THE UNIVERSITY OF KANSAS
PALEONTOLOGICAL CONTRIBUTIONS

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BIOSTRATIGRAPHY OF CENOZOIC OSTRACODA FROM SOUTH CAROLINA

By William Kenneth Pooser

The University of Kansas Paleontological Institute

The University of Kansas
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By WILLIAM KENNETH POOSER
Department of Geology, The University of Kansas

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ABSTRACT

A detailed study of the strata and ostracodes of Cenozoic age in South Carolina was undertaken to define adequately the rock-stratigraphic units, to determine their stratigraphic relationships, and to determine the nature of the ostracode faunas within these units so that this area might serve as a reference with which future geological investigations might be correlated.

Fifty-nine species belonging to 32 genera of ostracodes are described from the Paleocene-lower Eocene, middle Eocene, Oligocene, and upper Miocene strata of South Carolina. The species discussed include four new species, *Paracypris kaesleri, Eocytheropteron blackmingoensis, Trachyleberis? johnsoni,* and *Buntonia reticulata;* six new combinations, *Triginglymus whitei* (SWAIN), *Clithrocytheridea harrisi* (STEPHENSON), *Hemicytherura howei* (PURI), *Trachyleberis florienensis* (HOWE & CHAMBERS), *Trachyleberis spinosissima* (JONES & SHERBORN), and *Murrayina dictyolobus* (MUNSEY); one species with a tentative identification, *Loxoconcha* sp. cf. *L. claibornensis* MURRAY; one species identified as *Cytheropteron* sp. A; and 47 previously described species. The primary emphasis was not placed on taxonomy, but rather on determining the utility of the ostracodes as stratigraphic indicators; consequently, no attempt was made to describe all of the ostracodes recovered in the course of the investigation.

The ostracodes are abundant, particularly in the calcareous facies, and may be used with a high degree of confidence as paleoecological indicators for strata as old as Miocene. Of the 16 species of ostracodes identified from the upper Miocene, Duplin Formation, 10 have living representatives. Based on the results of Recent ecological studies of ostracodes within the Gulf of Mexico, it is postulated that the Duplin Formation was deposited in a near-shore, inner-neritic environment with the maximum depth of water probably not exceeding 75 to 100 feet.

The ostracode assemblages of the Black Mingo, Cooper Marl, and Duplin Formation are sufficiently distinct to be used as stratigraphic indicators. The assemblages of the Warley Hill Formation and Santee Limestone have the same forms in common and the ostracodes thus cannot be used to separate these units; however, the assemblage is readily distinguished from those of the other formations. The ostracode assemblage of the upper Miocene, Duplin Formation is strikingly different from those of the older formations.

The Black Mingo Formation is a time-transgressive unit with deposition beginning in the Paleocene and continuing into the early Eocene. Two ostracode assemblage zones are recognized within this formation.

The Congaree Formation, Warley Hill Formation, and Santee Limestone of middle Eocene age are not separated by unconformities as has previously been suggested, but rather are lithologic facies representing deposition in shallow brackish to inner-neritic environments. The McBean Formation lies unconformably upon the Congaree and the Warley Hill formations and the basal Santee Limestone. The upper portion of the Santee Limestone is the off-shore facies of the McBean Formation.

The Cooper Marl is Oligocene in age and was deposited in relatively deep water.

INTRODUCTION

SCOPE AND PURPOSE OF STUDY

The stratigraphy and microfauna of South Carolina have not been previously well-studied; consequently, this biostratigraphic study of the Eocene, Oligocene, and Miocene strata of South Carolina was undertaken to serve as a reference with which Cenozoic strata elsewhere in the state could be correlated. The primary purposes of this investigation were: (1) to delineate the strata into mappable rock-stratigraphic units and to ascertain their age and stratigraphic relationships, (2) to study and describe the ostracodes and to determine if the ostracode assemblages could serve as tools to interpret ages and environments of deposition of the stratigraphic units, (3) to describe the ostracodes so that they could be used as stratigraphic indicators for future subsurafce investigations, and (4) to revise the existing Cenozoic stratigraphic section in the light of the evidence gained from this study. During the course of study of the ostracodes the primary emphasis was not placed on taxonomy but rather on determining the utility of the ostracodes as stratigraphic indicators.

PREVIOUS STUDIES

Preliminary geological investigations within South Carolina were begun in 1826 by Vanuxem and continued by Ruffin (1843). In 1848 Tuomey, utilizing the data obtained by Vanuxem & Ruffin plus the observations made by himself, published a report on the geology of South Carolina in which he included the first geologic map. This map is extremely generalized and is of little value to the field geologist of today; however, it does incorporate all of the geologic knowledge available at that time.

Sloan (1907, 1908), while working on the economic geology of the state, conducted the first comprehensive study of the Cenozoic strata and proposed many of the names that are presently used for rock-stratigraphic units. One of the publications by Sloan (1908) has served as a nucleus from which all subsequent geologic work has stemmed. Cooke (1936) published the results of a regional study of the Coastal Plain of South Carolina in which he relied to a large extent on the localities established by Sloan. In 1952 Cooke & MacNeil revised the classification of the Cenozoic formations of South Carolina in the light of knowledge gained by further examination of the fauna. Cooke (1936) had included all middle Eocene strata within the McBean Formation, but in 1952 he and MacNeil subdivided the McBean Formation into three separate rock-stratigraphic units and revived several of the formational names utilized by Sloan (1908); however, they neither clearly defined the newly proposed units nor revised Cooke's geologic map of 1936. Malde (1959) studied the phosphate rock in the area of Charleston, and made an important contribution to the understanding of the megafauna from the Oligocene and Miocene strata near the coast.

The megafauna of South Carolina has been studied by such early workers as Lyell (1845). Other paleontologists who have contributed to the study of the megafauna may be found in the list of references in this report and in Petty (1950). In the past the megafauna has not been collected and studied in detail; however, Jules DuBar is presently doing paleoecological studies on the Neogene formations along the coasts of North and South Carolina.

With the exception of the identification of Foraminifera for Cooke & MacNeil (1952) by Ruth Todd from three localities, the designation of a new ostracode species from a locality near Charleston by Puri (1956), and the reporting of a single ostracode species from the Cooper Marl by Murray & Hussey (1942), the microfauna of the Cenozoic strata of South Carolina has not been studied. The present study represents the first attempt to study, report, and determine the applicability of ostracodes to geologic investigations within the state. The author has not attempted to report all of the ostracodes recovered in the course of the study, but rather has concentrated on those that have proven to be of stratigraphic value in other areas where ostracodes have been studied in detail.

LOCALITY AND AUGER HOLE NUMBERING SYSTEM

The localities and auger holes within the study area are referred to by two numbers, the first of which indicates the county in which the locality or auger hole is located, and the second number refers to the specific locality or auger hole within that county. For example: Locality 18-1 refers to locality number one within Dorchester County, and Auger Hole 38-14 refers to auger hole number 14 within Orangeburg County. The county numbers are given in Figure 1. The locations of the exposures and auger holes are shown on Figure 2. Descriptions of the exposures and auger holes are given in the Appendix.

FIELD AND LABORATORY TECHNIQUES

The summer months of 1959, 1960, and 1961 were devoted to field studies and the collection of samples for micropaleontological examination. Aerial photographs and topographic maps of a scale of 1:62,500 were used extensively in both the planning of the study and the field work. The aerial photographs facilitated the loca-

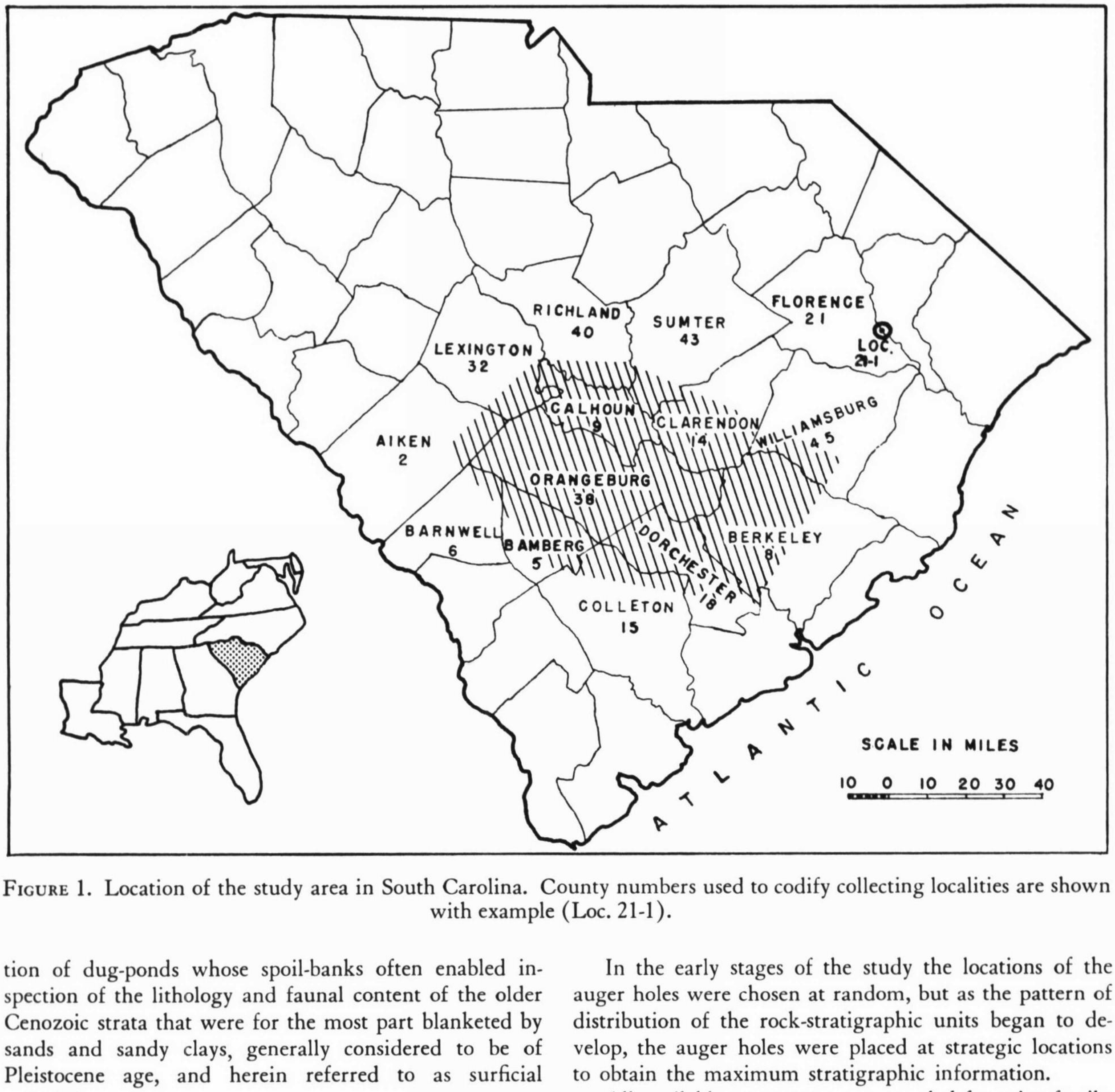


FIGURE 1. Location of the study area in South Carolina. County numbers used to codify collecting localities are shown with example (Loc. 21-1).

tion of dug-ponds whose spoil-banks often enabled inspection of the lithology and faunal content of the older Cenozoic strata that were for the most part blanketed by sands and sandy clays, generally considered to be of Pleistocene age, and herein referred to as surficial material.

Rock exposures are few as the area is blanketed by Pleistocene?, surficial material. Rarely are more than a few feet of strata exposed at a single locality. A rotary-type power auger, capable of drilling to a depth of 100 feet, and mounted on the back of a Willys Jeep pickup truck, was used extensively in the course of the study. The auger rods used were 5 feet in length by 4 inches in diameter and were connected by means of a clip. The relatively unconsolidated sediments of the Coastal Plain were easily penetrated by the drill, except when well-indurated layers of limestone were encountered which proved impossible to penetrate with such light equipment. The samples were caught as they were brought to the surface by the auger flights.

In the early stages of the study the locations of the auger holes were chosen at random, but as the pattern of distribution of the rock-stratigraphic units began to develop, the auger holes were placed at strategic locations to obtain the maximum stratigraphic information.

All available exposures were sampled for microfossils, but it soon became apparent that microfossils were restricted chiefly to calcareous lithofacies. The samples collected for micropaleontological examination were first washed through 20-, 40-, 60-, and 80-mesh screens; however, it was found later that a greater number of samples could be processed at a much faster rate and with an adequate recovery of microfossils by utilizing the carbon tetrachloride flotation method. A heated sample was placed in carbon tetrachloride resulting in the flotation and concentration of the microfossils. The ostracodes were then picked from the floated concentration, mounted on faunal slides, identified, and their distribution within the study area was plotted. In addition, the portion of the sample that did not float was examined for micro-

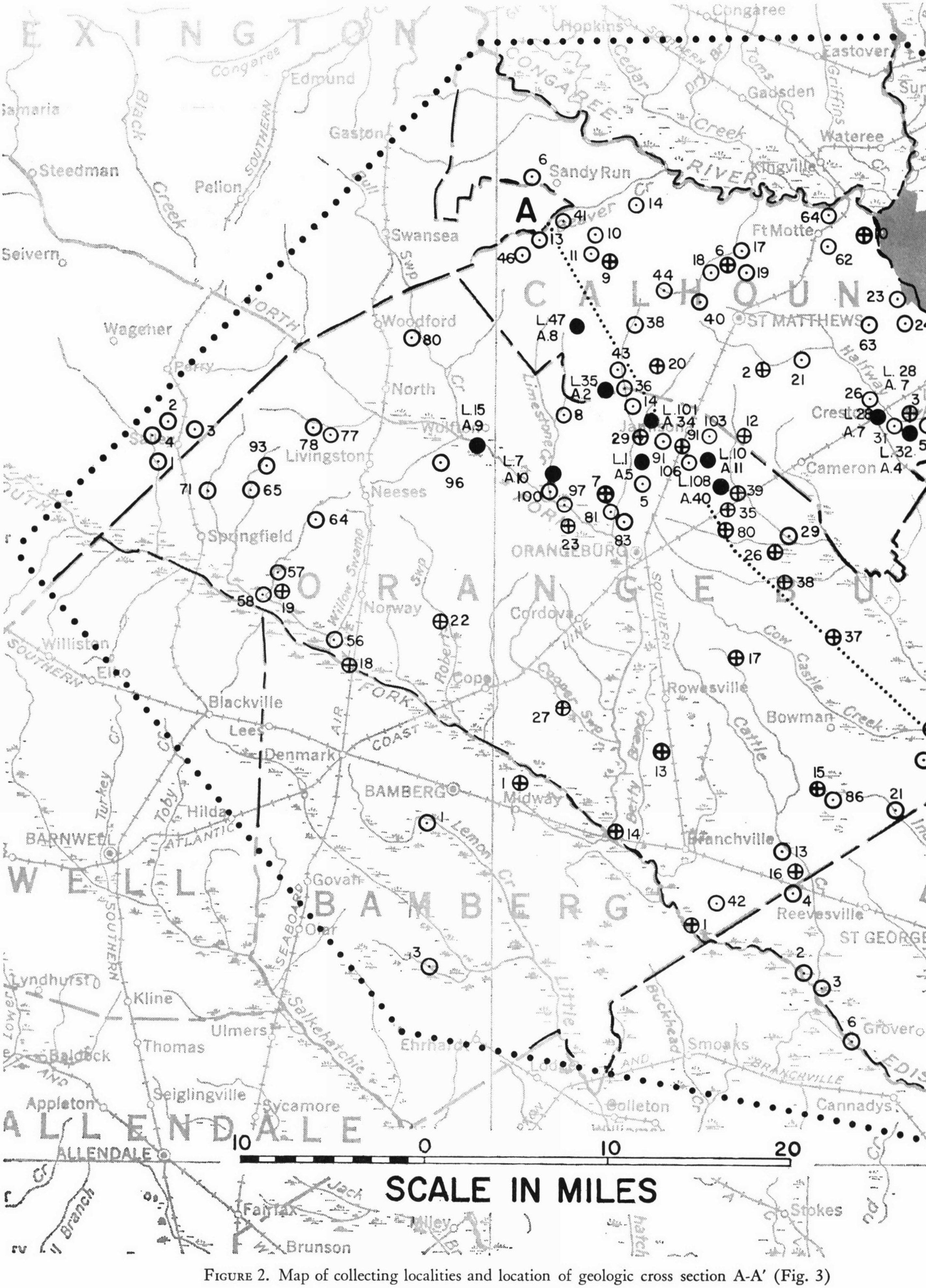
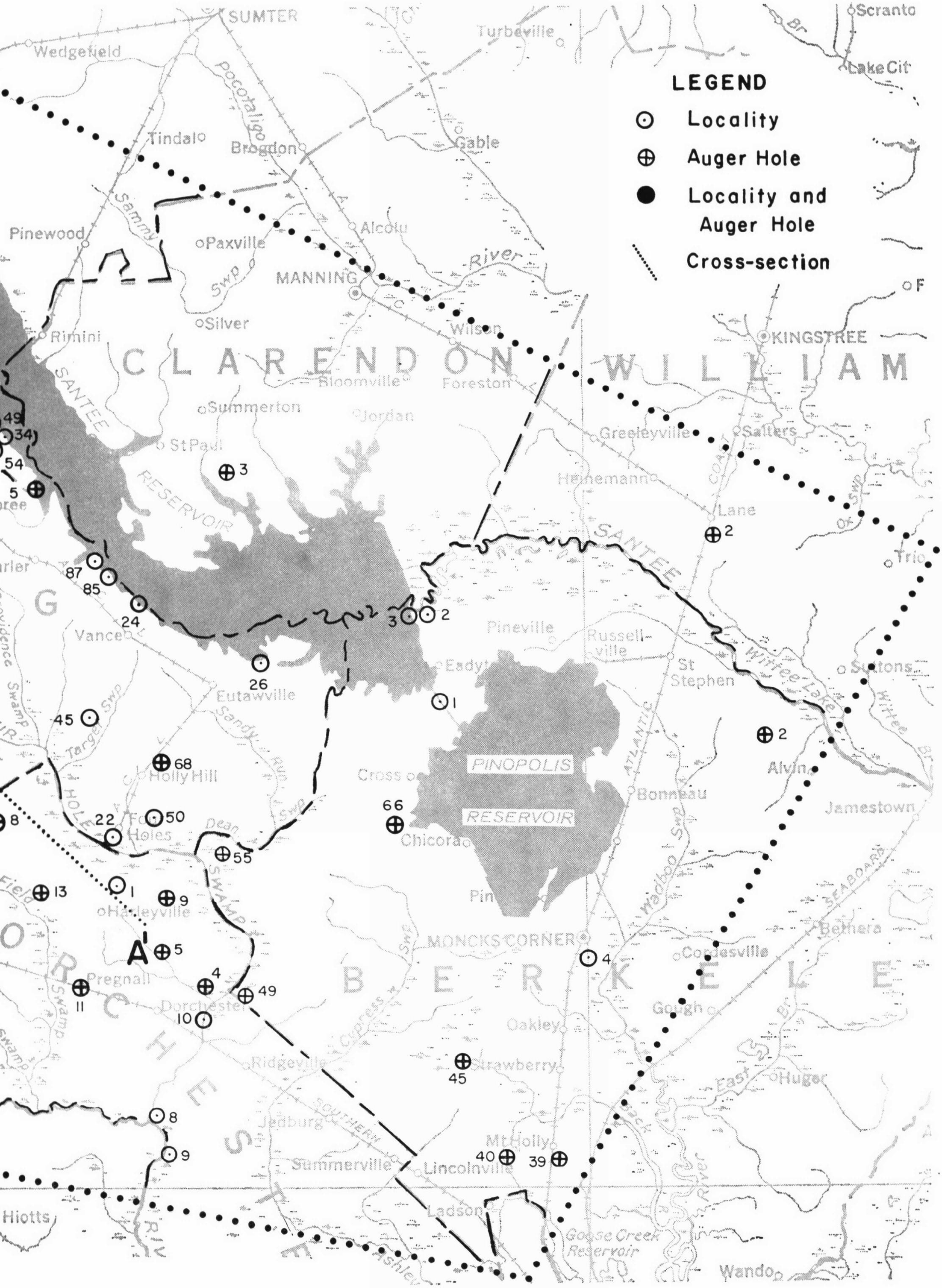


FIGURE 2. Map of collecting localities and location of geologic cross section A-A′ (Fig. 3)


LEGEND
Locality
Auger Hole
Locality and Auger Hole
Cross-section
SUMTER
Wedgefield
Turbeville
Scranto
Lake Cit
Tindal
Brogdon
Gable
Pocotaligo
Sammy Swp
Pinewood
Paxville
Alcolu
River
MANNING
Silver
Rimini
Wilson
KINGSTREE
CLARENDON
WILLIAM
Bloomville
Foreston
Summerton
Jordan
St Paul
SANTEE
RESERVOIR
Greeleyville
Salters
Heinemann
Lane
COAST
SANTEE
Vance
Eutawville
Pineville
Russellville
St Stephen
Eadytown
Suttons
Wittee Lake
Target Swp
Holly Hill
Sandy Run Swp
PINOPOLIS
RESERVOIR
Cross
ATLANTIC
Bonneau
Alvin
Jamestown
Four Holes
Dean Swamp
Chicora
Wadboo Swp
SEABOARD
Harleyville
A
MONCKS CORNER
Cordesville
Bethera
Pregnall
Dorchester
BERKELE
Gough
Oakley
Ridgeville
Strawberry
Huger
Jedburg
SOUTHERN
Mt Holly
Summerville
Lincolnville
Hiotts
Ladson
Goose Creek Reservoir
Wando
Ashley
DORCHESTER
Cypress Swamp
East Br
Black River

fossils to ensure maximum representation. Representative specimens were coated with five-percent silver nitrate solution and photographed by standard photographic techniques.

The measured sections and auger hole logs were plotted on geologic cross sections and fence diagrams to determine the relationships between the diverse rock-stratigraphic units.

ACKNOWLEDGMENTS

This study was submitted as a thesis at the University of Kansas under the direction of R. H. BENSON in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Appreciation is expressed to H. S. JOHNSON, JR., South Carolina State Geologist, for his consultation and assistance in the field. The author wishes to thank H. A. IRELAND, A. B. LEONARD, and C. O. DUNBAR for constructive criticism. In addition, the suggestions on ecology and taxonomy, as well as the identification of ostracodes by R. H. BENSON from the Santee Limestone during the initial phase of the field work, is gratefully acknowledged.

Facilities for the washing of samples, drafting, and photography, as well as references were made available by the Museum of Invertebrate Paleontology of the University of Kansas.

The field work was supported by the Division of Geology, South Carolina State Development Board.

DESCRIPTION OF STUDY AREA

The study area is located in south-central South Carolina and incorporates all or portions of the following counties: Orangeburg, Calhoun, Clarendon, Aiken, Bamberg, Barnwell, Colleton, Dorchester, Berkeley, Williamsburg, Lexington, Sumter, and Richland (Fig. 1). In addition to collecting localities in these counties, ostracodes were studied from Bostick Landing (Loc. 21-1) on the Pee Dee River in Florence County approximately 40 miles northeast of the study area, a locality from which numerous upper Miocene mollusks have previously been collected.

South-central South Carolina was chosen for study because it offers the most complete and virtually the only exposures of Eocene strata within the state, and contains the type-localities of three of the middle Eocene formations.

The study area is situated within the Sea Island Section of the Coastal Plain Province of the Atlantic Plain and can be subdivided into two physiographic regions: the Upper Coastal Plain and the Lower Coastal Plain. The line of demarcation is sharp between the two areas and is expressed physiographically as a NNE-SSW trending escarpment which passes through the city of Orangeburg. The Upper Coastal Plain has considerably more relief than the Lower Coastal Plain, with as much as 140 feet of relief along the courses of the major drainage. This difference in relief is due to differential erosion. The more resistant rocks of the Upper Coastal Plain consist chiefly of clays, sands, and fullers earth; whereas, the Lower Coastal Plain is underlain for the most part by calcareous strata. The Lower Coastal Plain is nearly flat and featureless. This region owes most of its relief to sinkholes and the presence of numerous NW-SE trending Carolina Bays.

