuous, often spinose at the intersection with the spirals, less frequently foliaceous; simple costals usually present in addition to the varices, often reduced upon the later whorls to peripheral tubercles; spiral sculpture developed, as a rule, over the entire conch; aperture subcircular, elliptical or ovate; labrum varicated, lirate or denticulate within; labium nonplicate, heavily glazed, often rugose or denticulate in front of the commissure and along the pillar; anterior canal long and straight or short and recurved, generally closed in the adult.

Murex has a limited representation in the Cretaceous. In the succeeding Tertiary the genus becomes increasingly abundant, while the known Recent species number well over 200, the majority of them denizens of the tropical and subtropical waters from between tides to a depth of 50 fathoms.

Subgenus ARGOBUCCINUM Herrmannsen

1846. *Argobuccinum* Herrmannsen, Indicis Generum Malacozoorum, vol. 1, p. 77.
= *Argobaccinum* Klein, 1753 (pre-binomial).

Type. *Ranella argus* Gmelin. (Recent in the circum south polar seas off South Africa, Australia, Chile and the Tristan da Cunha Islands.)

Shell of medium size, the whorls short, often obtusely angulated at the periphery, increasing rather rapidly in diameter. Both axial and spiral sculpture well developed; primary spirals frequently beaded or tuberculated; terminal varix prominent; a second varix, almost equally prominent, placed *Ranella*-like on the opposite side

of the whorl, but unlike *Ranella*, not uniformly continuous on the whorls of the spire. Body relatively large and inflated, constricted abruptly into the short recurved anterior canal. Aperture ovate, slightly oblique, channelled posteriorly; outer lip thickened and lirate within; inner wall of aperture excavated and heavily washed with callous. Extremity of short, twisted anterior canal truncate and emarginate.

The group has not been recognized in strata older than the Tertiary. The Recent species are apparently restricted to waters south of the Equator.

MUREX (ARGOBUCCINUM) MANSFIELDI Gardner new species

Pl. 23, figs. 3-6

Shell small for the group, rather stocky. Whorls of conch 4 to 5 in number, short, obtusely angulated at the periphery, increasing rather rapidly in diameter. Protoconch small, smooth, naticoid, twice coiled, cut off from the ornate conch by a distinct rib. Conch ornamented with a double reticulation, that of the strong primary spirals, 4 in number upon the whorls of the spire and twice that number upon the body, and the axials which are rather weak except for the nodulous intersection with the spirals, and a microscopically fine reticulation of the growth lines and the secondary spirals; the growth lines *Ficus*-like in their regularity and sharpness and overriding both the secondary and the primary spirals. Varices 2 in number and opposite in position, the one terminal, the other, halfway around the whorl, not continuous upon the spire. Aperture ovate and slightly oblique, probably channelled posteriorly, but filled with a matrix obscuring the characters. Outer lip strongly arcuate and strongly varicose. Inner lip excavated by the contraction of the body. Anterior canal short, slender, sharply recurved, and emarginate at its extremity.

Dimensions.—Cotype with anterior canal preserved: height, 15.5 millimeters; diameter including the terminal varix, 9.0 millimeters; diameter not including the terminal varix, 7.0 millimeters.

Cotypes (3).—U. S. Nat. Mus. No. 370936.

Type locality.—U.S.G.S. Sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass. Wills Point formation.

I have the pleasure of naming this most interesting species in honor of Dr. Wendell C. Mansfield, for many years my co-worker.

An individual from the lower fossiliferous section on the Colorado River, though imperfect, is apparently identical.

Murex mansfieldi closely resembles its probable Eastern Gulf analogue, *Murex shoualteri* Conrad, but the spiral sculpture in the Texas species is not so imbricated and the axials, especially at the intersection with the peripheral spiral, much more nodose. A related but not identical species occurs in the greensand of the Kincaid formation on Cedar Creek, 3 miles southeast of Williams' store (U.S.G.S. Sta. 11909), and possibly in the Wills Point half a mile northeast of Cedar Creek Crossing on the Austin-Red Rock road (U.S.G.S. Sta. 11906).

Rather similar indeterminate fragments occur in the Tehuacana member of the Kincaid formation, 2½ miles northwest of Groesbeck, Limestone County (U.S.G.S. Sta. 11936), and juveniles from the Colorado River section (U.S.G.S. Sta. 11914) indicate allied or identical species.

The genus is also represented by specifically indeterminate molds from the Kincaid formation on the Brazos River (U.S.G.S. Sta. 11926) and in Caldwell County, 5½ miles north of Lockhart (U.S. G.S. Sta. 11707).

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11696. Colorado River, 1½ miles below the Travis County line.

Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass.

Family TRITONIDAE
Genus RANULARIA Schumacher

1817. *Ranularia* Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 253.

Type (designated by Gray, 1847).—*Murex clavator* Chemnitz. (Recent in the Indo-Pacific.)

Spire short, rapidly enlarging; protoconch rather small, smooth, abruptly terminating; body whorl large relatively, abruptly constricted into a long twisted anterior canal; sculpture dominantly spiral, the axial sculpture reduced, for the most part, to the nodulation of the strong spirals and to the varicose outer lip and its

vestiges on the preceding whorls: aperture ovate to subcircular, often obtusely angulated at the shoulder of the body whorl; outer lip varicose, dentate within; columella excavated at the base of the body, changing its direction at the entrance to the arcuate canal, smooth excepting for a denticle at the posterior opening of the canal; both columella and body whorl rather heavily washed with callous.

Ranularia is distinguished in the large family of frog shells or tritons by its medium size, low, often tabulated spire, the abrupt constriction of the body, the long, slender twisted anterior canal.

There is no record of the genus in the Cretaceous but it is already established in its characteristic features by the opening of the Eocene and persists in the warmer waters to the present day.

RANULARIA HULA Gardner new species

Pl. 23, figs. 1, 2

Shell rather small for the group and friable. Protoconch not preserved. Conch made up of 5 or 6 volutions, the early whorls broadly convex, the later broadly tabulated and acutely angulated at the periphery. Body whorl with a broad nearly horizontal shoulder; very feebly convex and slightly tapering between the peripheral keel and the less accentuated and more obtuse keel at the base of the body; constricted abruptly in front of the basal keel. Spirals low but sharp and fairly regular in size and spacing, about 8 in number on the shoulder and about 8 on the side of the whorl in the type but double that number in fragments of larger and probably more mature individuals. Axial sculpture restricted to the regular crenulation of the shoulder, the crenulae numbering about 15, with feeble reflections on the basal keel; and to the obtuse terminal varix with the traces of former terminal varices still extant on the later whorls of the spire. Aperture ovate, with an obscure posterior channel, abruptly constricted into the narrow arcuate anterior canal. Outer lip obscurely angulated at both the shoulder and the basal keel, varicose, dentate within. Columella sigmoidal. Base of body and columella washed with callous.

Dimensions.—Immature individual: height, 33.5 millimeters; greatest diameter, 15.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370935.

Type locality.—U.S.G.S. Sta. 10519, mouth of Brushy Creek, Milam County. Wills Point formation.

Ranularia hulo is doubtless kin to *Triton (Ranularia) eocensis* (Aldrich) but it is a more angular shell with no trace of the prominent spiral which is developed upon the base of the body of *eocensis*.

Occurrence. Wills Point formation. *Milam County:* U.S.G.S. Sta. 10519, mouth of Brushy Creek at San Gabriel River. *Caldwell County:* U.S.G.S. Sta. 11699, Mercer well, 2 miles southwest of Joliet.

Suborder TAENIOGLOSSA
Family TRITONIDAE
Genus TRITONIUM Link

1807, May. *Tritonium* Link, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, pt. 3, p. 121.

Type.—*Murex tritonis* Linnaeus. (Recent in the Indo-Pacific.)

Shell fusoid or buccinoid in outline, often large and heavy; spire more or less elevated; whorls nodulated, varicose, the varices often very irregular and discontinuous; aperture oval; outer lip thickened and usually varicated externally, dentate or lirate within; inner lip smooth, corrugated or plicated; anterior canal more or less produced.

The genus is first cited in the Cretaceous and is moderately abundant in the Tertiaries. The Recent species are confined largely to the warmer waters and are particularly characteristic of the Asiatic seas. The name *Tritonium* is no longer in good repute but the triton or frog-shells are widely known and no other name has been generally accepted.

Subgenus COLUBRARIA Schumacher

1817. *Colubraria* Schumacher, Essai d'un nouveau système des habitations des vers testacés, pp. 76, 251.

Type. *Murex morchaus* Gmelin. (Recent in the East Indies and Philippines.)

The subgenus is characterized by the relatively slender outline, concomitant with the relatively elevated spire and narrow aperture, the presence of columellar plications, and the rather short anterior canal.

TRITONIUM (COLUBRARIA) CEDRI Gardner new species

Pl. 21, figs. 9, 10

Shell small, slender, fusiform, the body decidedly more than half as high as the entire shell but the maximum diameter falling a little in front of the median horizontal. Protoconch not preserved; remaining volutions which probably represent the entire conch, 6 in number, high, feebly convex posteriorly. Sculpture ornate. Spirals fine, flat threadlets, 5 or 6 on the whorls of the spire and about three times that number on the body; interspirals wider than the spirals. Axials low, obtuse, numbering 15 or 16 to the whorl, 2 of them usually modified into varices. Terminal varix the most prominent, slightly flaring. Aperture oblique, excavated at the base of the body, terminating anteriorly in a short, broad, slightly patulous canal.

Dimensions.—Height, 9.1 millimeters; greatest diameter, 3.2 millimeters. The diameter does not include the terminal varix.

Holotype.—U. S. Nat. Mus. No. 370933.

Type locality.—U.S.G.S. Sta. 11903, small branch below tank on north side of Cedar Creek-Lytton Springs road, one-half mile northeast of crossing on Austin-Red Rock road, Bastrop County, Texas, Wills Point formation.

The columellar folds which characterize the subgenus are obscured by the matrix but the affinities of the single specimen collected seem obvious. The group is well represented in the European Eocene but it has not been commonly recognized in this country.

The genus is also represented by indeterminable material from the lower part of the fossiliferous section on the Colorado River (U.S.G.S. Stas. 5230 and 11914), about 1½ miles below the Travis-Bastrop County line.

An allied species, differing in the finer, sharper and more numerous spirals, is represented by a body whorl collected from the upper part of the fossiliferous section on the Colorado River (U.S.G.S. Sta. 10527).

Occurrence.—Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11903, small branch below tank on north side of Cedar Creek, Lytton Springs road, one-half mile northwest of crossing on Austin-Red Rock road.

Family FICIDAE
Genus FICUS ("Bolten") Roeding

1793. *Ficus* ("Bolten") Roeding, Museum Boltenianum, pt. 2, p. 148.
Type, *Bulla ficus* Linnaeus. (Recent in the East Indies.)

Shell rather large, thin, almost papyraceous, inflated, pyriform, imperforate; spire low, rounded rather than angulated; protoconch smooth, obtuse, not prominent; sculpture spiral or delicately reticulate; aperture wide, pyriform, terminating anteriorly in a long, narrow canal; outer lip thin, simple, arcuate; columellar lip slightly sinuous, destitute of plications.

Ficus was initiated in the Cretaceous and culminated in the Tertiary. The representation in the Recent waters is rather meager and confined to the tropical and subtropical regions, notably the Antilles, the Indian Ocean, and the Phillipine Islands.

FICUS JUVENIS (Whitfield)?

1865. *Pyrula juvenis* Whitfield, Am. Jour. Conchology, vol. 1, p. 259.
1886. *Pyrula juvenis* Whitfield, Aldrich, Geol. Survey Alabama, Bull. 1, p. 25, pl. 6, fig. 8.
1890. *Ficula juvenis* Whitfield, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 101, pl. 7, fig. 54.
1894. *Pyrula* sp. Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 46, pl. 3, fig. 3.
1896. *Pyrula juvenis* Whitfield, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 102, pl. 10, figs. 5, 6.

Shell small and fragile; spire elevated; columella slender, slightly bent; aperture large, elongate, ovate or subelliptical; volutions three, marked on the periphery by three distinct carinae or subangular revolving ridges, the upper one marked with closely arranged longitudinally elongate nodes, the others simple; entire surface marked by very fine revolving lines, which are somewhat fasciculate below the lower carina, there being three finer ones between each large one.

Dimensions.—Length, .6 inch, transverse diameter, a little less than .3 inch.

Locality.—Six miles above Claiborne, Alabama, west side of river. (Whitfield, 1865.)

Casts referable to this group occur in the weathered greensands of the Wills Point formation at U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass, Maverick County, but it is doubtful indeed if the Claiborne species was established so early as the Midway.

FICUS? species

An imperfect cast, apparently of *Ficus*, indicates a species of about 32 millimeters in height and 18 millimeters in diameter. The spire is very low, the body relatively very large, acutely angulated at the periphery of the broad and very gently sloping shoulder, almost vertical in front of the periphery and obtusely angulated and abruptly constricted at the base of the body. The shoulder and the base of the body were apparently outlined by prominent spirals with an equally prominent intermediate spiral and there are traces of an intermediate spiral toward the aperture. The canal is not preserved.

Only the single individual is known, from a float in the bed of the Hondo River, doubtless dislodged from one-fourth mile above the crossing due east of Elstone, Medina County, Texas (U.S.G.S. Sta. 6230).

Family CYPRAEIDAE
Genus CYPRAEA Linnaeus

1758. *Cypraea* Linnaeus, Systema naturae, 10th ed., p. 718.
Type.–*Cypraea tigris* Linnaeus. (Recent in the Indo-Pacific.)

Shell solid, ovoid, ventricose; spire slightly elevated in the young, involved in the adult forms; surface highly polished, smooth, lirate or tuberculate; aperture long, narrow, canaliculate at each extremity; both outer and columellar lips crenulated within.

The genus has been reported by Stefani in strata as old as the Jurassic. The Cretaceous and Tertiary representatives are increasingly abundant while the Recent species of this genus, best known as the cowry shells, constitute a conspicuous element in the tropical and sub-tropical molluscan faunas. They are also a prominent factor in the political economy of many of the uncivilized tribes. Along the west coast of Africa and inland, where the cowries are the accepted currency, the rate of exchange varies from two thousand to six thousand cowries for one dollar of the American coinage.

CYPRAEA? species

Pl. 21, figs. 10, 11

A single mold a little less than 25 millimeters in height and a little more than 15 millimeters in breadth was collected from the Littig glauconitic member of the Kincaid formation (U.S.G.S. Sta. 11678), one-half to three-fourths of a mile above Cedar Creek road

on Half Mile Creek, Bastrop County, Texas. The body is broad, when viewed from the rear, and gradually tapering, but rather slender when viewed from the front. The outer lip is obviously much thickened and the aperture rather wide.

Figured specimen.—U. S. Nat. Mus. No. 370937.

CYPRAEA species

The cast of a very much inflated form measuring approximately 31.0 millimeters in height and 25.8 millimeters in breadth was collected on Cedar Creek, 100 yards upstream from the bridge (Bureau Economic Geology Sta. 1951). The apical area is flattened and very broad. The posterior portion of the shell is much inflated while in front of the median horizontal the shell abruptly contracts.

Another smaller and less inflated species is indicated in the greensands of the upper part of the Kincaid formation, 5½ miles north of Lockhart (U.S.G.S. Sta. 11707).

CYPRAEA ESTELLENSIS Aldrich?

1921. *Cypraea estellensis* Aldrich, Bull. Am. Paleontology, vol. 9, No. 37, p. 14, pl. 2, fig. 1.

Shell small; rotund; smooth; aperture narrow; outer lip curving into the apex which is open. Length 12 mm. Breadth 10 mm.

Locality.—Sucarnoochee beds, Pursley Creek, Wilcox Co., Ala.

Type.—Alabama State Museum.

Remarks.—This specimen has only preserved the shell in part but the interior is hard rock and gives the form quite accurately. The aperture is all filled with matrix, hiding the dentition. Professor Harris mentions finding one species at Fort Gaines on the Chattahoochee and another (which is probably the one subsequently described ½ mile north of Ripley, Miss.) They are figured and named as they seem to be rare and peculiar to this horizon. (Aldrich, 1921.)

Individuals collected one-half mile below the old Myrick apiary on the Frio River, Uvalde County (U.S.G.S. Sta. 3130), present no characters excepting a slightly larger size by which they may be separated from the Alabama species. However, the characters are so generalized that a specific determination is not possible. The Alabama shell probably comes from a slightly lower horizon than that upon the Frio River.

Family APORRHAIDAE

Genus and species indeterminate

Pl. 24, fig. 9

Specimens of the family Aporrhaidae but not certainly determinable generically occur at U.S.G.S. Sta. 11707, 5½ miles north of Lockhart, Caldwell County, at the second greensand horizon of the Kincaid formation. The terminal flange is widely flaring and produced backward and adherent to the spire for a considerable distance. Traces of a fine and regular spiral threading are clearly visible toward the aperture.

Only the molds remain but one of these indicates a shell fully 60 millimeters in height.

APORRHAIS? species

1896. *Aporrhais* sp. Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 105, pl. 10, fig. 9.

We have as yet obtained no really good specimens of this genus in the Midway. The figure represents an imperfect specimen obtained from near the southeast line of Hogan's Survey, Falls County, on the west bank of the Brazos. It is quite probably *A. gracilis* Aldrich, since that author lists it from Black Bluff, Ala. Similar specimens were found by the writer near Tehuacana, Texas, about 50 feet below the Midway limestone ledges. A cast in our last summer's collection is from 1 mile north of Midway; it is with little doubt *A. gracilis*. (Harris, 1896.)

No similar specimens have been observed in later collections.

Genus CALYPTRAPHORUS

Calyptrophorus Conrad, 1866, Smith. Misc. Coll. 200, p. 13 (nomen nudum).

Calytraphorus Gabb, 1868, Am. Jour. Conchology, vol. 4, p. 142.

Not *Calyptrophorus* Cabanis, 1847, Archiv. fur Naturgeschichte, vol. 13, pt. 1, p. 329.

Type. *Calytrophorus velatus* Conrad (Claiborne Eocene of the Gulf.)

Though Gabb's name differs by one letter from that proposed twenty years earlier for a bird by Cabanis, the two names are obviously of the same derivation.[7] The Commission on Zoological Nomenclature has considered synonymous, words which differ only in the vowel connecting two roots and has as a rule recognized only the name having priority of publication. Cabanis specified his

[7] Καλύπτρα, veil; φορέω, carry, wear.

type and *Calyptrophorus* is in good standing among the ornithologists, but long and general usage will perchance justify the retention of Gabb's name *Calyptraphorus* among the malacologists.

Shell elongate, fusiform, spire high, anterior canal long and straight; posterior canal long, closely appressed to the spire and arching on the back, as in some species of *Hippochrenes;* outer lip moderate, rounded, and thickened on the margin by a smooth border: young shell showing all the volutions, which are hidden in the adult by a polished incrustation covering the entire surface, and in some species bearing tubercles or bosses, their shape, size and number varying in different species. (Gabb, 1868.)

Calyptraphorus, like many other highly specialized forms, seems to have been uncommonly sensitive and, for that reason, a good time-marker. Unfortunately, however, it is rarely well preserved. The basal Midway beds both in Alabama and in Texas carry a small, relatively slender compressed species, rarely more than three-quarters of a centimeter in greatest diameter. This is *Calyptraphorus compressus* (Aldrich). *Calyptraphorus aldrichi* from the upper part of the Kincaid formation in Texas is more than twice the size of *compressus*. The upper Midway species *C. popenoe* has been recognized in Maverick County only. It is closely related to *C. aldrichi* but shorter and stouter. Fragments of *Calyptraphorus* from the lower part of the Wills Point formation occur farther north but they are rare.

The group is considered one of the dependable indicators of relatively warm-water conditions and is widespread in the Tethyan province during the early Eocene. It is interesting to find it in Texas associated with *Cucullaea*, the equally dependable indicator of the northern fauna.

CALYPTRAPHORUS COMPRESSUS Aldrich

1881. *Anchura* White, U. S. Geol. Survey, Bull. 4, p. 17.

1886. *Rostellaria velata* Conrad, Aldrich, Geol. Survey Alabama, Bull. 1, p. 59 (name only).

1891. *Calyptrophorus velatus* (Conrad), Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 16.

1894. *Rostellaria (Calyptraphorus) velata* Conrad var. *compressa* Aldrich, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 211, pl. 12, figs. 2, 2a–b.

1896. *Calyptraphorus velatus* var. *compressa* Aldrich, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 101, pl. 10, figs. 7, 7a–b, 8 (in part).

1912. *Calyptraphorus velatus* Conrad var. *compressus* Aldrich, Maury, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 15, p. 88, pl. 12, figs. 8–10?

This form is intermediate between *R. trinodifera*, Con., and *R. velata* Con. The adult has the enamel on the front part as in *R. trinodifera*, but on the opposite side the line of demarkation of the enamel comes down only to the whorl. The specimens are also much smaller than the normal adult. A similar form that cannot be separated from this variety is common in the Matthews' Landing group but is nearly twice as large, more rotund than those figured. The figures given are somewhat larger than the types. (Aldrich, 1894.)

Dimensions.—Altitude, 19.5 millimeters; maximum diameter, 7.5 millimeters. The dimensions given are of one specimen of three imperfect individuals labelled *Type*. So imperfect are the individuals and so idealized are the figures that some doubt of their validity must be expressed.

Type locality.—Allenton, Alabama.

Type.—Aldrich Collection, Johns Hopkins University, Baltimore, Maryland.

Molds of *Calyptraphorus* have been observed in many of the fossiliferous outcrops of the Littig glauconitic member of the Kincaid formation. It is quite possible that these should be referred to *compressus*, but they run about 25 rather than 20 millimeters in altitude and are seemingly less compressed than the Aldrich species. Such molds are common at U.S.G.S. Sta. 11669 in the Littig member on the Austin-Bastrop road, one-half mile east of the Travis County line and at U.S.G.S. Sta. 11673 on Half Mile Creek, one-half to three-fourths mile above Cedar Creek road, Bastrop County.

CALYPTRAPHORUS ALDRICHI Gardner new species

Pl. 24, figs. 1–3

1896. *Calyptraphorus velatus* var. *compressa* Aldrich, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 104 (in part).

1926. *Calyptraphorus compressus* (Aldrich), Cooke, Geology of Alabama, Geol. Survey Alabama, Special Report 14, pl. 93, figs. 1a, 1b.

A similar form that cannot be separated from this variety (*velatus* var. *compressus*) is common in the Matthews' Landing group, but is nearly twice as large, more rotund than those figured. (Harris, 1896, from Aldrich, 1894.)

The specimens from the lower part of the fossiliferous section on Wilbarger Creek and the Colorado River (U.S.G.S. Sta. 11696, U. S. Nat. Mus. No. 373064, Figure 3), run even larger than the holotype from Matthews Landing, Alabama (U. S. Nat. Mus. No. 373063,

Figures 1 and 2), probably reaching when perfect a height of 100 millimeters. The compression of the side away from the aperture is very marked. The young are multispiral, the whorls enlarging regularly and with a fair degree of rapidity, and they are sculptured with somewhat irregular arcuate axials not far from 25 to the whorl and sharp spiral threadlets, evenly spaced. Individuals from the same locality, however, show a wide range of variation in the axial sculpture of the early whorls. This is conspicuously true of the juveniles from the Webberville bluff (U.S.G.S. Sta. 5232).

An indeterminate cast from the Tehuacana member of the Kincaid formation near Bibora tank in Maverick County (U.S.G.S. Sta. 11753) is very close in dimensions and outline to the average *Calyptraphorus aldrichi* from Matthews Landing, Alabama. Similar casts also occur on the south bank of Elm Creek near the Schuddemagen ranch, 11 miles south of Sabinal, Uvalde County (U.S.G.S. Stas. 6279 and 11765). The same species, apparently, but more imperfectly preserved, occurs in the limestone on the D'Hanis-Yancey road 7½ miles southeast of D'Hanis (U.S.G.S. Sta. 6534).

The specimens from the Kincaid formation on the Brazos River are miserably preserved but they seem to indicate a shorter, stouter form than that on the Colorado. The axials run lower, too, in some individuals, not more than 12 to the whorl.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Sta. 11926?, Milam Bluff, Brazos River, 0 to one-fourth mile below the Falls County line (bed No. 4); U.S.G.S. Stas. 11916 (bed No. 1), 11919, and 11921, 1 mile below the Falls County line. *Travis County:* U.S.G.S. Sta. 5232, bluff at Webberville. *Bastrop County:* Colorado River, U.S.G.S. Stas. 11696, 11914, and 12112, 1½ miles below the Travis-Bastrop County line. *Medina County:* U.S.G.S. Sta. 6534?, 7½ miles southeast of D'Hanis. *Uvalde County:* U.S.G.S. Stas. 6279? and 11765?, Elm Creek, 11 miles south of Sabinal. *Maverick County:* U.S.G.S. Sta. 11753, Bibora tank, 18 miles southeast of Eagle Pass.

