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THE VENERICARDIA PLANICOSTA GROUP IN THE GULF PROVINCE

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THE VENERICARDIA PLANICOSTA GROUP IN THE GULF PROVINCE

BY

JULIA GARDNER AND EDGAR BOWLES

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ABSTRACT

Venericardia planicosta of authors is considered as a monophyletic group of species rather than as a single specific unit. This group is restricted stratigraphically to the Eocene, but it is world-wide in geographic distribution. Each of the included species is generally confined to a single formation or member, but within its zone each is widely distributed, abundant, and conspicuous by reason of its size and ornamentation. As guide fossils the members of the *planicosta* group are therefore among the most significant of the Mollusca. Although no ancestral types have been recognized in the Cretaceous of the Gulf region, two virile branches of the *planicosta* group were already established in the region at the beginning of the Eocene epoch, and the present study is an attempt to trace their progress and development through the Eocene. Both of the branches, represented in the Midway deposits by *V. smithii* and *V. mediaplata*, are abundantly represented in the Wilcox deposits, particularly in the eastern Gulf province, by descendants of the Midway species. During the deposition of the middle Wilcox Tuscahoma and Bashi formations the *planicosta* group probably attained its greatest prominence in the size and abundance of individuals and in the diversification of the species, but their development is provincial. The faunas of the lower Claiborne deposits, on the other hand, especially those from the upper part of the lower Claiborne, are the most cosmopolitan of all the Eocene venericard faunas. The transgressional seas were not confined to the Gulf province but invaded Mexico, the Isthmus of Panama, and northern South America. So far as the venericards are concerned, the marine upper Claiborne, best represented by the Gosport sand, contains nothing more than a greatly reduced lower Claiborne fauna. After the widespread emergence at the end of Claiborne time, the venericards failed to regain their former prominence. Several species are known in Jackson deposits, but none of them are abundant, and the decline in the number of individuals and species during the Jackson epoch heralded the extinction of the group at the end of the Jackson. The occurrences of the *planicosta* group in western North America, South America, and the Old World are briefly considered. For the Asio-European representatives of the *planicosta* group, the life cycle was essentially the same as in America. In this paper 44 species and subspecies are described and illustrated; of these, 24 are new.

INTRODUCTION AND ACKNOWLEDGMENTS

A study of the distribution of the Eocene faunas of the Mexican border has been made possible by extensive collections submitted by the petroleum companies of Mexico and by funds for their investigation granted through the generosity of the National Research Council and the Penrose Bequest of the Geological Society of America. To the donors of the collections, to those who have financed this investigation, to W. H. Twenhofel and Albert L. Barrows, to L. W. Stephenson and John B. Reeside, Jr., of the Geological Survey, for their sustained and lively interest and their ever timely suggestions, and to Nell L. Bowen, who has done our secretarial work, we are deeply grateful.

The present paper is concerned only with the *Venericardia* of the *planicosta* group and their geographic and stratigraphic distribution, particularly in the east coast and Gulf regions, but the results have been partially checked against other members of the fauna. (See pls. 29 and 30 and correlation chart.)

Timothy Abbott Conrad, the leader of the early coterie of malacologists in Philadelphia, characterized *Venericardia planicosta* as "the finger post of the Eocene", for no true *planicosta* had been recognized below the base of the Midway, and it has been very doubtfully identified above the top of the Jackson. No other group of Eocene pelecypods, for *planicosta* as it has been commonly used on the American Continent is a group rather than a specific name, is so widespread nor, in its manifold variations, of greater stratigraphic significance. On the Western Hemisphere conventional members have been recovered from New Jersey to Argentina and west to the Pacific coast.

The wide distribution of a fauna is commonly interpreted as indicating an ancient origin, and the wider the distribution of a given restricted group the deeper, presumably, are its roots in geologic time. Although the focus of origin and the strand lines of dispersal of *Venericardia planicosta* are largely speculative, there is reason to believe that the group is not definitely foreshadowed in the Gulf Cretaceous but in more remote regions, and that the development and general distribution in the Western Hemisphere were largely accomplished between the end of the fossiliferous Upper Cretaceous and the beginning of the Eocene.

STRATIGRAPHIC BACKGROUND OF THE VENERICARDIA PLANICOSTA GROUP ON THE AMERICAN CONTINENT

EOCENE EPOCH

The general relationships of the Eocene formations of the east coast and Gulf regions are indicated in the correlation chart.

MIDWAY GROUP

The name "Midway", first used by Smith and Johnson,[1] was derived from Midway Landing, on the

[1] Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama Rivers: U. S. Geol. Survey Bull. 43, p. 62, 1887.

CHART 1.—*Correlation of east coast and Gulf Eocene formations in the United States*

	European	Generalized American	New Jersey	Maryland, Virginia	North Carolina	South Carolina	Georgia	Florida	Alabama	Mississippi	Tennessee	Kentucky	Missouri	Arkansas	Louisiana	Texas
Upper.	Ludian.	Jackson group.	Missing?		Missing?	Cooper marl.	Ocala limestone.		Jackson formation.	Yazoo clay member.	Missing?		Not exposed.	Jackson formation.		Jackson group.
	Bartonian.				Castle Hayne marl.	Santee limestone.	Barnwell sand.			Moodys marl member.						
Middle.	Auversian.	Claiborne group.	Shark River marl (probably middle Eocene).	Not exposed.		McBean formation.		Not exposed.	Gosport sand.[e] Lisbon formation. Tallahatta formation.[d]	Yegua formation. Kosciusko sandstone member. Winona sand member.	Missing?			Yegua formation. Cook Mountain formation.[e] Sparta sand. Cane River formation.		Cook Mountain formation. Sparta sand. Weches greensand member. Queen City sand member. Reklaw member. } Mount Selman formation.
	Lutetian.						Tallahatta formation.								Carrizo sand.	
Lower.	Ypresian.	Wilcox group.	Manasquan marl. Rancocas group.	Nanjemoy formation. Aquia formation.	Not exposed.	Black Mingo formation.[b]	Undifferentiated Wilcox.	Not exposed.	Hatchetigbee formation. Bashi formation. Tuscahoma sand. Nanafalia formation. Ackerman formation.	Grenada formation. Not exposed. Bashi formation. Not exposed. Holly Springs sand. Ackerman formation.			Not exposed.	Undifferentiated Wilcox.		
Basal.	Thanetian.	Midway group.	Missing?	Missing?			Undifferentiated.	Not exposed.	Naheola formation. Sucarnoochee clay.	Tippah sandstone member. Porters Creek clay.	Undifferentiated Midway.		Undifferentiated Midway.	Not exposed.		Wills Point formation.
	Montian.						Midway.		Clayton formation.	Clayton formation.						Kincaid formation.

[a] Saint Maurice of Spooner, 1926.

[b] Possibly of lower Midway age.

[c] Probably a facies equivalent to the Moodys marl member.

[d] Equivalent in part to the Winona sand member of Mississippi and the Mount Selman formation of Texas.

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Alabama River, where the basal Eocene is well exposed. Synchronous deposits were laid down across Alabama into Georgia (with possibly an embayment in central New Jersey) and to the west through northeastern Mississippi into Tennessee and Kentucky, down across southeastern Missouri, through central Arkansas, and in a great sigmoidal curve across eastern and southern Texas into Mexico.

The Midway group is remarkably uniform in general make-up and is characterized throughout the greater part of its extent by a lower glauconitic sand and sandy limestone series overlain by clays and fine sandy clays. Both in the Alabama sections and in those of the western Gulf region the highly calcareous and fossiliferous beds are succeeded by a relatively barren series of clays and sands. Many sections in both the eastern and the western Gulf regions show no perceptible break between Midway and Wilcox sedimentation, and consequently confusion in the correlation has arisen. After the long Cretaceous-Eocene quiescence the early Midway was apparently a time of rather marked erosional activity. The streams were rejuvenated and cut deeply into the Cretaceous sands and limestones, so that the lower Midway, like its lithologic antecedents, is a dominantly calcareous series. At the end of the lower Midway there was a fairly abrupt change in the character of sedimentation. The streams were restricted in their activities largely to the finer argillaceous sediments of the Upper Cretaceous, and the resultant ecology was much less favorable, especially to the larger bivalves. Not only was the source of the coarse sands apparently cut off, but also the source of the abundant lime, and it seems probable that the upper Midway muds and silts were transported largely by old, sluggish streams meandering through a low hinterland of Upper Cretaceous clays and were laid down in waters of no considerable depth.

The Midway is divisible in Alabama into three formations—the Clayton formation, the Sucarnoochee clay, possibly in part contemporaneous with the Clayton, and the Naheola formation. The oldest of these, the Clayton,[2] resting with marked unconformity upon the Cretaceous, extends from the Chattahoochee River on the Georgia border to the Alabama River, west of which it is overlapped by the Sucarnoochee clay. The Clayton formation consists largely of limestone, grading from a hard stone to unconsolidated sandy limestone and calcareous sand. The name is derived from the town of Clayton, in Barbour County, near which it is admirably exposed. The Sucarnoochee clay[3] takes its name from Sucarnoochee Creek, in Sumter County, although the most characteristic outcrop is in Black Bluff, on the Tombigbee River below the mouth of Sucarnoochee Creek. This formation is exposed from Butler County westward to the Mississippi State line in Sumter County. East of Butler County the sediments are either missing, overlapped by the Naheola, or represented by clay, but the base is in some places calcareous, making an exact distinction between this formation and the Clayton difficult. Cooke[4] said of this relation:

> The two formations appear to be conformable and were laid down during one epoch in which the deposition of limestone and calcareous clay was succeeded by the deposition of clay, the change taking place first in the west and gradually proceeding eastward. As a result of this the boundary between the two formations transgresses several zones. In other words, the Sucarnoochee clay and the Clayton formation in different areas are partly of the same age.

The Naheola formation[5] derives its name from Naheola Landing on the Tombigbee River. The constituent sands and clays in varying proportions are exposed from the Mississippi State line almost to the Chattahoochee River, although only in the western portion are they fossiliferous. The nonfossiliferous clays and sands of the Chattahoochee River area have not been definitely correlated with the fossiliferous western beds, but as they occupy a similar stratigraphic position they are tentatively considered[6] to be the equivalent of the Naheola on the Tombigbee.

In Georgia the deposits mapped as undivided Midway formation appear to be equivalent to the Clayton formation.[7] The Midway formation has not been definitely recognized northeast of the Ocmulgee Valley.

In the calcareous deposits of the lower Midway two virile races of *Venericardia planicosta* were already established. The present study will be focused upon them and their progress and development through the Eocene (chart 3). The "*Turritella* rock" of Aldrich, 1886 (Clayton formation), at Allenton, Wilcox County, Ala., is the type locality for both *Venericardia mediaplata*, n. sp., and *Venericardia smithii*, but for *V. mediaplata* it is the upper stratigraphic limit of distribution, while for *V. smithii* it is the lower limit. There is thus an overlap in the range of *V. mediaplata*, a characteristic species of the lower fossiliferous Midway, particularly of the limestone, and of *V. smithii*, which is best developed in the higher glauconitic zone. *Venericardia mediaplata* averages about 48 millimeters in width and is characterized by the low, broad outline and flat, close-set ribs, 29 to 31 in a short series, persisting without modification to the ventral border. The beaks are not well preserved, but there is no perceptible trace of serration or lateral ridging. The posterior area is well defined both by the angulation of the whorl and by the narrower cordlike ribs. The

[2] Langdon, D. W., Jr., Variations in the Cretaceous and Tertiary strata of Alabama: Geol. Soc. America Bull., vol. 2, p. 594, 1891. Smith, E. A., Langdon, D. W., Jr., and Johnson, L. C., Report on the geology of the Coastal Plain of Alabama, p. 192, Alabama Geol. Survey, 1894.

[3] Smith, E. A., Sketch of the geology of Alabama, p. 28, Birmingham, Roberts & Son, 1892.

[4] Cooke, C. W., Geology of Alabama; The Cenozoic formations: Alabama Geol. Survey Special Rept. 14, p. 255, 1926.

[5] Smith, E. A., and Johnson, L. C., op. cit. (Geol. Survey Bull. 43), p. 57.

[6] Cooke, C. W., op. cit., p. 257.

[7] Cooke, C. W., oral statement.

hinge plate is broad and low, adequate though not conspicuously heavy. Harris [8] figured an excellent specimen of this species from the basal limestone at the old river landing on the Chattahoochee River at Fort Gaines, Ga. The species has not been recognized north of Marshallville, Macon County, Ga.

Venericardia smithii indicates in the rudely quadrate inflated outline and the ridged serrate ribs a closer relationship to the *V. alticostata* group than that shown in *Venericardia mediaplata*. The characters to be noted in *V. smithii* are the rather small and not very heavy, highly inflated valves, the rather obscure definition of the posterior area, the numerous (30 to 33) very high and narrow ribs with serrate crests, and the narrow hinge plate. The species is represented in the lower Midway from Wilcox County, Ala., eastward to Ellaville, Schley County, Ga. A single mold of the interior of the double valves of a similar *Venericardia* a little more than 50 mm high and almost equally wide and 40 mm in diameter was recovered by Cooke and Stephenson from the Hornerstown marl of New Jersey, which they consider to be of Wilcox age.

Venericardia antiquata Whitfield, from the Shark River marl, is a compressed rounded trigonal species 20 to 25 millimeters in height and width, suggesting in its outline the *Venericardia rotunda* group. The ribs are crested and sharply serrate, with well-developed lateral terracing, and the affinities of the species are probably with the smaller species of *Venericardia* of the middle Eocene faunas rather than with those of the lower Eocene.

West of the Alabama line the Midway outcrops occupy a wide belt extending through Mississippi northward across Tennessee and the extreme southwestern tip of Kentucky. The Clayton, the lowest of the three Midway formations in the Alabama section, is definitely recognizable and the name has been adopted both in Mississippi and in Tennessee.[9] The overlying clays and sandy clays, the Porters Creek, have not yet been studied in great detail. Many of the older reports include in the Porters Creek both deposits of lower and upper Midway ages, but the typical Porters Creek clay is similar to the Wills Point of Texas and is of upper Midway age.

The Clayton is rather poorly developed in the Mississippi outcrops, but it unconformably overlies the Owl Creek formation at the type locality on Owl Creek. The reconnaissance geologic map of Mississippi [10] represents it as outcropping discontinuously in Kemper and Noxubee Counties and continuously, in a north-south belt about 3 miles wide, from Houston, in Chickasaw County, to the State line, about 75 miles to the north. Lowe [11] reports a very pure basal limestone overlain by sandy glauconitic marl and micaceous sands, carrying fossils in considerable abundance locally but very poorly preserved. The fauna contains several species not reported from the Clayton of Alabama but present in the Midway of Texas. Superimposed upon the Clayton is the Porters Creek clay, typically an unctuous gray joint clay, very fine grained and slightly micaceous, breaking with a conchoidal fracture and exfoliating as it dries. Locally it is lignitic or sandy and thin-bedded and exceedingly difficult to separate from the overlying Wilcox. Fossils are rare, and it is probable that many of the species reported in the earlier observations from the Porters Creek came from the Clayton formation beneath. The name was proposed by Safford [12] for a clay which "has the usual characters, contains mica scales, is dark when wet and whitish gray when dry." He also observes that "I have met with hard layers (rocks) in this series containing shells, but as yet have found no determinable ones."[13] It is probable that the "hard layers" are properly referable to the Clayton rather than to the present conception of Porters Creek. Plant remains have been recorded from a few localities. At or near the top of the Porters Creek in northern Mississippi is the Tippah sandstone member, interpreted by Lowe as representing "a period of shallow, turbulent, swift-flowing water bearing great quantities of coarse sand."[14]

Good fossil localities are rare both in Mississippi and in Tennessee. In Mississippi, from beds of Midway age near New Albany, Union County, *Venericardia francescae*, n. sp., has been described. It is a very compact little form with a subquadrate outline and relatively few but prominent radials. *V. francescae* is known only from the holotype. *Venericardia mediaplata* has been recognized in the Clayton near Ripley, and it is possibly present at a similar horizon in Tennessee.

Venericardia hijuana, n. sp., is described from the vicinity of Middleton, in Hardeman County, Tenn. The umbonal region is broadly inflated, the ventral and posterior margins are flattened, and there is a distinct sculptural break between the disk and the posterior region. The radial sculpture is very characteristic, the simple juvenile ribbing followed by the laterally ridged adolescent costae and these in turn succeeded by a return to the simple ribbing in the adult portion of the shell. This form seems most closely allied to *V. jewelli*, from southern Texas.

An internal mold of a large *Venericardia* probably related closely to *V. smithii* was recovered from the Tippah sandstone member exposed 2½ miles south-

[8] Harris, G. D., The Midway stage: Bull. Am. Paleontology, vol. 1, no. 4, pl. 4, fig. 13, 1896.

[9] Roberts, J. K., Tertiary stratigraphy of west Tennessee: Geol. Soc. America Bull., vol. 39, p. 436, 1928.

[10] Stephenson, L. W., Logan, W. N., and Waring, G. A., The ground-water resources of Mississippi: U. S. Geol. Survey Water-Supply Paper 576, geologic map, 1928.

[11] Lowe, E. N., Coastal Plain stratigraphy of Mississippi. Midway and Wilcox groups: Mississippi Geol. Survey Bull. 25, pt. 1, p. 3, 1933.

[12] Safford, J. M., On the Cretaceous and superior formations of west Tennessee: Am. Jour. Sci., 2d ser., vol. 37, pp. 361, 368, 1864.

[13] Idem, p. 369.

[14] Lowe, E. N., op. cit., p. 4, 1933.

southwest of Walnut, Tippah County, Miss. Similar molds were collected east of Bolivar, north and west of Crainesville, and near Middleton, Hardeman County, Tenn.

No venericards are reported among the few impressions in the clays from the vicinity of Paducah, McCracken County, Ky. The beds were referred by Roberts [15] to the Porters Creek, because of their field relations and their characteristic lithology.

Overlying the Porters Creek clay of Mississippi is a wide band of nonfossiliferous sediments known as the Ackerman formation. This series of cross-bedded sands and lignite were correlated by Cooke [16] in 1925 with the Nanafalia formation (basal Wilcox) of Alabama. In his later discussion of the formation,[17] however, he postulated a correlation of the Ackerman formation with the Coal Bluff beds, placed by Smith,[18] Langdon,[19] and Brantley,[20] at the base of the Nanafalia formation of Alabama.

Cooke [21] in 1926 followed Smith [22] in giving the Nanafalia formation a threefold division, but in 1933 he stated: "I followed Smith's threefold division of the Nanafalia formation in the 'Geology of Alabama,' although I suspected that the lower member [†Coal Bluff beds [23]] does not logically form part of the Nanafalia." Adams [24] thought that the †Coal Bluff stratum could not be properly included in the Nanafalia, and he found that the beds could be traced westward across the Alabama-Mississippi State line into the Ackerman formation.

The general lithology and field relations of the Porters Creek clay and the Ackerman formation are strongly reminiscent of the Wills Point formation and the upper sand exposed near New Hope, Tex. There is, unfortunately, no faunal evidence to sustain the argument.

The west side of the Mississippi embayment has been the scene of an uncommonly interesting series of recent observations and collections. Greenish glauconitic clays carrying molds of marine shells were discovered and collected by F. E. Matthes in Crowleys Ridge, near Ardeola, Stoddard County, Mo., in the course of his geomorphologic studies of the lower Mississippi Valley, and an additional collection was made by W. Farrar, of the Missouri Geological Survey and Water Resources. The fauna was reported to be lower Midway with mechanically introduced Cretaceous fossils (identified by L. W. Stephenson). Further investigations by Stephenson, of the Geological Survey, in company with W. Farrar and H. S. McQueen, of the Missouri Bureau of Geology and Mines, revealed the Owl Creek clayey sand underlying the glauconitic clays. Still further investigations disclosed above the glauconitic bed some 35 to 40 feet of gray clay, apparently barren and referred to the Porters Creek. Two species of venericards are included in the small fauna from the glauconite bed of probable Clayton age. These are small internal molds, less than a centimeter in width and similar in a general way to those found north of Cumby, in Hopkins County, Tex., and south of Greenville, in Hunt County, Tex. There are also fragments of a larger form with relatively few and wide tripartite ribs separated by linear interspaces. The crests of the ribs are sharply defined and strongly and evenly nodose. No relationship to any member of the *V. planicosta* group is indicated, but it is hoped that future collections may include some representative of the widespread group. It may not seem irrelevant to repeat Matthes' observations: [25]

> This simple conception of the structure of Crowleys Ridge is, of course, in harmony with the general conception of the arrangement of the Cretaceous and Tertiary strata in the Mississippi embayment in the form of a spoon-shaped geosyncline, the beds all dipping gently from the periphery inward, disturbed only by minor flexures. The eastern half of the geosyncline very probably has a simple spoon-shaped structure, to judge from the concentric arrangement of the outcrops, more especially of the Upper Cretaceous formations, which form the outer border. These formations crop out in an almost continuous belt extending northward through Mississippi and Tennessee and curving northwestward through Kentucky and westward and southwestward through southern Illinois. The western half of the geosyncline, however, is decidedly more irregular. This fact was already somewhat evident from the varying depths at which the Cretaceous has been reported in deep wells, but it is now suddenly made conspicuous by the discovery of Ripley and overlying Clayton beds in Crowleys Ridge at a height of 160 feet above the plain of the Mississippi.

In Arkansas the lower Midway limestone forms a prominent topographic feature along the western margin of the Coastal Plain. The outcrop occupies a narrow and interrupted belt in southeastern Independence County, western Jackson County, and northeastern White County, and from Little Rock southwestward through Pulaski and Saline Counties nearly to Rockport, in Hot Springs County. The limestone is, locally at least, highly fossiliferous, but the shells are not preserved, and *Venericardia* is indicated in our collections only by specifically indeterminate molds. In southwestern Arkansas the expression of the Midway is quite different. The basal beds in Nevada and Hempstead Counties are highly glauconitic, frequently

[15] Roberts, J. K., Cenozoic fauna and flora: Kentucky Geol. Survey ser. 6, vol. 36, p. 412, 1931.

[16] Cooke, C. W., Correlation of the Eocene formations in Mississippi and Alabama: U. S. Geol. Survey Prof. Paper 140, pp. 133, 134, 1925.

[17] Cooke, C. W., Ackerman formation in Alabama: Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 2, pp. 192–195, 1933.

[18] Smith, E. A., Report on the geology of the Coastal Plain of Alabama, p. 170, Alabama Geol. Survey, 1894.

[19] Langdon, D. W., Jr., in Smith, E. A., op. cit. p. 421.

[20] Brantley, J. E., Petroleum possibilities of Alabama, pt. 2, Southern Alabama: Alabama Geol. Survey Bull. 22, p. 149, 1920.

[21] Cooke, C. W., Geology of Alabama; The Cenozoic formations: Alabama Geol Survey Spec. Rept. 14, p. 258, 1926.

[22] Smith, E. A., op cit., p. 170.

[23] A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in the publications of the Geological Survey.

[24] Adams, G. I., quoted by Cooke in 1933 from an unpublished manuscript submitted to him just prior to the death of Professor Adams.

[25] Matthes, F. E., Cretaceous sediments in Crowleys Ridge, southeastern Missouri: Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 8, p. 1006, 1933.

phosphatic, soft dirty chalks or sandy clays, abounding in Foraminifera. Molluscan remains, however, are uncommon and where present, imperfectly preserved. Hull [26] reports a *Venericardia*, determined by H. V. Howe, from a locality 3 miles north of Emmet, in Nevada County. The Wills Point formation (upper Midway) extends from northeastern Texas into Arkansas, but no determinable molluscan remains have been reported from the Arkansas outcrops. In Louisiana the Midway is exposed only by doming, and no venericards from the few exposures of this sort have been recorded.

Two formations of the Midway group have been recognized in Texas. The Kincaid, outcropping, with some interruptions, from Hopkins County to the Rio Grande, includes a series of basal glauconitic and fossiliferous sands and clays, calcareous glauconitic sands characteristically indurated with a calcareous cement, and highly fossiliferous loosely indurated sands similar both lithologically and faunally to the Clayton, with which they are probably synchronous, and the Wills Point formation, which crops out less conspicuously but more persistently from the Arkansas line to the Rio Grande. The name "Basal or Wills Point clays" was introduced by Penrose [27] in 1890 to cover the entire Midway section. His description, written 40-odd years ago, is still adequate:

> 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 nonfossiliferous limestone, the latter much cut up by veins of brown crystalline calcite and varying in size from a few inches to 6 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.

Although the formations and members of the Midway in Texas are fairly constant in general character, the lithologic and faunal variations are sufficiently great to preclude any assumption of the existence in the Midway epoch of an unbroken shore line, especially during early Midway time. Streams much like those of the present day were probably existent during the Tertiary and may have formed barriers, possibly of fresh water, between the faunal provinces. In all the Tertiary deposits a marked change in the character of the sediments and in the contained fauna is coincident with the change in strike of the outcrops south of San Antonio. The general conditions of sedimentation were probably the same in southern Texas and in Limestone County, but there was no direct communication between the embayments. The species common to both faunas are pelagic forms such as the Bryozoa, or forms that pass through a pelagic larval stage, or cosmopolitan types. None of the heavy-shelled in-shore 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.

The invading sea apparently entered the Rio Grande embayment from the south and east and withdrew in the same direction. Certainly the Midway section in Mexico is enormously thickened and includes Midway both lower and higher than any recognized in southern Texas. Although the Rio Grande section may be thinned by overlap, the wells on the Farias ranch, near the Dimmit-Maverick County line, revealed only 300 feet of Midway, and those drilled along the same structural feature farther east less than 200 feet, while the Mexican Midway probably exceeds 1,500 feet in thickness.

One of the most striking features of the Kincaid faunas is the abrupt appearance of the *Venericardia*. Only feebly foreshadowed in the Late Cretaceous of the western Gulf, the two major groups of probably the dominant genus in the Eocene pelecypods are represented in the limestone by eight described species and several other species too imperfectly represented to name. Among these, four are peculiar to the Rio Grande embayment, all of them coarse, heavy-shelled forms suggesting in-shore waters.

Venericardia mediaplata has a meager representation in the Kincaid formation through Texas to the Rio Grande. *V. smithii* is widely distributed, both in the Kincaid formation and in the Wills Point formation, and is locally abundant from Kaufman County, Tex., south to the Rio Grande. A float specimen carrying a fine example of *V. smithii* was picked up on the Mexican side.

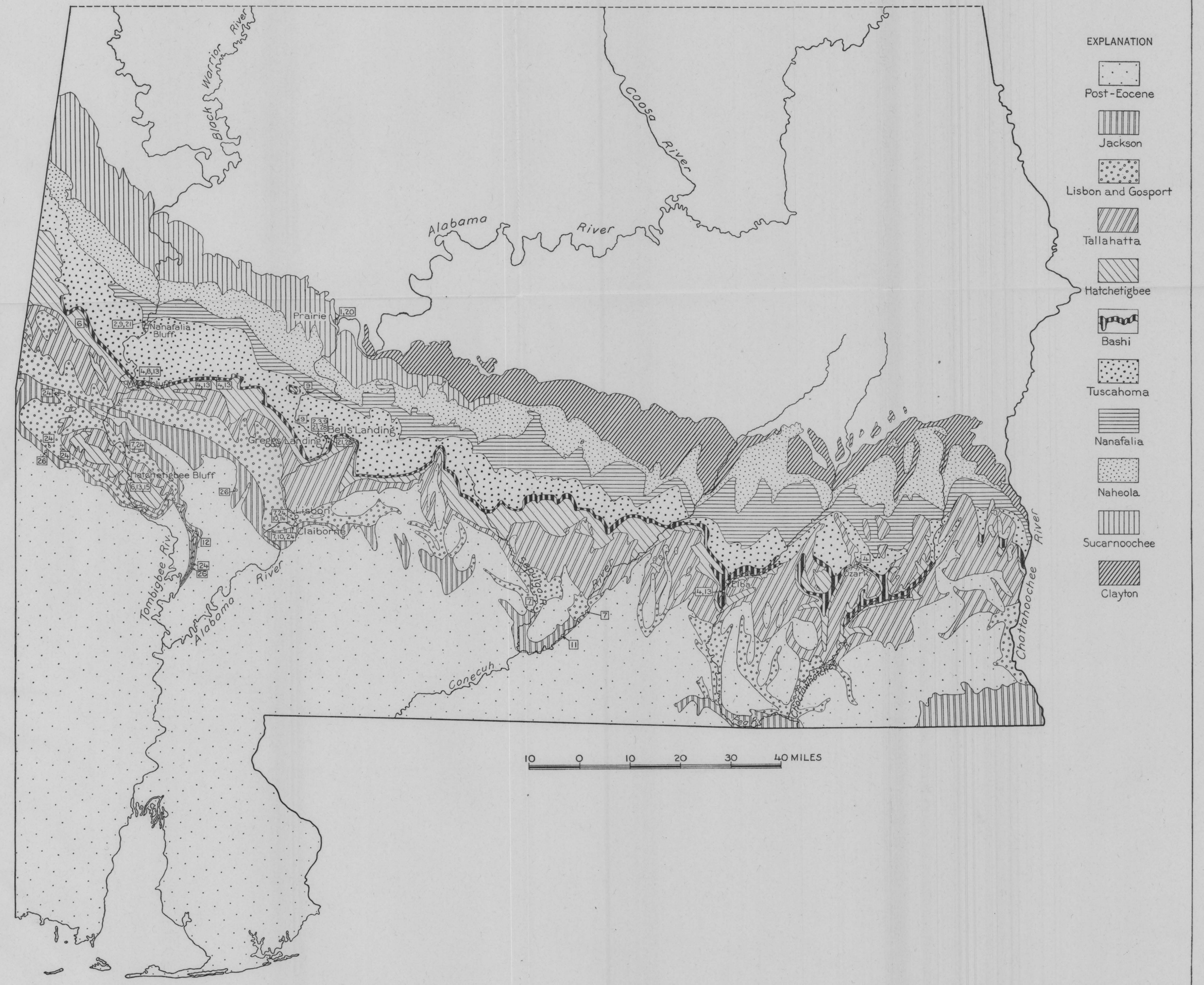
In addition to these two major races of *Venericardia* in the Gulf and Rio Grande Midway, we have recorded other species of doubtful relationships. These are all of local occurrence, *V. smithii* and *V. mediaplata* being the only members of the basal Eocene faunas that are at all cosmopolitan in their distribution.

Venericardia moa is present in the Kincaid of Maverick County, Tex. This form is probably closer to the *V. alticostata* group than to the *V. planicosta* group, but it is included in this discussion because of the possibility of its constituting a link between the two major races of the east American Eocene venericards. The radials number about 19 and are tripartite, the large central riblet being bordered on each side by a smaller riblet. This tripartite condition of the ribs is much more characteristic of the *alticostata* group, but the few ribs, their rather low serrations, and the lack of strong inflation, especially in the umbonal region, suggest a fairly close relationship to the *planicosta* group.

Venericardia hesperia Gardner, from the Kincaid of

[26] Hull, J. P. D., Guide notes on the Midway in southwestern Arkansas: Am. Assoc. Petroleum Geologists Bull., vol. 9, p. 169, 1925.

[27] Penrose, R. A. F., Jr., Preliminary report on the geology of the Gulf Tertiary of Texas: Texas Geol. Survey 1st Ann. Rept., pp. 19–22, 1890. Kennedy, W. A., A section from Terrell, Kaufman County, to Sabine Pass, on the Gulf of Mexico: Texas Geol. Survey 3d Ann. Rept., p. 49, 1892. Deussen, Alexander, Geology and underground waters of the southeastern part of the Texas Coastal Plain: U. S. Geol. Survey Water-Supply Paper 335, pp. 36–37, 1914; Geology of the Coastal Plain of Texas west of Brazos River: U. S. Geol. Survey Prof. Paper 126, p. 40, 1924.



THE OCCURRENCE OF SPECIES OF THE VENERICARDIA PLANICOSTA GROUP IN THE EOCENE OF ALABAMA.

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Medina and Uvalde Counties, is a rather close approach to some of the higher variants of *V. moa*. *V. hesperia* is, however, decidedly larger, much more inflated, and less produced posteriorly. This species is probably another link in the chain of venericards that flourished in the lower Midway but that became extinct with the changing ecologic conditions of the upper Midway.

Venericardia jewelli, also from the Kincaid formation, may be related to the Tennessee form *V. hijuana*. *V. jewelli* is characterized by a marked flattening of the shell toward the ventral margin by the few broad, simple radials, and by an absence of any well-defined sculpture on the posterior area. Some molds of *V. hijuana* suggest a relationship with the Texan species much better than the shells themselves. In both species the posterior region has very feeble sculpture, and the general outline of the shells of the two forms is similar.

A trace of the early Midway faunas has been noted by Miss Maury [28] in the Soldado Rock, off the extreme southwest corner of Trinidad, and by Harris [29] in the Marac quarry, on the island of Trinidad, and possibly 2 miles southeast of Poonah, Trinidad. Both the *planicosta* and the *alticostata* groups are apparently represented in these faunas, but from the figures they cannot be determined more definitely. Rutsch [29a] records *Venericardia parinensis* Olsson of the Peruvian lower Eocene from the Marac Quarry.

Liddle [30] has recorded "*Venericardia planicosta*" from the basal Eocene at many Venezuelan localities, often in association with "*Turritella mortoni*." In the absence of figures, it is impossible to be sure of the identity of the shells so named, but it is very possible that the early Eocene beds outcropping in Trinidad are present in Toas, on the mainland. The one species of *Venericardia* that we have seen from Venezuela is new but has more in common with those of the lower Eocene than with those of the upper Eocene.

The correlation of the mainland deposits in Brazil and Argentina is still in the controversial stage. Our single species, *Venericardia austroplata*, from the generalized locality Point Malaspina, cannot be correlated closely with any of the North American forms, but it suggests a middle Eocene stage of development rather than a lower stage.

The microfaunas and macrofaunas are to a certain extent mutually exclusive. In the Wills Point, from which so fine a foraminiferal fauna has been described, the Mollusca are for the most part rare and little more than a greatly reduced Kincaid fauna. This relation to the Kincaid fauna is no doubt due in part to the restriction of the known molluscan fauna of the Wills Point virtually to the glauconitic clays directly above the contact and in part to the scarcity of mollusks in the higher beds. With the apparent shallowing of the seas and the finer sedimentation in middle and late Wills Point time, living conditions may have become more difficult for the mollusks. Whatever may have been the retarding factors, molluscan remains are exceedingly rare. The record of the very late Wills Point faunas is less incomplete, but no venericards are included in the fauna from New Hope, in Freestone County, Tex.

WILCOX GROUP

A discussion of the orogenic movements associated with the depression of the Gulf of Mexico and with the Sabine uplift may seem rather irrelevant to a description of the development of the *Venericardia planicosta* group; but it is a relevant fact that, whatever the cause, there is a marked increase in complexity in Tertiary sedimentation in passing from the east to the west. The Alabama area, the site of such intense activity during the Paleozoic era, was relatively quiescent during Tertiary time, and the Eocene formations were laid down in more orderly sequence and now exhibit relatively uniform lithology, dip, and width of outcrop. On the west side of the Mississippi embayment, however, there is a conspicuous lack of uniformity in materials, thickness, dip, and width of outcrop. Moody,[31] in his stratigraphic history of the Eocene of Louisiana and contiguous territory, has stressed the variation in the thickness of the Wilcox sediments and their close correlation with the structure. His contour map [32] of the thickness of the Wilcox sediments from Texas to Alabama also records the anticlinal and synclinal areas. The nomenclature accepted for the Wilcox section in Alabama will be followed here, because that was the first to be studied with care, and although the Wilcox group in this section is thin, it includes the most important marine deposits that are known north of the Mexican border. Along the Atlantic seaboard in Georgia the shore line was advanced beyond the Midway strand and the marine sediments buried beneath the later nonmarine deposits. The head of the Mississippi embayment was also silting up during this epoch, and in Mississippi, as in Georgia and west of the embayment in Louisiana, the Wilcox is for the most part nonmarine; in Texas the marine beds were only locally developed, for the most part at the beginning and near the end of Wilcox time. South of the border, in Mexico, a superb section, in part marine, in part nonmarine, is strikingly exposed.

The Wilcox of Alabama has a fourfold, or, if the nonmarine Ackerman formation and the Salt Mountain

[28] Maury, C. J., A contribution to the paleontology of Trinidad: Acad. Nat. Sci. Philadelphia Jour., 2d ser., vol. 15, pp. 28–39, 48–53, 57–58, 60–68, 85–102, pls. 5–13, 1912.

[29] Harris, G. D., in Waring, G. A., Notes on the paleontology, in Geology of the Island of Trinidad, B. W. I.: Johns Hopkins Univ. Studies in Geology, no. 7, pp. 99–101, pl. 18, 1926.

[29a] Rutsch, Rolf, Beiträge zur Kenntnis tropisch-amerikanischer Tertiärmollusken, 4, Die stratigraphische Bedeutung der *Venericardia planicosta* und ihrer Verwandten: Eclogae geol. Helvetiae, vol. 29, p. 177, 1936.

[30] Liddle, R. A., The geology of Venezuela and Trinidad, p. 182, 1928.

[31] Moody, C. L., Tertiary history of region of Sabine uplift, La.: Am. Assoc. Petroleum Geologists Bull., vol. 15, no. 5, pp. 531–551; 1 pl., 5 text figs., correlation chart, 1931.

[32] Idem, fig. 1.

limestone are included, a sixfold division. Blanpied [32a] from a study of well logs placed the Salt Mountain limestone in the Wilcox group between the Nanafalia formation and the Tuscahoma sand. Cooke [32b] corroborated this correlation and explained its anomalous position adjacent to the Vicksburg group by upthrusting along the Jackson fault. At the base of the marine Wilcox is the Nanafalia formation, first described by Aldrich [33] as the "Nanafalia and Coal Bluff section." It is significant that the earliest studies of the Alabama Eocene in sections that have long since become classic were inspired by the interest in the fossils that they carried. The Nanafalia fauna is restricted largely to the lower 20 feet of the *Ostrea thirsae* bed, the middle arenaceous member characterized by the small, plump, and relatively smooth oyster that is abundant through the 60 feet of sand. Below the *Ostrea thirsae* reef is the †Coal Bluff bed of Brantley [34] (the Ackerman of Cooke), a series of cross-bedded sands and sandy and lignitic clays, for the most part nonmarine and of debatable age. Above the *Ostrea thirsae* reef are 40 to 50 feet of clays and sandy clays that tend, particularly in west-central Alabama, to indurate into a pseudobuhrstone. The Nanafalia has been traced from Choctaw County on the western line eastward to the Chattahoochee River, where, in the bluff at Fort Gaines, *Ostrea thirsae* beds overlie the Clayton formation. *O. thirsae* has not, however, been followed beyond Webster County in western Georgia. The synchronous deposits in Mississippi are nonmarine, but *Ostrea thirsae* has been found near Marthaville, La., on the southern side of the Sabine uplift, possibly also near the border southeast of Eagle Pass and on the Mexican side of the Rio Grande. Marine sedimentation in the lower Eocene was apparently unbroken in northern Mexico, but there are no venericards associated with the abundant *Ostrea* which so closely resemble *O. thirsae*. All along the ancient Gulf shore line a deeper-water fauna must have been developing contemporaneously with the *Ostrea* fauna, but only at a few localities is it recorded, notably at Nanafalia Bluff, on the Tombigbee River, the type locality for the formation.

Three species of the *Venericardia planicosta* group have been recognized in the glauconitic shell marl overlying the *Ostrea thirsae* beds at Nanafalia Landing. The possible descendant of *Venericardia mediaplata* of the lower Midway is *Venericardia nanaplata*, n. sp., a species similar in dimensions and outline to the Midway form, though rather more compressed. The general type of ribbing is the same in both, although the ribs of *V. mediaplata* are more numerous by four or five and consequently more closely spaced. The umbonal sculpture in the Nanafalia form is apparently not so simple as that of the Midway species, but nodes at the intersections of the ribs and the growth lines are, for the most part, restricted to the five or six anterior and the three or four posterior ribs. There is also a stronger tendency in the Nanafalia species toward disappearance of the ribs near the ventral margin and a higher, heavier hinge.

Venericardia aposmithii, the form figured under the Greek letter beta in Harris' discussion of the †Lignitic faunas,[35] is in its early stages a replica of *Venericardia smithii*, its probable progenitor. The tips of the umbones are serrated like those of *V. smithii*, but at a later growth stage, in *V. aposmithii*, lateral ridges are developed which unfortunately are not clearly shown in the Harris figure. The type of *V. smithii* shows nothing of the sort—only high, acutely V-shaped ridges cresting the ribs. The number of ribs in *aposmithii* runs 28 to 36, the highest of all the members of the *smithii* stock. The hinge plate is adjusted to the high, heavy shell, and the heavy right cardinal is a scimitar in shape. A third species, *Venericardia pilsbryi*, on which Stewart founded his *Leuroactis*, may have arisen from some remote *mediaplata* radical, but the relationships are by no means certain. In any case, *V. pilsbryi* is an uncommonly well characterized species, with compressed beaks and narrow hinge plate, with a rib count running as high as 39, and with these numerous ribs separated by linear interspaces.

The faunal integrity of the lower Wilcox is indicated by the continuation into the Tuscahoma of each of the three Nanafalia species of venericards. They are, however, restricted in their known distribution to Alabama.

The Tuscahoma sand, described by Langdon [36] from Tuscahoma Landing, on the Tombigbee River, is a series of shallow-water sands and sandy clays, in large part nonmarine, extending entirely across the State and including the two classic outcrops at Greggs and Bells Landings on the Alabama River. These two marl beds have received member names, and in the early sections taken at Bells Landing the Greggs Landing marl was reported to crop out at the water's edge about 25 feet below the Bells Landing marl. In the later sections, however, this member is reported to be concealed. The faunas are very similar, but there are facies differences, and only three out of the five venericards present at Greggs Landing have been recovered from the higher Bells Landing member. The only abundant species common to both is the ponderous *V. aposmithii*, enormously plentiful at both Greggs and Bells Landings but not recognized in the western Gulf.

Although three of the Tuscahoma species were already present in the Nanafalia, there are in the Tuscahoma race modifications not sufficiently marked to be recognized in the taxonomy nor of consistent

[32a] Blanpied, B. W., Guidebook of the Ninth Annual Fieldtrip of the Shreveport Geological Society, p. 9, 1932.

[32b] Cooke, C. W., Notes on the Vicksburg group: Am. Assoc. Petroleum Geologists Bull., vol. 19, no. 8, p. 1163, 1935.

[33] Aldrich, T. H., Alabama Geol. Survey Bull. 1, p. 12, 1886.

[34] Brantley, J. E., Petroleum possibilities of Alabama, part 2, Southern Alabama: Alabama Geol. Survey Bull. 22, p. 148, 1920.

[35] Harris, G. D., The Lignitic stage, pt. 1, Stratigraphy and Pelecypoda: Bull. Am. Paleontology, vol. 2, no. 9, p. 55, pl. 9, fig. 1, 1897.

[36] Langdon, D. W., Jr., Variations in the Cretaceous and Tertiary strata of Alabama: Geol. Soc. America Bull., vol. 2, p. 596, 1891.

value in determining single individuals but of a certain weight in a long series. The rib count in the Tuscahoma *nanaplata* is higher by 2 or 3 than in the Nanafalia, the noding pattern of the umbonal ribs is continued over a greater extent, and there is a much stronger tendency toward the evanescence of the ribs near the ventral margin. There are, however, intermediate forms that would be of no aid in interpreting a stratigraphic section.

One of the most abundant forms in the Tuscahoma sand at Greggs Landing is a small variant of the *nanaplata* race that has been designated *Venericardia nanaplata nanna*. This differs from the true *nanaplata* in the greater number of ribs, smaller size, and more compressed outline.

Venericardia aposmithii from the Tuscahoma is larger, higher, and heavier than the form from the Nanafalia, and the tendency toward the evanescence of the anterior and medial ribs is stronger, but the pattern of the ribbing is similar both on the disk and on the posterior area, and in both the Nanafalia and Tuscahoma individuals the umbones are ridged and serrate and carry at least obscure traces of lateral terracing. The apparent restriction of this form to the Alabama sections may be due to the burial in other regions of the deposits in which it would be preserved, or it may be that Alabama represents the southern and western extension of its range. This is suggested by the prominence of the very similar species *Venericardia regia* Conrad in the probably synchronous greensands of the Aquia formation of Maryland and Virginia. There are differences in the outline and sculpture of *Venericardia aposmithii* and *V. regia* that justify the retention of distinct names for the two forms, but the resemblances are sufficiently striking to suggest a basis for correlation.

Another distinctive descendant of the *smithii* stock at both Greggs and Bells Landings is *Venericardia greggiana* Dall, a species that exhibits a more ornate ribbing than its progenitor in the Midway. This species has a very narrow stratigraphic range, apparently having reached its culmination and extinction in the Tuscahoma sea.

Plant fragments are common throughout the Tuscahoma, and the first recorded deposits of the Bashi formation on the Alabama River are carbonaceous. Thin seams of lignite record continued lagoonal conditions during middle Bashi time, but the 15 to 20 feet of glauconitic marl at the top is packed with the remains of a prolific shallow-water fauna. In this formation, as in the Tuscahoma, the outcrop most renowned faunally is not that which has given an accepted name to the formation. The Bashi, named by Langdon [37] from Bashi Creek, a tributary of the Tombigbee River in northern Clarke County, was best known among the earlier paleontologists as the †Woods Bluff beds, from Woods Bluff, 1 mile in an air line below the mouth of Bashi Creek. The outcrop that has furnished prized material for collections all over the world is now covered by backwater from a recently constructed dam. The marl beds tend to indurate and weather into characteristic pillow-shaped masses of marlstone, by which they can be recognized even in the absence of diagnostic fossils.