Most of the area is readily accessible by roads and the only obstacles to free access to any portion of the area are the numerous swamps scattered throughout the Lower Coastal Plain.

The entire Coastal Plain is blanketed by the sands and sandy clays of the Pleistocene? surficial material. Exposures of the underlying strata are few. The natural exposures as well as the better road cuts that reveal strata beneath the Pleistocene? surficial material are developed in the Upper Coastal Plain along the courses of the major drainage. Within the Lower Coastal Plain virtually no exposures are present with the exception of the Carolina Giant Cement Company quarry near Harleyville and along the southern shoreline of Lake Marion. The spoil-banks of ponds constructed for the watering of cattle offer the only other opportunity to examine the lithology and fauna of the underlying units. Stratigraphic investigations within the Coastal Plain are virtually impossible without the aid of subsurface drilling.

STRATIGRAPHY

GENERAL FEATURES

A wedge of Cretaceous and younger sediments, which begins at the Fall Zone and thickens to more than 3,500 feet along the coast, covers the basement complex. The Cenozoic strata were deposited for the most part in brackish and inner-neritic environments. The shorelines shifted continuously with the numerous transgressions and regressions of the sea. In general, the Paleogene formations are exposed inland, whereas the Neogene formations are exposed nearer the present-day coast.

The Cenozoic strata within the study area for the most part consist of unconsolidated sand, semi-consolidated sandstone, clay, gravel, marl, and limestone (Table 1, column 2). The regional dip of the strata is slightly greater than the slope of the land and ranges from 7 to 15 feet to the southeast.

SYSTEMATIC STRATIGRAPHY

PALEOCENE-LOWER EOCENE STRATA

BLACK MINGO FORMATION

SLOAN (1907) applied the name "Black Mingo Shales" to laminated sandy shale exposed along the Black River from Brewington Lake, Clarendon County, to the mouth of Black Mingo Creek, and up Black Mingo Creek to a point between Rhems and the General Marion Bridge in Georgetown County. In 1908 he used the term "Black Mingo Phase" to include two subphases: the "Upper Black Mingo" which consisted of the "Williamsburg Pseudo-Buhr" and the "Rhems Shale"; and the "Lower Black Mingo" which retained the name "Black Mingo Shale." In addition the "Lang Syne?" beds were tentatively placed under this phase. COOKE (1936, p. 41) employed the name Black Mingo Formation for all the Eocene strata older than the McBean Formation (middle Eocene).

Lithologic Character. The Black Mingo Formation consists of quartzose sand, commonly green from the presence of glauconite grains, thin layers of gray to light-green silty clay, dark-gray unctuous clay with minute particls of pyrite, and fuller's earth. The fuller's earth is a very porous shale that is dark gray to black on fresh surfaces but weathers to light gray and appears to have been a mudrock that has subsequently been silicified. A calcareous facies is present in the area east of Lake Marion (Loc. 8-2 and Auger Hole 45-2) and consists of dark-gray to light-green marl and well-indurated beds of light-gray limestone up to two feet thick.

Distribution and Stratigraphic Relationship. The Black Mingo Formation underlies the entire area of study. The thickness ranges from 30 to 55 feet in northwest Calhoun County; however, TABER (1939) reports that this formation has a thickness of more than 125 feet in the area of the Santee Dam (Loc. 8-2). Exposures of the Black Mingo Formation within the study area are restricted to northern Calhoun, southwestern Sumter, southern Clarendon, southern Williamsburg, and northern Berkeley Counties. To the south and east of its outcrop belt the Black Mingo Formation is overlain in the subsurface by younger Cenozoic strata.

The contact of the Black Mingo Formation with the underlying Tuscaloosa Formation of the Upper Cretaceous is sharp and well-exposed at Locality 9-10 in northwestern Calhoun County where the contact undulates with a relief of one to two feet. At this locality and others where the contact is exposed, the basal portion of the Black Mingo Formation contains a moderately large amount of kaolinitic clay and angular feldspar grains that were derived from the underlying Tuscaloosa Formation. The erosional surface that was developed upon the Tuscaloosa Formation has a relief of 30 to 50 feet in western Calhoun County.

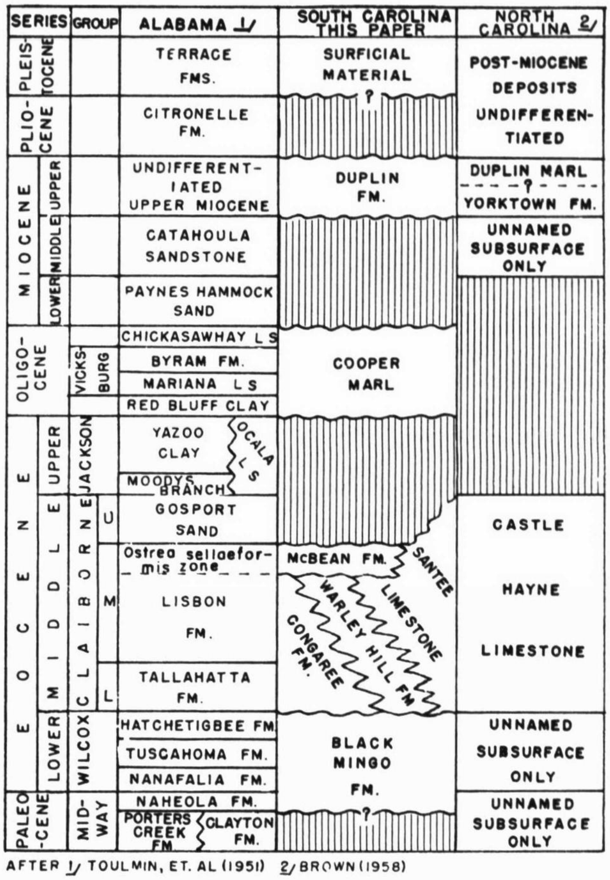


TABLE 1. Correlation of Cenozoic strata in South Carolina with that in North Carolina and Alabama.

Mode of Deposition. The lithology and fauna of the Black Mingo Formation indicate that it was not deposited under uniform conditions. The fuller's earth, interbedded quartzose sands and silty clays, cross-bedded sands, pockets of silicified mollusks, and the abundance of *Ostrea* suggest that much of the formation was deposited in estuarine and littoral environments. Pyrite in the dark-gray, unctuous clay is indicative of deposition in tidal flats. Interbedded marl and limestone, *Turritella*, large specimens of *Ostrea*, and ostracodes are found in the eastern portion of the study area near Santee Dam (Loc. 8-2) and the town of Lane in Williamsburg County (Auger Hole 45-2). These suggest that in this area the Black Mingo was deposited in a large lagoon behind a barrier beach in which the degree of salinity and turbulence was subject to considerable variation.

Fauna. The megafauna of the Black Mingo Formation is not abundant, and the most frequently reported forms include: *Ostrea arrosis* ALDRICH, *Ostrea compressirostra* SAY, *Turritella mortoni* CONRAD, and *Venericardia planicosta* LAMARCK.

Ostracodes were obtained from only two localities, the south bank of the Santee River near Santee Dam (Loc. 8-2) and near the town of Lane in Williamsburg County (Auger Hole 45-2), from which 14 species were identified (Table 2).

The ostracode assemblages of Locality 8-2 and Auger Hole 45-2 are sufficiently unique to warrant the establishment of two biostratigraphic assemblage zones. Whether the contrasting faunal composition of these two zones is due to difference in age or ecological conditions or both is unknown; however, the zones may prove to be useful tools for the delineation of strata within the Black Mingo Formation in future geologic work.

The *Brachycythere interrasilis* Assemblage Zone at 21 to 29 feet in Auger Hole 45-2 is characterized by the following forms:

Ostracodes of Brachycythere interrasilis Assemblage Zone

Brachycythere interrasilis Alexander
Cytherella excavata Alexander
Haplocytheridea stuckeyi Stephenson
Actinocythereis stenzeli (Stephenson)

None of these forms with the exception of *A. stenzeli* occur in the middle Eocene formations of the study area.

The *Cytherelloidea nanafaliensis* Assemblage Zone of beds 2 and 4 at Locality 8-2 is characterized by the following ostracodes:

Ostracodes of Cytherelloidea nanafaliensis Assemblage Zone

Cytherelloidea nanafaliensis Howe
Clithrocytheridea harrisi (Stephenson)
Clithrocytheridea virginica Schmidt
Haplocytheridea leei (Howe & Garrett)
Haplocytheridea moodyi (Howe & Garrett)
Brachycythere marylandica (Ulrich)
Murrayina dictyolobus (Munsey)
Eocytheropteron blackmingoensis Pooser, n. sp.
Cushmanidea caledoniensis (Munsey)
Cushmanidea mayeri (Howe & Garrett)
Actinocythereis stenzeli (Stephenson)

Age. Cooke (1936) assigned the Black Mingo Formation to the lower Eocene primarily because of the presence of *Ostrea arrosis* Aldrich and *Turritella mortoni* Conrad. *Ostrea arrosis* was originally described from the Nanafalia Formation and is now known to be restricted to that formation in Alabama. *Turritella mortoni* is abundant in both the Nanafalia and the Tuscahoma formations. In 1952 Cooke & MacNeil indicated that the

SPECIES	South Carolina Loc 8-2	South Carolina A.H 45-2	Gulf Coast Paleocene Kincaid Fm.	Gulf Coast Paleocene Wills Point Fm.	Gulf Coast Paleocene Porters Creek Fm.	Gulf Coast Paleocene Clayton Fm.	Gulf Coast Paleocene Naheola Fm.	Gulf Coast Lower Eocene Nanafalia Fm.	Gulf Coast Lower Eocene Sabine Group	Gulf Coast Lower Eocene Tuscahoma Sand	Gulf Coast Lower Eocene Hatchetigbee Fm.	Atlantic Coast Paleocene North Carolina	Atlantic Coast Lower Eocene North Carolina	Atlantic Coast Lower Eocene Aquia Fm.	Atlantic Coast Lower Eocene Hornerstown Fm.	Middle Eocene
Cytherelloidea nanafaliensis	x							x								
Clithrocytheridea harrisi	x								x	x						
Clithrocytheridea virginica	x						x					x	x	x		x
Haplocytheridea leei	x						x	x	x					x		
Haplocytheridea moodyi	x							x			x	x	?			
Brachycythere marylandica	x							x	x		x	x	x	x	x	
Murrayina dictyolobus	x						x									
Eocytheropteron blackmingoensis	x															
Cushmanidea caledoniensis	x						x									
Cushmanidea mayeri	x						x	x	x					x		
Actinocythereis stenzeli	x	x											x			x
Cytherella excavata		x	x	x			x									
Brachycythere interrasilis		x	x	x	x	x						x				
Haplocytheridea stuckeyi		x														x

Table 2. Distribution of ostracodes in Paleocene and lower Eocene formations.

Black Mingo Formation may include beds of both Paleocene and early Eocene age. COOKE (1936) had identified a form from the Black Mingo Formation as *Turritella mortoni* CONRAD, a species common to the lower Eocene of the Gulf states; however, BOWLES (1939) later identified it as *T. mortoni mediavia* BOWLES, which occurs typically in the lower part of the Paleocene, Midway Group of Alabama. Therefore BOWLES considered the Black Mingo Formation to be Paleocene and not early Eocene in age. In addition, COOKE noted that the Black Mingo Formation at Warley Hill, near Lone Star in Calhoun County (Loc. 9-24), contained an oyster that resembled *Ostrea crenulimarginata* GABB, a species common in the Midway Group of Alabama and western Georgia.

DRUID WILSON (personal communication, Aug. 10, 1961) of the U. S. National Museum identified *Ostrea compressirostra* SAY, *Turritella mortoni* cf. *T. mortoni postmortoni* HARRIS, and *Mesalia* sp. from a limestone bed (unit 3) at Locality 8-2 and indicated that, "As now understood *Ostrea compressirostra* appears to be limited to beds of Wilcox age and according to Bowles . . . *Turritella mortoni* and its subspecies are confined to early Eocene (Wilcox) or Paleocene (Midway) beds. The poorly preserved material in the present collection seems to be closest to the subspecies *postmortoni* Harris from the Wilcox of Alabama."

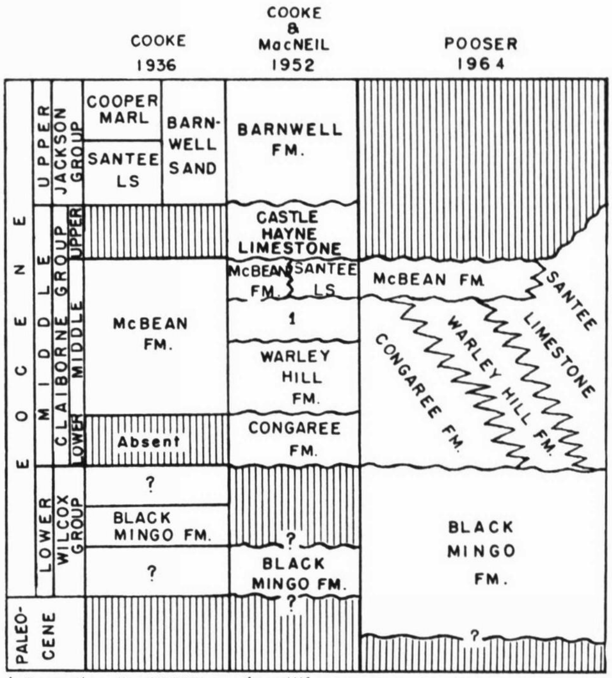
The ostracode assemblage of Locality 8-2 in Berkeley County indicates a strong affinity for both a Paleocene and an early Eocene age for the Black Mingo Formation; however, a Paleocene age is strongly suggested for this formation at Auger Hole 45-2 because of the presence of *Brachycythere interrasilis* ALEXANDER and *Cytherella excavata* ALEXANDER, species that have thus far been reported only from Paleocene strata (Table 2).

The mega- and microfaunal evidence strongly suggests that the Black Mingo Formation is time-transgressive with its basal portion Paleocene and the upper portion early Eocene. COOKE & MACNEIL (1952, p. 21) have proposed that, "If the lower shales of the Black Mingo should prove to be of Paleocene age, one of Sloan's names (1907, 1908), Rhems shale or Lang Syne shale, may be available." This would be totally unacceptable because according to the American Commission on Stratigraphic Nomenclature (1961, p. 649), a rock-stratigraphic unit is completely independent of time concepts.

MIDDLE EOCENE STRATA

INTRODUCTION

COOKE (1936) included under the McBean Formation all of the strata in South Carolina above the Black Mingo Formation but below the Santee Limestone (Table 3). At that time he thought the Santee Limestone rested unconformably upon the McBean Formation and was of late Eocene age. Later COOKE & MACNEIL (1952, p. 21) subdivided the McBean into three formations, "For the lowest beds of Claiborne age, equivalent to the Tallahatta formation, Sloan's name (1908, p. 455) Congaree is revived. For the intermediate beds, equivalent to the Winona formation of Mississippi, Sloan's name (1908, p. 457) Warley Hill is revived. The name McBean formation is retained, in a restricted sense, for the zone represented by the type locality of that formation. This zone, the *Ostrea sellaeformis*, is equivalent to the Cook Mountain formation of Texas and Mississippi, the upper part of the middle Claiborne." In addition COOKE & MACNEIL concluded that the Santee Limestone, ". . . represents the *Ostrea sellaeformis* zone of the Claiborne group, equivalent to the restricted McBean formation, of which it is an offshore facies."



1 According to COOKE nonfossiliferous, nonglauconitic limestone at Cave Hall may be of this age.

TABLE 3. Comparison of Eocene stratigraphic section of the present study with those presented in COOKE (1936) and COOKE & MACNEIL (1952).

The results of this study have shown that the stratigraphic relationships between the Congaree, Warley Hill, and Santee formations are inconsistent with the "layer-cake" arrangement as postulated by COOKE (1936) and later by COOKE & MACNEIL (1952). The interpretation of this paper is that the Congaree and Warley Hill formations and the basal portion of the Santee Limestone were deposited penecontemporaneously as lithofacies of a transgressive middle Eocene sea upon the eroded surface of the Black Mingo Formation. Near the close of

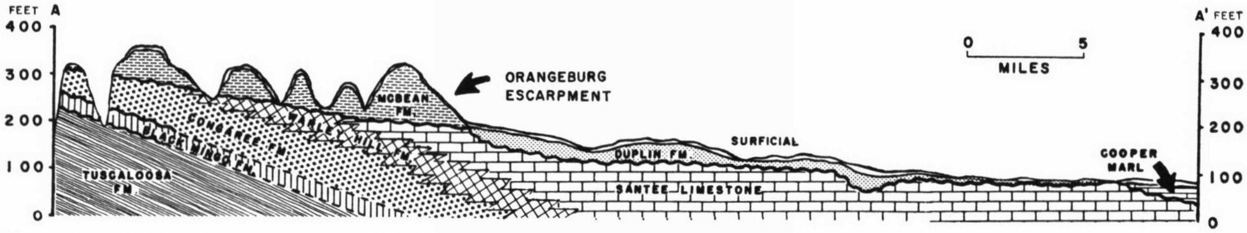


FIGURE 3. Geologic cross section A-A′ showing the disposition of the stratigraphic units present in the study area as interpreted in this report (refer to Fig. 2 for location).

the middle Eocene the shoreline retreated, thus exposing the updip portion of the Congaree, Warley Hill, and Santee sediments to the agents of subaerial erosion, while seaward deposition of the limes of the Santee Limestone continued. Prior to the termination of the middle Eocene the sea once again transgressed upon the land and deposited the clastic McBean Formation with the Santee Limestone as its off-shore facies. Faunal evidence suggests that deposition of the Santee Limestone continued into the late middle Eocene in the area of Harleyville, Dorchester County (Loc. 18-1). The updip clastic equivalents of this portion of the Santee Limestone have been removed by post-Eocene erosion (Fig. 3).

Faunal evidence fails to prove the facies relationships outlined above conclusively, but an intertonguing facies relationship is definitely indicated by the lithologic transition from the paralic environments in which the angular, quartzose sands and silty clays of the Congaree Formation were deposited, to the deeper water glauconitic sands and then to the glauconitic limestones of the Warley Hill Formation, and finally to the fossiliferous, nonglauconitic limestones of the Santee Limestone. There is no evidence of an unconformity between these formations. The transitional beds between the clastic McBean Formation and its off-shore facies the Santee Limestone have been removed by post-Eocene erosion; however, the faunal similarity between these two formations strongly suggests contemporaneous deposition.

CONGAREE FORMATION

SLOAN's "Congaree Phase" (1908, p. 499, 455) included shales, sands, and buhrstones of late early and early middle Eocene age which overlie the "Black Mingo Phase" and underlie the "Warley Hill Phase." COOKE (1936, p. 41) referred part of SLOAN's "Congaree Phase" to the Black Mingo Formation (early Eocene) and part to the McBean Formation. In 1952 COOKE & MACNEIL revived SLOAN's term "Congaree" and applied it to strata that they considered equivalent to the Tallahatta Formation of Mississippi and Alabama. COOKE & MACNEIL stated that, "Cooke's map of South Carolina (1936, pl. 2) included beds of Claiborne age in the supposed Jackson south of the Congaree River, but north of that river the lower Claiborne was mapped as Black Mingo Formation (Wilcox)."

Lithologic Character. The Congaree Formation consists of poorly sorted quartzose sands, interbedded sand and silty to arenaceous light-green clays, and hard well-indurated siltstone and sandstone layers. As noted by COOKE & MACNEIL this lithology strongly resembles the lithology of the Tallahatta Formation of Mississippi and Alabama. The sands and clays of the Congaree Formation at many localities are very similar to those of the underlying Black Mingo Formation.

Distribution and Stratigraphic Relationship. The Congaree Formation crops out throughout Calhoun and western Orangeburg Counties. It intertongues to the southeast with the Warley Hill Formation and is consequently absent in the area of the Santee Dam in Berkeley County (Loc. 8-2 and 8-3) where the Warley Hill Formation lies unconformably upon the Black Mingo Formation. SLOAN (1908) did not designate a type-locality for his "Congaree Phase," but COOKE (1936, p. 59) suggested that SLOAN's locality 505 on the Elmore Williams' place at the head of First Creek in Lexington County be regarded as typical. COOKE & MACNEIL (1952, p. 22) designated a roadcut on S. C. Highway 33, 0.5 miles northeast of Creston, Calhoun County, as a typical exposure (Loc. 9-26 of this report). The author considers the strata exposed at Locality 9-26 typical of the Congaree Formation; however, the strata designated by COOKE (1936, p. 59) as Congaree at SLOAN's locality 505 on the Elmore Williams' place in Lexington County consists of fuller's earth and thus is far more typical of the Black Mingo Formation than the Congaree Formation. Excellent exposures of the Congaree Formation are located throughout Calhoun County, and the contact with the overlying Warley Hill Formation is well-exposed in Calhoun County near Creston (Loc. 9-26), at Warley Creek (Loc. 9-24), and at Lyons Creek (Loc. 9-21). The contact with the underlying Black Mingo Formation can be seen along Big Beaver Creek (Loc. 9-13 and 9-41), and along Little Beaver Creek (Loc. 9-11).

The Congaree Formation represents the shoreward facies of a middle Eocene transgressive sea. Seaward it intertongues with the Warley Hill Formation which represents the transition to a deeper environment of deposition (FIG. 3). The boundary between the Congaree and the overlying Warley Hill Formation indicates no evidence of an unconformity but rather is indicative of a change in regimen from deposition of the clays and sands of the Congaree Formation to the glauconitic, argillaceous, quartzose sands of the basal Warley Hill Formation.

The lower contact of the Congaree with the underlying Black Mingo Formation is marked by a prominent unconformity. The lower 1 to 2 feet of the Congaree Formation consist of very coarse-grained quartzose sand, well-rounded quartzose pebbles, and cobbles and boulders of pisolitic, bauxitic, kaolinitic clay, some of which measure 1.5 feet in diameter. MACNEIL (*in* COOKE & MACNEIL, 1952, p. 23) indicated that these boulders are, ". . . common in eastern Georgia and as far east as Calhoun County, S.C., where they occur sporadically in a coarse sandy bed at the base of the Congaree formation and rest directly on dark shale of the Black Mingo formation."

The Tuscaloosa-Black Mingo contact in western Calhoun County has as much as 30 to 50 feet of relief, and in all probability the pisolitic boulders within the basal Congaree Formation were derived from Tuscaloosa highs that extended above the Black Mingo Formation. The elongated shape of the pisolitic boulders and the presence at the base of the Congaree Formation in the vicinity of Big Beaver Creek of a 1.5-foot boulder, with its long axis nearly vertical, indicates that the boulders were not transported a great distance, but rather were more or less rolled to their present positions from the Tuscaloosa highs.

Fauna and Mode of Deposition. The number and variety of fossils reported from the Congaree Formation is small in comparison with the other middle Eocene formations. No microfossils were recovered from this formation, and the most commonly reported megafossils include *Ostrea johnsoni* ALDRICH, *Anodontia augustana* GARDNER and poorly preserved and unidentifiable specimens of solitary and colonial corals. *Anodontia augustana* GARDNER has been collected from exposures near St. Matthews (Loc. 9-19), Warley Creek (Loc. 9-24), and Creston (Loc. 9-26). *Ostrea johnsoni* ALDRICH was reported by SLOAN (1908, p. 344) in the immediate vicinity of Salley in Aiken County (Loc. 2-1).