CALYPTRAPHORUS POPENOE Gardner new species

Pl. 24, figs. 4, 6-8

Shell a little large for the group, and rather stout. Whorls of the spire numerous, trapezoidal, tapering rather rapidly to an acute apex. Protoconch smooth, small, acute, probably coiled 3 times,

not very well preserved. Both axial and spiral ornamentation developed upon the spire, the axials little more than puckers along the anterior suture of the later coils of the spire, though on the adolescent coils they traverse the whorl and are feebly arcuate and protractive. Spiral lirae fine and sharp, inclined to be irregular in size and spacing, 15 to 20 to the later whorls of the spire. A sharp incremental sculpture also visible, most distinctly in the interspiral areas. Enveloping callous very heavy, the folds uniting along a seam on the apertural face, frequently leaving bare or thinly veiled an elliptical area directly behind the aperture. Body whorl large, slightly compressed, tapering rather rapidly toward the anterior canal. Anterior canal not preserved.

Dimensions.—Height (of holotype, an incomplete individual), 43.0 millimeters; greatest diameter, 21.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370938; paratype, U. S. Nat. Mus. No. 370939.

Type locality.—U.S.G.S. Sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass, Maverick County, Texas. Wills Point formation.

I have the pleasure of naming this species in honor of Willis Parkison Popenoe, whose skill and patience have discovered the delicate details of the ornamentation in a most unpromising and resistant matrix.

Calyptraphorus popenoe is less compressed than *C. aldrichi*, the whorls increase more rapidly in diameter, and the spiral sculpture is less feeble upon the unveiled spire.

A juvenile, apparently *C. popenoe*, was recovered from limestone boulders in the bed of the Blanco River in Uvalde County about 6 miles above the Zavala County line.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

CALYPTRAPHORUS species cf. C. POPENOE Gardner

Pl. 21, fig. 5

A closely related juvenile from 3 miles southwest of Thornton (U.S.G.S. Sta. 11939) indicates a species more slender than *C. popenoe* from Maverick County.

Juveniles only have been recovered from the Tehuacana member of the Kincaid formation, 7½ miles northwest of Groesbeck (U.S. G.S. Sta. 11935) and 2½ miles northwest of Groesbeck (U.S.G.S. Sta. 11936) and from 3 miles southwest of Thornton (U.S.G.S. Sta. 11939), one of which has been figured. They are slender little forms with a rather obscure sculpture both axial and spiral. An impression, probably of the same species, was also recovered from the Pisgah member, 6 miles west of Kosse. A stouter race occurs, however, in the limestone in Falls County (U.S.G.S. Sta. 11941), probably the same as that on the Brazos.

Another species is doubtless represented by the stouter more closely ribbed juvenile spire from the Wills Point formation of the Mercer well (U.S.G.S. Sta. 11699), 2 miles southwest of Joliet in Caldwell County.

CALYPTRAPHORUS species

Casts of *Calyptraphorus* occur commonly in the Kincaid formation of the Mexican Border. An unveiled spire from 1 mile northwest of Indio Wells, Maverick County, is not like that of any described species. The whorls are broad and taper rather rapidly. The earliest whorls are axially puckered, the flutings numbering 15 to 20 to the whorl, least feeble anteriorly and slightly arcuate. The spirals are fine sharp threadlets, 10 or 11 to the whorl, and though more persistent than the axials, they too evanesce before the body is reached. The canal is broken off. Traces of the enveloping callous still exist but they are not sufficiently well defined to determine the outline of the callous.

Family CERITHIIDAE
Genus CERITHIUM Bruguière

1789. *Cerithium* Bruguière, Encyclopédie Méthodique Histoire Naturelle, vol. I, p. XV.

Type, *Cerithium adansonii* Bruguière. (Recent off the coast of west equatorial Africa.)

Shell large or small; spire high and many whorled; the body short, contracted abruptly into a short, slightly oblique canal; protoconch small, paucispiral, not sharply delimited; spiral sculpture the first to be initiated; later, the often ornate axial sculpture;

and, at their intersection, nodes of greater or less prominence; aperture moderately large, obliquely ovate, commonly notched posteriorly and contracted anteriorly into the short canal; columella twisted; parietal callous heavy.

Cerithium is one of the many well known names with a clouded title. The question of the authenticity of the type is still under discussion and until a definite decision has been reached, the continued use of the long established name may perhaps be permissible.

CERITHIUM? species

A cerithioid doubtless new but too imperfectly preserved to describe occurs rather commonly in bed No. 4 of the Kincaid section at Milam Bluff on the Brazos River (U.S.G.S. Sta. 11926). The species is rather small, made up of numerous short rather evenly inflated whorls, which increase very slowly in diameter. The surface is not preserved but the more important details of the sculpture include a prominent simple spiral directly behind the suture line, two nodose spirals, the anterior medial, the posterior near the suture, an axial sculpture expressed chiefly in the nodulation of the spirals and a very fine secondary spiral striation which covers the whorl.

CERITHIUM? species

The rather widespread but not abundant molds of a high-spired species with numerous, narrow, trapezoidal whorls acutely angulated at the periphery are probably referable to *Cerithium*. These occur at Water Hill, 5 miles northeast of Kemp, Kaufman County (U.S.G.S. Sta. 11665) and 2½ miles northeast of Kemp (U.S.G.S. Sta. 10711).

CERITHIUM? species

A remarkably dainty and well characterized little species from the Kincaid formation on the Colorado River is too imperfectly preserved to describe or even to determine generically. The shell does not exceed 5.0 millimeters in height. The whorls are numerous and increase regularly but not very rapidly in diameter. Both the outline and the sculpture contribute to the conspicuously pagodiform aspect of this small conch. The whorls are overhanging, acutely angulated at the periphery and evenly trapezoidal behind the

periphery. The spirals are three in number, increasing regularly in prominence so that the strongest outlines the angle of the whorl. The axials are numerous and with the spirals form a delicate and regular net-work on the sloping shoulders of the whorl. Neither the nucleus nor the apertural characters are well known. The body terminates abruptly in a short and twisted canal and a marginal fold is indicated by the pinched and twisted edge of the columella.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11914. Colorado River, 4 miles below Webberville.

CERITHIUM? species

Another small species possibly referable to *Cerithium* sensu lato has height of 5.0 millimeters and a diameter of 2.4 millimeters. The protoconch is small, smooth, and glassy and the 3 component whorls increase rapidly in height and in diameter. The 8 whorls of the conch also increase in diameter with a fair degree of rapidity. The body is only about one-third the height of the entire shell and is obtusely angulated at the periphery and abruptly constricted into a slightly concave base. The axial sculpture has much to do with determining the apparent outline of the whorls. The axials run 14 to 15 to each of the later whorls, 9 to 10 to the earlier. They are sharply pinched and on the posterior portion of the shell extend from suture to suture. On the last whorls of the spire and on the body they are reduced to peripheral nodes set in front of the median line, giving to the whorl an overhanging pagodiform aspect. The entire conch is shagreened with microscopically fine crowded spirals and incrementals which, directly in front of the suture, are sufficiently strong to form a series of minute puckers. The outer lip is broken away but the aperture is constricted into a short recurved canal.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11914. Colorado River, 4 miles below Webberville.

CERITHIUM? species

Several specimens of a small species between 5 and 10 millimeters in height, quite slender and many-whorled, occur in the Kincaid formation at Milam Bluff on the Brazos River (U.S.G.S. Sta. 11926). There are two, possibly three in some individuals, strong spirals to the whorl and 12 to 15 axials which are nodose at the intersection

with the spirals. An occasional feeble varix is developed on the body. The aperture is not accessible.

Genus BITTIUM ("Leach") Gray

1847. *Bittium* Gray, Annals and Mag. Nat. Hist., vol. 20, p. 270.
Type, *Murex reticulatus* Montagu. (Recent in the European seas.)

Shell very small and slender, many-whorled; the spire high and slowly tapering, the body short; protoconch small, glassy, coiled about 4 times, with or without spiral lirations; conch sculptured with both axials and spirals, the spirals usually dominant; aperture obliquely ovate, constricted into a very short, broad, often spout-like anterior canal.

Subgenus BITTIUM sensu stricto

Bittium (Bittium) is characterized by the spiral lirations upon the two final whorls of the protoconch and the varicose conch.

The small but ornate species described by Aldrich as *Cerithiopsis estellensis* seems to be a true *Bittium*. It is interesting to find the group and probably the species represented in the Sucarnoochee clay of Alabama and the upper part of the Kincaid formation and lower part of the Wills Point formation of Texas.

BITTIUM (BITTIUM) ESTELLENSIS (Aldrich)

Pl. 24, figs. 12, 13

1921. *Cerithiopsis estellensis* Aldrich, Bull. Am. Paleontology, vol. 9, No. 37, p. 15, pl. 2, fig. 11.
Shell minute; whorls eleven or more, the first two smooth, the next two with raised ribs; the balance showing two strong, heavily beaded spirals on the peripheral part of each whorl with a third spiral much finer just below the suture; one or more whorls are missing from the basal part.
Length, 3 millimeters.
Locality.—Sucarnoochee clays, near Estella, Ala.
Type. In Alabama Museum at University, Ala. (Aldrich, 1921.)

This dainty little shell is beautifully preserved in some of the marls along the Colorado River and fragments, probably referable to this species, are rather widespread in east-central Texas.

A fine secondary spiral is commonly introduced between the anterior and medial primaries and less commonly between the medial and posterior primaries. There is also a very fine beading

along the anterior margin of the suture. The axial sculpture is indicated by the regular sub-spinose nodulation of the primary spirals. There are also irregular bulges on the adult whorls, which are not evident on the figure of the type species, possibly because the later whorls are broken away, possibly because there are taxonomic differences between the Alabama and the Texas species.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Sta. 11926, Milam Bluff, Brazos River (bed No. 4), 0 to one-fourth mile below Falls County line. *Bastrop County:* U.S.G.S. Sta. 5230, right bank of Colorado River, 1 miles below Webberville; and U.S.G.S. Stas. 11696, 11915, 11914, and 12112, Colorado River, 1½ miles below the Travis-Bastrop County line.

Wills Point formation. *Bastrop County:* U.S.G.S. Stas. 11690, 11913, and 12113, Colorado River, 1½ to 2 miles below the Travis-Bastrop County line; U.S.G.S. Sta. 12109, directly above bridge over Cedar Creek on Austin-Red Rock road.

BITTIUM species

Another of the very considerable number of minute gastropods which await description in the hope of better material is quite certainly a *Bittium*, but it does not conform well to any known group of that genus. The shell is only 4.0 millimeters in height and very slender. Both the conch and the protoconch include 5 whorls. The protoconch is smooth and shining and rather long and slender. A slight varix marks the beginning of the conch. The whorls of the conch are straight-sided, increasing very slowly in diameter and feebly constricted at the suture. They are evenly wound with 3 flattened spirals which override the 10 to 12 narrow but sharply pinched axials. The axials persist from suture to suture with uniform strength but they disappear abruptly at the periphery of the body. The sculpture of the base of the body is spiral only. The aperture is obliquely lenticular, possibly channeled anteriorly. The outer lip is broken. The inner lip is thickened slightly and reflected against the parietal wall.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11914, Colorado River, 4 miles below Webberville.

Family EPITONIIDAE ("Bolten") Roeding

The taxonomic relationships of the family are not well established.

Genus EPITONIUM ("Bolten") Roeding

1798. *Epitonium* ("Bolten") Roeding, Museum Boltenianum, pt. 2, p. 91.
Type.—*Turbo scalaris* Linnaeus. (Recent in the western Pacific.)

Shell turriculate, perforate or imperforate; whorls numerous, convex, often very loosely coiled; sculpture dominantly axial; axial flanges and varices often very prominent, usually continuous and fused at the suture, in many species forming the only lines of contact between the whorls; aperture subcircular or ellipsoidal; peristome entire, thickened or reflected.

The genus has been gradually increasing in prominence since the Triassic and is represented in the Recent seas by some 150 to 200 species of "wentletrap" distributed from the polar regions to the tropics and from between tides to abysmal depths.

EPITONIUM COOKII Gardner new species

Pl. 23, figs. 8, 9

Shell of moderate size for the genus, tapering rather rapidly from a broad base. Apical whorls not preserved. Three and a part of the fourth whorl extant, inflated and constricted at the sutures. Sculpture ornate. Axials 18 on the whorls of the spire, 20 on the body, heavy, regular in size and spacing, reflexed at the posterior suture, converging at the umbilical chink. A microscopically fine spiral sculpture developed, obsolete only toward the margins of the axial laminae. Base well rounded and not delimited by any carina or other modification of the shell. Umbilical chink narrow. Aperture entire, well rounded, the margin thickened, and adnate for the space of only two interaxials between the umbilicus and the suture line.

Dimensions.—Height, 12.5 millimeters; greatest diameter, 7.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 371264.

Type locality.—U.S.G.S. Sta. 11632, 6 miles due north of Lockhart in draw one-half mile west of Austin-Lockhart highway, Caldwell County. Littig glauconitic member of Kincaid formation.

I have the pleasure of naming this species in honor of Carroll E. Cook, who has so generously shared with the Federal geologists his intimate knowledge of the fault zone stratigraphy.

Occurrence.—Kincaid formation. *Caldwell County:* U.S.G.S. Sta. 11682, 6 miles north of Lockhart; and U.S.G.S. Sta. 11684, 4 miles northwest of Lockhart.

EPITONIUM species cf. E. COOKII Gardner

The final whorl of a species adorned with the same general type of sculpture as *E. cookii* Gardner but with only 12 axials to the turn instead of 18 or 20 was collected in the Littig glauconitic member of the Kincaid formation one mile northeast of Staples, Guadalupe County (U.S.G.S. Sta. 11693).

EPITONIUM species

Pl. 23, fig. 10

Two whorls of a very fine *Epitonium* were collected from the Wills Point formation 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass, Maverick County. They indicate a species of moderate size, rather broad at the base, with strongly convex whorls obliquely flattened posteriorly and adorned with stout flanges, 21 to the whorl. Traces of a fine spiral lineation are also faintly visible. The maximum latitude of the whorls preserved is 11.2 millimeters.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

Subgenus FERMINOSCALA Dall

1908. *Fermiuoscala* Dall, Bull. Mus. Comp. Zool., Harvard Coll., vol. 43, No. 6, p. 315.

Type.—*Epitonium (Fermiuoscala) fermiuiauum* Dall. (Recent along the West Coast from the Gulf of California to Panama.)

Description.—Whorls in contact, turritelloid, reticulate, with a single heavy varix for the fully mature shell; base with no umbilicus, a basal disk present; type, *Scala ferminiana* Dall. (Dall, 1908.)

Fermiuoscala is apparently synonymous with *Textiscala* de Boury, 1911 which includes a number of species from the Piedmont Tertiaries and the Recent *decussata* Lamarck.

EPITONIUM (FERMINOSCALA?) DOLOSUM (Aldrich)

Pl. 23, fig. 7

1907. *Scala dolosa* Aldrich, Nautilus, vol. 21, p. 11, pl. 1, fig. 13.

Shell rather small, cancellated; whorls eight, the first two smooth, balance with spiral lines which are coarse near the middle of each whorl; these lines give each whorl an angulated profile. The spirals are nodular in part at the intersections with the longitudinals. The figured specimen shows a varix; aperture nearly circular, outer lip expanded and rounded, interior smooth. Umbilicus open, and carrying a groove. Base of shell carrying numerous spirals, but no nodes, the lines of growth being very fine. Length 7 mm., breadth 4 mm.

Locality.—Near Grave Yard Hill, Wilcox Co., Ala. Midway Stage. (Aldrich, 1907.)

The Alabama specimens seem to be more sharply sculptured than the Texas and the differences may prove to be of specific value. In any case, the forms are closely related.

There is no subgenus of the great *Epitonium* genus to which *E. dolosum* conforms satisfactorily. It has much in common with *Fermínoscala* Dall—the general outline and sculpture and characters of the aperture—but the sculpture is not so sharp nor the basal disk so well defined. The marked umbilical chink in the Midway species is also a separating character, but there seems to be so much variation in this feature in species that seem otherwise closely allied that it may not be of very great taxonomic importance.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 11914, 11696, and 12112, Colorado River, 4 miles below Webberville.

Wills Point formation. *Bastrop County:* U.S.G.S. Stas. 11913, 10527, 11890, Colorado River, 4½–4¾ miles below Webberville.

EPITONIUM species

A species of the same general dimensions and outline differs in the fewer sharper axials and spirals and less pronounced umbilical chink. The periphery of the earlier whorls is emphasized by two sharp spiral threads with an occasional secondary between the anterior spiral and the suture. The spirals override the 14 or 15 sharp and narrow axials and nodulate them at their intersection. On the later whorls, the spirals are increased to 3 or even 4 and become less regular in size and spacing.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 11914, 11915 and 12112, Colorado River, 4 miles below Webberville.

Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11390, Colorado River, 4½–4¾ miles below Webberville.

Family VERMETIDAE
Genus LEMINTINA Risso

1826. *Lemintina* Risso, Histoire naturelle des principales productions de l'Europe méridionale, vol. 4, p. 114.

Type. *Lemintina cuvieri* Risso = *Serpula arenaria* Linnaeus. (Recent in the Mediterranean.)

The shell is tubular, and irregularly coiled or twisted and attached or free. The external surface is usually lirate and often more or less granulose. No longitudinal laminae are developed, but the tube is frequently segmented vertically by pouches concave forward. The operculum is absent. The genus is present in the warmer waters of the Recent seas.

LEMINTINA? GONIOIDES Gardner new species

Pl. 26, figs. 11, 12

Tubes of *Serpulorbis* or *Lemintina* about 1 millimeter in diameter are locally common in the Tehuacana member of the Kincaid formation. They are loosely interwoven and are remarkable for the strength of the concentric growth sculpture.

The incrementals are not, however, in the form of a simple annular sculpture but are strongly reentrant along the sides of the tubes, thus defining obtuse lateral keels and lending to the tubes a quadrate appearance.

Holotype.—U. S. Nat. Mus. No. 373059.

Type locality.—U.S.G.S. Sta. 11871, Frio River, just above the Evans' (Myrick's) apiary. Tehuacana member of Kincaid formation of Midway group.

The species is abundant in the Tehuacana member of the Kincaid formation of the Frio River and is probably present in the Tehuacana on the south bank of Elm Creek on the Schuddemagen ranch, 11 miles south of Sabinal, and in the Southern Pacific Railroad cut, 5.2 miles southeast of Dunlay, Medina County, and in Tehuacana Quarry, Limestone County.

It is interesting to note that crab claws and bryozoa are quite generally associated with the *Lemintina?* both in the Kincaid of the Mexican Border and that in Limestone County.

Occurrence.—Kincaid formation, Tehuacana member. *Limestone County:* U.S.G.S. Sta. 11933, Tehuacana Quarry, Tehuacana. *Medina County:* U.S.G.S. Sta. 11871?, in the Southern Pacific Railroad cut, 5.2 miles southeast of Dunlay. *Uvalde County:* U.S.G.S. Stas. 6279? and 11765?, south bank of Elm Creek near the Schuddemagen ranch, 11 miles south of Sabinal; U.S.G.S. Sta. 11871, Frio River, just above the Evans' (Myrick's) apiary; U.S.G.S. Sta. 11873, at foot of trail leading down from the Evans' (Myrick's) apiary, Frio River; and U.S.G.S. Sta. 11768, on the Frio River about 4 miles above the Kincaid ranch.

Genus TUBULOSTIUM Stoliczka

1868. *Tubulostium* Stoliczka, Cretaceous Fauna of Southern India, vol. 2, p. 237.

Type.—*Tubulostium discoideum* Stoliczka (Upper Cretaceous "Ootatoor" of India).

The principal characteristic, upon which this genus is proposed, consists in the narrow and tube-like prolonged aperture. The form of the shells varies from planorboid to broadly conical. The embryonal whorls are distinctly spirally coiled, but not any of the very numerous specimens of the two species give a decided proof that they have been attached to any foreign object. These embryonic whorls are, however, often worn off. In advanced age the shells were evidently quite free, and thus it is not unlikely that they had a somewhat more developed foot than other attached Vermetidae, and approached, in this respect, the family Cæcidae.

The internal space of the whorls is tubular, but externally the callosity is generally largely developed. In a microscopical section the shell distinctly shows three layers, of which the middle one is somewhat thicker than the internal or external one. These two thinner layers appear to be composed of a rather consistent (milky white) substance, while the central one seems to present some kind of transverse striation, as if indicating the succeeding layers of growth, though these distinctions are not sufficiently clear to be observed. The outer or callous mass is quite homogenous. The Gastropodous character of these shells is pronounced, as already stated, in the spiral nuclear whorls and the three layers of which they are formed. The callosity has also more probably been deposited from the mantle of a Gastropod than from an Annelid. We are not acquainted with any living species, which possesses a similar tubular aperture, to that known in the fossil forms. Of these the Serpulae, like *S. spirulaea*, Lamarck, will probably have to be placed in this genus, although I am for the present unable to compare good specimens of this species with our original-. The Jurassic *Vers. tuvidus*, Sow., is certainly a

Tubulostium. The *Spirorbis leptostoma*, Gabb (Journ. Ac. Phil., 2nd ser., vol. IV, p. 385, pl. 67, fig. 36 (not 41), from the American tertiaries, would seem to belong also to this genus; and several others may be found subsequently. The two new species from South India are *T. discoideum* and *T. callosum*. (Stoliczka, 1868.)

TUBULOSTIUM TOBAR Gardner new species

Pl. 26, figs. 1–5

Shell a small angular tube coiled almost in a single plane, with one surface flattened, and the other slightly depressed centrally. The tube, increasing very slowly in diameter, rudely quadrate in cross section, the outer angles lined by ill-defined spirals; outer margin between the spirals flattened. The upper and lower surfaces very feebly concave. Outer margin of the aperture subquadrate, the inner circular, firmly coherent to the preceding coil. Evidence of former growth lines probably discernible in certain rugosities which parallel the aperture and minutely wrinkle the shell.

Dimensions.—Diameter of individual, 6 millimeters; diameter of tube at aperture, 1 millimeter.

Holotype.—U. S. Nat. Mus. No. 370940.

Type locality.—U.S.G.S. Sta. 11754, 6 miles south of McFarland sheep pens and 27 miles southeast of Eagle Pass, Maverick County, Texas. Wills Point formation.

The dimensions of the specimen figured (U. S. Nat. Mus. No. 373166), from U.S.G.S. Sta. 12109 directly above the bridge over Cedar Creek on the Austin-Red Rock road, Bastrop County, are the same as those of the type.

An astonishing amount of variation is displayed by these simply constructed shells. The Kincaid and Wills Point species is characterized by the discoid outline and the quadrate outer margin of the aperture.

Some but not all of the specimens of *Tubulostium* species from the Bastrop County sections develop a third spiral midway upon the keel, almost equal in prominence to those at the margins of the keel (Figure 5). As this seems to be a variable character among otherwise similar individuals from the same locality, it has probably little or no taxonomic significance. Then, too, the apex is as a rule more depressed upon the Maverick County forms than upon those of the Colorado River drainage.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line; U.S.G.S. Stas. 11911 and 10526, Colorado River, 4 miles below Webberville.

Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11697?, 3 miles southwest of Cedar Creek Post Office; U.S.G.S. Sta. 11903?, one-half mile northeast of Cedar Creek crossing on the Austin-Red Rock road; U.S.G.S. Sta. 12109? directly above bridge over Cedar Creek on Austin-Red Rock road. *Maverick County:* U.S.G.S. Sta. 11754, 6 miles below the McFarland sheep pens and 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

TUBULOSTIUM species

A *Tubulostium* from the Littig glauconitic member of the Kincaid formation is a smaller, less angular and less regularly coiled shell than the later *T. tobar*. The peripheral angle is not so pronounced nor so uniformly developed. The shell was apparently thinner than that of the Wills Point species and is often crushed. Traces of secondary spirals on the periphery are faintly visible on a few individuals and the shells have a granular aspect. The Littig species is probably distinct. The material was collected from 2 miles north of Lockhart, Caldwell County (U.S.G.S. Sta. 11635).

Family TURRITELLIDAE
Genus TURRITELLA Lamarck

1799. *Turritella* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 74.
Type. *Turbo terebra* Linnaeus. (Recent in the Indo-Pacific.)

A slender, polygyrate form spirally sculptured; aperture holostomous, oval or subquadrangular; outer lip thin, simple, slightly produced anteriorly; columella simple, concave; posterior portion of shell vacant and partitioned at each half turn.