Although nonmarine conditions were prevalent in Alabama during a large part of Bashi time, the Bashi marked elsewhere a period of expansion of the Wilcox seas, particularly to the south, and a very considerable change in the make-up of the molluscan faunas. Deposits of Bashi age are recognizable by their venericards from western Georgia to Souwashee Creek and Purdues Cut, south and southeast of Meridian, Miss., and from Sabinetown, on the Texas side of the Sabine River, to northern Nuevo León, Mexico. It is possible that embayments of the Bashi sea existed on the Atlantic side of the mid-Americas and that there were synchronous marine deposits in northern Peru.

Venericards of the *planicosta* group related to those from the Nanafalia and Tuscahoma have been determined from the Bashi, but no identical species have been recognized.

Venericardia bashiplata, n. sp., the dominant representative of the group, is apparently in the direct line of descent from *Venericardia mediaplata* of the lower Midway. The species is generally larger than *V. nanaplata* of the Tuscahoma, the umbones are high and broad, the posterior area is rather obscurely defined, and the ribs are elevated but not ridged upon their summits and show no trace of lateral terracing. The valve with the reversed dentition (pl. 34, fig. 4) is an example of this species. *Venericardia bashiplata* has been recognized near the Alabama line in Stewart County, Ga.; at numerous localities in Alabama; near Meridian, Miss.; on the Texas side of the Sabine River; and in northern Mexico. *Venericardia ascia* of the Nanjemoy of Maryland and Virginia may be a northern relative.

A species commonly associated with *Venericardia bashiplata* but less widely distributed is that figured by Harris [38] under the Greek letter gamma and described by the senior author from Sabinetown, Tex., under the name "*V. horatiana*." The ancestry is rather obscure, though it may perhaps be related to *Venericardia pilsbryi* Stewart, a possible lateral offshoot of *mediaplata* of the early Eocene. The extreme tips of the umbones of *horatiana* show no trace of radial sculpture, only a strong concentric rippling suggesting *Astarte* or *Crassatellites*. Not only are the radials of *horatiana* absent in the initial stages, but they evanesce usually about one-third of the distance from the umbones to the anterior margin of the adult shell. They number no more than 22 to 25 and are separated by

[37] Langdon, D. W., Jr., op. cit., p. 596.

[38] Harris, G. D., Bull. Am. Paleontology, vol. 2, no. 9, p. 55, pl. 10, figs. 1-4, 1897.

linear interradials. There is a probable descendant of *horatiana* in the lower Claiborne, but the Bashi species may be separated from its descendants by the less inflated tips and less pronounced twist of the umbones.

The *V. aposmithii* stock apparently left no direct descendants in the upper Eocene of the eastern Gulf.

Venericardia potapacoensis, from the Nanjemoy of Maryland and Virginia, has no close analog among the described species from the eastern Gulf. The ribbing is tripartite in its early stages, and the form is perhaps more closely related to *V. smithii* than to the *media-plata* stock. The curiously lop-sided outline of *potapacoensis* is shared by the *diga* of northern Mexico.

The end of the Bashi epoch was marked by continued emergence and by a withdrawal of the *planicosta* fauna from much of the Gulf province. Even in Alabama, the Hatchetigbee formation is in large part nonmarine. The type locality for which Langdon [39] named the formation is Hatchetigbee Bluff, on the Tombigbee River, 3 miles south of the Choctaw County line. The fossil-bearing bed is a sandy marl about 5 feet thick underlain by 15 feet of clay and overlain by about 70 feet of clays and sands, some of them marine and sparsely fossiliferous, some of them lignitic. The general color of the clays is brown rather than gray. In the eastern part of the State the outcrop of the Hatchetigbee is interrupted by overlap. To the west it is continued across the State line into Lauderdale County, Miss.

Three species of the *Venericardia planicosta* group are recorded from the shallow Hatchetigbee sea—the abundant *Venericardia hatcheplata*, n. sp., of the simple-ribbed stock; *Venericardia horatiana*, first recorded from the Bashi; and *Venericardia turneri*, n. sp., possibly of the same stock. *Venericardia hatcheplata* possesses more ribs than its probable Bashi ancestor, the outline is usually more cordate, and the hinge plate is higher and heavier. The species is abundantly represented at Hatchetigbee Bluff, but single valves occur only rarely. The hinge teeth are so large and so closely interlocked that they are usually broken in forcing the valves apart. *Venericardia turneri* is a curiously quadrate form with evanescent ribbing, having no known progenitors, descendants, or synchronous related species.

In recapitulation, the intimate relation between the faunal distribution and the distribution of the sea and the land cannot be too strongly stressed. The Wilcox faunas of the eastern Gulf are essentially provincial. They lived and died and were buried in shallow waters that were in some manner and to some degree isolated. Because of the greater interest in the marine beds, attention has been focused largely upon them, and it is easy to be indifferent to the minor role that they fill in a general section that was during Wilcox time, even in Alabama, dominantly nonmarine. Even those beds, such as the Greggs and Bells Landing members of the Tuscahoma, which in western Alabama carry excellent faunas are nonmarine in eastern Mississippi, and indeed the Mississippi Tertiary deposits are in large measure the discharge from an ancestral Mississippi River. The volume of fresh water poured out must have been an important factor in the ecology along the nearby shores, and the in-shore faunas, depending for their continuity upon a moderately stable salinity, led a precarious existence. The struggle in that section was not so much between the sea and the land as between the sea and probably the greatest of the eastern rivers and was carried on along an exceedingly narrow front. A slight advance of the fresh water involved the destruction of the fauna within the restricted area recorded in the sections open to us. Only in the Middle Wilcox is there evidence that the faunas of the eastern Gulf, represented fairly by the venericards, were anything more than faunules segregated in some circumscribed bit of lagoonal shore and not in long-continued direct communication with those of the western Gulf or the Atlantic seaboard. More cosmopolitan assemblages must have been flourishing off shore, but of these we have no record.

[39] Langdon, D. W., Jr., op. cit., p. 597.

CLAIBORNE GROUP

From more than one point of view the Claiborne is the most important of the four Eocene groups. The marine faunas of the Lisbon, the middle formation, mark in many areas the outposts of the transgressive Eocene sea. Barriers, both land and fresh water, which had been in existence since early Eocene time were eliminated and, in sharp contrast to the few late Wilcox faunas recorded, the Lisbon takes on a cosmopolitan air. It is, however, the fauna of a localized lens of sand at the extreme top of the Claiborne that has been world-renowned since the days of the Conrad-Lea struggle for prior publication in the early 1830's. This remarkable sand was trenched by the Alabama River and in recent years has been well exposed at another locality by a highway, so that optimum conditions for collection prevail—indeed, have prevailed since the beginning of geologic investigations in the Gulf Coastal Plain. Both of these justly famous fossiliferous zones may fall within the upper third of the Claiborne section in Alabama. The lower two-thirds of the section is largely nonmarine. A fairly well marked erosion interval is postulated between the Wilcox and the Claiborne, and the Tallahatta formation, at the base of the Claiborne, thins from several hundred feet near the axis of the Mississippi embayment to not more than 20 feet at the Georgia line. It has little to offer in the way of a fauna,[39a] for even the marine phases are made up largely of barren sands. In Alabama the break in the records of life includes not only the break

[39a] Recent investigations indicate that the fauna of the Tallahatta of eastern Alabama is larger than has been commonly supposed.

between the Wilcox and the Claiborne but also most of Tallahatta time.

The Tallahatta buhrstone of Smith [40] was so called from the Tallahatta Hills, in Choctaw County, which owe their existence to the aluminous quartzitic sandstones that make up a large part of the Tallahatta formation. The indurated sands cropping out in northwestward-facing scarps are most prominent in the western part of the State. To the east the beds are not so hard, are more argillaceous, and carry a higher calcareous content. Oysters have been reported from a number of localities but our faunal records from the Tallahatta formation are meager and inconclusive. Smith remarked that "they are always poor in fossils except the microscopic siliceous shells of marine diatoms and Radiolaria." However, glauconite is a fairly rare constituent in Alabama and still rarer in Mississippi. In Mississippi "the prevailing rocks of the Tallahatta formation are white, gray, or cream-colored brittle claystone or diatomaceous earth, interbedded with hard gray sandstone or quartzite. A peculiar breccialike rock composed of patches of claystone enclosed in coarse sandstone is not uncommon."[41] The strike of the Tallahatta swings up the Delta, and in Grenada County the formation is buried beneath the loess. No certainly determinable venericards have been recognized in the Tallahatta.

The succeeding Lisbon formation of Smith was described from Lisbon Bluff on the Alabama River, a few miles above Claiborne.

> Between the Buhrstone and the base of the Gosport sand are the Lisbon beds, consisting of about 115 feet of calcareous clayey sands and sandy clays, generally fossiliferous. The lower half of these beds contains a great number and variety of well-preserved shells; in the upper half the shells of *Ostrea sellaeformis* and several species of *Pecten* greatly preponderate over other forms.[42]

It is interesting that the first definition of the formation so clearly establishes the relationship of the two most characteristic and wide-ranging Lisbon bivalves—*Ostrea sellaeformis* and *Venericardia densata*. Both of these species can be traced westward across Mississippi and Louisiana, through Texas, and well into northern Mexico.

The Lisbon and its time equivalents represent the maximum extension of the Claiborne sea, and the extent of that sea is reflected in the widely distributed faunas, in marked contrast to the provincial aspect of the Hatchetigbee. The abundantly fossiliferous bed both in the Lisbon of Alabama and in the equivalent beds to the west is near the top of the formation as it is exposed along the Alabama River. *Venericardia densata* Conrad, a heavy but rather small species with strong dentition and ribs well noded along the summits and strongly undercut laterally, is the most common venericard in the Lisbon and the most widely recorded. This may be a descendant in the *V. smithii* line. Although intermediate forms have not been observed in the Wilcox of Alabama, they are suggested in forms from the Pendleton Ferry section on the Sabine River, beds probably synchronous with the Tuscahoma. In any case, the stunted look and heavy hinge of *V. densata* suggest an advanced stage of development rather than a new stock. In the long interval between the Tuscahoma and Lisbon epochs, the evolutionary lines were obscured, and with the material available the line of descent is speculative. The simple ribbed stock seems to be represented in the Lisbon by *Venericardia claiboplata*, a higher and more inflated species than *hatcheplata* and of all the American forms, the one most nearly approaching *planicosta* s. s. of the Paris Basin. This stock is characterized in the lower Eocene by simple ribbing, but in some individuals there is a sharp change in direction of the incremental striae along the side of the rib, especially on the anterior surface of the inflated umbonal area. A faintly raised thread may sometimes, even in the lower Eocene forms, be developed along these successive angles in the incremental striae. In the Lisbon species this raised lateral thread is a not uncommon but incidental character, but in the later Gosport it commonly persists from the juvenile serrate stage through the adolescent. The close of the adolescent stage is usually indicated by a prominent resting stage, and the adult ribbing is simple. In *V. densata*, however, the ribbing pattern is uniform and a constant specific character, whereas in *Venericardia claiboplata* there is much more individual variation.

A less conspicuous but well-characterized and widely distributed group is that which is apparently in the line of descent from *Venericardia horatiana* of the upper Wilcox. *V. stewarti*, like its possible progenitor, has been recovered both from the western Alabama sections and from that on the Sabine River. It is not easy to understand why it should be more readily recognizable and separable from *V. horatiana* by its juvenile sculpture than by any adult characters. *Venericardia tonosiensis* from strata of presumable Claiborne age on the Isthmus of Panama, represents a southern extension of the group and is in turn remarkably like *V. pacifica* Olsson, from the Salina formation of northern Peru, a species compared by Stewart to his *V. calafia*, from the Domengine of the Simi Valley of southern California. *Venericardia pilsbryi* may be continued in the rare *V. angustoscrobis* from Lisbon Landing.

The history of the Claiborne north and east of the Alabama section is much more simple than that west and south of it. The characteristic Tallahatta deposits feather out near the Chattahoochee River, and the Gosport sand has been recognized only in western Alabama. The McBean formation, which includes all of the Claiborne of eastern Georgia and South Carolina,

[40] Smith, E. A., Underground water resources of Alabama, p. 17, Alabama Geol. Survey, 1907.

[41] Stephenson, L. W., The ground-water resources of Mississippi: U. S. Geol. Survey Water-Supply Paper 576, p. 50, 1928.

[42] Smith, E. A., Underground water resources of Alabama, p. 18, Alabama Geol. Survey, 1907.

is the approximate equivalent of the Lisbon of Alabama, thus indicating that only during middle Claiborne time was the Atlantic seaboard submerged, and although the sea encroached almost to the Fall Line on the west, to the north it extended only as far as the Santee drainage basin. It is possible that there was also during middle Claiborne time a short marine invasion in east-central New Jersey and that the record is contained in the Shark River marl. The McBean formation, so called from the town of McBean, near the Savannah River in east-central Georgia, was named and defined by Veatch and Stephenson in 1911.[43]

> The formation consists mainly of clays in the nature of fuller's earth, shell marls, sandy limestones, and calcareous glauconitic sands. The marls are for the most part massive-bedded and friable, but hard, compact, and even partially silicified beds were noted on Savannah River. They may also be represented by alternate layers of marl or calcareous sand and laminated clay.

In South Carolina, according to Cooke,[43a] the McBean extends eastward as far as Calhoun County.

The McBean formation, which includes the fossiliferous Claiborne of eastern Georgia, is best developed in the northeastern area of the Tertiary outcrop near the South Carolina line,[43b] and even there very few determinable specimens of the *Venericardia planicosta* group have been recovered. The species most commonly represented, *V. claiboplata*, though rare in Georgia, is abundantly represented in South Carolina, particularly in the vicinity of Orangeburg and of Cawcaw Swamp. These South Carolina venericards show certain constant differences from the Alabama forms, differences which may, however, be unduly exaggerated by the character of preservation in the South Carolina species. The limy shells have been invariably replaced by silica, and certain details in the sculpture have been exaggerated while others have been obscured. However, the umbones are less prominent and less incurved, and the shell as a whole is more compressed in the South Carolina specimens than in those from Alabama; the posterior area is more sharply cut off both by the contour and by the sharper, narrower costals persistent to the margin. The larger individuals show certain senile characters, such as the obsolete anterior and medial ribbing. From *Venericardia hatcheplata*, which some of the larger individuals resemble in both the transverse and the vertical outline of the valves, the South Carolina race is separable by the much more sharply and persistently ribbed posterior area.

The Claiborne and Jackson sedimentation west of the standard Alabama section was more sandy than that to the east and offered on the whole a more favorable environment to the larger bivalves. In Mississippi the succession is similar in a general way to that in Alabama. The Lisbon includes the old †Wautubbee marl, characterized faunally by an abundance of *Ostrea sellaeformis*.

There is no faunal evidence that the Claiborne sea extended up the embayment to the present site of Arkansas, but marine Jackson beds have been recognized as far north as Crowleys Ridge, across the river from Memphis, Tenn. The head of the embayment was silting up in the meantime, and no marine middle or upper Eocene has been recorded from Tennessee or Kentucky.

The available material that covers the *planicosta* group in Louisiana is not representative. In the glauconitic sands of the Cane River,[44] the lowest of the Claiborne deposits in Louisiana, no determinable *planicosta* were observed. The sea, after the slight advance indicated by the Cane River, again withdrew, but in the succeeding lower Claiborne time [45] a marine invasion synchronous with that of the Lisbon of Alabama swept along the east side of the Sabine uplift but did not isolate it. The scattered representation of the two most common Lisbon members of the *planicosta* group, *V. densata* and *V. claiboplata*, reflects the inadequacy of our collections rather than the absence in Louisiana of good fossiliferous outcrops of Cook Mountain (St. Maurice of Spooner). In Texas the distribution of venericards is much more general, both stratigraphically and areally, but we have been disappointed that we have not been able to correlate more closely the wide range of individual variation in *densata*, the most abundant and widely distributed species, with the established sections. In the Rio Grande embayment, on the other hand, possibly because the section thickens and ecologic conditions were less uniform, the variations make much better tools for excavating in the past. In his study of the Lutetian of the Paris Basin, with which the Lisbon is commonly correlated, Abrard[46] believed that he had in *Venericardia planicosta* an exceedingly valuable indicator of a transgressing sea, that the abundant occurrence of the species was evidence of the base of the stage, whether of the lower or of the upper Lutetian, but that he had never found it in the upper Lutetian at a locality in which the lower Lutetian was present—in other words, that it played no part in a recurrence of the fauna.[47] We have no records in the Texas outcrops, at least in those north of the Rio Grande embayment, of such extraordinary abundance as that of *densata* at Lisbon Bluff, nor do we have, except in the Mexican part of the Rio Grande embayment, the association, also reminiscent

[43] Veatch, J. O., and Stephenson, L. W., Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 26, p. 238, 1911.

[43a] Cooke, C. W., Geology of the Coastal Plain of South Carolina: U. S. Geol. Survey Bull. 867, pl. 2, 1936.

[43b] Cooke, C. W., op. cit., pp. 55–72.

[44] Spooner, W. C., Interior salt domes of Louisiana: Am. Assoc. Petroleum Geologists Bull., vol. 10, no. 3, p. 235, 1926.

[45] Harris, G. D., Pelecypods of the St. Maurice and Claiborne stages: Bull. Am. Paleontology, vol. 6, p. 6, 1919.

[46] Abrard, René, Le Lutétien du bassin de Paris, 388 pp., 32 text figs., 4 pls., 4 maps, Angers, 1925.

[47] Idem, p. 210.

of Lisbon Bluff, with *Ostrea sellaeformis*. The lower Claiborne of Texas, which includes the Mount Selman [48] and Cook Mountain,[49] records three major submergences of the land below the salt water. These diastrophic disturbances are involved with the Sabine uplift, and in fact the history of the lower Claiborne in north and east Texas is the story of the loading of the trough to the north and west of the Sabine uplift and the progressive emergence of this trough from the north to the south. The early Claiborne sea lapped the shores of the present Sabine uplift but did not advance over it. North of the uplift the beds are for the most part nonmarine, for that area suffered only two short invasions of the sea—one near the beginning of the Claiborne epoch, the other toward the end of the Mount Selman epoch. The Reklaw [50] is characteristically a coarse, highly oxidized glauconitic sand or a blackish-brown micaceous pyritiferous clay, with or without fine sand and commonly with stringers of glauconite. The coarseness of the glauconite and the high oxidation are evidence of a long-continued period of equilibrium, and along the northern and western margins of the Sabine uplift reworked balls of the Wilcox clays beneath are associated with the contact. The basal contact, especially in northeastern Texas, is coincident with an abrupt change from the relatively low relief of the Wilcox to the more rugged topography of the Claiborne. The Reklaw roughly parallels the Cretaceous-Eocene contact and shares with it the abrupt change in strike. It has been correlated with the lower part of the Cane River of Louisiana and traced south to the latitude of San Antonio and correlated with the Bigford [51] of the Rio Grande embayment. The Reklaw venericards are rare and imperfectly preserved. *V. claiboplata* was identified from a mold of the exterior recovered from the indurated ferruginous sandstones east of the Capote Hills, in Gonzales County. The venericards from northeastern Atascosa County, near Leming, are probably identical with *V. claiboplata*, but they are all juveniles, and the molds are not very sharp. In the locality which has furnished by far the best lower Mount Selman fauna, the section across the river from Upton, on the Colorado in Bastrop County, small gastropods dominate the fauna; the environment was obviously unfavorable to the venericards, and only a few young *V. densata* have been observed. Not even a fragment of a *planicosta* rib was recovered, however, in the extensive collections of marine Bigford material made by James R. Day in Webb County. Both the clays near Upton and those of the Bigford of Webb County indicate soft-bottom lagoonal or in-shore conditions, an ecology unsuited to shells so heavy as those of the large venericards. The Queen City [52] records the accumulation, in the east Texas trough and on the emergent shores, of fine sandy materials, for the most part derivatives from the Wilcox sediments. It is largely nonmarine and rarely fossiliferous.

In southern Texas nonmarine conditions persisted through early Claiborne time at the head of the Rio Grande embayment, but in northern and eastern Texas the so-called East Texas syncline suffered a second early Claiborne invasion, from waters that left their record in the thin, highly ferruginous capping of the Queen City Hills, the northern outpost of the Weches sea.

The Weches,[53] the upper marine beds of the Mount Selman, are the most important beds of the formation in point of thickness and composition, commercially, scenically, and faunally. They carry an extraordinary amount of glauconite, most of it oolitic, which by the leaching out of the potash and the concentration of the iron has been altered to a low-grade but commercially promising iron ore. These indurated and highly resistant ferruginous beds cap the Queen City Hills on the dissected divides in eastern Texas and give rise to the long red slopes so closely associated with the area. The section of more than 200 feet exposed east of the town of Mount Selman, in Cherokee County, is not excelled in the Claiborne of Texas. The Weches thickens abruptly in the latitude of Henderson, Rusk County, both on the Texas side of the Sabine uplift and, to a lesser degree, on the western margin of the bordering syncline. Though the formation ranges in thickness from 5 feet on the northern flank of the uplift to almost 400 feet on the southern flank, the general character of the sediments remains the same—a ferruginous sandstone, commonly oolitic and glauconitic, with occasional lenses and stringers of intercalated clays—a shallow-water deposit laid down for the most part south of the uplift on a sinking bottom. South of the Colorado River the Weches is not so well individualized, and in the Rio Grande embayment it is largely estuarine and lagoonal. On the Mexican border the Mount Selman is largely a gypsiferous clay with interbedded sands and sandstones and a few thin lenses of gray concretionary limestone, and the sequence comprehends over 1,150 feet in maximum thickness.

A few poorly preserved Mollusca, but no venericards, have been collected in Webb County directly above the Bigford. The Mount Selman is for the most part nonmarine on the Texas side of the Rio Grande embayment, but in northern Mexico *V. densata* may be present. The Mexican material, though fairly abundant, is poorly preserved and inconclusive. Molluscan imprints are common in the eastern Texas iron ores, but well-preserved shells have been recovered only from

[48] Kennedy, William, Texas Geol. Survey 3d Ann. Rept., pp. 52–54, 1892.
[49] Idem, pp. 54–57.
[50] Wendlandt, E. A., and Knebel, G. M., Lower Claiborne of east Texas, etc.: Am. Assoc. Petroleum Geologists Bull., vol. 13, p. 1352, October 1929.
[51] Trowbridge, A. C., A geological reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131-D, p. 92, 1923.
[52] Kennedy, William, Texas Geol. Survey 3d Ann. Rept., p. 50, 1892.
[53] Wendlandt, E. A., and Knebel, G. M., op. cit., p. 1356.

the softer unindurated layers, notably in San Augustine and Nacogdoches Counties and at Smithville, on the Colorado. Both *Venericardia densata* and *V. claiboplata* have a scattered representation in the greensands from the Sabine to the Colorado and, though widely distributed, are nowhere conspicuously abundant. The shells of both species are relatively thin and not large. The Weches epoch was followed by a short emergent period in which the Sparta sand,[54] probably in large part a derivative of the Carrizo and Queen City, was deposited by wind and stream action and rolled along by the advancing waves of the Cook Mountain sea. The Sparta has a more limited extent than the Queen City—largely, perhaps, because it is a loose sand, readily blown by the wind, over which no protective cover has been laid down and which has suffered greatly from the destructive forces of erosion. It has not been followed beyond eastern Atascosa County, and it carries no established record of marine life.

By the beginning of Cook Mountain time the emergence of the former East Texas syncline had so far progressed that the Cook Mountain sea did not enter it; at least, no trace of the Cook Mountain[55] has yet been observed north of the somewhat inadequate type locality, Cook Mountain, 2 miles west of Crockett, in Houston County. Marine deposits of Cook Mountain age flank the south side of the Sabine uplift, however, and extend westward along the normal line of outcrop to the Rio Grande and into Mexico. The glauconitic sands and marls, which make up a large part of the formation, both in the Brazos River and Wheelock outcrops and in the breaks of the Rio Grande, have furnished paleontologic type specimens for most of those who were working during the early years on the Tertiary beds of Texas. Many of Gabb's types, and quite possibly Conrad's *Venericardia moorei*, came from the vicinity of Wheelock, in Robertson County. Those described in the Southern Pacific Railroad reports by Conrad came from the glauconitic sandstone below Laredo. *Ostrea sellaeformis* has been observed in a reef outcrop only at Stone City, although there is no obvious reason why the depositional conditions of the Cook Mountain, particularly of the Rio Grande section, should not have been favorable for oyster growth. In Mexico *Ostrea sellaeformis* is found in abundance. *Venericardia claiboplata* has not been recorded from the Cook Mountain in Texas, although it is probably present in northern Mexico. Specimens of *V. densata* indistinguishable from those recovered from the Weches of Anderson and Houston Counties are not uncommon at Wheelock and Moseleys Ferry, on the Brazos. Both at Wheelock and at Moseleys Ferry small gastropods are particularly abundant, and the relationship of the Claiborne faunas at these localities to the faunas above and below them have been greatly clarified by the careful study of Renick and Stenzel.[56] The common *V. densata* of the Rio Grande section is larger, more trigonal, more compressed, and resembles more closely the *densata* from Lisbon Landing than those from the Weches. In both the Brazos and the Rio Grande sections the occurrence of *densata* is apparently restricted to the lower half of the Cook Mountain, so that the differences between the forms from the Cook Mountain and from the Weches probably indicate two basins of deposition, each isolated from the other by a barrier that was at least intermittently effective. The Brazos River embayment seems to have been the greater loser by the isolation, for the Cook Mountain fauna of that area is more remote from the faunas of the eastern Gulf and more largely a development in place from the Weches fauna. No venericards except those present in the Weches have been reported even in the high Cook Mountain of the Brazos, while in the Rio Grande embayment two and possibly three new venericards are present in the later Cook Mountain sandstones. Both *V. zapatai* and a small unnamed variant, also from Zapata County, Tex., are related to *V. densata*, but *V. cacamai* more probably sprang from the *claiboplata* stock. There is not yet any record of any member of the *V. horatiana* group in the Rio Grande embayment, although it is represented on the Isthmus of Panama. In Chiapas, Mexico, less than 10 miles behind the mountain front, a fauna extraordinarily similar to that of the Simi Valley of southern California is clearly recorded. A north Peruvian fauna includes a *Venericardia pacifica* closely approaching *V. tonosiensis*. A California species, *V. calafia* Stewart, also from the Simi Valley, was considered comparable with *V. pacifica* by Stewart. The eastern shore line of South America, however, had apparently emerged, for no marine Claiborne fauna is recorded in Brazil or Argentina. The *Venericardia planicosta* reported by Liddle[57] from local limestone lenses of the Misoa-Trujillo formation in both eastern and western Venezuela suggests the lower Eocene rather than the middle.

The Gosport[75a] was described by Smith as the Gosport greensand. It seems particularly fortunate that the man whose name was so long and so honorably associated with the State of Alabama should be the author of the best-known Alabama Tertiary formation.

This division, which, so far as yet known, does not appear in any other of the Gulf States, embraces the strata of Claiborne group lying between the top of the Lisbon and the base of the St. Stephens. The beds are in general highly glauconitic sands about 30 feet in thickness at the Claiborne and Gosport Bluffs

[54] Vaughan, T. W., A brief contribution to the geology and paleontology of north western Louisiana: U. S. Geol. Survey Bull. 142, pp. 25, 26, 1896.

[55] Kennedy, William, op. cit., pp. 54–57, 1892.

[56] Renick, B. C., and Stenzel, H. B., The lower Claiborne on the Brazos River, Texas: Texas Univ. Bull. 3101, pp. 73–108, 1931. Stenzel, H. B., A new formation in the Claiborne group: Texas Univ. Bull. 3501, pp. 267–279, 1936.

[57] Liddle, R. A., The geology of Venezuela and Trinidad, p. 182, 1928.

[75a] Shown by latest work of C. W. Cooke to be a facies of the Moodys marl.

and include the fossiliferous greensands which have made the name Claiborne famous and which have furnished the greater part of the Claiborne fossils described and figured by Conrad and Lea. While this division, as above mentioned, is not known in Mississippi, Louisiana, or Texas, yet its importance in Alabama, from the historical point of view and because of the great number and variety and beautiful state of preservation of its fossils, is such as to compel mention and a distinct name. * * * The name is from Gosport, a landing on the Alabama River a few miles below the Claiborne Bluff.[58]

The upper Claiborne fauna is remarkable for the abundance and diversity of the smaller gastropods. The environment was not, however, particularly favorable to the venericards, and their representation is relatively unimportant.

The only member of the *planicosta* group clearly recorded from the Gosport sand is a form so closely allied to *V. claiboplata* that it does not seem reasonable to recognize differences so inconsequential in taxonomy. It is notable, however, that the tendency toward a lateral threading in the youthful stages is a character much more fixed in the Gosport individuals than in those from the Lisbon. Upper Claiborne marine deposits are known at only a very few localities, and from none of them except in Alabama and possibly in northern Mexico have venericards been recovered.

The implication carried in the terms upper and lower Claiborne is not fortunate, for certainly the lower Claiborne accounted for a much longer period of time than the upper Claiborne. In any case the upper Claiborne has not been recognized east of the Chattahoochee; and west of Alabama, in the presumably equivalent Yegua, the sediments seem to have been brought down by sluggish streams and deposited in marshes and lagoons and estuaries. This type of sedimentation, though inconstant in detail, shows a remarkable uniformity in general character on each side of the Mississippi embayment and as far south as the Rio Grande embayment. Reef oysters (*Ostrea alabamiensis*) characterize the base of the Yegua toward the Mexican border, and on the Mexican side true marine conditions are recorded.

JACKSON GROUP

In the eastern Gulf region the Jackson is given formational status; in the western Gulf region it is a group.

The Jackson formation was named by Timothy Conrad [59] in 1856, his determination being based on collections of shells made by Benjamin Leonard Covington Wailes at Jackson, Miss. Wailes described this deposit in 1854,[60] referring even then to the obvious differences between the fauna of this locality and the collections from Vicksburg, Miss.

Jackson, in Hinds County, Miss., is the type locality of the formation. Deposits of this age are exposed in a wide band across the State from Clarke County to the east edge of the alluvium of the Mississippi Delta at Yazoo City. Its widest exposure is near Yazoo City on the west, and it is here that the deepest section may also be found, where a bluff face near the city exposes at least 180 feet of Jackson, overlain by about 100 feet of loess of a much later date. The deposits are probably even thicker at some localities in the vicinity. In Mississippi the formation has been divided by most authors into two members, the Moodys marl and the Yazoo clay; Lowe,[61] however, included a third, called the Madison sands, a preoccupied name later changed by Cooke [62] to Forest Hill sand. These beds are now referred to the Vicksburg.

The lowest member of the Jackson is the Moodys marl, lying with local unconformity on the Yegua formation of the Claiborne.[63] It takes its name from Moodys Branch, a small creek flowing into the Pearl River at Jackson, Hinds County, from which Wailes' early collections were made. That pioneer of Mississippi geology said of the outcrop :[64]

> This latter deposit is seen most advantageously in the bed of the creek emptying into Pearl River immediately below the crossing of the Jackson & Brandon Railroad. The bed lies about 15 feet below the level of the adjacent plain, and about 4 feet of its thickness are exposed in the banks of the creek. Its entire depth has not been ascertained.
>
> The marl is of a bluish-green color in its moist state, and in the bed is of considerable toughness and tenacity. Upon exposure, and becoming thoroughly dried, it parts with much of its color, crumbles to a granular sandlike substance, and assumes a grayish appearance, owing to the large proportion of finely comminuted shell contained in it.
>
> The quantity of entire shells embedded in it is very great, lying almost in contact with each other, and forming perhaps one-sixth of the volume of the deposit.

Later observers have given us accounts that tally well with this first report of the outcrop. The locality has received the enthusiastic attention of all Tertiary paleontologists, as the specimens are usually in a nearly perfect state of preservation and are easily removed from the crumbling matrix. The Moodys marl also crops out near Shubuta, Clarke County, and at several points in Scott, Jasper, Smith, and Clarke Counties.

At the base of the Yazoo clay, the upper member of the Jackson formation in Mississippi, is a discontinuous layer of indurated marl or impure limestone that has been called the "*Zeuglodon* beds",[65] for it carries many bones of *Zeuglodon*, a cetacean which serves as one of

[58] Smith, E. A., Underground water resources of Alabama, pp. 18–19, 1907.

[59] Conrad, T. A., Observations on the Eocene deposit of Jackson, Miss., with descriptions of 34 new species of shells and corals: Acad. Nat. Sci. Philadelphia Proc., vol. 7, p. 257, 1856.

[60] Wailes, B. L. C., Agriculture and geology of Mississippi, 1st Rept., p. 274, 1854.

[61] Lowe, E. N., Mississippi, its geology, geography, soils, and mineral resources: Mississippi Geol. Survey Bull. 12, pp. 79, 82–84, 1915.

[62] Cooke, C. W., Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama: Washington Acad. Sci. Jour., vol. 8, pp. 186–198, 1918.

[63] Lowe has the order of the Jackson members reversed in the paper just cited (Mississippi Geol. Survey Bull. 12), placing the Moodys Branch marl at the top of the Jackson instead of at the base, but the correct order was given by Cooke (op. cit., p. 188).

[64] Wailes, B. L. C., op. cit., pp. 274-275.

[65] Schuchert, Charles, U. S. Nat. Mus. Proc., vol. 23, p. 328, 1901. Lowe, E. N., op. cit., p. 79, 1915.

the best guide fossils of the lower Yazoo clay in the Gulf States.

The bulk of the Yazoo clay, as exposed at Yazoo City, consists of drab or yellowish calcareous clays, showing heavy bedding. The fossils are usually rather poorly preserved, and the molluscan fauna is not particularly rich. The upper member is much thicker in western Mississippi than in the eastern part of the State, and in Alabama it thins rapidly and merges into the underlying member.

Deposits of Jackson age extend across Alabama from Choctaw County to Georgia and Florida. They were formerly united with the overlying Vicksburg group under the name "St. Stephens white limestone." The "white limestone" was first supposed to be Cretaceous; then it was transferred to the Eocene; and later Smith, Johnson, and Langdon, who first applied the name St. Stephens to it, recognized that it included deposits of Jackson and Vicksburg (Oligocene) ages. The name "St. Stephens limestone" was abandoned by the United States Geological Survey when Cooke [66] in 1918 divided it into several formations. West of the 88th meridian the Eocene part of the St. Stephens is called the Jackson formation; east of that meridian it is called the Ocala limestone. In November 1933 Cooke [67] defined the Cocoa sand member and correlated it with the lower part of the Yazoo clay.

Dall [68] in 1892 correctly referred the Ocala to the Eocene but Dall [69] in 1903 and Matson and Clapp [70] in 1909 placed the Ocala at the top of the Vicksburg, following Heilprin's earlier correlation.[71]

The Ocala limestone rests conformably on the Gosport sand or is separated from it, according to Cooke,[72] only by local unconformities. The white Marianna limestone of the Vicksburg group, which overlies it in western Florida, may be conformable with it, and there appears to be no sharp break between the Ocala and the Red Bluff clay, which overlies it in Alabama. However, the *Zeuglodon* remains, among the most reliable of the guide fossils of the Jackson in Mississippi, have been found in the Ocala limestone, and in 1915 Cooke [73] correlated the Ocala with the upper Jackson.

There is a marked paucity of macrofossils in the Alabama Jackson, in sharp contrast with the extremely rich faunas of Mississippi. The Ocala is commonly nonfossiliferous, and even where fossils other than echinoids and *Pecten perplanus* are present they are usually indicated by molds.

In Florida the Jackson is represented by extensive outcrops of the Ocala limestone. The base of the formation has not been found in the State, but it is overlain with apparent conformity by the Vicksburg, except where the Oligocene deposits have been overlapped by Miocene or younger beds. The formation is fairly uniform in lithology, consisting for the most part of rather fine grained white limestone.

The Jackson deposits in Georgia extend in a southwest-northeast band completely across the State from the Florida and Alabama boundaries to the South Carolina line at Burke County. The greatest area of outcrop is in the southwestern part, where the Ocala is represented over a wide surface area; in the middle of the State the deposits are partly overlapped by the later Flint River formation; and between the Ocmulgee River and the South Carolina State line the Ocala limestone is replaced by the Barnwell formation.

The Ocala limestone, presumably contemporaneous with the Barnwell, was probably laid down in a region more abundantly supplied with calcareous material and farther from the eroding land surface. The transition between the sands and muds of the Barnwell and the limestone of the Ocala is oscillatory, and the Tivola tongue of Cooke and Shearer,[74] a tongue of calcareous material extending far into the Barnwell area, probably indicates an arm of the early Ocala sea in which calcareous deposition prevailed.

Sloan [75] first named the Barnwell sand from the type locality in Barnwell County, South Carolina, and correlated it with the Claiborne group. Stephenson and Veatch [76] followed Sloan in referring the sand to the Claiborne, and Cooke and Shearer [78] in 1918 included under the Barnwell the so-called †Congaree clay member of Veatch and Stephenson [79] and the *Ostrea georgiana* zone of their McBean formation.[80] Cooke in 1925 proposed the present correlation of the Barnwell sand with the Ocala limestone of western Georgia. The name †Congaree clay in Georgia was changed by Cooke and Shearer [81] to Twiggs clay member, because they found that the beds in Georgia occupied a much higher stratigraphic position than

[66] Cooke, C. W., op. cit.

[67] Cooke, C. W., Definition of Cocoa sand member of Jackson formation: Am. Assoc. Petroleum Geologists Bull., vol. 17, pt. 2, pp. 1387, 1388, 1933.

[68] Dall, W. H., Correlation papers—Neocene: U. S. Geol. Survey Bull. 84, pp. 103, 104, 1892.

[69] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, pp. 1556–1558, 1903.

[70] Matson, G. C., and Clapp, F. G., Preliminary report on the geology of Florida: Florida Geol. Survey 2d Ann. Rept., p. 51, 1909.

[71] Heilprin, Angelo, On the occurrence of nummulitic deposits in Florida and the association of Nummulites with a fresh-water fauna: Acad. Nat. Sci. Philadelphia Proc. for 1882, pp. 189–193, 1882.

[72] Cooke, C. W., Alabama Geol. Survey Special Rept. 14, p. 275, 1926.

[73] Cooke, C. W., The age of the Ocala limestone: U. S. Geol. Survey Prof. Paper 95, p. 108, 1915.

[74] Cooke, C. W., and Shearer, H. K., Deposits of Claiborne and Jackson age in Georgia: U. S. Geol. Survey Prof. Paper 120–C, p. 53, 1918.

[75] Sloan, Earle, Handbook of South Carolina: South Carolina Dept. Agr., Commerce, and Immigration, pp. 86, 90, 1907.

[76] Veatch, J. O., and Stephenson, L. W., Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 26, p. 285, 1911; Underground waters of the Coastal Plain of Georgia: U. S. Geol. Survey Water-Supply Paper 341, p. 79, 1915.

[78] Cooke, C. W., and Shearer, H. K., op. cit., p. 52.

[79] Veatch, J. O., and Stephenson, L. W., Georgia Geol. Survey Bull. 26, p. 267, 1911; U. S. Geol. Survey Water-Supply Paper 341, p. 77, 1915.

[80] Stephenson, L. W., and Veatch, J. O., op. cit. (Water-Supply Paper 341), p. 76.

[81] Cooke, C. W., and Shearer, H. K., op. cit. (Prof. Paper 120–C), p. 52.

Sloan's original †Congaree shales of South Carolina.[82] This Twiggs clay member is found at the base of the Barnwell and occupies a position near the landward margin of the formation.

In South Carolina the Jackson is represented by the Barnwell formation in the south and west, and the Santee limestone and Cooper marl toward the north and east. The most recent work on this region is that by Cooke.[83]

In North Carolina the upper Eocene is represented only by isolated outcrops of the Castle Hayne marl,[84] the equivalent of the Santee marl of South Carolina and of the *Ostrea georgiana* zone of the Barnwell sand and the Tivola tongue of the Ocala limestone of Georgia. The molluscan fauna is known chiefly from molds, and these do not include determinable *Venericardia planicosta*. North of the Hatteras axis only the lower Eocene has been certainly recognized in the outcrop.

At the head and on the west side of the Mississippi embayment, also, the beginning of Jackson sedimentation was heralded by an invasion of the sea covering lands that had been above the surface of the water since the end of the Midway. The group is exposed along the base of Crowleys Ridge from Cross County to Phillips County in northeastern Arkansas, resting upon earlier Eocene deposits and overlain with marked unconformity by the so-called Lafayette. In both northern and southern Arkansas it is a shallow-water marine series of clays and marly cross-bedded sands grading into lignitic clays. The beds are fossiliferous, though not abundantly so, and leaf remains here and there bear witness to nearby vegetation.

In the southern part of Arkansas the formation has been mapped from Jefferson to Ashley County, although the outcrops are interrupted by the tributaries of the Ouachita River. Many of the outcrops are highly fossiliferous, especially in the Crowleys Ridge region and in the vicinity of Rison, in Cleveland County, and Pine and White Bluffs, in Jefferson County.

The earliest report on these beds that are known to be of Jackson age is Owen's discussion [85] in 1860, in which at the end of the description of the section at White Bluff he made the statement that "The fossils found in the above section * * * belong to the Eocene Tertiary."

Harris [86] in 1894 referred the White Bluff section to the Claibornian, following in this correlation the earlier determinations of Heilprin [87] and Call.[88] However, in discussing the White Bluff fauna,[89] he qualified his correlation by the observation that although "The general aspect of this fauna is indeed Claibornian as was suggested by Heilprin and maintained more confidently by Call, yet the presence of such forms as *Solarium bellastriatum*, *Mitra millingtoni*, and *Bullinella jacksonensis* var., shows that the fauna is uppermost Claibornian or perhaps transitional between that and the Jackson."

In 1902 Harris [90] definitely recognized the Jackson age of these deposits:

> At the time of writing my report on the Tertiary of Arkansas (1892), I felt strongly inclined to refer the fossiliferous beds at White Bluff on the Arkansas River to the Jackson; yet they had always been referred to the Claiborne, and there seemed not enough positive evidence in favor of the Jackson affinities to entirely warrant the change. Since then some of the new or supposedly new species from White Bluff have been found in abundance at Jackson, Miss., and at well-developed Jackson beds throughout Louisiana and east Texas.

Later investigations of the Coastal Plain deposits of Arkansas include those by Veatch [91] in 1906 and by Stephenson and Crider [92] in 1916.

The Jackson formation in Louisiana extends from Wyants Bluff, on the Ouachita River, to the Sabine River in Vernon Parish, on the Texas line, interrupted in Natchitoches Parish by the alluvium of the Red River. Conrad [93] first recognized the Eocene in Louisiana from a collection of Jackson fossils. He wrote: "We know of no locality west of this [Claiborne] in Alabama or Mississippi, of the Eocene, but on the Washita River it occurs near the town of Monroe." He also made, in a footnote to the reference cited above, a rather interesting reference to the *Zeuglodon* bones that are commonly found in these deposits: "Some large saurian vertebrae from this place have been erroneously supposed to belong to the Eocene period. They doubtless occur only in the Cretaceous beds, as Judge Bry informs us that *Ammonites* and other Cretaceous fossils abound in the vicinity." This is especially interesting, as the characteristic *Zeuglodon* of the upper Jackson formation was described from this locality in the same year as the publication of Conrad's comments.[94] The Jackson deposits in the vicinity of the Ouachita River [95] and along the Sabine

[82] Sloan, Earle, Catalogue of the mineral localities of South Carolina: South Carolina Geol. Survey, ser. 4, Bull. 2, p. 454, 1908; Handbook of South Carolina: South Carolina Dept. Agr., Commerce, and Immigration, p. 89, 1907.

[83] Cooke, C. W., Geology of the Coastal Plain of South Carolina: U. S. Geol. Survey Bull. 867, 196 pp., 18 pls., 2 figs. 1936.

[84] Kellum, L. B., Paleontology and stratigraphy of the Castle Hayne and Trent marls in North Carolina: U. S. Geol. Survey Prof. Paper 143, pp. 1–42, 11 pls., 1926.

[85] Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, p. 152, 1860.

[86] Harris, G. D., The Tertiary geology of southern Arkansas: Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, pp. 87–89, 1894.

[87] Heilprin, Angelo, The Tertiary geology of the eastern and southern United States: Acad. Nat. Sci. Philadelphia Jour., vol. 9, p. 151, 1884.

[88] Call, R. E., Geology of Crowleys Ridge: Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, p. 3, 1891.

[89] Harris, G. D., op. cit., p. 93.

[90] Harris, G. D., Report on the geology of Louisiana, for 1902, pt. 1, The Tertiary geology of the Mississippi embayment, p. 22, Louisiana Geol. Survey, 1902.

[91] Veatch, A. C., Geology and underground water resources of northern Louisiana and southern Arkansas: U. S. Geol. Survey Prof. Paper 46, p. 39, 1906

[92] Stephenson, L. W., and Crider, A. F., Geology and ground waters of northeastern Arkansas: U. S. Geol. Survey Water-Supply Paper 399, pp. 79–81, 1916.

[93] Conrad, T. A., Observations on the Tertiary and more recent formations of a portion of the Southern States: Acad. Nat. Sci. Philadelphia Jour., vol. 7, p. 120, 1834.

[94] Harlan, Richard, Notice of fossil bones found in the Tertiary formation of the State of Louisiana: Am. Philos. Soc. Trans., new ser., vol. 4, pp. 397–403, 1834.

[95] Veatch, A. C., Notes on the geology along the Ouachita: Louisiana Geol. Survey Rept. for 1902, no. 4, p. 164, 1902.

River at the Texas State line [96] were described by Veatch in 1902. He stated then that beds of Jackson age had but recently been discovered in Texas.