The poorly sorted quartzose sands, silty clays, pockets of silicified fossils, and siltstone that has apparently been leached of its calcium carbonate indicate deposition of the Congaree Formation in an estuarine or near-shore environment. The presence of *Anodontia augustana* GARDNER within the light-green, silty clays suggests a relatively quiet environment at least for the deposition of this portion of the formation. GARDNER (1951, p. 10) who identified this form from the Tallahatta Formation of Alabama states that, "*Anodontia? augustana* must have been a fragile shell and in need of protection through the environment. It probably lived on soft muddy bottoms near the mouths of rivers and in sheltered bays in waters of shallow or only moderate depths sheltered from strong current action. Such bottom conditions are reflected in the fine silicified clays of the so-called Buhrstones of the Tallahatta formation."

Age. COOKE & MACNEIL (1952, p. 22) assigned the Congaree Formation to the early middle Eocene and correlated it with the Tallahatta Formation of Alabama and Mississippi on the basis of similar lithology and the presence of *Anodontia augustana* GARDNER and *Ostrea johnsoni* ALDRICH, species that appear to be restricted to the Tallahatta Formation in Alabama.

DRUID WILSON (personal communication, August 24, 1960) identified specimens submitted to him by L. N. SMITH from the Congaree Formation as *Anodontia augustana* GARDNER and is of the opinion that inasmuch as this species, as far as now known, is confined to comparable facies in Alabama and South Carolina its value as a guide fossil outside the Tallahatta Formation seems questionable and the possibility that the limiting factor is facies, not time, should be considered.

The upper time-span represented by the deposition of the Congaree Formation is not known, but based on its stratigraphic relations with the other middle Eocene formations, deposition probably continued into the middle part of the middle Eocene.

WARLEY HILL FORMATION

The term "Warley Hill Phase" was first introduced by SLOAN (1907, p. 90). In 1952 COOKE & MACNEIL employed the name Warley Hill Marl to include the dominantly glauconitic beds that intervene between the Congaree Formation and the McBean Formation. It is hereby proposed that the name be changed to Warley Hill Formation because the term marl is inappropriate for the composite lithology of this formation.

Lithologic Character. The basal portion of the Warley Hill Formation consists of noncalcareous, glauconitic, quartzose sand which grades both seaward and upward into a calcareous, glauconitic, quartzose sand, and finally into an arenaceous, glauconitic limestone prior to intertonguing with the essentially nonglauconitic Santee Limestone.

Distribution and Stratigraphic Relationship. The type-locality of the Warley Hill Formation is at Locality 9-24 in northeastern Calhoun County on Warley Creek. COOKE & MACNEIL recognized this formation at only three localities; however, the results of this study have shown that the Warley Hill Formation crops out throughout most of Calhoun County and has been encountered in auger holes in southeastern Calhoun, northern Orangeburg, southern Clarendon, and northwestern Berkeley Counties. An excellent exposure of the calcareous facies may be seen at Locality 8-3 on the Santee River near Santee Dam, where the Warley Hill Formation is overlain by the Santee Limestone. A few hundred feet down-

SPECIES	Loc. 9-28	A.H. 9-3	Loc. 9-33	Loc. 9-34	A.H. 14-3	Loc. 8-3
Actinocythereis stenzeli		x	x	x	x	x
Brachycythere martini						x
Buntonia howei					x	x
Clithrocytheridea garretti						x
Clithrocytheridea ruida		x	x			
Cytheropteron variosum	x		x	x		
Digmocythere russelli					x	x
Echinocythereis jacksonensis	x	x				
Haplocytheridea montgomeryensis	x	x	x			
Loxoconcha sp. cf. L. clairbornensis	x			x		x
Trachyleberis bassleri	x	x	x			x
Trachyleberis? johnsoni		x				
Trachyleberis? pauca					x	x
Trachyleberis spinosissima						x

TABLE 4. Distribution of ostracode species within the Warley Hill Formation.

stream between Localities 8-2 and 8-3, boulders and ledges of ferruginous sandstone that apparently represent the noncalcareous facies of the Warley Hill are exposed on the southern bank and immediately below water level. The maximum thickness of the Warley Hill is estimated to be less than 50 feet.

The lower boundary with the Congaree Formation is well exposed at Lyons Creek (Loc. 9-21), near Creston (Loc. 9-26) and at Warley Creek (Loc. 9-24). The boundary shows no evidence of an unconformity, but the overlying argillaceous glauconitic sands of the Warley Hill Formation are a gradation from the sands and clays of the Congaree Formation. At Locality 9-21 the transition takes place in a vertical distance of 8 feet; whereas, at the type-locality of the Warley Hill Formation (Loc. 9-24) the boundary is sharper with clay fragments of the Congaree Formation incorporated within the argillaceous, glauconitic, quartzose sands of the overlying Warley Hill Formation.

The upper boundary of the Warley Hill Formation with the Santee Limestone is exposed near the mouth of Halfway Swamp Creek (Loc. 9-33) and near Santee Dam (Loc. 8-3). At Locality 9-33 the olive to dark-green, glauconitic, arenaceous limestone of the Warley Hill Formation grades into the only slightly glauconitic, creamy Santee Limestone. The boundary between the Warley Hill and Santee Limestone formations was chosen at this horizon rather than at the lowermost calcareous beds, because evidence of the glauconitic nature of the strata would be more readily preserved after weathering than that of calcium carbonate, which would readily be leached out.

The Warley Hill Formation is sharply delineated from the overlying Santee Limestone at Locality 8-3 by a layer of brown, plastic, silty clay ranging in thickness from a knife-edge to a foot thick. The layering of the clay is undulatory with interbedded seams of fine- to coarse-grained quartzose and glauconitic sand and some lignitic material. In all probability this clay zone does not represent a residuum from the subaerial erosion of the Warley Hill glauconitic limestone, but rather the clay was deposited upon the less permeable Warley Hill Formation by ground waters circulating through cavities in the overlying Santee Limestone.

Mode of Deposition. The Warley Hill Formation represents a transition from the near-shore and estuarine environments of the Congaree Formation to deposition in deeper water, while contemporaneously the Santee Limestone was deposited seaward and removed from the sites of deposition of detrital material.

Fauna and Age. Megafossils reported from the Warley Hill Formation include *Venericardia* sp., *Ostrea lisbonensis* HARRIS, and numerous other poorly preserved specimens of *Ostrea*. All of the ostracodes identified from this formation were recovered from the glauconitic limestone facies.

According to COOKE & MACNEIL (1952, p. 23), SLOAN obtained *Ostrea lisbonensis* HARRIS from the Warley Hill Formation at Cave Hall, a deep ravine draining into Lake Marion near the mouth of Halfway Swamp Creek (Loc. 9-34). This species is reported to be a reliable and characteristic fossil of the lower part of the Winona Formation of Mississippi and of the basal glauconitic marl of the Lisbon Formation of Alabama, both of early middle Eocene age. The Warley Hill Formation does not contain a distinctive ostracode fauna, because all of the forms with the exception of *Trachyleberis spinosissima* (JONES & SHERBORN) also occur in the overlying Santee limestone (Table 4). In addition, the reported ranges of the ostracodes are too great to enable determination of a more precise age than middle Eocene.

The restriction of *Trachyleberis spinosissima* (JONES & SHERBORN), a species previously reported only from Paleocene strata, to Locality 8-3 (near Santee Dam) strongly suggests that the Warley Hill Formation is older in this portion of the study area than further updip. In addition, specimens of *Trachyleberis? pauca* (SCHMIDT), a species found in the lower Eocene, Aquia Formation of Maryland, were identified from the Warley Hill Formation in Auger Hole 14-3 and at Locality 8-3, and from the overlying Santee Limestone at Locality 8-3, thus suggesting that both the Warley Hil and Santee Limestone are older in the area east of Lake Marion than they are further updip.

SANTEE LIMESTONE

The name Santee has been used by numerous early workers such as LYELL, TUOMEY, and SLOAN in various ways such as "Santee beds," "Santee marl," etc. COOKE (1936, p. 75) was apparently the first to employ the term Santee Limestone.

Lithologic Character. The Santee Limestone is a creamy-white to yellow, calcilutite to calcirudite that is slightly glauconitic and arenaceous near its base where it

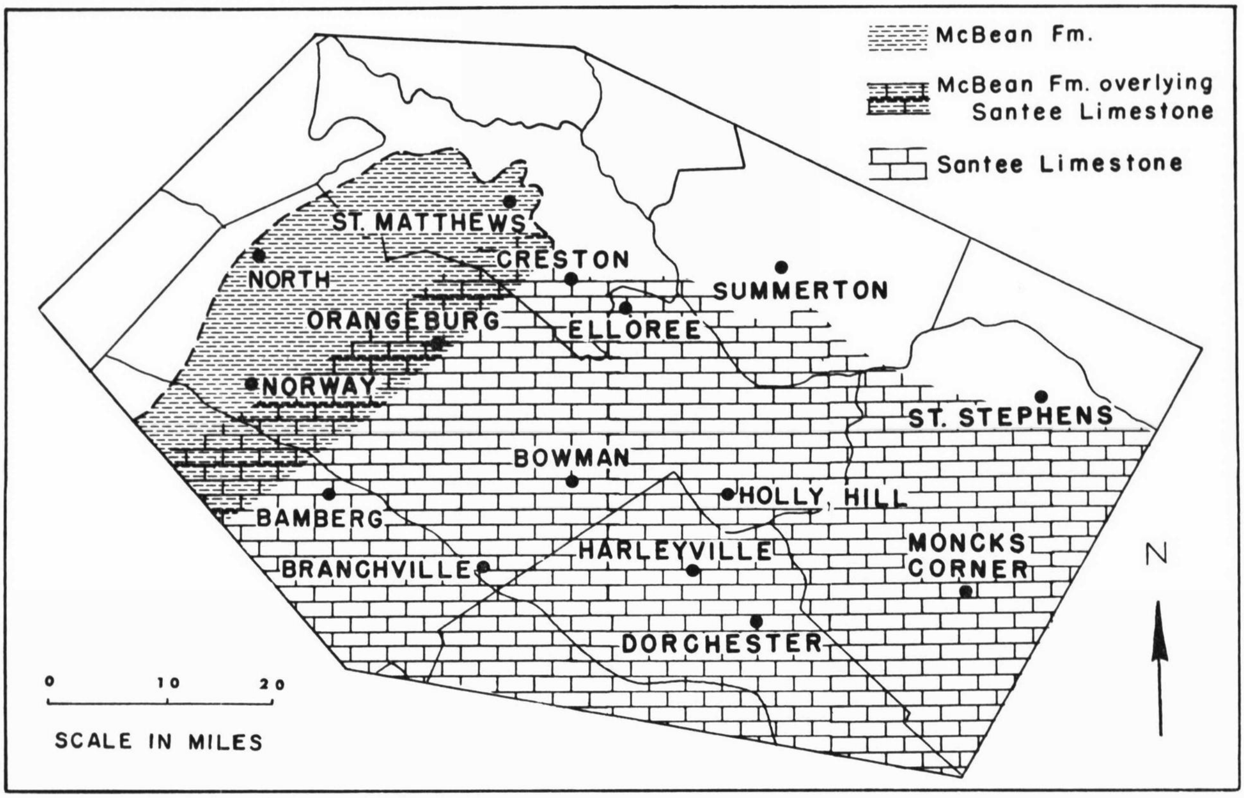


FIGURE 4. Areal distribution of the Santee Limestone, the McBean Formation, and the area in which the Santee Limestone is overlain by the McBean Formation.

intertongues with the arenaceous, glauconitic limestone of the Warley Hill Formation. Pale-greenish tints, due to the presence of small quantities of glauconite, have been encountered at various horizons throughout the formation. The limestone is consolidated, but in general is not well indurated. It is extremely fossiliferous, with numerous specimens of bryozoans, mollusks, and microfossils, and at some localities it is a coquina.

Distribution and Stratigraphic Relationship. The Santee Limestone crops out in southeastern Calhoun County and along the southern shore of Lake Marion in Orangeburg County. Elsewhere it occurs at shallow depths throughout much of the study area (Fig. 4). The type-locality of the Santee Limestone is at Eutaw Springs, Orangeburg County (Loc. 38-26) where most of the exposure has been inundated by backwaters from Lake Marion; however, a few feet of creamy-white limestone is still exposed on the south bank of the lake within the confines of Eutaw Battlefield.

The lower portion of the Santee Limestone represents the off-shore facies of the Congaree and Warley Hill Formations; consequently, the lower boundary with the Warley Hill Formation is transitional from a glauconitic, dark-green and olive, arenaceous limestone to an essentially nonglauconitic, slightly arenaceous cream-colored limestone. At Locality 8-3 in northwestern Berkeley County the Santee Limestone rests upon the calcareous facies of the Warley Hill Formation; however, TABER (1939, p. 5) reports that on the southeast shore of Lake Moultrie near the Pinopolis dam site, the Santee Limestone has a thickness of 93 feet and rests on the eroded surface of the Black Mingo Formation.

In Orangeburg County, the Santee Limestone is overlain unconformably by the McBean Formation from the Orangeburg Escarpment, a NNE-SSW trending escarpment that extends through the city of Orangeburg, to a line approximately 5 miles to the northwest (Fig. 4). To the southeast of the Orangeburg Escarpment the Santee Limestone is overlain by a thin veneer of the upper Miocene Duplin Formation and still further south in southernmost Orangeburg, Dorchester, and southern Berkeley Counties it is overlain by the Oligocene Cooper Marl (Fig .3). In southeastern Calhoun and northeastern Orangeburg Counties the Santee Limestone is overlain directly by Pleistocene? surficial material.

Faunal evidence indicates that much of the Santee Limestone to the east of the escarpment represents the seaward facies of the McBean Formation. In addition, faunal evidence indicates that deposition of the Santee Limestone may have continued into the late middle

Eocene in the area of Harleyville, Dorchester County (Loc. 18-1); however, the updip clastic equivalents have been removed by post-Eocene erosion.

Fauna. The Santee Limestone is extremely fossiliferous and contains abundant remains of bryozoans, pelecypods, and microfossils. The megafossils attracted the attention of such early workers as LYELL (1845), CLARK (1891), and DALL (1898). Bryozoa are by far the most abundant megafossils within this formation, and CANU & BASSLER (1920) have described numerous forms from the Santee Limestone at Eutaw Springs, Orangeburg County (Loc. 38-26). Among the most significant and abundant pelecypods are *Ostrea sellaeformis* CONRAD, *Kymatox lapidosus* (CONRAD), and *Chlamys wautubbeana* (DALL). Numerous fossiliferous boulders of Santee Limestone are exposed on the spoil bank of the Santee-Cooper Diversion Canal between Lake Marion and Lake Moultrie in Berkeley County (Loc. 8-1). HARBISON (1944) has studied many of the forms from this locality. In addition COOKE & MACNEIL (1952, p. 24) have listed numerous forms collected from the spoil banks of the canal.

The exposure of the Santee Limestone at the Carolina Giant Cement Company quarry near Harleyville, Dorchester County (measured section of Loc. 18-1) was considered by COOKE & MACNEIL (1952) to be the Castle Hayne Limestone because the contained fauna indicated to them that this unit was of late Claiborne age and equivalent to the Gosport Sand of Alabama and the Castle Hayne Limestone of North Carolina. The designation of the limestone at the Carolina Giant Cement quarry as the Castle Hayne Limestone is inadvisable, and the author considers the limestone at this locality typical of the Santee Limestone because: (1) rock-stratigraphic units are defined not on the basis of time but on lithologic character, (2) the lithology of the limestone at Locality 18-1 is essentially the same as that of the Santee Limestone elsewhere throughout the study area, and (3) no hiatus between this rock and the Santee has been demonstrated.

Fossils from the Santee Limestone at Locality 18-1 include megafossils reported by COOKE & MACNEIL (1952, p. 26) and foraminifers identified by RUTH TODD for COOKE & MACNEIL.

Fossils from Santee Limestone at Locality 18-1

Chlamys cookei (KELLUM)
Glycymeris staminea CONRAD
Chlamys sp. aff. *C. deshayesii* (LEA)
Ostrea trigonalis CONRAD
Periarchus lyelli (CONRAD)
Endopachys sp.
Turritella sp. cf. *T. arenicola* CONRAD
Miltha sp. aff. *M. claibornensis* CONRAD
Crassatella alta CONRAD
Lucina sp. cf. *L. pandata* CONRAD
Spiroplectammina wilcoxensis CUSHMAN & PONTON?
Textularia recta CUSHMAN
Globulina sp.
Entosolenia sp.
Bolivina sp.
Reussella sp.
Angulogerina byramensis (CUSHMAN) var.
Valvulineria n. sp. (cf. *V. crassisepta* KEIJZER)
Gyroidina soldanii octocamerata CUSHMAN & HANNA
Eponides sp.
Alabamina wilcoxensis TOULMIN
Cibicides danvillensis HOWE & WALLACE
C. lobatulus (WALKER & JACOB)
C. planoconvexus CUSHMAN & TODD

The ostracode fauna of the Santee Limestone is both abundant and varied. Table 5 indicates the occurrences of the ostracodes identified within the study area.

Age. LYELL (1845) correctly assigned the Santee Limestone to the Eocene. In 1936 COOKE placed the Santee Limestone along with the Cooper Marl in the upper Eocene, but in 1952, after further paleontological study, he and MACNEIL concluded that the Santee Limestone was equivalent to the Cook Mountain Formation of the Gulf states (middle Claiborne).

The middle Eocene age of the Santee Limestone is indicated by the presence of *Ostrea sellaeformis* CONRAD, *Chlamys wautubbeana* (DALL), and *Kymatox lapidosus* (CONRAD), species thus far reported only from strata of this age. In addition, according to STENZEL (1957, p. 130), *Ostrea sellaeformis* and *Kymatox lapidosus* are restricted to the Cook Mountain Formation of the Gulf and its lateral equivalents.

The presence of *Kymatox lapidosus* also within the McBean Formation near Early Branch (Loc. 38-1) and near Orangeburg (Locs. 38-81, 38-83) adds further proof to the stratigraphic evidence that the Santee Limestone is the off-shore facies of the McBean Formation. This is further strengthened by the presence of *Ostrea sellaeformis* within both the Santee Limestone of the study area and the McBean Formation at its type-locality at McBean Creek, Georgia.

The presence of *Crassatella alta* CONRAD, a species apparently restricted to upper middle Eocene strata, indicates that deposition of the Santee Limestone continued into the late middle Eocene in the area of Harleyville (Loc. 18-1). The updip clastic equivalents of this portion of the Santee Limestone have been removed by post-Eocene erosion.

The ostracode assemblage indicates that the Santee Limestone is middle Eocene in age; however, the stratigraphic ranges of the species are too great to give a more accurate age determination. The presence of *Trachyleberis? pauca* (SCHMIDT) at Locality 8-3 suggests that the Santee Limestone may be older at this locality than further updip. However, this species has been reported only from the lower Eocene, Aquia Formation of Maryland, and its value as a stratigraphic indicator is questionable.

McBEAN FORMATION

The McBean Formation was originally named by VEATCH & STEPHENSON (1911, p. 237) for exposures near the town of McBean, Georgia, and was considered to be equivalent to the Tallahatta and Lisbon formations of Alabama. Cooke & Shearer (1918) restricted the name McBean in Georgia to deposits of Claiborne age in the Savannah River drainage basin. Later Cooke (1936, p. 55) introduced the name McBean in South Carolina to include all middle Eocene strata. In 1952 Cooke & MacNeil restricted the McBean Formation to include only the Cook Mountain equivalent, the *Ostrea sellaeformis* zone of the Lisbon Formation of Alabama.

Lithologic Character. The McBean Formation at its type-locality near McBean, Georgia according to Cooke (1943, p. 54), ". . . consists chiefly of fine loose yellow sand containing a few discontinuous ledges of sandstone and patches of carbonaceous and calcareous matter. The sand merges downward into white, gray or greenish marl containing *Ostrea sellaeformis* and other fossils. Sandy marlstone, fine sand, olive-green platy clay, and fullers earth are the prevailing constituents elsewhere."

Within the study area the McBean Formation consists of interbedded yellow and light-green arenaceous clays and argillaceous, quartzose sands that weather brick red, and light-weight, light-green to gray siltstone that contains molds and casts of numerous pelecypods. Pockets of silicified mollusks are common within the arenaceous clays and argillaceous sands. In the updip area, the lithologies of the Congaree and McBean formations are very similar. Both of these formations were deposited under similar conditions; consequently, it is often difficult to distinguish them.

Distribution and Stratigraphic Relationship. The McBean Formation crops out to the northwest of the Orangeburg Escarpment within the Upper Coastal Plain in southwest Calhoun County and in most of northwestern Orangeburg County where it lies unconformably across the Congaree, Warley Hill, and Santee beds (Figs. 3, 4). The lower contact of the McBean with the Congaree and Warley Hill formations is generally marked by boulders and beds up to 2 feet thick of silica-cemented sandstone and chertlike material. Where the McBean Formation overlies the Santee Limestone the basal McBean consists of light-green, light-weight siltstone with molds and casts of pelecypods. The siltstone apparently represents part of the Santee Limestone that was incorporated within the basal McBean, but has subsequently been leached of its calcium carbonate content.

The McBean Formation overlaps the Santee Limestone for a distance of from 4 to 5 miles to the northwest of the Orangeburg Escarpment (Fig. 4); however, the McBean Formation has been removed east of the escarpment by the Miocene transgressions that sculptured the escarpment. It is postulated that the hiatus between the McBean Formation and the Santee Limestone represents a relatively short time interval, and that the unconformity terminates a relatively short distance to the southeast of the escarpment where there was continuous deposition

SPECIES	Loc 9-28	Loc 9-31	Loc 9-32	Loc 9-33	Loc 9-54	A.H. 38-29	A.H. 38-5	A.H. 38-7	Loc 38-103	Loc 38-10	A.H. 38-11	A.H. 38-23	A.H. 38-40	A.H. 38-35	A.H. 38-26	A.H. 38-22	A.H. 39-18	Loc 38-85	Loc 38-87	A.H. 38-37	A.H. 38-13	A.H. 38-17	A.H. 39-27	A.H. 5-1	Loc 38-26	Loc 8-3	A.H. 39-15	Loc 38-22	Loc 18-1
Actinocythereis davidwhitei	x	x	x	x	x	x	x		x		x	x	x	x		x		x		x					x				x
Actinocythereis stenzeli	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x				x
Brachycythere russelli	x		x	x	x									x											x				
Buntonia alabamensis						x	x	x				x	x		x	x	x			x									
Buntonia howei							x										x												
Clithrocytheridea garretti							x	x	x		x		x	x			x		x	x		x					x		
Clithrocytheridea ruida	x	x	x	x	x	x			x	x	x		x	x													x		x
Clithrocytheridea virginica							x	x				x			x	x	x			x	x	x	x						x
Cytheropteron variosum	x	x	x	x	x			x	x		x	x	x	x		x		x	x	x				x					
Cytheretta alexanderi	x				x	x	x		x		x	x		x							x	x					x	x	x
Cytherelloidea montgomeryensis									x			x																	
Digmocythere martini	x					x	x		x	x	x	x	x	x				x		x					x		x	x	x
Echinocythereis jacksonensis	x	x	x	x	x				x	x			x	x															x
Haplocytheridea montgomeryensis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x			x	x
Loxoconcha sp. cf. L. claibornensis	x	x	x			x		x			x	x		x		x	x	x	x				x	x	x	x	x	x	x
Loxoconcha mcbeanensis												x				x		x	x										
Monoceratina alexanderi					x																								
Occultocythereis delumbata																													x
Trachyleberis bassleri	x	x	x	x	x	x	x		x	x	x		x	x			x	x		x							x		x
Trachyleberis? johnsoni			x						x			x		x	x	x													
Trachyleberis? pauca																										x			

Table 5. Distribution of ostracode species within the Santee Limestone.

of the Santee Limestone. Prior to the termination of the middle Claiborne, the sea readvanced and deposited the McBean Formation with the Santee Limestone lithology continuing as an off-shore facies. All evidence of the unconformity and the intertonguing beds of the Santee Limestone and McBean formations to the east of the escarpment have been removed by post-Eocene erosion (FIG. 3).

Mode of Deposition. The McBean Formation was deposited in shallow marine and brackish environments. This mode of deposition is indicated by the presence of a considerable amount of carbonaceous material, numerous burrowing pelecypods, interbedded sands and clays, and cross-bedded sands.