Turritella originated quite early in the Mesozoic and before the end of the Cretaceous had become one of the more conspicuous elements in the gastropod faunas of North America. The culmination of the genus occurred, however, during the Tertiary, when it was represented by a large number of very prolific species. The representation in the Recent seas is relatively meagre and confined, for the most part, to the warm waters of the Old World.

There is no group of Eocene Mollusca more widely distributed or better known among the laity than *Turritella*. The gastropod faunas from Maryland to Texas were dominated during lower Eocene times by two great groups of this genus—one the *T. mortoni* group with flexuous or trapezoidal whorls undercut at the sutures; the other, the *humerosa* group with straight sided volutions and a more or less pronounced sutural collar or groove. The majority of the Midway turritellas of Texas fall into these two groups.

The number of species represented is doubtless very considerable but the material is inadequate for the assured determination and description of so variable a group.

TURRITELLA SAFFORDI Gabb

1933. *Turritella saffordi* Gabb, Plummer, Univ. Texas Bull. 3232, pp. 815, 816, pl. 10, fig. 1.

The Ola Quarry species figured by Plummer is doubtfully identical with Gabb's type from Hardeman County, Tennessee. Our material from Hardeman County indicates a more slender shell with more numerous whorls and a faint spiral sculpture.

Group of TURRITELLA MORTONI Conrad

1830. *Turritella mortoni* Conrad, Acad. Nat. Sci. Philadelphia, Jour., 1st ser., vol. 6, p. 221, pl. 10, fig. 2.
Turritella mortoni auctores.

Shell turreted, conical, thick, with revolving distant, and finer intervening, striae; whorls with an elevated acute carina near the base of each; volutions about eleven: the striae are largest on the elevations of the whorls, which are slightly concave above and abruptly terminate at the sutures: the lines of growth on the last whorl are strong and much undulated.

I dedicate this species to my friend Dr. S. G. Morton, who has so ably illustrated the geology of this country connected with its organic remains. (Conrad, 1830.)

No type locality is definitely specified, but it was certainly in the vicinity of Fort Washington, in Prince Georges County, Maryland.

The true *Turritella mortoni* is probably of rather limited distribution and not represented in Texas but the group is second only to *Venericardia planicosta* in its abundant occurrence over a wide area.

Three general types of the *T. mortoni* group are developed in the Kincaid formation of Texas: (1) the *T. alabamiensis* type in which the whorls are overhung and finely striate spirally, with two emphatic

spirals—one at the periphery, the other less than halfway from the periphery to the posterior suture; (2) a type known only from very poor material in which the periphery is more rounded, and the spirals few and coarse and restricted largely to the anterior portion of the shell; and (3) a type in which the whorl is divided into three sub-equal parts by the peripheral spiral and the two primaries behind it.

The first is the common type from Falls County to the Colorado, the second in Limestone County and north of Limestone County, and the third from Medina County to the Mexican Border.

TURRITELLA ALABAMIENSIS Whitfield?

1865. *Turritella alabamiensis* Whitfield, Am. Jour. Conchology, vol. 1, p. 267.

1890. *Turritella alabamiensis* Whitfield, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 128.

1894. *Turritella alabamensis* Whitfield, Aldrich, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 246, pl. 13, fig. 2.

1896. *Turritella alabamiensis* Whitfield, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 109, pl. 11, fig. 6.

1933. *Turritella alabamiensis* Whitfield, Plummer, Univ. Texas Bull. 3232, pp. 815, 816, pl. 10, figs. 5, 5a.

Shell slender; volutions twelve or more; sub-quadrangular, lower margin sometimes projecting; suture distinctly marked; aperture sub-elliptical, slightly oblique; surface marked by numerous fine revolving lines, which are scarcely alternate, and crossed by distinct lines of growth, which make a deep sinus on the body of the volution, and are again bent backwards on the lower angle.

This species scarcely differs from *T. cuelata*, Conrad, from the Vicksburg (Miss.) beds, except that it is destitute of the lines of granules which give so decided a character to that species.

Locality.—Nine miles below Prairie Bluff, Alabama. (Whitfield, 1865.)

Aldrich's specimen which he figures as "a variety without the spiral raised lines" is apparently a decorticated individual which was probably normal when fresh.

A *Turritella* allied to *T. alabamiensis* Whitfield, but not identical, is indicated by very imperfect material from the Little Brazos above Rocky Crossing, Falls County (U.S.G.S. Sta. 11929) and from the Whitaker Survey, about 6 miles northwest of Kosse, Limestone County (U.S.G.S. Sta. 11931); probably identical juveniles from one-fourth mile northwest of the Stranger School in Falls County (U.S.G.S. Sta. 11932); four adults from 5 miles northeast of Kemp.

Kaufman County (U.S.G.S. Sta. 11665); and from about 2½ miles northeast of Kemp, on the public road (U.S.G.S. Sta. 10714). The species is rather small, but a little larger than the usual *T. alabamiensis* with trapezoidal whorls undercut at the base. The spiral outlining the periphery is pronounced and possibly feebly undulatory. Another strong spiral is usually developed a little less than halfway from the periphery to the posterior suture. Secondaries are sharp, numerous, closely-spaced, and fairly uniform in size. Six or eight are commonly developed upon the undercut portion of the whorl between the periphery and the anterior suture, while in the typical *alabamiensis*, the secondaries are not so sharp nor so regular nor so numerous. A sinus is indicated as in *T. alabamiensis* by the strongly flexed growth lines.

The same species is abundant in the Kincaid formation of Bastrop County, one-half mile east of Williams' store (U.S.G.S. Sta. 11911); and 3 miles southeast of Williams' store (U.S.G.S. Sta. 11909). Though the material is very imperfect, the molds with bits of shell adhering, which were collected from 14 miles southeast of Greenville, Hunt County (U.S.G.S. Sta. 10264), and from 4 miles northeast of Kemp, Kaufman County (U.S.G.S. Sta. 2440), are probably referable to this same species.

TURRITELLA KINCAIDENSIS Plummer

1933. *Turritella kincaidensis* Plummer, Univ. Texas Bull. 3232, pp. 815, 816, pl. 10, figs. 3, 3a.

Apical angle 12.5°; 14 finely beaded lirae. Convex with greatest diameter anterior.

The smaller specimen, Figure 3, from the quarry south of Ola in Kaufman County; Figure 3a, from one-fourth of a mile south of the mouth of Dry Creek, on right bank of Colorado River, Bastrop County.

Kincaid formation.

Collections of the Bureau of Economic Geology at Austin. (Plummer, 1933.)

Nothing specifically identical with *T. kincaidensis* has been found although the general type of outline and sculpture is common and widespread. The forms most closely comparable in our collections are molds retaining traces of a very fine sculpture recovered from the Kincaid outcropping on Cedar Creek (U.S.G.S. Sta. 11910).

TURRITELLA species

Molds running about 40 millimeters in height and showing the characteristic trapezoidal whorl of the *T. mortoni* group are very

common in the second greensand, 5½ miles north of Lockhart, Caldwell County (U.S.G.S. Sta. 11707). Similar but smaller molds were observed in the Littig glauconitic member of the Kincaid formation 1½ miles southwest of Littig, Travis County (U.S.G.S. Sta. 11676), on the Austin-Bastrop road, one-half mile east of the Travis County line (U.S.G.S. Sta. 11630), and on Half Mile Creek, Bastrop County (U.S.G.S. Sta. 11675). Two whorls of a larger species with a much more prominent overhanging keel were collected from the basal greensand 1 mile north of Staples (U.S.G.S. Sta. 11605). Molds of a species of similar outline but not so large occur below the *Venericardia bella* horizon, 3½ miles above the Cedar Creek bridge on the Austin-Red Rock road. Traces of a very fine spiral liration which covered the entire whorl are still retained. The same species probably occurs in an outcrop about 1 mile downstream.

TURRITELLA species cf. T. MORTONI Conrad

The turritellas which crowd the Tehuacana in Limestone County are probably new and distinct though the characters of the sculpture have been much obscured by the partial solution of the lime. The shells are larger than those of the Alabama species, *T. alabamiensis*, probably reaching a height of 50 millimeters and a diameter of 20 millimeters. The sutures are channeled and overhung by the obtuse keel of the preceding volution. Traces of a spiral sculpture are still faintly visible on a few individuals, strongest apparently on the anterior third of the shell. The growth lines are distinct and strongly arcuate, the base of the arc being slightly behind the median horizontal. The molds are flexuous in outline, the anterior half of the whorl expanding and rounding rather sharply into the suture.

This type of *Turritella* is well represented in Limestone County in the Tehuacana member of the Kincaid formation at Comanche Crossing on Navasota Creek, 6 miles west of Mexia (U.S.G.S. Sta. 6559); 7½ miles northwest of Groesbeck (U.S.G.S. Sta. 11935); and at Noakenney Hills (U.S.G.S. Sta. 2061).

The same species is present in abundance at Rocky Crossing on the Little Brazos in northern Falls County (U.S.G.S. Sta. 11929).

TURRITELLA new species cf. T. MORTONI Conrad

Turritellas from the limestones near the Mexican Border are quite distinct from those in central and north Texas. They are of about

the same size, with a more obtuse keel, and two spirals almost as strong as the peripheral spiral, behind the periphery, so spaced that the whorl is divided into three parts, the anterior and posterior subequal, the medial slightly wider and feebly concave. Fine sharp secondaries, a dozen or more to the whorl, are intercalated with a certain regularity. The height of well developed individuals from Bibora tank, Maverick County, runs about 4 centimeters.

Molds suggesting *T. mortoni* in the trapezoidal outline of the whorls and the overhanging periphery are fairly common in the Tehuacana member of the Kincaid formation on the Frio, one-half mile below the old Myrick apiary, Uvalde County (U.S.G.S. Sta. 3139), and also just above the apiary (U.S.G.S. Sta. 3135).

Juveniles, possibly identical with the specimens from Maverick County, were collected from the Tehuacana on the Schuddemagen ranch, 11 miles south of Sabinal, Uvalde County (U.S.G.S. Sta. 11765). A specimen from western Medina County with probably a third of the shell broken away measures 40 millimeters.

Fragments of 2 and 3 whorls from the Kincaid formation on the Brazos River (U.S.G.S. Stas. 11919 and 11926) show a similar spacing of the primary spirals as those from the Mexican Border but the secondaries are not so numerous nor do the spirals show so clearly the minute crinkling by the incrementals that may usually be detected in the specimens from Maverick County.

The southern representative of the *mortoni* of the eastern Gulf is a much smaller, much less coarse shell than the common *mortoni* of Maryland with not so much undercutting of the whorls at the sutures and with the sculpture restricted for the most part to the anterior half of the whorl.

Occurrence.—Kincaid formation. *Uvalde County:* U.S.G.S. Sta. 11767, Frio River, just above trail from Bob Evans' (Myrick's) apiary. *Maverick County:* U.S.G.S. Sta. 4393, 13 miles southeast of Eagle Pass.

TURRITELLA species

A species of *Turritella*, possibly distinct from the common Uvalde County species and suggesting *T. mortoni* Conrad from Maryland in the dimensions and outline of the whorls, is common in the Tehuacana member of the Kincaid formation on the Schuddemagen ranch, 11 miles south of Sabinal, Uvalde County (U.S.G.S. Stas. 6279 and

11765). The overhanging peripheral keel is acutely rounded. The spiral sculpture is obsolete but the growth lines are prominent and bent far back upon the medial portion of the whorl forming a broad U. The same species is present in the equivalent bed in Medina County, notably in the Southern Pacific Railroad cut, 5.2 miles southeast of Dunlay (U.S.G.S. Sta. 11871).

TURRITELLA species cf. T. HUMEROSA Conrad

Pl. 25, figs. 1, 2, 10

1835. *Turritella humerosa* Conrad, Geol. Sur. Penn-sylvania, Trans., vol. 1, pt. 2, p. 340, pl. 13, fig. 3.
1865. *Turritella multilira* Whitfield, Am. Jour. Conchology, vol. 1, p. 266.
1865. *Turritella eurynome* Whitfield, Am. Jour. Conchology, vol. 1, p. 266.
1886. *Turritella bellifera* Aldrich, Geol. Survey Alabama, Bull. 1, p. 34, pl. 1, fig. 13.
1890. *Turritella eurynome* Whitfield (sp. dub., De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 127.
1890. *Turritella (Proto) catherdralis bellifera* Aldrich, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 127, pl. 11, figs. 17, 38.
1891. *Turritella humerosa multilira (multilira)* Whitfield, Aldrich, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 216, pl. 13, fig. 3.
1891. *Turritella humerosa* Conrad var., Aldrich, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 216, pl. 13, fig. 5.
1891. *Turritella multilira?* Whitfield, Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, vol. 2, p. 48.
1896. *Turritella humerosa* Conrad, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 110, pl. 11, figs. 10?, 11, 12, 13.
1899. *Turritella humerosa* Conrad, Harris, Bull. Am. Paleontology, vol. 3, No. 11, p. 75, pl. 10, figs. 5–7.
1912. *Turritella humerosa* Conrad, Maury, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 15, p. 92.

Shell turrited, subulate; whorls with fine regular revolving striae, an obtuse slight elevation on the summit, and a shallow groove at base of each.

From the Eocene of Piscataway, Maryland. (Conrad, 1835.)

Turritella humerosa as it is commonly used is really a group name rather than a specific, but in the absence of adequate material it is better to hold to the broader designations. The European analogue is *Turritella hybrida* Deshayes from the Ypresian (lower Wilcox) of the Paris Basin. Guillaume[1] in his classification of the turritellas

[1]Guillaume, Louis, 1924. Essai sur la Classification des Turritelles, ainsi que sur leur Evolution et leurs Migrations, depuis le début des Temps Tertiaires: Soc. Géol. de France, Bull., 4 ser., vol. 23, pp. 283–311, pls. 10, 11.

has selected *T. hybrida* as the type of the group characterized by a deep and relatively narrow inflection of the growth lines a little behind the median horizontal and a second inflection near the anterior suture. The direction of the growth lines indicating the former character of the posterior canal is a major factor in the classification of the turretids and there is no *a priori* reason why such a character should not be equally stable in the turritellas.

A considerable degree of variation is shown in the collections made from the weathered greensands 27 miles southeast of Eagle Pass. In some individuals the suture follows directly in front of a narrow but very definite channel excavated in the preceding whorl and there may be a broad and very slight constriction of the whorl a little behind the median horizontal. In others, the anterior undercutting of the whorl is much less marked but there is a slight tabulation of the whorl in front of the suture and a more or less pronounced collar. This variation is in part due to age but not entirely. (Figures 1, 10.)

Molds suggesting *Turritella humerosa* in general dimensions and outline of the whorls are not uncommon in the limestone on the Frio River, one-half mile below the old Myrick apiary, Uvalde County (U.S.G.S. Sta. 3130). A few specimens with the characteristic *humerosa* outline and a fine, much worn spiral sculpture were collected from the Tehuacana member of the Kincaid formation on the Schuddemagen ranch, 11 miles south of Sabinal (U.S.G.S. Stas. 6279 and 11765) and also in the equivalent limestone of Medina County, 5.2 miles southeast of Dunlay (U.S.G.S. Sta. 11871).

"*Turritella humerosa*" from Limestone County (U.S.G.S. Stas. 11935 and 11936) differs from that of Maverick County in certain sculpture details. The posterior sutural collar is more prominent and the depression on the anterior portion of the whorl more slight and not continuous to the suture, but separated from it by an obscure band. The resultant profiles of the spires are quite distinct. (Fig. 2.)

A single shell and a number of casts from the Wills Point formation in southern Bastrop County indicate a species identical with that from the weathered greensands of Maverick County.

Occurrence.– Wills Point formation. *Bastrop County:* U.S.G.S. Sta. 11693?, 3 miles southwest of Cedar Creek Post Office; U.S.G.S. Sta. 12110, directly above bridge over Cedar Creek on Austin-Red Rock road. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

TURRITELLA species cf. T. HUMEROSA Conrad

Representatives of the *T. humerosa* group are apparently present in Kaufman County (2½ miles northeast of Kemp, U.S.G.S. Sta. 10744). The two individuals in question are much worn but they retain the characteristic outline and threading of *T. humerosa*. The sutural collar, however, is much less distinct than in the Border species. The specimens from Water Hill, 5 miles northeast of Kemp (U.S.G.S. Sta. 11665) are more numerous and in a better state of preservation. There is no perceptible collar but an anterior concave band from one-fourth to one-fifth the total width of the whorl. The entire whorl is finely threaded with an occasional stronger, feebly beaded spiral intercalated.

TURRITELLA BIBORAENSIS Gardner new species

Pl. 25, fig. 3

1887. cf. *Turritella elicita* Stoliczka, White, Contributions to the Paleontology of Brazil, Arch. Mus. Nac., vol. 7, p. 162, pl. 18, figs. 6, 7.

1868. Not *Turritella elicita* Stoliczka, Geol. Survey India, Memoirs, Paleontologia Indica, Cretaceous Fauna of Southern India, vol. 2, p. 221, pl. 14, fig. 3; pl. 19, figs. 15, 16.

1912. cf. *Turritella humerosa elicitatoides* Maury, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 15, p. 93, pl. 12, fig. 22.

A specimen from 18 miles southeast of Eagle Pass is well characterized by the very slowly tapering spire, the broad whorls, the strong rounded collar directly in front of the suture, and the fine, even, and evenly spaced spiral sculpture which covers the entire whorl.

The species bears a certain resemblance to the species from Allenton, Wilcox County, Alabama, described by Whitfield under the name of *multilira*, a form with more rapidly increasing whorls and without the prominent swelling in front of the suture. The resemblance is even more marked to a form from the Maria Farinha beds of Pernambuco described by White under the name of *Turritella elicita* Stoliczka. The Mexican Border species and that from Brazil exhibit the same general outline and the prominent sutural collar. The sculpture of the Brazilian form, however, though regular, is coarser than that from the Rio Grande. Stoliczka's species with which White erroneously identified his Brazilian species is a form of the same general outline from the Cretaceous of India, but more slender and more slowly tapering with the spiral sculpture restricted to the

earlier whorls. A form from the Argentinian Eocene also exhibits the same general outline though it is much larger and coarser and the same general type of sculpture though the collar is more acute and two strong spirals are developed on the anterior portion of the whorl. In Miss Maury's *Turritella humerosa* var. *elicitatoides*, the collar is reduced to a slight posterior tabulation of the whorl.

Turritella biboraensis is doubtfully distinct specifically from *T. humerosa*. It is, however, a smaller, more delicate and more delicately sculptured shell than the eastern and usually younger species and may be held apart for the present.

Dimensions.—Height of broken individual, 42.4 millimeters; greatest diameter, 15.9 millimeters.

Holotype.—U. S. Nat. Mus. No. 370989.

Type locality.—U.S.G.S. Sta. 6583, Bibora tank on the Indio ranch, 18 miles southeast of Eagle Pass, Maverick County, Texas.

Occurrence. Kincaid formation. *Maverick County:* U.S.G.S. Sta. 6583, Bibora Creek just below Bibora tank, about 18 miles southeast of Eagle Pass; U.S.G.S. Sta. 11758, Indio Wells (Indio ranch), 29 miles southeast of Eagle Pass; and U.S.G.S. Sta. 11763, 3½–4 miles southwest of the Windmill (Jacal) ranch house on Las Islas Crossing road.

TURRITELLA OLA Plummer

1933. *Turritella ola* Plummer, Univ. Texas Bull. 3232, pp. 815, 816, pl. 10, fig. 2.

Apical angle 18.0°; 2 narrow, high spirals and faint posterior spiral line. Whorls separated by a fine, nearly invisible liza. Height, 3.5 ± millimeters.

Holotype.—Collection of the Bureau of Economic Geology, Austin, Texas.

Type locality. Quarry south of Ola, Kaufman County; Kincaid formation. (Plummer, 1933.)

This species has not been recognized in our collections. The figured specimen seems to be a juvenile.

TURRITELLA NERINEXA Harris

1895. *Turritella nerinexa* Harris, Acad. Nat. Sci. Philadelphia, Proc., p. 82, pl. 9, fig. 9.

1896. *Turritella nerinexa* Harris, Bull. Am. Paleontology, vol. 1, No. 1, p. 111, pl. 11, fig. 14.

1912. *Turritella nerinexa* Harris, Maury, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 15, p. 91, pl. 12, fig. 25.

Size and general form of a fragment (the only known specimen) as indicated by the figure; number of whorls unknown, ornamented by (1) fine even spiral

striae, (2) a subsutural row of pustules or crenules, and (3) a slightly raised or faint ridge at the base of each whorl becoming obsolete in the lower whorls, but increasing in strength above so as to nearly equal in size the subsutural line of crenules.

Locality. Black Bluff, Brazos River, extreme northern limit of Milam County, Milam Bluff of Penrose's Report.

Geological horizon. Midway Eocene.

Type.—Texas State Museum. (Harris, 1895.)

The species represented in Caldwell County (U.S.G.S. Sta. 11706) is much larger and coarser than that indicated by Harris's description of the Brazos form but it is characterized by the same narrow, tightly wound whorls and the same sutural beading. The single individual from the greensand of the Kincaid formation, 5½ miles north of Lockhart (U.S.G.S. Sta. 11707), is even larger (probably 60± millimeters in height and 20 in diameter), and though the outlines of the whorls are alike there is not only a beaded spiral directly in front of the suture but also a similar beaded spiral directly behind the suture.

Occurrence.—Kincaid formation. *Caldwell County:* U.S.G.S. Sta. 11706, 5½ miles southwest of Lockhart, on the Martindale farm.

TURRITELLA HILLI Gardner new species

Pl. 25, figs. 4-6

1933. *Turritella levicunea* Harris, Plummer, Univ. Texas Bull. 3232, pp. 815, 816, pl. 10, figs. 4, 4a.

Not *Turritella mortoni* var. *levicunea* Harris, 1896, Bull. Am. Paleontology, vol. 1, No. 1, p. 110, pl. 11, fig. 9.

The material from Matthews Landing, Alabama, in our collections indicates a species with a higher apical angle than *T. hilli*, a much less prominent spiral directly behind the suture and sharper, more beaded spirals upon the rest of the whorl. It is possible that the Kincaid species is a precursal form from which *T. levicunea* developed.

Shell rather small for the genus, not very heavy. Apical angle between 20° and 25°, the early whorls evenly trapezoidal, the later marked by a broad and shallow medial depression and with an increasingly prominent overhang directly behind the anterior suture. Early apical whorls sculptured with 2 strong simple spirals on the anterior half of the whorl, another of almost equal strength a little

behind the middle and except on the very earliest whorls, a finer spiral directly in front of the posterior suture. Intercalaries introduced between the primary spirals and between the spirals and the suture lines, the anterior of the primary spirals following the peripheral keel of the later whorls. Spirals on adult whorls irregular in size and spacing; the coarsest spirals, 1 to 4 in number, at the periphery and directly in front of or behind it; those on the posterior fourth of the whorl obliterated on the latest adult volutions by the overriding growth lines; adult spirals tending to be wavy and dissected by strong and crinkled incrementals bent backward in a broad and symmetrical U. No perfect apertures observed.

Dimensions.—Height of holotype (incomplete), 36.0 millimeters; diameter of holotype, 13.0 millimeters.

Holotype and 2 paratypes.—U. S. Nat. Mus. No. 373054.

Type locality.—U.S.G.S. Sta. 10526, Colorado River, 4± miles below Webberville, Bastrop County. Kincaid formation of the Midway group.

The molds are loosely wound and the whorls rounded in the juvenile stages though trapezoidal in the adult.

The shells are unusually fragile and although fragments are abundant, no adequate type material has been collected. The holotype by no means reaches the maximum dimensions attained by some of the more imperfect individuals.

Turritella hilli is, so far as we know, a faithful indicator of the upper part of the Kincaid formation. I have the honor to name it for Dr. Robert T. Hill, whose early work on Texas paleontology has taken its place among the classics.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 11606, 12112, and 10526, Colorado River, 4± miles below Webberville, 1½ miles below the Travis-Bastrop County line, and one-half to three-fourths mile above the mouth of Dry Creek.

TURRITELLA species

Fragments of a very fine species on the border line between *Turritella* and *Mesalia* occur above the *Venericardia hulla* zone, 7½ miles southwest of Elgin on the north bank of Dry Creek about one-half mile above the bridge on the first road west of the Travis-Bastrop County line (U.S.G.S. Sta. 11912). The whorls are trapezoidal, very closely wound and separated by inconspicuous suture lines. The

shell is threaded from suture to suture with spiral cords numbering about 12 to the whorl with fortuitous intercalated secondaries. The 3 or 4 anterior spirals are a little coarser than those upon the medial and posterior portions of the whorl. There is no marked uniformity in size or spacing nor in the tesselation due to the cutting by the growth lines.