The Jackson group is exposed intermittently from the Sabine River at the Louisiana-Texas State line to the Rio Grande in Starr County, Tex. The upper Eocene in Texas has been commonly known under the name Fayette sandstone, a name proposed by Penrose [97] in 1890 from a locality in Fayette County. He included in this division deposits that range in age from Claiborne to Miocene. Dumble [98] in 1892 divided the Fayette of Penrose into two formations, calling the lower one the Yegua and the upper one the Fayette. In 1903 [99] he separated from the Fayette the Oakville sandstone and the clay that immediately underlies it. Trowbridge [1] in 1923 used Fayette as defined by Dumble, and he was followed in this usage by Deussen [2] and Bailey.[3] Later, however, Dumble [4] again divided the Fayette into two units, the lower of which he said was the "true Fayette" and correlated it with the Claiborne group. The upper division he called the "Whitsett", and this was correlated by Trowbridge,[5] at least in part, with the Frio clay. The Frio clay, originally described by Dumble [6] as upper Eocene but later correlated with the Claiborne group,[7] included higher beds of Catahoula age. Deussen [8] correlated these deposits at least tentatively with the Jackson formation, and Trowbridge [9] also tentatively with the Oligocene, and so it stands on the reconnaissance map of Texas (March 1934). Berry [10] recorded the flora and discussed the general stratigraphy in 1924. Plummer [11] made a threefold division—Whitsett, McElroy, and Caddell—in eastern Texas, and a twofold division—Whitsett and Lipan—in central and southern Texas. Miss Ellisor [12] regarded the Whitsett, McElroy, and Caddell as formations and carried them across the State. Each of the units was subdivided for the most part on micropaleontologic evidence. The marine macrofaunas are local in their distribution in Texas and are limited to the embayments of the Sabine River and the Rio Grande.

Three species of the *Venericardia planicosta* stock have been found in deposits of Jackson age in the Mississippi and Rio Grande embayments, *V. apodensata*, n. sp., *V. klimacodes*, n. sp., and *V. cookei*, n. sp. Only one of these, however, *V. apodensata*, is at all cosmopolitan in its distribution. This species is found in deposits of lower Jackson age, the Moodys marl member, in Mississippi, and it is abundantly represented in the western embayment in Arkansas and Louisiana. It has been recorded from a few outcrops in Alabama, but it is unknown north and east of the Tombigbee River. *V. apodensata* is an obvious descendant of *V. densata* Conrad of the Claiborne, but it differs from that species in its more rounded outline, lighter shell structure, much lower hinge plate with shorter and more arcuate teeth, and lower umbones. The shell is small and compact, as in the Claiborne form, and the umbonal ribs are serrate and slightly terraced. The statement has frequently been made that the average rib count of the venericards increases from the Midway to the Jackson. In our counts, which included about 1,500 valves, the Tuscahoma counts center about 29; the Bashi, 29 and 30; the Lisbon, 26 and 27; the Gosport, 29; and the Jackson, 31 and 32. The rib count of the Moodys marl species runs higher by one or two than that of the succeeding Yazoo clay species. Apparently within a certain stock the rib count tends to be higher with a rise in the section, and the relatively low rib count of the Lisbon is due to the abundance of the aberrant *densata*.

In the upper Jackson of Mississippi, the Yazoo clay member, *V. apodensata* is replaced by *V. klimacodes*, a more trigonal form with a smaller hinge plate, more sharply incised intercostals, and more distinct lateral terracing, extending over a greater area. This form is found only in Mississippi in the upper beds in the vicinity of Yazoo City. In Alabama, in the vicinity of the Conecuh River, the third species, *V. cookei*, is found, restricted apparently to the sandy deposits underlying the Ocala limestone. This form appears to be the culmination of the *V. pilsbryi* stock of the Wilcox that was represented in the Claiborne by *V. angustoscrobis*, from which it differs in its more posteriorly produced ventral margin, more numerous costae, and the different shape of the median cardinal tooth.

There is a new, rather small and well-characterized species of *Venericardia* in the Jackson of Robinsons Ferry. It is also well represented in northern Polk County, but for most of the species of the lower and middle Eocene of Alabama the Sabine River is the western outpost.

[96] Veatch, A. C., The geography and geology of the Sabine River: Idem, p. 131.

[97] Penrose, R. A. F., Jr., A preliminary report on the geology of the Gulf Tertiary of Texas from Red River to the Rio Grande: Texas Geol. Survey 1st Ann. Rept., pp. 47–58, 1890.

[98] Dumble, E. T., Report on the brown coal and lignite of Texas, pp. 148–157, Texas Geol. Survey, 1892.

[99] Dumble, E. T., Geology of southwestern Texas: Am. Inst. Min. Eng. Trans., vol. 33, pp. 953–957, 1903.

[1] Trowbridge, A. C., A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131, p. 97, 1923.

[2] Deussen, Alexander, Geology of the Coastal Plain of Texas west of Brazos River: U. S. Geol. Survey Prof. Paper 126, p. 80, 1924.

[3] Bailey, T. L., The Gueydan, a new middle Tertiary formation from the southwestern Coastal Plain of Texas: Texas Univ. Bull. 2645, p. 38, 1926.

[4] Dumble, E. T., A revision of the Texas Tertiary section with special reference to the oil-well geology of the coast region: Am. Assoc. Petroleum Geologists Bull., vol. 8, pp. 431–434, 1924.

[5] Trowbridge, A. C., Tertiary and Quaternary geology of the lower Rio Grande region, Texas: U. S. Geol. Survey Bull. 837, pp. 141–142, 1932.

[6] Dumble, E. T., The Cenozoic deposits of Texas: Jour. Geology, vol. 2, pp. 554–555, 1894.

[7] Dumble, E. T., Geology of southwestern Texas: Am. Inst. Min. Eng. Trans., vol. 33, pp. 953–956, 1903.

[8] Deussen, Alexander, op. cit. (Prof. Paper 126), p. 92.

[9] Trowbridge, A. C., op. cit. (Bull. 837), pp. 156–157.

[10] Berry, E. W., The middle and upper Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 92, 1924.

[11] Plummer, F. B., Geology of Texas, vol. 1, Stratigraphy, pt. 3, Cenozoic systems in Texas: Texas Univ. Bull. 3232, p. 685, 1933.

[12] Ellisor, A. C., Jackson group of formations in Texas, with notes on Frio and Vicksburg: Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 11, p. 1298, November 1933.

In the Ocala limestone of eastern Alabama, Florida, Georgia, and the contemporaneous deposits of the Carolinas no venericards are found. The Ocala was possibly laid down in waters too deep for inshore faunas, as only echinoids, pectens, and similar forms of less shallow water have been recovered from these sediments.

The *Venericardia planicosta* stock ends with the Jackson. The rise, eminence, and decline of an organic group, whether it be the titanotheres, the ancient Greeks and Mayans, or *Venericardia planicosta*, seem to be so governed that, with an independence of physical conditions that is not understood, they run their course as individuals do and are finished. The *planicosta* group survived during early and mid-Eocene time under conditions apparently almost as severe as those which befell them toward the end of the Eocene. Between the end of Wilcox time and the beginning of Claiborne time there was a widespread restriction of marine life, but with the advance of the Lisbon sea the venericards of the *planicosta* group returned to their former position of prominence in the molluscan faunas. The retreat of the middle Claiborne sea covered perhaps a wider front than that which took place at the end of Wilcox time. In any case, the venericards did not regain their former position with the advance of the late Claiborne and Jackson seas, and their approaching decline and extinction was foreshadowed in the decrease in the number of individuals and species. The life cycle was the same for Eurasian representatives of the genus as it was for the American planicostas and might more readily be explained by diastrophic movements, for at the end of the Eocene epoch the European marine faunas were withdrawn farther and for a longer period than those of the American waters. The relative abundance of the species of the *planicosta* group in the successive stages of the Eocene is indicated in figure 27.

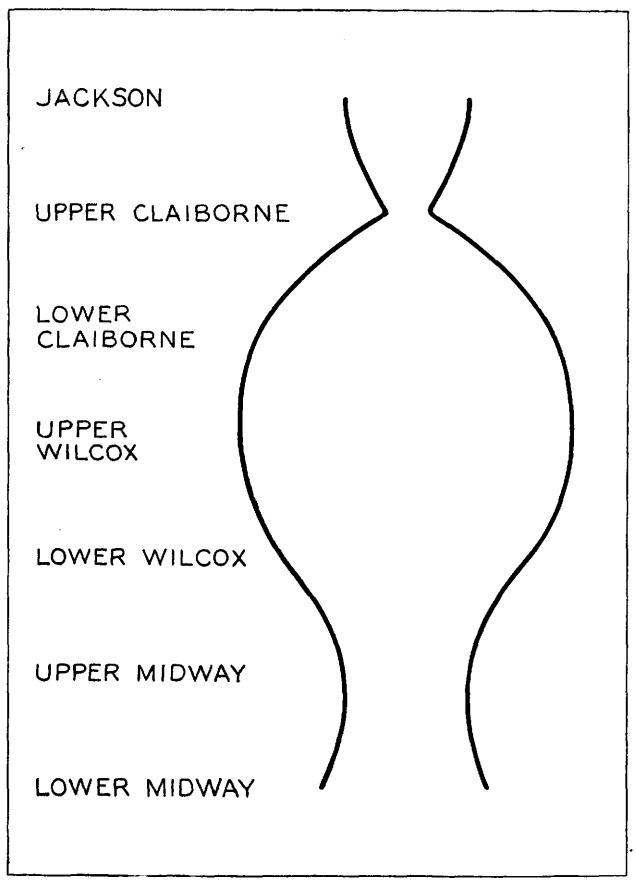


FIGURE 27.—Distribution of species of the *Venericardia planicosta* group in the Eocene of the Gulf embayment and eastern Atlantic slope.

WORLD DISTRIBUTION OF EARLY EOCENE SPECIES COMPARABLE TO VENERICARDIA PLANICOSTA [13]

On the assumption that a common origin for the members of the *Venericardia planicosta* group is less difficult to accept than the multiple origin of a group so specialized, we may speculate, possibly with more interest than profit, upon the focus of distribution. Because of the "abundance in varieties, individuals, and their wide distribution in America" Dall [14] was "persuaded that America is the center from which the group has been distributed." Such a postulate is also strengthened by the abrupt development of the group during the early Eocene upon the American shores, and by the absence of any recorded abundance in the European deposits until the medial Eocene. However, there are too many unknown factors to argue convincingly for any given source, and no theory is adequately supported by the known facts.

The present records of the lower Paleocene molluscan faunas are exceedingly few, scattered, and fragmentary. (See pl. 31.) An attempt is here made to include all those that are relevant and significant. Venericards which from the printed descriptions and figures seem to be allied with the *planicosta* group are registered from a few widely separated outcrops.

1. Miss Maury [15] has recorded from bed 2 of the supposed Midway in the Soldado Rock, off the southwest corner of Trinidad, in La Boca de la Sierpe, a *Venericardia planicosta* which from the figure alone seems very closely related to our Gulf *mediaplata*. There are other allied shells, both bivalve and univalve, and the ensemble of the Soldado fauna suggests a relationship to the Midway faunas of the Gulf similar to that existing between the Gulf and Trinidad faunas today.

Other outcrops were later discovered on Trinidad by Waring [16] and were included by him under the Marac formation. Their contained faunas were discussed by

[13] The excellent paper of R. Rutsch upon "Die stratigraphische Bedeutung der *Venericardia planicosta* und ihrer Verwandten" (Eclogae geologicae Helvetiae, vol. 29, no. 1, pp. 151–186, June 1936) was received after this paper had been submitted for publication.

[14] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, pp. 1418, 1419, 1903.

[15] Maury, C. J., A contribution to the paleontology of Trinidad: Acad. Nat. Sci. Philadelphia Jour., 2d ser., vol. 15, p. 51, pl. 8, figs. 15, 16, 1912.

[16] Waring, G. A., The geology of the Island of Trinidad, B. W. I.: Johns Hopkins Univ. Studies in Geology, no. 7, pp. 40, 41, 1926.

Harris.[17] A small planicostate species with a few low ribs, evanescent toward the ventral margin, resembles *Venericardia diga* of the Mexican faunas and *V. potapacoensis* of the Maryland and Virginia Nanjemoy. The hinge, however, which is one of the best characters of the Mexican and Maryland forms, is not figured, and it is quite possible that the resemblance is by no means so close as the single figured exterior might suggest. The Trinidad form is associated with a venericard suggesting *V. hesperia*, with *Calyptraphorus* cf. *C. velatus*, and with *Hercoglossa*, all species of pronounced Midway affinities. The horizon has been reported in Toas, on the mainland in Venezuela, but the report is not confirmed in the few and inadequate collections accessible to us. As Miss Maury observed, never before its discovery off Trinidad had *Venericardia planicosta* been found so close to the Equator.

2. *Venericardia duponti*, described by Cossmann [18] from the type locality of the Montian of Belgium, is without question a member of the *planicosta* group. In outline and general aspect it most closely suggests *V. mediaplata*. Cossmann in his thoroughly adequate description remarks that at first sight one might think it nothing more than an ancestral mutation of *Venericardia planicosta*, and a close comparison might be made even more truly to *Venericardia mediaplata*. Fortuitous or not, the relatively low rib count and the low, broad hinge plate are characteristic, though not universally present, in the early Eocene venericards both of Belgium and of the Gulf. The occurrence of a species of this character in the Montian has a broad significance, for the Montian fauna is generally accepted as one of the parent faunas of the Lutetian of the Paris Basin. One may more readily assume that these two early Eocene venericards came from a common fatherland and that *Venericardia planicosta* of the Paris Basin developed in place from the *duponti* stock than that the mid-Eocene European form arose from a lower Eocene mid-American parentage. However, it is only fair to remember in this connection the Trechmann record [19] that the Tethyan sea apparently reached Jamaica and that certain elements in the Gulf faunas may have returned by the same route by which the large Tethyan lucinoids and cerites, *Carolia* and *Gisortia*, arrived.

3. On some of the later paleogeographic maps the North Sea-Baltic Paleocene gulf is extended across northern Europe to the lower Volga. The direction of such an embayment has, incidentally, a much stronger east-west component when viewed on a globe than it does on most of the flat projections, and is based upon very meager records of a northern fauna not quite as old as the Montian. One ecologic phase of this fauna is best recorded in the excavations made for the gas works at Copenhagen.[20] In it the gastropods, particularly the smaller gastropods, are dominant, and the turrids are conspicuously abundant in species. There are very few of the larger bivalves and no venericards. A similar early Eocene fauna is also recorded at Klagshamm, in southern Sweden,[21] and in Swedish and north German erratics and wells, but in erratics from Ysted, Skania, larger Turritellas of the *T. mortoni* and *T. humerosa* types are particularly common. The most remarkable fauna, not only intrinsically but also because of its extraordinary likeness, considering the distance involved, to our own Gulf faunas, is that from the Paleocene of the lower Volga.[22] Four horizons have been recognized at which *Volutocorbis*, *Levifusus*, several familiar Turritellas, and *Enclimatoceras* have been found. Three species of simple-ribbed venericards are included, and among them *Cardita longa*, from the upper Syzranian, invites the closest comparison. In none of the South Russian venericards, however, is the individual resemblance to the Gulf venericards so strong as that of *V. duponti* of the Montian to *V. mediaplata*, although the general set-up and balance of the Volga and Gulf faunas is as close if not closer. There may also have been a transgression of the northern sea over the low lands of northern Siberia, but the records of that area are very imperfectly known. The major transgression, which united the Arctic and the Mediterranean seas through the broad Turgai Straits and made an archipelago of the Kirghiz Steppes, was an event of middle or late Eocene time. The fauna of the Thanet sands of the old Thames Valley is a dominantly bivalve fauna resembling in the abundance of a few species that of the Aquia formation of Maryland and Virginia, but there are no venericards included in the collections from the Thanet sands that have been available for study. The Paleocene of Limbourg,[23] which is also a little younger than the Montian, carries *Cucullaea*, *Ostrea*, and a few lucinoids, but the fauna is for the most part one of brackish waters. The greater part of western Europe was drained before the beginning of the Tertiary period. There are a very few fragmentary Paleocene records in the Paris Basin, most of them in fresh- or brackish-water deposits.

4. At some time during the early Eocene, probably the Thanetian, the boreal sea penetrated as far south

[17] Harris, G. D., Notes on the paleontology, in Waring, The geology of the Island of Trinidad, B. W. I.: Johns Hopkins Univ. Studies in Geology, no. 7, pp. 99, 100, 1926.

[18] Cossmann, Maurice, Pélécypodes du Montien de Belgique: Mus. royale histoire nat. Belgique Mém., vol. 5, p. 52, pl. 5, figs. 12–17; pl. 6, figs. 1–3, 1908.

[19] Trechmann, C. T., Yellow limestone of Jamaica and its Mollusca: Geol. Mag., vol. 60, no. 710, pp. 337–367, 1923.

[20] Von Koenen, A., Über eine Paleocäne Fauna von Kopenhagen: K. Gesell. Wiss. Göttingen Abh., vol. 32, pp. 3–128, pls. 1–5, 1885.

[21] Holst, N. O., and Grönwall, K. A., Paleocen vid Klagshamm: Sveriges geol. undersöknings Skrifter, ser. C, no. 208, pp. 1–27, 1907.

[22] Archangelsky, A. D., Dépôts paléocènes de la région volgienne du gouvernement de Saratov et leur faune: Materialien zur Geologie Russlands, vol. 32, pp. 1–207, 12 pls., 1904. Netschaew, A. V., Die Fauna der Eocänablagerungen an der Wolga unterhalb Saratow: Trudui Obschestva Kazan, vol. 32, pt. 1, pp. 1–247, pls. 1–10, 1897.

[23] Vincent, Émile, Mollusques des couches à Cyrènes (Paléocène du Limbourg): Mus. royale histoire nat. Mém. 43, 43 pp., 7 fossil pls., portrait of Émile Vincent and his bibliography, 1930.

as Kressenberg [24] in Bavaria, and left in the coarse glauconitic sands at the base of the Kressenberg section the remains of a rich boreal fauna, which, however, was soon replaced by one in which *Gisortia*, one of the characteristic elements in the old Tethyan fauna, became increasingly abundant. The shores of the old Tethyan sea are not sharply defined. There was probably communication between the Mediterranean and the Atlantic, and the French Pyrenees were apparently engulfed from the late Cretaceous into the Paleocene. Probably later in the Eocene the Adriatic was extended northward across Italy and eastward to the Vienna Basin. The Pyrenean Gulf opened in the direction of the Bay of Biscay. The assemblage of fossil forms is distinct from any recovered to the north, and in the sequence of fossiliferous deposits with no perceptible break the lower beds carry rudistids suggesting the Maestrichtian and the upper beds yield Paleocene Foraminifera. Venericards or carditas are common, and several species have been separated, but they are known from molds only, and none of them are strikingly suggestive of planicostate forms. As in the Kressenberg series, the lower Paleocene fauna is more closely allied with that of the Montian, and the Foraminifera of the uppermost bed are more closely associated with the Tethyan fauna. A border-line deposit has also been recorded from the Vienna Basin, but for the most part the Upper Cretaceous and Paleocene of southern Europe is, macrofaunally, a lost interval. Cox [25] emphasized our ignorance of this area, for we have no way of knowing the extent to which the compressional folding in the Alpine synclinorium and all the attendant earth movements affected the physiography of the Euro-African Continent.

5. The Tethyan sea, extending eastward as far as the Cathaysia of Grabau,[26] the old land mass which united the East Indies with Malaysia and isolated the Pacific, filled the Atlas syncline and washed unknown shores possibly far to the west of the African coast. India was almost cut off by a sea which occupied the Himalayan synclinorium through late Cretaceous and early Eocene time and in which was laid down our finest record of a little-known interval—a record, however, which is not relevant to the present discussion, for no venericards of the *planicosta* group are included in it. The eastern Tethyan shores were for some reason inhospitable to the group, for neither are members of this group included in the remnants of early Eocene faunas nor are they foreshadowed in the late Cretaceous, which is uncommonly well represented in the area. The shores of the Tethyan sea have not been defined. The Eocene section has been recognized but not adequately studied and interpreted in Persia,[27] Arabia, and Palestine. The upper part at least of the Paleocene is developed in Egypt, and later developments include the nummulitic limestone of which the Pyramids are built. The late Cretaceous is exceptionally well developed in the Libyan Desert [28] but although the lithology remains similar there is apparently a time break at the base of the Eocene section. The lower Eocene is also responsibly reported from both the eastern [29] and western [30] coasts of Africa south of the Equator and along the Guinea coast from Cameroon to Senegal. That these marine deposits are something more than a wash along the old African shore lines is indicated by the Nigerian deposits, in which the deep-water sediments lie to the north and their landward extensions toward the south. *Cardita*-like forms with tripartite ribs, the close descendants, perchance, of *Cardita beaumonti*, are widely scattered through the north African deposits, but unhappily there are no recorded African descendants of the smooth and simple-ribbed *Cardita baronetti* of the Tunisian Upper Cretaceous or of the possibly identical form, *Cardita libyca* Zittel. A genetic relationship to *Cardita duponti* of the Montian is suggested, although the Montian gulf was probably not in direct communication with the Tethyan sea, and none of the characteristic Tethyan univalves are recorded in the Montian fauna.

6. The Paleocene of the Pacific is so little known and its few representatives are separated by so vast expanses of sea or land or both that an attempt to focus speculations as to its history would be futile. All the recognized fossiliferous marine sections of Japan are now considered later than Paleocene, and the most recent work of Nagao [31] indicates that even the marine

[24] Schlosser, Max, Die Eocaenfaunen der bayerischen Alpen: Bayer. Akad. Wiss. Abh., Math.-naturwiss. Abt., Band 30, Abh. 7, 1. Teil, Die Fauna des Unter- und Mitteleocaen, 207 pp., pls. 1-6; 2. Teil, Die Obereocaenfauna, 68 pp., pls. 7, 8, 1925.

[25] Cox, L. R., The Mollusca of the Hangu shales: India Geol. Survey Mem., Palaeontologia Indica, new ser., vol. 15, pt. 8, pp. 136, 137, 1930.

[26] Grabau, A. W., Summary of the Cenozoic and Psychozoic deposits with special reference to Asia: Geol. Soc. China Bull., vol. 6, pp. 151-264, 1927.

[27] De Morgan, J., Mission scientifique en Perse, vol. 3, pts. 2 and 4, 1904. Douvillé H., in DeMorgan, J., Mission scientifique en Perse, vol. 3, Études géologiques, pt. 4, Paléontologie Mollusques fossiles. pt. 2, pp. 191-380, pls. 25-50, 1904.

[28] Quaas, A., Die Fauna der Overwegischichten und der Blätterthone in der libyschen Wüste, in Beitrag zur Kenntniss der Fauna der obersten Kreidebildungen in der libyschen Wüste: Palaeontographica, vol. 30, pt. 2, 4th sec., pp. 153-334, pls. 20-33, correlation tables, 1902.

[29] Schlosser, Max, Über Tertiär und obere Kreide aus Portugiesisch-Ostafrika: Bayer. Akad. Wiss. Abh., Math-naturwiss. Abt., Band 32, Abh. 2, pp. 1-25, pls. 1-3, bibliography, 1928.

[30] Bohm, J., Eozäne und miozäne Versteinerungen aus Angola: Deutsche geol. Gesell. Zeitschr., Band 81, p. 450, 1929. Douvillé, H., La limite entre le Crétacé et l'Éocène en Aquitaine, aux Indes et au Soudan: Acad. sci. Paris Comptes rendus, vol. 170, pp. 154-159, 1920; Douvillé, H., L'Éocène au Soudan et au Sénégal: Com. études hist. et sci. Afrique occidentale française Bull. 2, pp. 113-171, pls. 1-5, 2 text maps, correlation table, 13 text figures of fossils, 1920. Newton, R. B., On the lower Tertiary Mollusca of the Fayum province of Egypt [presidential address]: Malacol. Soc. London Proc., vol. 10, pp. 56-89, pls. 3, 4, 1912; Eocene Mollusca from Nigeria: Nigeria Geol. Survey Bull. 3, 1922. Oppenheim, Paul, Zur Kenntnis alttertiärer Faunen in Ägypten: Palaeontographica, Band 30, Abt. 3, Lief. 1, Der Bivalven, erster Teil (*Monomyaria*, *Heteromyaria*, und *Siphonida intergripalliata*), pp. 1-164, pls. 1-17, 1903; Idem, Lief. 2, Der Bivalven, zweiter Teil, Gastropoda, Cephalopoda, pp. 165-348, pls. 18-27, 1906; Die eocäne Invertebraten-Fauna des Kalksteins in Togo: Beitr. geol. Erforsch. deutschen Schutzgebiete, Heft 12, 126 pp., 5 pls., bibliographic footnotes, 1915. Pervinquière, Léon, Études de paléontologie tunisienne, vol. 2, p. 241, pl. 18, figs. 1-3, Direction gén. travaux publics, 1912. Vincent, Émile, La faune paléocène de Landana: Mus. Congo belge Annales de géologie, sér. 3, vol. 1, fasc. 1, pls. 1-10, pp. 1-92, 1913.

[31] Nagao, Takumi, Palaeogene coal-bearing formations of the island of Kyûshû: Tohoku Imp. Univ. Sci. Repts., 2d ser., Geology, vol. 11, no. 1, pp. 1-21, 1 text map, 1 correlation table, Sendai, Japan, 1927.

lenses in the Miike coal field are probably of Lutetian age. The old Cathaysia apparently extended eastward beyond the present coast line of Japan. Along some unknown shore, however, the group perhaps pushed southward and left a seemingly authentic record in the Wangaloa beds in Canterbury and Otago, on the south island of New Zealand,[32] the farthest outpost in the Southern Hemisphere. A large venericard was determined by Marshall as *Venericardia patagonica* Sowerby, and although the specific identity is highly improbable, the possible occurrence of the group in the Antipodes is significant. *Venericardia patagonica* Sowerby, with which the Wangaloa species was identified, was described by G. B. Sowerby from material recovered by Darwin on the voyage of the *Beagle*. The locality is the gravel-capped cliff at the mouth of the Santa Cruz River, Patagonia, the type locality of the Santa Cruz beds, a formation now referred to the upper Miocene. The hinge of the Wangaloan species is not figured, and no specimens are included in the collections available for study.

7. The one sure early Eocene venericard in the Pacific fauna is *Venericardia venturensis* Waring,[33] from the Martinez formation at the base of the Eocene section in north-central California. The route by which it arrived is not known, but in the light of our present information a temporary entrance from the mid-Atlantic seems more plausible than a migration along Pacific shores either northward through the length of South America or along the north Asiatic and Alaskan shores southward, areas in which no record has yet been discovered. The resemblance, furthermore, between the Midway *Venericardia mediaplata* of Wilcox County, Ala., and the probably synchronous Martinez *Venericardia venturensis* Waring is surprisingly close. It is interesting if not relevant in this connection to recall the remarkable similarity between the middle Eocene fauna from the Simi Valley, in southern California, and a small fauna collected several years ago on the Isthmus of Tehuantepec, less than 10 miles behind the mountain front facing the Gulf of Mexico. We do not know that there was an intermingling of the Atlantic and Pacific faunas at that time, but we do know that the barrier separating them must have been exceedingly narrow. If those conditions existed during the middle Eocene, it is possible that they prevailed during some short part of the late Cretaceous or in the invasion that heralded the Tertiary. At such a time a few species by reason of some unusual adaptability in either the larval or the adult stages may have been able to establish themselves on the Pacific coast.

Although widely scattered and not clearly related occurrences do not indicate the focus of distribution, they tend to push it backward in geologic time. Such a group may be reasonably supposed to have its roots deeper in the past than one in which the development is localized. Although the representation of the *Venericardia planicosta* group on the Gulf and mid-Atlantic shores is the most extensive among the recorded faunas, the occurrence of members of the group in European, possibly Antipodean, and certainly west coast American faunas of possibly synchronous age renders highly improbable the evolution of the entire group in mid-American waters during the period immediately preceding the Tertiary.

[32] Marshall, P., The Wangaloa beds: New Zealand Inst. Trans. and Proc. for 1916, vol. 49, pp. 450–460, pls. 34–37, 1917.

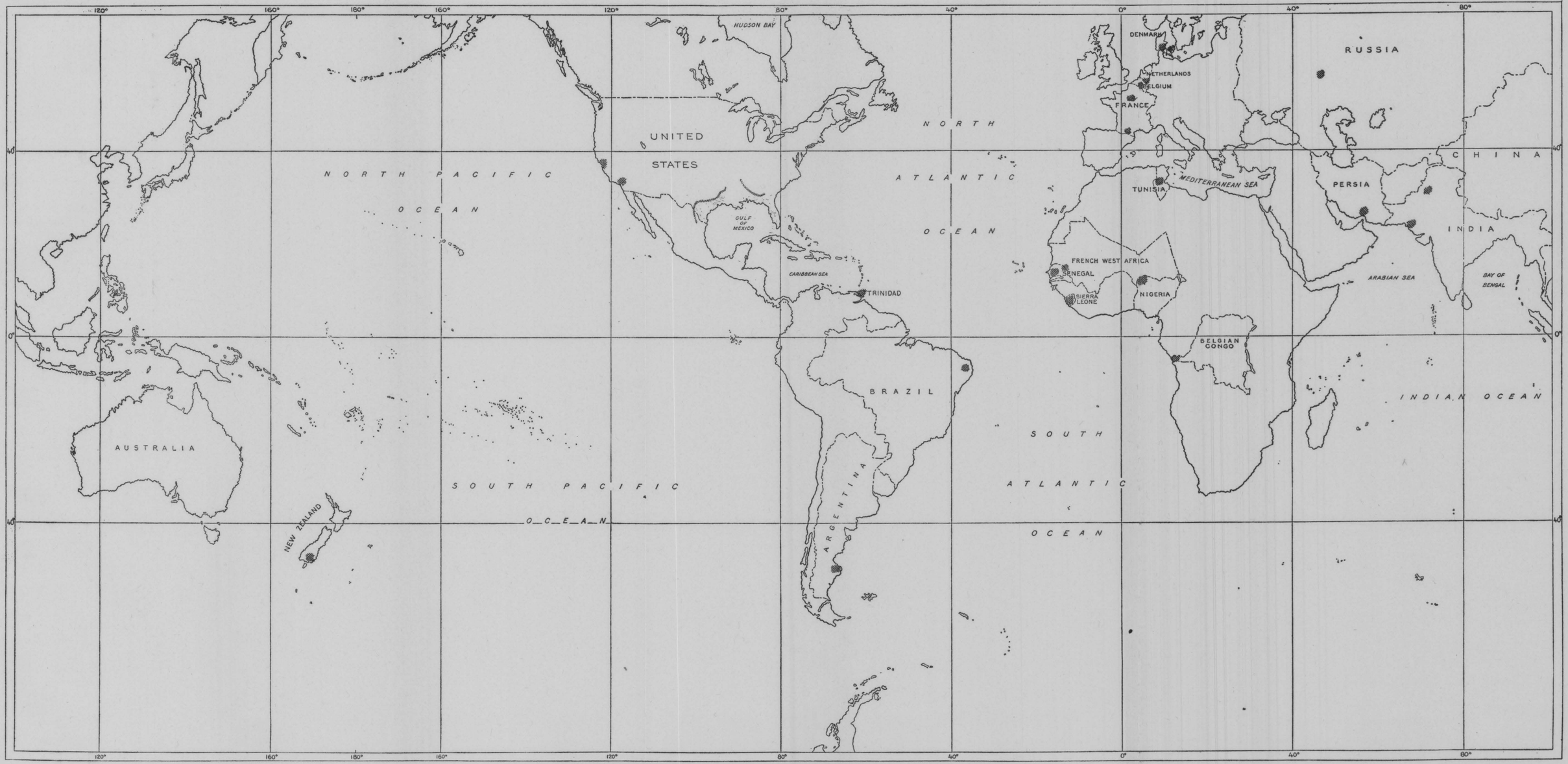
[33] Waring, C. A., Stratigraphic and faunal relations of the Martinez to the Chico and Tejon of southern California: California Acad. Sci. Proc., ser. 4, vol. 7, no. 4, p. 80, pl. 11, figs. 6–9, 1917.

HINGE INVERSION IN PELECYPODS

In his study of a long series of venericards the junior author noted one left valve of *Venericardia bashiplata* in which the hinge dentition is the mirror image of that of the normal right valve. This specimen was collected from the headwaters of Beaver Creek, Clarke County, Ala.

In this abnormal *Venericardia* (pl. 34, fig. 4) several points are of interest. The hinge armature includes three cardinal teeth radiating from the tip of the umbo to the margin of a hinge plate which is not symmetrical but obliquely produced behind the umbo, thus offering a more effective support for the ligament. The anterior of the three cardinals has, unfortunately, been worn down, probably upon the old Bashi beach. The middle cardinal is very heavy and deltoid. This, too, is worn toward the beaks, but a reconstruction can be made with assurance. The posterior cardinal is laminar and extends from the tip of the umbo to the ventral margin of the hinge plate. The dorsal portion of this left valve; the ligament, and the hinge plate and teeth are normal for the right; it is a fair inference that the missing right valve must have exhibited the normal left dentition, for otherwise the hinge teeth could not have functioned. The muscle impressions, the pallial line, and the lateral and ventral margins are normal for the left valve. It is again a fair inference that the orientation of the soft parts must have been normal. The only suggestion of an anatomical anomaly is in the pedal scar, which, though occupying its normal position between the lunule and the anterior retractor, is abnormally long and slightly more dorsal and more marginal. The differences are not sufficiently great, however, to occasion published comment were it not for the remarkable dentition. The rather considerable thickening of the shell over the area of the adherent mantle indicates that the shell reached full maturity and probably old age. It has attained a height of 80 millimeters and an almost equal breadth and offers no indication of an unusually severe or unsuccessful struggle for existence.

Sinistral shells are not uncommon among the gastropods. Certain genera, such as the common fresh-water *Physa*, are characteristically sinistral; normally dextral genera, such as *Fulgur* of the east coast and Gulf Ter-



AREAS OF OUTCROP OF MARINE BEDS OF PROBABLE EARLY EOCENE AGE.

20412—39 (Face p. 164)

tiary and Recent, include sinistral species—for example, *Fulgur perversum*—and pathologic sinistral individuals like the sacred Chank shells of India have been recognized in a large number of species and genera among the univalves. In the Chanks, which have been rather fully recorded because of their ethnographic interest, the estimated proportion of sinistral to dextral shells is 1 to 6,000,000.

Abnormalities in pelecypods have been much more rarely observed, and their records are confined to relatively few groups. However, as Popenoe and Findlay [34] suggest (p. 312): "Inverse coiling in gastropods involves the whole shell and hence is usually at once apparent. On the other hand, a transposed lamellibranch hinge is seldom readily apparent, even in well-preserved specimens, and is to be found only by careful search." They prove their point by finding "transposed" hinges among the normal in a ratio of 1 to 180 in the venericards and 1 to 130 among the astartids. Short papers by Morley-Davies [35] and that by Popenoe and Findlay cover the most that has been published on the abnormalities of the bivalve hinge. The hinges cited occur for the most part in the fresh-water groups, in the more primitive of the Teleodesmacea, the astartids, the venericards, the chamids, the rudistids, the lucinoids, the carditids, and a single venerid, the genus *Transenella*. Unfortunately, few of the earlier references to abnormalities are accompanied by figures and for that reason are difficult to evaluate. However, Vest [36] figures a right valve of the Recent *Astarte corrugata* Brown which indicates a true hinge "inversion", and Reynell [37] figures a left valve of *Astarte mutabilis* Searles Wood from the Coralline Crag (Pliocene) of Suffolk, England, in which the cardinals and anterior lateral are reversed. In both of these forms, as in the valve of *Venericardia bashiplata*, there is almost no evidence of abnormality in the shell characters exclusive of the hinge.

Dall [38] observed that

> a peculiarity which has been noticed in several of the genera of Astartidae is the tendency to reversal of the hinge teeth in relation to the valves, the dentition normal to the right valve being found in the left, and vice versa. This peculiarity is especially notable in *Goodallia*, where, out of one lot examined, nearly one-third had the hinge reversed.

The genotype of *Goodallia* is a Recent species of which every individual examined by us presented a normal hinge. No abnormalities were observed in any of the Recent or of the later Tertiary species, but in the subgenus *Microstagon* Cossmann,[39] founded on several species from the Eocene of the Paris Basin, the large deltoid cardinal is usually in the left valve. In this group, however, the anterior end of the shell is produced and there are still vestiges of an anterior cardinal, which is obsolete in the later *Goodallia*. The relative position and prominence of the cardinals seem much less stable than in the other astartids, and it is hard to be sure whether the irregularities are of the same nature as those occurring in groups in which the dentition has not yet been fully adjusted and established or whether the *Microstagon* hinge offers a true "inversion" of the cardinal teeth. Hanna [40] noted and adequately figured "a very interesting pair of valves belonging to the low-beak variety of *Venericardia hornii*. * * * The hinge characters of the right valve are found in the left and vice versa." The only published records we have noted of transposition in the east coast and Gulf *Venericardia* are those by Popenoe and Findlay,[41] who observed an apparent inversion in the cardinals and anterior laterals of 6 right and 2 left valves of *Venericardia parva* Lea from the Claiborne sand, in 2 left valves of *Venericardia granulata* from the Pliocene of North Carolina, and also in 7 right and 2 left valves of *Venericardia ventricosa* from the Pleistocene of California. In all these valves "the cardinals and anterior laterals are found to be completely transposed, leaving only the posterior laterals normal to the hinge in which they occur."

A transposition of the cardinals and the anterior laterals is recorded in a left valve of *Astarte concentrica* from the upper Miocene at Yorktown, Va., and in a left valve of *Astarte sima* from the middle Miocene Shoal River formation of Florida. In the Astartes, as in the venericards, the posterior laterals remain normal. A similar transposition of cardinals and anterior laterals with the posterior laterals absent was noted in *Transenella stimpsoni*, a Recent species found off the Florida Keys. Abnormalities in the posterior laterals were noted in a right and a left valve of *Venericardia parva* from Claiborne Bluff in which the cardinals and anterior laterals remained normal. A curious condition is also noted in two paired *Unio japanensis* in which the cardinals are normal, the anterior laterals absent, and the posterior laterals transposed.

No shell was found in which the transposition was complete, nor any in which the transfer of the anterior laterals was unaccompanied by that of the cardinals. By way of explanation, Popenoe and Findlay cite the close genetic relationship of the cardinals and anterior laterals and the independent development of the posterior laterals. In 25 of the 26 abnormal valves which they studied the posterior laterals are a specific character. In 21 of the 25 the posterior laterals are normal but the cardinals and anterior laterals are trans-

[34] Popenoe, W. P., and Findlay, W. A., Transposed hinge structures in lamellibranchs: San Diego Soc. Nat. History Trans., vol. 7, no. 26, pp. 299–318, pl. 19 (17 figs.), 1933.

[35] Morley-Davies, A., L'inversion de la charnière chez les lamellibranches: Soc. géol. France Compte rendu, 8 juin, 1925, pp. 156–158.

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[37] Reynell, A., On *Astarte mutabilis* with reversed hinge dentition: Malacol. Soc. London Proc., vol. 8, pp. 4, 5, text figure, 1908.

[38] Dall, W. H., Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1482, 1903.

[39] Cossmann, Maurice, Catalogue illustré des coquilles fossiles de l'Éocène des environs de Paris, app. 2, p. 11, 1896.

[40] Hanna, M. A., Notes on the genus *Venericardia* from the Eocene of the west coast of North America: California Univ. Dept. Geol. Sci., Bull., vol. 15, no. 8, p. 287, pl. 36, fig. 4, pl. 38, fig. 4, 1925.

[41] Popenoe, W. P., and Findlay, W. A., op. cit., p. 306.

	Height			Width			Outline of shell	Outline of ribs[1]		Rib count				
	Low	High	Average	Low	High	Average		Juvenile	Adult	Low	High	Average		
Venericardia planicosta Lamarck	75	84	80	75	82	79	Trigonocordate			27	34	31	High, heavy	
mediaplata Gardner and Bowles, n. sp.	34	58	45	35	60	48	Ovate-trigonal			29	31	30	Low, light	
nanaplata Gardner and Bowles, n. sp.	41	60	49	40	61	52	Trigonocordate			25	29	26	Rather low	
nanaplata nanna Gardner and Bowles, n. subsp.	21	39	30	21	40	30	Quadrocordate			27	31	29	Low, broad	
negritensis Olsson	Not given						Obliquely subtrigonal[2]	Unknown			22–24[2]		Not described	Not figured
bashiplata Gardner and Bowles, n. sp.	58	79	65	56	76	68	Trigonocordate			24	31	27	High, wide	
ascia Rogers		80[3]			80[3]		Transversely ovate-trigonal			27	29	28	Low, wide	
hatcheplata Gardner and Bowles, n. sp.	59	85	70	59	78	68	Obliquely cordate			27	32	29	High, massive	
claiboplata Gardner and Bowles, n. sp.	55	78	72	55	72	70	Trigonocordate			29	32	31	High, heavy	
cacamai Gardner and Bowles, n. sp.	55	70	65	55	65	61	Ovate-trigonal			27	32	30	Very high, heavy	
restinensis Olsson	Rarely exceeding 50 mm.[2]						Well-rounded to subquadrate[2]	Unknown			22–23[2]		Not described	Not figured
gulielmi Gardner and Bowles, n. name		14			17.5		Broad ovate[4]				25		Low, light	Unknown
pilsbryi Stewart	83	93	87	82	103	93	Trigonal			32	38	35	High, heavy, trigonal	
angustoscrobis Gardner and Bowles, n. sp.		30			32		Transversely ovate to obliquely trigonal				32		Low, rather light	
cookei Gardner and Bowles, n. sp.	37	40	38	39	41	40	Transversely ovate-trigonal			37	40	38	Low, rather light	
claviger Gardner and Bowles, n. sp.	62	74	66	61	75	67	Transversely ovate-trigonal			26	28	27	Low, narrow	
horatiana Gardner	60	86	74	63	90	77	Ovate-trigonal to hatchet-shaped		Obsolete	21	25	24	High, heavy	
stewarti Gardner and Bowles, n. sp.	69	94	79	72	97	80	Ovate-trigonal to hatchet-shaped		Obsolete	24	29	27	High, heavy	
tenosiensis Rutsch	48	90	55	48	86	55	Rounded to transversely ovate		Obsolete	27	30	28	Low, narrow	
pacifica Olsson	49	50	49	52	53	52	Rounded to subquadrate		Obsolete	28	32	31	Low, narrow	
turneri Gardner and Bowles n. sp.	66	85	70	73	94	77	Quadrate			28	28	28	Low, wide	
peruviana Olsson		66			80		Subquadrate		Obsolete		24		High, heavy	Not figured
potapacoensis Clark and Martin	27	43	36	26	42	35	Obliquely trigonal		Obsolete	21	24	22	Very high, heavy	
labreaensis Olsson	34	41	38	34	40	37	Obliquely trigonal			19	20	19	High, heavy	
diga Gardner and Bowles, n. sp.	59	74	63	51	65	58	Obliquely trigonal to ovate-trigonal	Not preserved	Obsolete	24	27	25	High, heavy, trigonal	
clavidens Grzybowski		80–100[2]			75–94[2]		Hatchet-shaped[2]	Unknown			About 21[2]		Very wide and massive[2]	
parinensis Olsson		130			115		Obliquely trigonal	Not preserved			22		High, wide, massive	
francescae Gardner and Bowles, n. sp.		28			27.5		Trigonoquadrate	Not preserved			19		Low, narrow	
jewelli Gardner	60	67	65	63	70	68	Transversely ovate-trigonal	Not preserved		18	20	19	Unknown	Unknown
hijuana Gardner and Bowles, n. sp.	Specimens incomplete									20	23	21	Heavy, narrow	Unknown
smithii Aldrich	40	53	50	43	56	52	Inflated-cordate			25	36	29	Low, wide, light	
aposmithii Gardner and Bowles, n. sp.	70	117	95	64	113	93	Hatchet-shaped			28	36	32	High, narrow, massive	
regia Conrad	75	90	85	82	95	90	Hatchet-shaped			28	30	29	Rather high, heavy	
austroplata Gardner and Bowles, n. sp.	64	105	90	65	103	95	Obliquely cordate			22	22	22	Low, very heavy	
densata pendletonensis Gardner and Bowles, n. subsp.	22	29	27	22	30	28	Transversely ovate			27	30	29	Low, wide	
densata Conrad	21	47	37	21	49	38	Obliquely cordate			23	29	27	High, wide, heavy	
zapatai Gardner and Bowles, n. sp.	55	70	66	52	68	64	Trigonocordate			24	26	25	High, narrow	Unknown
apodensata Gardner and Bowles, n. sp.	45	71	55	45	70	55	Trigonocordate			27	34	31	Low, wide	
klimacodes Gardner and Bowles, n. sp.	33	53	47	33	49	45	Trigonal			27	31	29	Medium, narrow	
greggiana Dall	52	55	53	47	53	50	Subglobose			33	35	34	Low, light	
mingoensis Gardner and Bowles, n. sp.	Specimens incomplete						Outline incomplete	Not preserved		26	28	27	High, light	Unknown
hesperia Gardner		37			37		Transversely ovate	Not preserved			20		Low, rather heavy	Unknown
moa Gardner		30			34		Transversely ovate	Not preserved		18	22	19	Unknown	Unknown

[1] For each species the upper part of the drawing shows the vertical section and the lower part the longitudinal section.
[2] According to Olsson.
[3] According to Clark and Martin.
[4] According to Dall.