Fauna and Age. Numerous mollusks have been identified from the pockets of silicified fossils found within the clays and sands of the McBean Formation. COOKE (1936, p. 64) lists forms collected from Locality 38-1, near Orangeburg.

Although numerous samples were washed for microfossils, none were recovered from the McBean Formation within the study area. The Foraminifera of the McBean Formation at its type-locality have been described by CUSHMAN & HERRICK (1945).

The presence of *Kymatox lapidosus* (CONRAD) and *Ostrea sellaeformis* CONRAD, species apparently restricted to the Cook Mountain Formation and its lateral equivalents, within both the McBean Formation and its offshore equivalent, the Santee Limestone, strongly suggests that the McBean Formation was deposited during the late middle middle Eocene.

OLIGOCENE STRATA

Strata of Oligocene age have not been reported from the Atlantic Coastal Plain north of the study area, with the exception of a unit questionably assigned to the Oligocene by SWAIN (1951) in two deep wells in Dare County, North Carolina.

COOPER MARL

Many names have been applied to this formation since it was first studied in the early 1800's. RUFFIN (1843) included both of what is now considered the Santee Limestone and Cooper Marl in his "Great Carolinian bed." In 1884 TUOMEY referred to this formation under the heading "Eocene Beds of the Ashley and Cooper Rivers." HOLMES (1870) referred to the "Cooper River Beds" and considered them to be Eocene. DALL (1898) used the term "Cooper River Marls" and referred the strata to the lower Oligocene. SLOAN (1908) designated the "Ashley-Cooper Phase," "Ashley Marl," and "Cooper Marl" for strata now considered as Cooper Marl. STEPHENSON (1914) referred to the "Cooper Marl" as the foraminiferal marl which outcrops in the vicinity of Charleston. COOKE (1936, p. 72, 82) later synthesized all the data available at that date and placed the Cooper Marl in the upper Eocene.

Lithologic Character. As defined by PETTIJOHN (1936, p. 369), "Marls, proper, are semifriable mixtures of clay materials and lime carbonate . . . Marl has been defined as a rock with 35 to 65 percent carbonate and a complementary content of clay . . . ." According to MALDE (1959, p. 9), "The Cooper Marl consists dominantly of carbonates (25-75 percent), sand (10-45 percent), clay (2-3 percent), and phosphate (5-20 percent). Mixed with these constituents is 15 to 25 percent water to make a smooth, compact, homogeneous mass. When dry the marl is hard and white, or pale gray, but when fresh (moist) it is soft and olive (5 Y 5/3) or olive gray (5 Y 6/2)."

Technically the Cooper Marl is not a true marl because it contains very little clay but does contain some quartzose sand. However, because no other term appears as suitable for such a lithology, and because the name Cooper Marl has become so firmly entrenched in the literature and the vocabulary of the geologists of the Coastal Plain, the term marl is retained to refer to this consolidated, arenaceous, very fine-grained carbonate unit.

The Cooper Marl is sufficiently soft and impermeable to house tunnels for the Charleston water supply. The tunnels are unlined and have a bore of 7 feet. MALDE (1959, p. 9) examined the Cooper Marl within the McDowell tunnel during its construction and noted that ". . . the marl is uniform in color and texture without traces of bedding, but faint laminae of sorted grains can be seen on close inspection."

The Cooper Marl because of its relative softness, impermeability, and extreme thickness near the coast may possibly afford excellent sites for future underground storage of commercial products and radioactive by-products. JOHNSON (1960, p. 49) has suggested the possibility of utilizing the Cooper Marl in the Charleston area for the storage of natural gas.

Distribution and Stratigraphic Relationship. The areal distribution of the Cooper Marl is shown in Figure 5. It lies unconformably upon the Santee Limestone, with the lower contact exposed within the study area solely at the Carolina Giant Cement quarry near Harleyville, Dorchester County (Loc. 18-1). Here, the contact is sharp and essentially flat, with only a slight undulation. The thickness of the formation, which is quite variable because both the upper and lower surfaces are marked by unconformities, increases from a feather-edge at Locality 18-1 to 275 feet at Fechtig in Hampton County and 177 feet along the coast at Charleston. It is overlain by a thin veneer of upper Miocene (Duplin Formation) and ?Pleistocene surficial material.

Mode of Deposition. The lack of cross-bedding and other sedimentary structures indicative of near-shore

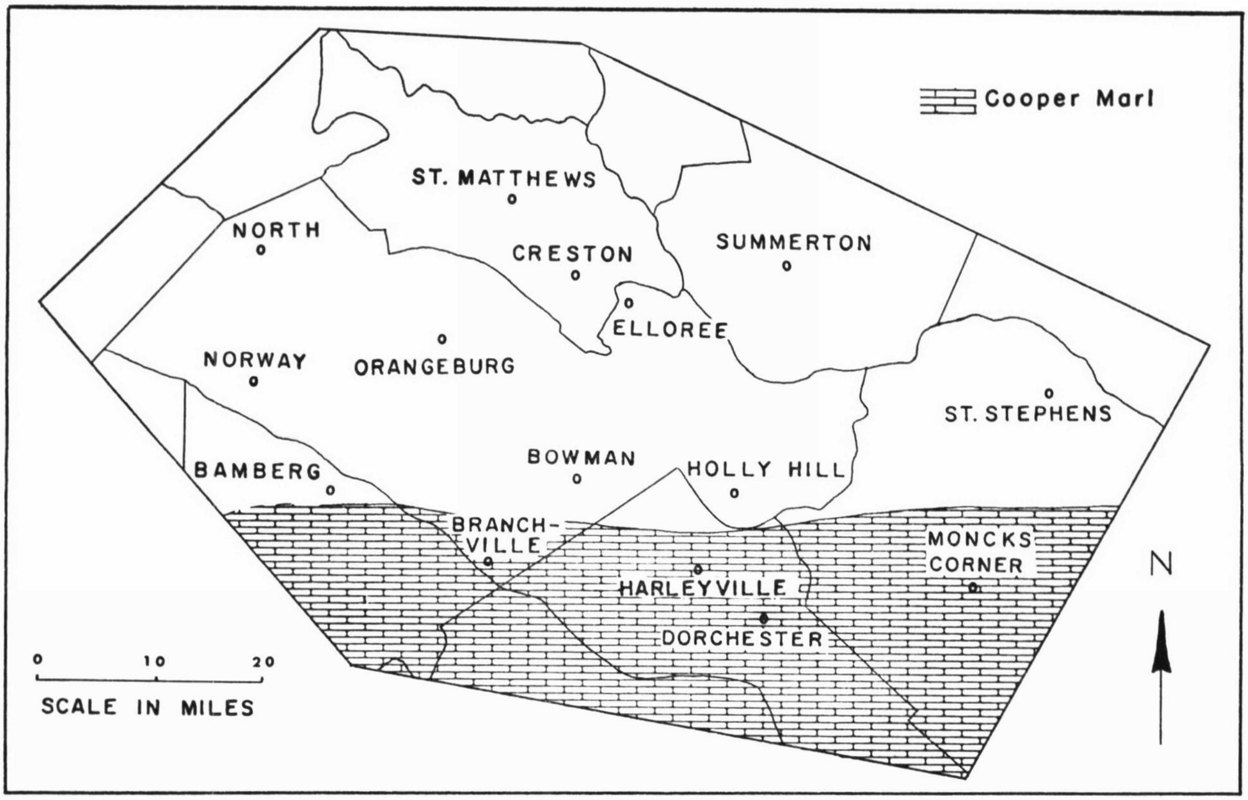


FIGURE 5. Areal distribution of the Cooper Marl.

deposition suggests that the Cooper Marl probably was deposited in relatively deep water. According to E. B. LEOPOLD in MALDE (1959, p. 25) the hystrichosphaerids indicate that the Cooper Marl was deposited in moderately deep marine waters. Although only a single ostracode species from the Cooper, *Pterygocythereis americana* (ULRICH & BASSLER), has living representatives, this species and two additional species of the genus *Echinocythereis* shed some light on the nature of the environment of deposition of the marl. *P. americana* has been reported by CURTIS (1960) from the open shelf at depths beyond 15 fathoms east of the Mississippi delta area. In addition, BENSON & COLEMAN (1963) have reported *P. americana* from the Recent of the eastern Gulf of Mexico, and found that although this species occurs in shallower water it is most abundant at depths exceeding 60 feet. BENSON & COLEMAN did not find specimens of *Echinocythereis* at depths of less than 70 feet, and CURTIS has reported this genus as characteristic of the open shelf.

Fauna. MALDE (1959) has given a comprehensive account of the megafauna collected from the Cooper Marl in the Charleston area. Forms reported include corals, pelecypods, gastropods, skeletons of primitive toothed whales, and shark teeth. Within the study area the most abundant megafossils are *Ostrea, Chlamys cocoana* (DALL), and shark teeth. The microfauna include hystrichosphaerids, foraminifers, and ostracodes. The foraminifers identified by RUTH TODD from the Cooper Marl at the Carolina Giant quarry are listed by COOKE & MACNEIL (1952, p. 28). Foraminifera identified from localities near Charleston by TODD are listed in MALDE (1959, p. 17).

The ostracodes and their occurrences within the Cooper Marl of the study area are shown in Table 6. *Buntonia reticulata* n. sp. and *Trachyleberis florienensis* (HOWE & CHAMBERS) appear to be restricted to the downdip portion of the study area, whereas ***Alatacythere ivani*** HOWE, ***Eocytheropteron spurgeonae*** HOWE & CHAMBERS, ***Haplocytheridea montgomeryensis*** HOWE & CHAMBERS, ***Cytheretta alexanderi*** HOWE & CHAMBERS, and *Trachyleberis bassleri* (ULRICH) are restricted to the updip portion.

The ostracode assemblage has relatively few forms in common with assemblages reported from the Oligocene of the Gulf and North Atlantic states. Of the ostracodes identified from the Cooper Marl only *Leguminocythereis scarabaeus* and *Trachyleberis bassleri* were reported by SWAIN (1951) from the Oligocene? in wells in North Carolina. Moreover, the Cooper Marl ostracode assemblage shares only *Alatacythere ivani* and *Leguminocythereis scarabaeus* in common with that of the Vicksburg Group of Louisiana (HOWE & LAW, 1936).

Within the study area the ostracode assemblage of the Cooper Marl is sufficiently distinct from that of the

SPECIES	Loc. 38-29	A.H. 38-26	A.H. 38-38	Loc. 38-45	Loc. 38-42	Loc. 5-3	Loc. 18-9	Loc. 21-1
Aurila conradi conradi	x		x		x		x	x
Munseyella subminuata			x					
Cytheromorpha warneri	x	x	x			x		
Cytherura johnsoni			x		x			
Cytherura wardensis		x	x		x			
Cytherelloidea leonensis								x
Haplocytheridea bassleri	x	x				x		
Hemicytherura howei			x					
Hulingsina ashermani				x	x			
Murrayina barclayi	x							
Murrayina martini	x		x	x	x		x	x
Orionina bermudae			x	x	x		x	x
Protocytheretta karlana				x	x			x
Pterygocythereis americana								x
Puriana rugipunctata			x		x		x	x
Triginglymus whitei				x	x			x

TABLE 6. Distribution of ostracode species within the Cooper Marl.

underlying Santee Limestone and the overlying Duplin Formation to serve as a reliable stratigraphic indicator. The *Henryhowella evax* Assemblage Zone, as hereby proposed, constitutes all of the Cooper Marl within the study area. Definitive species include:

Ostracodes of Henryhowella evax Assemblage Zone

Henryhowella evax (ULRICH & BASSLER)
Pterygocythereis americana (ULRICH & BASSLER)
Paracypris kaesleri n. sp.
Buntonia reticulata n. sp.
Eocytheropteron spurgeonae HOWE & CHAMBERS
Alatacythere ivani HOWE
Leguminocythereis scarabaeus HOWE & LAW
Echinocythereis clarkana (ULRICH & BASSLER)
Echinocythereis jacksonensis (HOWE & PYEATT)

The basal portion of the Cooper Marl is exposed solely at the Carolina Giant Cement quarry (Loc. 18-1). *Eocytheropteron spurgeonae, Cytheretta alexanderi, Haplocytheridea montgomeryensis,* and *Trachyleberis bassleri* were recovered from this locality but from none of the other Cooper Marl localities. In addition all of these species from the basal Cooper Marl at this locality with the exception of *Eocytheropteron spurgeonae* occur within the underlying Santee Limestone. Further study may indicate that the basal portion of the Cooper Marl constitutes a separate biostratigraphic assemblage zone.

Age. The age of the Cooper Marl has long been controversial, with various workers assigning the formation either to the Eocene or Oligocene or both. COOKE (1936, p. 82) assigned it to the late Eocene. COOKE & MACNEIL (1952, p. 27) reassigned it to the early Oligocene because of the following: (1) the presence of primitive toothed whales that have not been found elsewhere in known Eocene deposits, (2) the presence of *Chlamys cocoana* (DALL), a pelecypod that is abundant at Locality 18-1 and also occurs in the early Oligocene in Alabama, and (3) the Foraminifera from Locality 18-1 include *Bolivinella rugosa* HOWE, a Red Bluff species, the genus of which has not been reported from beds older than Oligocene.

MALDE (1959) assigned the Cooper Marl to the Oligocene and considered it to have been deposited throughout that epoch, with the beds near the coast being late Oligocene and those further inland at the Carolina Giant Cement quarry (Loc. 18-1) being early Oligocene. MALDE (1959, p. 19) reports that, "Collections near the coast, and higher in the Cooper, contain several new species that suggest to MacNeil approximate equivalence with the Upper Oligocene Chickasaway limestone of the Gulf Coast (Alabama and Mississippi) and with the middle Miocene Calvert formation (Virginia and Maryland)."

The ranges of the individual ostracode species are too great to determine the age of the Cooper Marl accurately, but the assemblage strongly suggests an Oligocene age. Of the 11 previously described species of ostracodes identified from the Cooper, three have been reported only from Eocene strata, five from the Eocene and Oligocene, one from Eocene through Miocene, and two apparently are restricted to the Miocene.

Based on the evidence of COOKE & MACNEIL (1952), MALDE (1959), and Ostracoda found in this study, the Cooper Marl is considered to be Oligocene in age.

UPPER MIOCENE STRATA

DUPLIN FORMATION

The term Duplin was first employed by DALL (1896, p. 40) for fossiliferous beds at Natural Well in Duplin County, North Carolina. COOKE (1936) introduced the term Duplin Marl in South Carolina and considered it to be upper Miocene. The term marl is inappropriate for this formation because of its variable lithology; consequently, the name Duplin Formation is hereby proposed.

Because the Duplin Formation lacks lithologic continuity and is not readily distinguished from the overlying ?Pleistocene surficial material it is deliniated primarily on the basis of fauna and not on lithologic character. Thus the Duplin is actually a time-stratigraphic unit. Because of the apparent impossibility of delineating it into mappable units, the name is retained.

Lithologic Character. The Duplin Formation within the study area consists primarily of noncalcareous, and calcareous quartzose sands with numerous shells. Thin beds of bluish-green and gray, calcareous, arenaceous, fossiliferous clay interbedded with noncalcareous, quartzose sands have been encountered in drill holes. At the exposure near Givhans Ferry, Dorchester County (Loc. 18-9) it consists of massive, pale-yellow or white limestone. Further towards the coast the formation consists predominantly of white, coquinoidal limestone.

Distribution and Stratigraphic Relationship. The Duplin Formation occurs chiefly as a thin veneer over the underlying Santee Limestone and Cooper Marl. Because both of these underlying units are calcareous and have considerable relief due to subaerial corrasion and solution, the Duplin Formation is as much as 50 feet

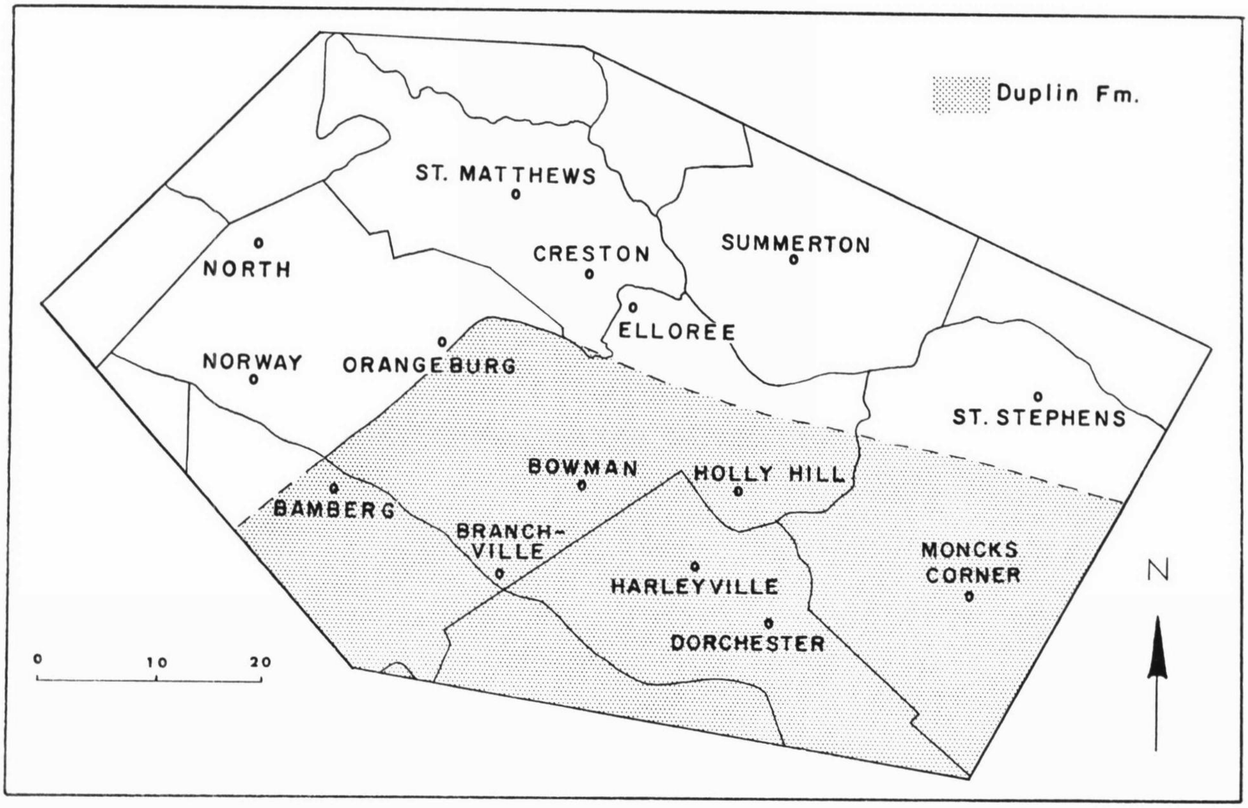


Figure 6. Areal distribution of the Duplin Formation.

thick in places. Figure 6 shows the distribution of the Duplin within the study area. Because of the few exposures available, the areal extent of the Duplin is based primarily on drill-hole data and the presence of shells on the spoil banks of the dug ponds. To the north of the study area near the Pee Dee River in Florence County the Duplin overlies the Upper Cretaceous, Peedee Formation; and further south and west of the Pee Dee River it lies on the Paleocene-lower Eocene Black Mingo Formation. The Duplin Formation is overlain throughout its extent by ?Pleistocene surficial material.

Cooke (1936, p. 115) proposed the name "Raysor Marl" for upper Miocene strata older than the Duplin Marl. The only known occurrence of this formation was at Raysor Bridge on the Edisto River (Loc. 18-6). Later Cooke (1945, p. 182) abandoned this name; consequently, the "Raysor Marl" is now considered part of the Duplin Formation.

Malde (1959, p. 26) considered the 1-foot thick sandy limestone bed (unit 3 of Loc. 18-9) that lies between the Cooper Marl and the Duplin Formation at Givhans Ferry as lower? Miocene. Cooke (1936, p. 86) had placed this bed in the Cooper Marl. Malde based the age of this bed on paleontological evidence submitted by MacNeil (in Malde, 1949, p. 27) who indicated that, "This fauna contains none of the characteristic Cooper Marl species found elsewhere. Some elements are like things known previously only in the upper Oligocene. Others are close to Trent marl species. My best guess is that this bed is Miocene, probably lower. I see no indication that it is Eocene, as it has been called by several people."

If this bed should prove to be early Miocene then it will represent the only known deposit in the state of this age. Because of the lithologic similarity of this bed to the underlying Cooper Marl, and because of the eight fosil identified by MacNeil, six were listed as "sp. cf." and two as "sp.," the author concurs with the findings of Cooke (1936) that this bed is part of the Cooper Marl.

Fauna. The megafauna of the Duplin Formation is very diversified but consists primarily of pelecypods and gastropods. Fossils that have been reported from the Duplin Formation are listed in Cooke (1936), Malde (1959), and DuBar & Solliday (1961). The author did not study the megafossils but did note that the spoil banks of dug ponds within the study area revealed numerous specimens, among which were *Chlamys jeffersonius* (Say), *Ecphora quadricostata* (Say), *Chione* sp., *Ostrea* sp., and *Glycymeris* sp. Most of the specimens are broken and occur as shell fragments, but a few pelecypods are still hinged. Shells with circular holes, apparently resulting from the boring action of organisms, are common.

The ostracodes appear to be restricted to the calcareous sands, calcareous clays, and limestones of the study area

SPECIES	Loc 38-13	Loc 18-1	Loc 18-3	A.H. 18-5	A.H. 18-4	Loc 18-10	A.H. 8-49	Loc 8-4	Loc 18-8	Loc 18-9	A.H. 8-39	A.H. 8-40
Alatacythere ivani		x	x									
Buntonia reticulata								x		x	x	x
Cytheropteron sp. A											x	
Cytheretta alexanderi		x										
Echinocythereis clarkana	x		x		x		x		x	x		x
Echinocythereis jacksonensis		x	x			x		x	x	x	x	x
Eocytheropteron spurgeonae		x										
Haplocytheridea montgomeryensis		x										
Henryhowella evax		x		x		x	x	x	x	x	x	x
Leguminocythereis scarabaeus	x		x						x			
Paracypris kaesleri			x					x			x	
Pterygocythereis americana	x		x		x		x	x	x	x	x	x
Trachyleberis bassleri		x										
Trachyleberis florienensis								x			x	x

Table 7. Distribution of ostracode species within the Duplin Formation.

and are not nearly as abundant as those of the underlying Santee Limestone and Cooper Marl. Table 7 shows the ostracodes identified and their distribution within the study area.

The ostracode assemblage is strikingly different from that of the underlying Cooper Marl and shares only *Pterygocythereis americana* (Ulrich & Bassler) with it. The assemblage should prove to be a reliable stratigraphic indicator for discrimination of the Duplin Formation from the underlying Cooper Marl. Because most of the species identified from the Duplin have been reported from Recent sediments, the ostracode assemblage as yet cannot readily be used to separate the Duplin Formation from the younger Cenozoic units; however, closer study and comparison of the morphology of the species ranging from the Miocene to the Recent, such as has been made by Benson & Coleman (1963), should facilitate separation of the Miocene from younger units.

Mode of Deposition. The angular quartzose sands, calcareous silty to sandy clays, the thousands of mollusks on the spoil banks of dug ponds, and the faunal assemblage indicate a littoral to inner-neritic environment of deposition for the Duplin Formation.

Because many of the fossil species have living representatives, it is possible to reconstruct the environment of deposition of the Duplin in the light of recent studies on the distribution of living forms. However, great care must be exercised in the application of ecologic data from present studies to the interpretation of environments of the past because the composition of any particular assemblage is influenced by many factors such as temperature, depth, salinity, currents, etc. It is often difficult to determine which or what combination of these factors are responsible for the composition of an assemblage. In addition, it is possible that many of the organisms have evolved physiologically without any apparent morphological changes; thus the forms of the Miocene may have had slightly different limits of tolerance of salinity, temperature, depth, substratum, etc. than present-day forms.