This is doubtless related to the form from the Colorado River but the peripheral keel is later or not at all developed and the spiral threading is sharper and more uniform.

TURRITELLA species

A *Turritella* suggesting *T. plebeia* Conrad in the rounded outline of the whorls and the numerous spirals occurs in a very imperfect state in the Tehuacana member of the Kincaid formation on the south bank of Elm Creek, 11 miles south of Sabinal, Uvalde County (U.S.G.S. Stas. 6279 and 11765).

TURRITELLA species

A rather slender *plebeia*-like form with the higher whorls not so much drawn in at the sutures, sculptured with 10 to 15 or more rather sharp spirals not very regularly spaced, the 3 to 5 peripheral spirals rather more prominent than the rest, is the common *Turritella* in the uppermost part of the Wills Point formation on the Guadalupe River (U.S.G.S. Sta. 6283).

A closely related, possibly identical, species is indicated in the clays on Cibolo Creek midway between Merkel and New Berlin (U.S. G.S. Sta. 6225).

Genus MESALIA Gray

1840. *Mesalia* Gray, Synopsis Contents British Museum, p. 147 (nomen nudum).

1842. *Mesalia* Gray, *op. cit.*, ed. 44, p. 61.

1847. *Mesalia* Gray, Zool. Soc. London, Proc., p. 155. For *Turritella mesal* Deshayes.

Type.—*Cerithium mesal* Adanson. (Recent off the coast of northwest Africa.)

The Recent species are separated from the Turritellas by certain characters of the operculum which suggest *Littorina* rather than *Turritella*. In the absence of the operculum *Mesalia* may be separated from *Turritella* by the more rapidly enlarging whorls, which

are on the whole more convex, the more prominent spiral sculpture and the sinuous, slightly patulous outer lip.

Mesalia has been recognized in the Upper Cretaceous and still survives on the West African shores but its maximum development was reached during the Eocene. It is particularly well represented in the Paris Basin and was far from rare in the Eocene of North Africa.

MESALIA WILCOXIANA (Aldrich)

1894. *Turritella wilcoxiana* Aldrich, in Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 247, pl. 13, fig. 11b.

1896. *Mesalia pumila* var. *wilcoxiana* Aldrich, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 112, pl. 11, figs. 16, 17.

Suture impressed, bounded by an angular space above and below, whorls with the general shape of *T. mortoni*, Con., a raised cord below the suture, then two equidistant raised spaces, then another raised cord followed by a slightly concave space to suture. No perfect specimen found. My collection. (Aldrich, 1894.)

Harris has reported this species from 1 mile up Salt Branch of Little Brazos River; and from Tehuacana, Texas.

MESALIA MAVERICKI Gardner new species

Pl. 25, figs. 7, 8

A few coils of a rather large coarse species with inflated, rapidly enlarging whorls were collected from the weathered greensands, 27 miles southeast of Eagle Pass. The species is strongly reminiscent of *Mesalia wilcoxiana* Aldrich and, like it, is wound with three prominent spiral cords. The Maverick County species tapers more rapidly, however, than that from Wilcox County, Alabama, the spirals are stronger, relatively more elevated, though perhaps not so broad, and are more concentrated toward the medial portion of the whorl. The secondary spiral liration which covers the entire surface from suture to suture is finer in the Texas species and sharper. An incremental sculpture reticulates the secondary spirals and at regular intervals strengthens into tiny axials which are bent backwards between the sutures in a broad arc, the axis of which is the periphery of the whorl. The apertural features, unfortunately, have not been preserved.

Dimensions.—Diameter of whorl, 17.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 370911.

Type locality.—U.S.G.S. Sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass, Maverick County, Texas. Wills Point formation.

The excellent state of preservation of the fine sculpture seems to justify the naming of this very incomplete individual in an area where good material is exceptional.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 6 miles below the McFarland sheep pens and 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road. Surface shingle of "red beds."

MESALIA species cf. M. MAVERICKI Gardner

Pl. 25, fig. 9

A rather fine specimen of *Mesalia* closely allied to *M. mavericki* was collected near the Stranger School in Falls County, 7½ miles northwest of Kosse. It is smaller than the specimens from Maverick County and possibly not fully mature, which may account for the slight sculpture differences between the Maverick and Falls County specimens. In the Falls County shell the apical angle is higher, the posterior of the three spirals which gird the whorls relatively more prominent, and the growth sculpture less pronounced. These variations may be nothing more than individual or at most of subspecific value. Only the single shell is known from the Stranger School: U. S. Nat. Mus. No. 370990; U.S.G.S. Sta. 11940: Kincaid formation.

MESALIA species

A coarsely sculptured *Mesalia*, possibly *M. mavericki*, was collected from the Tehuacana member of the Kincaid formation just above the old Myrick apiary on the Frio River, Uvalde County (U.S.G.S. Sta. 3185). It is quite certainly present in the limestone at the foot of the trail leading down from the apiary (U.S.G.S. Sta. 11878) and just above the water hole opposite the apiary (U.S.G.S. Sta. 3181).

MESALIA species

The much worn body of a species, closely resembling *M. mavericki*, was recovered from the glauconitic sands, 2½ miles northeast of Kemp, Kaufman County (U.S.G.S. Sta. 10741). The details of

the spiral sculpture do not seem to be identical, but this may be nothing more than the effect of erosion upon the Kaufman County fragment. Another equally worn fragment was found at the same horizon at Water Hill, 5 miles northeast of Kemp (U.S.G.S. Sta. 11665). It is possibly this species that Harris referred to *M. pumila hardemanensis* Gabb.

An indeterminate mold from the upper part of the Kincaid formation at U.S.G.S. Sta. 11707, 5½ miles due north of Lockhart in Caldwell County, is allied but probably not specifically identical.

MESALIA PUMILA HARDEMANENSIS (Gabb)

1860. *Turritella hardemanensis* Gabb, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 392, pl. 68, fig. 15.

1896. *Mesalia pumila hardemanensis* (Gabb), Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 112, pl. 11, fig. 19.

Turrited; whorls seven, strongly carinated at the middle; mouth rounded; surface marked by two or three large ribs below the carina and two above.

Dimensions.—Length, .6 inch; width of body whorl, .27 inch, length of mouth, .2 inch.

Locality.—With the above (Hardeman County, Tennessee). Prof. Safford. (Gabb, 1860.)

Harris has recorded this species from Kemp, Kaufman County, Texas, but no medially carinate mesalias have been observed in our collections.

MESALIA? species

Impressions and a few broken whorls from the Wills Point formation of Bexar County on Cibolo Creek (U.S.G.S. Sta. 6225) and 1 mile east of San Antonio on Salado Creek (U.S.G.S. Sta. 8246) indicate a species of 10 to 15 millimeters in height, and 5 to 6 in maximum diameter, made up of 10 or more whorls, the earlier trapezoidal, the later overhanging and slightly convex. There is some undercutting at the suture and the periphery is emphasized by a primary spiral. Two other subequal primaries are set with even spacing between the periphery and the posterior suture and one or two secondaries are intercalated between each pair of primaries and between the primaries and the suture. The spiral sculpture is, however, irregular and the primaries and secondaries intergrade. The body whorl is rounded and this character, together with the large apical angle, seems to ally the species with *Mesalia* rather than with *Turritella*.

Family XENOPHORIDAE
Genus XENOPHORA G. Fischer von Waldheim

1807. *Xenophora* G. Fischer von Waldheim, Muséum-Demidoff, vol. 3, p. 213.

Type.—*Trochus conchyliophorus* Born. (Recent off the eastern coast of the United States from Hatteras to the Antilles and in the Gulf of Mexico. Fossil throughout the East Coast and Gulf Tertiaries and in the Pleistocene.)

Shell low, trochiform but never nacreous, imperforate or narrowly umbilicate; whorls flattened, armoured with agglutinated extraneous objects; base sub-conic, or flattened with a sharp, peripheral keel; aperture obliquely quadrilateral.

The persistence of this genus from the Mesozoic to the Recent bears testimony to the efficiency of the extraordinary device by which this mollusc protects itself. The bulk of the shells and pebbles carried by the ardent little collector is often astonishing; turritellas, cardiums an inch and a half in altitude, chamas—all are utilized by the enterprising univalve. It is by no means uncommon among the Recent forms for the diameter of the shell to be doubled by the load that it carries.

XENOPHORA CONCHYLIOPHORA (Born) Fischer von Waldheim

1780. *Trochus conchyliophorus* Born, Testacea Musei Caesarei Vindobonensis, p. 333, pl. 12, figs. 21, 22.

1808. *Xenophora levigata* G. Fischer von Waldheim, Tableaux Synoptiques Zoognosie, p. 113.

1834. *Trochus leprosus* Morton, Synopsis Organic Remains, p. 46, pl. 15, fig. 6.

1847. Not *Phorus humilis* Conrad, Acad. Nat. Sci. Philadelphia, Proc., vol. 3, p. 285.

1854. *Phorus reclusus* Conrad, in Wailes, Rept. Agriculture and Geol. Mississippi, p. 289, pl. 17, figs. 6a, 6b.

1855. *Phorus reclusus* Conrad, Acad. Nat. Sci. Philadelphia, Proc., vol. 7, p. 262.

1865. *Phorus reclusus* Conrad, Am. Jour. Conchology, vol. i, p. 33.

1890. *Xenophora humilis* Conrad, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 1, p. 182, pl. 4, figs. 10, 10a.

1890. *Xenophora reclusa* Conrad, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 144.

1892. *Xenophora conchyliophora* Born, Dall, Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, p. 360, pl. 4, figs. 10, 10a.

1899. *Xenophora conchyliophora* (Born) Harris, Bull. Am. Paleontology, vol. 3, p. 85, pl. 11, fig. 17.

1904. *Xenophora conchyliophora* (Born), Martin, Maryland Geol. Survey, Miocene vol., p. 251, pl. 59, figs. 7a, 7b, 7c.

1905. *Xenophora conchyliophora* Born, Rogers, Shell Book, p. 155, pl. facing p. 149, figs. 2, 3, 4.

1906. *Xenophora conchyliophora* Born, Böse, Inst. Geol. Mexico, Bol., num. 22, pp. 33, 83.

1909. *Xenophora conchyliophora* (Born), Grabau and Shimer, North American Index Fossils, vol. 1, p. 723, fig. 1053.

Descriptione. Testa convexo-conica, tenuis, subpellucida, testis Zoophytorum et Testaceorum adglutinatis onerata; Anfractus declives, imbricati, plicato-rugosi: Apertura compressa, subquadrangularis: Labrum integerrimum, falcatum, Labium horizontale, reflexum, imperforatum; Color albus, radiis obliquis curvatis luteis. (Born, 1780.)

Since this group remounts in the geological scale to the Devonian, it is not so extraordinary that one of the species should persist from the uppermost Cretaceous to the present day. No differential characters have ever been recorded which would separate Morton's shell from the Eocene form which follows it, and I can assert with confidence that the latter cannot be discriminated from the Miocene and recent forms by any constant characters. If this succession be admitted, it is a strong testimony to the protective value of the device by which the members of this family defend themselves. (Dall, 1890.)

Shell low, pyramidal; umbilicate only in the young; whorls flattened; periphery sharply carinate; feeble spiral sculpture developed but usually concealed by the extraneous objects agglutinated to the outer surface.

Though specific identification is impossible, no characters are preserved by which the early Eocene species can be separated from the later Tertiary and recent *X. conchyliophora*. The cast from Kaufman County, 2¼ miles northeast of Kemp (U.S.G.S. Sta. 10744), has a maximum diameter of 11.0 millimeters. Harris, in the first volume of the Bulletin of American Paleontology, page 231, refers to two casts from the Alabama Midway, one from 1 mile north of Midway, the other from 1 mile north of Prairie Bluff, neither one of them specifically determinable. *Xenophora humilis* (Conrad) is a late Eocene and Oligocene species, larger as a rule than *X. conchyliophora*. It is probable that good material would present specific differences by which the early Eocene forms might be separated, one of which might be the relatively small size.

Family CALYPTRAEIDAE
Genus CALYPTRAEA Lamarck

1799. *Calyptraea* Lamarck, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 78.

Type.—*Patella chinensis* Linnaeus. (Recent on the European Coast from the British Isles to the Mediterranean. Fossil in the Pliocene and Pleistocene.)

Shell conic to trochiform; base circular or rarely oval; apex medial, spiral; inner diaphragm developed analogous to inner cup of *Crucibulum* and posterior lamina of *Crepidula;* columellar margin of diaphragm twisted to form a false umbilicus; outer margin adherent to periphery of shell; free margin convex.

The genus originated in the Cretaceous and the distribution of the Recent representatives is world-wide. The forms attach themselves to extraneous objects and are peculiarly characteristic of the inshore waters.

CALYPTRAEA species

Two specimens of a thin-shelled *Calyptraea* with an irregularly nodose or finely spinose sculpture swirling around the spire were collected on Wilbarger Creek (U.S.G.S. Sta. 11902).

The genus is also represented on Colorado River both above (U.S.G.S. Sta. 12113) and below (U.S.G.S. Sta. 12112) the *Venericardia bulla* zone and in Kaufman County (U.S.G.S. Sta. 11665).

Family CAPULIDAE?

A mold of a small, narrow, but much inflated species, probably a capulid, and possibly *Hipponyx*, occurs in the weathered greensands 27 miles southeast of Eagle Pass. Vestiges of the muscle scar and of a radial lineation are preserved.

Family ARCHITECTONICIDAE
Genus ARCHITECTONICA ("Bolten") Roeding

1798. *Architectonica* ("Bolten") Roeding, Museum Boltenianum, p. 78.
= *Solarium* Lamarck, 1799, Prodrome d'une Nouvelle Classification des Coquilles, Mémoires de la Société d'Histoire Naturelle de Paris, p. 74.
Architectonica Dall, 1909, U. S. Geol. Survey, Prof. Paper 59, p. 80.

Type.—*Trochus perspectivus* Linnaeus. (Recent in the Indo-Pacific.)

Shell solid, perforate; outline sub-discoidal to depressed-conic; whorls numerous, regularly increasing in size; periphery rounded or carinate; dominant sculpture of simple or beaded spirals; aperture semi-elliptical to subquadrate; columella usually straight, simple; outer lip thin and sharp; umbilicus funicular or scalar.

Architectonica was apparently most abundant near its initiation, that is, during the Eocene. It is particularly well represented, both in species and individuals, in the Eocene of the Gulf. The Recent species, the "sun-dial" shells, are relatively few in number and are restricted to the warmer waters.

ARCHITECTONICA PLANIFORMIS (Aldrich)?

1895. *Solarium planiforme* Aldrich, Nautilus, vol. 9, p. 2.

Shell flat, whorls six, apical one smooth, the balance with a beaded spiral boundary followed closely by a smaller spiral likewise beaded, two faint spirals near suture; lines of growth fine, coarser nearer aperture, the side of the body-whorl forming an acute angle with the top and nearly a right angle with the base; the side is slightly convex, with a granular raised line immediately below the periphery and two fainter ones near the base; the basal keel beaded; umbilicus wide, marked with two or three beaded lines. Aperture wedge-shaped, narrower at junction with body-whorl. Maximum diameter, 19 mm.; elevation, 6 mm.

Locality.—Near Roseland P. O., Wilcox Co., Ala., in Matthews' Landing beds. (Aldrich, 1895.)

The specimens from the Wills Point formation in the lower bed on Dry Brushy Creek, 6 miles south of Thrall (U.S.G.S. Sta. 10120) and from the Kincaid formation on the Colorado River (U.S.G.S. Sta. 12112) are imperfect juveniles but they retain sufficient characters to indicate a very close relationship with the forms from Wilcox County, Alabama.

ARCHITECTONICA PHOENICEA Gardner new species

Pl. 26, figs. 6, 7

Shell small, depressed, conic. Nucleus small, smooth, sunken, 2 whorls visible from the apical surface. Beginning of conch indicated by a distinct varix. Whorls of conch between 3 and 4 in number, slightly depressed between the sutures. Entire apical surface crowded with spiral lirae, those nearest the periphery the least fine and the most sharply beaded and those near the posterior suture not so fine as the threadlets upon the medial portion of the whorl. Incrementals strong, tesselating the spirals. Periphery acute, outlined by a beaded spiral with a similar spiral directly in front of and another directly behind it. Base of the whorl obliquely convex and angulated at the umbilical keel, closely threaded, the spirals

relatively coarse and flat near the periphery, and even coarser and more sharply beaded around the umbilicus, but very fine and crowded medially. Umbilicus broadly funicular, open to the apex, sculptured with the successive beaded keels of the whorls and the strong incrementals. Aperture rudely quadrilateral and adnate to the preceding whorl along its inner margin.

Dimensions.—Height, 2.1 millimeters; greatest diameter, 6.6 millimeters; diameter at right angles to greatest diameter, 5.3 millimeters.

Holotype. U. S. Nat. Mus. No. 370995.

Type locality.—U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line. Kincaid formation.

There is no lower Eocene species very close in sculpture detail to this elegant little form from the Colorado River.

Occurrence. Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 11696, 11914, and 12112?, Colorado River, 1 ± miles below Wilsberville, and 1½ miles below the Travis-Bastrop County line.

Wills Point formation. *Williamson County:* U.S.G.S. Sta. 10120, Dry Brushy Creek, 6 miles south of Thrall.

An imperfect individual from above the *Venericardia bella* zone on the Colorado River (U.S.G.S. Sta. 12113) exhibits a sharper sculpture, both spiral and incremental, than the Kincaid forms. The spire is also more depressed but that may be due to crushing.

Family NATICIDAE
Genus NATICA (Adanson) Scopoli

1777. *Natica* (Adanson) Scopoli, Introductio at Historiam Naturalem, p. 391. Type.—*Nerita ritellus* Linnaeus. (Recent in the west Pacific.)

Shell porcellaneous, solid, ovate or globular, generally umbilicate, the umbilicus usually furnished with internal ridges and in one subgenus plugged with callous; external surface of the majority of forms smooth and polished; aperture holostomous, semicircular or oval in outline; outer lip sharp, smooth within; columellar lip subvertical, calloused, non-plicate; operculum calcareous.

The genus has been prominent since the mid-Mesozoic and is abundantly represented in the temperate and tropical seas of today.

The Naticas and the closely related *Polinices* show an unusual sex variation due to the size of the egg sac. In consequence the

whorls of the shell of the female are much more inflated in front of the suture and the general outline more turreted.

NATICA REVERSA Whitfield

1865. *Natica reversa* Whitfield, Am. Jour. Conchology, vol. 1, p. 264.

1890. *Natica reversa* Whitfield, sp. dub., De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 151.

1896. *Natica reversa* Whitfield, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 119, pl. 12, fig. 19.

Shell small, globose; spire moderately elevated; volutions ventricose; suture deep; aperture semicircular, and moderately large, equaling two-thirds the length of the shell; outer lip sharp; inner lip slightly thickened, spreading over the preceding volution; callus represented by a thickened spiral ridge, deposited on the left side of the umbilicus, and uniting with the peristome at the inner basal angle; substance of the shell thick; surface polished.

Dimensions.—Height, .3 inch.

Locality.—Nine miles below Prairie Bluff, Alabama. (Whitfield, 1865.)

The umbilical rib is much less heavy and later in development in the Texas species.

Natica reversa Whitfield is well characterized by the shouldered whorls of the spire, the indented sutures, the well rounded body and the margin of the umbilicus pinched into a rib which becomes increasingly heavy toward the aperture. Spiral striae are in some individuals faintly visible near the umbilicus.

Occurrence.—Kincaid formation. *Milam County:* U.S.G.S. Sta. 11926?, Brazos River, Milam Bluff, 0 to one-fourth mile below the Falls County line. *Bastrop County:* U.S.G.S. Stas. 5280, 11696, 11914, and 12112, Colorado River, 4 miles below the Travis County line.

Wills Point formation. *Milam County:* U.S.G.S. Sta. 10519, San Gabriel River at the mouth of Brushy Creek. *Bastrop County:* U.S.G.S. Stas. 5231?, 11390, and 10527, Colorado River, 4½ to 4¾ miles below the Travis County line.

NATICA PERSPECTA Whitfield

1865. *Natica perspecta* Whitfield, Am. Jour. Conchology, vol. 1, p. 264.

1890. *Natica perspecta* Whitfield, De Gregorio, Mon. Faune Éocénique de l'Alabama, p. 151.

1896. *Natica perspecta* Whitfield, Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 119, pl. 12, fig. 21.

Shell oblique, of medium size; substance thick; volutions four in the largest individuals, very ventricose; spire low; suture very distinctly channelled;

umbilicus proportionally large, entirely destitute of a callus, the volutions being distinctly visible to the apical one; aperture semilunate, the inner lip spreading somewhat on the preceding volution, opposite the umbilicus it is thin and emarginate; outer lip sharp; surface polished.

This beautiful little shell differs from any described species, in the deep channelling of the suture and the characters of the umbilicus.

Locality. Nine miles below Prairie Bluff, Alabama. (Whitfield, 1865.)

A young form apparently referable to this species was collected in perfect condition from the Wills Point formation on Tehuacana Creek, 3½ to 4 miles south of Wortham, Limestone County (U.S. G.S. Sta. 10346).

The determinations of *Natica perspecta* are not very satisfactory. Whitfield did not figure his species, and the type is not available. In the species commonly accepted as *perspecta* and that which Harris figures, the whorls are closely wound and appressed at the sutures. It is hard to see how they could be described as "very distinctly channeled," nor are the whorls so ventricose as those of *N. reversa*. The personal equation does, however, enter into a description and in the absence of definite proof in the way of type or figure, the common interpretation of the species is accepted.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 11696 and 11914, Colorado River, 4 + miles below Webberville. *Uvalde County:* U.S.G.S. Stas. 6279? and 11765?, Elm Creek, 11 miles south of Sabinal.

Wills Point formation. *Limestone County:* U.S.G.S. Sta. 10346, 3½ to 4 miles south of Wortham.

NATICA cf. N. PERSPECTA Whitfield

Forms similar to *Natica reversa* in general outline and dimensions but with distinctly channeled sutures and lacking the characteristic umbilical rib occur at a number of localities in the fossiliferous Midway section on the Colorado River.

In the "very ventricose" whorls the "very distinctly channeled" suture and the large and open umbilicus, these forms seem closer to *Natica perspecta* than those which are commonly referred to it.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Stas. 5230, 10526, 11914, 11915, and 12112, Colorado River, 4± miles downstream from Webberville, one-half to three-fourths mile above the mouth of Dry Creek.

Wills Point formation. *Bastrop County:* U.S.G.S. Stas. 10527 and 12113, Colorado River, 4½ to 13¼ miles downstream from Webberville.

NATICA SAFFORDIA Harris?

1896. *Natica saffordia* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 118, pl. 12, fig. 18.

Size and form about as figured though there is a slight tendency towards a humeral zone just below the suture, somewhat as in *alabamiensis* though far less marked; whorls from four to five; umbilicus small, nearly closed by the thickening of the labium. In young specimens, as in many species of the genus, there is a trace of a notch or transverse groove across the labium at about the horizon of the upper margin of the umbilicus.

Mr. Stanton of the U. S. National Museum has sent us a fine set of *N. rectilabrum* Con. from the Upper Cretaceous. They are far more elongate and *Vivipara*-shaped than *saffordia*.

Locality. Tennessee, 2 mi. E. of Middleton (Tennessee).

Type. Dr. Safford's collection. (Harris, 1896.)

The specimen from Water Hill, 5 miles northeast of Kemp in Kaufman County (U.S.G.S. Sta. 11665) may be distinct taxonomically from *N. saffordia* by reason of its heavier shell, slightly higher spire, and heavier labial callous. A close relationship, however, is obvious.

A juvenile, possibly of this species, was collected on the Little Brazos (U.S.G.S. Sta. 11929) above Rocky Crossing.

Genus POLINICES Montfort

1810. *Polinices* Denys de Montfort, Conchyliologie Systématique, vol. 2, p. 223. Type.—*Natica mammillaris* Lamarck. (Recent in the West Indies.)

The shell characters of *Polinices* are very similar to those of *Natica:* it differs, however, in the possession of a corneous, rather than a calcareous operculum.

The shell is of medium size, ovate in outline, including a few closely wound whorls appressed at the suture. The aperture is semi-ovate, the parietal callous heavy and indented near the upper margin of the umbilicus.

The genus, though of later origin than *Natica*, is much more abundantly represented in the middle and late Tertiaries and in the East Coast waters of today and constitutes, indeed, one of the most

conspicuous elements of the univalve faunas of eastern North America.

POLINICES HARRISII Gardner new species

Pl. 26, fig. 13

1899. *Natica eminula* var. Harris, Bull. Am. Paleontology, vol. 3, p. 48, pl. 11, fig. 22. (Synonymy in part excluded.)