DIAGRAMMATIC REPRESENTATION OF DIAGNOSTIC CHARACTERS OF THE AMERICAN SPECIES OF THE VENERICARDIA PLANICOSTA GROUP.

posed. The other 4 show transposed posterior laterals, though the rest of the hinge is normal. They believe that—

> the abnormal hinges * * * represent examples of a systematic abnormality, not pathologic in its origin, in which certain of the primary lamellae from which hinge teeth are derived have developed in the opposite valve from that in which they are normally found. The fact that teeth become transposed in groups corresponding to these primary lamellae and that these teeth are precisely similar to those occurring in a normal hinge are considered as evidence for this opinion. The fundamental causes bringing about this transposition are unknown.[42]

This paper of Popenoe and Findlay is the most exhaustive in its treatment of a restricted subject; they assembled the published material, added a large amount of new material, and made a successful attempt to rationalize it.

Ødner [43] reported an apparent hinge inversion in a *Pisidium* which carried normal young in its gills, thereby indicating to him that the character was not heritable. This is dubious proof, however, for Crampton [44] in his study of the land gastropod *Partula* found that, with 5 exceptions out of more than 3,000 shells examined, the young produced at a given time were similarly coiled but that they might or might not inherit this character from the parent. A more significant observation is that in the subsequent dissection of the animal of *Pisidium* the organization of the soft parts was proved to be normal.

Although shell abnormalities have been observed and recorded for years past, they have never been explained.

Ødner [45] in commenting upon Reynell's "assumed" inversion of *Astarte mutabilis* and of some *Pisidium* hinges is inclined to treat them as displaying "a mere displacement of the hinge elements", and Bernard,[46] who devoted his professional life to the observation of the lamellibranch hinge, stated in his last paper that he knew of no true inversions among the lamellibranchs, that each tooth had its own individuality, and that there was no record of its being transferred from one valve to the other.

This may very possibly be true of *Pisidium*, for the hinge characters in that group of fresh-water bivalves are notably unstable, but in Vest's and in Reynell's figured *Astarte*, in the shells figured by Popenoe and Findlay, and in the *Venericardia* under observation a "mere displacement", which is the mirror image of the normal hinge of the opposing valve, is more difficult to accept.

[42] Popenoe. W. P., and Findlay, W. A., op. cit., p. 312.

[43] Ødner, N. H., Studies on the morphology, the taxonomy, and the relations of Recent Chamidae: K. svenska Vetensk. akad. Handl., Band 59, no. 3, pp. 7, 8, 1919.

[44] Crampton, H. E., The coincident production of dextral and sinistral young in the land gastropod *Partula:* Science, new ser., vol. 59, pp. 558–559, June 20, 1924.

[45] Ødner, N. H., op. cit., p. 8.

[46] Bernard, Félix, Sur le développement et la morphologie de la coquille chez les lamellibranches: Soc. géol. France Bull., 3e sér., vol. 23, pp. 104–154, 28 text figs., 1895; vol. 24, pp. 54–82, 15 text figs., pp. 412–449, 15 text figs., 1896; vol. 25, pp. 559–566, 1897.

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SYSTEMATIC DESCRIPTIONS

Genus VENERICARDIA Lamarck, 1801

1801. Lamarck, Système des animaux sans vertèbres, p. 123.

Type by subsequent designation *Venericardia imbricata* Lamarck = *Venus imbricata* Gmelin (Schmidt, C. F., Versuch über die beste Einrichtung zur Aufstellung, Behandlung und Aufbewahrung der verschiedenen Naturkörper und Gegenstände der Kunst, vorzüglich der Conchyliensammlungen; nebst kurzer Beurtheilung der conchyliologische Systeme, pp. 57, 176, 1818).

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 umbo 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 Λ-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 cardinal 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, semielliptical. 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 Gosport 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, thin, and anterior to the heavy subumbonal tooth.

Cox, in "The fossil fauna of the Samana Range" (Palaeontologia indica, new ser., vol. 15, p. 206), cites *Cardita variegata* Bruguière as the genotype, based

upon Fleming's reference to it in the Encyclopedia Britannica supplement to the 4th, 5th, and 6th editions, vol. 3, p. 305, probably February 1818. Under the subject heading "Linnaean genera," Fleming writes of "the genus *Cardita* of Brüguière, represented by *C. variegata* Lister, tab. 344, fig. 84." This does not seem to constitute a type designation. *Cardita variegata* is a mytiliform species distinct generically from *Venericardia imbricata* Lamarck of the Paris Basin. The acceptance of *variegata* as the type of *Cardita* would necessitate the realinement of *Venericardia* as well as *Cardita*.

Subgenus VENERICOR Stewart

1930. *Venericor* Stewart, 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 anteromedial portion of the left valve, possibly 1 more on the right and 7 on the posterior area; the earliest ribbing very narrow, sharply crested and finely crenate, the adolescent and early adult ribs on the anteromedial portion simple, flat-topped and slightly wider than the U-shaped channels that separate them; the ribs upon the posterior area narrow, crenate, 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 discernible. 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 ligament pit, 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 based on the subgenotype, U. S. National Museum no. 12704 (pl. 35, figs. 1, 2; pl. 36, figs. 5, 6), 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, higher hinge plates, slightly lower rib count, and less persistent ribbing.

The diagnostic characters of some of the species considered are diagrammatically represented on plate 32.

VENERICARDIA MEDIAPLATA stock

Venericardia (Venericor) mediaplata Gardner and Bowles, n. sp.

Plate 33, figures 1, 3

1894. *Venericardia planicosta* Lamarck. Aldrich, Report on geology of Coastal Plain of Alabama, p. 242, pl. 12, fig. 3. Not *Venericardia planicosta* Lamarck, 1806.
1896. *Venericardia planicosta* Lamarck [part]. Harris, Bull. Am. Paleontology, vol. 1, no. 4, p. 58, pl. 4, fig. 13.
1903. *Venericardia mooreana* Conrad [part]. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1422.
1909. *Venericardia planicosta* Lamarck [part]. Grabau and Shimer, North American index fossils, Invertebrates, vol. 1, p. 545, fig. 747 (left valve).

Shell of moderate dimensions for the genus. Umbones low, anterior, pointed forward toward the small and not very conspicuous lunule. Valves most inflated anteriorly, flattening toward the posterior ventral margin. Posterior area delimited both by the sculpture and by an obtuse rostrum. Sculpture worn but probably retaining its original character, excepting upon the decorticated umbones; radials simple, flattening away from the umbones; 20 upon the anterior and medial portions of the valve, separated by only linear interspaces; the 9 posterior radials not so wide nor so flattened as those upon the disk. Hinge plate low and broad. Dentition normal for the group but not conspicuously heavy.

Dimensions of holotype: Height 58.0 millimeters, width 60.0 millimeters, convexity 25.0 millimeters.

Holotype, a left valve: U. S. National Museum, no. 137241.

Type locality: Geological Survey station 281, Prairie Creek, Wilcox County, Ala. Clayton formation of the Midway group.

Venericardia mediaplata differs from *V. smithii* Aldrich in the heavier, less inflated shell and the lower, broader, and more closely spaced radials. The rib counts run about the same. *V. mediaplata* is probably more limited in its distribution both in time and in space.

The description and figures of *Venericardia duponti*

Cossmann [47] suggest a relationship to *V. mediaplata* much closer than that usually indicated by two species separated by an oceanic basin. No examples of *duponti*, unfortunately, are available for comparison.

Distribution:[47a]

Midway group undifferentiated:

Georgia, Houston County, 4956[p], Robert Sappy's place, 4 miles east of Marshallville on the east side of a branch of Spring Creek in a ravine below negro cabins. Clay County 5488[p], Fort Gaines, Chattahoochee River, limestone at the base of the bluff.

Midway group, Clayton formation:

Alabama, Wilcox County, 264[p] and 281[p], Prairie Creek.

Mississippi, Tippah County, 6497[r], Bluff on south side of Owl Creek, 2¾ miles northeast of Ripley and about one-fourth mile east of the Ripley-Troy road, near the base of the formation.

Tennessee, Hardeman County, 2141[r], Porters Creek.

Midway group, Kincaid formation:

Texas, Limestone County, 6560[r], near Horn Hill. Maverick County, 6575[p], White Bluff, Rio Grande River, 4½ miles west of south of Windmill (Jacal) ranch house.

Venericardia (Venericor) nanaplata Gardner and Bowles, n. sp.

Plate 33, figures 2, 7

Shell small, solid, cordate-trigonal, not, as a rule, very highly inflated. Posterior area defined by the modified sculpture rather than by the contour. Lunule small, deep-set, wider in the right valve than in the left. Ligament marginal and external; no true escutcheon. Ribs in the holotype, 21 on the anterior and medial portions of the left valve, 6 on the posterior; 20 on the anterior and medial portions of a right valve, 6 on the posterior; umbonal ribbing narrow and fairly strong, the ribs broadening both relatively and absolutely toward the ventral margin, so that at the margin in the types the interradials are linear; posterior ribs low, increasingly obscure toward the margin, the 3 nearest the dorsal margin, nodose near the umbones and broadening away from the umbones, the remaining 3 narrower and cordlike. Growth lines crowded and fairly strong ventrally. Hinge plate wide, fairly high. Medial cardinal in right valve obliquely cuneate and heavy, the remaining teeth adequate. Ligament groove deep; the nymph rather heavy for the size of the shell. Interior thickened over the area of the mantle attachment. Pedal scar small, deep-set; adductor scars, relatively large, sunken. Inner margins coarsely crenate.

Dimensions of holotype: Height, 49.0 millimeters; width, 52.0 millimeters; convexity, 18.3 millimeters.

Holotype, a left valve: U. S. National Museum, no. 137226.

Type locality: Geological Survey station 271, Nanafalia Bluff, Tombigbee River, Marengo County, Alabama. Wilcox group, Nanafalia formation.

Venericardia nanaplata of the Nanafalia and Tuscahoma formations is apparently descended from *V. mediaplata*, from which it differs in the slightly lower rib count, the less distinct posterior area, and the higher anterior and medial costae. The umbonal ribbing in some of the younger individuals is well preserved and shows a very distinct crenation.

Venericardia nanaplata includes the smallish trigonocordate species with rib counts running usually from 25 to 27, the half dozen upon the posterior area dying out away from the umbones. The characters that show variation to a marked degree are the umbonal inflation and the persistence of the ribs anteriorly and medially. This variation has been recognized in the taxonomy. Only in the more compressed forms do the ribs die out toward the anterior and ventral margin, while inflated individuals of the same or greater dimensions show ribbing as strong at the margins as on the medial part of the disk and have an immature aspect. While the persistence of the ribbing and the convexity do not vary independently, they do show an unbroken sequence, so that any taxonomic break is more or less arbitrary. However, a certain racial fixity is indicated, for the more compressed individuals have not been recognized in the later formations, while the inflated race apparently persists in the Bashi in the form of the much larger *bashiplata*. The compressed race, the *V. nanaplata nanna* with evanescent anterior and medial ribbing, has much the general appearance of *V. densata* of the Claiborne, but the later form may be definitely recognized by the nodose and laterally ridged umbonal costals. Both the Nanafalia and the Tuscahoma carry compressed and inflated races but the inflated individuals are less rare in the later formation.

Distribution:

Wilcox group, Nanafalia formation:

Alabama, Marengo County, 271[c] and 5641[c], Nanafalia Bluff, Tombigbee River.

Wilcox group, Tuscahoma sand:

Alabama, Monroe County, 3118[p], Greggs Landing, Alabama River.

Venericardia (Venericor) nanaplata nanna Gardner and Bowles, n. subsp.

Plate 33, figures 4, 5, 10, 11

Shell small, solid, evenly but not strongly inflated, the beaks not very prominent and the resultant outline rather squarish. Posterior extremity obtusely truncate. Ribbing close and regular, crenate at the umbones, low and broad and overridden by the incrementals near the ventral margin; ribs 20 upon the medial and anterior areas, 9 upon the posterior area of the cotypes; posterior ribs cordate and persistent, with some loss of strength,

[47] Cossmann, Maurice, Pélécypodes du Montien de Belgique: Mus. royal histoire nat. Belgique Mém., tome 5, pp. 52–53, pl. 5, figs. 12–17, pl. 6, figs. 1–5, 1908.

[47a] [r] Rare; [p] present; [c] common; [a] abundant; [pr] prolific.

to the border. Hinge area low and broad, the cardinals inflected to be rudely parallel to the dorsal margin. Muscle scars not conspicuous. Inner ventral and lateral margins crenate.

Dimensions of cotypes: Right valve, height 28.0 millimeters, width 31.0 millimeters, convexity 11.8 millimeters. Left valve, height 30.6 millimeters, width 31.3 millimeters, convexity 12.5 millimeters.

Cotypes, a right and a left valve of different individuals: U. S. National Museum, no. 373028.

Type locality: Geological Survey station 5604, Greggs Landing, Alabama River, Monroe County, Ala. Wilcox group, Tuscahoma sand.

The subspecies *nanna* from the Tuscahoma differs from the Nanafalia *nanaplata* in the smaller size, less trigonal and more uniformly compressed outline, and higher rib count. Among 388 rib counts from Greggs Landing, 118 carried 29 ribs; 85 carried 30; 82 carried 28; ribs on the remaining valves numbered more than 30 or less than 28. This increase over the *nanaplata* rib count is due to the increase in number of the posterior ribs from six or seven to nine, the number of medial and anterior ribs running about the same in the Nanafalia species and the Tuscahoma subspecies. Although the shells do not have the aspect of adolescents, the tendency toward an obsolete ribbing at the ventral margins, particularly upon the posterior area, is less pronounced in the subspecies. The subspecies apparently died out at the end of the Tuscahoma epoch, while *nanaplata* species strictu, which persists in greatly reduced numbers in the Tuscahoma, may have given rise to *V. bashiplata* n. sp., a prominent *Venericardia* of the Bashi.

Distribution:

Wilcox group, Tuscahoma sand:

Alabama, Monroe County, 268^{pr}, 3118^{pr}, and 5604^{pr}, Greggs Landing, Alabama River.

Venericardia (Venericor) negritensis Olsson

Plate 33, figure 6

1922. *Venericardia planicosta* Lamarck (group), form A. Woods, Geology of northwest Peru, pp. 66–67, pl. 4, fig. 1.
1928. *Venericardia planicosta* var. *negritensis* Olsson, Bull. Am. Paleontology, vol. 14, no. 52, p. 26, pl. 5, figs. 1, 2.
1930. *Venericardia planicosta* var. *negritensis* Olsson. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 172.
1936. *Venericardia negritensis* Olsson. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 169, 170, 177.

This variety is the common and characteristic type in the Negritos formation. The usual form is obliquely subtrigonal with low, flattened umbos and with erect or but slightly curved or inclined beaks. The shells are but slightly convex, sometimes appearing flattened or depressed, especially near the ventral or basal margins. The sculpture is strong, with relatively few, heavy persistent ribs, widening out very noticeably toward the ventral margins. On the umbos the ribs are high and narrower than the deep, groovelike interspaces, but they broaden rapidly and near the ventral margin flatten and become 5 or 6 times the width of the shallow but distinct interspaces. From the anterior extremity to the umbonal slope the ribs number from 17 to 19.

The umbonal slope or ridge is usually well defined, and the sculpture of the dorsal-posterior submargins is quite different from the rest of the shell disk. Except in the very earliest stages, the ribbing of the dorsal margins is weak, the ribs quickly fading out distally, and the surface becoming smooth or sculptured simply by crowded growth lines. The low ribs of the posterior-dorsal submargin number 4 or 5, so that the total number of ribs over the whole surface is 22 to 24.

Localities and geologic occurrence.—Negritos formation, Negritos La Brea.—Olsson, 1928.

Woods says of this form: "The latter [specimens from the *Turritella* series] approach closely the North American form named *V. planicosta* var. Conrad (1865), from the Aquia formation of Maryland and the Wilcox group of the Southeastern States. Near the umbo the ribs are narrower than the grooves, but they soon broaden, and at the ventral margin are much broader than the grooves."

Stewart remarks: "*V. planicosta negritensis*, from the Negritos formation, resembles *V. planicosta* from the Wilcox, particularly those from Thomasville. The Alabama specimens have the weaker dorsal ribs described by Olsson."

No specimens of the Peruvian species are available for comparison. The outline of the individual figured by Woods [48] and its clean-cut ribs recall *Venericardia bashiplata* of the fauna at Woods Bluff, the species which Stewart probably had before him from Thomasville. Olsson's figures suggest a less inflated form than the common Bashi species. The rib count runs lower in the Peruvian *negritensis* than it does in *V. bashiplata*, but the character of the ribs is apparently the same in both. *Venericardia regia*, which Woods suggested as a possible analog, is now restricted to the heavy trigonal species from the Aquia formation of Maryland and Virginia, a species characterized in the early stages by crested ribbing.[49]

[48] Woods, Henry, op. cit., pl. 4, fig. 1.

[49] A very fine suite of Peruvian venericards has been described by Henry Woods and by Olsson, and although we have very little comparative material from the Peruvian Eocene, it is tempting to speculate upon the possible analogies with the Gulf species. Olsson (Olsson, A. A., Contributions to the Tertiary paleontology of northern Peru, pt. 1; Bull. Am. Paleontology, vol. 14, no. 52, p. 9, 1928) suggests the following correlation for the Eocene of northern Peru:

American time subdivisions	Formations	Bosworth's divisions
Upper.	Saman formation.[a] Talara formation.[a]	Lobitos formation.
Middle.	Restin, Parinas } Parinas group. Pale Greda, Salina } Salina group.	Negritos formation. Clavilithes series.
Lower.	Negritos.	Turritella series.

[a] Olsson, A. A., Contributions to the Tertiary paleontology of northern Peru, pt. 3; Bull. Am. Paleontology, vol. 17, no. 62, pp. 5–18, 1930.

A few of the planicostate forms have been introduced for possible comparison with East American species.

Venericardia (Venericor) bashiplata Gardner and Bowles, n. sp.

Plate 33, figure 9; plate 34, figures 3–6

1897. *Venericardia planicosta* (of authors). Harris, Bull. Am. Paleontology, vol. 2, no. 9, pl. 10, fig. 5.
1917. *Venericardia planicosta* var. 5 [error for δ], Harris. Waring, California Acad. Sci. Proc., 4th ser., vol. 7, no. 4, p. 54.
1930. *Venericardia planicosta* (of authors). Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, pp. 157, 161.

Shell moderately large and heavy, cordate-trigonal, truncate posteriorly, the umbones prominent and inflated, the tips incurved and turned slightly forward. Lunule sharply delimited, wider in the right valve than in the left. Ligament area prominent but no defined escutcheon. Ribs coarse, simple, serrated by the incrementals at the extreme tips, persistent anteriorly and medially to the ventral margin; 19 in number exclusive of the posterior area; posterior cording close and even near the umbones, dying out away from the umbones and obscured toward the ventral margin by the overriding incrementals; cords 8 in the right valve of the type, 6 in the left, distinct from the angular ribs upon the disk. Hinge plate moderately high and broad, the medial right cardinal scimitar-shaped. Interior thickened over the area of the adherent mantle. Muscle scars unusually large. Pallial line rather distant from the margin. Inner ventral and anterior margins coarsely crenate.

Dimensions of cotypes: Right valve, height 77.2 millimeters, width 75.2 millimeters, convexity 27.0 millimeters. Left valve, height 75.8 millimeters, width 71.5 millimeters, convexity 27.0 millimeters.

Cotypes, a right and a left valve of different individuals: U. S. National Museum, no. 371914.

Type locality: Geological Survey station 7153, Choctaw Corners, Clarke County, Ala. Wilcox group, Bashi formation.

Venericardia bashiplata includes the coarsely ribbed, moderately large and inflated individuals, in the probable line of *mediaplata* and *nanaplata*. It is decidedly larger than its probable ancestors, and the ribbing is more angular and more vigorous than in the majority of the *nanaplata*. The more inflated of the *nanaplata* have a similar sculpture, but they do not approach *bashiplata* in weight and dimensions.

An abnormal left valve of this species was noted at locality 7153. (See discussion on pages 163–165.) It is recorded as U. S. National Museum no. 371914.

Distribution:

Wilcox group, Bashi formation:

Alabama, Dale County, 11093[c], Hillside at swimming pool, near A. C. L. R. R. station, Ozark. Coffee County, 10781[p], Pea River at Churchwell's Bridge, NE¼ sec. 12, T. 4 N., R. 19 E. Clarke County, 10770[c], roadside and corner SE¼ sec. 4, T. 11 N., R. 21 E., 1.6 miles south of Bashi; 3100[c], beds at Woods Bluff, near Choctaw Corners and Thomasville; 7153[c], headwaters of Beaver Creek about a quarter of a mile east of Choctaw Corners (lower bed); 7155[c], gully near middle of sec. 7, T. 11 N., R. 3 E., about 3 miles west of Choctaw Corners; 262[a], 3099[a], 5470[a], Woods Bluff, Tombigbee River.

Mississippi, Lauderdale County, 2134[c], McLemare's Hill, near Meridian; 10055[p], southeast outskirts of Meridian; cut on M. & M. R. R. near overhead crossing of M. & O. R. R.; 7267[p], cut on M. & M. R. R. 300 yards south of Seymour's Hill and 1½ miles south of Meridian (fossils from lower 12 inches of basal yellow sand); 2105[p], McKay's marl bed, Souwashee Creek, 2 miles south of Meridian.

Texas, Sabine County, 5120[p], 200 yards below Sabinetown Ferry; 10728[p], a quarter of a mile downstream from Sabinetown Ferry.

Venericardia (Venericor) ascia Rogers

Plate 35; figures 3–7

1839. *Venericardia ascia* Rogers, H. D., and W. B., Am. Philos. Soc. Trans., vol. 6, pp. 374–375, pl. 29, fig. 2.
1848. *Venericardia ascia* Rogers. Lea, H. C., Acad. Nat. Sci. Philadelphia Proc., vol. 4, p. 107.
1848. *Venericardia ascia* Rogers. Lea, Henry, Catalog of Tertiary Testacea, p. 15.
1865. *Venericardia ascia* Rogers. Conrad, Am. Jour. Conchology, vol. 1, p. 7.
1884. *Venericardia ascia* Rogers. Rogers, H. D., and Rogers, W. B., Geology of the Virginias, p. 671, pl. 4, fig. 2.
1891. *Venericardia ascia* Rogers. Heilprin, Acad. Nat. Sci. Philadelphia Proc. for 1890, p. 402.
1896. *Venericardia ascia* Rogers. Harris, Bull. Am. Paleontology, vol. 1, no. 4, p. 58.
1896. *Venericardia ascia* Rogers. Clark, U. S. Geol. Survey Bull. 141, p. 80.
1901. *Venericardia ascia* Rogers. Clark and Martin, Maryland Geol. Survey, Eocene, p. 177.
1901. *Venericardia marylandica* Clark and Martin, Maryland Geol. Survey, Eocene, p. 179, pl. 40, figs. 7, 7a.
1903. *Venericardia ascia* Rogers. Dall, Wagner Free Inst. Sci. Trans., vol. 3, no. 6, pp. 1419, 1422.
1903. *Venericardia marylandica* Clark and Martin. Dall, Wagner Free Inst. Sci. Trans., vol. 3, no. 6, pp. 1419, 1423.
1917. *Venericardia marylandica* Harris. Waring, California Acad. Sci. Proc., 4th ser., vol. 7, no. 4, p. 54.
1922. *Venericardia ascia* Rogers. Woods, Geology of northwest Peru, p. 69.
1922. *Venericardia marylandica* Clark and Martin. Woods, Geology of northwest Peru, p. 69.
1930. *Venericardia ascia* Rogers. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, pp. 163, 164.
1930. *Venericardia marylandica* Clark and Martin. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 151.
1936. *Venericardia ascia* Rogers. Rutsch, Eclogae geol. Helvetiae, vol. 29, p. 164.

Shell subovate, subcordate, not thick; costae much depressed except on the beak, about 30; transverse striae numerous from the margin to the umbones, nearly obliterating some of the longitudinal sulci; lunule profound, subcordate, triangular and equilateral; anterior muscular impression rather remote from the hinge; cardinal teeth arcuated, oblique; inferior and posterior margins crenulated. Length 3.2 inches, breadth 3.6 inches.

Locality, King George County, Virginia, near the Potomac, in the Eocene.

Remarks.—This shell can be confounded only with the *V. planicosta*, to which it is possible we ought to refer it as a variety. They are readily distinguished, however, by the greater length

and curvature of the whole anterior margin, especially the portion along the ligament; the hinge is broader and longer, and the teeth are less prominent and more arcuated; the muscular impression, on the anterior side, is farther from the hinge; and the whole valve is wider, flatter, and thinner. These differences, with the flatness of the costae, appear to warrant us in regarding this shell as a distinct species from *Venericardia planicosta*. That shell also is found in the Eocene of Virginia, but usually not in the same bed with *V. ascia*.—H. D. and W. B. Rogers, 1839.

The *Venericardia planicosta* of the Rogerses was almost certainly *V. regia*, which occurs in the Eocene of Virginia but at a lower horizon than *ascia*.

Sixty-two years later Clark and Martin described from an equivalent horizon in Maryland a species which they called *V. marylandica* but which probably is specifically identical with *V. ascia*.

Shell thin; outline circular; valves shallow; about 27 ribs, broad and flat on top, with deep, narrow interspaces near the beaks, but very flat, and separated by narrow, impressed line toward the periphery.

This species resembles very closely in outline *V. pectuncularis* from the Paris Basin. It is restricted to the Woodstock substage.

Length 80 millimeters, width 80 millimeters—Clark and Martin, 1901.

Collections from the Nanjemoy formation both in Maryland and in Virginia reveal only the one species of simple-ribbed, subcircular to subovate venericard. The Maryland and Virginia forms have in common a broad hinge plate, shallow valves with only feebly inflated umbones and about 27 or 28 simple flat-topped ribs that remain distinct to the ventral margin and are separated by rather wide interspaces. There is no evidence in the material at hand to indicate that more than one species is involved. *Venericardia potapacoensis*, the only other member of the group that is coexistent with *ascia*, is a lop-sided, very high deltoid or subcordate little species with less than 25 ribs, which are strongly noded in the early growth stages and evanesce in the later.

Distribution:

Wilcox group, Nanjemoy formation:

Maryland, Charles County, 12541[p], bluff on Potomac River, 1 mile below Popes Creek; (Maryland Geological Survey), 2 and 2½ miles above Popes Creek.

Virginia, King George County (Maryland Geological Survey), Woodstock. County unknown, 1453[p], Pamunkey River.

Venericardia (Venericor) hatcheplata Gardner and Bowles, n. sp.

Plate 33, figures 8, 12; plate 34, figures 1, 2

1886. *Venericardia planicosta* Lamarck. Aldrich, Alabama Geol. Survey Bull. 1, pt. 2, p. 50 [name only].

1897. *Venericardia planicosta* var. δ Harris [part], Bull. Am. Paleontology, vol. 2, no. 9, p. 55 [figures excluded].

1903. *Venericardia planicosta* var. *laticardo* Wood. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1422. Not *Venericardia planicosta* var. *laticardo* Wood, Monograph of the Eocene bivalves of England, vol. 1, p. 150, pl. 21, fig. 5d. 1871.

1903. *Venericardia planicosta* form δ Harris [part]. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1422.

1926. *Venericardia planicosta* Lamarck. Cooke, Alabama Geol. Survey Special Rept. 14, pl. 94, fig. 7. (Specimen figured from Hatchetigbee and not from Nanafalia.)

1930. *Venericardia planicosta* form δ Harris [part]. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 156.

Shell not very large relatively but heavy, rather compressed, high cordate with well-rounded margins and remarkable for its senile aspect both in the external and the internal views. Umbones very high but not strongly inflated, inclined forward. Lunule unusually deep and moderately wide, the shell of the adults flattened in front and simulating an outer lunular area. Ligament area very prominent, but no defined escutcheon. Posterior area indicated by a change in the character of the radial sculpture. Ribs ridged and crenate in the umbonal region, low and broad away from the umbones and separated by only linear interradials, evanescent toward the ventral and lateral margins. Ribs in the double paratype, 23 upon the medial and anterior areas, 8 upon the posterior; in the single right cotype, 22 upon the medial and anterior areas; 8 upon the posterior; in the single left cotype, 22 upon the medial and anterior areas, 8 upon the posterior. Posterior ribs more cordlike and not so high as those upon the disk but by no means sharply distinct from them. Growth lines conspicuous toward the outer margins. Ligament attachment adjusted to an unusually heavy ligament. Hinge plate very high, trigonal. Dentition unusually heavy, and the teeth so closely locked that in only about 1 out of every 10 could the valves be forced apart without breaking the hinge. Pedal scar deeply impressed. Adductor scars rather narrow but sunken. Pallial line ragged. Interior thickened over the area of the adherent mantle. Inner margins feebly crenate.

Dimensions of cotypes: Right valve, height 70.0 millimeters, width 68.0 millimeters. Left valve, height 73.0 millimeters, width 69.5 millimeters.

Cotypes, a right and a left valve of different individuals and a paratype, a locked pair of valves: U. S. National Museum, no. 372173.

Type locality: Geological Survey station 261, Hatchetigbee Bluff, Tombigbee River, Washington County, Ala. Wilcox group, Hatchetigbee formation.

Venericardia hatcheplata is remarkable for the high, rather compressed valves with rounded outlines, worn and not very prominent ribbing, which tends to become obsolete in the adult and gives to the shell a senile look, the very high deltoid hinge plates, the strong, closely interlocked teeth, and the very distinct scars and ragged pallial line. The species is probably in line with *V. nanaplata* and *V. bashiplata*. It is not so inflated as its Bashi progenitor; the ribs are not so strong but more numerous and much more inclined to become obsolete ventrally. The hinge plate is higher and not so wide, the scars are not so large but more distinct,

and the pallial line is nearer the margin. The species is exceedingly common in the early collections from Hatchetigbee Bluff and is restricted to the Hatchetigbee formation of the Wilcox group.

Distribution:

Wilcox group, Hatchetigbee formation:

Georgia, Stewart County, 12097[p], 1¼ miles northeast of Troutman, spring west of Georgia, Florida & Alabama Railroad, fossils from weathered yellow clay about 5 feet above level of spring.

Alabama, Washington County, 547[p], 261[pr], and 5873[pr], Hatchetigbee Bluff, Tombigbee River; 10768[p], roadside half a mile west of Butler.

Venericardia (Venericor) claiboplata Gardner and Bowles, n. sp.

Plate 36, figures 1–4

1919. *Venericardia planicosta* Lamarck form δ [part]. Harris, Bull. Am. Paleontology, vol. 6, no. 31, p. 77, pl. 27, figs. 5 and 6, pl. 28, figs. 1 and 2.

1936. *Venericardia claiboplata* Gardner and Bowles, nude name. Cooke, U. S. Geol. Survey Bull. 867, pp. 61, 62, 63, 64.

Shell moderately large and solid, high trigonocordate with broadly rounded margins and elevated, broadly inflated umbones, the tips incurved over the deeply sunken lunule. Posterior area defined by the change in sculpture rather than by the contouring of the valve. Ribs elevated, ridged and serrate near the tips of the umbones, high and angular away from the umbones, flattening and tending to become obsolete near the ventral margin, 24 upon the anterior and medial portion of the cotypes, 6 upon the posterior area of each. Hinge area high, dentition heavy; cardinals produced, the posterior cardinal of each valve following the curve of the dorsal margin; middle right cardinal flattened, arcuate-cuneate. Pedal scar deeply inset; adductor scars large, distinct. Pallial line distinct but not conspicuous, rather close to the ventral margin.

Dimensions of cotypes: Right valve, height 73.0 millimeters, width 70.0 millimeters, convexity 26.0 millimeters. Left valve, height 73.0 millimeters, width 72.0 millimeters, convexity 26.5 millimeters.

Cotypes, a right and a left valve of different individuals: Right valve, U. S. National Museum, no. 11365; left valve, U. S. National Museum, no. 1434.

Type locality: (U. S. N. M. 11365) Claiborne, Monroe County, Alabama. (U. S. N. M. 1434) Clarksville, Clarke County, Ala.

Venericardia claiboplata is closely allied to its probable ancestors. From *V. hatcheplata* it may be separated by the more convex outline, the lower average rib count, and the relatively smaller, lower hinge plate.

The rib count upon the anteromedial portion is higher by four or five than upon *V. bashiplata*, and the umbones are higher and more inrolled. The dentition is, however, very similar in the Bashi and the Claiborne forms. *V. claiboplata* differs from *Venericardia densata* Conrad in the less sharply beaded umbonal riblets, the narrower anterior ribs, and the lesser tendency toward the undercutting of the ribs away from the umbones. *V. densata* is appreciably smaller in the adult state. The two species have the same general distribution, but *V. claiboplata* is less common and not so widespread. In Texas it is most commonly represented in the Weches greensand member of the Mount Selman formation in Anderson and Houston Counties.

Specimens from southeastern Atascosa County near Leming, Tex., from concretionary beds probably of Reklaw age, indicate a common species closely related and possibly specifically identical with *claiboplata*. The shells are preserved in the form of molds only and are apparently all immature. The large inflated species occurring near Magnolia Crossing on the Trinity River in southern Anderson County is not *V. claiboplata* but probably a new species more closely allied to some of the Mexican forms. Associated with it are roundish, rather heavy venericards linearly grooved somewhat after the manner of some of the variants of *V. diga*. If the Magnolia Crossing outcrop is lower Claiborne, it is extremely difficult to understand why in the midst of a fossiliferous lower Claiborne sequence it should carry, without apparent lithologic change, a fauna so distinct.

Distribution:

Claiborne group, McBean formation:

South Carolina, Lexington County, 7731[p], 7 miles east of Swansea. Orangeburg County, 7724[p], Bull Swamp Road east of Limestone Creek, 6½ miles northwest of Orangeburg Court House; 4579[c], 4580[c], Bull Swamp road, 5.1 miles northwest of Orangeburg Court House; 2012[c], Pooser's Hill, 5 miles northwest of Orangeburg Court House; 2013[c], Cawcaw Swamp, 4½ miles northwest of Orangeburg Court House; 2011[p], Cawcaw Swamp, 3½ miles northwest of Orangeburg Court House; 7723[p], Bull Swamp road east of Cawcaw Swamp, 2½ miles northwest of Orangeburg Court House; 2009[p], Cawcaw Swamp, 2 miles west of Orangeburg Court House; 7992[p], 4 miles east of Springfield.

Claiborne group, Lisbon formation:

Alabama, Monroe County, 2396[c], 3105[c], Lisbon Bluff, 1 mile below Lisbon Landing, Alabama River. Clarke County, 278[p], Coffeeville; ?Clarksville[p].

Claiborne group, Mount Selman formation, Reklaw member:

Texas, Gonzalez County, 12468?[r], half a mile below Willow Springs ranch house on Capote Hills road.

Claiborne group, Mount Selman formation, Weches greensand member:

Texas, Anderson County, 9968[r], half a mile west of Palestine; 2054[r], Colgins Hill, 1 mile south of Palestine; 9265[p], 1 mile south of Elkhart. Houston County, 9255[p], 9258[p], Percilla. Leon County, 13058[p], half a mile east of Robins on the Centerville road. Bastrop County, 5284[p], near the county line in the southernmost part of the county.

Claiborne group, Cook Mountain formation:

Louisiana, Bienville Parish, 2911[p], near Mount Lebanon.

Texas, Houston County, 10735[r], Trinity River, Alabama Crossing, bed no. 1.

Claiborne group, Gosport sand:
Alabama, Monroe County, 263[p], 2391[p], 2867[p], 13044[p], 13086[p], Claiborne Bluff, Alabama River. Covington County, 1010[r], Conecuh River, 3 miles west of Andalusia; 6737[r], Sepulga River, 6½ miles north of Brooklyn.

Venericardia (Venericor) cacamai Gardner and Bowles, n. sp.

Plate 37, figures 4, 5, 8, 11

Shell large and heavy, inflated, cordate. Umbones full and prominent, twisted forward over the narrow but rather high lunule. Posterior region clearly differentiated not only by the obtuse flattening of the shell but also by a marked change in the ribs, which become narrow and closely spaced with linear intercostals and overridden by the incrementals, which cut sharply into them, obscuring their outline. Sculpture on the extreme tips not preserved in the cotypes, but costals sharply noded near the tips, flat and simple on the disk and separated by narrower U-shaped intercostals; traces of lateral threading preserved in the adolescent stage of the shell, but preservation too poor to determine its importance; ribs relatively narrow and cordlike anteriorly, 23 on the anteromedial portion, 7 on the posterior. Ligament marginal, supported on prominent nymphae. Hinge very high and heavy. Right anterior cardinal almost vertical; the middle cardinal heavy, deltoid, arched obliquely forward toward the tips; posterior cardinal produced parallel to the ligament groove; left anterior and posterior cardinals high, rather heavy and bent slightly forward toward the tips of the umbones. Characters of the rest of the interior concealed by the matrix, but the adductor and pedal scars probably deep and large to function adequately in so heavy a shell.

Dimensions of cotype: Left valve, height (estimated) 75.0 millimeters.

Cotypes, an incomplete right and left valve of different individuals: U. S. National Museum, no. 373032.

Type locality: Geological Survey station 13142, on the west side of the Loma Guajardo road to Dr. Coss, Zacate, Nuevo León, Mexico.

Venericardia cacamai is the heavy-shelled and heavy-hinged venericard most widely distributed in the upper part of the Cook Mountain of northern Mexico. It occupies in the faunas above the Arroyo Chacon assemblage the same position which *Venericardia densata* occupies in the faunas carrying *Ostrea sellaeformis*. *V. cacamai* is a more massive shell than *V. densata*, and the average dimensions and the rib count are higher than in *V. claiboplata* or *V. zapatai*.

The species has not been recognized on the Texas side, but in northern Mexico it is sufficiently common to be of stratigraphic value.

Venericardia (Venericor) restinensis Olsson

Plate 37, figure 6

1928. *Venericardia planicosta* var. *restinensis* Olsson, Bull. Am. Paleontology, vol. 14, no. 52, p. 27, pl. 6, fig. 2.

1930. *Venericardia planicosta restinensis* Olsson. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 172.

1936. *Venericardia restinensis* Olsson. Rutsch, Eclogae geol. Helvetiae, vol. 29, p. 172.

During the Restin or the upper middle Eocene the conditions for the growth and evolution of this series of *Venericardia* do not appear to have been specially favorable, and the shells are generally small, rarely exceeding 50 millimeters in length. They vary from well-rounded to subquadrate in form, strongly convex, with heavy ribs extending over two-thirds of the surface, becoming obsolete or fading over the central portion. The ribs number about 17 to the umbonal angle, with 5 or 6 additional ones on the dorsal-posterior submargins. The umbos are full, convex, with small, curved beaks and small, deeply sunk lunule. The posterior submargin is somewhat ridged in the middle, bordered with a depressed or concave zone on the outer side.

An interesting *Venericardia*, probably belonging to the *planicardia* [*planicosta*] stock, was described by Grzybowski as *V. clavidens*, and he lists the fossils both from Zorritos and Rica Playa. From Grzybowski's Zorritos records one would presume the fossil to be of Miocene age, but the species is not mentioned by Spieker in his studies on the Zorritos fauna, nor have any specimens been found in the course of our own extensive collecting in the Miocene rocks of northern Peru. It is therefore most probable that Grzybowski's specimens were collected only at Rica Playa, where Miocene beds are found overlapping on the upper Restin and lower Saman Eocene. *V. clavidens* resembles variety *restinensis* by its small size and in sculpture but differs by its strongly pointed posterior extremity and by its hinge. The hinge of *clavidens* shows in the right valve a small tooth rising from the posterior end of the nymphs. In this feature *clavidens* shows an approach to *samanensis*, occupying an intermediate position between that variety and *restinensis*, which its stratigraphic position at Rica Playa would also indicate.

Localities and geologic occurrence.—Restin formation, Negritos, Pozo Valley near Lagunitas and Lower Verdun, Jabonillal, Restin.—Olsson, 1928.

Olsson figured only the exteriors of his venericards. Unless the species shows some striking individuality externally, which this one does not, comparisons without comparative material are of little value.

POSITION UNCERTAIN

Venericardia gulielmi Gardner and Bowles, n. name

Plate 42, figure 4

1903. *Venericardia simplex* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1426, pl. 56, fig. 12 [not *V. simplex* Wood, 1864].

Shell inequilateral, broad ovate, with small, rather low beaks; anterior end short, rounded, posterior longer, arcuate dorsally, broadly rounded behind; base gently arcuate; sculpture of about 25 simple, low, subequal ribs, separated by wider, shallow, unchanneled interspaces; lunule small, impressed; hinge normal, basal margin internally fluted. Length 17.5, height 14.0, diameter 9.0 millimeters.

Chickasawan (or Lignitic) Eocene of Woods Bluff, Clarke County, Ala., Frank Burns.

At first glance this species recalls a very much worn young *alticostata*, but an examination shows the surface to be intact and the sculpture naturally as described.—Dall, 1903.

Holotype, a left valve: U. S. National Museum, no. 154725.

Type locality: Geological Survey station 3100, Woods Bluff, Clarke County, Ala. Wilcox group, Bashi formation.

Dall described this species originally under the name *V. simplex*, a name preoccupied by Wood's species from the British Tertiary described in 1864. The type of the species, a left valve, is unique, and the affinities are doubtful.

The cardinals, particularly the anterior, are remarkably slender and laminar.

Distribution:

Wilcox group, Bashi formation:

Alabama, Clarke County, 3100', Woods Bluff, Tombigbee River.

Section LEUROACTIS Stewart

1930. Stewart. Gabb's California Cretaceous and Tertiary type lamellibranchs: Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 154, 158–160.

Type by original designation: *Venericardia pilsbryi* Stewart, lower Wilcox (Nanafalia and Tuscahoma formations) of Alabama.

An apparently new species is described from Yellow Bluff (Wilcox) which is believed to be related to *V. horatiana* rather than to *V. planicosta*, and these two species are given a new section name *Leuroactis*.—Stewart, p. 154, 1930.

The short straight right cardinal of *V. pilsbryi* resembles the corresponding tooth in the hinge of *V. horatiana*, and the species seem more closely related to that species than to *V. planicosta* and its allies. In *V. planicosta* the right cardinal curves anterodorsally. The difference is best shown in immature specimens (25 to 50 millimeters in length), and there also the resemblance to *V. horatiana* may be seen. While this difference is not very great it indicates that *V. pilsbryi* is off the main stem of *V. planicosta*. The new section name *Leuroactis* is here proposed, with *V. pilsbryi* as type species. *V. horatiana* and its Pacific relative *V. aragonia* are placed in this section because they have the straight right cardinal. While all the adult specimens of *V. pilsbryi* have the straight cardinal, the character is not so well marked on some of the large specimens of *V. horatiana* particularly when compared to the hinge of large specimens of *V. regia*, which appears to belong with *V. planicosta* in *Venericor*. *V. pilsbryi* has the most unique hinge, while that of *V. horatiana* approaches the hinge of *Venericor*.—Stewart, p. 160, 1930.

Venericardia (Venericor) pilsbryi Stewart

Plate 38, figures 9, 10

1930. *Venericardia pilsbryi* Stewart, Acad. Nat. Sci. Philadelphia, Special Pub. 3, pp. 158–160, pl. 9, figs. 4, 5; pl. 10, figs. 1, 2.

1936. *Venericardia pilsbryi* Stewart. Rutsch, Eclogae geol. Helvetiae, vol. 29, p. 164.

Shell large, heavy, rather flat, with prominent umbo, well-rounded anterior end and the posterior end produced ventrally; ventral margin almost straight; 38 close-set radiating ribs, those over the central portion being smooth and flat, while those on the dorsal slopes are slightly rounded and crossed by prominent growth lines; lunule wide and deep, escutcheon not defined; internal callus heavy and the ventral and anterior margins coarsely crenulated internally; the prominent cardinal tooth in the right valve straighter and shorter than is usual for this genus. Length 103 millimeters, height 93 millimeters, thickness of right valve 32 millimeters; type no. 12510 * * *.

Horizon, Eocene, Lignitic-Sabine-Wilcox; locality, Yellow Bluff, on the Alabama River * * *.

This species occurs with *V. planicosta* and *V. regia* in the lower Wilcox of Alabama, and in contrast to the abundance of those species, only 28 specimens have been recognized. The number of ribs varies from 32 to 38, a plurality (6) having 35 ribs. The species may be easily recognized by its smooth, flat central ribs and linear interspaces * * *.

The short, straight right cardinal of *V. pilsbryi* resembles the corresponding tooth in the hinge of *V. horatiana*, and the species seems more closely related to that species than to *V. planicosta* and its allies. In *V. planicosta*, the right cardinal curves anterodorsally. The difference is best shown in immature specimens (25 to 50 millimeters in length), and there also the resemblance to *V. horatiana* may be seen. While this difference is not very great, it indicates that *V. pilsbryi* is off the main stem of *V. planicosta*. * * *.—Stewart, 1930.

Venericardia pilsbryi does not seem to bear any close relationship to the other lower Wilcox forms. Apparently it arose from some ancestor common with the *mediaplata* stock but probably left the main strain prior to Midway time. It is found in both the Nanafalia and the Tuscahoma, but no descendants of the stock are encountered throughout the upper Wilcox. In the Claiborne two possible descendants have been recognized—*V. angustoscrobis* n. sp. from the Lisbon formation in Alabama, and *V. claviger* n. sp., from the South Carolina and Alabama undifferentiated Claiborne. *V. cookei* n. sp., from the Jackson of Alabama, is a very similar type and is probably the culmination of the race.

Distribution:

Wilcox group, Nanafalia formation:

Alabama, Marengo County, 271p, Nanafalia Landing, Tombigbee River.

Wilcox group, Tuscahoma sand:

Alabama, Wilcox County, Acad. Nat. Sci. Philadelphia no. 12510, Yellow Bluff, Alabama River; 10779r, descent to Lower Peachtree Ferry, Alabama River. Monroe County, 3118r, Greggs Landing (lower bed), Alabama River.