The ecology of ostracodes has not received such attention as has that of foraminifers and megafossils; however, in recent years several studies have been conducted within the Gulf of Mexico that bear directly on the paleoecological interpretation of the upper Miocene of South Carolina. Swain (1955) studied the distribution of the ostracodes of San Antonio Bay, Texas, and delineated several biofacies. In 1957 Puri & Hulings published the results of work conducted in the Panama City and Alligator Harbor areas of northwestern Florida and the Florida Bay area, and in 1960 Puri described the species collected from these areas.

Benson & Coleman (1963) conducted a comprehensive study of the open-shelf neritic ostracode fauna from Tampa Bay to Florida Bay and attempted to show the evolutionary and geographic relationships between the Miocene forms and those of the Recent.

Of the 16 species of ostracodes identified from the Duplin Formation of South Carolina, 10 have living representatives. Based on the results of the recent ecological studies within the Gulf of Mexico, the fauna of the Duplin indicates that this formation was deposited in a near-shore, inner-neritic environment with much of the sediment representing littoral deposits. The maximum depth was in all probability not more than 75 to 100 feet.

Studies by Benson & Coleman (1963) on the open shelf of the west coast of Florida indicated that *Puriana rugipunctata* occurs from depths of 19 to 239 feet but is most common at depths less than 50 feet; *Hulingsina ashermani* and *Pterygocythereis americana* were present in shallower water but most abundant at depths in excess of 75 feet; *Cytherura johnsoni* and *Aurila conradi floridana* occurred from the shallowest water sampled down to a depth of 150 feet.

Studies by other workers on the ecology of Recent ostracodes tend to confirm the results obtained by Benson & Coleman (1963). Puri (1960) reported *Aurila conradi, Cytheromorpha warneri, Cytherura johnsoni, Haplocytheridea bassleri, Orionina bermudae,* and *Puriana rugipunctata* from the bays and shallow waters off the west coast of Florida. Curtis (1960), working on the ecology of ostracodes from the east Mississippi Delta area, reported *Pterygocythereis americana* from the open shelf, *Cytherura johnsoni* (reported as *C. forulata*) from the open shelf, estuarine, and open lagoonal environments, and *Haplocytheridea bassleri* from the estuarine and open lagoonal environments. Swain (1955) reported *Cytherura johnsoni, Haplocytheridea bassleri,* and *Aurila conradi* from the shallow waters of San Antonio Bay, Texas.

Table 8 shows the distribution of the ostracodes of the Duplin Formation within the Miocene deposits of the Atlantic Coast. The table indicates that the ostracode species were widespread geographically throughout the late Miocene, suggesting that the environments of deposition were comparatively similar from Florida to Virginia. Most of the upper Miocene forms from South Carolina are considerably larger than their living representatives, which strongly suggests that the late Miocene shallow seas were somewhat cooler than those of today.

Age. Most of the ostracodes within the Duplin Formation have living representatives; however, *Hemicytherura howei, Munseyella subminuata,* and *Murrayina barclayi* have thus far been reported only from upper Miocene strata.

A late Miocene age is also indicated by the presence of *Ecphora quadricostata* (SAY) at Locality 38-45. This species has been reported only from strata of late Miocene age. In addition, MALDE (1959, p. 33) collected specimens of *Glycymeris americana* (DEFRANCE) from the Duplin Formation within the McDowell tunnel near Charleston. According to DRUID WILSON (personal communication, April 8, 1964) the short range of the rugose mutation of *Glycymeris americana* in the late Miocene, first reported by NICOL (1953, p. 453), has been upheld by extensive subsequent investigation.

SPECIES FROM SOUTH CAROLINA	FLORIDA 1/ ALUM BLUFF			FLORIDA 1/ CHOCTAWHATCHEE				N.C. 2/	N.C. 3/	Va 4/	Va 5/	
	OAK GROVE	SHOAL RIVER	CHIPOLA	YOLDIA	ARCA	ECPHORA	CANCELLARIA	DUPLIN MARL	YORKTOWN FM.	YORKTOWN FM.	YORKTOWN FM.	RECENT 6/
Aurila conradi conradi					x	x	x	x	x	x	x	
Cytherelloidea leonensis						x	x					
Cytheromorpha warneri					x	x	x		x	x	x	x
Munseyella subminuata					x	x	x					
Cytherura johnsoni								x			x	x
Cytherura wardensis					x	x	x	x			x	x
Haplocytheridea bassleri	x	x	x	x	x							x
Hemicytherura howei						x						
Hulingsina ashermani	x	x	x		x	x	x	x	x	x	x	x
Murrayina barclayi										x		
Murrayina martini					x	x	x		x	x		
Orionina bermudae			x		x	x	x	x	x	x	x	x
Protocytheretta karlana	x	x	x					x	x			
Pterygocythereis americana		x	x		x	x	x			x	x	x
Puriana rugipunctata		x		x	x	x	x	x	x	x	x	x
Triginglymus whitei									x			x

1/ PURI (1953d), HOWE AND OTHERS (1935) 2/ EDWARDS (1944) 3/ BROWN (1958) 4/ McLEAN (1957) 5/ MALKIN (1953) 6/ BENSON & COLEMAN (1963), BENSON & KAESLER (1963), CURTIS (1960), GROSSMAN (1964), PURI (1960), PURI & HULINGS (1957), SWAIN (1955), VAN DEN BOLD (1957a and 1963b).

TABLE 8. Distribution of ostracode species within the middle and upper Miocene of the middle and southeastern Atlantic Coast and Florida compared to their occurrence in the Recent.

SURFICIAL MATERIAL

The Eocene, Oligocene, and Miocene strata of the study area are blanketed by a surficial covering consisting of very argillaceous, poorly sorted, mottled red and rusty-gray, quartzose sand with well-rounded quartzose and feldspathic pebbles and cobbles. The surficial material is generally considered to be Pleistocene in age, but much of this deposit within the study area is a residuum and may be as old as Eocene. No attempt was made by the author to study in detail this nonfossiliferous deposit. The reader is referred to a recent progress report by COLQUHOUN (1962) for a more detailed description and summary of the surficial deposits.

The surficial material within South Carolina has been studied by numerous workers. COOKE (1936, p. 130) recognized seven Pleistocene formations with shorelines from 25 to 270 feet in elevation, each corresponding to the seven high stages of the Pleistocene seas. He delineated the formations primarily on the basis of topography. FLINT (1942, p. 236) recognized only two shorelines along the Atlantic Coast, the Surry scarp with an elevation at its toe of 90 to 100 feet, and the Suffolk scarp at 20 to 30 feet. He considered the higher terraces to be of fluvial origin. RICHARDS (1959), who has conducted numerous recent studies of the Pleistocene of the south Atlantic Coastal Plain, concluded that paleontological evidence indicates one Pleistocene shoreline (Pamlico) at an elevation of about 25 feet from New Jersey to Florida that is approximately equivalent to the Suffolk scarp. COLQUHOUN (1961) conducted a study of the surficial material within the study area near Harleyville and Holly Hill in southeastern Orangeburg and northwestern Dorchester Counties, and on the basis of physiography and sedimentary petrology concluded that a shoreline at 95 to 100 feet which he called Wicomico (Surry scarp of FLINT) is present within this area.

Field observations made by the author in the course of this study indicate that the surficial material in the area to the northwest of the Wicomico shoreline (Surry scarp) consists of fluvial deposits and residuum developed from the weathering of the underlying formations. The fluvial origin is indicated by mud balls impregnated with very coarse sand, by channeling, and by undulating pebble lines.

A prominent southeast-facing escarpment with a relief of approximately 120 feet in a linear distance of 2 miles strikes NNE through the city of Orangeburg. It is most readily apparent to the northeast of Orangeburg where it is crossed by U. S. Highway I-26 in Orangeburg County (FIG. 3) and along the eastern side of the Wateree River in western Sumter County. The escarpment, herein called the Orangeburg Escarpment, separates the rolling topography of the Upper Coastal Plain from the nearly flat Lower Coastal Plain. The Orangeburg Escarpment corresponds to the 215-foot Coharie terrace and formation of COOKE (1936, p. 132).

DOERING (1960) conducted a study of the Pleistocene formations in the southern part of the Atlantic Plain and classified the sediments, herein called surficial material, to the northwest of the escarpment in the study area as the Citronelle Formation, and those to the southeast between the escarpment and the present 120-foot contour line as the Sunderland Formation. He postulated an uplift within the Piedmont area and the Blue Ridge Mountains at the beginning of the Pleistocene, thus initiating rejuvenation of streams with the subsequent deposition of the Citronelle Formation as a continuous fluvial apron. This was followed by marine erosion of the Citronelle Escarpment (Orangeburg Escarpment of this paper), uplift and warping of the erosional escarpment, recession of the coast line to the present 120-foot contour, and building of barriers along that line. The Sunderland Formation was deposited by streams issuing from the escarpment onto the sloping former sea bottom between the escarpment and the new coast line.

DOERING (1960, p. 189) also indicated that the main body of the Citronelle Formation in the southern part of South Carolina is present in the broad upland area between the valleys of the Santee River, North and South Forks of the Edisto River, and the Savannah River, with a thickness in places exceeding 100 feet, and that the pre-Citronelle formations (Black Mingo, Congaree, and McBean formations of this paper) are ". . . at levels in the valley slopes considerably below the crests of the upland ridges." The thickness as stated by DOERING is far in excess of that indicated by the field investigations of the author. The average thickness of the surficial material is 10 to 15 feet and the maximum thickness is on the order of 50 feet. The surficial material lies as a blanket upon the underlying older Cenozoic strata with its base at a considerably higher elevation upon the uplands than along the stream valleys.

It is hereby postulated that the Orangeburg Escarpment was not notched by a Pleistocene sea as suggested by DOERING (1960), but rather by marine transgressions during the Miocene. Study of exposures and samples from auger holes within Orangeburg County have shown that the upper Miocene Duplin Formation does not occur to the northwest of the base of the Orangeburg Escarpment which is at an elevation of approximately 200 feet (FIG. 3). The fact that the shoreward extent of the upper Miocene strata coincides with the escarpment may be coincidental; however, it strongly suggests that the escarpment may have been sculptured by one or more marine transgressions prior to the deposition of the Duplin Formation. The shallow sea in which the Duplin Formation was deposited could not have been the erosional agent responsible for the escarpment because its lithology consists of fine-to very coarse-grained, quartzose sands without any indication of pebbles or cobbles that should accompany sediments that have resulted from the erosion of an escarpment of this magnitude. However, the escarpment could have been cut by earlier Miocene seas, with the subsequent removal of the coarse detrital material by erosion. The Duplin Formation may have then been deposited upon this erosion surface.

The evidence of the Miocene origin of the Orangeburg Escarpment is far from conclusive. It is further realized that the possibility of faulting cannot be overlooked; however, the evidence compiled from this investigation strongly suggests that the escarpment was not eroded by a Pleistocene sea but by one or more Miocene transgressions prior to the deposition of the Duplin Formation.

SUMMARY OF CENOZOIC GEOLOGIC HISTORY

The Cenozoic geologic history of the study area and the Coastal Plain of South Carolina in general is characterized by a series of marine transgressions and regressions upon a gently sloping continental shelf. The lithologies and faunal assemblages indicate that all of the Cenozoic sediments except the Cooper Marl were deposited in relatively shallow water. The sites of deposition include tidal flat, estuarine, lagoonal, littoral, and inner-neritic environments.

Within the study area the earliest Cenozoic sea transgressed upon an erosion surface of considerable relief that had been developed upon the Upper Cretaceous Tuscaloosa Formation. The sands and clays of the Black Mingo Formation were deposited for the most part in tidal flats, lagoons, and estuaries. Ostracodes and mollusks indicate that the sediments of the Black Mingo Formation were first deposited during the Paleocene with deposition continuing into the early Eocene. Prior to the middle Eocene the area was subjected to subaerial erosion. During the early part of the middle Eocene the seas advanced once again upon the continental shelf, the sands and clays of the Congaree Formation being deposited in lagoons, estuaries, and deltas while to the seaward in deeper waters the lower glauconitic sands and the upper glauconitic limestones of the Warley Hill Formation were forming. The Santee Limestone was deposited still further seaward but in shallow quiet water. Prior to the termination of the middle Eocene, the seas retreated, but it is postulated that the hiatus was of relatively short duration, and that deposition of the Santee Limestone continued in an area a short distance to the southeast. The seas then readvanced landward with the deposition of the McBean Formation and the Santee Limestone as its off-shore facies.

The area of study remained land throughout the late Eocene, but in the Oligocene shallow seas deposited the Cooper Marl on the continental shelf as limy muds and sands.

The area probably underwent subaerial erosion throughout the early and middle Miocene; however, the Orangeburg Escarpment may have been eroded during this interval of time. During the late Miocene, shallow seas covered much of the Coastal Plain of South Carolina and deposited the Duplin Formation across older strata, even as old as Late Cretaceous in the northern part of the state.

The post-Miocene history is one of erosion and deposition of fluvial deposits. The most landward extent of the Pleistocene seas is that of the Wicomico shoreline at 95 to 100 feet in northwestern Dorchester and southeastern Orangeburg Counties.

CONCLUSIONS

1. The ostracodes proved to be a reliable means of determining the geologic age of the Cenozoic units, differentiating the strata into readily recognizable biostratigraphic units, and interpreting with a high degree of confidence the environments of deposition for strata as old as Miocene.

The Black Mingo Formation is time-transgressive with its basal portion Paleocene and its upper portion early Eocene. Two distinct ostracode assemblage zones are recognizable within this formation: the *Brachycythere interrasilis* and the *Cytherelloidea nanafaliensis* Assemblage Zones.

The middle Eocene Warley Hill and Congaree formations, and the Santee Limestone are not separated by unconformities as postulated by Cooke & MacNeil (1952), but represent facies changes grading seaward from shallow to deeper water. The Congaree Formation was deposited in brackish and inner-neritic environments. The lower glauconitic sands and upper glauconitic limestones of the Warley Hill Formation were deposited on the shelf, just offshore, contemporaneously with the Congaree Formation while seaward in quieter but still shallow water the Santee Limestone was deposited. The McBean Formation lies unconformably upon the Congaree, Warley Hill, and basal Santee; however, the upper portion of the Santee Limestone represents the offshore facies of the McBean Formation.

The assignment of the limestone at the Carolina Giant Cement quarry near Harleyville (Loc. 18-1) by Cooke & MacNeil (1952) to the Castle Hayne Formation on paleontological criteria is contrary to the principles of stratigraphic nomenclature. According to the Code of Stratigraphic Nomenclature the definition of rock-stratigraphic units is completely independent of time concepts. The limestone at this locality does not differ lithologically from the Santee Limestone throughout the study area, nor has a hiatus been shown to exist between the "Castle Hayne" and the Santee Limestone; consequently, the limestone at this exposure is considered as the Santee Limestone.

The Oligocene Cooper Marl was deposited in deeper water than the other Cenozoic units and contains a distinctive ostracode assemblage, the *Henryhowella evax* Assemblage Zone.

Because many of the ostracode species of the upper Miocene have living representatives, the results of studies on the distribution of Recent forms were applied directly to the interpretation of the environments of the Duplin Formation within the study area. The ostracodes indicate that the Duplin Formation was deposited very near to shore, with a maximum depth of water probably not more than 100 feet.

The ostracode assemblages of the lower Eocene, middle Eocene, Oligocene, and upper Miocene strata are sufficiently distinctive to serve as stratigraphic indicators (biostratigraphic units) for future surface and subsurface geological work in the Coastal Plain of South Carolina.

2. It is postulated that the Orangeburg Escarpment was not eroded by a Pleistocene sea as inferred by Doering (1960), but rather was eroded during the Miocene prior to the deposition of the upper Miocene, Duplin Formation. Field evidence indicates that the Pleistocene seas did not transgress above the 100-foot contour (Wicomico shoreline), and that the surficial material to the northwest of this shoreline is of fluvial and residual origin.

3. It is virtually impossible to undertake a geological study of Coastal Plain sediments without an extensive drilling program. A power auger of the type used during the course of this work proved adequate because several rock-stratigraphic units could be penetrated at a relatively shallow depth; however, the next phase of investigation should be to trace downdip the rock-stratigraphic and biostratigraphic units delineated in the course of this study. To accomplish this aim drilling equipment capable of depths of several hundred feet will be necessary.

4. Great care must be exercised to ensure that time-stratigraphic units are not designated as rock-stratigraphic units (formations, members, etc.) as has been done in the past within the study area.

SYSTEMATIC PALEONTOLOGY

The holotypes as well as representative ostracodal assemblages from the Cenozoic rock-stratigraphic units studied within South Carolina have been deposited in the U.S. National Museum, Smithsonian Institution, Washington, D.C. Approximately 40 percent of the ostracode species were compared with topotypes and the identification of the remaining forms was based on descriptions and illustrations from published literature. In general, the preservation of the carapaces is excellent; however, many of the more ornamented specimens from the Santee Limestone required ultrasonic vibration in order to remove the calcareous matrix.

Subclass OSTRACODA Latreille, 1806

Order PODOCOPIDA Müller, 1894

Suborder PLATYCOPINA Sars, 1866

Family CYTHERELLIDAE Sars, 1866

Genus CYTHERELLA Jones, 1849

Cytherella JONES, 1849, p. 28; SARS, 1865, p. 125; MÜLLER, 1894, p. 386; ———, 1912, p. 390; BENSON, 1959, p. 39; REYMENT, 1961, p. Q328, BENSON & COLEMAN, 1963, p. 14.
Morrowina LOETTERLE, 1937, p. 51.
Type-species. Cytherina ovata ROEMER, 1840, p. 104, pl. 16, fig. 21.

Diagnosis. Recognized by its smooth or pitted surface, ovate outline, and adont hinge. Right valve overreaches left valve around entire periphery and receives left valve in prominent accommodation groove. Pronounced sexual dimorphism. Pinnate adductor muscle-scar pattern. *Penn.-Rec.*

Remarks. LOETTERLE (1937, p. 51) distinguished *Morrowina* from *Cytherella* on the basis of the presence of a shallow centrodorsal pit and a narrow thickened rim at each end. REYMENT (1961, p. Q382) considered *Morrowina* as a junior synonym of *Cytherella.* The presence or absence of a shallow pit is in all probability not a characteristic of generic significance.

CYTHERELLA EXCAVATA Alexander, 1934

Pl. 2, figs. 1, 2, 4

Cytherella beyrichi JONES, 1856, p. 55, pl. 5, fig. 12 (*non C. beyrichi* REUSS, 1851).
Cytherella excavata ALEXANDER, 1934, p. 211, pl. 32, figs. 3, 4, pl. 35, figs. 5, 6.
Morrowina excavata (Alexander), MUNSEY, 1953, p. 2, pl. 1, figs. 1, 2, 9, 10.

Diagnosis. Distinguished by its discrete punctae, shallow sulcus just dorsal to median line of carapace and slightly anterior to middle, and narrow marginal ridge on anterior border of left valve. *Paleo.-L.Eoc.*

Remarks. MUNSEY (1953, p. 2) noted that there were approximately twice as many females as males present in the Paleocene Coal Bluff Marl Member of the Naheola Formation of Alabama. All of the specimens examined from South Carolina appear to be females.

Dimensions. Female: (left valve) length 0.70 mm, height 0.40 mm; (right valve) length 0.76 mm, height 0.48 mm; (whole) thickness 0.33 mm.

Material. Black Mingo Formation: 6 specimens.

Occurrence. Black Mingo Formation: Auger Hole 45-2 (21-29 ft.).

Reported from the Paleocene Kincaid and Wills Point formations of Texas (ALEXANDER, 1934, p. 211), and the Coal Bluff Member of the Naheola Formation of Alabama (MUNSEY, 1953, p. 2).

Genus CYTHERELLOIDEA Alexander, 1929

Cytherelloidea ALEXANDER, 1929, p. 55; HOWE, 1934, p. 27; SEXTON, 1951, p. 808; MUNSEY, 1953, p. 2; BENSON, 1959, p. 39; BENSON & COLEMAN, 1963, p. 15.
Cytherella (Cytherelloidea) Alexander, REYMENT, 1961, p. Q383.
Type-species. Cythere williamsoniana JONES, 1849, p. 31, pl. 7, fig. 26a-f.

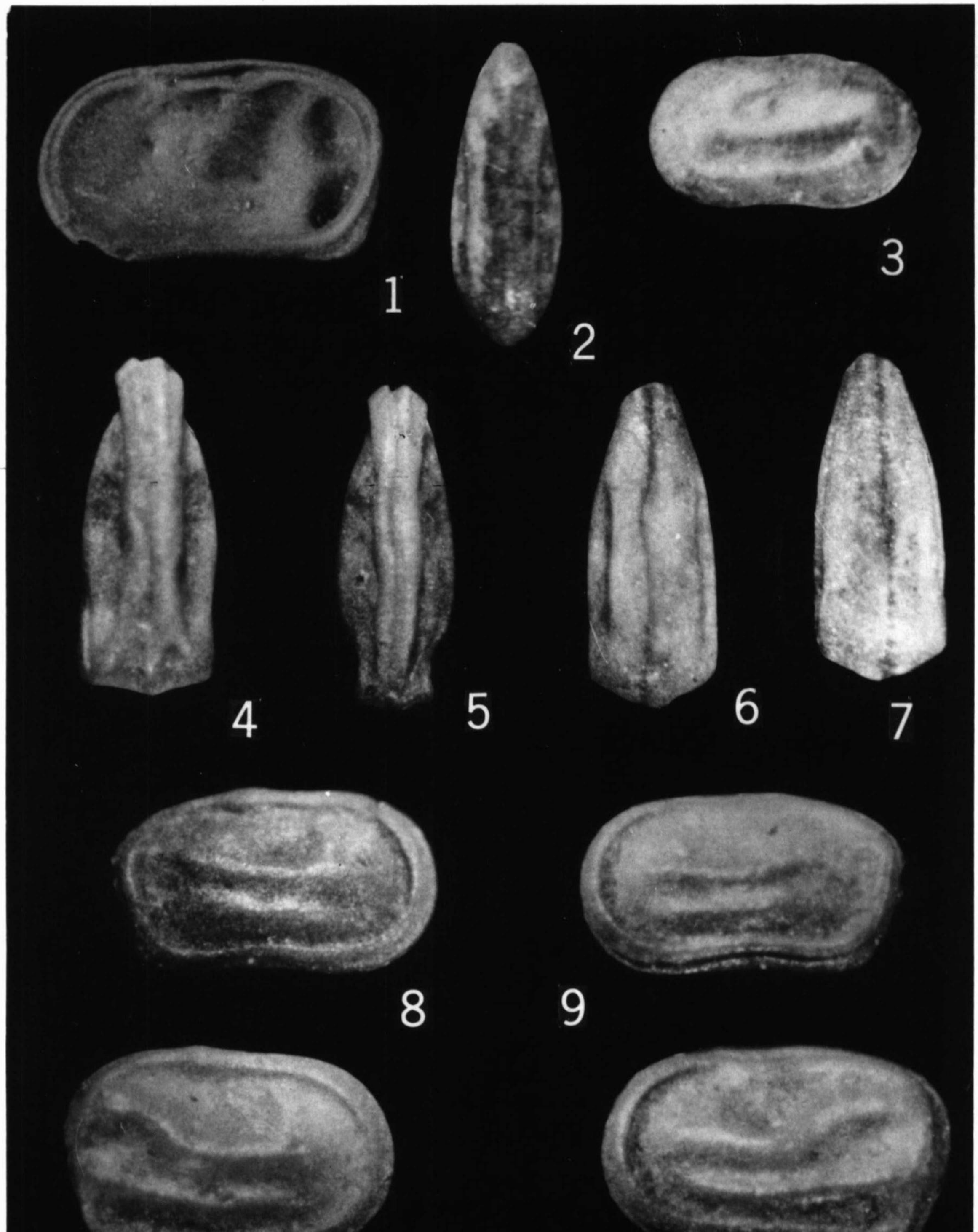
Diagnosis. Distinguished from *Cytherella* by the ridges on the surface of the carapace. *?Jur., L.Cret.-Rec.*