Shell of moderate dimensions, rather heavy, ovate in outline. Whorls 5 in all, the line between the conch and protoconch obliterated, the initial turn largely submerged, the succeeding volutions increasing rapidly in diameter. Later whorls obscurely shouldered, obliquely expanding in front of the shoulder. Sutures distinctly impressed but not channeled. Body smoothly but not conspicuously rounded, base rounding smoothly into the umbilicus. Incremental sculpture strong but no other axial or spiral ornamentation. Aperture ovate, obtusely angulated at the posterior commissure, smoothly rounded anteriorly. Parietal wash rather heavy, the margin of the wash constricted medially, the body wall partially concealing the small umbilical opening.

Dimensions.—Height, 17.7 millimeters; greatest diameter, 15.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 373060.

Type locality.—U.S.G.S. Sta. 12112, below the *Venericardia bulla* zone, one-half to three-fourths mile above the mouth of Dry Creek on the Colorado River, Bastrop County, Texas. Kincaid formation of the Midway group.

This form differs considerably from true *eminula* from the Claiborne sands, but its general form and appearance is such as to suggest a close relationship to the latter. *N. eminula* at Claiborne differs somewhat in its proportions, but it is generally thin, with only a slight tendency to form a columellar callosity. This form is thicker, wider in proportion to its height; with a callosity showing an indentation or notch above—a characteristic which, however, I have noticed in Jackson specimens from White Bluff, Ark. These differences are probably due to difference of environment. These differential characteristics are carried slightly further in *N. marylandica* Con.; *i.e.*, *marylandica* is lower or wider than the Lignitic specimens of the South and are apt to have a larger umbilicus. *N. marylandica*, too, sometimes attains a larger size than any of its southern representatives. If *marylandica* were the older name, I would be inclined to place this Lignitic form as a variety of that species, for the interrelationship of the two is close and well marked. (Harris, 1899.)

The synonymy includes "*N. eminula*" Harris from his Midway Bulletin, which is correct except for a too comprehensive synonymy and three check list references which can not readily be verified. The Maryland individuals are larger and heavier than those from the South and have a much more northern aspect. They can be separated without difficulty. The Wills Point forms of Texas seem, however, identical with those from the Wilcox group of Alabama.

Polinices harrisii is the largest of the naticoids in the present collection. It stands apart by reason of its relatively large size, ovate outline and small umbilical chink.

Occurrence.—Kincaid formation, *Bastrop County:* U.S.G.S. Stas. 11696 and 11911, Colorado River, 1 ± miles below Webberville, and U.S.G.S. Sta. 12112, one-half to three-fourths mile above the mouth of Dry Creek.

Wills Point formation, *Bexar County:* U.S.G.S. Sta. 6153?, Jett Crossing, Medina River on Palo Alto road.

Family AMPULLINAE
Genus LACUNARIA Conrad

1866. *Lacunaria* Conrad, Am. Jour. Conchology, vol. 2, p. 77.

Type.—*Natica (Girodes) alabamiensis* Whitfield (Midway of the Gulf).

Ovate-conoid or subglobose, thin in substance, with delicate, close, revolving lines; aperture entire, rounded or round-ovate, angulated posteriorly, margins disunited; columella flattened, with a long groove descending from the umbilicus. (Conrad, 1866.)

The validity of *Lacunaria* has been questioned and Cossmann has given it place under the Naricidae, a family separated from the Naticidae by the characters of the operculum. The American paleontologists have, for the most part, reserved the name for the group of exclusively Eocene forms characterized by an acute spire, the absence of callous upon the base, and the tendency toward a spiral striation. In the absence of an operculum it may well be left in the family with *Ampullina* which it resembles.

LACUNARIA LITHAE Gardner new species

Pl. 26, figs. 16, 17

Shell rather thick, of moderate size for the genus, broad at the base, rapidly dwindling to an acute apex. Whorls at least 6 in number, the first whorls of the conch small and trapezoidal in outline, the whorls of the median and anterior parts of the shell narrowly

tabulated posteriorly, broadly but not strongly convex medially. Body relatively large, smoothly rounded. Protoconch not preserved. A spiral sculpture of exceedingly fine and faint incised lines developed over the entire shell. Aperture ovate, broader anteriorly and somewhat patulous. Characters of aperture not well preserved. An umbilical groove quite possibly developed similar to that of *L. alabamiensis.*

Dimensions.—Height, 16.5 millimeters; greatest diameter, 11.0 millimeters.

Holotype and paratype.—U. S. Nat. Mus. No. 370941.

Type locality.—U.S.G.S. Sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass, Maverick County, Texas.

Lacunaria lithae is smaller than *Lacunaria alabamiensis* Whitfield, the type of the genus from the Midway group of Alabama, and differs further from *alabamiensis* in the relatively higher spire, and the more delicate spiral sculpture.

It is remarkable that so fine a sculpture on so heavy a shell is frequently preserved on the molds.

Occurrence.—Wills Point formation. *Maverick County:* U.S.G.S. Sta. 11754, 27 miles southeast of Eagle Pass on the Windmill (Jacal) ranch road.

LACUNARIA species

Fragments of a high-spired species, relatively slender for the genus, were recovered from the Kincaid formation on the Colorado River, about 4 miles below Webberville (U.S.G.S. Sta. 11696). The entire surface is microscopically netted by the spiral striae and the incrementals.

Suborder GYMNOGLOSSA
Family PYRAMIDELLIDAE

A pyramidellid which does not conform to any of the described groups and is too imperfect to form the basis of a new group was recovered from clays of the Wills Point formation above the *Venericardia bulla* zone on the Colorado River (U.S.G.S. Sta. 11913). The shell, from which the anterior extremity is broken, measures 3.5 millimeters. The small three-whorled nucleus is set directly at right angles to the plane of the post-nuclear turns. The smooth and polished conch includes 5½ volutions which increase in diameter with

a moderate degree of rapidity, thus forming a slender little cone with shallow indentations at the sutures. The body is obtusely angulated at the periphery. There are 2 folds upon the columella and, in addition, a horizontal fold on the base of the body and at least 4 strong lirations upon the inner surface of the outer lip.

Another species of pyramidellid in which the characters of the aperture are not accessible is characterized by a minutely puckered band directly in front of the suture. It is represented by a single individual collected from the Kincaid formation in the Colorado River section (U.S.G.S. Sta. 11914.)

Genus ODOSTOMIA Fleming

1817. *Odostomia* Fleming, Edinburgh Encyclopedia, vol. 7, pt. 1, p. 76.
Type.—*Turbo plicatus* Montagu. (Recent off the British coasts.)

Shell very small, short, subconic or ovate; whorls few in number; apex sinistral; surface smooth or sculptured, the dominant sculpture usually spiral; aperture entire, obliquely ovate; outer lip thin, sharp, often patulous anteriorly; inner lip reflected upon the parietal wall; a single columellar fold, not always apparent at the aperture; umbilicus close or narrowly perforate.

Subgenus ODOSTOMIA *sensu stricto*

The subgenus is characterized by the short subconic shell devoid of all sculpture excepting growth lines.

ODOSTOMIA? INSIGNIFICA (Aldrich)

1897. *Odontostomia insignifica* Aldrich, Bull. Am. Paleontology, vol. 2, No. 8, p. 13, pl. 1, fig. 8.

1899. *Syrnola trapaquara* Harris, Aldrich, Bull. Am. Paleontology, vol. 3, No. 11, p. 99, pl. 12, fig. 15 (*ex. parte*).
Not *Syrnola trapaquara* Harris, Acad. Nat. Sci. Philadelphia, Proc., p. 77, pl. 8, fig. 10, 1895.

Shell small, robust; surface smooth; whorls five; outer lip striate internally; inner lip with a strong plait nearly horizontal in front and expanded into a callus to base of shell.

Locality.—Alabama: Gregg's Landing. (Aldrich, 1897.)

Harris's *trapaquara* with which he united the Wilcox species of Aldrich comes from the Claiborne group and is more slender than the earlier form. It shows, however, lirations upon the inner surface of the outer lip similar to those which characterize its predecessor.

A small form, 2.3 millimeters in height, and ovate-conic in outline includes a minute nucleus immersed almost at right angles to the plane of the 4 post-nuclear whorls. The outer lip is lirate internally, a character not recognized in any of the recent *Odostomia*. There are four lirations and the suggestion of a fifth which become increasingly feeble toward the aperture and do not reach the margin of the outer lip. The posterior lirae are more prominent than the anterior. The other characters are normal for the genus. The single individual was recovered from the lower Kincaid formation of the Colorado River section (U.S.G.S. Sta. 12112). There are no characters recognizable from the description and figure by which it may be separated from the lower Wilcox species but the type has not been examined.

An individual from above the *Venericardia bulla* zone in the same section (U.S.G.S. Sta. 10527) is smaller and obtusely angulated at the periphery of the body. It is probably immature and quite possibly distinct from the species below it.

Genus TURBONILLA Risso

1826. *Turbonilla* Risso, Histoire naturelle des principales productions de l'Europe méridionale, vol. 4, p. 224.

1909. *Turbonilla* Dall and Bartsch, U. S. Nat. Mus., Bull. 68, p. 28.

Type.—*Turbonilla plicatula* Risso.

Shell with sinistral apex, cylindro-conic, many whorled, generally slender, with a single columellar fold which varies in strength and frequently is not visible in the aperture. The sculpture both axial and spiral ranges from obsolete to strongly incised lines or raised lamellae. (Dall and Bartsch, 1909.)

Subgenus MORMULA A. Adams

1864. *Mormula* A. Adams, Linnean Soc. London, Jour., Zoology, vol. 7, p. 1.

Type.—*Mormula rissoina* A. Adams.

The subgenus is characterized by the lirations upon the inner surface of the outer lip.

TURBONILLA (MORMULA) CLINENSIS Aldrich

1921. *Turbonilla (Ptycheulimella) clinensis* Aldrich, Bull. Am. Paleontology, vol. 9, No. 37, p. 9, pl. 1, fig. 10.

Shell small, narrow; whorls eight, two embryonic, the next three longitudinally striated, balance smooth. Spire blunt, suture distinct, aperture small. Outer lip smooth within, inner lip with a strong fold curving up into the aperture and bordering the base. Length 3± mm.

Locality.—Gregg's Landing, Ala.

Type.—Alabama Museum, University, Ala. (Aldrich, 1921.)

The single individual from the lower bed on Dry Brushy, 6 miles south of Thrall, has fewer whorls by two than the Greggs Landing (lower Wilcox) species but it is not quite so high and may be immature. If not identical, it is plainly an ancestral type with the feeble axial sculpture developed over a greater part of the whorl. In any case it is another liaison species between the Midway and the Wilcox.

Occurrence.- Wills Point formation. *Williamson County:* U.S.G.S Sta. 10120, Dry Brushy Creek (lower bed), 6 miles south of Thrall.

Family MATHILDIDAE
Genus MATHILDA Semper

1955. *Mathilda* Semper, Journal Conchyliologie, vol. 13, p. 330.
Type. *Turbo quadricarinatus* Brocchi. (Pliocene of Italy.)

Shell small or of medium size, made up of numerous slender, rounded whorls; nucleus heterostrophous; outer surface netted with a delicate reticulate sculpture; aperture entire, broadly ovate; outer lip sharp, patulous; inner lip reflected against the parietal wall, leaving a narrow umbilical chink.

MATHILDA species

Juveniles with the three-whorled protoconch directly at right angles to the beautifully cancellated whorls of the conch were collected in a perfect state of preservation from the Kincaid formation of the Colorado River section, 4 miles below Webberville (U.S.G.S. Sta. 11914). They may be the young of the species figured by Aldrich (30d) under the name of *Mathilda leona*, though they are not sufficiently developed to determine with assurance. Aldrich's specimen was collected in the Matthews Landing horizon, 1 mile west of Oak Hill, Wilcox County, Alabama, but he considered the Midway species identical with a form which he had earlier described from the Woods Bluff horizon under the name of *Tuba (Mathilda) leana* (28a). The difference in the vowel in the specific name is doubtless a typographical error but the figure of the Woods Bluff form does not show the characteristic *Mathilda* nucleus, and the species may be distinct. In that case the typographical error may be used to advantage and the name *leona* retained for the Midway species.

Another species of *Mathilda* is represented by a characteristic form from U.S.G.S. Sta. 11913 of the Colorado River section above the *Venericardia bulla* zone.

Family MELANELLIDAE
Genus MELANELLA Boudich

1822. *Melanella* Bowdich, Elements Conchology, vol. 1, p. 27.
Type.—*Melanella dufresnii* Boudich. (Recent in the Indo-Pacific.)

Shell small or of medium size, smooth, white, and highly polished; spire moderately elevated and gradually tapering; straight in *Melanella* sensu stricto, flexed in the subgenus *Balcis;* body whorl produced and attenuated at the base; aperture ovate, the outer lip expanded and slightly patulous, the inner lip closely appressed against the parietal wall; imperforate.

MELANELLA (MELANELLA) species

A single individual establishes the presence of the group in the Kincaid formation of the Colorado River section. The shell is moderately slender; the whorls number 11 and increase gradually in diameter and altitude. The body is between one-third and one-half as high as the entire shell and is obtusely angulated at the periphery. The anterior extremity is broken away but an expanded outer lip is indicated and a thickened and appressed inner lip. The surface is smooth and polished. The height of the broken shell is 7.2 millimeters, the diameter, 2.0 millimeters.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11914, Colorado River, 4 miles below Webberville.

Order SCUTIBRANCHIATA
Family VITRINELLIDAE

A vitrinellid, characterized by an evenly but not strongly convex apical surface, drawn in at the sutures, and a periphery outlined by a very prominent band, was recovered from the lower bed on Dry Brushy Creek, 6 miles south of Thrall (U.S.G.S. Sta. 11420). The umbilical surface is very finely striated, the umbilicus small and funicular and obtusely angulated at the margin. The margin of the aperture is broken. The lines are now so finely drawn on these small forms that it is impossible to make generic determinations without perfect material.

Genus TEINOSTOMA A. Adams

1853. *Teinostoma* Arthur Adams, Zool. Soc. London, Proc., pt. 21, p. 183.
Type.—*Teinostoma politum* Arthur Adams. (Recent off the coast of Ecuador.)

Shell orbicular, depressed, subspiral, polished, last whorl rounded at the periphery; umbilical region covered with a large, flat callosity; aperture transverse, rounded, greatly produced and elongated, ending anteriorly in a slightly canaliculated point; inner lip smooth and callous, not emarginate or truncated anteriorly; outer lip thin, simple, not marginated or reflected. (Arthur Adams, 1853.)

The genus is known from the Tertiaries of the East Coast of North America and from the Paris Basin. The Recent forms occur most abundantly in the China and Japan seas although there are a few representatives in the tropical and subtropical waters of eastern America.

TEINOSTOMA EOA Gardner new species

Pl. 26, figs. 8 10

Shell minute, depressed, so thin that it is translucent. Apical surface flattened: one protoconchal and two conchal turns which very rapidly enlarge. Periphery narrow but rounded. Umbilical surface flexuous. Umbilicus closed with a heavy opaque callous and surrounded by a less opaque area which extends not quite half way to the periphery. Outer surface smooth excepting for exceedingly fine incrementals. Aperture transversely elliptical, the columellar margin heavy and smoothly and strongly excavated, the peristome thin, smooth, slightly retracted at the periphery; not emarginate anteriorly, though feebly notched at the posterior margin of the outer lip.

Dimensions.—Height, 0.3 millimeters; greatest diameter, 1.5 millimeters.

Holotype.—U. S. Nat. Mus. No. 371257.

Type locality.—U.S.G.S. Sta. 9656, 638 to 659 feet, Smith tract, Somerset field, Bexar County, Texas.

The genus is doubtless more commonly represented in the Midway than one might suppose from the literature. *T. eoa* is associated with a fauna of probably upper Midway age, but *Teinostoma* is certainly present in the Kincaid formation on the Colorado River, 4 miles below Webberville (U.S.G.S. Sta. 11914).

Occurrence.—Wills Point formation, *Bexar County:* U.S.G.S. Sta. 9656, Smith tract, Somerset field, 621 to 638 feet and 638 to 659 feet.

Genus SOLARIORBIS Conrad

1865. *Solariorbis* Conrad, Am. Jour. Conchology, vol. 1, p. 30.

Type (by subsequent designation, Dall, W. H., 1892, Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, p. 414.—*Delphinula depressa* Lea (Claiborne), Gosport sand of Alabama.

Shell small but moderately heavy, depressed; nautiliform; protoconch of 2 or more than 2 very small, smooth, opaque, partially submerged whorls; conch paucispiral, shining and slightly translucent; external surface finely punctate spirally; umbilicus surrounded by a smooth collar more dense in texture than the rest of the shell and occupying a half or more of the basal surface; aperture entire; outer lip channeled at posterior commissure; parietal wash thin; inner lip thickened at umbilical collar; umbilical perforation small but deep, often partially concealed in the adult by the inner margin of the collar drawn over it.

Conrad's genus includes a compact group of minute Tertiary species characterized by the depressed apical surface, finely punctate spiral sculpture, and small umbilical pit. The size and the contour suggest *Teinostoma* but that name has been restricted to forms in which the umbilical opening is entirely covered by a flat pad of callous.

Solariorbis in its known distribution is restricted to the Tertiary. The genus has not been previously reported from so low a horizon.

SOLARIORBIS PROIUS Gardner new species

Pl. 26, figs. 13, 14

Shell depressed, minutely nautiliform, relatively heavy. Apical surface flattened; periphery sharply rounded. A little less than 3 partially submerged, minute nuclear whorls opaque and devoid of sculpture. Line between conch and protoconch sharp, the beginning of the conch indicated by the more shining translucent shell and the 4 or 5 faint spiral grooves, strongest at the first whorl of the conch and evanescent on the last of the 2 post-nuclear whorls. Incrementals cutting the grooves and giving to them a minutely punctate appearance. No additional spirals introduced in front of the few original grooves on the apical surface of the types, the spiral sculpture on the final whorl restricted to the few faint and evanescing

grooves directly in front of the sutures and others of similar character between the periphery and the thickened, less translucent area surrounding the umbilicus; incremental sculpture strongest on the medial portion of the umbilical surface. Sutures distinct, impressed. Aperture rudely trigonal, the periphery forming the obtuse apical angle; posterior angle between the outer lip and body wall acute and channeled; parietal wash thin; lip conspicuously thickened at the umbilical collar. Umbilicus small, perforation small but deep, circular in the young, partially concealed in the adult by the inner margin of the collar drawn over it. Umbilical collar occupying more than half of the basal surface, sharply defined by the relatively dull and heavy shell texture.

Dimensions (cotypes).—Height, 1.3 and 1.2 millimeters; greatest diameter, 2.8 and 2.5 millimeters.

Cotypes (2).—U. S. Nat. Mus. No. 373061.

Type locality.—U.S.G.S. Sta. 12112. Colorado River, one-half to three-fourths mile above the mouth of Dry Creek, Bastrop County, Texas. Kincaid formation below *Venericardia bulla* zone.

The spiral sculpture upon these minute forms is more or less fortuitous and inconstant in areal development. It is never so strong, however, as it is in the genotype, *S. depressa* (Lea) from the Claiborne of Alabama, nor is the punctation by the incrementals so sharp and so regular.

The following gastropods were described from Smileys Bluff on the Brazos River, a locality which was formerly referred to the Midway but is now considered Wilcox in age. As the names occur repeatedly in earlier monographs and check lists, they have been included for reference in this paper.

CORONIA OSTRARUPIS (Harris)

1896. *Pleurotoma (Surcula) ostrarupis* Harris, Bull. Am. Paleontology, vol. 1, No. 1, p. 78, pl. 7, fig. 13.

This is only a fragment and cannot be fully characterized. The more obvious and peculiar features are: (a) the rather fine, oblique, and somewhat curved longitudinal costae which in all probability die-appear on the larger whorls of adult, and (b) the regular spiral striation.

Locality. Sta. 104, Smiley's Bluff, Brazos River, two miles above the mouth of Pond Creek, Milam Co.

Geological horizon. Midway Eocene.

In the collection of the U. S. Nat. Mus., a specimen occurs among others marked "*Pleurotoma perse* Whitf." by Aldrich. All came from Matthews' Landing. This particular specimen is evidently not *P. perse*, but, as far as can be determined, should be labelled *P. ostrarupis*.

This species is quite common in material from Matthews' Landing. When entire the general outline of the shell is not far from that of *Pl. anacona*. A small specimen is in the Pal. Mus., U. T., from 1 mile west of Oak Hill.

Type.—Texas State Museum. (Harris, 1896.)

The type has apparently been lost. The species has not been certainly recognized in later collections. The group, however, is the most prolific and the most widely distributed in the lower Wilcox, the horizon to which Smileys Bluff is now referred.

CORONIA ANACONA (Harris)

1895. *Pleurotoma (Pleurotomella) anacona* Harris, Acad. Nat. Sci. Philadelphia, Proc., p. 56, pl. 4, fig. 4.

1896. *Pleurotoma (Pleurotomella?) anacona* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 77, pl. 7, fig. 12.

General form as figured; whorls 8; 1 nearly or quite smooth; 2, 3, 4, 5, 6 with (a) a broad slightly concave band showing very faint spiral striae and a deep retral curve in the longitudinal striae, (b) a slight basal carina with two or three strong spiral lines and rather faint, slightly oblique nodules; body whorl with more or less alternating coarse and fine spiral lines from the nodose carina to the end of the beak.

Localities.—Well at Elgin, northeast corner of Bastrop County; Smiley's Bluff, Brazos River, 2 miles above Pond Creek, and perhaps on Rocky Cedar Creek, 5 miles west of Elmo.

Geological horizon.—Midway Eocene.

Type.—Texas State Museum. (Harris, 1895.)

Type locality.—Sta. 104, Smileys Bluff, Brazos River, Milam County, Texas. Kennedy Collection.

The body of the type bears 13 nodes. The species has not been recognized in later collections. The Smileys Bluff section is now referred to the lower Wilcox.

PSEUDOLIVA OSTRARUPIS Harris

1895. *Pseudoliva ostrarupis* Harris, Acad. Nat. Sci. Philadelphia, Proc., p. 75, pl. 8, figs. 3, 3a.

1896. *Pseudoliva ostrarupis* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 99, pl. 9, figs. 18, 19.

Size and general form as figured; volutions 6, spiral whorls shouldered and somewhat costate; suture obscured by foliae developed by the intermittent

mode of growth of the sutural callosity; body whorl below scarcely distinguishable from the non-umbilicate varieties of *P. retusa*, while above, the shoulder and the sutural foliae at once definitely characterize the species.

Locality. Smiley's Bluff, Brazos River, 2 miles above the mouth of Pond Creek, Milam Co., Tex.

Geological horizon.—Midway Eocene.

Type.—Texas State Museum. (Harris, 1895.)

Both *Pseudoliva ostrarupis* and the subspecies *pauper* have been recognized in deposits of equivalent age on a branch of Wilbarger Creek on Mr. Solomon's land, 4 miles south of Elgin. These beds, together with the Smileys Bluff section, are now referred to the lower Wilcox.

PSEUDOLIVA OSTRARUPIS PAUPER Harris

1895. *Pseudoliva ostrarupis pauper* Harris, Acad. Nat. Sci. Philadelphia, Proc., p. 76, pl. 8, fig. 4.

1896. *Pseudoliva ostrarupis pauper* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 99, pl. 9, fig. 20.

Figured without description or comment in 1895.

Locality.—Smiley's Bluff, Brazos River, 2 miles above the mouth of Pond Creek, Milam Co., Tex.

Geological horizon.—Midway Eocene.

Type.—Texas State Museum. (Harris, 1896.)

The *pauper* is a much more slender shell than *Pseudoliva ostrarupis* and more fusoid in outline, the maximum diameter falling near the median horizontal.

CERITHIUM PENROSEI Harris

1895. *Cerithium penrosei* Harris, Acad. Nat. Sci. Philadelphia, Proc., p. 79, pl. 9, fig. 4.

1896. *Cerithium penrosei* Harris, Bull. Am. Paleontology, vol. 1, No. 4, p. 107, pl. 11, fig. 4.

Whorls at least 15, gradually tapering, ornamented as follows: by (1) about seven laterally compressed, oblique subcentral or basal nodes, or costae on each whorl, those on the smaller whorls of the spire not so distinctly defined as represented by the figure; by (2) spiral lines or striae, about five of which are strong and occupy the lower one-third of each whorl, three or four more are finer and occupy a narrow, irregular central zone, while four or five more occupy the upper or non-costate portion of the whorls.

The costae on the several whorls are arranged in lines corresponding in direction to the obliquity of the costae.

Unfortunately only fragments of this large *Cerithium* have been found; it doubtless measured eight or ten inches in length when entire.