Venericardia (Venericor) angustoscrobis Gardner and Bowles, n. sp.

Plate 38, figures 4, 7

Shell small, solid, inflated, ovate-trigonal in outline. Umbo low, not prominent. Lunule relatively wide and shallow. Anterior margin broadly rounded, posterior margin obscurely truncate and slightly produced ventrally. Umbonal ribs relatively wide, separated by deep, narrow intercostals and bearing prominent serrations. Ribs 32, wide, flat-topped, and separated by deeply incised, narrow intercostals; 8 of these on the posterior region, 24 on the anteromedial, complete and distinct to the ventral margin. Nymph narrow and not prominent. Hinge plate low and rather wide; median cardinal of right valve asymmetrically trigonal. Adductor scars small and not deeply incised. Pallial line simple, indistinct, and close to the ventral margin. Inner ventral margin crenulate.

Dimensions of holotype: Height 30.0 millimeters, width 32.5 millimeters, convexity 12.0 millimeters.

Holotype, a right valve: U. S. National Museum, no. 372691.

Type locality: Geological Survey station 13060, Lisbon Bluff, Monroe County, Ala. Claiborne group, Lisbon formation.

The holotype was collected by Dr. Earl Turner, who generously presented it to the United States Geological Survey.

Venericardia angustoscrobis is known only from the type, which is probably not fully adult. A doubtful right valve (pl. 38, figs. 3, 8), which presents some characters of extreme old age, is possibly related to this species and probably from the Gosport sand. The young form suggests, in the compact outline and fine, crowded, but very regular ribbing, *Venericardia cookei* from the Jackson. The Jackson species differs superficially in the more transversely ovate outline and the higher rib count and fundamentally in the trigonal right middle cardinal, in which the posterior leg is longer than the anterior, but both margins are straight as in *V. pilsbryi*, while in *angustoscrobis* the right middle cardinal is cuneiform and bent forward near the umbones. The hinge of the gerontic right valve questionably allied to *V. angustoscrobis* is very similar to that of *V. densata* but the costals are more numerous and less ornamented.

Distribution:
Claiborne group, Lisbon formation:
Alabama, Monroe County. 13060[r], Lisbon Bluff, Alabama River.
Claiborne group, Gosport sand:
Alabama, Monroe County, ?Claiborne Bluff[r], Alabama River (F. E. Turner).

Venericardia (Venericor) cookei Gardner and Bowles, n. sp.

Plate 38, figures 5, 6

Shell small, compact, inflated, ovate-trigonal; the anterior lateral margin merging smoothly into the upcurved base, the posterior obscurely truncate. Umbones broad, low, with inconspicuous tips turned inward and forward. Lunule wide and not at all deep-set. Posterior area indicated by a flattening of the shell and by the more narrow, cordlike costals and stronger incremental wrinkling. Radial sculpture close and crowded over the entire shell, the costals, 39 in all, 30 on the anteromedial portion, 9 on the posterior; sharply noded in the early growth stages, low, flat, and simple in the later and separated by deeply incised linear intercostals, which remain distinct to the ventral margin. Ligament marginal, deeply inset, the nymph narrow but expanded slightly toward the umbones. Hinge plate low but rather broad. Anterior right cardinal very short; the middle right cardinal an asymmetric triangle with the posterior dorsal margin straight and not bent forward as in the great majority of the group; posterior right cardinal a slender lamina produced beyond the extremity of the ligament nymph; anterior left cardinal short, the posterior more produced and slightly expanded ventrally. Interior thickened slightly over the area of the adherent mantle. Pedal scar a deep dent at the dorsal extremity of the anterior adductor. Adductor scars very large for the size and weight of the shell, sunken, and distinct. Pallial line rather far removed from the ventral margin. Inner margins sharply crenate from the lunule to the ligament groove.

Dimensions of holotype: Height 38.0 millimeters, width 41.5 millimeters, convexity 15.2 millimeters.

Holotype, a right valve: U. S. National Museum, no. 129767.

Type locality: Geological Survey station 269, Catons Bluff, Conecuh River, Covington County, Ala. Rocks of Jackson age.

Venericardia cookei is the last known descendant of the *pilsbryi* stock. From *Venericardia angustoscrobis* of the Lisbon fauna, it is separated by the more ovate outline, the slightly higher and less anterior umbones, the lack of curvature in the middle right cardinal, and the ribs more numerous by 5 or 6.

The species is known only from the type locality. It is named in honor of C. Wythe Cooke, who has so generously shared with us his intimate knowledge of the upper Eocene of the Gulf.

Distribution:
Rocks of Jackson age:
Alabama, Covington County, 269[p], Catons Bluff, Conecuh River.

Venericardia (Venericor?) claviger Gardner and Bowles, n. sp.

Plate 38, figures 1, 2

1936. *Venericardia claviger* Gardner and Bowles, nude name. Cooke, U. S. Geol. Survey Bull. 867, p. 58.

Shell moderately large and heavy; rounded ovate to trigonal with broadly arcuate anterior and ventral margins and obtusely truncate posterior margin. Umbo inflated; prosogyrate. Lunule narrow and deep. Posterior area defined by the truncation of the posterior extremity and by the costae, which become narrow and close-set, and wrinkled by many fine, concentric incremental striae. Umbonal sculpture consisting of narrow, high ribs, serrate on the extreme umbonal tips, particularly on the more anterior costae. Adult sculpture consisting of 27 wide, gently arched costae, 21 on the anteromedial portion of the disk and 6 on the posterior area, separated by deeply incised intercostals which are little more than narrow lines but which remain distinct and complete to the ventral margin. Hinge plate very small; the teeth coarse and concentrated; median cardinal tooth of right valve peglike, extremely high and heavy, although very short, forming a trigonal wedge that is almost as high as it is long. Pedal scar very large and close to anterior adductor scar. Adductor muscle scars large but not deeply incised; pallial line simple and relatively far from the ventral margin.

Dimensions of holotype: Height 74.0 millimeters, width 75.0 millimeters, convexity, 27.5 millimeters.

Holotype, a right valve: U. S. National Museum, no. 136973.

Type locality: Geological Survey station 2666, Jackson, Clarke County, Ala. Undifferentiated Claiborne group.

This species seems to be most closely related to the *Venericardia pilsbryi* stock of the lower Wilcox, although the ribs are much fewer in number than in *V. pilsbryi*, the hinge is not so high, and the right middle cardinal is less produced. *V. claviger* may be distinguished from *V. claiboplata* by its wide, arched ribs, separated by almost linear intercostals, as contrasted to the narrower, higher flat-topped ribs of *claiboplata*, which are separated by distinct, comparatively wide intercostals. The more rounded or transversely ovate outline and the differences in the dentition will also readily separate the two species.

Distribution:

Claiborne group, undifferentiated:

South Carolina, Aiken County, 4600[r], Kennedy's scarp, half a mile west of Cox's Bridge, south side of Tinker's Creek (base of Cooke section, stratum no. 1).

Alabama, Clarke County, 2666[r], Selma & Mobile R. R. cut near Jackson.

Venericardia (Venericor) horatiana Gardner

Plate 39, figures 1–3, 5; plate 40, figures 1, 2, 5

1897. *Venericardia planicosta* form γ Harris [part], Bull. Am. Paleontology, vol. 2, no. 9, p. 55, pl. 10, figs. 1–4.

1903. *Venericardia hornii* Gabb [part]. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1422. [Not *Cardita hornii* Gabb, Paleontology of California, vol. 1, sec. 4, pp. 174, 232, pl. 24, fig. 157, 1864.]

1903. *Venericardia planicosta* form γ Harris [part]. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1422.

1917. *Venericardia planicosta* Harris [not Lamarck?] [part]. Waring, California Acad. Sci. Proc., 4th ser., vol. 7, no. 4, p. 54.

1927. *Venericardia horatiana* Gardner, Washington Acad. Sci. Jour., vol. 17, no. 14, p. 369, figs. 28, 29.

1928. *Venericardia planicosta* form γ Harris [part]. Olsson, Bull. Am. Paleontology, vol. 14, no. 52, p. 27.

1930. *Venericardia horatiana* Gardner. Stewart, Acad. Nat. Sci., Philadelphia Special Pub. 3, p. 180, pl. 9, figs. 1, 2, 3; pl. 10, fig. 3.

1936. *Venericardia horatiana* Gardner. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 163, 171, 174.

1936. *Venericardia aragonia* Arnold and Hannibal [part]. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 163, 164, 168, 170, 171, 174, 177, 180. Not *Venericardia aragonia* Arnold and Hannibal, 1914.

Shell rather small, thin, rudely quadrate, moderately inflated; obscurely flattened posteriorly. Umbones quite small, incurved, prosogyrate, acutely tapering, placed a little in front of the median vertical. Lunule minute, deeply impressed. Anterior end very broadly rounded; posterior dorsal margin obliquely sloping, rounding into the vertically truncate lateral extremity; base line feebly arcuate. Tips of umbones reticulately sculptured; radials, excepting on weathered specimens, restricted to the dorsal posterior portion of the shell, most closely spaced posteriorly, not developed on the extreme half or third of the shell; radials usually 20 or 21 in number, moderately elevated near the umbones and showing a slight tendency to be nodose; interradials near the umbones broadly U-shaped, the incrementals very fine and sharp and evenly developed in the channels but not overriding the radials; radial sculpture away from the umbones subcutaneous; the interradials appearing as very feebly incised lines, least feeble posteriorly; a scalloped incremental sculpture showing faintly upon the ventral portion of the shell. Hinge plate moderately heavy. Ligament external, the area narrow and much produced. Dentition normal; anterior cardinal of right valve nearly obsolete; medial cardinal heavy, asymmetrically cuneate, posteriorly produced, feebly striated transversely; posterior right cardinal slender, elevated; anterior left cardinal short, stout; posterior cardinal much produced, relatively slender, the inner surface of the anterior and both the lateral surfaces of the posterior cardinal transversely striated. Characters of interior sharply defined by the slight thickening of the shell over the surface of the adherent mantle. Adductor scars very distinct, the anterior rudely reniform, the posterior semielliptical; pedal scar small but deeply impressed, directly dorsal to the anterior adductor. Pallial line simple, rather far removed from the ventral margin; inner margins strongly crenate.

Dimensions: Altitude 25 millimeters, latitude 27 millimeters, semidiameter 9 millimeters.

Holotype: U. S. National Museum, no. 369238.

Type locality: 1½ miles west of Sabinetown, Sabine County, Tex.

Geologic horizon: Wilcox formation.

Venericardia horatiana is remarkable for the quadrate outline and the character of the sculpture. Beneath the outer shell layer the radials are angular and persistent to the ventral margin; but in perfectly preserved specimens they are almost entirely concealed by the epidermal veil. This epidermis is produced, at the lower margin, a trifle beyond the layers beneath, and the scalloping of this thin edge is remarkably sharp.—Gardner, 1927.

This species, unfortunately, was described from a young form. The adult outline is not quadrate but cordate-trigonal. However, *Venericardia horatiana* is a species well characterized both in its youthful and in its adult stages and restricted in its known distribution to the upper Wilcox formations. The peculiar bulbous, strongly incurved tips separate the young of *V. stewarti* of the Lisbon formation; and the adult *V. horatiana* differs from the Claiborne species in the higher, more trigonal outline. *V. horatiana* shares with *V. potapacoensis* Clark and Martin an obsolete radial sculpture in the adult stages, but it seems improbable that an intimate relationship is indicated by this common character. There is, on the contrary, much in the simple umbonal sculpture, the ill-defined posterior area, the high hinge plate, and the pallial line rather distant from the ventral margin to suggest for *V. horatiana* a line of descent from *V. pilsbryi* Stewart of the lower Wilcox.

Distribution:

Wilcox group, Bashi formation:

Alabama, Coffee County, 10012[p] and 10781[p], Pea River at Churchwell's Bridge, NE¼ sec. 12, T. 4 N., R. 19 E., about 5½ miles south of Elba; 10013[p] and 10780[p], power plant, Pea River, 4 miles below Elba. Clarke County, 10770[p], roadside and SE¼ sec. 4, T. 11 N., R. 21 E., 1.6 miles south of Bashi; 3100[p], beds at Woods Bluff near Choctaw Corners and Thomasville; 7155[p], gully near middle of sec. 7, T. 11 N., R. 3 E., about 3 miles west of Choctaw Corners; 262[p], 2667[p], and 3099[p], Woods Bluff, Tombigbee River.

Texas, Sabine County, 4789[c] and 11100[c], Sabinetown Bluff, 300 feet to a quarter of a mile below Sabinetown Ferry; 5142[p], 1½ miles west of Sabinetown.

Wilcox group, Hatchetigbee formation:
Alabama, Choctaw County, 13051[r], Hatchetigbee Bluff, Tombigbee River (F. E. Turner).

Venericardia (Venericor) stewarti Gardner and Bowles, n. sp.

Plate 39, figures 4, 6, 7

1930. *Venericardia horatiana* Gardner [part]. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 161.

Shell large, heavy, roundly ovate in outline. Umbo inflated and beginning with a curiously characteristic bulbous tip. Lunule very deeply set. Anterior margin broadly rounded; posterior margin rounded and only slightly produced ventrally. Umbonal ribs high and narrow, with slight serrations, particularly on the extreme anterior ribs. Posterior region very well defined by the abrupt rounding of the ventral margin and bearing 6 indistinct, wrinkled costae; anterior region not distinctly separated from the medial portion; anteromedial portion of disk bearing above the first strong growth line 16 wide, rounded costals separated by linear intercostals, which, however, become obsolete over the major portion of the disk. Ligament marginal and external, but no true escutcheon developed; nymphae low and heavy. Hinge plate high and heavy; teeth high, narrow, and curved. Pedal and adductor muscle scars prominent. Pallial line distinct and simple. Inner and outer margins very faintly crenulate.

Dimensions of paratype: Height 78.0 millimeters, width 96 millimeters, convexity 54 millimeters.

Holotype, a left valve: U. S. National Museum, no. 154933; paratype, the right and left valves of a single individual, U. S. National Museum, no. 116027.

Type locality: Geological Survey station 3105, bed 4 of Cooke section, Lisbon Bluff, Monroe County, Ala. Claiborne group, Lisbon formation, associated with *Ostrea lisbonensis*.

Venericardia stewarti is abundantly represented in the *Ostrea lisbonensis* zone at Lisbon Bluff and is restricted apparently to that zone. It is close to *V. horatiana* Gardner, of the Bashi formation, and is probably in the line of descent. The two species may be most readily distinguished by the characteristic bulbous tips of *V. stewarti*.

Stewart [50] spoke of a form similar to *V. horatiana* being found in the Lisbon of Alabama, and suggested that it be considered a distinct species, but because of the paucity of his material he did not definitely separate it.

The species is restricted in its known distribution to the lower Caliborne of Alabama and Texas.

[50] Stewart, R. B., Gabb's California Cretaceous and Tertiary type lamellibranchs: Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 161. 1930.

Distribution:

Claiborne group, Lisbon formation: *Ostrea lisbonensis* zone and its time equivalents:
Alabama, Monroe County, 2668[p], 3105[p], and 5511[p], Lisbon Bluff, a short distance below Lisbon Landing, Alabama River.

Claiborne group, Mount Selman formation, Weches greensand member:
Texas, Sabine County, 11107[r], Sulphur Branch near Sabinetown.

Venericardia (Venericor) tonosiensis Rutsch

Plate 40, figures 6, 7

1919. *Venericardia planicosta* var. *horni* (Gabb) Vaughan, U. S. Nat. Mus. Bull. 103, p. 548. Not *Cardita hornii* Gabb, Paleontology of California, vol. 1, sec. 4, pp. 174, 232; pl. 24, fig. 157, 1864.

1919. *Venericardia planicosta* Lamarck. Vaughan, U. S. Nat. Mus. Bull. 103, p. 577. Not *Venericardia planicosta* Lamarck, Mus. hist. nat. Paris Annales, vol. 7, p. 55. 1806.

1936. *Venericardia tonosiensis* Rutsch, Eclogae geologicae Helvetiae, vol. 29, pp. 168, 169, 170, pl. 16, figs. 2–4.

Shell relatively small, not very heavy, evenly but not strongly inflated, approaching much more closely to the rotund than the usual venericard. Umbones moderately prominent, broadly expanded, full to the incurved, prosogyrate and proximate tips. Lunule very small and sunken, defined by a deeply impressed line. A false escutcheon suggested by shallow grooves extending from the umbones to about midway along the truncated posterior margin, the narrow cordate area thus enclosed occupying more than half of the posterior area. Anterior lateral margin bowed and rounding smoothly into the up-curved base. Posterior lateral margin obscurely truncate, the posterior area indicated by a flattening of the shell and a change in the character of the ribbing. Sculpture feeble and restricted largely to the early growth stages. Ribs on the umbones narrow, high, and finely noded but with no trace of lateral threading, fading out in the adolescent shell and almost or entirely obsolete in the adult, the 20 ribs on the anteromedial portion separated by linear interspaces and tending to arch slightly as in *V. stewarti*, the 8 low cords on the posterior area evanescing even more rapidly than those upon the disk. Incremental sculpture rarely preserved but apparently unusually sharp and crowded. Ligament marginal, sunken, the nymphae heavy. Hinge plate rather short, the ventral margin curved slightly upward and the dentition concentrated. Anterior cardinal of right valve very short and slender, the medial deltoid, obliquely produced and moderately heavy, the posterior produced and rather slender; left cardinals laminar, almost equally heavy, the posterior the more produced. Interior thickened slightly over the area of the adherent mantle. Pedal and adductor scars deeply sunken in the adult shell. Pallial line distinct, normal in position. Extreme ventral and lateral inner margins feebly crenate.

Dimensions of figured specimen: Height 71.0 millimeters, width 70.0 millimeters, convexity 26.0 millimeters.

Holotype, Mus. Basel, no. 211. Figured specimen, a left valve, U. S. National Museum, no. 372923.

Type locality: Between Bucaru, at the mouth of the Rio Tonosi, and Punta Guanico, Province of Los Santos, Panama. Figured specimen, Geological Survey station 6586, mouth of the Rio Tonosi. Eocene (middle?).

The figured specimen is one of a number collected by Donald MacDonald.

Vaughan quotes Cooke as saying, "A species of *Venericardia* from this locality is scarcely distinguishable from a specimen labeled *Venericardia planicosta* var. *horni* from Claiborne, Ala., but it does not closely resemble specimens that I have seen from the Eocene of California, Washington, and Oregon." The specimens in question in the Museum collections are now referred to *Venericardia stewarti*, a larger shell with a higher hinge plate and with more prominent and prosogyrate umbones terminating in a curiously characteristic bulbous tip. *V. horatiana* of the Bashi, another member of the group, is also larger, more hatchet-shaped, with higher hinge plate and umbones turned more strongly inward and forward and with a slightly lower rib count. The resemblance of *Venericardia tonosiensis* to *Venericardia pacifica* Olsson, from the Salina formation of northern Peru, is remarkable. The Panamanian species runs a little higher than the Peruvian, and there are slight differences in the character of the lunule, but in the general size and shape and sculpture pattern the two forms might very well be conspecific. The holotype of *V. tonosiensis* is unusually large.

Distribution:

Eocene (middle?):

Panama, 6586[p], Mouth of Tonosi River; 8414[p], Bucaru; 8282[c] and 8295[p], Guaniquito River.

Venericardia (Venericor) pacifica Olsson

Plate 37, figure 12; plate 41, figure 8

1928. *Venericardia pacifica* Olsson, Bull. Am. Paleontology, vol. 14, no. 52, p. 30, pl. 6, figs. 3–5.

1930. *Venericardia pacifica* Olsson. Stewart, Acad. Nat. Sci. Philadelphia, Special Pub. 3, pp. 172, 173.

1936. *Venericardia pacifica* Olsson. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 170, 171.

Shell small or moderate size, rounded or subcircular in outlines and rather strongly convex; the beaks are situated about the anterior one-fourth; the dorsal margin is straight, while the anterior and posterior extremities are well rounded and together with the base or ventral margin form part of a curve which is nearly circular; umbos full and quite prominent with small, slightly prosogyrate, adjacent beaks; lunule very small; sculptured with about 28 ribs (about 19 to the umbonal slope); on the umbos, the ribs are narrow, elevated and beaded, and with deep U-shaped interspaces fully three times the width of the ribs themselves; the ribs change abruptly at a resting mark and below this point become wide, flattened or rounded on top, and separated simply by incised lines.

Length 41 millimeters, height 42 millimeters, diameter 31 millimeters.

Remarks.—This species occurs with the preceding [*Venericardia peruviana* Olsson] and from which it is recognized by its circular form and character of its ribs.

Locality and geologic occurrence.—Salina formation, Negritos.—Olsson, 1928.

Stewart compares *V. pacifica* to his *V. hornii* subsp. *calafia* of the Domengine formation of the Pacific coast, a comparison suggested by their common subcircular or almost quadrate outline. However, he further observes that "it [*V. pacifica*] also has noded ribs, but the deep U-shaped interspaces and larger number of ribs tend to indicate that the two forms are not closely related, the similarity in outline being fortuitous. However, the possibility that *V. pacifica* is related to the California form rather than to any of the Gulf species is not excluded, since the development of the ribs of the subsp. *calafia* is practically unknown."

Venericardia pacifica is, to the stratigrapher, the most interesting species in the Peruvian series. There are in the collections of the Johns Hopkins University two valves, a right and a left, in which all the essential characters are preserved, both external and internal. They indicate the farthest outpost of a small, probably never abundant group which includes *V. horatiana* of the Bashi and Hatchetigbee, possibly *V. turneri* of the Hatchetigbee, *V. stewarti* of the Lisbon, and *V. tonosiensis* of the lower middle Eocene of Panama. It is indeed interesting to be able to extend the range of this group confidently to the lower middle Eocene of northern Peru and to quote Stewart's suggestion that there may be a Pacific ally. The Peruvian and Panamanian species are extremely close. The Panamanian form is a little higher, the umbones are fuller, and in all our examples the lunule is wider and deeper than in the two Peruvian valves. The growth sculpture upon *V. pacifica* is remarkably strong. Something of the sort is indicated on *V. tonosiensis* but the surface is not well preserved, and we cannot be sure that the two species are similar in this detail. The stratigraphy is still rather sketchily known, but there is no reason to assume that the Peruvian and Panamanian forms were not contemporaneous.

Venericardia (Venericor) turneri Gardner and Bowles, n. sp.

Plate 41, figures 1, 2

Shell large, heavy, remarkably quadrate, not strongly inflated. Dorsal and posterior lateral margins approximately at right angles, but rounding smoothly into one another. Anterior lateral margin shorter than the posterior, broadly arcuate, merging into the base; ventral margin pulled down at the posterior lateral extremity. Beaks within the anterior fourth, inflated at the tips, involute and prosogyrate, broadly but rather feebly arched away from the tips. Lunule exceedingly small. Umbones badly eroded but sculptured with 28 narrow ribs, 6 of which are posterior; obscure traces of a serrate cresting preserved; ribs

dying out on the adolescent shell, the adult sculpture reduced to incised lines separated by scarcely perceptible arches. Incremental lines strongest and most crowded toward the anterior ventral margin. Ligament marginal, deeply sunk. Hinge of right valve only known. Anterior cardinal short and oblique, the medial and posterior cardinals strong, the posterior cardinal produced parallel to the dorsal margin, the medial produced at a low angle to it. Muscle impressions strong, the interior slightly thickened over the area of the adherent mantle. Pedal scar a small but deep pit between the anterior cardinal and the anterior adductor scar. Pallial line simple, rather far removed from the base. Ventral margin rather feebly crenate within, the crenations corresponding to the impressed lines which mark the interradials.

Dimensions of holotype: Height 66.0 millimeters, width 73.5 millimeters, convexity 20.5 millimeters.

Holotype, a right valve: U. S. National Museum, no. 372921.

Type locality: Geological Survey station 13051, Hatchetigbee Bluff, Tombigbee River, Washington County, Ala., 3 miles south of the Choctaw County line. Wilcox group, Hatchetigbee formation.

This species is named in honor of Dr. F. Earl Turner, of the Agricultural and Mechanical College, College Station, Tex., who collected the type specimen and generously donated it.

Venericardia turneri is known only from two specimens, the holotype and a left valve (paratype) larger by a third than the holotype but with the entire hinge missing. It suggests, in the bulbous umbonal tips, the umbonal ribbing, and the obsolete adult sculpture, the coexistent *V. horatiana*; in the impressed lines which demark the interspaces it suggests *V. pilsbryi*. In the quadrate outline, the horizontal dorsal margin, the narrow hinge plate, and the greatly produced medial and posterior teeth it is unique among described Gulf species and exceptionally well characterized.

The closest approach to *Venericardia turneri* is, strangely enough, *Venericardia peruviana* Olsson, of the Peruvian lower middle Eocene. The southern form is more rounded, but both species are remarkable in their approximation to a quadrate outline. The umbones of *V. turneri* are constricted, especially posteriorly, and the posterior region is wide, flattened, and flaring. Neither species is much inflated, and the body cavity in both is shallow. The hinge plate of the Peruvian form is higher than that of the Alabama species, an adjustment doubtless to the more rounded outline of the shell of *peruviana*. Both species run about 28 ribs, separated by mere linear intercostals, but continuing complete to the ventral margin as in *V. pilsbryi*.

Distribution:

Wilcox group, Hatchetigbee formation:

Alabama, Washington County, 13051, Hatchetigbee Bluff, Tombigbee River.

Venericardia (Venericor) peruviana Olsson

Plate 41, figure 9

1928. *Venericardia peruviana* Olsson, Bull. Am. Paleontology, vol. 14, no. 52, pp. 29, 30, pl. 6, fig. 1.

1930. *Venericardia peruviana* Olsson. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, pp. 151, 173.

1936. *Venericardia peruviana* Olsson. Rutsch, Eclogae geol. Helvetiae, vol. 29, p. 170.

Shell rather large, inequilateral, broadly ovate or subelliptical in form and with the low beak situated very close to the anterior extremity; posterior side widely rounded, the dorsal somewhat arched, the ventral gently rounded or nearly straight, anterior margin shorter; the shell is moderately convex, greatest just about the center of the disk, the umbos are low and not conspicuous with small, prosogyrate, and closely adjacent beaks; the lunule is very small; there is a faint depression or sinus, extending across the dorsal side of the umbos to the posterior margin and serves to separate the faintly sculptured posterior-dorsal submargins from the heavier-sculptured surface below; sculpture consists of moderately heavy V-shaped ribs which cover most of the shell surface; on the umbos the ribs are heavy and strongly V-shaped or ridged but become rounded and wider toward the posterior-ventral extremity; the ribs number about 19 from the anterior margin to the faint umbonal sinus, with 5 very faint additional ribs on the posterior-dorsal slope; interior concealed.

Length 80 millimeters, height 66 millimeters, diameter 41.5 millimeters.

Remarks.—There appear to be no closely related species to which this shell need be compared. It differs from the *planicosta* group by its form and V-shaped ribs. The umbonal surface is somewhat weathered in our specimens, but the ribs appear to have been slightly beaded and keeled.

Locality and geologic occurrence.—Salina formation, Negritos.—Olsson, 1928.

Stewart suggests that this form may be close to *V. pectuncularis* Lamarck, from the Thanetian of the Paris Basin, a *Venericardia* in the strict sense.

A single left valve in the collections of the Johns Hopkins University shows the characteristic quadrate outline and ribbing pattern described by Olsson. The umbonal sculpture on that valve is very similar to that of *V. pacifica* and *V. stewarti*, and the *Leuroactis* group is further suggested by the fairly high hinge plate, the cardinal dentition, and a pallial line remote from the margin as in *V. pilsbryi*. The quadrate outline is duplicated in *V. turneri*, from the Hatchetigbee, but the hinge plate in the Wilcox species is much more narrow, and its dorsal and ventral margins are more nearly parallel.

Venericardia (Venericor) potapacoensis Clark and Martin

Plate 41, figures 3, 4, 6

1896. *Venericardia planicosta* Lamarck [part]. Clark, U. S. Geol. Survey Bull. 141, p. 80, pl. 23, figs. 1a, 1b; pl. 24, figs. 1a, 1b.

1901. *Venericardia potapacoensis* Clark and Martin, Geol. Survey Maryland, Eocene, p. 179, pl. 40, figs. 4, 5, 5a, 6, 6a.

1903. *Venericardia potapacoënsis* Clark and Martin. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1423. Not *Venericardia* aff. *potapacoensis*, Dumble, Tertiary

deposits of northeastern Mexico, Science, new ser., vol. 27, p. 273, 1908. Not *Venericardia potopacoenses*?, Dumble, Eogene history of Mexican Gulf coastal area: Jour. Geology, vol. 23, p. 490, 1915. Not *Venericardia potopacoensis*, Dumble, Tertiary deposits in Northeastern Mexico: California Acad. Sci. Proc., 4th ser., vol. 5, p. 182, 1915.

1917. *Venericardia potapacoensis* Harris. Waring, California Acad. Sci. Proc., 4th ser., vol. 7, no. 4, p. 54.

1919. *Venericardia potapacoensis* Clark and Martin. Harris, Bull. Am. Paleontology, vol. 6, no. 31, p. 77.

1922. *Venericardia potapacoensis* Clark and Martin. Woods, Geology of northwest Peru, p. 69.

1930. *Venericardia potapacoensis* Clark and Martin. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. no. 3, pp. 158, 160.

1936. *Venericardia potapacoensis* Clark and Martin. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 164, 169 [not p. 167, = *V. diga*].

Shell small, very thick; valves relatively deep, and elongate along the line of the beak and posterior basal margin; beak anteriorly situated; lines of growth strong; ribs 20 to 24 in number, elevated and crenulated toward the beak and obsolete toward the periphery; lunule deeply impressed; muscular scars deeply impressed; margin strongly crenulate.

This form is restricted to the Nanjemoy formation, and is most typically developed in the lower or Potapaco substage * * *.

Length, 40 millimeters, width, 33 millimeters.—Clark and Martin, 1901.

Venericardia potapacoensis is distinct from the Gulf species, *V. diga*, by reason of the solid dwarfish adult shell with the radial sculpture obsolete upon the final two-thirds, and the 19 to 22 rather strongly and regularly corrugated ribs upon the early part of the shell. They have in common the high hinge plate and scimitar-shaped right cardinal. The strong umbonal noding suggests that the affinities of this species may possibly be not with the *mediaplata* stock and the section *Leuroactis* but with some lateral branch of *V. smithii*.

Distribution:

Pamunkey group, Nanjemoy formation:

Maryland, Prince Georges County, 2489[e], Piscataway Creek; (Maryland Geological Survey) Upper Marlboro, gully southwest of town; 1 mile southeast of Piscataway. Charles County (Maryland Geological Survey), La Plata, east and west of Port Tobacco, head of Nanjemoy Creek, half a mile below Chapel Point, 2 and 2½ miles above Popes Creek, river bluff below Popes Creek, Potomac River.

Virginia, King George County, 13159[e], Woodstock, about half to three-quarters of a mile west of Mathias Point, Potomac River; (Maryland Geological Survey), Potomac Creek, 50 feet from top of bluff.

Venericardia (Venericor?) labreaensis Olsson

Plate 42, figure 5

1929. *Venericardia planicosta* var. *labreaensis* Olsson, Bull. Am. Paleontology, vol. 15, no. 57, pp. 7, 8, pl. 3, figs. 1, 2.

In this form the shell is small or medium-sized, moderately convex or inflated and with 19 or 20 strong, persistent ribs; umbos prominent, with strongly curved, adjacent beaks; lunule cordate, moderate in size and deeply sunken; on the umbos the ribs are high, narrow, and knifelike with deep, wide and flat interspaces; ventrally the ribs become wider and on the medial portion of the valve are broad and flat-topped, with the interspaces remaining deep but only about one-half the width of the ribs themselves; the first 5 anterior ribs are tripartite with a central, larger riblet bordered on each side by a smaller riblet; on the next 3 or 4 ribs (8–9) the central riblet increases rapidly in size, becoming wide and flat, while the lateral riblet is very small and threadlike, or simply a low, vanishing terrace; the following 5 ribs (to 14) lie across the medial portion of the valve to the umbonal ridge; the remaining ribs (to 19 or 20) on the posterior-dorsal submargins are low, narrow, with wide interspaces.

Length 36.50 millimeters, height 34 millimeters, diameter 27 millimeters.

Remarks.—This variety is the dominant form in the Negritos formation or the *Turritella* beds of La Brea. It is distinguished from the other members of the *planicosta* group by its constantly tripartite anterior ribs. It is always a small or medium-sized shell, our largest specimen being about 45 millimeters in length.

Locality and geologic occurrence.—Negritos formation, La Brea.—Olsson, 1929.

The hinge plate and dentition of *Venericardia labreaensis* are very similar to that of *Venericardia potapacoensis* from the Nanjemoy of Maryland and Virginia and to *Venericardia diga* from possibly a time equivalent formation in northeastern Mexico. The ribs of the northern species are noded but not tripartite; those of the Mexican form are very imperfectly preserved but apparently have no conspicuous ornamentation. In both of the North American species there is a wide variation in the number of the ribs and in their persistence.

Venericardia (Venericor) diga Gardner and Bowles, n. sp.

Plate 41, figures 7, 10–12

1908. *Venericardia* aff. *potapacoensis* Dumble, Tertiary deposits of northeastern Mexico: Science, new ser., vol. 27, p. 273. Not *Venericardia potapacoensis* Clark and Martin, 1901.

1915. *Venericardia potopacoenses*? Dumble, Eogene history of Mexican Gulf coastal area: Jour. Geology, vol. 23, p. 490. Not *Venericardia potapacoensis* Clark and Martin, 1901.]

1915. *Venericardia potopacoensis* Dumble, Tertiary deposits of northeastern Mexico: California Acad. Sci. Proc., 4th ser., vol. 5, p. 182. Not *Venericardia potapacoensis* Clark and Martin, 1901.

1936. *Venericardia potapacoensis* Clark and Martin. Rutsch, Eclogae geol. Helvetiae, vol. 29, p. 167, not pp. 164, 169.

Shell large, solid, heavy, trigonal, hunched posteriorly, very slightly inflated; anterior margin almost vertical, the tips of the umbones being almost in a line with the anterior extremity; posterior margin obliquely produced, making the shell very high and narrow. Anterior region not distinguished from the medial portion by any marked change in ribbing but merely by a gradual narrowing of the costae and a greater curvature of the shell margin; posterior region indicated by a flattening of the contour of the shell and by a change

in the rib characters, the concentric incremental lines traversing and wrinkling the narrowed, close-set costae. Earliest ribbing not well preserved at tips of any of the specimens but distinct in the cotypes within 7 or 8 millimeters of the extreme summit and low, broad, and flat-topped, the intercostals being about as wide as the costae. Anteromedial region of the disk bearing 17 ribs, the posterior region 8. Ribs broad and flat-topped in the adult portion, separated by narrow intercostals, evanescing on the ventral portion of the disk, ultimately disappearing at the ventral margin. Ligament external, set in a rather narrow and deep groove; no true escutcheon present; lunule long, narrow, and rather deep-set. Hinge plate very high and asymmetrically trigonal, between one-third and one-half the altitude of the shell in the adult form. Dentition of right valve only known; all three of the cardinal teeth much produced vertically, the anterior cardinal laminar, the middle cardinal relatively slender and scimitar-shaped, the posterior laminar, arcuate, and produced more than half the distance from the tips of the umbones to the posterior ventral margin. Body cavity unusually shallow. Pedal scar small and very close to the narrow, deep-set anterior adductor scar. Pallial line simple.

Dimensions of cotypes: U. S. National Museum, no. 373030, height 63.0± millimeters, width 57.0± millimeters, convexity 22.0 millimeters. U. S. National Museum, no. 373029, height 71.0 millimeters, width 65.0 millimeters, convexity (double valves) 40.0 millimeters.

Cotypes, a pair of locked valves: U. S. National Museum, no. 373029 (Geological Survey station 13139) and a single right valve, U. S. National Museum, no. 373030 (Geological Survey station 13140).

Type localities: Geological Survey station 13139, left bank of Rio San Juan at Ermita Abajo, Nuevo León, Mexico; Geological Survey station 13140, Arroyo Ermita at crossing of main road from Ermita to La Arena, Nuevo León, Mexico. Wilcox group. Probably middle Wilcox.

In 1908 Dumble reported that "Among these [Mexican fossils] is * * * a *Venericardia*, which Dr. Dall states is allied to *potapacoensis* of the Maryland Eocene, in beds that are stratigraphically the continuation of the marine stage of the Texas section." Dall's statement must have been made in a personal communication; at least, no published record of it can be found. In the fall of 1915 Dumble wrote: "In the San Juan region, associated with the *Venericardia planicosta*, there are found vast numbers of a varietal form very similar to if not identical with *V. potopacoenses* of the Maryland Eocene." In December of the same year he cited the occurrences of *Venericardia potopacoensis*, from the Loma Larga escarpment, 2 miles north of Herreras; from a railroad cut 1 mile east of Herreras; from a hill half a mile west of La Ciga (Dumble, 1915; La Ceya on the field labels in the collections of the U. S. National Museum); and at the Jaboncillos ranch 20 miles south of San Juan, all in northeastern Mexico. Specimens obtained at "La Ceya" are still in the collections of the United States National Museum.

Venericardia diga has the general lop-sided outline and the high hinge plate of *Venericardia potapacoensis* Clark and Martin, of the Nanjemoy Eocene of Maryland. The shells are larger, however, and the young forms have a much more quadrate outline. The surface sculpture is for the most part obliterated, but there is no suggestion retained of the strong and regular nodding such as that which characterizes the early stages of *V. potapacoensis*. There is no doubt that *V. diga* is specifically distinct from the Maryland species, but it may be a southern analog and the two species may have lived contemporaneously. The *Volutocorbis* which is commonly associated with *V. diga* is of the type abundantly represented at Woods Bluff, the classic collecting ground of the Bashi fauna.

Most of the specimens of *V. diga* are preserved as double valves, the strong teeth effectively locking the shells even in death. The shell itself is exceedingly thick, and the body cavity within very small, forming the rather incongruous picture of a very small animal with a very large shell. It seems impossible for this to have been at all an active form, and any movement was probably accomplished only with the greatest difficulty.

The two pairs of locked valves figured on plate 37, figures 1–3, may represent the *diga* which has not yet assumed senile characters.

Distribution: This species is abundantly represented in the Wilcox group of northeastern Mexico.

Venericardia (Venericor) clavidens Grzybowski

Plate 41, figure 5

1899. *Venericardia clavidens* Grzybowski, Neues Jahrb., Beilage-Band 12, p. 636, pl. 19, figs. 1, 1a.
1922. *Venericardia planicosta* Lamarck (group), form D. Woods?, Geology of northwest Peru, pp. 68, 69, pl. 4, fig. 4.
1922. *Venericardia clavidens* Grzybowski. Woods, Geology of northwest Peru, p. 69.
1928. *Venericardia clavidens* Grzybowski. Olsson, Bull. Am. Paleontology, vol. 14, no. 52, pp. 27, 28.

Schale dreieckig, mit bogenförmigem, nach hinten abfallendem Schlossrand, kurzem, fast geradem Vorderrand und zugerundetem Stirnrand. Sie ist sehr dick, auf der Oberfläche verlaufen 17–18, in der Wirbelgegend tiefe, dann seichtere Furchen, die ebensoviele flache Rippen begrenzen. In der Mitte der Schale verschwinden dieselben, und von da an wird die Schale bis zu ihrem leicht gekerbten Rande nur mit concentrischen Zuwachsstreifen versehen. Das ungemein starke Schloss besteht aus drei Zähnen, von denen der vordere ganz klein, der mittlere der stärkste, und der hintere von der Mitte gespalten ist. Höhe 45 mm, Länge 50 mm, Dicke (einer Klappe) 18 mm.

Diese Art ist der *V. planicosta* aus dem Pariser Eocän zum Verwechseln ähnlich. Der einzige Unterschied liegt nur darin, dass die Wirbel hier weniger hervorragen und der hintere Zahn erst von der Mitte gespalten ist.

Vorkommen: Zorritos, Rica Playa.—Grzybowski, 1899.

There are no examples of this species available for comparison, but the figures and descriptions and the laws of chance indicate that the specimens collected on a reconnaissance trip over 30 years ago represent the same species as that described much later by Olsson under the name *V. samanensis* and reported common over a wide area and through several formations of the higher Eocene.

Venericardia clavidens may perhaps be a later Peruvian analog of *V. diga*, of the lower Eocene faunas of northeastern Mexico.

Venericardia (Venericor) samanensis Olsson

Plate 40, figure 4

1928. *Venericardia planicosta* var. *samanensis* Olsson, Bull. Am. Paleontology, vol. 14, no. 52, pp. 26, 28, 29, pl. 5, figs. 4, 5; pl. 6, fig. 6.

1930. *Venericardia samanensis* Olsson. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 172.

1930. *Venericardia planicosta* var. *samanensis* Olsson, Bull. Am. Paleontology, vol. 17, no. 62, pp. 6, 9, 12, 21; pl. 1, fig. 1.

1936. *Venericardia samanensis* Olsson. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 168, 169, 171, 172.

In this variety we have the final and culminating product of evolution of the Peruvian group of *V. planicosta*. It occurs rarely in the Restin rocks but becomes at once common and typical in the succeeding Saman. The shells are often very large, massive, typically hatchet-shaped with height exceeding the width. They are moderately or strongly convex, with wide, full umbos and strongly coiled beaks (but less than in *parinensis*). The ribbing is strong in young shells and on the umbos of larger specimens, and persists over a larger area than usual in var. *parinensis*. Usually in large shells the ribbing extends over the upper half, leaving the lower part smooth or simply marked by faint radiating lines representing the faded-out ribs and by the growth lines. The usual number of ribs is about 21, those on the posterior-dorsal submargins being low and subobsolete. On the Restin specimens the ribbing is heavier and persists over a relatively larger area, and the interspaces are deeper and more groove-like (see fig. 4), while the ribbing on the Saman shells is more rounded, and the interspaces are much narrower.

The hinge of the full-grown shell is very wide and massive. Its most striking feature is the development of wide, high, and vertically flattened nymphs, which project upward and around which the ligament is attached. This adaptation is a natural one, as the area of ligamental attachment must be increased to care for the increased size and weight of the mature shell. In rare cases the ligament itself has been preserved and shows as a large, massive plug, projecting above and in a posterior direction along the dorsal area of two valves. A similar development of the nymphs, but to a much less degree, is seen amongst the typical *planicosta* of the Parisian basin. *V. planicosta* from the southern United States do not show this condition, and the nymphs are relatively small and narrow.

Length 94 millimeters, height 100 millimeters, diameter 65 millimeters (type), Saman sandstone; length 75 millimeters, height 80 millimeters, diameter 63 millimeters, Restin specimen.

Localities and geologic occurrence.—Restin formation; Que. Salado. Saman formation; horizon of the Saman conglomerate, Negritos, near Lagunitas, etc. Very abundant and large in the Saman sandstone of the Chira Valley, Paita, Bayovar, etc.—Olsson, 1928.

In the light of our sketchy information upon this species, we do not find adequate evidence for separating it from *Venericardia clavidens* Grzybowski, 1899.

Venericardia (Venericor) parinensis Olsson

Plate 40, figure 3

1922. *Venericardia planicosta* Lamarck (group), form B. Woods, Geology of northwest Peru, p. 67, pl. 3, fig. 2.

1922. *Venericardia planicosta* Lamarck (group), form C. Woods, Geology of northwest Peru, pp. 67, 68, pl. 3, fig. 3.

1928. *Venericardia planicosta* var. *parinensis* Olsson, Bull. Am. Paleontology, vol. 14, no. 52, pp. 26, 27, 28; pl. 5, fig. 3.

1930. *Venericardia parinensis* Olsson. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 172.

1936. *Venericardia parinensis* Olsson. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 168, 169, 170, 176, 177, 178, 180, pl. 16, figs. 1, 5.

This variety begins in the Salina formation, continues up through the Pale Gredas into the Parinas, or characteristic of the group of rocks placed by Bosworth in his *Clavilithes* series. Usually the earlier forms are but moderately convex, with stronger ribbing extending over the umbos onto the center of the shell disk but fading out rapidly nearer the ventral margins. (See Woods' fig. 2.) In the Parinas sandstone the shells are generally larger, heavy, with full convex umbos, curved beaks, and a heavy, high hinge. (See Woods' fig. 3.) The sculpture is weak and confined to the umbos and earlier portion of the shell disk, leaving the major part of the surface smooth, except for growth lines. The umbonal slope is rounded as in the Parisien and Claibornian shells, and the dorsal submargins are but feebly differentiated. The ribs number as in *negritensis*, about 17 to the umbonal slope and 22 to 23 over the whole surface.

In this type we find a close approach to the smoother forms of *V. planicosta* from the upper Wilcox and St. Maurice horizons of Louisiana and Alabama, designated as variety gamma by Harris, and to *V. ionensis* Waring (*V. merriami* Dickerson), from Oregon and California. In such case these smooth *Venericardia* are found in rocks of middle Eocene age.—Olsson, 1928.

Olsson, Woods, and Stewart all agree that this form is comparable to the middle Eocene forms of the *V. horatiana* and *V. stewarti* type. Stewart raises it to specific rank and places it at least tentatively in his subgenus *Leuroactis*, with *V. horatiana*, *V. pilsbryi*, and *V. aragonia*.

Venericardia parinensis is a higher and much more massive species than any of the suggested analogs. The umbones are very full, the hinge plate high, and the thin dorsal third of the medial cardinal of the right valve is bent forward almost at right angles; at least, that is the case in the single valve referred to this species in the collections of the Johns Hopkins University, a valve 130 millimeters high and 110 millimeters wide.

POSITION UNCERTAIN

Venericardia (Venericor) francescae Gardner and Bowles, n. sp.