EXPLANATION OF PLATE 1

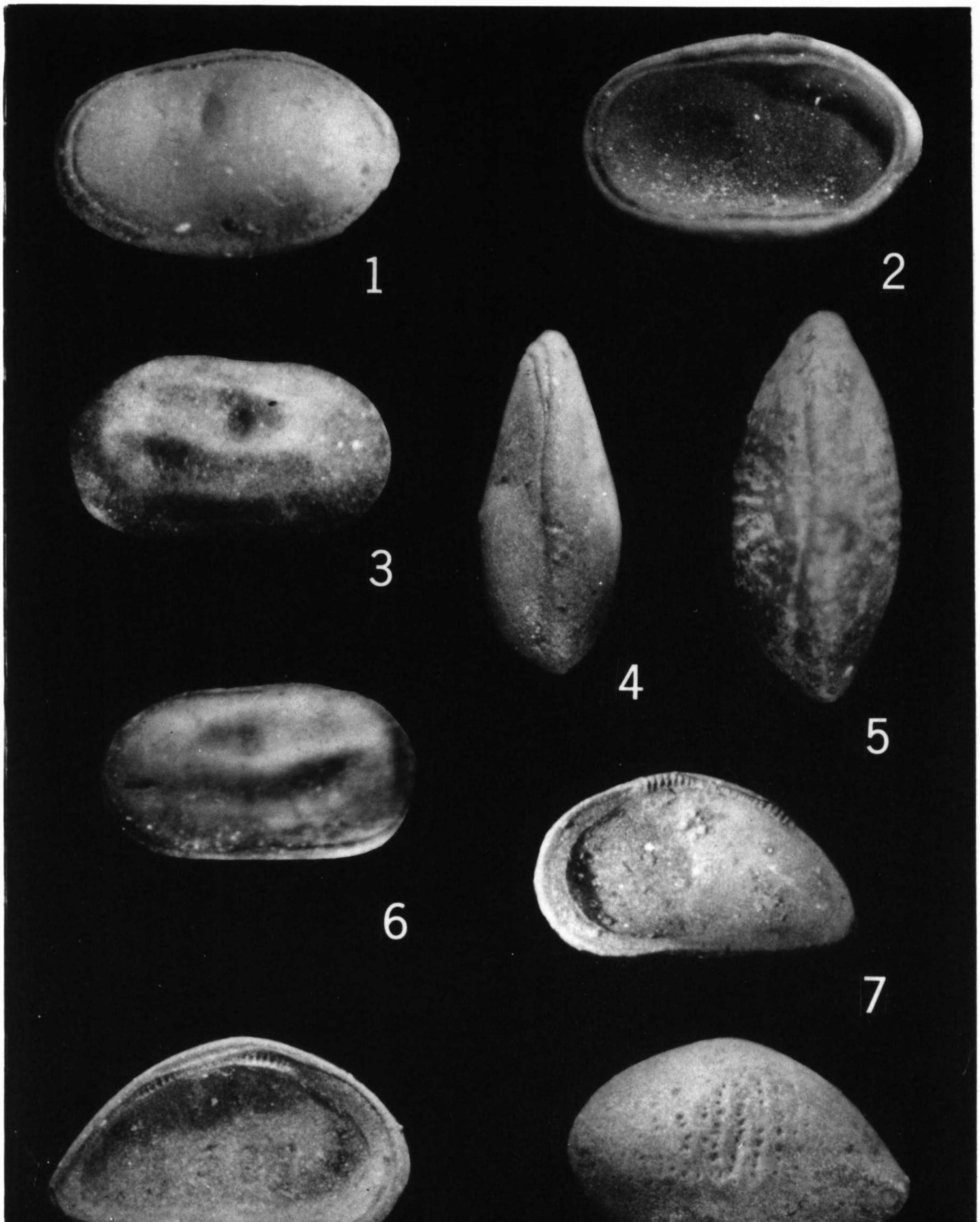
CYTHERELLOIDEA

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,4,5,8-11.—Cytherelloidea montgomeryensis HOWE; ——*1,* interior lateral view of right valve of female, ×90;——*4,* dorsal view of female, ×90; ——*5,* dorsal view of male, ×85;——*8,* exterior lateral view of right valve of complete male specimen, ×85;——*9,* exterior lateral view of left valve of complete male specimen, ×85;——*10,* exterior lateral view of right valve of female, ×85;——*11,* exterior lateral view of left valve of complete female specimen, ×85	29
2,3,6,7.—Cytherelloidea nanafaliensis HOWE;——*2,* dorsal view of male, ×95;——*3,* exterior lateral view of complete male specimen, ×85; *6,* dorsal view of female, ×95;——*7,* ventral view of female, ×95	29



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

CYTHERELLOIDEA LEONENSIS Howe, 1934

Cytherelloidea leonensis HOWE, 1934, p. 34, pl. 5, fig. 9; VAN DEN BOLD, 1946, p. 62; SEXTON, 1951, p. 808, pl. 115, fig. 5; PURI, 1953, p. 301, pl. 17, fig. 3, text-fig. 14c; VAN DEN BOLD, 1958, p. 396; ———, 1963b, p. 372.
Cytherelloidea purii SEXTON, 1951, p. 815, pl. 117, fig. 16.

Diagnosis. Characterized by an elongate U-shaped rim that parallels the dorsal, anterior, and ventral margins, and two longitudinal ribs originating as swellings on posterior margin. Uppermost rib restricted to posterior one-third of carapace whereas lower rib connects with U-shaped marginal rim just dorsal to anteroventral angle. *U.Mio.-Plio.*

Remarks. The species described by SEXTON (1951, p. 815) as *Cytherelloidea purii* from the upper Miocene of Florida is conspecific with the older species *C. leonensis.* The reticulate carapace and the denticles around the anterior margin of *C. umbonata* EDWARDS (1944, p. 506) readily distinguish it from *C. leonensis.* The specimens were too poorly preserved to enable adequate illustration.

Dimensions. Left valve: length 0.68 mm, height 0.33 mm. These dimensions compare quite favorably with the holotype: length 0.62 mm, height 0.32 mm.

Material. Duplin Formation: 6 specimens.

Occurrence. Duplin Formation: Locality 21-1 (unit 2).

This distinctive species was originally described from the upper Miocene, *Ecphora* facies of Florida (HOWE, 1934, p. 34). It has subsequently been reported from the *Ecphora* and *Cancellaria* facies of Florida by PURI (1953d, p. 301), the Miocene of British Honduras and Guatemala (VAN DEN BOLD, 1946, p. 62), the Miocene and Pliocene of Trinidad (VAN DEN BOLD, 1958, p. 396), and the upper Miocene, Springvale Formation of Trinidad (VAN DEN BOLD, 1963b, p. 372).

CYTHERELLOIDEA MONTGOMERYENSIS Howe, 1934

Pl. 1, figs. 1, 4, 5, 8-11

Cytherelloidea montgomeryensis HOWE, 1934, p. 31, pl. 5, fig. 1; HOWE & CHAMBERS, 1935, p. 7, pl. 5, fig. 4; GARRETT, 1936, p. 786; MONSOUR, 1937, p. 94; SEXTON, 1951, p. 808, 810, pl. 115, fig. 21; KRUTAK, 1961, p. 772, pl. 93, figs. 7, 10.

Diagnosis. Female carapaces characterized by two longitudinal ridges. Both ridges originate at posterior rim with ventral ridge essentially straight and dorsal ridge curving ventrally beneath sulcus. Both ridges terminate short of anterior margin. Male carapaces characterized by dorsal ridge being slightly longer than ventral ridge with both ridges terminating short of anterior and posterior margins. *M.Eoc.-U.Eoc.*

Remarks. The female is readily distinguished from the male by a wider posterior and the presence of two circular depressions, one at the posterodorsal angle and the other at the posteroventer. Hinge of the right valve consists of a peripheral groove which receives the peripheral ridge of the left valve. Just posterior to the center and within the peripheral groove of the right valve is a prominent depression which corresponds to a toothlike extension of the peripheral ridge of the left valve.

HOWE & CHAMBERS (1935, p. 7) recognized a variety of *Cytherelloidea danvillensis* that was differentiated on the basis of the lack of a low rounded semicircular ridge above the external depression. Actually this form is the male of *C. montgomeryensis.*

A form illustrated by BROWN (1958, p. 56, pl. 1, fig. 7) from the upper? Eocene of North Carolina as *Cytherelloidea danvillensis* may be *C. montgomeryensis.*

Dimensions. Female: length 0.65 mm, thickness 0.26 mm, height 0.39 mm. Male: length 0.61 mm, thickness 0.22 mm, height 0.35 mm.

Material. Santee Limestone: 7 specimens of which 5 were females.

Occurrence. Santee Limestone: Locality 38-103, Auger Hole 38-23 (50′).

Reported from the Jackson Group of Louisiana and Mississippi (HOWE, 1934, p. 32), Ocala Limestone of Alabama (GARRETT, 1936, p. 786), and the Cocoa Sand Member of the Jackson Group of Alabama (KRUTAK, 1961, p. 772).

CYTHERELLOIDEA NANAFALIENSIS Howe, 1934

Pl. 1, figs. 2, 3, 6, 7; pl. 2, figs. 3, 6

Cytherelloidea nanafaliensis HOWE, 1934, p. 30, pl. 5, fig. 10; HOWE & GARRETT, 1934, p. 27, pl. 1, fig. 4; SEXTON, 1951, p. 808, pl. 116, fig. 1.

EXPLANATION OF PLATE 2

CYTHERELLA, CYTHERELLOIDEA, HAPLOCYTHERIDEA

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,2,4.—Cytherella excavata ALEXANDER;——*1,* exterior lateral view of left valve of complete female specimen;——*2,* interior lateral view of right valve of female;——*4,* dorsal view of female, all ×80.	28
3,6.—Cytherelloidea nanafaliensis HOWE;——*3,* exterior lateral view of right valve of complete female specimen;——*6,* exterior lateral view of left valve of complete female specimen, all ×80.	29
5,7-9.—Haplocytheridea stuckeyi STEPHENSON;——*5,* dorsal view of female, ×75;——*7,* interior lateral view of right valve of female, ×70;——*8,* interior lateral view of left valve of female, ×70;——*9,* exterior lateral view of left valve of female, ×65.	42

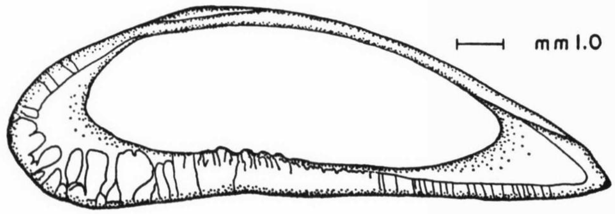


FIG. 7. Internal lateral view of left valve of *Paracypris kaesleri*.

Diagnosis. Characterized by its smooth surface, small rounded pit within depressed area just dorsal to middle, and lack of marginal rim. *L.Eoc.*

Remarks. The female of this form was well described by HOWE (1934, p. 30). The South Carolina material contains both male and female carapaces. The male lacks the posterior swelling that is so prominent on female carapaces and is thickest just posterior to middle, whereas the female is thickest at the posterior extremity. The male is shorter, narrower, and not so high as the female.

Dimensions. Female length 0.57 mm, thickness 0.24 mm, height 0.31 mm. Male: length 0.53 mm, thickness 0.20 mm, height 0.28 mm.

Material. Black Mingo Formation: 63 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4).

Reported from the lower Eocene, Nanafalia Formation of Alabama and Louisiana.

Suborder PODOCOPINA Sars, 1866

Superfamily CYPRIDACEA Baird, 1845

Family PARACYPRIDIDAE Sars, 1923

Genus PARACYPRIS Sars, 1866

Paracypris SARS, 1866, p. 12; BRADY & NORMAN, 1889, p. 31; G. W. MÜLLER, 1894, p. 243; ———, 1912, p. 125; SARS, 1923, p. 69; VAN DEN BOLD, 1946, p. 22; KEIJ, 1957, p. 51; BENSON, 1959, p. 40; SWAIN, 1961, p. Q245; BENSON & COLEMAN, 1963, p. 16.

Aglaia BRADY, 1868, p. 90.

Phlyctenophora BRADY & NORMAN, 1889, p. 94.

Type-species. *Paracypris polita* SARS, 1866, p. 12.

Diagnosis. Distinguished from other closely related genera by its large, wedge-shaped, posteroventrally pointed, smooth carapace. Left valve overlaps right anterodorsally. Hinge adont. Duplicature broad, with wide vestibules, radial pore-canals bifurcated. Muscle-scar pattern consists of anterior row of three or four scars with two posterior. *Sil?, Jur.-Rec.*

PARACYPRIS KAESLERI Pooser, n. sp.

Pl. 19, figs. 2, 3; text-fig. 7

Diagnosis. Characterized by a very finely pitted surface, regularly arched dorsum, anterior radial pore-canals extending from extremities of digitate vestibule, and denticulate inner margin. *Oligo.*

Description. Carapace elongate, fragile; elongate and tapered toward posterior in lateral outline; elongate in dorsal view. Greatest height and width just anterior to middle; dorsal margin evenly arched and slopes backward; ventral margin slightly sinuate; anterior end obliquely rounded; posterior end acuminate. Left valve overlaps right except around anterior with greatest overlap just anterior to anterior cardinal angle. Surface smooth, with very fine pits imparting an etched appearance.

Hinge simple, wiht flange of right valve fitting into accommodation groove of left valve and bar in left valve seated in groove below flange of right valve. Duplicature broad, with digitate anterior vestibule; large, regular, acuminate vestibule in posterior. Anterior radial pore-canals extend from digitations of vestibule; posterior radial pore-canals numerous, short, and simple. Denticulate inner margin. Muscle-scar pattern not observed.

Remarks. *Paracypris kaesleri* differs from *P. franquesi* HOWE & CHAMBERS (1935) in having an evenly

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EXPLANATION OF PLATE 3

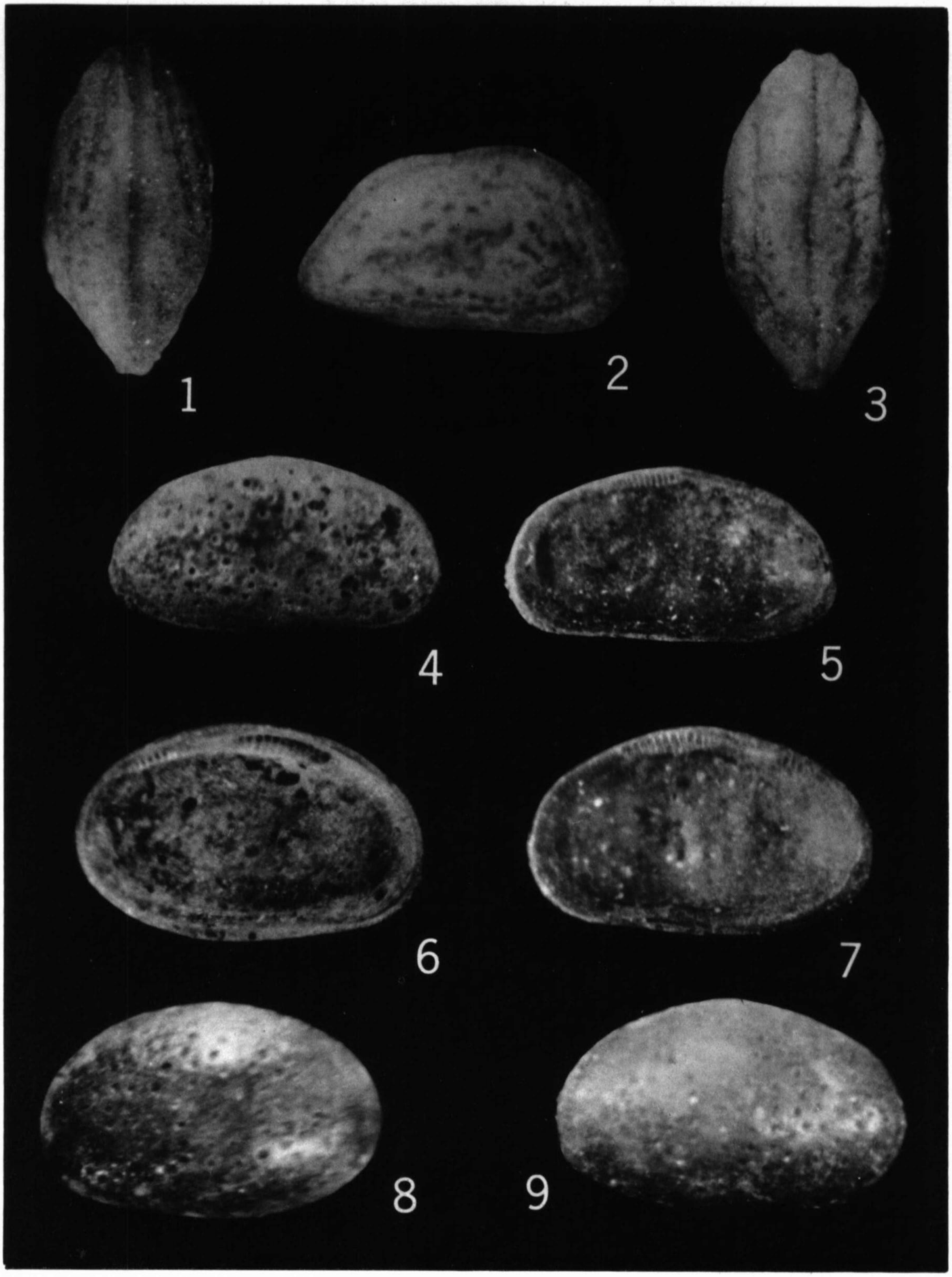
CLITHROCYTHERIDEA, HAPLOCYTHERIDEA

(All illustrated forms are from South Carolina)

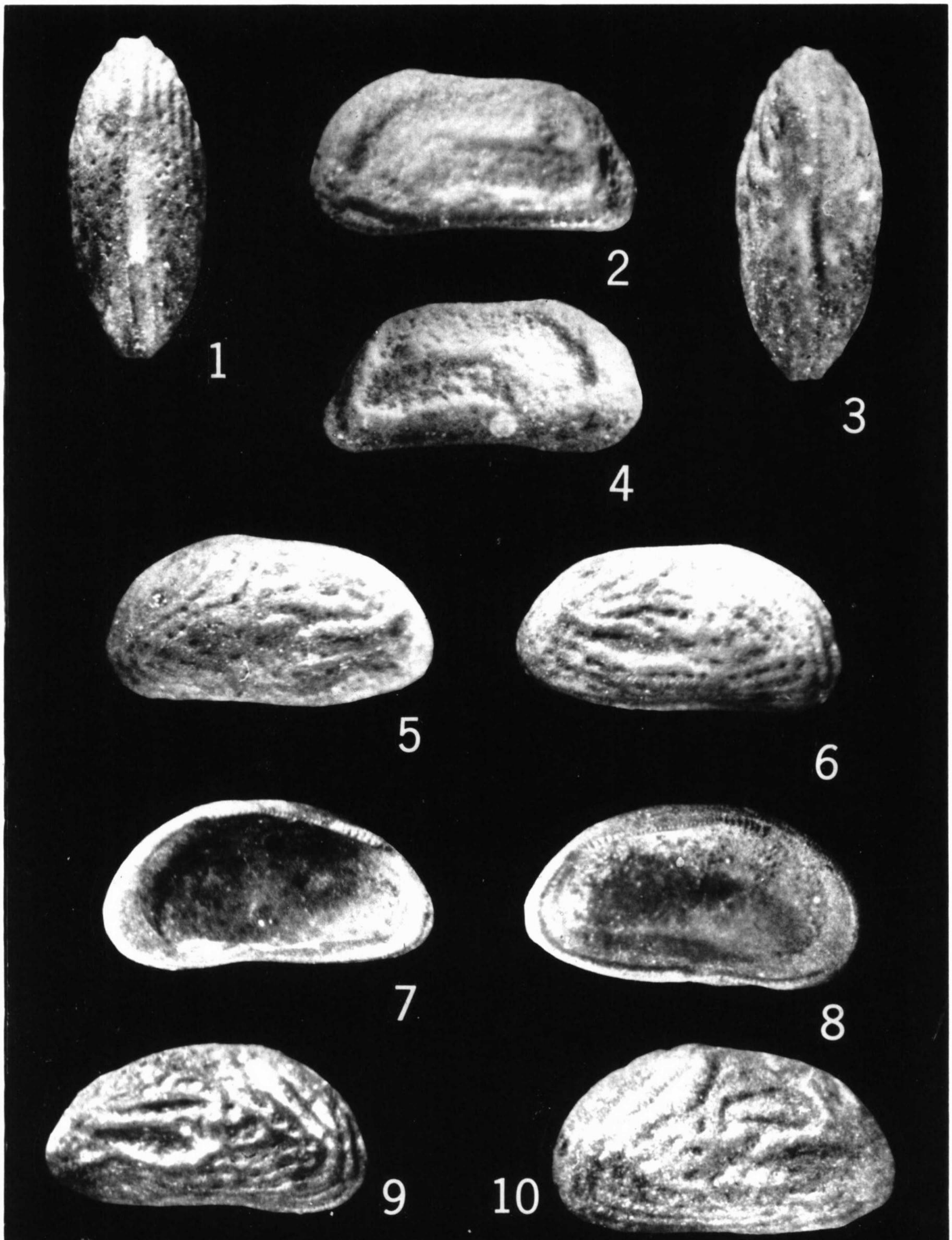
FIGURE PAGE

1-3.—Clithrocytheridea virginica SCHMIDT;——*1*, ventral view of female;——*2*, exterior lateral view of right valve of complete female specimen;——*3*, dorsal view of female, all ×75. 40

4-9.—Haplocytheridea bassleri STEPHENSON;——*4*, exterior lateral view of right valve of male;——*5*, interior lateral view of right valve of male;——*6*, interior lateral view of left valve of female;——*7*, interior lateral view of right valve of female;——*8*, exterior lateral view of left valve of complete female specimen;——*9*, exterior lateral view of right valve of complete female specimen, all ×60. 43



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

arched dorsum, an irregular anterior vestibule, and a denticulate inner margin. *P. rosefieldensis* HOWE & LAW (1936) is similar to *P. kaesleri* in shape but lacks the irregular anterior vestibule and digitate inner margin of *P. kaesleri*.

This species is named for Roger L. Kaesler, a fellow student attending the University of Kansas.

Dimensions. Holotype (right valve) from Auger Hole 8-39 (12?-21?'): length 1.27 mm, thickness 0.19 mm, height 0.43 mm. Left valve length 1.28 mm, thickness 0.22 mm, height 0.44 mm.

Material. Cooper Marl: A total of 7 specimens were examined. The holotype is deposited in the U.S. National Museum, Smithsonian Institution, Washington, D.C.; WKP821621.

Occurrence. Cooper Marl: Localities 18-3 and 8-4. Auger Hole 8-39 (12?-21?' and 25-30').

Superfamily CYTHERACEA Baird, 1850

Family BRACHYCYTHERIDAE Puri, 1954

Genus BRACHYCYTHERE Alexander, 1933

Brachycythere ALEXANDER, 1933, p. 204; MURRAY & HUSSEY, 1942, p. 164; STEPHENSON, 1946, p. 306, 331; MUNSEY, 1953, p. 10; BENSON, 1959, p. 49; HOWE, 1961, p. Q260.

Type-species. Cythere sphenoides REUSS, 1854, p. 141, pl. 26, fig. 2.

Diagnosis. Recognized by its subtriangular or subrectangular carapace. Surface smooth or reticulate, usually with a ventral keel; no vestibules; hinge hemiamphidont with accommodation groove above median bar of left valve. *U.Cret.-Rec.*

BRACHYCYTHERE INTERRASILIS Alexander, 1934

Pl. 21, figs. 1, 2, 11

Brachycythere interrasilis ALEXANDER, 1934, p. 217, pl. 33, fig. 4; KLINE, 1943, p. 67, pl. 8, fig. 5; HARRIS & JOBE, 1951, p. 70, pl. 12, fig. 4; BROWN, 1958, p. 60, pl. 2, fig. 6.