Locality.—Smiley's Bluff, Brazos River, 2 miles above the mouth of Pond Creek, Milam Co., Tex.

Geological horizon.—Midway Eocene.

Type.—Texas State Museum. (Harris, 1895.)

Cerithium penrosei has proved to be one of the most dependable of the local guide fossils of the lower Wilcox.

Class CEPHALOPODA
Order NAUTILOIDEA
Suborder HOLOCHOANITES
Family CLYDONAUTILIDAE
Genus HERCOGLOSSA Conrad

1866. *Hercoglossa* Conrad, Am. Jour. Conchology, vol. 2, p. 101.

1883. *Enclimatoceras* Hyatt, Boston Soc. Nat. Hist., Proc., vol. 22, p. 270.
Holotype.—*Nautilus ulrichi.*

Type by subsequent designation.—*Nautilus orbiculata* Tuomey (Hyatt, Boston Soc. Nat. Hist., Proc., vol. 22, p. 270, 1883).

1933. *Hercoglossa* Miller and Thompson, Jour. Paleontology, vol. 7, p. 313.

1933. *Cimomia* Miller and Thompson, Jour. Paleontology, vol. 7, p. 305 (in part).

Not *Cimomia* Conrad, Am. Jour. Conchology, vol. 2, p. 102, 1866.

Nautiloid; septa angular and linguiform; apex of the angle, or tongue-shaped lobe, not contiguous with the adjacent septum; siphon large or moderate, situated within the centre, or between the middle and inner margin, and not dorsal or funnelshaped, but tubular and gradually tapering. (Conrad, 1866.)

The genus was restricted by Miller and Thompson to forms characterized as follows:

Conch nautiliconic in its mode of growth and subdiscoidal in form. Whorls more or less flattened (but typically very broadly rounded) laterally, narrowly rounded ventrally, and deeply impressed dorsally. Umbilicus small. Surface of conch smooth. Septa numerous and each suture forms a broad, broadly rounded ventral saddle; a broad, deep rounded lateral lobe; a similar lateral saddle; a broad, very shallow rounded lobe on or near the umbilical wall, a broad, fairly deep saddle on the lateral side of the impressed zone; and a broad, moderately deep, narrowly rounded dorsal lobe. Siphuncle small and orthochoanitic in structure; its position varies considerably in the different species but it is in no case marginal.

Hercoglossa is perhaps more closely related to *Cimomia* than to any other described genus . . . . However, typically *Hercoglossa* differs from *Cimomia* in that the sutures of the latter are much less strongly sinuous. (Miller and Thompson, 1933.)

In their excellent study of the nautiloid cephalopods of the Midway group, Miller and Thompson have placed under *Hercoglossa*

ulrichi the large nautiloids from the Midway north of Lockhart in Caldwell County, and under the genus *Cimomia* those from the Rio Grande Embayment province described by me as *Enclimatoceras vaughani*.

Enclimatoceras was retained in former reports in preference to *Hercoglossa* because the title of the earlier genus is somewhat clouded. The type, *Nautilus orbiculatus* Tuomey, is a species curtly described by Tuomey from the "Cretaceous of Alabama." He states that "this is the largest of the genus found in our rocks, being ten inches in diameter. It resembles quite closely *N. Danicus*, especially in the undulations of the septa." It has been suggested that Tuomey had in mind the species later described as *Enclimatoceras ulrichi* but the type has been lost and nothing can be proved. The nomenclature is further involved by the possibility that both *Hercoglossa* and *Enclimatoceras* may fall under *Aganides* Montfort described in his Conchyliologie Systématique, vol. 1, p. 30. Montfort's unique type is *Aganides capucinus* Montfort, a species purporting to come from the vicinity of Namur, Belgium, and one which has never been satisfactorily identified by European paleontologists. The suggestion has been made that it is synonymous with *Hercoglossa danica* (Schlotheim) but in the absence of a type or a type locality, it is impossible to prove anything. Namur is in a Carboniferous belt which lends weight to the theory that *capucinus* is a goniatite though the figure certainly does not suggest it.

The fact that through many years no large nautiloid has been recognized in the Cretaceous of Alabama makes it reasonably certain that the type of *Hercoglossa orbiculata* came from the Eocene. *Hercoglossa* is the prior name, the more generally accepted and though it is unfortunate that the type has been lost and that we do not know where it came from, the lesser evil is, perhaps, to accept the better known name and rationalize its past associations as best we may. The large nautiloids of the lower Eocene of the Gulf Province seem, with the exception of the *Eutrephoceras*, to form so compact a group that their relationships both biologic and stratigraphic are better expressed by referring them all to *Hercoglossa* than by including under *Cimomia* those with more shallow lobes and saddles. These relatively shallow-lobed forms seem to be more closely related to the *ulrichi* type than to the Belgian genotype of *Cimomia* from an uncertain but possibly higher horizon. *Cimomia*

bartini Galeotti came presumably from the environs of Brussels, Belgium. The surface formation in that area is probably a little higher than that with which the Midway has been correlated.

HERCOGLOSSA ULRICHI White

1881. *Nautilus texanus* Shumard, White, U. S. Nat. Mus., Proc., vol. 1, p. 137. Not *Nautilus texanus* Shumard, 1860, Acad. Sci. St. Louis, Trans., vol. 1, p. 590.

1883. *Enclimatoceras ulrichi* White, Hyatt, Boston Soc. Nat. Hist., Proc., vol. 22, p. 270 (designated the type of the genus *Enclimatoceras*).

1884. *Enclimatoceras (Nautilus) ulrichi* White, U. S. Geol. Survey, Bull. 4, pp. 16–17, pl. 7, figs. 1–3; pl. 8, fig. 1; pl. 9, fig. 1.

1886. (?) *Enclimatoceras hyatti?* White, Aldrich, Geol. Survey Alabama, Bull. 1, p. 60.

1890. *Hercoglossa ulrichi* White, Foord and Crick, Annals and Mag. Nat. Hist., ser. 6, vol. 5, p. 392.

1891. *Enclimatoceras (Nautilus) ulrichi* White, Harris, Geol. Survey Arkansas, Ann. Rept. for 1892, pp. 36–39, pl. 2, figs. 1–3.

1896. *Enclimatoceras ulrichi* White, Harris, Bull. Am. Paleontology, vol. 1, No. 4, pp. 122–125, pl. 13, figs. 1–3; pl. 14, fig. 1; pl. 15, fig. 1.

1910. *Hercoglossa (Enclimatoceras) ulrichi* (White) Grabau and Shimer, North American Index Fossils, vol. 2, pp. 111–112, text fig. 1343.

1914. *Enclimatoceras ulrichi* White, Deussen, U. S. Geol. Survey, Water-Supply Paper 335, pl. 3, figs. 1, 1a, 1b.

1921. *Enclimatoceras ulrichi* White, Deussen, U. S. Geol. Survey, Prof. Paper 126, p. 41, pl. 14, figs. 1, 1a, 1b.

1933. *Hercoglossa ulrichi* (White) Miller and Thompson, Jour. Paleontology, vol. 7, p. 319.

Shell moderately large; somewhat narrowly but regularly rounded upon the periphery in the adult state, and broadly rounded at the sides; whorls almost completely involute, the umbilici being very small; septa somewhat deeply concave; ventral saddles large, prominent, and regularly rounded; lateral lobes broad and moderately deep; lateral saddles prominent and narrow, and rounded at the outer end, and also becoming laterally prominent in the later formed septa of adult shells. The character of the surface is unknown, but it was apparently plain; and the test was moderately thin. In the young state the shell was more globose in form, and the septa were much less deeply lobed.

All the specimens which have yet come under my observation are in the condition of natural casts, and all are imperfect. The best one of these specimens is figured on plates VII, VIII and IX, together with a fragment showing the inner volutions. The outlines which are added to the figures represent the supposed outline of the aperture of the adult shell.

The diameter of the coil of the type specimen, when perfect, was apparently about 180 millimeters. The greatest transverse diameter about 125 millimeters.

Some of the specimens already referred to, which were collected in Alabama by Mr. Johnson, indicate a considerably larger size . . . . The collection sent by Mr. Ulrich to the Smithsonian containing the type specimens of this species also contains representatives of numerous other species, but all of them, like these types, are imperfect. Among them are *Callianassa ulrichi* White, *Tubulosteum dickhauti* White, *Gryphaea pitcheri* Morton?, *Turritella, Anchura, Axinaea, Cucullaea,* etc.

The type specimens bear the Museum catalogue number 8349; and permission to use them in the preparation of this article has been given by the Director of the Museum. (White, 1884.)

When the report upon the Rio Grande Embayment was written, there was no nautiloid material from north Texas in our available collections. Fragmentary material from Caldwell County indicated a species with wider lobes than those of *Hercoglossa ulrichi*. Later and better material from north of Lockhart is not separable from *H. ulrichi* at the type locality in Pulaski County, Arkansas. *Hercoglossa ulrichi* is the species most readily comparable to the widely reported *Hercoglossa danica* Schlotheim and the species commonly advanced as evidence for the synchroneity of the Danian and Midway faunas.[1] Miller and Thompson have indicated the differences between the North American Gulf species and that of Denmark. The nautiloid faunas of Caldwell and Maverick counties are separable by no marked time interval and include a number of common molluscan forms, and yet there is no evidence that *Hercoglossa ulrichi* was able to establish itself in the Rio Grande Embayment. Granting unusual environmental conditions in the Embayment, the forms that we might reasonably expect to find in common with those of the north and central Texas faunas would be of the character reputed to *Hercoglossa ulrichi, i.e.*, wide-ranging species, with easily transportable shells. We know, of course, very little of the early Eocene oceanic currents but if they are invoked to account for trans-Atlantic distribution one might reasonably expect shore currents to be operative as well. But *Hercoglossa vaughani* has not been recognized to the north of the Rio Grande Embayment and *Hercoglossa ulrichi* has not been recognized to the south of Guadalupe

[1] Scott, Gayle. On a new correlation of the Texas Cretaceous: Amer. Jour. Sci., 5th ser., vol. 17, pp. 157–161, 1928.

———, ———, Études stratigraphiques et paléontologiques sur les terrains crétacés du Texas: Lyon, Grenoble, thesis, p. 111, 1928.

———, ———, Age of the Midway group: Bull. Geol. Soc. Amer., vol. 45, No. 6, pp. 1115–1155, pls. 132–151, 1934.

County. Certainly forms so highly organized as the cephalopods must have a stratigraphic value, if their diagnostic characters are recorded in the parts which are preserved.

Occurrence.—U.S.G.S. Sta. 11704?, 3 miles (air line) north of Lytton Springs in Caldwell County.

HERCOGLOSSA species

A specifically indeterminate juvenile was recovered from the Littig glauconitic member of the Kincaid formation (U.S.G.S. Sta. 13244).

HERCOGLOSSA VAUGHANI Gardner

Pl. 27; Pl. 28, figs. 1, 2

1923. *Enclimatoceras vaughani* Gardner, U. S. Geol. Survey, Prof. Paper 131-D, p. 115, pl. 33, figs. 1–3.
1933. *Hercoglossa vaughani* Gardner?, Plummer, Univ. Texas Bull. 3232, p. 817, fig. 53.
1933. *Enclimatoceras vaughani* Gardner, Miller, A. K., and Thompson, M. L., Jour. Paleontology, vol. 7, No. 3, p. 307.

Shell large, rather compressed toward the apex, more broadly rounded ventrally toward the aperture, obliquely flattened laterally; whorls numerous, increasing but slowly in latitude; the altitude of the earlier whorls a little more than three times their average width from suture to suture, of the later whorls a little less; final whorl of a half grown specimen rudely reniform in outline, somewhat auriculate laterally, concave, the diameter of the whorl approximately double the altitude; umbilici quite strongly depressed, their peripheries obscurely carinate; ventral saddle very broad and nearly horizontal; lateral lobes broad and very shallow; lateral saddles relatively narrow and moderately deep; siphuncle dorsal, migrating slowly toward the center with increasing age; surface not known.

Dimensions.—Maximum diameter of holotype, 168.0± millimeters; diameter of shell at right angles to maximum diameter, 140.0± millimeters; thickness, 100.0 millimeters. Adolescent paratype: maximum diameter of shell, 93.0± millimeters; diameter of shell at right angles to maximum diameter, 64.0± millimeters; maximum thickness, 73.0± millimeters. A larger but imperfect individual attains a maximum diameter of 220.0 millimeters.

Holotype.—U. S. Nat. Mus. No. 352261; paratype, U. S. Nat. Mus. No. 352262.

Type locality.—U.S.G.S. Sta. 3178, three-fourths mile northwest of Evans' (Myrick's) apiary, Frio River, Uvalde County.

Enclimatoceras vaughani is the South Texas analogue of *Enclimatoceras ulrichi* (White), of the Midway of Alabama, a form very similar in general dimensions and outline. The adult *E. vaughani* are, as a rule, more compressed than the adult *E. ulrichi*, but the young of the two species show similar ranges of variation.

The umbilici also seem to be a little more depressed in the Texas species. The most obvious and constant difference, however, is in the outline of the lobes and saddles. The sutures in *E. ulrichi* are much more flexuous than those of *E. vaughani*. In *E. vaughani* the ventral saddle is nearly horizontal and the lateral lobes exceedingly shallow. In *E. ulrichi* the ventral saddle is perceptibly arcuate and the lateral lobes are strongly incurved. The lateral saddles are well developed in both species, though they are deeper in the Texas form.

This is one of a large group of species of world-wide distribution in the late Cretaceous and early Eocene.

Occurrence.—Kincaid formation. *Uvalde County:* U.S.G.S. Sta. 3178, three-fourths of a mile northwest of Evans' (Myrick's) apiary, Frio River. *Maverick County:* U.S.G.S. Sta. 3179, one-half mile northwest of Evans' (Myrick's) apiary; U.S.G.S. Sta. 11756, Media tank, 26 miles southeast of Eagle Pass on Windmill (Jacal) ranch road; U.S.G.S. Sta. 6583, Bibora Creek, about 18 miles southeast of Eagle Pass.

Wills Point formation. *Navarro County:* Trinity River, 5½ miles east-northeast of Kerens. (Plummer.)

THE CORAL FAUNA OF THE MIDWAY EOCENE OF TEXAS

T. WAYLAND VAUGHAN
and
WILLIS PARKISON POPENOE

The coral fauna of the Midway Eocene of Texas includes thirteen separate species and varieties. Only two of the species, each represented in a single locality by a single specimen, belong to the colonial types. The remaining eleven species, containing probably 95 per cent of the specimens, are all of solitary forms. Evidently the Texas Midway seas did not afford conditions favorable to the growth of reef-building corals.

Eight of the thirteen species and varieties are new and have not been reported outside of Texas. Of the remaining five, one may prove to be identical with a doubtful single specimen described from the Midway of Alabama; the remaining four are represented in beds of Midway and Wilcox age outside of Texas. These four are: *Flabellum conoideum*, *Flabellum conoideum* var. *matthewsense*, *Balanophyllia ponderosa*, and *Haimesiastraea conferta*.

Flabellum conoideum, which is fairly abundant and widespread in the Texas Midway, is reported from both the Sucarnoochee clay and Naheola formation of Alabama; *F. conoideum* var. *matthewsense*, also well represented in Texas, appears to be restricted outside of Texas to the beds of the Naheola formation at Matthews Landing, Alabama; *Balanophyllia ponderosa*, represented in several localities in Texas by the varietal form *texana*, is reported elsewhere only from beds of the Clayton in the vicinity of Prairie Creek, Wilcox County, Alabama; while *Haimesiastraea conferta*, appearing in the Clayton, persists until Wilcox time, being found in formations referred to that epoch in Alabama, South Carolina, and Maryland.

Five of the eight genera to which the Texas Midway corals are referred are represented among living species. These five genera—*Flabellum*, *Caryophyllia*, *Trochocyathus*, *Parcyathus*, and *Balanophyllia*—are all of wide geographic distribution, some being practically cosmopolitan. They appear in the deeper and colder seas as well as in the shallower waters. No very definite testimony as to

the conditions of depth or temperature under which the Texas Midway sediments were deposited is thus offered by the contained coral fauna.

FLABELLUM CONOIDEUM Vaughan

Pl. 3, fig. 1

1894. *Flabellum conoideum* Vaughan nom. nud., Rept. Geol. Coastal Plain Alabama, Geol. Survey Alabama, p. 248.

1900. *Flabellum conoideum* Vaughan, U. S. Geol. Survey, Mon. 39, p. 56, pl. 3, figs. 1–4.

In 1900, Vaughan (29aa, p. 56) described this species as follows:

Attached by a small short pedicel. Slightly compressed conical in shape. No lateral wing or lateral processes. Cross section elliptical, rounded at the ends of the longer transverse axis, not angular, as is usually the case with the others of our Eocene species of *Flabellum*. Obscure costae correspond to the primary and secondary septa. Lines of growth are well marked; sometimes corresponding to them are girdling, rather shallow, depressions. The wall is thin at its upper edge, but thick in its lower portion, owing to internal calcareous deposit. Epitheca well developed, extending to the upper edge of the corallum wall. Septa slightly exsert, margins entire; inner free portion undulated, sides granulate. In the adult there are 16 principal septa. Septal arrangement four complete cycles, members of the fifth cycle appearing near the ends of the longer transverse axis. . . . The columella is typical for the genus, *i.e.*, is formed by the fusion of septal trabeculae. Calice not very deep. . . .

Dimensions of a specimen from U.S.G.S. Sta. 11946.—Altitude, 13.3 millimeters; greater diameter of calice, 11.2 millimeters; lesser diameter of calice, 9.0 millimeters.

Type locality.—Prairie Creek, Wilcox County, Alabama.

Types.—U. S. Nat. Mus. No. 157851.

Outside of Texas this species of *Flabellum* is abundantly represented in the Midway Eocene beds in the vicinity of Prairie Creek and Matthews Landing, Wilcox County, Alabama. The Texas forms are, on the average, perhaps slightly more elongate and more slender than the Alabama specimens, but this difference is not a constant one.

Occurrence.—Midway group. *Navarro County:* U.S.G.S. Sta. 10816, about 4 miles south of Wortham. *Limestone County:* U.S. G.S. Sta. 11948, Tehuacana (top member of Kincaid formation), Mexia. *Williamson County:* U.S.G.S. Sta. 10796, upper bed on Dry Brushy Creek 6 miles south of Thrall, on Taylor-Beaukiss road.

Bastrop County: U.S.G.S. Sta. 11913, Colorado River, 2 miles below Travis-Bastrop County line. *Caldwell County:* U.S.G.S. Sta. 10794, about 4.6 miles west and a little north of Lockhart in gully at jog in secondary road.

FLABELLUM CONOIDEUM var. MATTHEWSENSE Vaughan

Pl. 3, fig. 2

1900. *Flabellum conoideum* var. *matthewsense* Vaughan, U. S. Geol. Survey, Mon. 39, p. 58, pl. 3, figs. 5-6a.

Vaughan characterized this variety as follows:

Differs from typical *F. conoideum* in having well-developed costae, corresponding to the first and second cycles of septa, but grades directly into the typical form of the species.

All of the specimens of this variety that were examined have only 12 principal septa each. The epitheca is decidedly of the character of that of *F. lerchi*. It is highly probable that the latter species is a descendant of this variety.

Dimensions of a specimen from U.S.G.S. Sta. 10527.—Altitude, 14.9 millimeters; greater diameter of calice, 10.0 millimeters; lesser diameter of calice, 8.6 millimeters.

Type.—U. S. Nat. Mus. No. 157853.

Type locality.—Matthews Landing, Wilcox County, Alabama.

The only reported occurrence of this variety outside of Texas is from the type locality.

Occurrence.—Kincaid formation (lower Midway). *Navarro County:* U.S.G.S. Sta. 10346, about 4 miles south of Wortham. *Williamson County:* U.S.G.S. Sta. 11903, Dry Brushy Creek on Harvey Henson farm, 5 miles southeast of Coupland; U.S.G.S. Sta. 10420, Dry Brushy Creek, 6 miles south of Thrall, Taylor-Beaukiss road. *Bastrop County:* U.S.G.S. Sta. 11697, gully south of Cedar Creek, Lytton Springs road, 1 mile south of Cedar Creek; U.S.G.S. Sta. 11696, Colorado River, 1½ miles below Travis-Bastrop County line; and U.S.G.S. Sta. 10527, Colorado River, one-fourth mile above mouth of Dry Creek, about 1½ miles downstream from Webberville. *Guadalupe County:* U.S.G.S. Sta. 11702, 1½ miles southwest of Fentress.

FLABELLUM TEXENSE Vaughan and Popenoe new species

Pl. 3, figs. 3-5

Corallum compressed-conical in shape, base with a slight pedicel, not very sharply set off from the rest of the corallum. Cross section

subelliptical with a pronounced angle at the two ends of the greater diameter of the calice. Margin of the corallum in the longitudinal plane through the greater diameter of the calice, crenate and convexly curved. Outline in the longitudinal plane through the lesser diameter, almost straight or slightly concave.

Septa 48 in number in four complete cycles. Septa of the first and second cycles rather thick, those of the first cycle being somewhat the thicker, both cycles reaching the columella and fusing with it. Septa of the third and fourth cycles thin, and free on their inner margins. Septal faces sparsely granulate. Columella typical for the genus.

Costae opposite the first two cycles of septa, prominent at the rim of the corallum, those opposite the first cycle of septa prominent to the base. Margins along the ends of the major axis of the calice produced into a narrow keeled or winglike process which is transversely wavy in outline. Epitheca thin and polished, extending to the rim of the corallum.

Dimensions of the type.—Altitude, 9.5 millimeters; greater diameter of the calice, 7.6 millimeters; lesser diameter of the calice, 6.5 millimeters.

Type.—U. S. Nat. Mus. No. 371034.

Type locality.—U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line, Bastrop County, Texas.

Flabellum texense finds its closest analogues in the varieties of *F. cuneiforme* Lonsdale, common in the middle and upper Eocene of the Gulf Coastal Plain. The closest resemblance is between *F. texense* and *F. cuneiforme* var. *pachyphyllum* Gabb and Horn, represented in beds of lower Claiborne age from Alabama to Texas. The Claiborne variety is so similar, in the character of its costae and epitheca, in the appearance of its lateral wings, and in its general shape, to *F. texense* as to suggest that the latter species represents an ancestral form of *F. cuneiforme* and its varieties. The features distinguishing *F. texense* from *F. cuneiforme* var. *pachyphyllum* are its smaller size, fewer septa, with only 12 principal ones, fewer prominent costae, narrower basal portion, and more broadly ovate calicular outline.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County

line; and U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line.

TROCHOCYATHUS COLORADOENSIS Vaughan and Popenoe new species

Pl. 3, figs. 6, 7

Corallum small, simple, subconical, with a blunted, laterally compressed, and overturned base. Calicular outline broadly elliptical to circular. Fossa shallow.

Septa exsert, 36 in number in the larger specimens, in three complete cycles with some septa of the fourth cycle present. Septa of the first cycle stouter than the remainder, reaching the center of the calice and fusing there to form the columella. Septa of the second cycle reaching nearly to the center of the calice and fusing by their inner margins to the faces of the septa of the first cycle on either side. Septa of the second cycle not so stout as those of the first cycle but much stouter than those of the third and fourth cycles, which are narrow, thin, and free on their inner margins. Pali in two crowns before the first two cycles of septa, the narrower pali being before the septa of the first cycle. Septal faces granulate. Septal upper margins entire, rounded.

Costae corresponding in number to the septa, prominent at the rim of the corallum, inverted V-shaped in cross section, coarsely granulate on the crests and sides, becoming more obscure, lower, and more rounded in outline toward the base. Intercostal areas deep at the rim, shallower lower down on the corallum wall. The center of each area usually ornamented with a fine, raised, granulate stria extending from the calicular rim nearly to the base.

Dimensions of a cotype.—Altitude, 5.0 millimeters; diameter, 4.5 millimeters.

Dimensions of a second cotype.—Altitude, 7.0 millimeters; diameter of calice at the widest part, 6.0 millimeters.

Cotypes.—U. S. Nat. Mus. No. 371035.

Type locality.—U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line, Bastrop County, Texas. Above the *Venericardia bulla* zone.

Trochocyathus coloradoensis bears a superficial resemblance to *T. speciosus* (Gabb and Horn) from the Midway Eocene of Hardeman

County, Tennessee, in the general shape of the corallum and in the shape and granulation of the costae. *T. speciosus* is a larger coral than is *T. coloradoensis*, however, possesses more costae and septa, and has a fascicular columella with a pronouncedly depressed summit, while the columella of *T. coloradoensis* consists merely of the thickened and fused inner edges of the pali opposite the first and second cycles of septa, and lies very slightly below the level of the top of the cup. *T. woolmani* from the Matawan group (Upper Cretaceous) of New Jersey is also similar in superficial appearance to *T. coloradoensis*, and apparently approaches it closely in size. *T. woolmani* has only three cycles of septa, however, slender and inconspicuous pali, a fascicular columella, and distinct rows of granules along the costal crests, while *T. coloradoensis* usually has more than three cycles of septa, rather large and conspicuous pali, and small, scattered granules irregularly distributed over the costae.