Plate 46, figures 6, 7

Shell small but sturdy, rounded-trigonal in exterior outline, quadrate in the interior, not strongly inflated. Umbones moderately prominent, placed near the ante-

rior third, their tips turned forward. Lunule small, deeply sunken. Anterior margin bowed in front of the lunule, the posterior squarely truncate, the dorsal and ventral margins subparallel. Posterior area delimited both by the oblique truncation of the shell and by the finer sculpture. Anterior and medial portion of the shell ribbed with 13 cordlike radials strongly wrinkled by the growth lines; the 6 posterior radials narrow but uniform and persistent to the margin. Growth lines strong over the entire shell. Hinge plate narrow; ligament marginal and deeply inset. Dental armature very imperfectly preserved; a short anterior, very obliquely produced medial and a laminar posterior cardinal in the right valve. Interior filled with matrix concealing the adductor and pedal scars. Inner margins crenate.

Dimensions of holotype: Height 28.0 millimeters, width 27.5 millimeters, convexity 12.5 millimeters.

Holotype, a right valve: U. S. National Museum, no. 372925.

Type locality: Geological Survey station 6573, 1 mile southeast of New Albany, Union County, Miss. Clayton formation of the Midway group.

We have the pleasure of naming this little Midway species in honor of Miss Frances H. Walthall, formerly of Oxford, Miss., whose cordial kindness the senior author will always remember.

Venericardia francescae is characterized by the compactness of its small, squarish outline and by the relatively few but prominent radials.

It is known, unfortunately, only from the holotype.

Distribution:
Midway group, Clayton formation:
Mississippi, Union County, 6573[r], St. Louis-San Francisco Railroad cut, 1 to 1⅛ miles southeast of New Albany.

Venericardia (Venericor) jewelli Gardner

Plate 42, figures 2, 3

1935. *Venericardia jewelli* Gardner, Univ. Texas Bull. 3301, pp. 157, 158–159, 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 the types, separated by deep and squarely channeled interspaces which shallow a little toward the ventral margin; surface not preserved, but ribs apparently simple except for the strong concentric imbrication. Posterior threads 5 or 6 in the types, evanescent toward the ventral margin. Characters of the interior not known.

Dimensions of cotypes: Double valves, height 65 millimeters, width 65 millimeters, convexity 45 millimeters. Right valve, height 65 millimeters, width 70 millimeters.

Cotypes, two pairs of locked valves: U. S. National Museum, no. 370914.

Type locality: Geological Survey station 11758, limestone scarp near Indio Wells tank, about 29 miles southeast of Eagle Pass, Maverick County, Tex. Midway group, 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 on the posterior area.

This species is named in honor of the late 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. His death was a great loss to all of us who were working in the Border country.

Distribution:
Midway group, Kincaid formation:
Texas, Maverick County, 11752[p], Comanche Creek crossing on west road to Farias ranch; 11753?[r], Bibora tank, 7 miles east of new Indio ranch house; 11755[p], 3 miles north of Media tank; 11758[p], near Indio Wells, about 29 miles southeast of Eagle Pass.

Venericardia (Venericor) hijuana Gardner and Bowles, n. sp.

Plate 42, figures 1, 6–10

1860. *Cardita subquadrata* Gabb?, Acad. Nat. Sci. Philadelphia Jour., 2d ser., vol. 4, p. 395. Not *Cardita subquadrata* Conrad, 1848.
1896. *Venericardia planicosta* var. *smithii* Harris [part], Bull. Am. Paleontology, vol. 1, no. 4, p. 60.
1896. *Cardita subquadrata* Gabb?, Harris, Bull. Am. Paleontology, vol. 1, no. 4, p. 60.

Shell of moderate dimensions, crumbly and unusually thick; rounded in outline with broadly convex, submedial umbones and a rather compressed ventral portion; posterior area flattened and sharply cut off from the disk by sculpture differences rather than by the contour of the shell. Lunule very short and deep. Ribbing coarse and persistent, the ribs numbering 15 or 16 on the anteromedial portion and 6 to 8 on the posterior area; inverted V-shaped with serrate crests at the tips of the umbones; lateral ridges strongly developed on the adolescent shell but dying out toward the ventral margin of the adult, leaving a prominent but well-rounded ribbing upon the disk; much more persistent on the anterior costals; posterior costals simple and relatively low. Incremental lamination obscure except upon the posterior area and toward the ventral margin of the adult. Ligament marginal, the groove deep, opisthodetic. Hinge plate narrow but heavy. A laminar anterior, a short, narrow, trigona

medial cardinal, and a much-produced, moderately heavy, oblique posterior cardinal in the right valve; a short deltoid anterior cardinal and a slender, somewhat crescentic posterior lamina in the left valve. Pedal and adductor muscle scars deep. Inner margins sharply crenate.

Dimensions of adult cotype: Height and width, 50.0± millimeters, convexity 20.0 millimeters.

Cotypes: Two poorly preserved left valves; the dorsal portion of one cotype showing the juvenile and adolescent sculpture, U. S. National Museum, no. 372919; the second cotype showing the adult sculpture, U. S. National Museum, no. 372920.

Type localities: U. S. National Museum no. 372919, Geological Survey station 6091, milepost 481, east of Middleton, Hardeman County, Tenn.; U. S. National Museum, no. 372920, Geological Survey station 6495, cut on Southern Railway 1½ miles east of Middleton and 200 feet east of milepost 481, Hardeman County, Tenn. Lower Midway age.

Gabb's reference to the species is as follows:

> Professor Safford sent me with the other species several fragments of specimens, which must have been at least 2 inches in diameter. They are of the same outline and, as far as I can ascertain, have the same markings as the above species [*Cardita subquadrata* Gabb]. In the larger specimens the intermediate radiating ribs die out, leaving the ribs of nearly the same shape as *C. planicosta* of the Eocene formation.
>
> *Locality.*—They are from Hardeman County, Tenn.—Gabb, 1860.

In the course of his discussion of *Venericardia planicosta smithii* Harris remarked:

> The specimens collected by Dr. Safford and referred to by Gabb * * * as *C. subquadrata?* are a little different still; the tops of the ribs are rounded or flattened and are about as broad as the interspaces, near the umbones, or in young specimens each rib is placed upon a low, broader rib somewhat after the nature of the costation in *V. alticostata* Conrad; this feature soon dies out, however, leaving the ribs, as Gabb has remarked, "of nearly the same shape as *C. planicosta* of the Eocene formation." To us the most remarkable feature of Dr. Safford's specimens is the paucity of ribs, numbering from 20 to 23 only. The compound ribbing and the crenulations on the superimposed ribs have been noticed in very young specimens of *V. planicosta* many times from different horizons and localities, but in these specimens it occasionally shows, though faintly, nearly to the margin.—Harris, 1896.

Venericardia hijuana is described with many misgivings because of the fragmentary nature of the material. But it is so distinct and so well characterized that, with the hope of better material long deferred, we have done the best we could with imperfect specimens that have been held for many years. The diagnostic features are the broad inflation of the umbonal region, the flattening toward the ventral and posterior margins, the sharp sculpture break between the disk and the posterior area, the simple juvenile ribbing followed by the laterally ridged adolescent and later in the adult by a return to a simple ribbing. The ribs are unusual in that they are so prominent and so sharply defined but without angularity. *V. hijuana* may be related to *V. jewelli* of the lower Midway of the Mexican border, a larger, heavier species with obsolete ribbing upon the posterior area. One interior mold probably of this species suggests such a relationship more strongly than the shells themselves.

Distribution:

Midway group, Clayton formation:

Tennessee, Hardeman County, 6495 c, 1½ miles east of Middleton, 200 feet east of milepost 481; 6091 c, milepost 481, east of Middleton; 12028 c (mold), public road at northeast edge of Middleton.

VENERICARDIA SMITHII stock

Venericardia (Venericor) smithii Aldrich

Plate 43, figures 2, 3

1894. *Venericardia planicosta* Lamarck [part]. Harris, Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, p. 42.

1894. *Venericardia smithii* Aldrich, Alabama Geol. Survey Report on geology of Coastal Plain of Alabama, p. 243, pl. 12, figs. 1a–b.

1896. *Venericardia planicosta* var. *smithi* Aldrich [part]. Harris, Bull. Am. Paleontology, vol. 1, no. 4, pp. 59–61, pl. 4, fig. 14; pl. 5, figs. 1, 2.

1903. *Venericardia smithii* Aldrich. Dall, Wagner Free Inst. Sci. Trans., vol. 3, no. 6, pp. 1422, 1425.

1909. *Venericardia smithi* Aldrich. Grabau and Shimer, North American index fossils, Invertebrates, vol. 1, p. 544, fig. 747 (right valve).

1922. *Venericardia planicosta* var. *smithi* Aldrich. Woods, Geology of northwest Peru, p. 68.

1933. *Venericardia smithii* Aldrich. Plummer, Univ. Texas Bull. 3232, pp. 543, 547, 551, 552, 811, 812, pl. 8, figs. 4a, 4b.

1935. *Venericardia smithii* Aldrich. Gardner, Univ. Texas Bull. 3301, pp. 160–161, pl. 12, figs. 3, 4.

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* Lamarck, with which it is associated and of which a figure is also given.

Differs from *V. alticostata* Conrad (*transversa* Lea) in the flatness of the ribs. Figure 1 is from a specimen in my collection, the other (1b) is in the State collection. Rather abundant. Named in honor of Dr. Eugene A. Smith.—Aldrich, 1894.

Mr. Aldrich's collection was purchased by the Johns Hopkins University, and one of the cotypes (figs. 1–1a) is now in the Paleontologic Laboratory in Baltimore.

Dimensions of cotype: Height 40.5 millimeters, width 43.0 millimeters.

Type locality: "*Turritella* rock near Allenton, Wilcox County, Ala." Midway group, Clayton formation.

Venericardia smithii is widely distributed throughout the Midway from Georgia to the Mexican border, but rarely is it a particularly abundant member of the molluscan fauna. Although the type locality is in Alabama, the species is most commonly recorded from the Midway of Texas. Its large inflated valves and the numerous high, narrow costals without lateral

terraces or intercalaries characterize the species. This form differs from *V. mediaplata*, the other widespread Midway species, in the character of the ribs and the inflation of the umbones.

While the distinction between Stewart's *Venericor* and his Miocene group *Glyptoactis* typified by *Venericardia hadra* Dall is clear and striking in the type species, some of the early peripheral forms are difficult to aline. This is quite as it should be, for *Venericardia* was burgeoning in the early Midway, and the groups had not yet taken their later shapes. The character and inclination of the cardinal teeth in the Eocene forms is closely correlated with the outline of the shell and consequently, in many species, with the age of the shell. The small anterior pustule, cited by Stewart as a subgeneric character, is in many forms present at the base of the lunular groove but seems to be, at least in these early species, analogous not to a lateral tooth but to the crenulations upon the inner margins at the bases of the interradial grooves. *Venericardia smithii* has much in common with *V. alticostata*, the Eocene representative of *Glyptoactis*, and these two species are separated subgenerically with some misgivings. But *Venericardia smithii* is quite clearly genetically related to *V. aposmithii*, one of the massive venericards that has been commonly identified with *Venericardia planicosta*, and for that reason this shell, which is characterized by its inflated umbones, the relatively low, broad hinge plate, and the inclination of the teeth adjusted to the hinge plate is placed among the Venericors.

Distribution:

Midway group, undifferentiated:

Georgia, Schley County, 4032[r], Wall's Crossing, 4 miles west of Ellaville.

Midway group, Clayton formation:

Alabama, Wilcox County, 281[p] and 284[p], Prairie Creek.

Midway group, Kincaid formation:

Texas, Kaufman County, 11665[b], Water Hill, 5 miles northeast of Kemp; 10744[r], 2½ miles northeast of Kemp on public road. Limestone County, 6559?[r], Comanche Crossing, 6 miles west of Mexia; 11935?[r], 7½ miles northwest of Groesbeck on the Thelma road; 11939[r], 3 miles southwest of Thornton. Falls County, 11931?[r], about 6 miles northwest of Kosse. Bastrop County, 11696[p], Colorado River 1½ miles below Travis-Bastrop County line; 11899?[p], 50 to 60 feet west of bridge over Cedar Creek on Austin-Red Rock road; 11909[p], Cedar Creek 3½ miles southeast of Williams' store. Caldwell County, 11707[p], 5½ miles due north of Lockhart; 11706[p], 5½ miles southeast of Lockhart. Medina County, 6280?[r], Hondo Creek one-eighth mile below road crossing east of Elstone; 6584?[r], D'Hanis-Yancey road 7 miles southeast of D'Hanis; 11872?[r], 6.6 miles south of Dunlay, south of Noonan road. Uvalde County, 3180?[r], Bluff on Frio River half a mile below Evans' (Myrick's) apiary; 6279?[r], 11 miles south of Sabinal, south of junction of Elm Creek with Sabinal Creek. Maverick County. 11752?[p], Comanche Crossing on west road to Farias ranch; 11758[p], Indio Wells, about 29 miles southeast of Eagle Pass; 11761[p], Tobar Arroyo 2½ miles southwest of Tobar tank, about 35 miles southeast of Eagle Pass; 6275[r], White Bluff on Rio Grande, 4½ miles west of south of Windmill ranch house; 8792[a], Rio Grande, Texas side, 1 mile below Cerrito Prieto ranch house on Mexican side; 6577[a], 6½ miles southwest of Windmill ranch, Rio Grande, Mexican side.

Midway group, Wills Point formation:

Texas, Guadalupe County, 11883[r], 9½ miles northeast of Seguin. Maverick County, 11754[a], 6 miles below McFarland sheep pens, 27 miles southeast of Eagle Pass on Windmill (Jacal) ranch road.

Venericardia (Venericor) aposmithii Gardner and Bowles, n. sp.

Plate 43, figures 1, 6, 7; plate 44, figures 1, 2

1897. *Venericardia planicosta* Lamarck, form *β*, Harris, Bull. Am. Paleontology, vol. 2, no. 9, p. 55, pl. 9, fig. 1.

1903. *Venericardia regia* Conrad [part]. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1422.

1930. *Venericardia regia* Conrad [part]. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, pp. 154, 155, 156.

Shell massive, the maximum altitude more than 100 millimeters. Outline cordate-trigonal, the umbones high, inflated, incurved, prosogyrate. Posterior area flattened. Lunule small, wider in the right valve than in the left. Umbonal ribs high, with narrow serrate crests. Adult ribs broad, the anterior costals corrugated by the growth lines, the medial low and separated by little more than linear interspaces, the posterior area coarsely and rather closely corded; number of ribs in the type, 20 upon the medial and anterior areas, 10 upon the posterior, but as many as 36 in all in some individuals; lateral ridges frequently developed anteriorly but not persistent to the adult stage; ribs tending to evanesce toward the anterior ventral margin, where the growth sculpture is strong. Ligament and hinge armature adequately heavy for so ponderous a shell; hinge plate high and narrow, the middle cardinal in the right valve obliquely cuneate and massive. Muscle scars, especially the anterior and pedal, deeply impressed; the elliptical anterior and rotund posterior scars very large. Interior of shell slightly thickened over the area of the adherent mantle. Pallial line ragged, rather far removed from the margin. Inner marginal crenations very coarse.

Dimensions of holotype: Height 113 millimeters, width 117 millimeters.

Holotype, the right and left valves of a single individual: U. S. National Museum, no. 1434.

Type locality: Bells Landing, Alabama River, sec. 36, T. 10 N., R. 6 E., Monroe County, Ala. Wilcox group, Tuscahoma formation.

The differences between the Nanafalia and Tuscahoma races have not been recognized in the taxonomy, because the small number of specimens available for study from Nanafalia Bluff does not justify generalizations. The number of ribs in the Nanafalia individuals apparently runs higher by 2 or 3 to the valve, an in-

crease due to the closer cording upon the posterior area. The posterior cords in the Tuscahoma are usually 9 or 10, while in the Nanafalia they are more commonly 11 or 12. Those nearest the posterior dorsal margin are wider and less elevated than the half dozen or so in front of them, a differentiation which is much less marked in the Tuscahoma individuals than in those of the Nanafalia. The Tuscahoma forms are larger, higher, and heavier than those collected from the Nanafalia, but the pattern of the ribbing is the same both on the unbones and on the adult portion of the shell. The tendency toward the evanescence of the anterior and medial ribs has been noted only in the Tuscahoma representatives.

This species may well be descended from the *V. smithii* stock of the middle Midway. The outline of the early part of the shell in *V. aposmithii* is very similar to the adult *V. smithii*, and the ridged and serrate umbonal ribbing is similar in both. The lateral terracing in the Nanafalia and Tuscahoma species is, however, only vaguely foreshadowed in *V. smithii*. There is an appreciable variation in the degree and persistence of lateral terracing both in the Nanafalia and in the Tuscahoma. The Tuscahoma forms approach *V. regia* of the Aquia more closely than the Nanafalia forms.

Distribution:

Wilcox group, Nanafalia formation:

Alabama, Marengo County, 271[p] and 5642[p], Nanafalia Bluff, Tombigbee River.

Wilcox group, Tuscahoma sand:

Alabama, Monroe County, 2670[a], 3118[a], 5604[a], lower fossil bed, Greggs Landing, Alabama River; 260[a], 3098[a], 5593[a], 5594[a], and U. S. National Museum, no. 1434[a], Bells Landing, Alabama River. Choctaw County, 5472[a], lower bed, Tuscahoma Landing, Tombigbee River.

Venericardia (Venericor) regia Conrad

Plate 46, figures 8, 10

1830. *Venericardia planicosta* Lamarck. Conrad, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 6, p. 215.
1832. *Cardita planicosta* Lamarck [part]. Conrad, Fossil shells, p. 20, pl. 5, fig. 2.
1865. *Venericardia planicosta* var. *regia* Conrad, Am. Jour. Conchology, vol. 1, pp. 8, 364.
1866. *Venericardia regia* Conrad, Smithsonian Misc. Coll. no. 200, p. 5.
1891. *Cardita regia* Conrad Heilprin, Acad. Nat. Sci., Philadelphia Proc. for 1890, p. 402.
1894. *Venericardia planicosta* var. *regia* Conrad. Harris, Am. Jour. Sci., 3d ser., vol. 47, p. 302.
1896. *Venericardia planicosta* var. *regia* Conrad. Harris, Bull. Am. Paleontology, vol. 1, no. 4, p. 58.
1896. *Venericardia planicosta* Lamarck [part]. Clark, U. S. Geol. Survey Bull. 141, p. 80, pl. 21, fig. 3; pl. 22, fig. 2; pl. 23, fig. 1c; pl. 24, fig. 1c; pl. 25, fig. 1c.
1901. *Venericardia planicosta* var. *regia* Conrad. Clark and Martin, Maryland Geol. Survey, Eocene, p. 178, pl. 38, figs. 1, 1a; pl. 39, figs. 1, 1a; pl. 40, figs. 1, 2, 3.
1903. *Venericardia regia* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, no. 6, pp. 1420, 1421, 1422.
1909. *Venericardia planicosta* var. *regia* Conrad. Grabau and Shimer, Index fossils, vol. 1, p. 545, fig. 746.
1922. *Venericardia planicosta* var. *regia* Conrad. Woods, Geology of northwest Peru, pp. 66, 69.
1930. *Venericardia regia* Conrad. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, pp. 154, 155, 156, 157.
1936. *Venericardia regia* Conrad. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 162, 163, 164, 169, 180.

Shell large, very heavy, broadly rounded to subovate, not very highly inflated. Anterior margin broadly rounded, posterior margin obliquely produced and obtusely truncate. Umbones strongly curved forward; umbonal sculpture consisting of high, narrow ribs corrugated by large, regular serrations, which posteriorly and medially die out very close to the summit but anteriorly persist to the first major incremental line, some 20 to 25 millimeters from the tip. Sculpture on disk consisting of broad, flat-topped ribs that persist strongly to the ventral margin. Ribs of anteromedial portion 20; of the posterior region, 7. Posterior region well defined by a marked change in the character of the ribbing and by a decided change in the direction of the shell contouring. Posterior ribs close-set and wrinkled, traversed by many fine incremental striae; anterior ribs also cut by concentric lines but more widely spaced and less wrinkled than the posterior. Hinge plate rather high and very wide; dentition strong and prominent. Lunule very narrow and deep; nymphae high. Muscle scars prominent and deep-set, especially the pedal pit. Inner margin strongly crenulate.

Dimensions of probable holotype: Height about 100 millimeters, width about 110 millimeters.

Type: None designated by Conrad, but Stewart in 1930 thought that the specimen so well illustrated by Clark in 1896 and by Clark and Martin in 1901 was the same as that figured by Conrad in 1832 and should be taken as the type, because the figure was the only description of the shell offered by its author. The specimen figured by Clark is no. 12508 in the collections of the Philadelphia Academy of Sciences.

Type locality: Maryland(?), Pamunkey group, Aquia formation.

Conrad never actually described this species, the first mention of the name *regia* occurring in his check list of Tertiary fossils in 1865. He figured a form in 1832, however, which he called *Venericardia planicosta* and which he said was from Maryland, a large species that is undoubtedly the same as that which he subsequently designated *V. regia*. He mentioned in 1865 that his species differed from *V. planicosta* s. s. only in having the ribs distinctly separated at the base. It is interesting to note that the first discovery of the *V. planicosta* stock in this country was made by Conrad in 1830, when he found some large specimens in Maryland, undoubtedly *V. regia*, as it is the only large form recorded in the northern fauna.

Venericardia regia is restricted to the Aquia formation of Maryland and Virginia. It is the analog in

the northern fauna of *V. aposmithii* of the southern, but the species are readily separable and less similar than might be supposed from the confusion in the literature. Both Dall and Stewart regard the Maryland form as conspecific with the "form beta" of Harris (*V. aposmithii* n. sp.), from Greggs and Bells Landings, in Wilcox County, Ala. *V. regia* has a lower shell, however, the umbones are lower and less inflated, and the hinge plate broader. The character of the ribbing is the same in both, but in *V. regia* it runs a little stronger and is more strongly corrugated toward the margin by the incrementals.

Distribution:
Pamunkey group, Aquia formation:
Maryland, Prince Georges County, 2489[p], Piscataway Creek.
Virginia, Stafford County, 1 mile east of 12974[p], Stafford Courthouse; 2346[p], mouth of Potomac Creek.
(And numerous localities in Maryland cited by Clark and Martin in 1901.)

Venericardia (Venericor) austroplata Gardner and Bowles, n. sp.

Plate 42, figures 11, 12

Shell large, heavy, ovate cordate and inflated. Umbones high, full, and directed forward. Anterior margin bowed out in front of the small, deeply sunken lunule. Posterior margin produced ventrally, obtusely truncate laterally. Posterior area indicated both by a flattening of the shell and by an abrupt change in the character of the radial sculpture. Costals remarkably prominent; undercut and T-shaped in the umbonal region but without terracing or serrations; wide, high, and flat-topped on the medial portion of the disk; overridden toward the base by numerous concentric incremental lines but distinct and persistent to the margin; intercostals U-shaped, narrow, and deep; costals on the anterior part of the shell relatively high and slightly wrinkled, widening very rapidly and separated by little more than linear interspaces; posterior area heavily corded, 6 cordlike ribs in the left valve of the type, 5 in the right; 15 upon the anteromedial portion. Ligament marginal, the nymphs sunken, extending almost half the distance from the umbones to the posterior ventral margin, a part of the plug still remaining and indicating an extraordinarily powerful and adequate attachment. Hinge plate low, wide, and heavy, the teeth badly broken in the separation of the valves. Anterior right cardinal seemingly rather narrow but much produced obliquely; left cardinals relatively slender, produced and oblique rather than curved. Interior filled with matrix concealing the adductor and pedal scars.

Dimensions of holotype: Height, 91 millimeters; width 101 millimeters; convexity, 66 millimeters.

Holotype, the right and left valves of a single individual: U. S. National Museum, no. 372924.

Type locality: Geological Survey station 8077, Point Malaspina, Province of Chubut, Argentina.

Three excellent examples of this species are included in collections made by Bailey Willis and Chester W. Washburne. In all of them a replacement by crystalline gypsum is more or less complete. The hinge and ligament are very powerful in these forms, the specimens still being held together so tightly that the valves must be forced apart with great injury to the teeth.

This large and distinctive species is the only member of the *Venericardia planicosta* group recorded from the Eocene of Argentina. The age of the source formation is not known. The costal sculpture of *V. austroplata* is more vigorous than that adorning any of our Gulf venericards, and most of the Mid-American and North American species show an umbonal serration of which there is no trace in *V. austroplata*. The associated fauna at Point Malaspina includes a *Turritella* and a *Volutocorbis* which suggest the lower Eocene, but the evidence for correlation within the Eocene is very slight.

Distribution:
Eocene series, undifferentiated:
Argentina, Province of Chubut, 8077, Point Malaspina. The exact locality is in doubt, but the shell and its mode of preservation are so remarkable that it has been described in the hope that the locality may be more exactly defined later.

Venericardia (Venericor) densata pendletonensis Gardner and Bowles, n. subsp.

Plate 45, figures 12, 13

Shell relatively small and thin, ovate-trigonal to subquadrate in outline; inflated strongly in the umbonal region but flattening toward the ventral margin. Umbones full, the tips incurved and prosogyrate, proximate and overhanging the short deep-set lunule, which is wider in the right valve than in the left. Posterior area set apart from the rest of the disk not only by the oblique flattening of the shell but also by the finer, closer ribbing. Ribs 28 or 29 in all, the posterior area bearing 7 of these. Umbonal ribs sharp-ridged and serrate, the adolescent ones T-shaped and medially noded, the adult ribs simple and proximate, separated by linear channels; the adolescent nodes failing rather abruptly when the shell is about 1½ centimeters high. Hinge plate wide; anterior cardinal short and almost vertical, the medial cardinal obliquely deltoid, the posterior produced and laminar. Interior thickened slightly over the area of the adherent mantle. Muscle scars distinct, especially the anterior adductor and the pedal scar. Pallial line simple; inner margins strongly crenate.

Dimensions of holotype: Height 27.5 millimeters, width 29.5 millimeters, convexity 12.0 millimeters.

Holotype a right valve: U. S. National Museum, no. 372694.

Type locality: Geological Survey station 10743, Pendleton Bluff, Sabine River, Sabine County, Tex. Wilcox group, Tuscahoma sand.

Venericardia densata pendletonensis is the only form of *densata* which has been recognized below the Claiborne. It differs from the species so abundant at Lisbon Bluff in the lower average dimensions, the stronger flattening of the shell toward the anterior margin, and the lower adult hinge plate. The subspecies is recorded reluctantly, because aside from the occurrence at this single locality, *Venericardia densata* has served faithfully as a guide fossil of the lower Claiborne.

The bluff from which these collections were made is about a quarter of a mile above the ferry which in 1932 was still the usual means of crossing from the Texas to the Louisiana side.

Distribution:

Wilcox group, Tuscahoma sand:

Texas, Sabine County, 10743r, Pendleton Bluff, a quarter of a mile above Pendleton Ferry, Sabine River.

Venericardia (Venericor) densata malinchae Gardner and Bowles, n. subsp.

Plate 43, figures 4, 5

Shell heavy and compressed for the group. Outline of the adult specimens incomplete but rounded-trigonal in the young, with a broadly and smoothly rounded anteroventral margin and an obscurely truncate posterior extremity. Umbones very low, the tips proximate and turned slightly forward, anterior in position. Lunule small, cordate, defined by a deeply incised groove. Posterior area indicated by the flattening of the shell and the narrowing and partial evanescence of the radials. Ribs 20 on the anteromedial portion, 8 on the posterior, probably with noded crests in the early growth stages and a rather obscure lateral terracing; the adult ribs low and flat medially, more elevated anteriorly and more cordlike posteriorly; the intercostals narrow U-shaped channels. Ligament marginal, deeply inset. Hinge high and heavy; anterior right cardinal very short and thin; the medial massive, flattened along the vertical plane, broad at the base, with the posterior margin curved forward toward the tips of the umbones; posterior right cardinal very slender and produced; dentition of left valve not preserved. Pedal scar deep. Adductor scars and pallial characters lost.

Dimensions of holotype: Height (estimated) 48.0 millimeters.

Holotype, an incomplete right valve: U. S. National Museum, no. 373031.

Type locality: Geological Survey station 13141, about 1 mile southwest of El Mirador, China, Carlos Cantú, Nuevo León, Mexico.

A form so imperfectly known is described only because it represents a fauna rarely preserved. It seems to be related on the one hand to the more strongly sculptured *Venericardia diga*, from which it differs in the lower umbones and the higher rib count, and on the other hand to *Venericardia densata*, from which it differs in the more rounded outline, the lower umbones, and the less pronounced noding and terracing in the early and adolescent growth stages.

Venericardia (Venericor) densata Conrad

Plate 37, figure 7; plate 45, figures 1–11, 14

1845. *Cardita densata* Conrad, Acad. Nat. Sci. Philadelphia Proc., vol. 2, p. 173.
1848. *Cardita densata* Conrad, Lea, Henry, Catalogue of Tertiary Testacea of the United States, p. 5.
1848. *Cardita densata* Conrad. Acad. Nat. Sci. Philadelphia Jour., 2d ser., vol. 1, pt. 2, p. 130, pl. 14, fig. 24.
1848. *Cardita densata* Conrad. Lea, H. C., Acad. Nat. Sci. Philadelphia Proc., vol. 4, p. 97.
1850. *Cardita densata* Conrad. Tuomey, Alabama Geol. Survey 1st Bienn. Rept., p. 153.
1857. *Venericardia planicosta* Lamarck. Emory, Mexican Boundary Survey, Rept., p. 161, pl. 19, figs. 2a, 2b.
Not *Venericardia planicosta* Lamarck. Owen, Geological reconnaissance of Arkansas, 2d Rept., pl. 9, figs. 2, 2a, 2b, 1860.
Not *Cardita densata* Conrad. Owen, Geological reconnaissance of Arkansas, 2d Rept., p. 35, 1860.
1865. *Venericardia densata* Conrad (*Cardita*), Am. Jour. Conchology, vol. 1, p. 8.
1866. *Venericardia densata* Conrad, Smithsonian Misc. Coll., no. 200, p. 5.
1867. *Venericardia mooreana* Conrad, Am. Jour. Conchology, vol. 3, p. 190.
1867. *Venericardia densata* Conrad, Am. Jour. Conchology, vol. 3, p. 190.
1890. *Cardita* (*Venericardia*) *densata* Conrad. DeGregorio, Monographie de le faune éocénique d'Alabama, p. 214, pl. 32, fig. 11.
1891. *Cardita densata* Conrad. Heilprin, Acad. Nat. Sci. Philadelphia Proc. for 1890, p. 402.
1891. *Venericardia mooreana* Conrad? Heilprin, Acad. Nat. Sci. Philadelphia Proc. for 1890, p. 402.
1894. *Cardita dorsata* Conrad (obviously intended for *densata*). Cossmann, Notes complémentaires sur le faune éocénique d'Alabama, p. 14.
1896. *Cardita densata* Conrad. Harris, Bull. Am. Paleontology, vol. 1, no. 4, p. 58. Not *Cardita densata* Conrad. Harris, Arkansas Geol. Survey, Ann. Rept. for 1892, vol. 2, p. 150, 1894.
1896. *Venericardia mooreana* Conrad. Harris, Bull. Am. Paleontology, vol. 1, no. 4, p. 58.
1897. *Cardita densata* Conrad. Harris, Bull. Am. Paleontology, vol. 2, no. 9, pp. 54, 55.
1901. *Venericardia densata* Conrad. Cossmann, Soc. géol. France, Bull., 4e sér., vol. 1, pp. 652–656, 2 text figs.
1903. *Venericardia densata* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, pp. 1420–1422.
1903. *Venericardia mooreana* Conrad. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1422.
1919. *Venericardia "densata"* Conrad. Harris, Bull. Am. Paleontology, vol. 6, no. 31, p. 77.
1919. *Venericardia mooreana* Conrad. Harris, Bull. Am. Paleontology, vol. 6, no. 31, p. 77.
1922. *Venericardia densata* Conrad. Woods, Geology of northwest Peru, p. 69, 70.
1925. *Cardita densata* Conrad. Abrard, Le Lutétien du bassin de Paris, pp. 450–451.
1930. *Venericardia densata* Conrad. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, pp. 154, 157, 158.
1930. *Venericardia mooreana* Conrad. Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, p. 158.

1933. *Venericardia densata* Conrad. Plummer, Univ. Texas Bull. 3232, p. 625.
1936. *Venericardia densata* Conrad. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 163, 164, 170, 180.
1936. *Venericardia mooreana* Conrad. Rutsch, Eclogae geol. Helvetiae, vol. 29, pp. 161, 164.

Obliquely cordate, ventricose, thick, with about 25 flattened costae, obsolete toward the base, narrow, profound, elevated and crenulated on the umbo; umbo very prominent at the apex; anterior basal margin obliquely subtruncated; posterior extremity truncated, direct; cardinal area very thick, and dilated, the teeth oblique. Height 1⅝ inches, length the same.

Locality.—Claiborne, Ala.

This pretty species abounds in entire specimens in the argillaceous stratum near low-water mark in the Claiborne Bluff. I found none in the upper beds. Compared with *V. planicosta*, it is much smaller, comparatively shorter, thicker, and may always be readily distinguished by the crenulated ribs on the umbo.—Conrad, 1846.

Venericardia densata is a heavy, dwarfish shell with an average of 26 or 27 ribs, which become obsolete toward the ventral margin. The umbonal sculpture is very characteristic. The extreme tips of the umbones are sculptured with very narrow, sharply serrate ribs. When the shell is 2 or 3 millimeters high, the ribs upon the anterior and medial portions of the disk become shouldered on either side. These shoulders are smooth and horizontal and wedge out dorsally but broaden away from the umbones and overhang the interradials. The serration is continued as a broad and regular noding for usually a third to half the distance from the umbones to the ventral margin of the adult, where it disappears rather abruptly. The ribs on the later half of the shell are broad, flat-topped, and regular, except upon the posterior area, and are separated by little more than linear intercostals. The overhang that is so prominent upon the medial portion of the disk becomes less and less and disappears altogether near the ventral margin.

Venericardia densata is the most widely distributed of the Claiborne *planicosta* group and is abundant from Alabama to Mexico.

In 1867 Conrad described *Venericardia mooreana* from the Texas Eocene. His description read, "Cordate, thick, ventricose; ribs 27 or 28, flattened on the back, prominent, square, broader on the back than beneath, or the intersections are narrowed at the surface by a slight lateral carination of the ribs; ribs prominent on the ventral margin; narrow, close, and prominent on the anterior and posterior slopes; crenulated on the beak and umbo. Length 1⅛ inches." The only reference to a type locality is "Texas. Dr. Francis Moore. Eocene." He continued: "Distinguished from *planicosta* and *densata* by its size, by the prominence of the ribs on the margin of the valves and on the anterior and posterior slopes, and by the interior marginal teeth, which are not carinated on the margins." Although it would be difficult from the description given to say positively that this species is conspecific with his earlier form, *V. densata*, no forms approaching the description of *V. mooreana*, other than *V. densata*, have been found in Texas.

Cossmann in 1901 compared *V. densata* with the *V. planicosta* of the Paris Eocene, pointing out the dissimilarities, and proposing to call all the American forms by Conrad's name. He disregarded the earlier descriptions of *V. regia* and *V. ascia*. Dall, in 1903, did not seem sure whether or not the American species could be specifically distinct from the French forms, and he held that there was some justification in retaining the Lamarckian name for the American as well as the European forms. Stewart in 1930 said of this distinction of Cossmann:

> For those who wish to separate the forms, on geographical grounds at least, the name *V. ascia* has priority over *V. densata*. I should perhaps use the name *V. ascia* for the American forms and hold that the burden of proof rested upon those who claimed it was identical with *V. planicosta*. This is the attitude usually taken for closely related forms which are widely separated geographically. * * *

This common *densata* is probably the lower Claiborne descendant of the *smithii* stock of the Midway and Wilcox. It is closely related to the larger *aposmithii* form of the lower Wilcox, the sculpture and general rib characters of the two forms being very similar.

Rather small and compressed venericards from Hays Creek at Bedsole's old mill, on the road from Elba to Kinston, one of the very few Tallahatta outcrops from which fossils have been recovered, may be early *densata*, but the forms are too poorly preserved for definite determination. They differ from the Lisbon Landing individuals in their more compressed and thinner shells.

The species as it occurs in Alabama, though varying widely in size, shape, and rib count, presents an ensemble of characters which is unusually diagnostic. It is abundant and with *Ostrea sellaeformis* makes one of the best horizon markers in Alabama of the Lisbon formation. In Mississippi, at least so far as represented in our collections, the species is for the most part rare or poorly preserved. At a bluff on the Chickasawhay 3½ miles southeast of Quitman the species is fairly common, but it is thinner-shelled and more inflated with a slightly higher rib count than in the usual run of the Lisbon and lower Claiborne Bluff individuals on the Alabama River. The St. Maurice of Louisiana is not adequately represented in the collections that we have studied, and it is probable that the species is fairly widespread on the east side of the Sabine uplift. In Texas it is widespread and in many localities abundant. A number of variations are manifested both in the Weches faunas and in those of the Cook Mountain, but we have been unable to use these variations as a stratigraphic criterion. The common form in northeastern Texas, both in the Weches around Palestine, Elkhart, and Augusta and in the Cook Mountain along Cedar Creek near Wheelock, is a smallish roundish cor-

date species with broad, rather low radials. This was almost certainly the race that Conrad had before him when he described his *mooreana*. The same type occurs at Mosleys Ferry on the Brazos River, but at Smithville the only individuals which we have studied are compressed, moderately large, and high cordate-trigonal forms with a partly obsolete decoration upon the ribs of the umbones. A cordate-quadrate, rather highly inflated little individual from Lee County, with uncommonly low and broad ribs, is doubtfully referred to *densata*. *Venericardia densata* is common in the outcrops along the highway between Jourdanton and Pleasanton, in Atascosa County, and the form is similar to those in northeastern Texas. The concentric imbrication is unusually sharp on many of the individuals from these localities. The faunas of the Rio Grande embayment offer the widest range of variation and follow more closely the lines of variation of the Alabama forms. In the lower Cook Mountain in northern Webb County they are relatively large and coarse, with strongly decorated umbonal ribs. This is the race too that is commonly present in the faunas at the horizon exposed in Arroyo Chacon near Laredo. At Arroyo Valeño, 3½ miles southeast of Zapata, in Zapata County, there is another small variant, smaller even than those so commonly present in northeastern Texas but more cordate and more compressed. We have them from this one locality only, and only in the form of double valves. Later material with good hinges may prove these forms to be new. Molds of small double valves which like those from Arroyo Valeño are 2 to 3 centimeters high but with more highly decorated ribs occur near China, Carlos Cantú, Nuevo León, Mexico. This horizon is appreciably lower than that represented in Arroyo Valeño, and it is quite possible that the China forms may be related to the *rotunda* group rather than to *densata*. Other not very well preserved individuals closely resembling the *densata* of Arroyo Chacon have been recovered from the lower Cook Mountain near China and near Doctor Coss, in Nuevo León. In both these localities the venericards are associated with *Ostrea sellaeformis*.

Well-preserved typically sculptured *densata* can be determined with more assurance than almost any other species, but there are variants which make it easily confusable with *V. claiboplata*. There is appreciable variation in the thickness of the shell and in its convexity, and the ribs in the umbonal region are decorated with a beaded crest that varies in relative width. If these crests are relatively narrow and the ribbing not entirely exposed, they simulate the narrow serrate ribbing of the earlier stages of *claiboplata*. Ordinarily, however, *claiboplata* is a larger, thinner, more inflated shell with numerous ribs serrate on the umbones, but simple in the late adolescent and adult stages.

Distribution:

Claiborne group:

Lisbon formation:

Alabama, Monroe County, 2668, 3105, 5511, 1 mile below Lisbon Landing^{pr}, Alabama River, 263, 274, 2396, 6086, 1217, 13086; base of Claiborne Bluff^{pr}, Alabama River. Clarke County, 278, 2870, Coffeeville^{c}; 6157^{c}, 1 mile southwest of Rockville. Choctaw County, 7882^{p}, Okatuppa Creek half a mile above crossing, 1½ miles north of Barrytown; 7887^{p}, Little Turkey Creek crossing on road to Cullomburg.

†Wautubbee formation:

Mississippi, Clarke County, 2627^{p}, Chickasawhay River, 3½ miles southeast of Quitman.

†St. Maurice formation:

Louisiana, Winn Parish, 2916^{p}, Saline Bayou near St. Maurice. Webster Parish 13059^{p}, 2 miles southeast of Minden.

Mount Selman formation, Weches greensand member:

Texas, Sabine County, 13158^{p}, 2 ± miles above Goodwin Ferry; 11106^{p}, Dillon Shoals, 3½ miles south of Lows Creek, Sabine River. San Augustine County, numerous localities along the Nacogdoches-San Augustine road between Attoyac Bayou and San Augustine. Nacogdoches County, 13057^{p}, west bank of Attoyac Bayou on the road from Chireno to the town dump. Anderson County, 2054^{p}, Colgins Hill, 1 mile south of Palestine; 10252^{p}, cut in Boston road, 1½ miles southeast of Palestine; 9259^{p}, 9260^{p}, three-quarters of a mile south of Elkhart; 9262^{p}, 1 mile south of Elkhart. Houston County, 9255^{p}, Percilla; 9269^{p}, Augusta. Leon County, 13058^{p}, half a mile east of Robins on Centreville road. Lee County, 5283^{p}, Shaw's Branch, 1¼ miles southwest of Lexington; 2133^{p}, and 7564^{p}, early collections from the county but no definite locality. Bastrop County, 5285^{p}, 6088^{p}, 8810^{r}, Colorado River near Smithville; 5265^{r}, and 5284^{r}, near the county line in the southernmost part of Bastrop County.

Cook Mountain formation:

Texas, Robertson County, 2048^{p}, Montgomery's well, half a mile east of Wheelock; 2065^{p}, Collardstown Branch; (no number)^{p}, Wheelock. Brazos County, 4786^{p}, 5473^{p}, 10343^{p}, Mosley's Ferry, west bank of Brazos River near Stone City. Gonzales County, 4047?, well at Gonzales. Wilson County, 6141^{r}, Bluff on San Antonio River 4 miles south-southeast of Floresville. Atascosa County, 6152^{p}, crossing of creek on Pleasanton-Jourdanton road about 1½ miles southwest of Pleasanton; 8870^{p}, a quarter of a mile northwest of Jourdanton; 13056^{p}, 1 mile east of Jourdanton on the Pleasanton road. La Salle County, 9168^{p}, International-Great Northern R. R. near milepost 350, south of Cotulla; 6602^{c}, deep well 1 mile west of Fowlerton, 803-823 ft. Webb County, 9166^{p}, 5 miles north of Laredo in bottom of arroyo; 7491^{c}, 11 miles west of Espejo ranch; 10745^{p}, 2112^{c}, Arroyo Chacon, near Laredo; 7492^{p}, east side of

arroyo, 1 mile east of Laredo; 8771[p], 4 miles southeast of Laredo. Zapata County, 8836[p] and 8837[p], just above mouth of Arroyo El Burro, south of Jabali ranch; 9104[c], 4 miles northeast of Zapata; 9117[p], 3 miles southeast of Zapata on Roma road; 13170[c], Arroyo Veleño, 3½ miles southeast of Zapata, 1 mile above Laredo-Roma highway bridge.

Venericardia (Venericor) zapatai Gardner and Bowles, n. sp.

Plate 45, figure 17

Shell moderately large and solid; ovate-cordate in outline; rather strongly, broadly, and evenly inflated in the umbonal region. Lunule small, deeply sunken. Anterior margin strongly bowed in front of the lunule, rounding obliquely into the ventral margin, which is straight medially but rather abruptly up-curved into the obliquely produced and truncate posterior margin. Posterior area indicated by a flattening of the shell and by sculpture differences, but not sharply cut off from the disk. Tips of umbones very full and proximate, the ribs exceptionally high and narrow and probably sharply serrate. Radials 19 or 20 upon the anteromedial area, 5 or 6 upon the posterior region, total 25 on the holotype; juvenile and adolescent ribs very high and narrow, gradually broadening and on the fully adult appearing as low, broadly rounded ribs separated by very narrow, almost linear intercostal grooves. Incremental striae laminated and crowding into prominent resting stages near the ventral margins of the older individuals. Ligament marginal, probably unusually powerful. Hinge characters very imperfectly preserved; hinge plate high and narrow. Characters of the interior lost or concealed.

Dimensions of holotype: Height 68 millimeters, width 62 millimeters, convexity 42 millimeters.

Holotype, geodic double valves: U. S. National Museum, no. 372692.

Type locality: Geological Survey station 9109, 4.8 miles southeast of Zapata on Roma road, Zapata County, Tex. Claiborne group, Cook Mountain formation.

Venericardia zapatai is characterized by the high, trigonal-cordate outline and the relatively few apparently simple ribs, persistent to the basal margin. The mechanics of the hinge must have been unusually well developed, for several individuals are preserved in the form of geodic double valves, indicating that they were laid down in quiet water and so quickly buried that the silty sand did not penetrate the interior. Later there was solution and recrystallization of the calcite over the entire inner surface.

Inner molds of double valves occurring commonly about a mile southeast of Mier may very well be referable to this species. They are badly warped, however, and not sufficient characters are preserved for specific determination.

Distribution:

Claiborne group, Cook Mountain formation:

Texas, Zapata County, 9109[c], 4.8 miles southeast of Zapata on the Roma road.

Mexico, Tamaulipas, Chillipin Arroyo, 7.9 miles from Roma on the Mier road[c].

Venericardia (Venericor) apodensata Gardner and Bowles, n. sp.