Brachycythere marylandrica (Ulrich), MURRAY & HUSSEY, 1942, p. 174, pl. 27, figs. 7, 8, text-fig. 2, figs. 11-13.

Diagnosis. Characterized by an ovate to subpyriform lateral outline, highest anterior to middle, tumid portion coarsely reticulate, with the reticulate pattern on ventral half of carapace tending to be aligned parallel to ventral margin, whereas that on dorsal half of carapace more or less assumes a vertical alignment. A single strong curved ala parallels the ventrolateral edge of carapace. *Paleoc.*

Remarks. This form is very similar to and may be the ancestral form of *Brachycythere marylandica*. *B. interrasilis* differs from *B. marylandica* in having a more triangular lateral outline and in the possession of a prominent keel along the ventrolateral margin.

ALEXANDER (1934) did not mention in his description of *B. interrasilis* the ridges on the flattened venter; however, a study of specimens from the Midway of Texas as well as those from South Carolina indicates that there are four to five low, rounded, longitudinal ridges on the flattened venter which tend to coalesce both anteriorly and posteriorly. The hinge of the right valve consists of a pointed anterior tooth, a postjacent socket, a finely crenulate groove, and an elongated denticulate posterior tooth. The left valve is the antithesis of the right with the anterior socket bordered ventrally by a prominent rim and a wide accommodation groove above the median element. The interior surface is coarsely punctate.

Dimensions. Right valve: length 1.11 mm, height 0.59 mm. Left valve: 1.12 mm, height 0.66 m. Whole specimen: length 1.12 mm, thickness 0.65 mm.

Material. Black Mingo Formation: 9 specimens.

Occurrence. Black Mingo Formation: Auger Hole 45-2 (21-29').

Brachycythere interrasilis has been reported from the Paleocene, Kincaid and Wills Point formations of Texas (ALEXANDER, 1934, p. 217); the Paleocene, Porters Creek and Clayton formations of Mississippi (KLINE, 1943, p. 67); the Midway Group of Arkansas (HARRIS & JOBE, 1951); and a Paleocene, unnamed unit of North Carolina (BROWN, 1958, p. 60).

BRACHYCYTHERE MARYLANDICA (Ulrich, 1901), Schmidt, 1948

Pl. 19, figs. 4-11

Cythere marylandica ULRICH, 1901, p. 119, pl. 16, figs. 16-18.

Brachycythere nanafaliana HOWE & PYEATT, *in* HOWE & GARRETT,

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EXPLANATION OF PLATE 4

CLITHROCYTHERIDEA

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,3,5-10.—Clithrocytheridea harrisi (STEPHENSON); *1*, ventral view;——*3*, dorsal view;——*5*, exterior lateral view of left valve of complete specimen;——*6*, exterior lateral view of right valve of complete specimen;——*7*, interior lateral view of right valve;——*8*, interior lateral view of left valve;——*9*, exterior lateral view of right valve;——*10*, exterior lateral view of left valve, all ×85.	40
2,4.—Clithrocytheridea ruida (ALEXANDER);——*2*, exterior lateral view of left valve of male;——*4*, exterior lateral view of right valve of male, all ×95.	40

1934, p. 48, pl. 3, fig. 18, pl. 4, figs. 1-3; MURRAY & HUSSEY, 1942, p. 180, pl. 28, figs. 11, 12, text-fig. 2, fig. 2.
Brachycythere betzi JENNINGS, 1936, p. 47, pl. 6, fig. 12a-c.
Brachycythere marylandica (Ulrich), SCHMIDT, 1948, p. 416, pl. 63, figs. 17-20; *non* MURRAY & HUSSEY, 1942, p. 174, pl. 27, figs. 7, 8, text-fig. 2, figs. 11-13; SWAIN, 1951, p. 44, pl. 7, fig. 1; BROWN, 1958, p. 60, pl. 2, fig. 5.

Diagnosis. Characterized by its elongate-subquadrate carapace that is thickest in posteroventral region. Tumid portion of carapace coarsely reticulate and sharply defined from smooth and compressed anterior and posterior margins. Venter flattened, with small ridges paralleling ventral margin. *Paleoc.-L.Eoc.*

Remarks. MURRAY & HUSSEY (1942) considered *Brachycythere marylandrica* [*sic*] and *B. interrasilis* to be conspecific, but considered *B. nanafaliana* as a separate species. The author is of the opinion that *B. marylandica* and *B. nanafaliana* are conspecific and that *B. interrasilis* is a closely related species but may be readily distinguished from *B. marylandica* by its pyriform lateral outline and prominent ala.

Dimensions. Right valve: length 1.08 mm, height 0.56 mm. Left valve: length 1.09 mm, height 0.60 mm. Whole specimen: length 1.09 mm, thickness 0.64 mm.

Material. Black Mingo Formation: 39 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4).

Reported from the lower Eocene of North Carolina (SWAIN, 1951, p. 44); Paleocene and lower Eocene, unnamed unit of North Carolina (BROWN, 1958, p. 60); lower Eocene, Aquia Formation of Maryland (ULRICH, 1901, p. 119); Aquia Formation of Maryland and Virginia (SCHMIDT, 1948, p. 416); Hornerstown Formation of New Jersey (JENNINGS, 1936, p. 47); Nanafala and Hatchetigbee formations of Louisiana and Alabama (HOWE & GARRETT, 1934, p. 48).

BRACHYCYTHERE MARTINI Murray & Hussey, 1942

Pl. 16, figs. 11-13

Brachycythere martini MURRAY & HUSSEY, 1942, p. 177, pl. 28, figs. 6, 10, text-fig. 2, figs. 4, 8-10; STEPHENSON, 1946, p. 333, pl. 44, fig. 21, pl. 45, fig. 24; BLAKE, 1950, p. 177, pl. 30, figs. 28, 29; BROWN, 1958, p. 60, pl. 2, fig. 2.
Brachycythere sp. cf. *B. martini* Murray & Hussey, SWAIN, 1951, p. 44, pl. 6, fig. 26.

Diagnosis. Characterized by large shallow pits, restricted to the tumid portion of the carapace, which give a faint reticulated appearance, and a narrow but prominent concave ala that originates just dorsal to the anteroventer and terminates posterior to the middle as a short spine. *M.-U.Eoc.*

Remarks. Brachycythere martini is readily recognized by the faint reticulations on the tumid portion of the carapace. MURRAY & HUSSEY (1942, p. 178) reported that this type of ornamentation is characteristic of no other species.

Dimensions. Length 1.09 mm, thickness 0.64 mm, height 0.63 mm.

Material. Warley Hill Formation: 5 specimens. Santee Limestone: 48 specimens.

Occurrence. Warley Hill Formation: Locality 8-3 (units 1 and 3). Santee Limestone: Localities 9-28, 38-10, 38-22, 38-26, 38-85, 38-103, and 18-1 (units 1 and 3). Auger Holes 38-5 (70′ and 85-100′), 38-11 (10-15′ and 20-25′), 38-15 (70′), 38-23 (25′), 38-29 (14′), 38-35 (70-74′), 38-37 (56-65′), and 38-40 (65-70′).

Reported from the Weches Formation of Texas; Cane River, Cook Mountain, and Moodys Branch formations of Louisiana; Yazoo Formation of Mississippi; the McBean Formation of Georgia (MURRAY & HUSSEY, 1952, p. 178); Gosport Formation of Alabama (BLAKE, 1950, p. 177); Enterprise Marl of Mississippi (STEPHENSON, 1946, p. 333); and the middle Eocene of North Carolina (SWAIN, 1951, p. 44 and BROWN, 1958, p. 60).

Genus ALATACYTHERE Murray & Hussey, 1942

Alatacythere MURRAY & HUSSEY, 1942, p. 169; HOWE, 1961, p. Q260.
Type-species. Cythereis (Pterygocythereis?) alexanderi HOWE & LAW, 1936, p. 42, pl. 4, fig. 23, pl. 5, fig. 5. [=*Alatacythere ivani* HOWE, 1951, p. 538 *(nom. nov.)*].

Diagnosis. Identical in all essential features except hinge to *Pterygocythereis;* hinge hemiamphidont. *U. Cret.-Oligo.*

ALATACYTHERE IVANI Howe, 1951

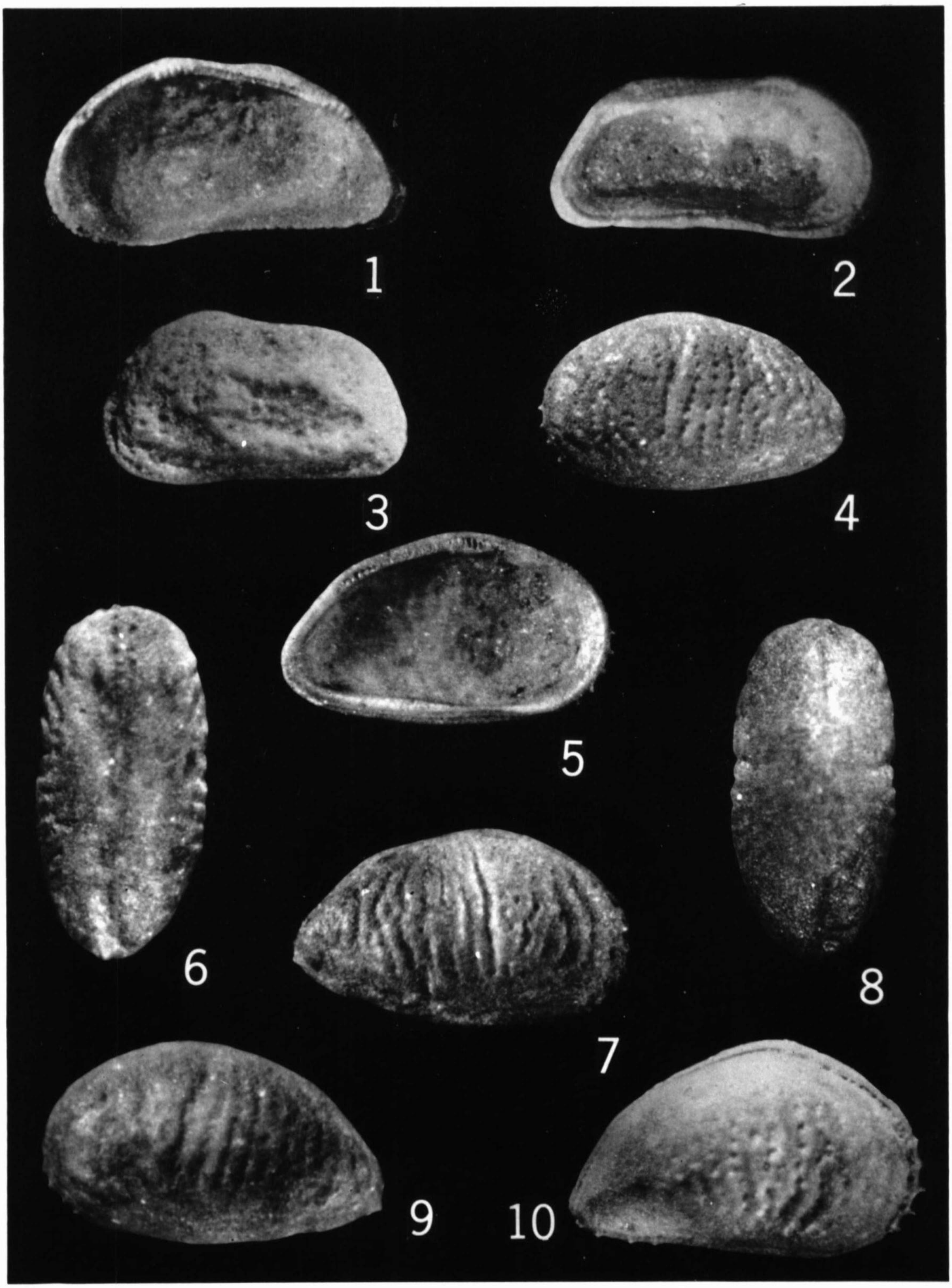
Pl. 18, figs. 9, 11

Cythereis (Pterygocythereis?) alexanderi HOWE & LAW, 1936, p. 42, pl. 4, fig. 23, pl. 5, fig. 5.
Alatacythere alexanderi (Howe & Law), MURRAY & HUSSEY, 1942, p. 171, pl. 27, figs. 10, 11, text-fig. 1, figs. 2, 10.

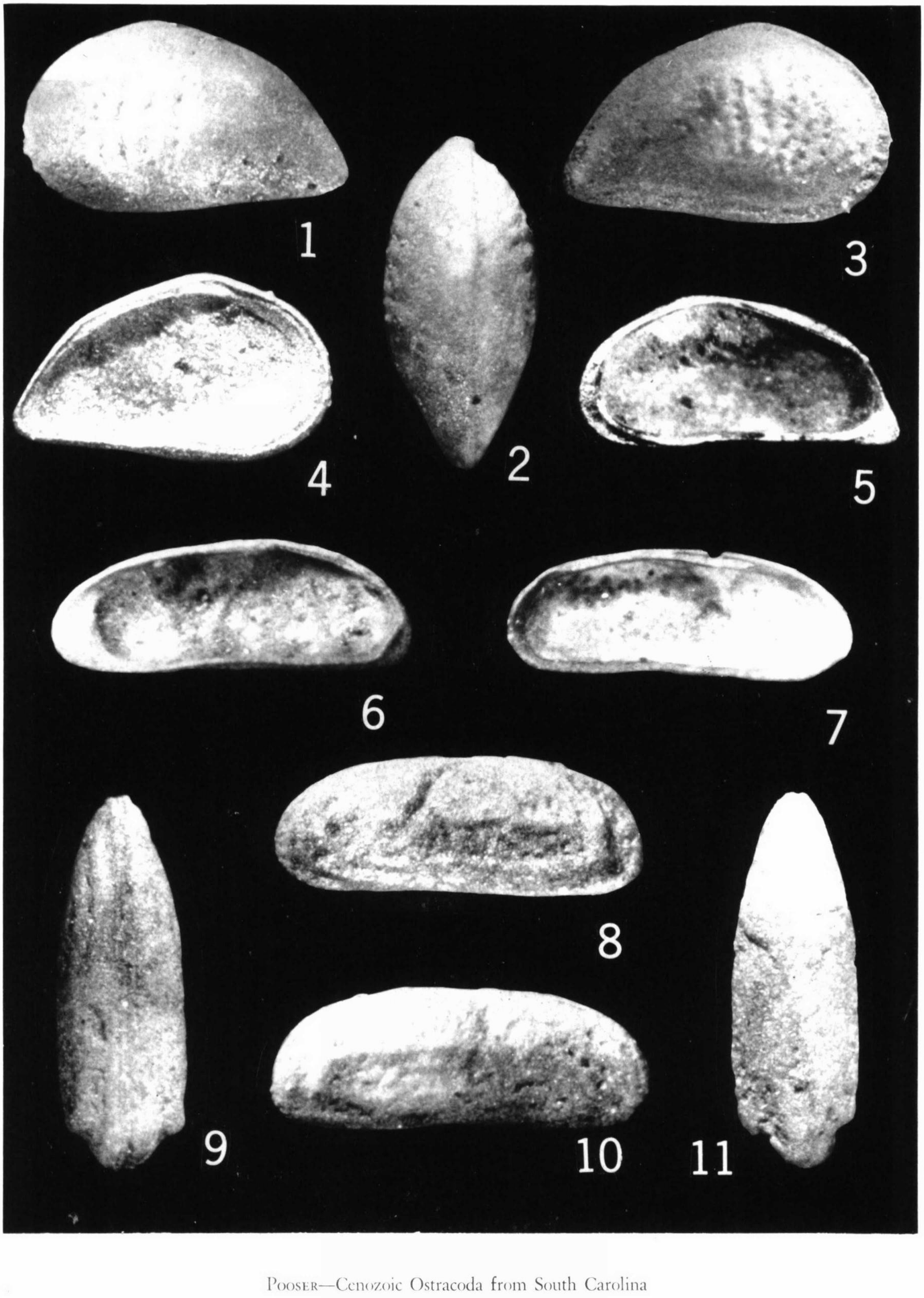
EXPLANATION OF PLATE 5
CLITHROCYTHERIDEA, HAPLOCYTHERIDEA

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1-3.—Clithrocytheridea ruida (ALEXANDER);——*1,* interior lateral view of right valve of male;——*2,* interior lateral view of left valve of male;——*3,* exterior lateral view of left valve of female, all ×95.	40
4-9.—Haplocytheridea moodyi (HOWE & GARRETT);——*4,* exterior lateral view of left valve, ×70;——*5,* interior lateral view of left valve, ×75;——*6,* ventral view, ×75;——*7,* exterior lateral view of right valve of complete specimen, ×70;——*8,* dorsal view, ×70;——*9,* exterior lateral view of left valve of complete specimen, ×75.	42
10.—Haplocytheridea montgomeryensis (HOWE & CHAMBERS); exterior lateral view of right valve of complete specimen, ×65.	41



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

Alatacythere ivani HOWE, 1951b, p. 538; BROWN, 1958, p. 62, pl. 8, fig. 4; HOWE, 1961, p. Q260, fig. 190, 4.

Diagnosis. Characterized by a large, fragile, subquadrate, strongly alate carapace. Dorsal margin partially obscured by series of thin plates. Posterior margin with 4 to 5 stout spines, the uppermost of which is located at the posterodorsal angle. Anterior margin bears a double row of flattened spines. *Paleoc.?, L.Eoc.-Oligo.*

Remarks. *Alatacythere ivani* has been well-described by HOWE & LAW (1936, p. 42) and MURRAY & HUSSEY (1941, p. 171). MURRAY & HUSSEY indicated that the present form is very similar to *A. lemnicata* ALEXANDER (1934) from the Midway of Texas and Claiborne of Louisiana and has probably evolved from that form. *A. ivani* differs from *A. lemnicata* in the possession of a double instead of a single row of spines around the anterior margin and in the absence of a row of low rounded beads just behind the base of the spines. In addition the culminating spine on the ala of *A. lemnicata* is more erect and less strongly developed than is that of *A. ivani*.

The South Carolina specimens exhibit widely and evenly spaced alar canals that terminate prior to reaching the periphery of the ala. The ala, originating just posterior to the anteroventral angle, possesses a curved plate on its posterior extremity between the terminal spine of the ala and the carapace proper. Left valves only were recovered from the South Carolina sediments, and the interior of these were filled with matrix.

Dimensions. Figured specimen: locality 18-1 (unit 4), Cooper Marl. Length 1.20 mm; height 0.69 mm.

Material. Cooper Marl: 4 broken left valves.

Occurrence. Cooper Marl: Localities 18-1 (unit 4) and 18-3. This species ranges in the Gulf states from the Jackson through the Vicksburg. It has been reported from the Cooper Marl of South Carolina which was previously considered Jackson in age. In addition BROWN (1958, p. 62) has reported *Alatacythere ivani* from the upper?, middle, and lower Eocene, and a Paleocene? unnamed unit of North Carolina.

Genus DIGMOCYTHERE Mandelstam, 1958

Digmocythere MANDELSTAM *in* ABUSHIK AND OTHERS, 1958, p. 277; MANDELSTAM, 1960, p. 388; HOWE, 1961, p. Q262; HOWE, 1962, p. 73.

Type-species. Brachycythere russelli Howe & Lea, *in* HOWE & LAW, 1936, p. 41, pl. 2, figs. 30, 31, pl. 3, figs. 23-25. (*non Brachycythere lünensis* TRIEBEL, 1941, *in* MANDELSTAM, 1960).

Diagnosis. Characterized by a smooth, brachycytherid shaped carapace with a weak eye tubercle. Hinge paramphidont with accommodation groove above median bar in left valve. Fused duplicature. *Paleoc.?, L.Eoc.-Oligo.*

DIGMOCYTHERE RUSSELLI (Howe & Lea, 1936), Mandelstam, 1958

Pl. 18, figs. 3, 5-7

Brachycythere watervalleyensis HOWE & CHAMBERS, 1935, pl. 3, fig. 4 (not pl. 3, figs. 1-3, 5, 6; not pl. 6, fig. 7).

Brachycythere russelli Howe & Lea, *in* HOWE & LAW, 1936, p. 41, pl. 2, figs. 30, 31, pl. 3, figs. 23-25; MURRAY & HUSSEY, 1942, p. 178, pl. 28, figs. 1, 4, 5, 8, text-fig. 1, figs. 19-24, text-fig. 2, fig. 1; STEPHENSON, 1946, p. 333, pl. 44, fig. 22, pl. 45, fig. 19.

Brachycythere sp. cf. *B. hadleyi* Stephenson, SWAIN, 1951, p. 44, pl. 7, figs. 7-9.

Diagnosis. Characterized by its smooth, elongate, subquadrate carapace; highest anterior to middle; flattened venter; and a narrow ventrolateral ala. *Paleoc.?, L.Eoc.-Oligo.*

Remarks. The South Carolina specimens were compared with specimens of *Digmocythere russelli* from the Jackson of Alabama and were found to be identical in all respects. In addition the South Carolina forms appear externally to be identical to the form illustrated by SWAIN (1951, p. 44, pl. 7, figs. 7-9) as *Brachycythere* sp. cf. *B. hadleyi*.

The interior of *Digmocythere russelli* is characterized by a paramphidont hinge with a smooth median element, moderately wide fused duplicature,

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EXPLANATION OF PLATE 6

HAPLOCYTHERIDEA, HULINGSINA, CUSHMANIDEA

(All illustrated forms are from South Carolina)

FIGURE PAGE

1-4.—Haplocytheridea montgomeryensis HOWE & CHAMBERS;——*1*, exterior lateral view of left valve;——*2*, dorsal view.——*3*, exterior lateral view of right valve of complete specimen;——*4*, interior lateral view of left valve, all ×75. 41

5.—Hulingsina ashermani (ULRICH & BASSLER); interior lateral view of right valve of immature form, ×80. 45

6-11.—Cushmanidea caledoniensis (MUNSEY);——*6*, interior lateral view of right valve;——*7*, interior lateral view of left valve;——*8*, exterior lateral view of left valve of complete specimen;——*9*, ventral view;——*10*, exterior lateral view of right valve of complete specimen; *11*, dorsal view, all ×90. 44

and a prominent flange groove around the entire free margin of the right valve. Well-preserved specimens exhibit spines on the ventral portion of the anterior and posterior margins as well as spines on the posterior portion of the upturned ala.

Dimensions. Length 1.04 mm, thickness 0.69 mm, height 0.61 mm.

Material. Warley Hill Formation: 3 specimens. Santee Limestone: 38 specimens.

Occurrence. Warley Hill Formation: Locality 8-3 (unit 3). Auger Hole 14-3 (62'?). Santee Limestone: Localities 9-28, 9-32, 9-33, 9-54, and 38-26. Auger Hole 38-85 (70-74').

Reported from the Claiborne Eocene through the Oligocene in the Gulf (Murray & Hussey, 1942, p. 178). The form identified by Swain (1951, p. 44) as *Brachycythere* sp. cf. *B. hadleyi* that appears to be conspecific with *D. russelli* occurs in the North Carolina Paleocene?, lower Eocene, and middle Eocene sediments.

Genus PTERYGOCYTHEREIS Blake, 1933

Pterygocythereis Blake, 1933, p. 239; Triebel, 1941, p. 385; van den Bold, 1946, p. 29; Sylvester-Bradley, 1948, p. 793; Keij, 1957, p. 94; Benson, 1959, p. 58; Howe, 1961, p. Q267; Benson & Coleman, 1963, p. 21.

Type-species. Cythereis jonesii Baird, 1850, p. 175, pl. 20, fig. 1.

Diagnosis. Distinguished by its subrectangular carapace with arrowhead-shaped dorsal view, prominent alae, and surface smooth or ornamented with spines or ridges. Holamphidont hinge. *Mio.-Rec.*

PTERYGOCYTHEREIS AMERICANA (Ulrich & Bassler, 1904), Malkin, 1953

Pl. 13, figs. 3, 7, 11-14; Pl. 14, fig. 12

Cythereis cornuta var. *americana* Ulrich & Bassler, 1904, p. 122, pl. 37, figs. 29-33.