Occurrence.—Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665?, Water Hill, 5 miles northeast of Kemp. *Williamson County:* U.S.G.S. Sta. 10420, Dry Brushy Creek, 6 miles south of Thrall on Taylor-Beaukiss road. *Bastrop County:* U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line; and U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line.

TROCHOCYATHUS UBER Vaughan and Popenoe new species

Pl. 3, figs. 8, 9

Corallum large, simple, mammiform, with a short nipple-like base. Calice nearly circular in outline, axial fossa round, not very deep.

Septa 58 to 60 in number in most specimens, in four complete cycles with some septa of the fifth cycle; exsert, those of the first and second cycles sometimes projecting as much as 2.0 millimeters above the top of the wall. Septa of the first and second cycles reaching the columella, those of the first cycle slightly stouter than those of the second. Septa of the third cycle thinner than those of the second, extending about two-thirds of the way from the wall to the columella, and fusing by their inner margins to the faces of the septa of the second cycle lying beside them. A few of the septa of the fourth cycle fusing by their inner margins to the faces of the third-cycle septa beside them. Pali before all of these. Remaining

septa narrow and thin and free on their inner margins. Septal upper margins arcuate, thinner and dentate toward the wall, thicker and smoother toward the columella. Almost vertical rows of granules ornamenting the septal faces, sometimes fusing near the upper margins to form short striae and alternating in position on opposite sides of the septal wall, giving a laterally wavy cross section to the septum when viewed from above. Septa noticeably thicker at the wall. Columella depressed below the level of the calicular rim, papillate on the summit.

Costae corresponding to the septa in number. Those opposite the first two cycles of septa the most prominent and projecting farthest above the top of the cup. Those of the third cycle not so prominent as those of the first two cycles but larger and more prominent than those opposite the fourth and fifth cycles. All costae granulate on the sides and crests.

Epitheca prominent and thick over the lower two-thirds of the corallum wall, with irregular encircling growth lines, thinner above, and consisting of discontinuous encircling shreds and wisps.

Dimensions of a cotype.—Altitude, 11.2 millimeters; diameter of calice, 17.3 millimeters.

Cotypes.—U. S. Nat. Mus. No. 371032.

Type locality.—U.S.G.S. Sta. 10846, 3½ to 4 miles south of Wortham, Navarro County, Texas.

This species greatly resembles *T. hyatti* Vaughan from the Midway Eocene beds at Black Bluff and Prairie Creek, Alabama, in its general features and septal arrangement. *T. hyatti* is more acutely conical in shape than the Texas species, however, has straighter sides, fewer septa, and usually is covered farther up the wall with epithecal deposit. In addition, all of the specimens of *T. hyatti* in the National Museum collections are much smaller than the smallest specimen of *T. uber*.

Occurrence.—Kincaid formation, *Navarro County:* U.S.G.S. Sta. 10816, about 4 miles south of Wortham. *Limestone County:* U.S. G.S. Sta. 11943, Tehuacana (top member of Kincaid formation), Mexia.

PARACYATHUS BASTROPENSIS Vaughan and Popenoe new species

Pl. 3, figs. 10, 11

Corallum simple, obtusely conical, usually slightly curved in the plane of the longer calicular diameter. Outline of the calice broadly elliptical. Fossa fairly deep.

Septa 48 in number, arranged in four complete cycles, the septa of the first three cycles reaching the columella, the septa of the fourth cycle reaching nearly to the columella and fusing by their inner margins to the lateral faces of the septa of the third cycle. Pali numerous before the first three cycles of septa. Those before the first two cycles subequal, stout, rather narrow. Those before the third cycle thinner and wider than those before the first two cycles. Lateral faces of the septa ornamented with minute, rather closely crowded, irregularly distributed spines. Summit of the columella depressed and papillate.

Costae corresponding to septa. Those opposite the first three cycles of septa low, narrow, subequal, bearing a single row of granules on the crests and extending to the base of the corallum. Those opposite the fourth cycle of septa less prominent than the costae opposing the first three cycles of septa but similarly ornamented. Wall smooth and slightly polished.

Dimensions of a cotype.—Altitude, 6.6 millimeters; greater diameter of calice, 7.6 millimeters; lesser diameter of calice, 6.7 millimeters.

Dimensions of a second cotype.—Altitude, 5.9 millimeters; greater diameter of calice, 7.3 millimeters; lesser diameter of calice, 5.9 millimeters.

Cotypes.—U. S. Nat. Mus. No. 371040.

Type locality.—U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line, Bastrop County, Texas.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line; and U.S.G.S. Sta. 10527, Colorado River, one-fourth mile above the mouth of Dry Creek, 4¼ to 4¾ miles downstream from Webberville.

CARYOPHYLLIA MEDIAVIA Vaughan and Popenoe new species

Pl. 3, figs. 12, 13

Corallum simple, subconical, with a small subpedicellate base usually, though not always, curved in the plane of the greater diameter, set off from the rest of the corallum by a constriction and terminating with a small scar of attachment. Calicular outline broadly elliptical. Margins at the ends of the major calicular axes somewhat lower than the margins near the ends of the minor axes. Corallum encircled with three or four depressed zones.

Septa about 40 in number, 20 reaching the columella and being alternately thicker and thinner, 20 alternating septa being thin, narrow, and free on their inner margins. Pali in a single crown, opposing the ten thinner members of the principal septa, broad, thin, projecting slightly above the columellar summit, and each terminating on the inner margin in a twisted lamella. Septal faces granular. Columella trabeculate with a depressed summit.

Costae corresponding to the septa, the more prominent costae opposing the thicker septa, prominent at the calicular rim, obscure toward the base. Cross section of costae at rim inverted V-shaped with prominent granulae on the crests and sides, cross section below the calicular margin a low, rounded arch. Crests finely granular. Wall smooth.

Dimensions of the type.—Altitude, 10.4 millimeters; greater diameter of calice, 9.4 millimeters; lesser diameter of calice, 8.3 millimeters.

Type.—U. S. Nat. Mus. No. 371041.

Type locality.—U.S.G.S. Sta. 10527, Colorado River, one-fourth mile above the mouth of Dry Creek, Bastrop County, Texas.

Caryophyllia mediavia is almost identical in its general appearance and septal arrangement with *Trochocyathus cingulatus* Vaughan, described from a unique specimen from beds of probable Midway age in the vicinity of Prairie Creek, Wilcox County, Ala. This single specimen is incomplete, the top of the calice being broken away and the upper septal margins being lacking. For this reason the palar characters of *T. cingulatus* cannot be certainly determined, but such characters as are present suggest that *T. cingulatus* may prove to be *Caryophyllia* rather than *Trochocyathus* and that *T. cingulatus* and *C. mediavia* are varieties of the same species. Until

specimens of *T. cingulatus* are available which will determine its genus definitely, however, the species must be considered separate.

Occurrence.—Kincaid formation. *Williamson County:* U.S.G.S. Sta. 11903, Dry Brushy Creek on Harvey Henson farm, about 5 miles southeast of Coupland. *Bastrop County:* U.S.G.S. Sta. 10527, Colorado River, one-fourth mile above mouth of Dry Creek, about 4½ miles downstream from Webberville. *Caldwell County:* U.S. G.S. Sta. 10794, about 4½ miles west and a little north of Lockhart in gully in secondary road. *Maverick County:* U.S.G.S. Sta. 11873?, 4 miles northwest of Burke ranch house and 3.3 miles southeast of Chilipitin tank.

CARYOPHYLLIA DUMBLEI Vaughan and Popenoe new species

Pl. 3, figs. 11-16

Corallum cornute, nearly straight to slightly curved in the plane of the longer diameter of the calice, encircled from base to top with three or four shallow, smooth, regular constrictions lying in the plane perpendicular to the axis of the columella. Base subpedicellate with a small scar of attachment in the younger forms, apparently free in the larger specimens. Cross section of corallum ovate or elliptical. Fossa shallow.

Septa 40 in number, 10 being rather stout, and reaching to and fusing with the columella; an alternate 10 also reaching to and fusing with the columella, but not quite so stout; the remaining 20 septa alternating with the principal 20, thin, narrow, fragile, apparently free on their inner margins. Septa ornamented on the lateral faces with ascending rows of granules passing inward from the wall to the columella, the larger granules in each row being nearer the columella.

Costae corresponding in number and size to the septa, those opposite the 10 stoutest septa being prominent, irregular, transversely wrinkled along the crests, and extending to the base of the corallum, those opposite the secondary group of 10 septa being not so prominent as those opposite the 10 stoutest septa, and not extending to the base of the cup but being similar to the larger costae in ornamentation, those costae opposite the 20 small septa being obscure, and indicated usually only by a low granular or transversely wrinkled stria opposite each septum. Costae apparently not the outer edges of the septa, appearing rather to be longitudinal

folds or wrinkles of the outer wall opposite the outer septal margins. Wall rather thick. Intercostal areas smooth and lustrous, or finely pustulate.

Dimensions of a cotype.—Altitude, 14.0 millimeters; greater diameter of the calice, 9.5 millimeters; lesser diameter of the calice, 8.4 millimeters.

Cotypes.—U. S. Nat. Mus. No. 371036.

Type locality.—U.S.G.S. Sta. 11948, Tehuacana (top member of Kincaid formation), Mexia, Limestone County, Texas.

This fine coral appears to be quite distinct from any other of our American species of *Caryophyllia*. The species is named for the late Edwin T. Dumble, an outstanding pioneer figure in geological work in East Texas.

Occurrence.—Kincaid formation. *Kaufman County:* U.S.G.S. Sta. 11665, Water Hill, 5 miles northeast of Kemp. *Navarro County:* U.S.G.S. Sta. 10846, about 4 miles south of Wortham. *Limestone County:* U.S.G.S. Sta. 11948, Tehuacana member, Mexia. *Milam County:* U.S.G.S. Sta. 11926, Milam Bluff, Brazos River (bed No. 4), 0 to one-fourth mile below the Milam-Falls County line. *Williamson County:* U.S.G.S. Sta. 11903, Dry Brushy Creek on Harvey Henson farm, about 5 miles southeast of Coupland. *Bastrop County:* U.S. G.S. Sta. 10527, Colorado River, one-fourth mile above mouth of Dry Creek, about 4½ miles downstream from Webberville; and U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line. *Caldwell County:* U.S.G.S. Sta. 11699, William Mercer well, 2 miles southwest of Joliet, 3 miles (air line) due south of Lockhart.

CARYOPHYLLIA CONSTRICTA Vaughan and Popenoe new species

Pl. 3, figs. 17, 18

Corallum small, slender, elongate-conical, with a rather prominent, expanded base set off from the rest of the corallum by a constriction and slightly bent to one side. Scar of attachment preserved. Longitudinal outline of the corallum uneven because of several irregularly alternating encircling constrictions and swellings on the outside of the wall. Cross section of corallum circular.

Septa 24 in number, arranged in three complete cycles. Septa of the first cycle reaching the center of the calice, their inner margins apparently fusing to form the columella. The septa of the second

cycle reaching very nearly to the center of the calice and fusing by their inner margins to the lateral faces of the septa of the first cycle lying on either side of them. The septa of the third cycle reaching about two-thirds of the distance from the wall to the center of the calice and fusing by pairs to the opposite sides of the septa of the second cycle lying between each pair. Septa subequal in thickness with little or no thickening at the wall. Septal faces ornamented with numerous short blunt spines. Pali in one crown before the second cycle of septa, thin, rather wide, with bent upper edges.

Costae corresponding in number to the septa, thin, ragged, uneven in height and thickness, occasionally obscured by the epitheca along the depressed zones of the external surface of the corallum but elsewhere usually projecting up through the epithecal layer. Wall thin. Epitheca prominent, showing fine growth lines slightly higher along the sides of the costae than in the middle of the intercostal area, thus giving a festooned appearance to the outside of the corallum.

Dimensions of a cotype.—Altitude, 5.6 millimeters; diameter, 3.1 millimeters.

Cotypes.—U. S. Nat. Mus. No. 371033.

Type locality.—U.S.G.S. Sta. 10420, lower bed, Dry Brushy Creek, 6 miles south of Thrall, Williamson County, Texas.

This species appears to be quite distinct from any other described species of Eocene corals. Its small size, thin and ragged costae, and peculiar irregularly swollen appearance are its most distinctive characters.

Occurrence.—Kincaid formation. *Williamson County:* U.S.G.S. Sta. 10420, Dry Brushy Creek, 6 miles south of Thrall, Taylor-Beaukiss road. *Bastrop County:* U.S.G.S. Sta. 10527, Colorado River, one-fourth mile above mouth of Dry Creek, about 1½ miles downstream from Webberville.

PLATYTROCHUS PRIMAEVUS Vaughan and Pepenoe new species

Pl. 3, figs. 19, 20

Corallum small, simple, compressed-conoidal in form, with a slender pedicellate base. Cross section elliptical. Margins at the ends of the major axes of the calice depressed somewhat below the level of the margins along the broader faces.

Septa 44 in number, 22 reaching to and fusing with the columella, being stouter than the remainder, 22 thinner and narrower septa

alternating with the principal ones fusing in pairs to opposite faces of the principal septum lying between each pair, each alternate septum of the 22 principal ones thus having a smaller septum fused to each of its lateral faces. Septal faces granular, the rows of granules roughly parallel to the upper septal margins. Septal upper margins smooth, exsert, arcuate. Columella elongate and narrow with a papillate summit.

Costae corresponding in number to the septa, thin, prominent, rather high at the rim of the corallum, lower and slightly more rounded over the crests toward the base of the cup. Twelve costae opposite twelve of the principal septa slightly higher and more prominent than the remainder and extending to the base of the corallum. Twelve costae alternating in position with the larger twelve not so prominent, and extending on the corallum wall about two-thirds of the distance from the rim toward the base. Costae corresponding to the smallest septa extending about one-third of the distance from the corallum rim to the base. Costal crests slightly dentate near the rim of the corallum, and on the costae near the ends of the major axis of the calice. Costae toward the base of the corallum usually discontinuous, and represented by short rows of a few prominent granules, particularly at the basal ends of the costae near the major calicular axes. Intercostal areas smooth or superficially pitted. Epitheca apparently absent.

Dimensions of the holotype.—Altitude, 4.7 millimeters; greater diameter of the calice, 5.6 millimeters; lesser diameter of calice, 3.6 millimeters.

Dimensions of the paratype.—Altitude, 4.6 millimeters; greater diameter of calice, 5.0 millimeters; lesser diameter of calice, 3.4 millimeters.

This species is described from two specimens from two different localities. The holotype has been broken at one end of the major calicular axis, and the paratype has had the lower portion of the base broken away; thus the dimensions given above are not those of perfect specimens.

Holotype.—U. S. Nat. Mus. No. 371031; paratype: U. S. Nat. Mus. No. 371030.

Type locality.—U.S.G.S. Sta. 11913, Colorado River, 2 miles below the Travis-Bastrop County line, Bastrop County, Texas.

This pretty little coral is quite distinct from the other species of *Platytrochus* reported from the American Eocene, and is the earliest reported occurrence of the genus. Some immature specimens of *P. claibornensis* de Gregorio from the Claiborne Eocene of Alabama resemble *P. primaevus* in having nearly smooth costal ridges on the broad face of the cup, and in their septal number and arrangement. They are to be immediately distinguished from *P. primaevus*, however, by their more broadly rounded and more densely granular bases, their wider costae with correspondingly narrower and shallower intercostal spaces, and in their more elongate appearance.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11902, Wilbarger Creek, one-half mile below Travis-Bastrop County line; and U.S.G.S. Sta. 11913, Colorado River section.

HAIMESIASTRAEA CONFERTA Vaughan

Pl. 4, figs. 1, 2

1900. *Haimesiastraea conferta* Vaughan, U. S. Geol. Survey, Mon. 39, p. 145, pl. 15, figs. 6-9; pl. 16, all figs.

1922. *Haimesiastraea conferta* Vaughan, Corals from the Eocene deposits of Peru: The geology and paleontology of northwest Peru, Section D, pp. 125, 131, pl. 22, figs. 1, 1a.

In 1900, Vaughan (29aa, p. 145) described this species as follows:

Colony rather massive, ramose. Corallites crowded together, rather shallow, subhexagonal in outline; calices circular, 1.5 mm. in diameter; the margins project very slightly above the rather dense coenenchyma. The coenenchymal walls between the calices frequently 1 mm. thick on the older portions of the colony. Costae distinct, corresponding to all cycles of the septa, granulate. The costae of one calice meet those of the adjoining calices. The line of the junction usually indicated by a delicate ridge. The whole outer surface of the coenenchyma is minutely granulate. The axial portions of the branches are spongy. In the axial portion the corallites are joined to one another directly by their walls or costae, or are separated by exotheca. As the colony grows older, the corallites bend outward, so that ultimately their axes are nearly at right angles to the external surface. Septa in three cycles; those of the first and second cycles reach the columella; margins entire; surfaces smooth; inner ends of those of the first and second cycles somewhat thickened. From the sides of the septa wing-like processes are developed, which extend across the interseptal loculi and fuse, thus forming the endotheca. The dissepiments are often inclined; are very abundant. No pali. Columella well developed, false, formed by the fusion of the internal margins of the septa of the first and second cycles. Its upper surface is not seen from above in perfect calices, and it is not revealed until a section of the corallite is made.

Type.—U. S. Nat. Mus. No. 158303.

Type locality.—Greggs Landing, Ala.

A single fragment of a corallum from Indio Wells represents the only recorded occurrence of this species in Texas. The surface of the corallum is considerably eroded so that the costae are distinguished with difficulty and the calices appear shallower than in well preserved specimens of *H. conferta*. The corallites are rather closely crowded, the intercorallite areas averaging about 0.8 millimeters in width.

Haimesiastraea conferta is one of the most widespread of our American Eocene coral species. Specimens referred to this species are found at various horizons in the Midway and Wilcox groups of Alabama; in the Black Mingo formation (probably of Wilcox age) in South Carolina; and in the Aquia formation (of Wilcox age) at Upper Marlboro, Prince Georges County, Maryland.

Other species of *Haimesiastraea*, to be distinguished only with difficulty from *H. conferta*, have been described by Vaughan (29aa, p. 146) from beds of doubtful Eocene age near Martinez, Contra Costa County, California, and from middle Eocene deposits of northwest Peru (43a, p. 130). Vaughan suggests (43a, p. 125) that these occurrences indicate a possible connection between the Atlantic and Pacific oceans across Central America prior to Lutetian time. The occurrence of *Haimesiastraea* in the Eocene of Texas in a locality geographically intermediate to the reported occurrences of the other species of this genus lends support to this suggestion.

Occurrence.—Kincaid formation. *Maverick County:* U.S.G.S. Sta. 11758, about 29 miles southeast of Eagle Pass.

SEPTASTREA? KERIOIDES Vaughan and Popenoe new species

Pl. 4, figs. 3–5

Corallum incrusting. Corallites closely crowded, subhexagonal to pentagonal in outline, attached to one another directly by their walls, rather shallow, averaging about 4.0 millimeters in depth. Calicular rim projecting from 1.0 to 1.5 millimeters above the upper septal margins. Calices usually 3.5 millimeters to 4.0 millimeters in diameter. Fossa broad and shallow.

Septa 24 in number arranged in three complete cycles, and six systems, thin, almost straight in vertical section, usually slightly

wavy or undulating in cross section. Septa of the first cycle extending to, or nearly to, the center of the calice, fusing by their inner margins to form a false columella, in some individuals the septa nearest the longer calicular diameter being the only ones to reach the center of the calice, the remaining septa of the first cycle turning to one side and fusing to the faces of the longer septa slightly to one side of the center of the calice. Septa of the second cycle usually extending about halfway from the wall to the center of the calice, sometimes free on their inner margins, sometimes fused to the faces of first-cycle septa beside them. Septa of the third cycle thin, free and inconspicuous, almost rudimentary. Septal faces probably smooth, slightly undulate. No pali evident. Dissepiments probably lacking, the interseptal loculi appearing open to the bases of the corallites. Corallite walls thin, ordinarily from .3 millimeter to .4 millimeter in thickness. Juncture of the walls of adjacent corallites indicated by a fine, irregular line.

Type.—U. S. Nat. Mus. No. 371042.

Type locality.—U.S.G.S. Sta. 11937, Rocky Crossing, Little Brazos River, just below bridge on Kosse road, Limestone County.

This species is quite distinct from any other known American Tertiary coral, and probably represents a new genus. The specimen from which this study is made is an encrusting patch upon the surface of a fragment of impure limestone. The revealed surface of the corallum is much eroded, and the calices are filled nearly to the rims with a compact limy deposit so that it is necessary to work out the internal structure from sections. There is also some suggestion that the surfaces of the walls and septa have been altered by solution. These conditions have masked or destroyed structures of systematic importance, such as the ornamentation of the surface of the corallum, and of the septal faces, and the structure of the septal margins. For these reasons, and for the reason that the characteristic features of a coral are not always fully revealed in the encrusting form, it is thought best to refer this species to the genus which it appears to resemble most closely, until material is available which will permit the complete structure of the species to be determined.

Occurrence.—Kincaid formation. *Falls County:* U.S.G.S. Sta. 11937, Rocky Crossing, Little Brazos River, just below bridge on Kosse road.

BALANOPHYLLIA PONDEROSA var. TEXANA Vaughan and Pepenoe new variety

Pl. 4, figs. 6-12

Corallum cornute to subconical, nearly straight in some specimens, usually curved, sometimes sharply curved near the base, the plane of curvature bearing no apparent constant relation to the planes of the calicular axes. Larger specimens usually free, smaller specimens free or with a small scar of attachment. Longitudinal outline of the corallum ordinarily marked with several irregular, encircling, constricted areas. Cross section subelliptical. Fossa, narrow and deep.

Septa usually about 65 in number, in a few specimens as many as 90, the 24 septa of the first three cycles reaching the columella and fusing to it by their inner margins, the remaining smaller septa fusing in groups of 3 or 4 to the lateral faces of alternates of the 24 principal septa, 12 of the 24 septa of the first three cycles thus having no other septa attached to them, each of the remaining alternate 12 having 3 or 4 smaller septa fused to its face. Columella spongy, summit papillate, convexly rounded, much depressed below the level of the rim of the corallum. Septal faces ornamented with sub-parallel rows of low, elongate granules, the rows apparently ascending slightly passing inward from the wall. Inner margins of the septa transversely wavy in vertical section, smooth or slightly wavy in profile at the top of the corallum, sometimes lobate just above the summit of the columella.

Costae apparently corresponding to the septa, low, flat-topped, and smooth toward the base of the corallum, farther up on the wall bearing a single row of rounded granules which seem to elongate laterally near the top of the cup and disintegrate into numerous, irregularly arranged, crowded, small granulae surmounting the costal crests. Twelve uniformly spaced costae on most of the specimens slightly more prominent than those remaining. Epitheca a thin chalky layer with thicker, irregular, encircling strands sometimes heavy enough to conceal the granular crests of the costae. Wall thick and spongy. Intercostal areas perforate.

Dimensions of a curved specimen (cotype).—Altitude, 22.5 millimeters; greater diameter at top of calice, 11.5 millimeters; lesser

diameter at top of calice, 6.6 millimeters; greater diameter, 5.0 millimeters below top of calice, 11.7 millimeters; lesser diameter, 5.0 millimeters below top of calice, 8.7 millimeters; depth of fossa, 3.8 millimeters.

Dimensions of a straight specimen (cotype).—Altitude, 25.0 millimeters; greater diameter of calice, 9.9 millimeters; lesser diameter of calice, 8.7 millimeters; depth of fossa, 4.0 millimeters.

Cotypes.—U. S. Nat. Mus. No. 371043.

Type locality.—U.S.G.S. Sta. 10816, 3½ to 4 miles south of Wortham, Navarro County, Texas.

This protean variety includes a series of forms ranging from stout, coarse, nearly straight forms very similar to typical *B. ponderosa*, through an intermediate series of stout, more or less curved individuals, to slender, curved, sometimes sharply curved, end-members. As a rule, the nearly straight stout forms reminiscent of typical *B. ponderosa*, have more than 70 septa, are free, have subequal costae, and include the largest specimens of the collection. These grade directly into a series of stout, curved forms that may be considered typical of the variety *texana*. The members of this second group are ordinarily curved evenly and moderately, have prominent encircling depressions on the corallum wall, generally show 12 evenly spaced costae more prominent than the remainder, have about 64 septa, and are free in the larger individuals. A few more slender, curved forms, some with a sharply curved basal portion, represent the extreme departure of the variety from the shape and size of typical *B. ponderosa*.