Plate 37, figure 13; plate 43, figure 8; plate 45, figures 15, 16

Shell of medium size for the group, inflated, rounded to cordate-trigonal in outline. Anterior margin broadly arcuate, merging into the upcurved base, the posterior margin obscurely truncate. Umbones prominent, full and high, the tips turned inward and forward over the small, relatively high, and deeply incised lunule. Posterior area defined both by the flattening of the shell and by the more cordate and incrementally wrinkled costals. Umbonal ribs high and narrow, with sharply noded crests and lateral terracing, strongest anteriorly and evanescing in the adolescent stage; adult sculpture of 23 high anteromedial ribs, wider than the deeply incised intercostals and distinctly continuous to the ventral margin, and on the posterior area 9 cordate costals. Ligament marginal, inset on a narrow nymph. Hinge plate wide and moderately low. Anterior right cardinal very short and laminar, medial cardinal cuneiform and bent forward near the umbonal extremity, posterior cardinal laminar and much produced parallel to the ligament groove; anterior left cardinal short and deltoid, the posterior bent forward obliquely and expanded toward the ventral extremity. Pedal scar deeply incised. Adductor muscle scars large and prominent, because of the slight thickening in the adult over the area of the adherent mantle. Pallial line simple. Inner margins crenate.

Dimensions of cotypes: Cotype 369599, left valve, height 51 millimeters, width 51 millimeters. Cotype 136644, right valve, height 68.0 millimeters, width 70.5 millimeters.

Cotypes: A left valve, U. S. National Museum, no. 369599, and a right valve, U. S. National Museum, no. 136644.

Type locality: Geological Survey station 6462, Moodys Branch, Jackson, Hinds County, Miss. Moodys marl member of Jackson formation.

The types are not fully adult, and the older individuals are more trigonal and their hinge plates higher. *Venericardia apodensata* may be in the line of descent from *V. densata*, so common and so widespread in the Claiborne. The Jackson species is a larger but not so heavy shell, with a lower and not so heavy hinge plate and a more sharply defined and deeply incised costal sculpture. It is quite possible that a lateral line is represented, for *Venericardia densata* suggests more strongly the last of the line than an ancestral form. The early stages of the Claiborne and Jackson species are, however, very similar, and there is probably some

genetic relationship. From *Venericardia klimacodes* of the Yazoo clay member, *apodensata* differs in the lower, less inflated umbones, the more angular ribbing, and the more pronounced and more persistent lateral terracing. These differences have apparently a stratigraphic significance.

Distribution:

Jackson formation, Moodys marl member:

Alabama, Clarke County, 7158[p], 2–2½ miles southwest of Whatley; 6157[p], 1 mile southwest of Rockville.

Mississippi, Clarke County, 330[p] and 2630[p], 4½ miles northeast of Shubuta. Hinds County, 54[p], 61[p], 62[p], 2665[p], 3735[p], 3746[p], 4250[p], 6458[p], 6462[p], 7386[p], Moodys Branch, Jackson; 3734[c], south of pump house, Jackson; 12178[c], gully south of the road east of flag station on Yazoo & Mississippi Valley Railroad.

Arkansas, St. Francis County, 4266[c], Little Crow Creek, a quarter of a mile above Choctaw Bridge, Crowleys Ridge near Forrest City. Jefferson County, 2402[c], White Bluff, Arkansas River. Cleveland County, 2231[p], 2413[p], Rison. Drew County, 2408[r], Long Prairie, 9998[p], Tennessee Spur, SW¼SE¼ sec. 30, T. 12 S., R. 7 W. Bradley County, 2411[p], 3 miles east of Warren.

Louisiana, Claiborne Parish, 2038[p], Pittmans Mill, SW¼SE¼ sec. 19, T. 19 N., R. 7 W. Louisiana Meridian. Bienville Parish, 2033[p], Holstun's place, sec. 17, T. 18 N., R. 5 W. Louisiana Meridian. Grant Parish, 2003[p], 2638[p], 4270[p], and 13085[p], Creole Bluff, a quarter to a half mile below the Ferry Landing, Montgomery; 4271[p], Bells Wood Landing, Red River 4 miles below Montgomery.

Texas, Sabine County, 10742[p], Sabine River, Robinson's Ferry, 2 miles north of Fairdale.

Venericardia (Venericor) klimacodes Gardner and Bowles, n. sp.

Plate 37, figures 9, 10

Shell rather small for the group, light, only slightly inflated, ovate-trigonal in outline. Anterior margin broadly rounded, merging into the upcurved base. Posterior curvature more decided. Umbones high, narrow, the tips turned inward and forward over the small and deeply sunken lunule. Posterior area indicated by the flattening of the shell and by sculpture differences. Ribs 23 on the anteromedial portion, 6 on the posterior; high, narrow, and noded on the umbones, flat-topped, and separated by deeply incised, sharp-angled intercostals that continue distinct to the ventral margin of the disk; lateral riblets well defined in the early and adolescent stages; posterior costals cordlike, those nearest the margin flattened and overridden by the incrementals, forming a sort of false escutcheon. Ligament marginal, deeply inset. Hinge plate rather high and narrow. Anterior right cardinal very short and thin, the middle cardinal scimitar-shaped, the posterior slender and produced parallel to the ligament groove; anterior left cardinal short and wedge-shaped, the posterior slender and produced. Pedal scar small and sunken; anterior adductor scar narrow, distinct, the posterior semi-elliptical and placed well down toward the ventral margin. Pallial line simple and well defined. Inner margins deeply crenate.

Dimensions of holotype: Height 53 millimeters, width 49 millimeters, convexity of single valve 16 millimeters.

Holotype, a left valve: U. S. National Museum, no. 372693.

Type locality: Geological Survey station 6472, large ravine about 1 mile south of Yazoo City, Yazoo County, Miss., along street-car line about a quarter of a mile north of the tile plant and just below the old reservoir.

The most closely related species is *Venericardia apodensata*, from the Moodys marl. From that form *Venericardia klimacodes* is separated by its less inflated, usually smaller shell, more sharply incised intercostals, and stronger and more persistent lateral terracing. *V. klimacodes* is restricted in its known distribution to the Yazoo Clay.

Distribution:

Jackson formation, Yazoo clay member:

Mississippi, Yazoo County, 10118[p], near the head of a ravine about three-quarters of a mile southeast of Free Run on the line between the SE¼ sec. 26 and the SW¼ sec. 25, T. 13 N., R. 1 W., about 10 miles northeast of Yazoo City; 7674[p], roadside on hill at Sims station, Yazoo & Mississippi Valley Railroad, 10 miles north of Yazoo City and 2 miles south of Eden; 6474[p], 1½ miles east of the Yazoo & Mississippi Valley Railroad station in the banks of a creek south of Broadway-Benton road; 6472[c], 1 mile south of Yazoo City, along street-car line about a quarter of a mile north of the tile plant and just below the old reservoir.

Venericardia, n. sp.

At two localities in the upper Eocene of northern Mexico remnants of a large venericard have been found which indicate a species quite unlike any now recognized in the Gulf. The shells are large, about 110 millimeters high and 90 millimeters wide, but the double valves are less than 50 millimeters in maximum thickness. The lateral margins are broadly curved, and so is the base line. The umbones are low, broad, and placed well in front of the median horizontal. The characters of the young and adolescent sculpture have been lost, but the adult ribs are low, apparently simple, wider on the disk than the U-shaped intercostals, probably about 20 in all, and evanescent at a considerable distance from the margins. The growth wrinkling toward the anterior and ventral margins is unusually strong and regular. The ligament seems to have been very powerful, and the hinge high and massive.

There is nothing remotely resembling these rounded, compressed, and few-ribbed forms in the Jackson of the Gulf.

Venericardia (Venericor?) greggiana Dall

Plate 46, figure 9

1897. *Venericardia alticostata* var. Harris, Bull. Am. Paleontology, vol. 2, no. 9, p. 55, pl. 11, fig. 1.
1903. *Venericardia greggiana* Dall, Wagner Free Inst. Sci. Trans., vol. 3, no. 6, p. 1425.

Shell large but relatively thin, with high beaks, but the line of the inner margins suborbicular; the ribs are narrow and high, about 34 in number, flattish above and even overhanging a little laterally, with flat, dentiform imbrications directed toward the umbones; the interspaces are subequal or slightly narrower than the ribs and channeled. The ribs in the young shell are accompanied by a narrow, elevated riblet on each side, but the adult has the posterior riblet generally obsolete toward the ends of the shell and both riblets obsolete in the middle of the disk below; the beaks are prosogyrate, the lunule small and convex, the hinge rather light, and the inner margin sharply crenulate. It reaches a maximum height of 55 millimeters and a diameter of 36 millimeters.

Lower bed at Greggs Landing, Ala., in the Chickasawan or Lignitic stage of the Eocene.

This form is rarely well preserved, but the sculpture, when perfect, is a clue to differentiate it from any other of our Tertiary species. It has a general resemblance to *V. smithii* Aldrich, but is without the rostration or the minor sculpture of that species.—Dall, 1903.

This species is unusually well characterized by its subglobose outline and elaborate sculpture and is genetically related to the *V. smithii* stock of the Midway; for that reason it is included under *Venericor*, although in general appearance it is far removed from the usual concept of that group. It has been recognized only in the Tuscahoma of Alabama.

Distribution:
Wilcox group, Tuscahoma sand:
Alabama, Monroe County, 5604[p], Greggs Landing, Alabama River; 3908[r], Bells Landing, Alabama River.

Venericardia (Venericor?) mingoensis Gardner and Bowles, n. sp.

Plate 46, figures 2, 3

1936. *Venericardia mingoensis* Gardner and Bowles. Cooke, U. S. Geol. Survey Bull. 867, p. 44.
1936. ?*Venericardia "planicosta"* Cooke, U. S. Geol. Survey Bull. 867, pp. 43, 47, 49, 50, 51.

Shell small for the group but rather heavy, high, rounded-trigonal in outline, compressed. Umbones small and pinched but full at the tips, submedial, prosogyrate. Margins broken but indicated by the incremental lines, the anterior and ventral margins broadly rounded, the posterior area sharply defined, and the margin probably obliquely truncate. Anterior area indicated by a very prominent, sharp, and regular corrugation of the 10 anterior ribs, the 10 upon the disk broad and flat and separated by deeply incised linear channels; the 6 posterior ribs much narrower, though apparently similar in character and persistence to those upon the disk. Hinge plate high; dentition very imperfectly indicated. Muscle scars deeply impressed, especially the anterior adductor and the pedal pit directly above it.

Dimensions of holotype: Height 50.0±millimeters, width 45.0±millimeters, convexity 20.0±millimeters.

Holotype, a right valve: U. S. National Museum, no. 372922.

Type locality: Geological Survey station 3981, Black River, Rhems field, near store, about 1 mile west of Steamboat Landing, Georgetown County, S. C. Collected by Frank Burns in 1904. Possibly from the undifferentiated Midway group.

So imperfect a specimen would not deserve a name were it not for the very unusual characters which even the battered and worn holotype presents. The narrow, pointed beaks, the simple ribs, so strongly corrugated on the anterior portion of the shell, so flat and closely spaced medially, so narrow but persistent posteriorly are uncommonly good diagnostics of a species collected more than 30 years ago and not observed in any subsequent collection.

Venericardia mingoensis stands quite apart from all described species in the narrow, pinched umbones, the strongly corrugated anterior area, the narrow, sharply distinct posterior area, and the broad, simple, regular ribbing on the central portion of the disk. There is something in the general look of the pinched umbonal region and the sculpture pattern that suggests *V. hijuana*, and it may be that a genetic relationship is thus faintly indicated. The Black Mingo formation, from which the shells were recovered, has been referred on field evidence to the Wilcox. The fossils indicate a lower Midway age.

Distribution:
Midway group, probably the lower Midway, undifferentiated:
South Carolina, Georgetown County, 7069[r], Black River 12 miles northwest of Georgetown; 3481[r], Black River 1 mile west of Steamboat Landing.

Subgenus GLYPTOACTIS Stewart

1930. Stewart, 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 *Leuroactis*. For this group the new subgeneric name *Glyptoactis* is proposed, with *V. hadra* Dall as the type species (Dall, 1903, p. 1429, 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. 1430, pl. 53, fig. 12), and his figures of both species have been reproduced by Gardner (U. S. Geol. Survey Prof. Paper 142–B, 1926, p. 90, pl. 17, figs. 11–13). The group is known from the Eocene—*V. alticostata* (Harris, Bull. Am. Paleontology, vol. 6, 1919, p. 82, pl. 30, figs. 1–5, Claiborne)—and is still living on the West Central American coast as *V. cuvieri* Broderip (Reeve, Conch. Iconica, vol. 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, Lutétien-Bartonien). *"Cardita" sandiegoensis* from the Eocene of California may also be a *Glyptoactis* (Hanna,

California Univ. Bull. Dept. Geology, vol. 16, 1927, p. 283, pl. 37, fig. 1–2, 8–9).

The hinge of *Glyptoactis* suggests the minute Mediterranean *Glans* Megerle 1811 (Bucquoy, Dautzenberg, and Dollfus, Moll. Roussillon, vol. 2, 1892, p. 231, pl. 38, figs. 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.

The two species that follow, *Venericardia hesperia* and *Venericardia moa*, may be referable to this subgeneric group. Unfortunately, their hinge characters are little or not at all known. They are included in this study because of their possible relationship to some of the earlier, more generalized venericards.

Venericardia (Glyptoactis?) hesperia Gardner

Plate 46, figures 4, 5

1896. *Venericardia alticostata* Conrad (part). Harris, 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.

1933. *Venericardia hesperia* Gardner. Plummer, Univ. Texas Bull. 3232, pp. 547, 550.

1935. *Venericardia hesperia* Gardner, Univ. Texas Bull. 3301, pp. 157, 164–165.

Shell of moderate dimensions, thick, porcelaneous, inflated-cordate in cross section; unbones 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; interradial channels broadly U-shaped; incremental sculpture very fine and sharp; hinge plate thick, heavy; adductor scars impressed, the anterior excavated; pallial line simple; inner margins deeply crenate.

Dimensions: Altitude 37 millimeters, latitude 44 millimeters, diameter 37 millimeters.

Type locality: Station 3180, bluff on Frio River half a mile below Myrick's apiary, Uvalde County [Texas].—Gardner, 1923.

Although this form is undoubtedly much more closely allied with the *V. alticostata* group, it is included in this report, as it seems to be related to the earlier members of the *planicosta* group. It differs from *V. moa* in being more inflated and bearing more radials.

Distribution:

Midway group, Kincaid formation:

Texas, Medina County, 10128?[p], Verde Creek, 4½ miles northeast of Hondo; 6584[p], D'Hanis-Yancey road, about 7 miles south of D'Hanis. Uvalde County, 3181[p], Frio River, just above waterhole opposite apiary below Englemann's ranch; 3180[p], bluff on Frio River half a mile below Evans' (Myrick's) apiary.

Venericardia (Glyptoactis?) moa Gardner

Plate 46, figure 1

1935. *Venericardia moa* Gardner, Univ. Texas Bull. 3301, pp. 157, 168–169, 170, 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 not preserved. Anterior margin bowed in front of the lunule. Posterior extremity obliquely produced and broadly rounded. Sculpture vigorous. Radials 19 on the type—the 7 on the posterior slope 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 of double valves of holotype from which a part of the shell has been removed: Height 30.0 millimeters, width 34.0 millimeters, convexity 20.0 millimeters.

Holotype, a pair of locked valves: U. S. National Museum, no. 370922. Allied form: U. S. National Museum, no. 370912.

Type locality: Holotype, Geological Survey station 4398, 18 miles south and east of Eagle Pass, Maverick County, Tex.; allied form, U. S. Geological Survey station 2439, 1 mile east of Webberville, Travis County, Tex. Midway group, Kincaid formation.

The holotype is figured.

Venericardia moa closely approaches in some of its higher variants *V. hesperia* Gardner, so common on the Frio River in Uvalde County, Tex. It runs decidedly smaller than *V. hesperia*, however, is normally much less inflated, and is more produced posteriorly. In general dimensions and outline it closely approaches *V. whitei* Gardner, 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 to it and may prove to be specifically identical, though the border form runs a little larger,

is more produced posteriorly, and apparently develops more radials upon the posterior and possibly the anterior area.

Although this species is probably more closely related to the *V. alticostata* group than to the *planicosta* strain, it has been included with *V. hesperia*, as it seems to fall between the two major Eocene types of the genus and to be a close approach to the rudimentary basal greensand form.

Distribution:

Midway group, Kincaid formation:

Texas, Maverick County, 4398[p], 6583?[p], and 11753[p], Bibora Creek, just below Bibora tank, about 18 miles southeast of Eagle Pass; 11755[p], 3 miles north of Media tank; 11757[p], hillside above small tank 2 miles west of Lopez tank, about 29 miles southeast of Eagle Pass; 11869[p], 1 mile northwest of Indio Wells; 6575, White Bluff on the Rio Grande, about 4½ miles west of south of Windmill (Jacal) ranch house.

PLATES 33–46

20412—39——5

PLATE 33

[All figures natural size unless otherwise indicated]

FIGURE 1. *Venericardia* (*Venericor*) *mediaplata* Gardner and Bowles, n. sp. (p. 168). Interior of holotype, a left valve (U. S. N. M. 137241) from Prairie Creek, Wilcox County, Ala.

FIGURE 2. *Venericardia* (*Venericor*) *nanaplata* Gardner and Bowles, n. sp. (p. 169). Exterior of holotype, a left valve (U. S. N. M. 137226) from Nanafalia Bluff, Tombigbee River, Ala.

FIGURE 3. *Venericardia* (*Venericor*) *mediaplata* Gardner and Bowles, n. sp. (p. 168). Exterior of holotype, a left valve (U. S. N. M. 137241) from Prairie Creek, Wilcox County, Ala.

FIGURES 4–5. *Venericardia* (*Venericor*) *nanaplata nanna* Gardner and Bowles, n. subsp. (p. 169). Cotypes (U. S. N. M. 373028) from Greggs Landing, Alabama River, Ala. 4, Exterior of left valve; 5, exterior of right valve.

FIGURE 6. *Venericardia* (*Venericor*) *negritensis* Olsson (p. 170). Exterior of holotype, a left valve, from Negritos, Peru; height 76.0 millimeters; width 70.0 millimeters. (After Olsson.)

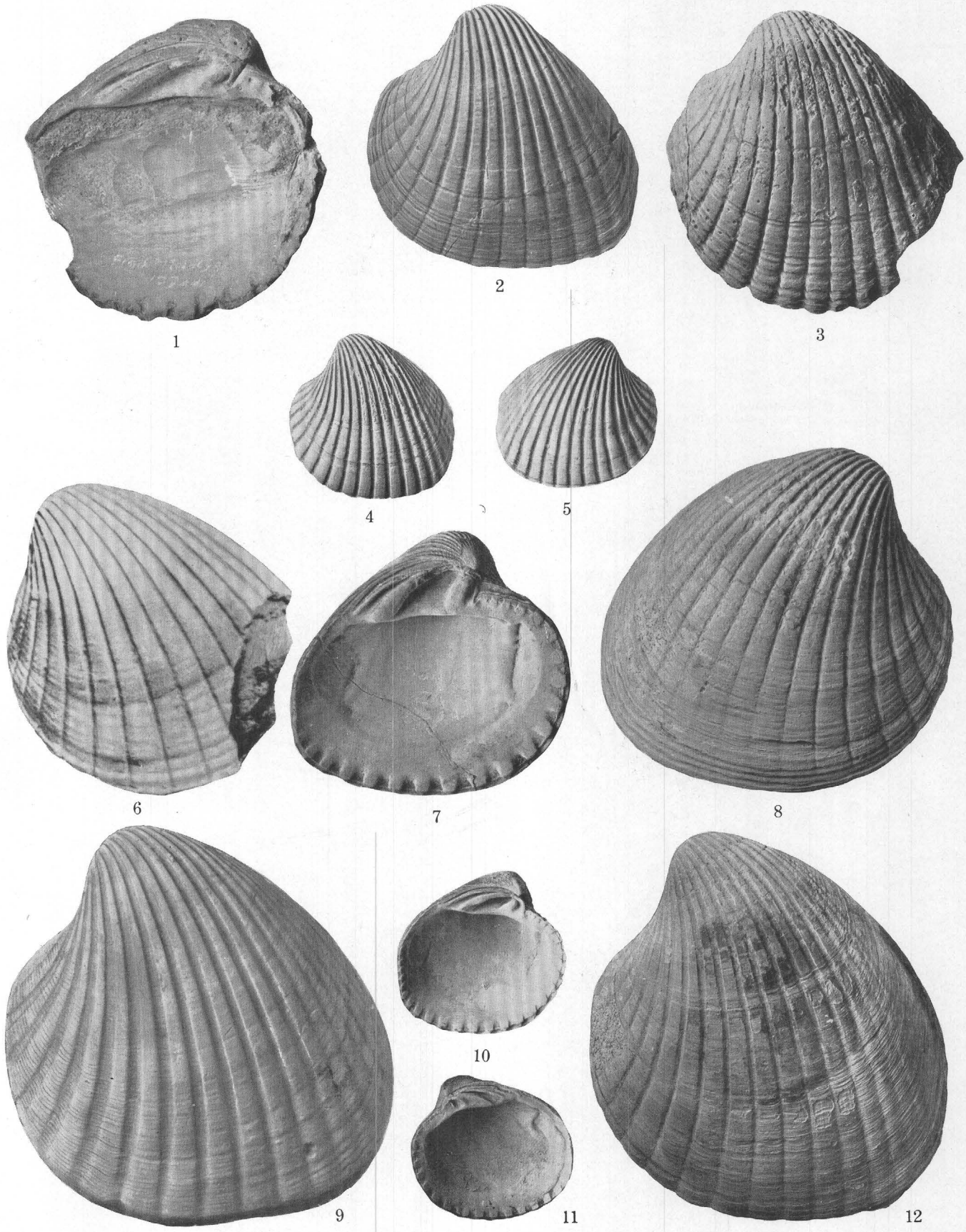
FIGURE 7. *Venericardia* (*Venericor*) *nanaplata* Gardner and Bowles, n. sp. (p. 169). Interior of holotype, a left valve (U. S. N. M. 137226) from Nanafalia Bluff, Tombigbee River, Ala.

FIGURE 8. *Venericardia* (*Venericor*) *hatcheplata* Gardner and Bowles, n. sp. (p. 172). Exterior of cotype, a right valve (U. S. N. M. 372173) from Hatchetigbee Bluff, Tombigbee River, Ala.

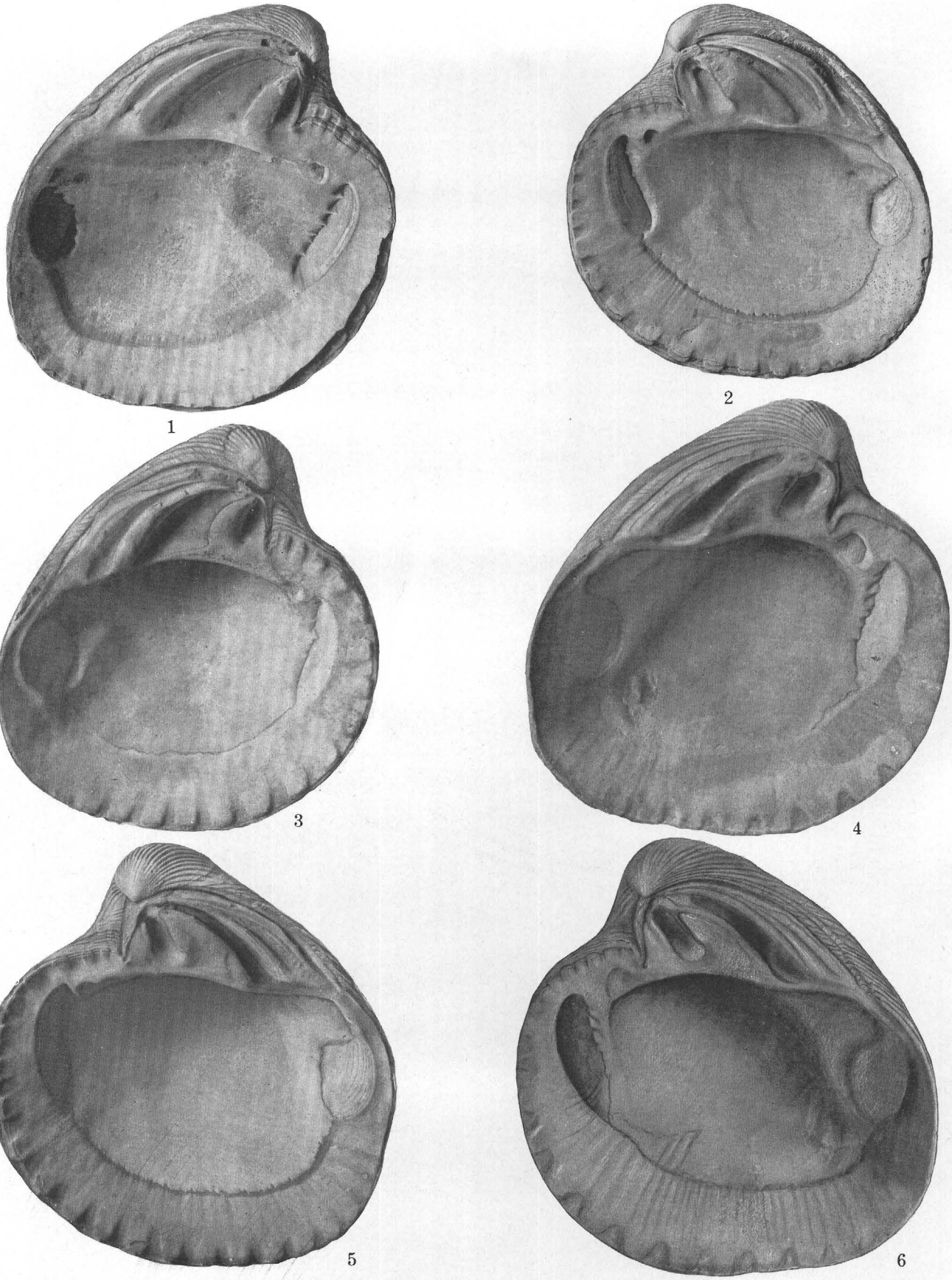
FIGURE 9. *Venericardia* (*Venericor*) *bashiplata* Gardner and Bowles, n. sp. (p. 171). Exterior of cotype, a left valve (U. S. N. M. 371914) from Beaver Creek a quarter of a mile east of Choctaw Corners, Clarke County, Ala.

FIGURES 10–11. *Venericardia* (*Venericor*) *nanaplata nanna* Gardner and Bowles, n. subsp. (p. 169). Cotypes (U. S. N. M. 373028) from Greggs Landing, Alabama River, Ala. 10, Interior of left valve shown in figure 4; 11, interior of right valve shown in figure 5.

FIGURE 12. *Venericardia* (*Venericor*) *hatcheplata* Gardner and Bowles, n. sp. (p. 172). Exterior of cotype, a left valve (U. S. N. M. 372173) from Hatchetigbee Bluff, Tombigbee River, Ala.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.

PLATE 34

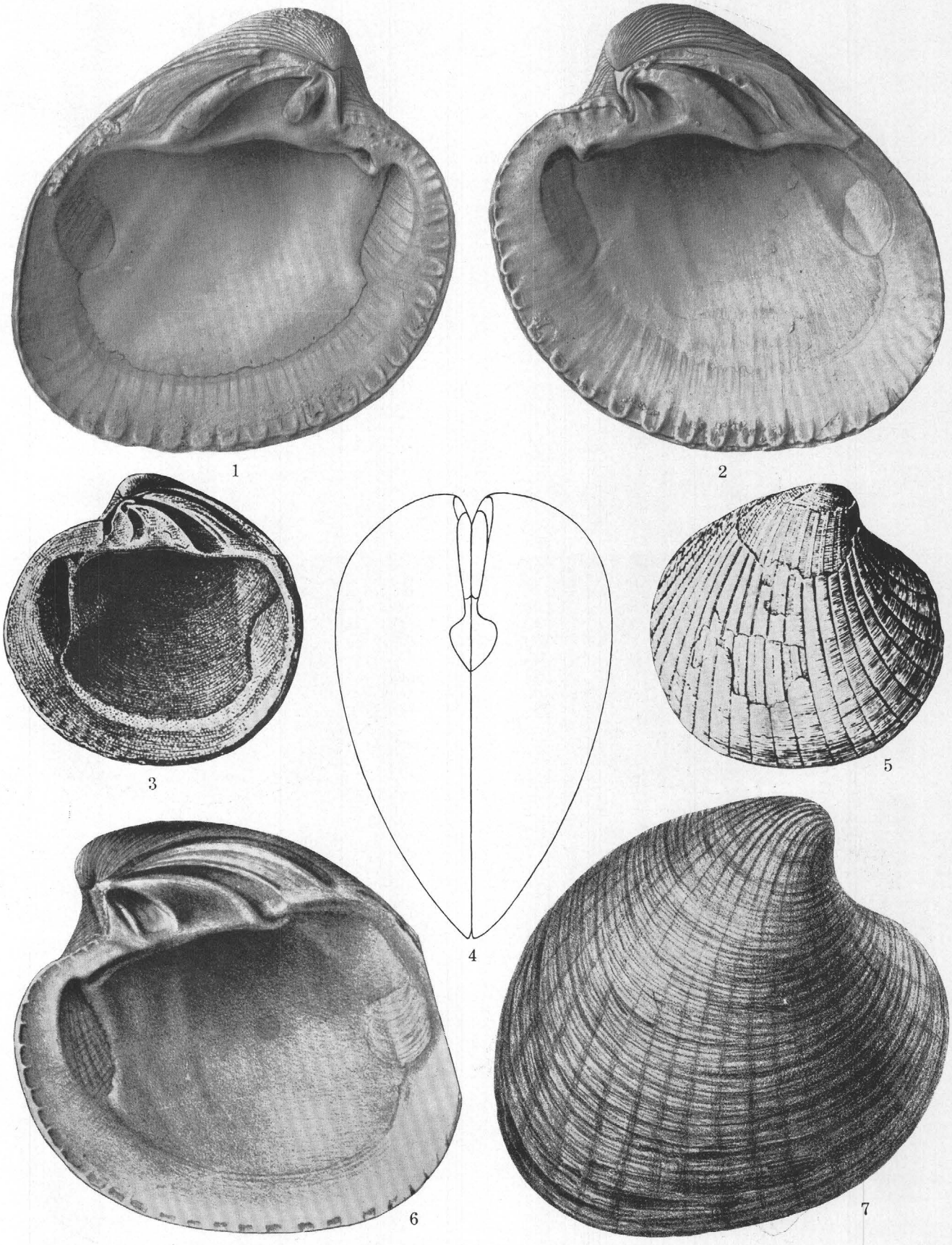
FIGURES 1–2. *Venericardia* (*Venericor*) *hatcheplata* Gardner and Bowles, n. sp. (p. 172). Cotypes and abnormal left valve (U. S. N. M. 372173) from Hatchetigbee Bluff, Tombigbee River, Ala. 1, Interior of left valve, shown on plate 33, figure 12; 2, interior of right valve, shown on plate 33, figure 8.

FIGURES 3–6. *Venericardia* (*Venericor*) *bashiplata* Gardner and Bowles, n. sp. (p. 171). Cotypes (U. S. N. M. 371914) from locality a quarter of a mile east of Choctaw Corners, Clarke County, Ala. 3, Interior of left valve (cotype); 4, interior of abnormal left valve showing dentition apparently normal to right valve; 5, interior of normal right valve (cotype); 6, mirror image of interior of abnormal left valve shown in figure 4.

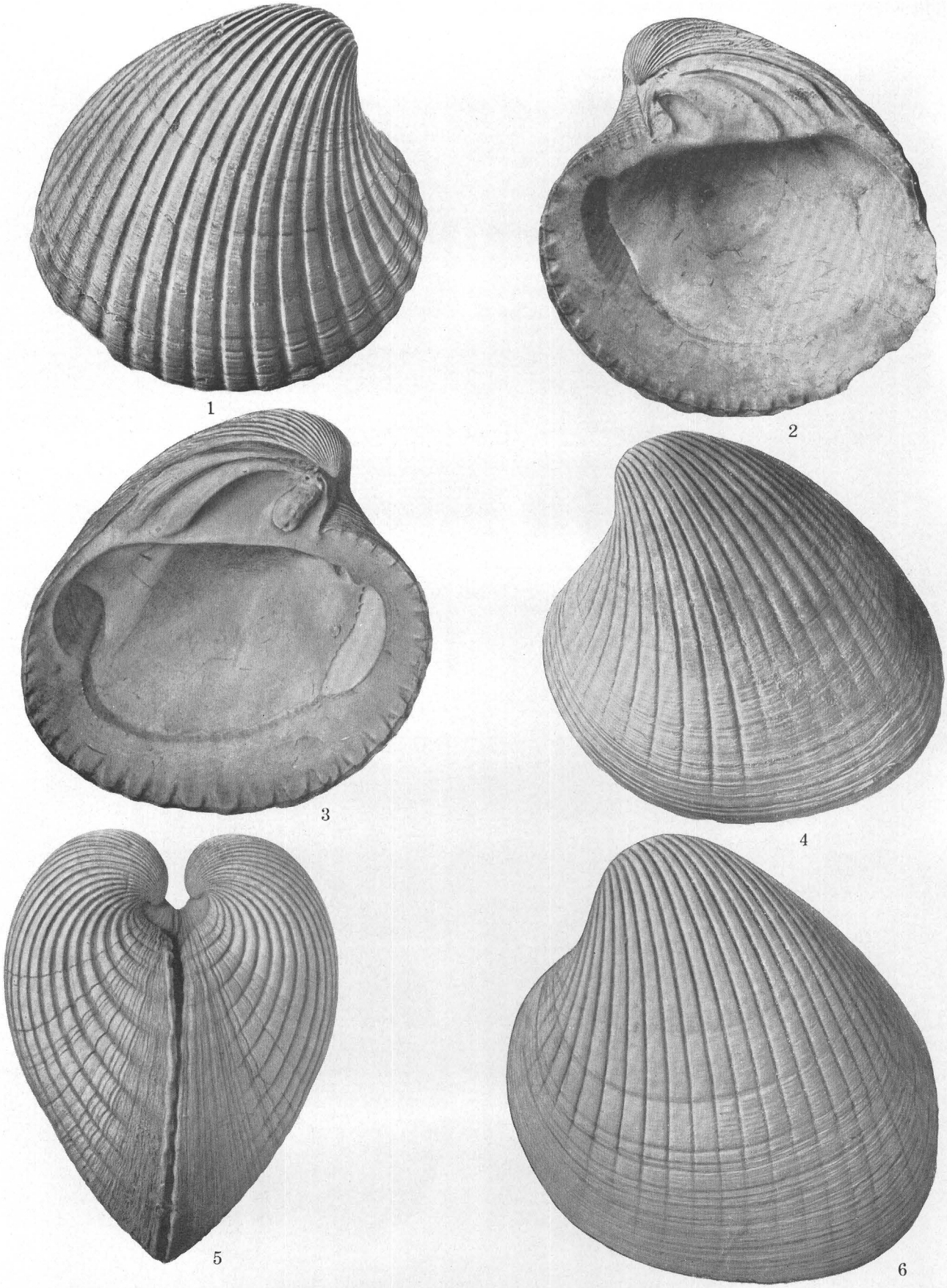
PLATE 35

FIGURES 1–2. *Venericardia* (*Venericor*) *planicosta* Lamarck (p. 168). Subgenotype (U. S. N. M. 12704) from Grignon, Seine et Oise, France. 1, Interior of left valve; 2, interior of right valve.

FIGURES 3–7. *Venericardia* (*Venericor*) *ascia* Rogers (p. 171). 3, Holotype of *Venericardia marylandica* Clark and Martin, from the Woodstock greensand marl member of the Nanjemoy formation, 2¼ miles above Popes Creek, Potomac River, Md. Interior of right valve: Height 80.0 millimeters, width 80.0 millimeters. (After Clark and Martin.) 4, Profile of double valves of holotype of *Venericardia ascia* Rogers from King George County, Va. (After Rogers.) 5, Exterior of right valve of holotype of *Venericardia marylandica* Clark and Martin shown in figure 3 (after Clark and Martin); 6, interior of right valve of holotype of *Venericardia ascia* Rogers from King George County, Va. (After Rogers.) 7, Exterior of right valve of holotype of *Venericardia ascia* Rogers shown in figure 6. (After Rogers.)



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.

PLATE 36

FIGURES 1–2. *Venericardia* (*Venericor*) *claiboplata* Gardner and Bowles, n. sp. (p. 173). Cotype (U. S. N. M. 11365) from Claiborne Bluff, Alabama River, Ala. 1, Exterior of right valve; 2, interior of right valve.

FIGURES 3–4. *Venericardia* (*Venericor*) *claiboplata* Gardner and Bowles, n. sp. (p. 173). Cotype (U. S. N. M. 1434) from Clarksville, Clarke County, Ala. 3, Interior of left valve; 4, exterior of left valve.

FIGURES 5–6. *Venericardia* (*Venricoer*) *planicosta* Lamarck (p. 168). Subgenotype (U. S. N. M. 12704) from Grignon, Seine et Oise, France. 5, Double valves viewed from the front; 6, exterior of left valve.

PLATE 37

FIGURES 1–3. *Venericardia* sp. cf. *V.* (*Venericor*) *diga* Gardner and Bowles, n. sp. (p 182). Two pairs of locked valves (U. S. N. M. 497005), from Rio Alamo, west of Mier, Tamaulipas, Mexico. 1, Double valves viewed from the left; 2, double valves viewed from the front; 3, double valves (second pair) viewed from the left.

FIGURES 4–5. *Venericardia* (*Venericor*) *cacamai* Gardner and Bowles, n. sp. (p. 174). Cotype, an incomplete left valve (U. S. N. M. 373032), from Zacate, Nuevo León, Mexico. 4, Hinge of incomplete left valve; 5, exterior of incomplete left valve.

FIGURE 6. *Venericardia* (*Venericor*) *restinensis* Olsson (p. 174). Exterior of holotype, a right valve, from the Pozo Valley, Restin formation, Peru; height 39.0 millimeters, width 42.0 millimeters. (After Olsson.)

FIGURE 7. *Venericardia* (*Venericor*) *densata* Conrad (p. 189). Exterior of right valve (U. S. N. M. 497006), from Arroyo Chacon near Laredo, Tex.

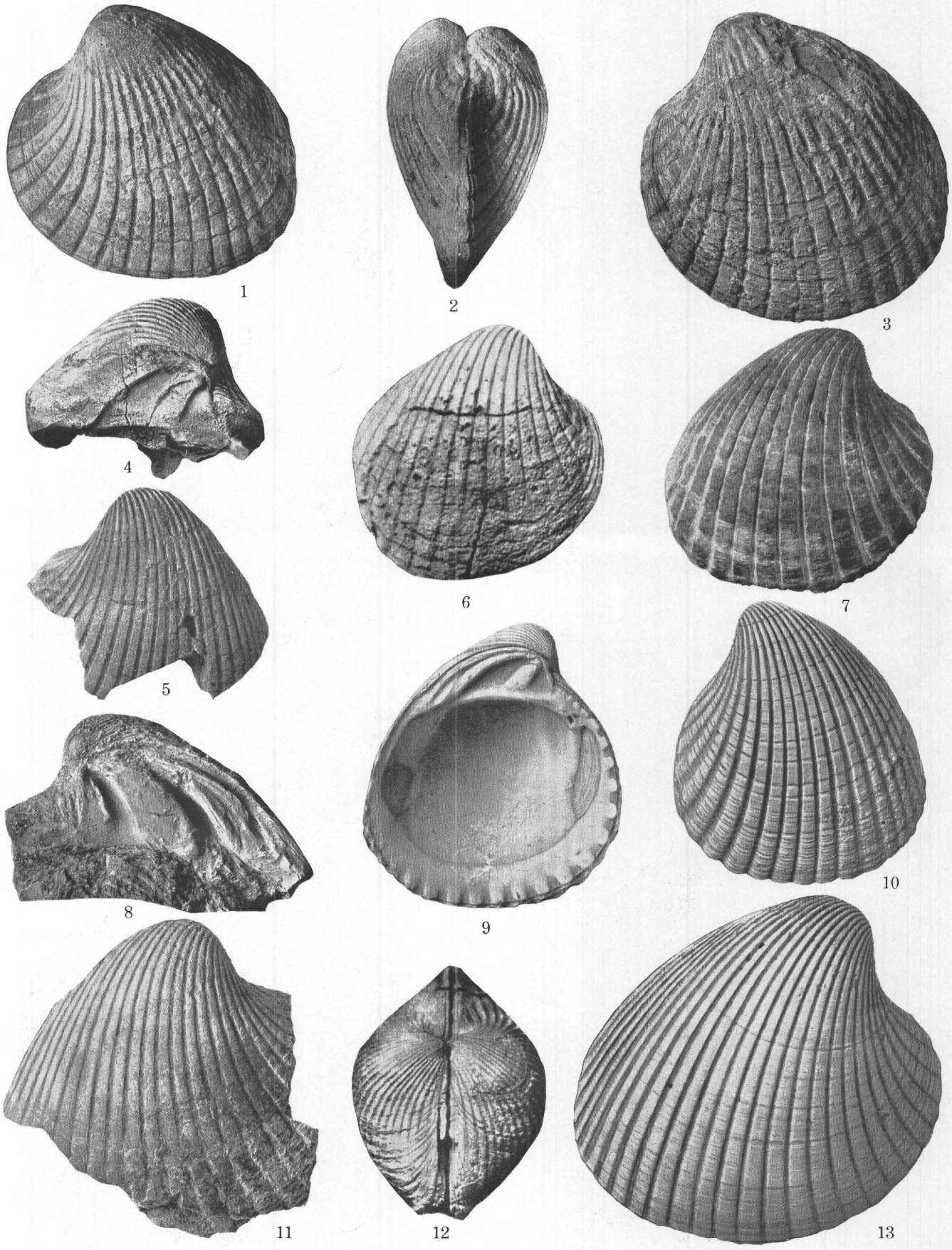
FIGURE 8. *Venericardia* (*Venericor*) *cacamai* Gardner and Bowles, n. sp. (p. 174). Hinge of cotype, an incomplete right valve (U. S. N. M. 373032), from Zacate, Nuevo León, Mexico.

FIGURES 9–10. *Venericardia* (*Venericor*) *klimacodes* Gardner and Bowles, n. sp. (p. 193). Holotype, a left valve (U. S. N. M. 372693), from 1 mile south of Yazoo City, Miss. 9, Interior of holotype; 10, exterior of holotype.

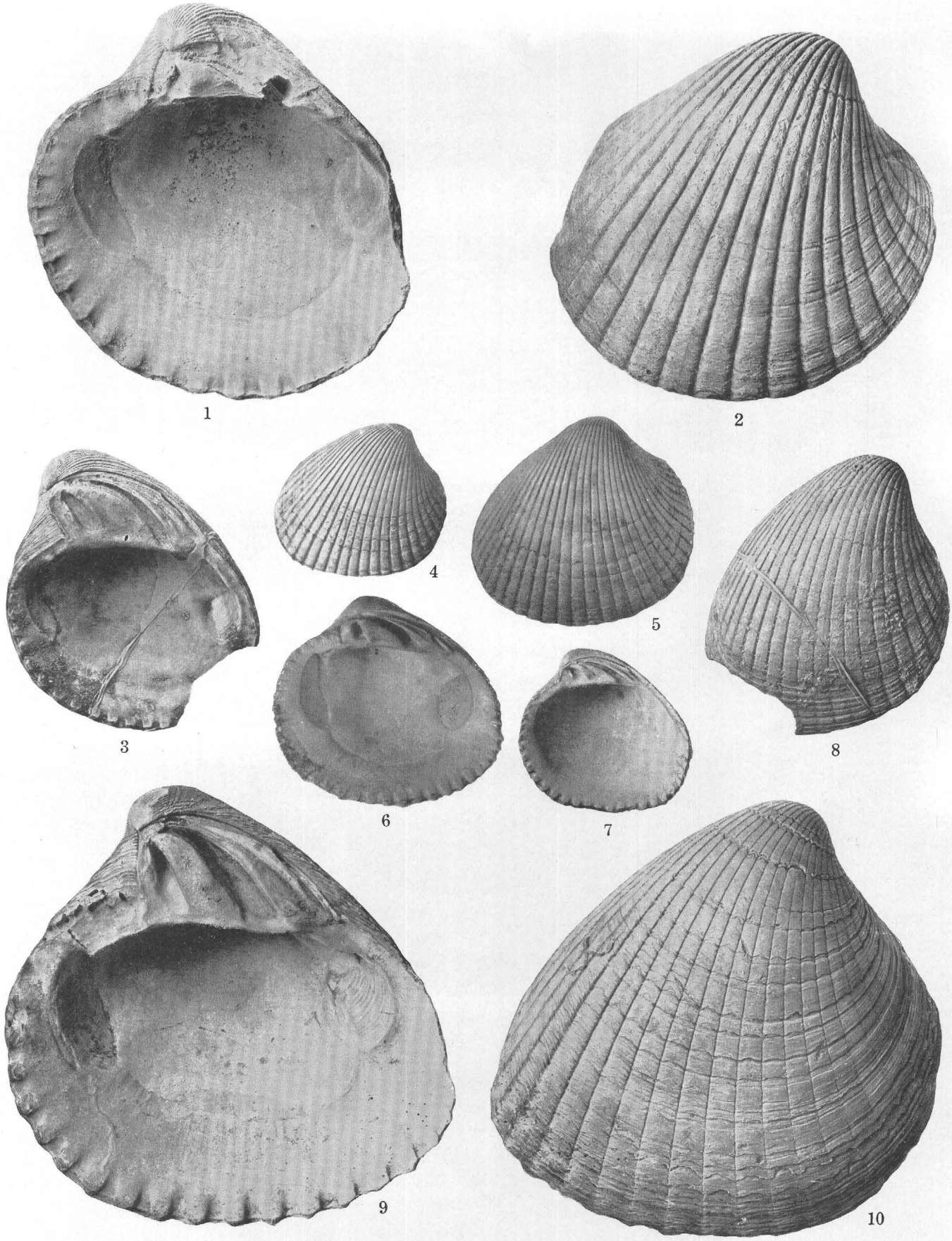
FIGURE 11. *Venericardia* (*Venericor*) *cacamai* Gardner and Bowles, n. sp. (p. 174). Exterior of cotype, an incomplete right valve (U. S. N. M. 373032), from Zacate, Nuevo León, Mexico.

FIGURE 12. *Venericardia* (*Venericor*) *pacifica* Olsson (p. 179). Dorsal view of double valves of holotype from the Salina formation, Negritos, Peru; diameter 31.0 millimeters. (After Olsson.)

FIGURE 13. *Venericardia* (*Venericor*) *apodensata* Gardner and Bowles, n. sp. (p. 192). Exterior of cotype, a right valve (U. S. N. M. 136644), from Jackson, Miss.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.

PLATE 38

FIGURES 1–2. *Venericardia* (*Venericor*?) *claviger* Gardner and Bowles, n. sp. (p. 176). Holotype, a right valve (U. S. N. M. 136973), from Jackson, Clarke County, Ala. 1, Interior of holotype; 2, exterior of holotype.

FIGURE 3. *Venericardia* sp. cf. *V.* (*Venericor*) *angustoscrobis* Gardner and Bowles, n sp. (p. 176). Interior of right valve from Claiborne Bluff, Monroe County, Ala., from collection of F. E. Turner, College Station, Tex., showing abnormally high rib count and senile characters both externally and internally.

FIGURE 4. *Venericardia* (*Venericor*) *angustoscrobis* Gardner and Bowles, n. sp. (p. 175). Exterior of holotype, a right valve (U. S. N. M. 372691), from Lisbon Bluff, Alabama River, Ala.

FIGURES 5–6. *Venericardia* (*Venericor*) *cookei* Gardner and Bowles, n. sp. (p. 176). Holotype, a right valve (U. S. N. M. 129767), from Catons Bluff, Conecuh River, Ala. 5, Exterior of holotype; 6, interior of holotype.

FIGURE 7. *Venericardia* (*Venericor*) *angustoscrobis* Gardner and Bowles, n. sp. (p. 175). Interior of holotype shown in figure 4.

FIGURE 8. *Venericardia* sp. cf. *V.* (*Venericor*) *angustoscrobis* Gardner and Bowles, n. sp. (p. 176). Exterior of right valve shown in figure 3.

FIGURES 9–10. *Venericardia* (*Venericor*) *pilsbryi* Stewart (p. 175). Right valve (U. S. N. M. 137225), from Nanafalia Bluff, Tombigbee River, Ala. 9, Interior of right valve; 10, exterior of right valve.

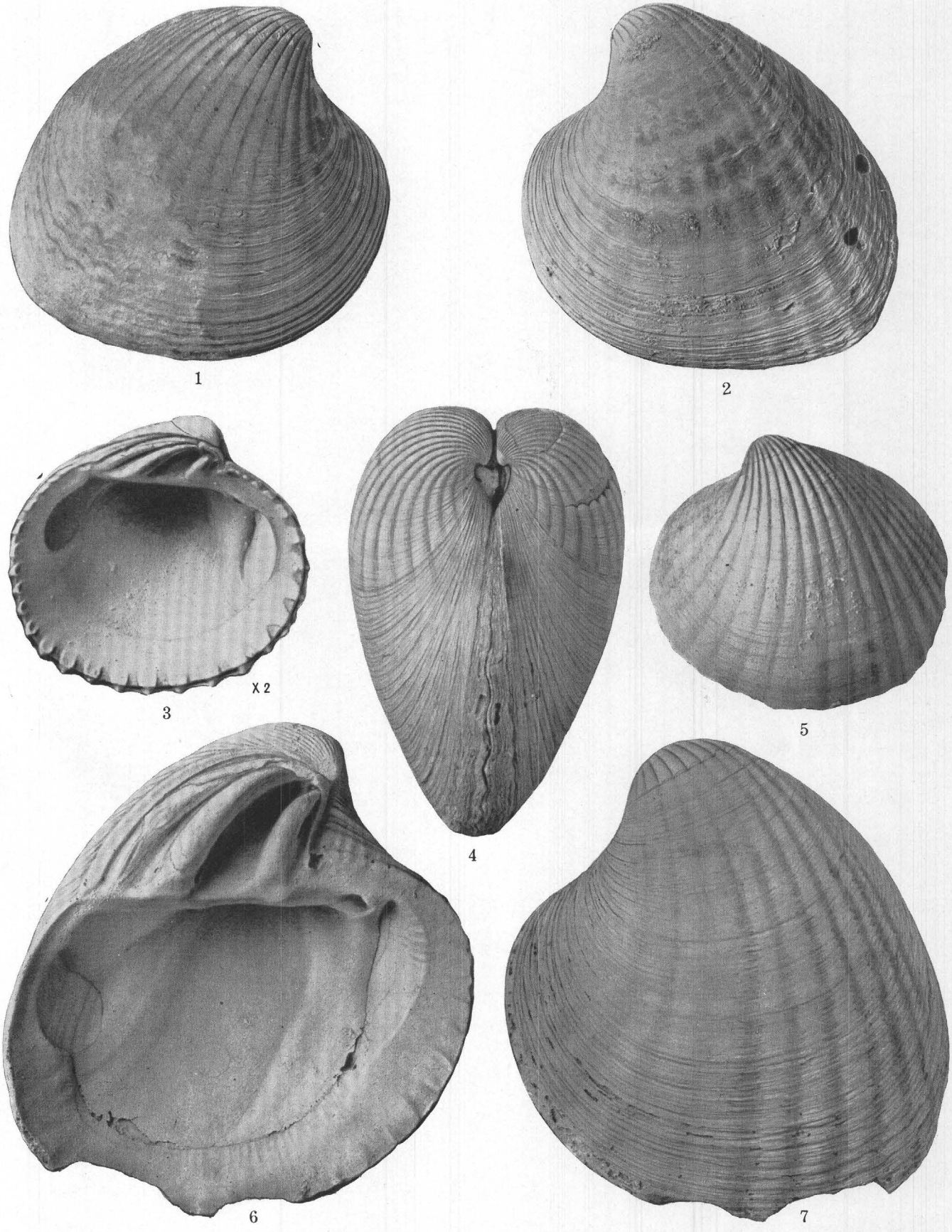
PLATE 39

FIGURES 1–3. *Venericardia* (*Venericor*) *horatiana* Gardner (p. 177). 1, Exterior of right valve (U. S. N. M. 373041), from point 5½ miles southwest of Elba, Coffee County, Ala.; 2, exterior of left valve (U. S. N. M. 373042), from Woods Bluff, Tombigbee River, Ala.; 3, interior of left valve of holotype (U. S. N. M. 369238), from point 1½ miles west of Sabinetown, Sabine River, Tex., ×2.

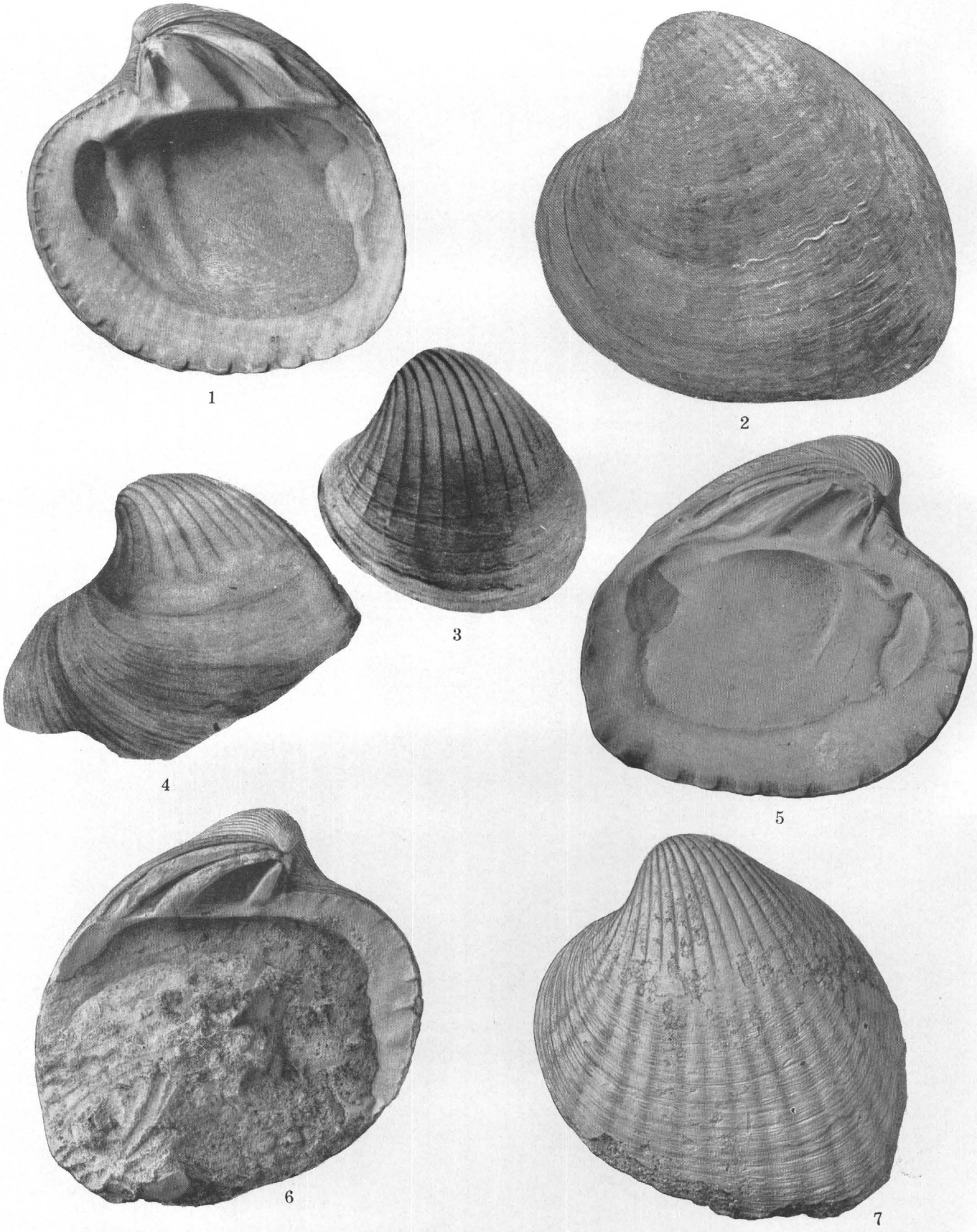
FIGURE 4. *Venericardia* (*Venericor*) *stewarti* Gardner and Bowles, n. sp. (p. 178). Front view of double valves of paratype (U. S. N. M. 116027), from Lisbon Bluff, Alabama River, Ala.

FIGURE 5. *Venericardia* (*Venericor*) *horatiana* Gardner (p. 177). Exterior of left valve of holotype shown in figure 3.

FIGURES 6–7. *Venericardia* (*Venericor*) *stewarti* Gardner and Bowles, n. sp. (p. 178). Holotype (U. S. N. M. 154933), from Lisbon Bluff, Alabama River, Ala. 6, Interior of left valve; 7, exterior of left valve.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.

PLATE 40

FIGURES 1–2. *Venericardia* (*Venericor*) *horatiana* Gardner (p. 177). 1, Interior of right valve (U. S. N. M. 373041), from point 5½ miles southwest of Elba, Coffee County, Ala.; 2, exterior of left valve of *Venericardia planicosta* form gamma Harris from Woods Bluff, Tombigbee River, Ala. (after Harris).

FIGURE 3. *Venericardia* (*Venericor*) *parinensis* Olsson (p. 183). Exterior of holotype, a left valve from Keswick Hills, Parinas formation, Peru; height 70 millimeters, width 85 millimeters (after Olsson).

FIGURE 4. *Venericardia* (*Venericor*) *samanensis* Olsson (p. 183). Exterior of cotype, an immature left valve from the Saman conglomerate, Negritos, Peru (after Olsson).

FIGURE 5. *Venericardia* (*Venericor*) *horatiana* Gardner (p. 177). Interior of left valve (U. S. N. M. 373042), from Woods Bluff, Tombigbee River, Ala.

FIGURES 6–7. *Venericardia* (*Venericor*) *tonosiensis* Rutsch (p. 178). 6, Interior of left valve (U. S. N. M. 372923), from mouth of Tonosi River, Panama; 7, exterior of valve shown in figure 6.

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PLATE 41

FIGURES 1–2. *Venericardia* (*Venericor*) *turneri* Gardner and Bowles, n. sp. (p. 179). Holotype, a right valve (U. S. N. M. 372921), from Hatchetigbee Bluff, Tombigbee River, Ala. 1, Interior of holotype; 2, exterior of holotype.

FIGURES 3–4. *Venericardia* (*Venericor*) *potapacoensis* Clark and Martin (p. 180). Immature left valve of specimen typical of Woodstock greensand marl member, Nanjemoy formation, from collections of Academy of Natural Sciences of Philadelphia. 3, Exterior of left valve (after Clark and Martin); 4, interior of left valve (after Clark and Martin).

FIGURE 5. *Venericardia* (*Venericor*) *clavidens* Grzybowski (p. 182). Exterior of left valve, probably from Rica Playa, Peru (after Grzybowski).

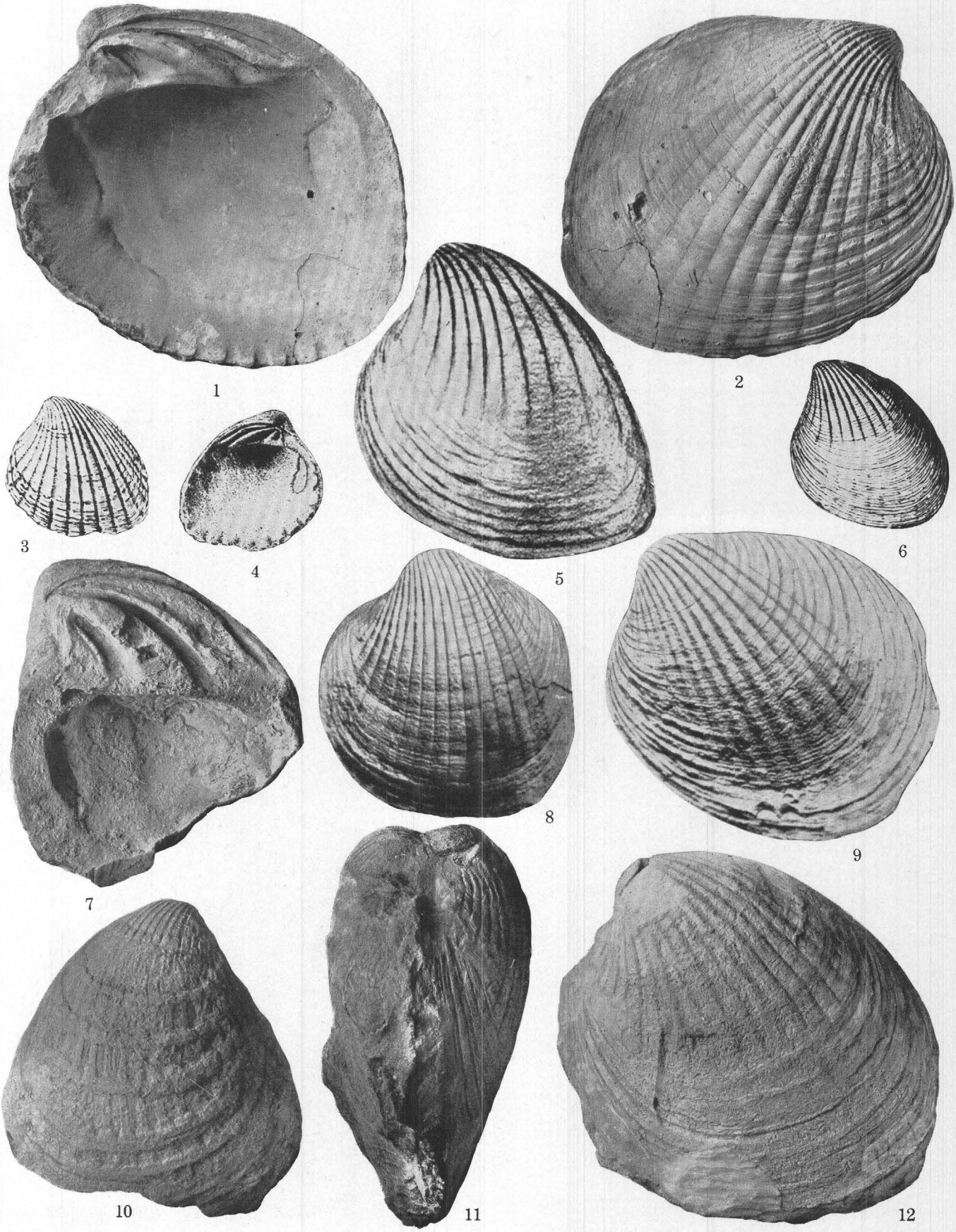
FIGURE 6. *Venericardia* (*Venericor*) *potapacoensis* Clark and Martin (p. 180). Exterior of left valve of type specimen from Potapaco clay member, Nanjemoy formation, west of Port Tobacco, Charles County, Md.; height 40.0 millimeters, width 33.0 millimeters (after Clark and Martin).

FIGURE 7. *Venericardia* (*Venericor*) *diga* Gardner and Bowles, n. sp. (p. 181). Interior of cotype, a right valve (U. S. N. M. 373030), from Arroyo Ermita at Ermita-La Arena road crossing, Nuevo León, Mexico.

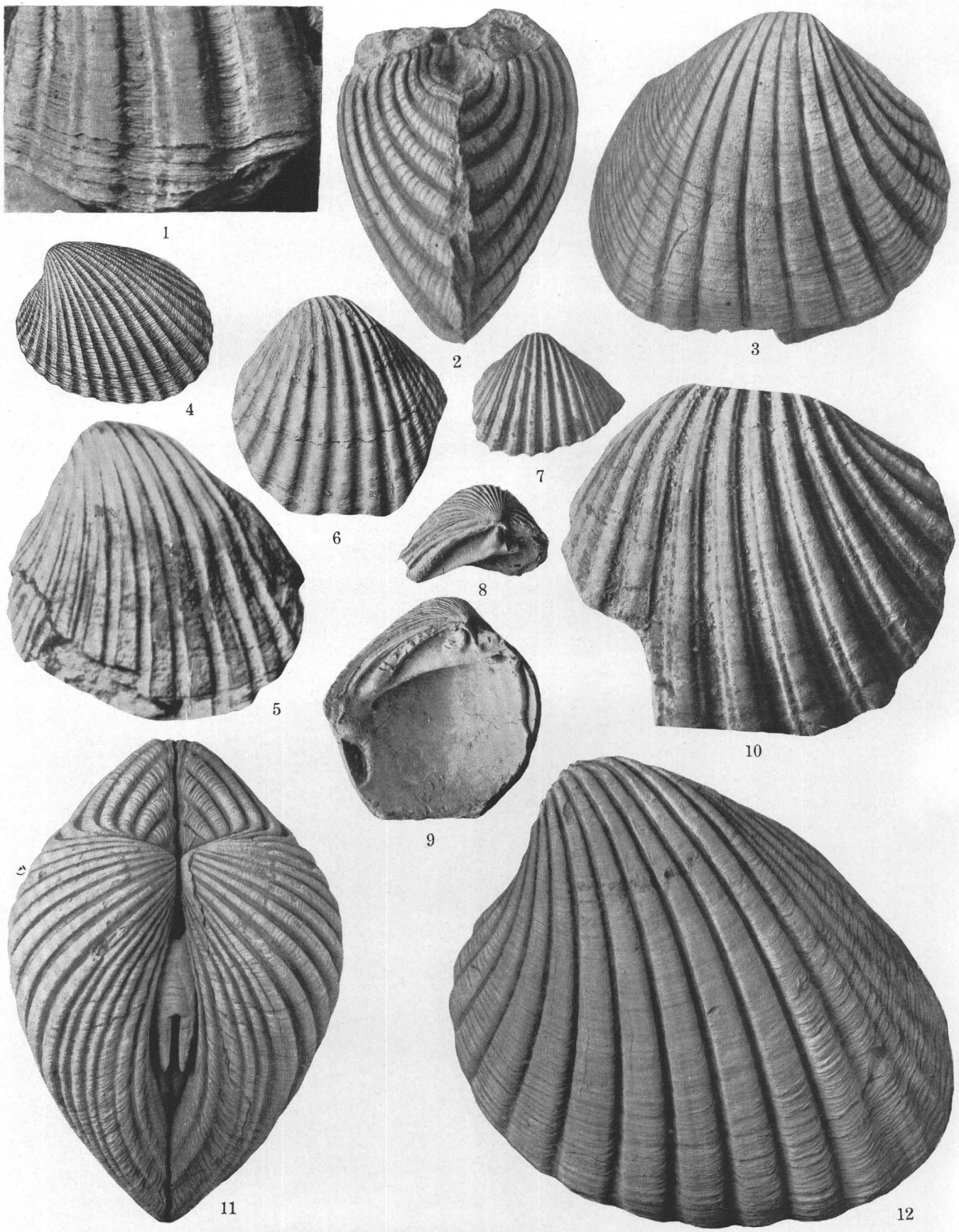
FIGURE 8. *Venericardia* (*Venericor*) *pacifica* Olsson (p. 179). Exterior of holotype, a left valve from the Salina formation, Negritos, Peru; height 42.0 millimeters, width 41.0 millimeters (after Olsson).

FIGURE 9. *Venericardia* (*Venericor*) *peruviana* Olsson (p. 180). Exterior of holotype, a left valve, from the Salina formation, Negritos, Peru; height 66.0 millimeters, width 80.0 millimeters (after Olsson).

FIGURES 10–12. *Venericardia* (*Venericor*) *diga* Gardner and Bowles, n. sp. (p. 181). 10, Exterior of cotype, a right valve (U. S. N. M. 373030), shown in figure 7; 11, double valves of cotype, viewed from the front (U. S. N. M. 373029), from the Rio San Juan at Ermita de Abajo, Nuevo León, Mexico; 12, double valves of cotype, viewed from the left (U. S. N. M. 373029).



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.

PLATE 42

FIGURE 1. *Venericardia (Venericor) hijuana* Gardner and Bowles, n. sp. (p. 184). Sculpture detail of anterior portion of left valve from Maverick County, U. S. G. S. sta. 6091, east of Middleton, Hardeman County, Tenn.

FIGURES 2–3. *Venericardia (Venericor) jewelli* Gardner (p. 184). Cotypes (U. S. N. M. 370914) from Midway limestone scarp, 29 miles southeast of Eagle Pass, Tex. 2, Double valves viewed from the front; 3, another pair of double valves viewed from the right.

FIGURE 4. *Venericardia gulielmi* Gardner and Bowles, n. name (p. 174). Exterior of holotype, a left valve (U. S. N. M. 154725), from Woods Bluff, Tombigbee River, Ala. (after Dall).

FIGURE 5. *Venericardia (Venericor) labreaensis* Olsson (p. 181). Exterior of holotype, a left valve, from La Brea, Negritos formation, Peru; height 34.0 millimeters, width 36.5 millimeters (after Olsson).

FIGURES 6–10. *Venericardia (Venericor) hijuana* Gardner and Bowles, n. sp. (p. 184). Cotypes and topotypes from sta. 6091, vicinity of Middleton, Hardeman County, Tenn. 6, Exterior of left valve of cotype (U. S. N. M. 372920); 7, exterior of umbonal region of left valve of cotype (U. S. N. M. 372919); 8, interior of left valve shown in figure 7; 9, interior of left valve shown in figure 6; 10, sculpture detail of anterior portion of right valve, ×3.

FIGURES 11–12. *Venericardia (Venericor) austroplata* Gardner and Bowles, n. sp. (p. 188). Holotype (U. S. N. M. 372924), from Point Malaspina, Province of Chubut, Argentina. 11, Dorsal view of holotype; 12, exterior of left valve of holotype.

PLATE 43

FIGURE 1. *Venericardia* (*Venericor*) *aposmithii* Gardner and Bowles, n. sp. (p. 186). Exterior of right valve (U. S. N. M. 137224), from Nanafalia Bluff, Tombigbee River, Ala. Figured to show greater persistence of ribbing pattern and closer cording on posterior area.

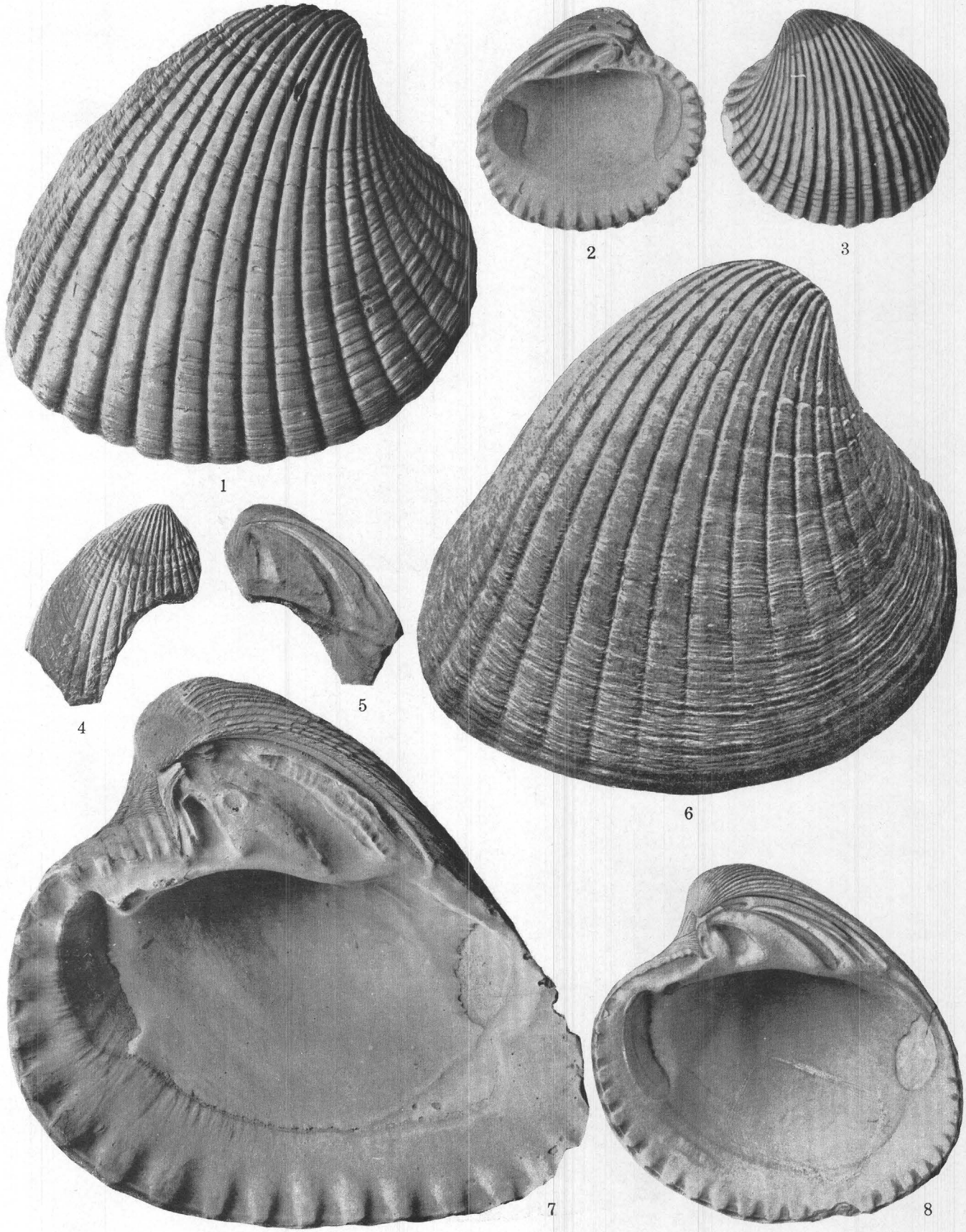
FIGURES 2–3. *Venericardia* (*Venericor*) *smithii* Aldrich (p. 185). Cotype from *Turritella* rock near Allenton, Wilcox County, Ala.; loaned from the Aldrich collection of the Johns Hopkins University, Baltimore. 2, Interior of left valve; 3, exterior of left valve.

FIGURES 4–5. *Venericardia* (*Venericor*) *densata malinchae* Gardner and Bowles (p. 189). Holotype, an incomplete right valve (U. S. N. M. 373031), from a point 1 mile southwest of El Mirador, Nuevo León, Mexico. 4, Exterior of holotype; 5, interior of holotype.

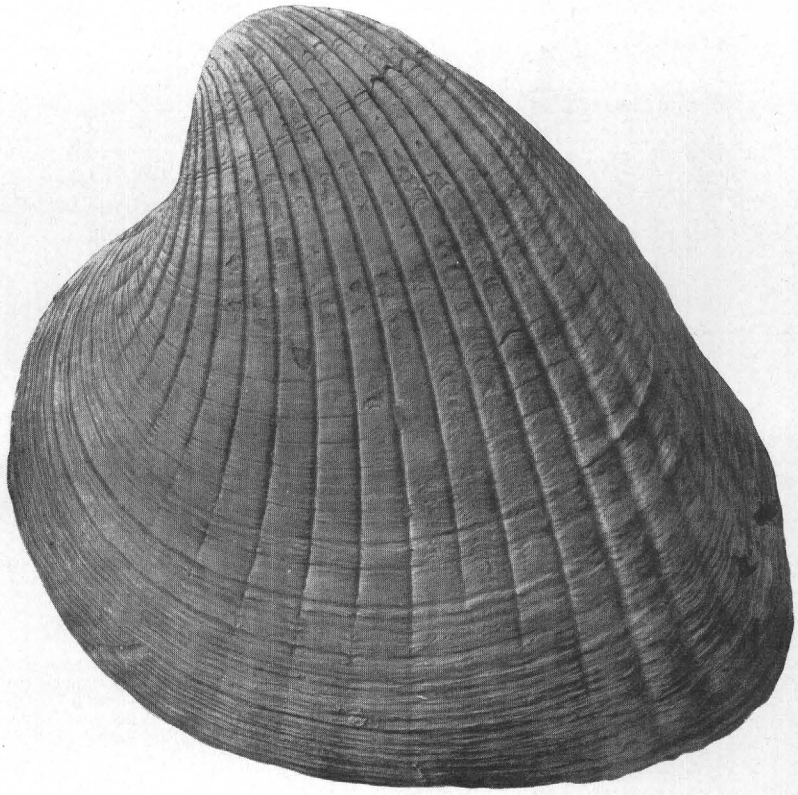
FIGURE 6. *Venericardia* (*Venericor*) *aposmithii* Gardner and Bowles, n. sp. (p. 186). Exterior of right valve of *Venericardia planicosta* form β, from Bells Landing, Alabama River, Ala., slightly reduced in original figure (after Harris).

FIGURE 7. *Venericardia* (*Venericor*) *aposmithii* Gardner and Bowles, n. sp. (p. 186). Interior of right valve of holotype (U. S. N. M. 1434), from Bells Landing, Alabama River, Ala.

FIGURE 8. *Venericardia* (*Venericor*) *apodensata* Gardner and Bowles, n. sp. (p. 192). Interior of cotype, a right valve (U. S. N. M. 136644), from Jackson, Miss.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.



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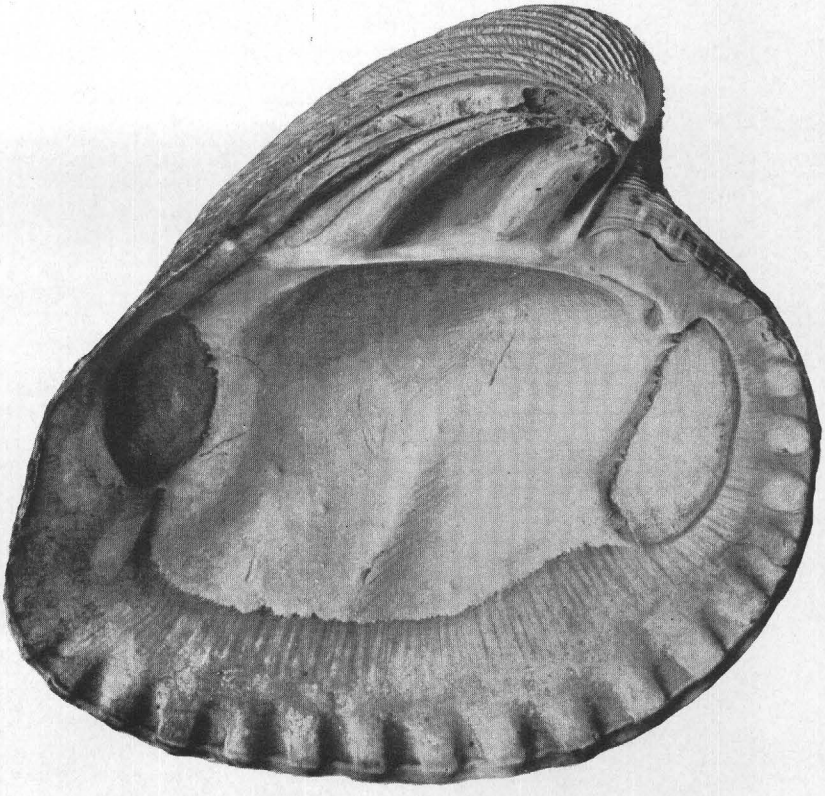


2

FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.

PLATE 44

FIGURES 1–2. *Venericardia* (*Venericor*) *aposmithii* Gardner and Bowles, n. sp. (p. 186). Holotype (U. S. N. M. 1434), from Bells Landing, Alabama River, Ala. 1, exterior of left valve of holotype; 2, interior of left valve of holotype.

PLATE 45

FIGURES 1–3. *Venericardia* (*Venericor*) *densata* Conrad (p. 189). Pathologic individual (U. S. N. M. 369601) cited by Stewart (see text) from Choctaw County, Ala. "The hinge is pathologic, the right cardinal not being fully developed, and near its base is an extraneous shell fragment embedded in the hinge. The groove on the opposite valve is modified to fit the irregular cardinal." 1, Interior of left valve; 2, interior of right valve; 3, exterior of left valve.

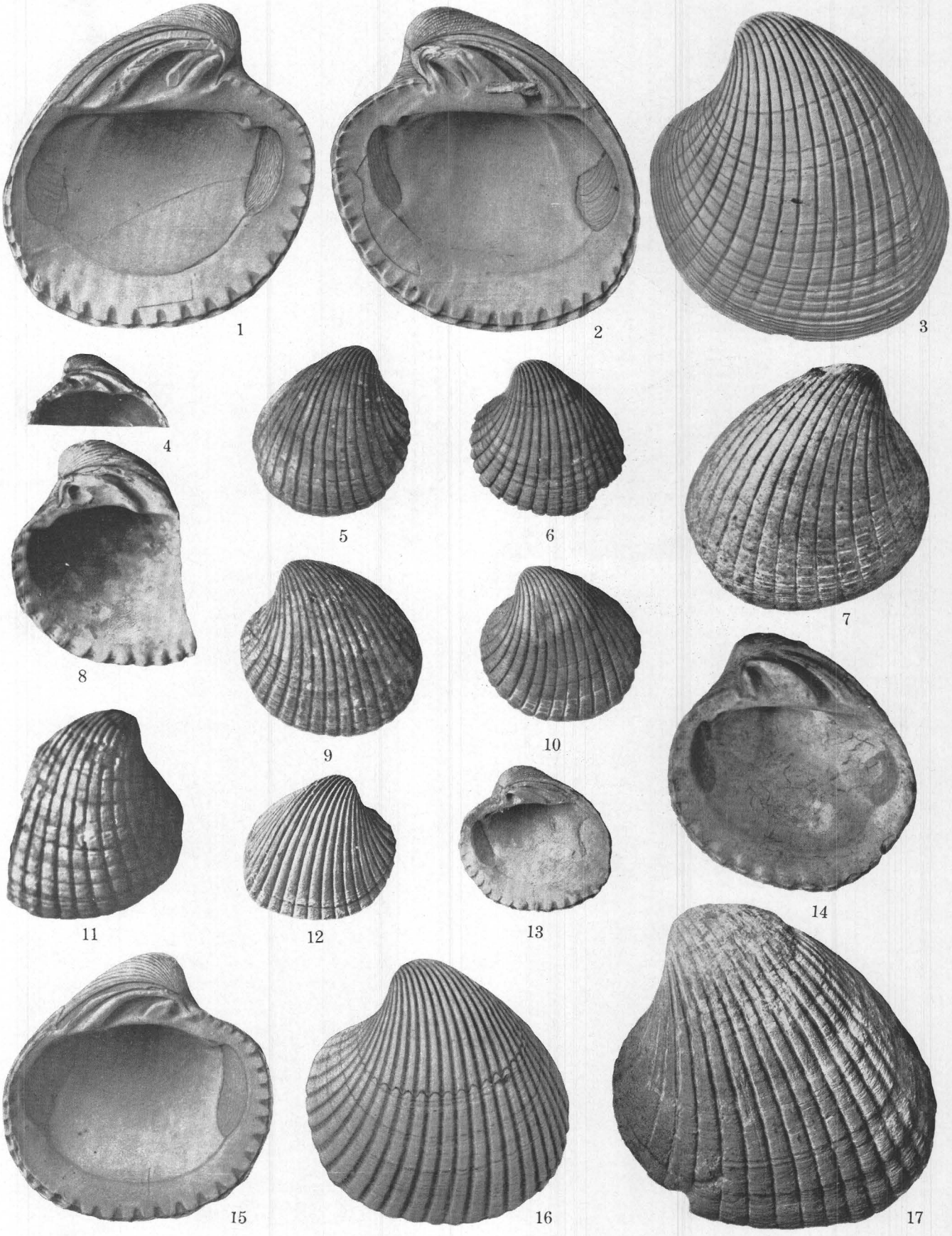
FIGURES 4–11. *Venericardia* (*Venericor*) *densata* Conrad, figured to show variation within the lower Claiborne of Texas (p. 189). 4, Hinge of right valve shown in figure 5; 5, exterior of right valve (U. S. N. M. 1818), from the vicinity of Wheelock, Robertson County, Tex., possibly the type locality of *V. mooreana* Conrad; 6, exterior of left valve (U. S. N. M. 497001), from point 1½ miles southwest of Pleasanton, Atascosa County, Tex.; 7, exterior of right valve (U. S. N. M. 497002), from Smithville, Bastrop County, Tex.; 8, interior of right valve (U. S. N. M. 497003), from point a quarter of a mile northwest of Jourdanton, Atascosa County, Tex.; 9, exterior of left valve (U. S. N. M. 1818), from the vicinity of Wheelock, Robertson County, Tex.; 10, exterior of left valve (U. S. N. M. 497004), from Mosleys Ferry, Brazos River, Burleson County, Tex.; 11, exterior of right valve (U. S. N. M. 497003), from point a quarter of a mile northwest of Jourdanton, Atascosa County, Tex.

FIGURES 12–13. *Venericardia* (*Venericor*) *densata pendletonensis* Gardner and Bowles, n. subsp. (p. 188). Holotype, a right valve (U. S. N. M. 372694), from Pendleton Bluff, Sabine River, Tex.; 12, Exterior of holotype; 13, interior of holotype.

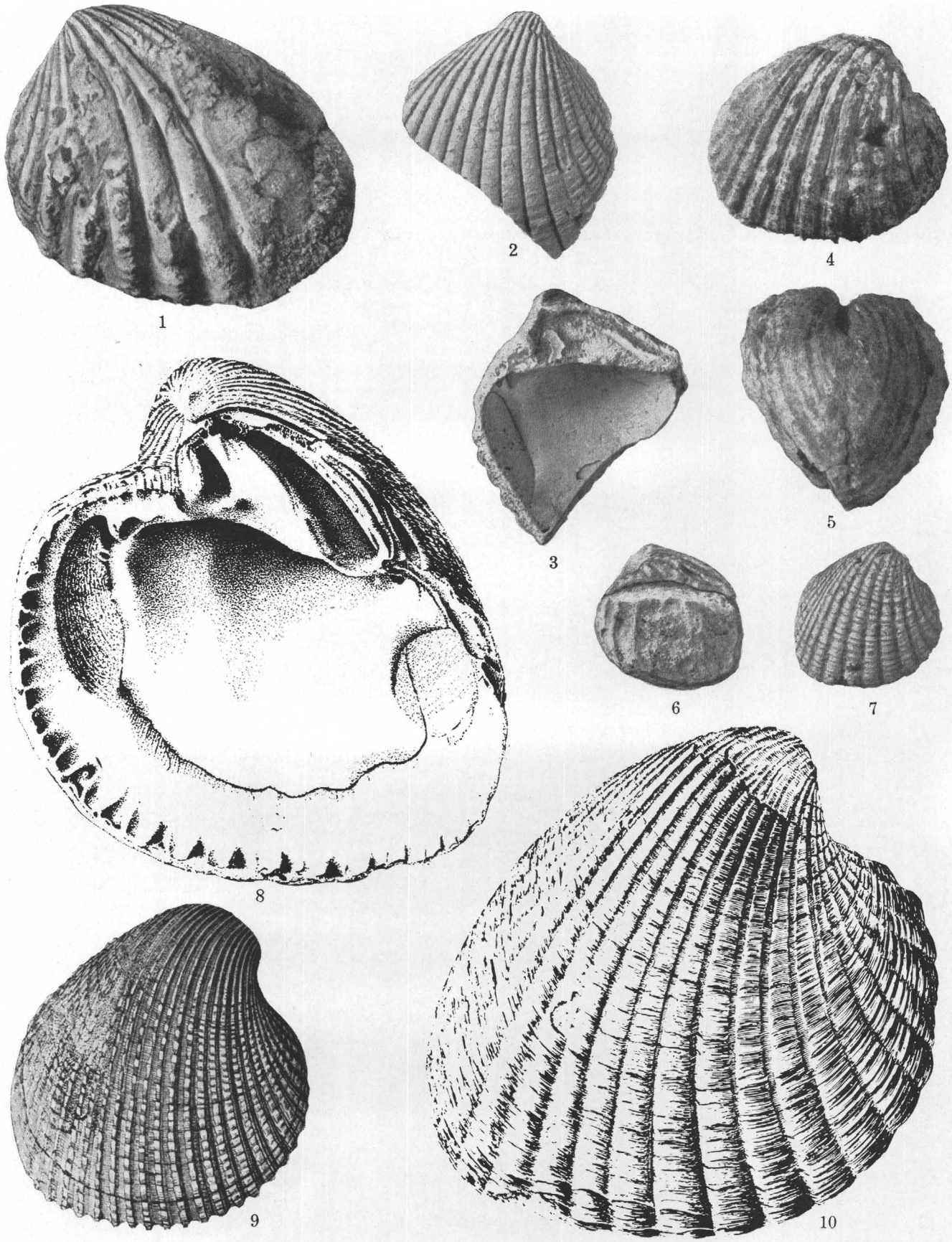
FIGURE 14. *Venericardia* (*Venericor*) *densata* Conrad (p. 189). Interior of valve shown in figure 7.

FIGURES 15–16. *Venericardia* (*Venericor*) *apodensata* Gardner and Bowles, n. sp. (p. 192). Cotype (U. S. N. M. 369599), from Moodys Branch near Jackson, Miss. 15, Interior of left valve; 16, exterior of left valve.

FIGURE 17. *Venericardia* (*Venericor*) *zapatai* Gardner and Bowles, n. sp. (p. 192). Exterior of double valves of holotype, viewed from the left (U. S. N. M. 372692), from point 4.8 miles southeast of Zapata, on the Roma road, Tex.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.



FOSSILS OF THE VENERICARDIA PLANICOSTA GROUP.

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FIGURE 1. *Venericardia* (*Glyptoactis?*) *moa* Gardner (p. 195). Double valves of holotype, view from left (U. S. N. M. 370922), from point 18 miles southeast of Eagle Pass, Maverick County, Tex., × 2.

FIGURES 2–3. *Venericardia* (*Venericor?*) *mingoensis* Gardner and Bowles, n. sp. (p. 194). Holotype, a right valve (U. S. N. M. 372922), from Black River, S. C. 2, Exterior of holotype; 3, interior of holotype.

FIGURES 4–5. *Venericardia* (*Glyptoactis?*) *hesperia* Gardner (p. 195). Holotype (U. S. N. M. 352268), from Frio River half a mile below Myrick's apiary, Uvalde County, Tex. 4, Double valves viewed from right; 5, double valves viewed from rear.

FIGURES 6–7. *Venericardia* (*Venericor*) *francescae* Gardner and Bowles, n. sp. (p. 183). Holotype, a right valve (U. S. N. M. 372923), from point 1 mile southeast of New Albany, Union County, Miss. 6, Interior of holotype; 7, exterior of holotype.

FIGURE 8. *Venericardia* (*Venericor*) *regia* Conrad (p. 187). Possibly Conrad's type from the Aquia formation, Piscataway, Md., collection of Academy of Natural Sciences of Philadelphia. Interior of right valve, × 9/10. (After Clark and Martin.)

FIGURE 9. *Venericardia* (*Venericor?*) *greggiana* Dall (p. 194). Exterior of holotype, a right valve, from Greggs Landing, Alabama River, Ala. (After Harris.)

FIGURE 10. *Venericardia* (*Venericor*) *regia* Conrad (p. 187). Exterior of right valve shown in figure 8, × 9/10. (After Clark and Martin.)

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