B. ponderosa var. *texana* is to be distinguished from specimens of typical *B. ponderosa* by its smaller size, fewer septa, and its usually more arcuate outline. Of the other species of *Balanophyllia* reported from the Texas Eocene, typical *B. augustinensis*, from the lower Claiborne of San Augustine, is more slender, more elongate, has a less prominent columella, and more coarsely granular costae. The several varieties of *B. irrorata* from the Texas Claiborne are to be distinguished from *B. ponderosa* var. *texana* by their very slight development of epitheca and their costae bearing a single row of coarse granules.

Occurrence.—Kincaid formation. *Bastrop County:* U.S.G.S. Sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line. *Freestone County:* U.S.G.S. Sta. 7424, city well at Wortham. *Navarro County:* U.S.G.S. Sta. 10846, about 4 miles south of Wortham. *Limestone County:* U.S.G.S. Sta. 11948, Tehuacana (top member of Kincaid formation), Mexia.

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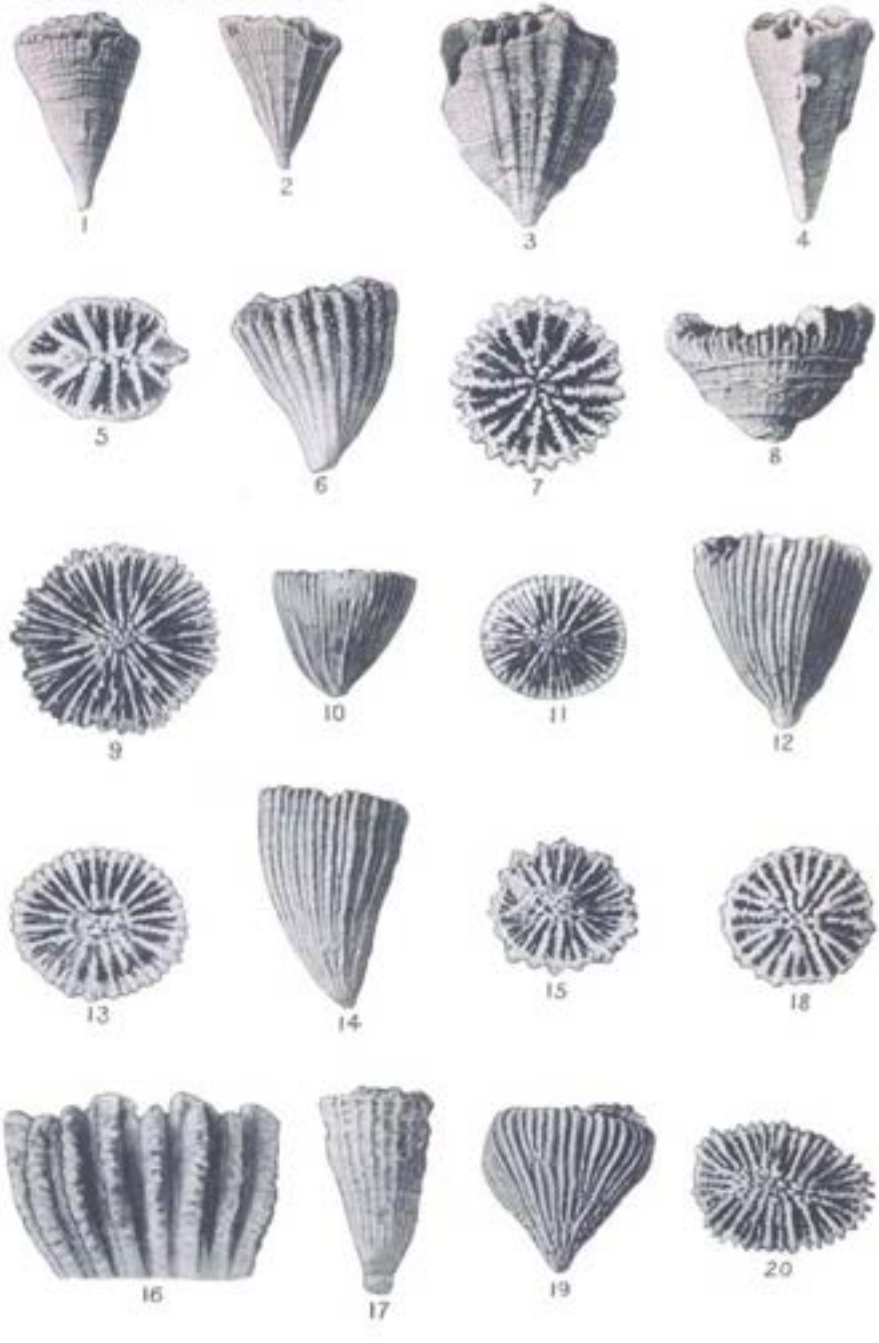

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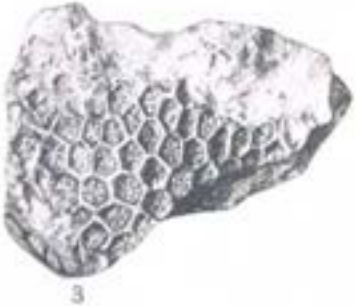
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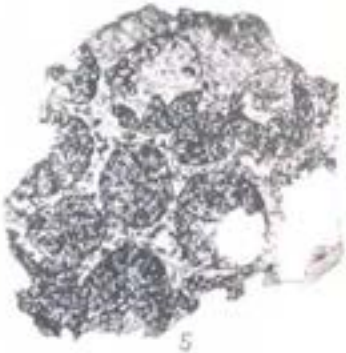
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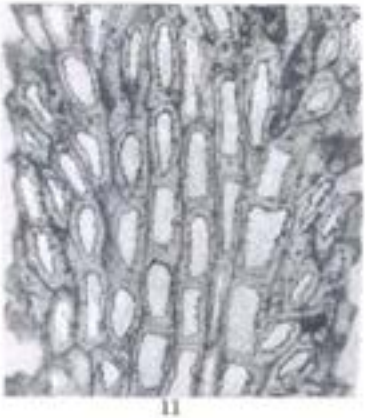
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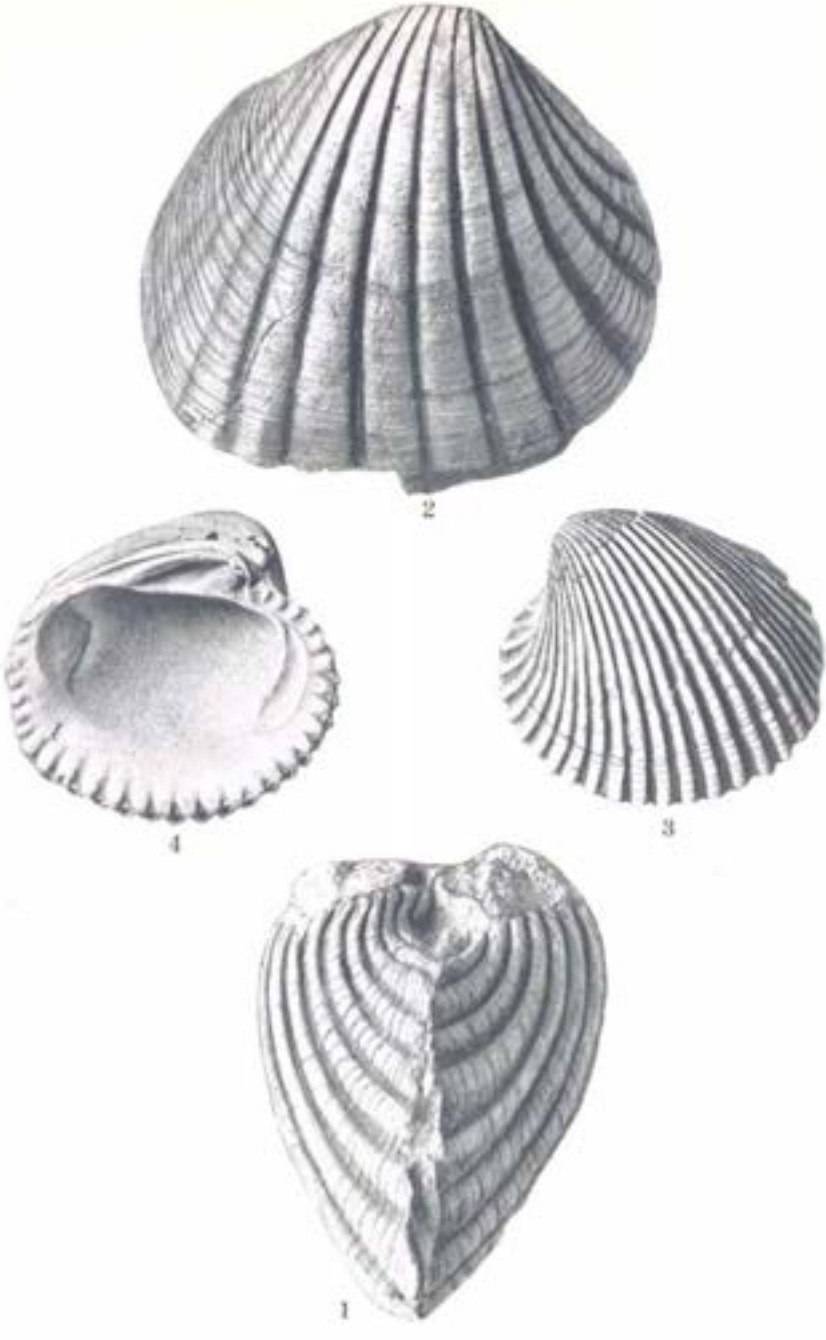

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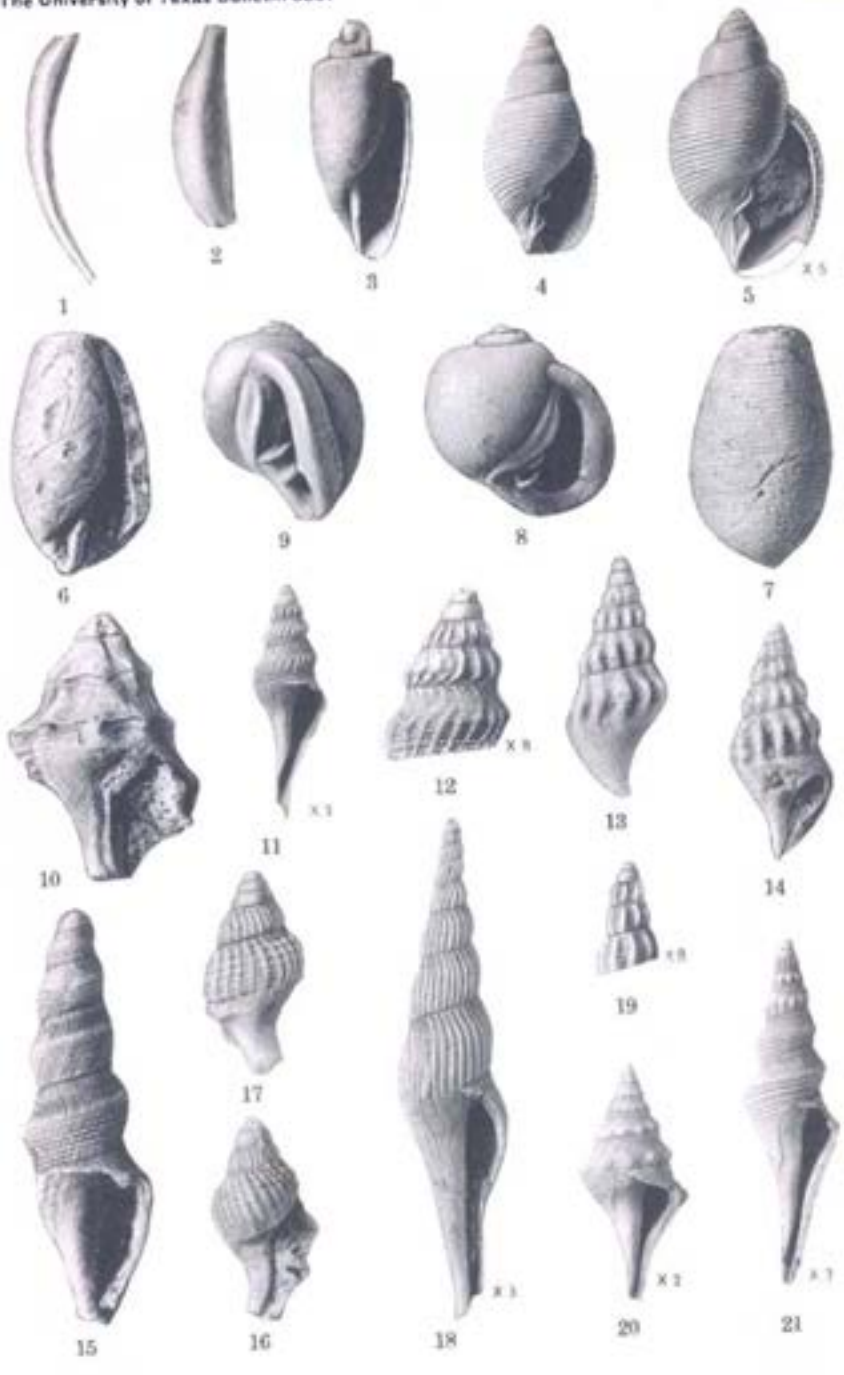

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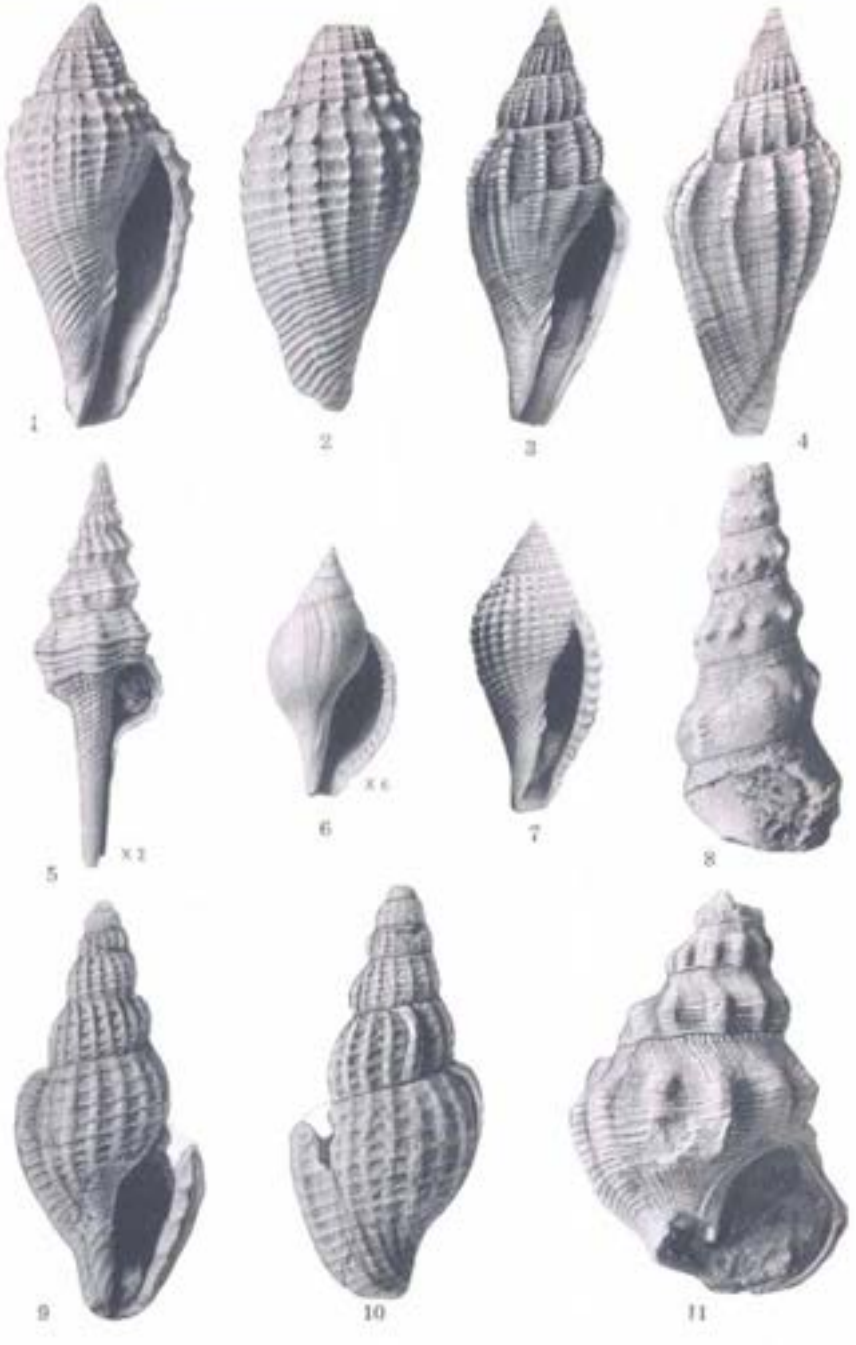

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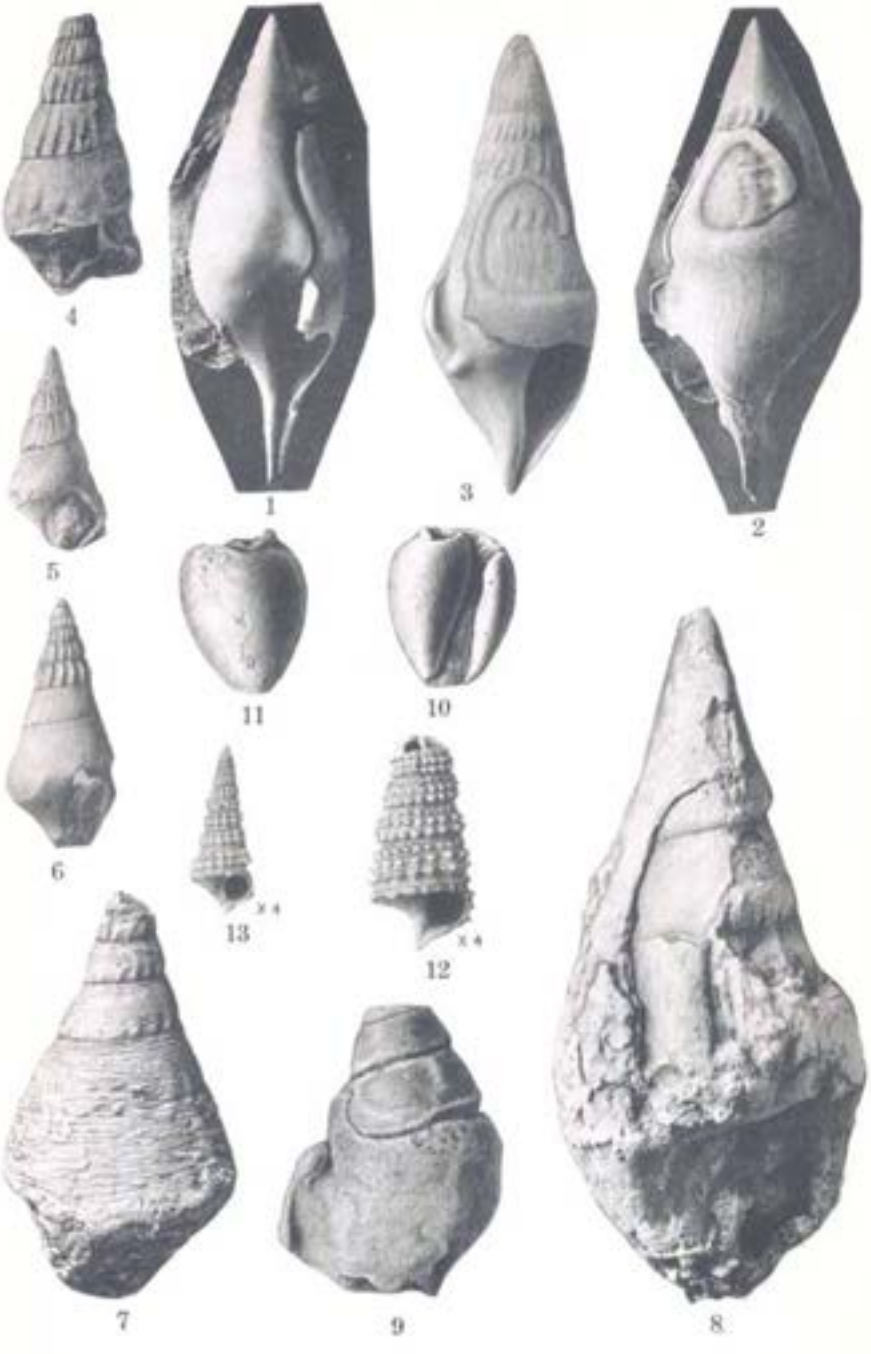

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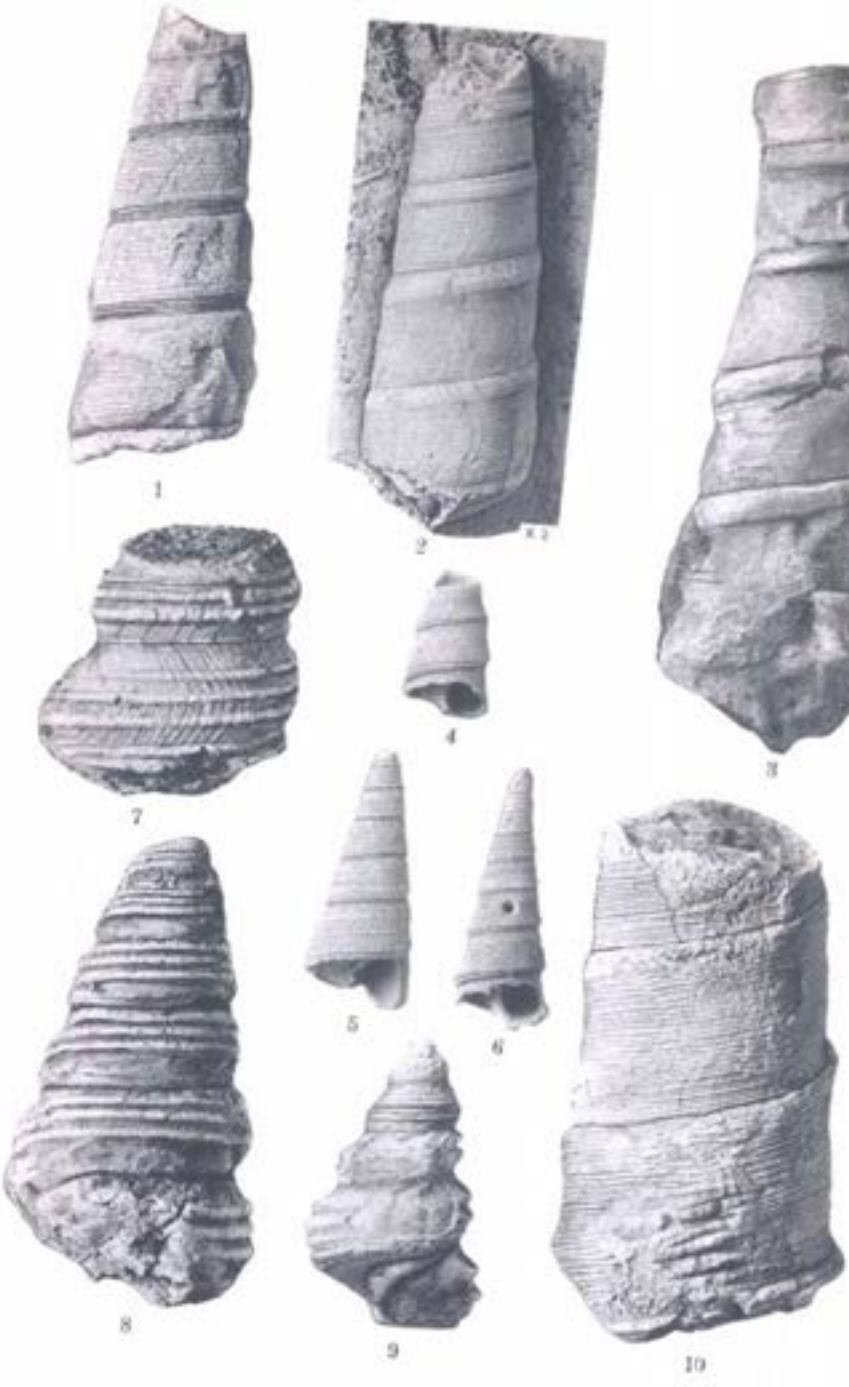

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