Cythereis alaris Ulrich & Bassler, 1904, p. 123, pl. 38, figs. 34-36.

Cythereis (Pterygocythereis) cornuta var. *americana* (Ulrich & Bassler), Howe and others, 1935, p. 26, pl. 2, figs. 19, 21-24, pl. 4, fig. 24; Swain, 1948, p. 206, pl. 14, fig. 4.

Pterygocythereis cornuta americana (Ulrich & Bassler), Swain, 1951, p. 41; Puri, 1953d, p. 261, pl. 13, figs. 1-5, text-figs. 9d-f.

Pterygocythereis americana (Ulrich & Bassler), Malkin, 1953, p. 795, pl. 80, figs. 26-29; Hill, 1954, p. 814; McLean, 1957, p. 80, pl. 9, figs. 5a-d, 6a-e.

Pterygocythereis sp. aff. *P. americana* (Ulrich & Bassler), Benson & Coleman, 1963, pl. 5, figs. 1-3, text-fig. 10.

Diagnosis. Characterized by an en echelon arrangement of fused plates along the dorsal margin. *Oligo.-Rec.*

Remarks. This form was originally described as a variety of *Pterygocythereis cornuta* (Roemer) by Ulrich & Bassler (1904); however, *P. cornuta* has only a short curved ridge in the posterodorsal region whereas *P. americana* is characterized by two *en echelon* plates that obscure the entire dorsal margin. These en echelon plates are sufficiently constant and diagnostic to warrant designating forms with this unique ornamentation as a separate species rather than a subspecies of *P. cornuta.*

The elongated rugose swelling just anterior to the posterodorsal angle of *P. retinodosa* Oertli (1956) readily distinguishes this species from *P. americana.* McLean (1957, p. 82) recognized *Cythereis alaris* Ulrich & Bassler as the young molt of *P. americana.*

Neither Ulrich & Bassler nor Howe and others (1935) made mention of crenulations on the median elements of *P. americana,* however a finely crenulate median bar and groove were noted by the author as well as by Swain (1951) and McLean (1957).

Dimensions. Length 1.05 mm, thickness 0.70 mm, height 0.52 mm.

Material. Cooper Marl: 43 specimens. Duplin Formation: 3 specimens.

Occurrence. Cooper Marl: Localities 18-3, 18-8 (unit 1), 18-9 (unit 2), 38-13, and 8-4. Auger Holes 8-39 (12?-21?' and 25-50'), 8-40 (4-7'), 8-49 (13'), and 18-4 (35'). Duplin Formation: Locality 21-1 (unit 2).

Originally described from the middle Miocene, Calvert Formation of Maryland (Ulrich & Bassler, 1904, p. 122). It has also been reported from the Calvert Formation of Maryland and the upper Miocene, Yorktown Formation of Virginia by Malkin (1953, p. 795); upper Miocene of Virginia (McLean, 1957); upper Miocene of North Carolina (Swain, 1951, p. 42); and the middle to upper Miocene of Florida (Howe and others, 1935 and Puri, 1953); the Recent of the Mississippi Delta by Curtis (1960), and the Recent of the eastern Gulf of Mexico (Benson & Coleman, 1963).

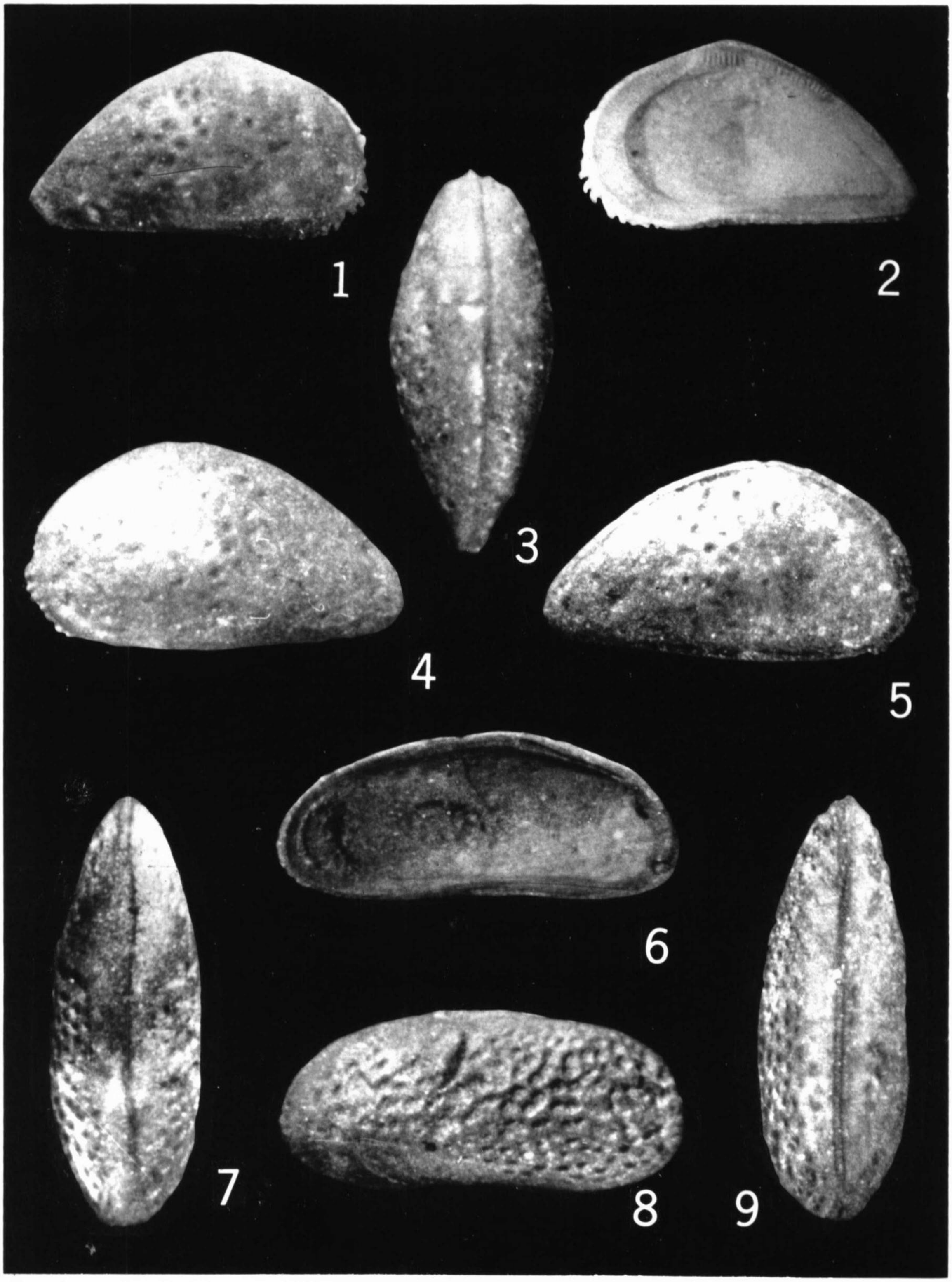
EXPLANATION OF PLATE 7
HAPLOCYTHERIDEA, CUSHMANIDEA

(All illustrated forms are from South Carolina)

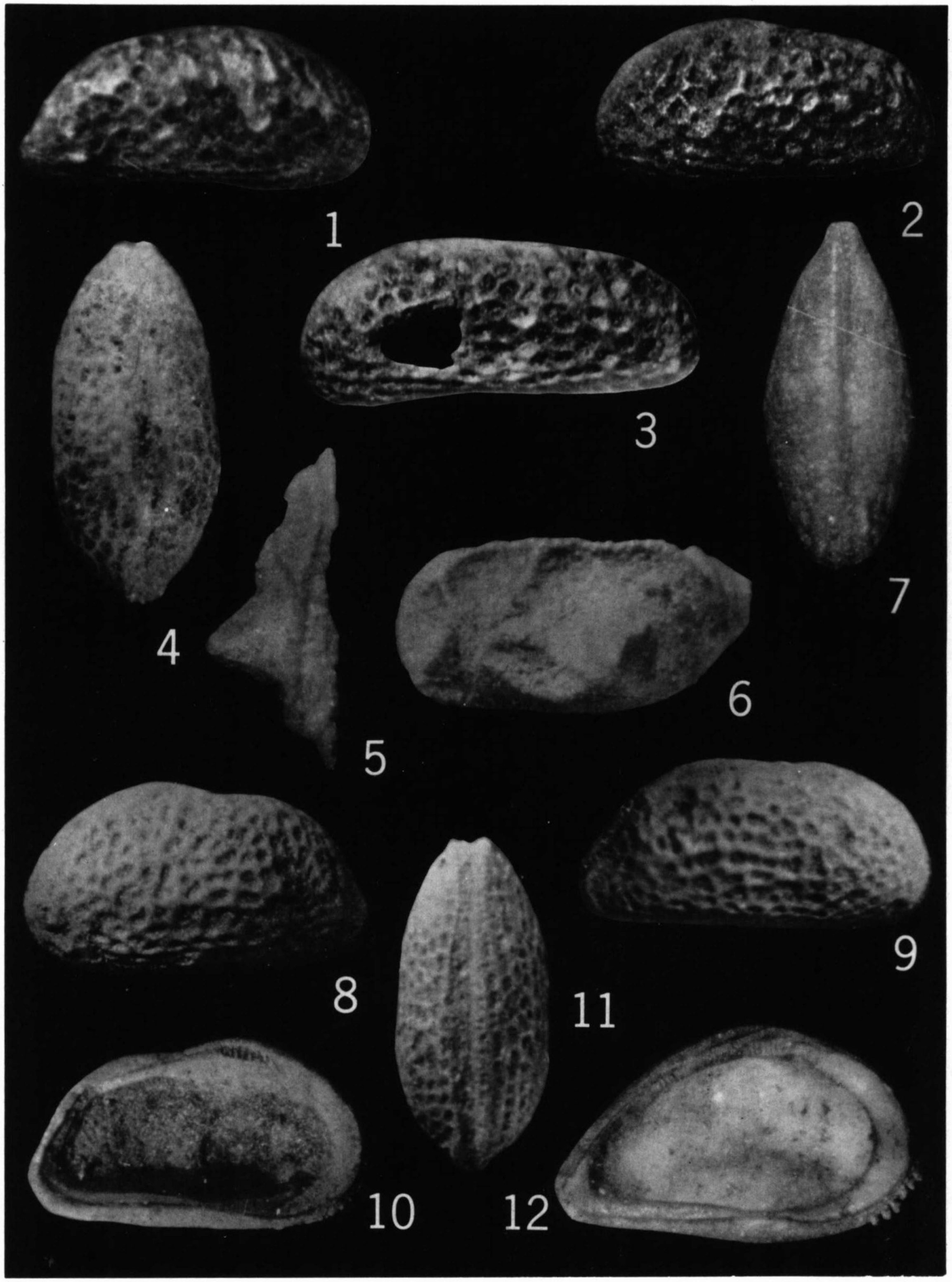
Figure — Page

1-5.—Haplocytheridea leei (Howe & Garrett);——*1,* exterior lateral view of right valve, ×90;——*2,* interior lateral view of right valve, ×90;——*3,* dorsal view, ×100;——*4,* exterior lateral view of left valve, ×100;——*5,* exterior lateral view of right valve of complete specimen, ×100. 42

6-9.—Cushmanidea mayeri (Howe & Garrett);——*6,* interior lateral view of right valve of male;——*7,* dorsal view of male;——*8,* exterior lateral view of left valve of female;——*9,* ventral view of male, all ×105. 44



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

Family CAMPYLOCYTHERIDAE Puri, 1960

Genus LEGUMINOCYTHEREIS Howe, 1936

Leguminocythereis HOWE, *in* HOWE & LAW, 1936, p. 61; VAN DEN BOLD, 1946, p. 31; PURI, 1953a, p. 751; OERTLI, 1956, p. 90; KEIJ, 1957, p. 123, POKORNÝ, 1958, p. 271; BENSON, 1959, p. 68; HOWE, 1961, p. Q307.

Type-species. Leguminocythereis scarabaeus HOWE & LAW, 1936, p. 63, pl. 4, figs. 12, 17, pl. 5, figs. 15-17.

Diagnosis. Characterized by an elongate-ovoid lateral and dorsal outline. Surface coarsely reticulate with dorsal half ornament radiating from dorsum and that of the ventra lhalf tending to parallel the ventral margin. Prominent muscle-scar node along median line and slightly anterior to center, duplicature broad with anterior and posterior vestibules, radial pore-canals few and widely spaced, hinge holamphidont. *Eoc.-Rec.*

LEGUMINOCYTHEREIS SCARABAEUS Howe & Law, 1936

Pl. 18, figs. 1, 2, 4, 8, 10

Leguminocythereis scarabaeus HOWE & LAW, 1936, p. 63, pl. 4, figs. 12, 17, pl. 5, figs. 15-17; KEIJ, 1957, p. 123; BROWN, 1958, p. 63, pl. 6, fig. 9; HOWE, 1961, p. Q307, fig. 188.2.

Leguminocythereis sp. cf. *L. scarabaeus* Howe & Law, SWAIN, 1951, p. 43, pl. 6, figs. 15, 16.

Diagnosis. The type-species of *Leguminocythereis* is characterized by elongate-ovoid lateral and dorsal outlines. Anterior border nonreticulate and separated from remainder of carapace by deep groove. Small but conspicuous muscle-scar node along median line and slightly anterior to middle. Duplicature broad with anterior and posterior vestibules and widely spaced, simple, radial, pore-canals. Hinge holamphidont; right valve consists of rounded anterior tooth and deep postjacent socket that tapers posteriorly to the median groove. The groove widens posteriorly and terminates at the slightly elongated ovoid posterior tooth. *U.Eoc.-Oligo.*

Remarks. Numerous species have been assigned to *Leguminocythereis* by OERTLI (1956), KEIJ (1957) and others that lack the elongate, tapering anterior socket in the right valve as well as the radiating reticulations from the dorsum. Until the concept of *Leguminocythereis* is broadened these forms should not be assigned to this genus.

Dimensions. Length 0.80 mm, thickness 0.49 mm, height 0.44 mm.

Material. Cooper Marl: 9 specimens.

Occurrence. Cooper Marl: Localities 18-3, 18-8 (unit 1), and 38-13.

Leguminocythereis scarabaeus was originally described from the Oligocene, Vicksburg Group of Louisiana and Mississippi (HOWE & LAW, 1936, p. 63). In addition it has been reported from the upper Eocene of North Carolina by SWAIN (1951, p. 43) and BROWN (1958, p. 63).

Genus TRIGINGLYMUS Blake, 1950

Triginglymus BLAKE, 1950, p. 181; KEIJ, 1957, p. 127; HOWE, 1961, p. Q307.

Type-species. Triginglymus hyperochus BLAKE, 1950, p. 181, pl. 30, figs. 4-9.

Diagnosis. Characterized by its elongate-subquadrate carapace, broadest posterior to middle. Ornamentation consists of reticulations, low ridges, or punctae. Marginal area fairly broad with numerous radial pore-canals around the anterior end. Muscle-scar pattern consists of vertical row of four adductor scars with two small antennal scars in front of upper part of row and two mandibular scars just above the ventral inner margin. Hinge; holamphidont and with triangular "anti-slip" tooth anterior to and below middle of dorsal margin. *Eoc.-Rec.*

Remarks. Moos (1957) considered *Triginglymus* BLAKE to be a junior synonym of *Leguminocythereis*. The author is of the opinion that the triangular "anti-slip" tooth of *Triginglymus* and the distinct ornamentation of *Leguminocythereis* readily differentiate these genera.

EXPLANATION OF PLATE 8

HULINGSINA, MONOCERATINA, HAPLOCYTHERIDEA, CLITHROCYTHERIDEA

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1-3.—Hulingsina ashermani (ULRICH & BASSLER); ——*1,* exterior lateral view of right valve;——*2,* exterior lateral view of left valve;——*3,* exterior lateral view of left valve (elongate form with hole in carapace), all ×70.	45
5,6.—Monoceratina alexanderi HOWE & CHAMBERS; ——*5,* dorsal view, ×80;——*6,* exterior lateral view of left valve, ×90.	37
7,12.—Haplocytheridea leei (HOWE & GARRETT); ——*7,* ventral view (anterior towards bottom of plate);——*12,* anterior lateral view of left valve, all ×90.	42
8-11.—Clithrocytheridea garretti (HOWE & CHAMBERS);——*8,* exterior lateral view of left valve of female, ×85;——*9,* exterior lateral view of right valve of complete male specimen, ×70; *10,* interior lateral view of left valve of female; ×85; *11,* ventral view of male, ×70.	39

TRIGINGLYMUS WHITEI (Swain, 1951), Pooser, (n. comb.)

Pl. 15, figs. 2, 5, 6, 8, 9

Leguminocythereis whitei SWAIN, 1951, p. 43, pl. 3, figs. 14, 16-18, pl. 4, fig. 1; *non* MALKIN, 1953, p. 786, pl. 80, figs. 7-12.
non Leguminocythereis? whitei MCLEAN, 1957, p. 80, pl. 9, figs. 4a-b.

Diagnosis. Characterized by a coarsely reticulate carapace with prominent marginal ridge; ridge around the anterior, venter, posterior, and posterior portion of dorsum; and shorter ridge around anterior that terminates at middle of venter. *Mio.-Rec.*

Description. Carapace elongate-ovate in lateral view, greatest height at anterior cardinal angle, greatest width in posterior one-third of carapace. Dorsal margin straight, ventral margin sinuate, anterior and posterior ends broadly and evenly rounded. Sharp marginal ridge parallels entire periphery of valve, second ridge originates at anterior cardinal angle, trends within and parallel to anterior marginal ridge to just dorsal to anteroventer, where it bends sharply and assumes irregular course along venter and posterior, terminating just within dorsal margin and slightly posterior to middle. A third ridge originates anteroventral to anterior cardinal angle, between the marginal ridge and second ridge, roughly parallels the bounding ridges, and terminates along venter at the middle. Entire carapace ornamented with high, rounded, narrow, anastomosing ridges imparting a cagelike appearance. Vertically trending depression at center of carapace directly posterior to subcentral swelling, more or less masked by the coarse reticulations.

Hinge of right valve consists of a small, rounded, anterior tooth; narrow, slightly elongate, shallow socket; straight, narrow smooth groove; and an elongate-ovate posterior tooth. Approximately one-fourth of distance from anterior end of hinge and directly below median groove a wedge-shaped protrusion appears to have a groove on its lower extremity. Hinge of left valve consists of elongate, anterior socket bounded anteriorly by an overhanging flange of the dorsal margin and ventrally by a curved rim, a posterior socket, and a long, smooth, median ridge having a small toothlike expansion at its anterior end. A protuberance similar to that of the right valve is located below median ridge and approximately one-fourth distance from anterior end of hinge. Marginal area wide, with greatest width at anterior. Line of concrescence nearly coincides with inner margin. Radial pore-canals few, simple, long, and widely spaced. Muscle-scar pattern not observed. Interior of carapace marked by scattered, coarse pits indicating position of normal pore-canals. Deep depression along the mid-line and slightly anterior to middle with external expression masked by the coarse reticulations.

Remarks. This species was originally described by SWAIN (1951, p. 43) and placed under the genus *Leguminocythereis;* however, *Leguminocythereis* (HOWE & LAW, 1936, p. 61) is characterized by ". . . a reticulate pattern of raised ridges which, in the dorsal half, tend to radiate from the center of the dorsal margin and which, in the ventral half, tend to parallel the ventral margin." In addition the hinge of *Leguminocythereis* does not have the wedge-shaped protuberance directly beneath the median element of the hinge.

The single valve described by MCLEAN (1957, p. 80) and the forms described by MALKIN (1953, p. 785) as *Leguminocythereis whitei* differ from *T. whitei* in shape, ornamentation, and hinge structure.

Dimensions. Length 0.73 mm, height 0.41 mm, thickness (single valve) 0.21 mm.

Material. Duplin Formation: 10 specimens.

Occurrence. Duplin Formation: Localities 38-45, 38-42, and 21-1 (unit 2).

This form has been reported from the Pleistocene, lower Miocene or Oligocene, and middle and upper Miocene of North Carolina

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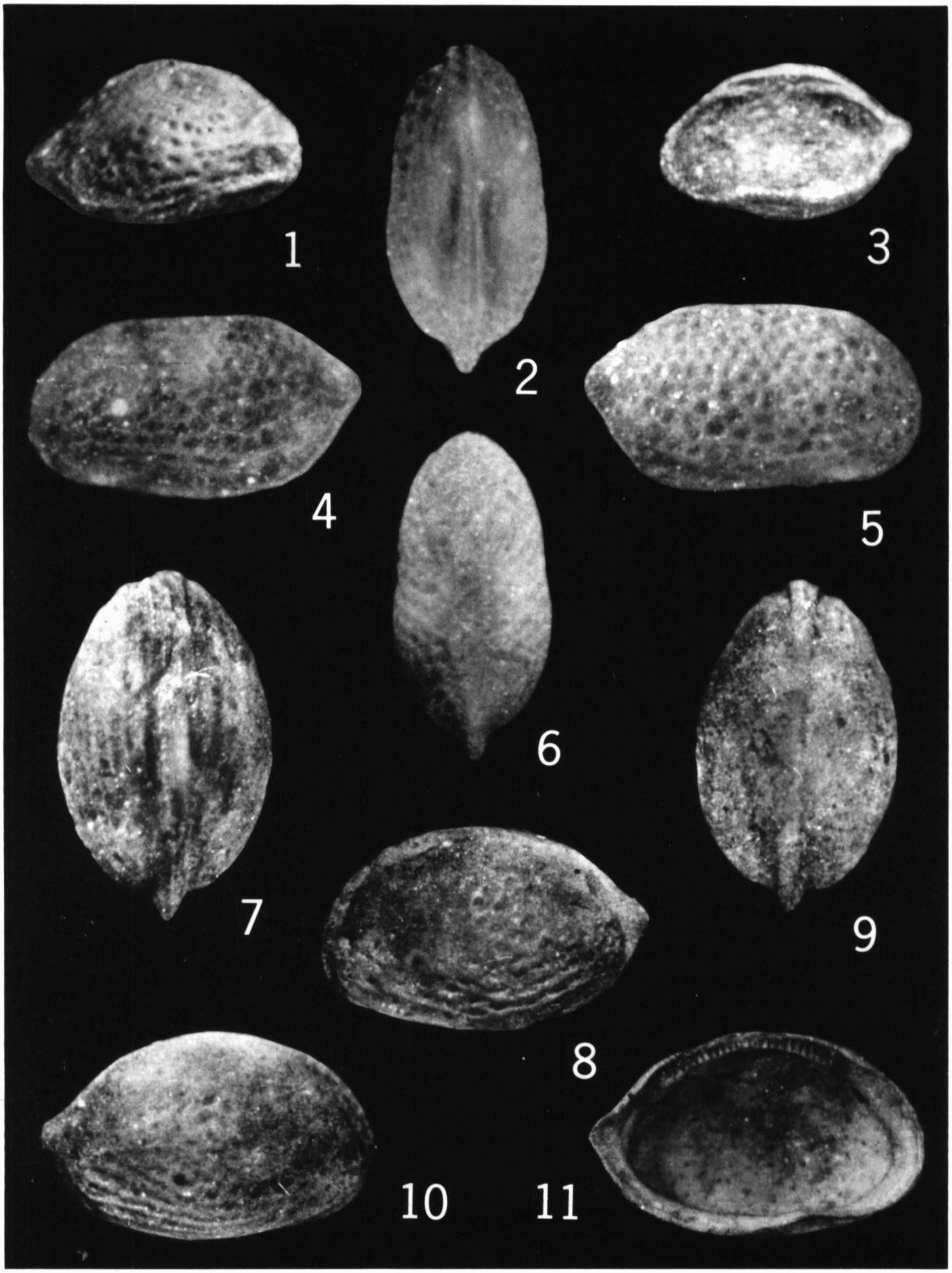
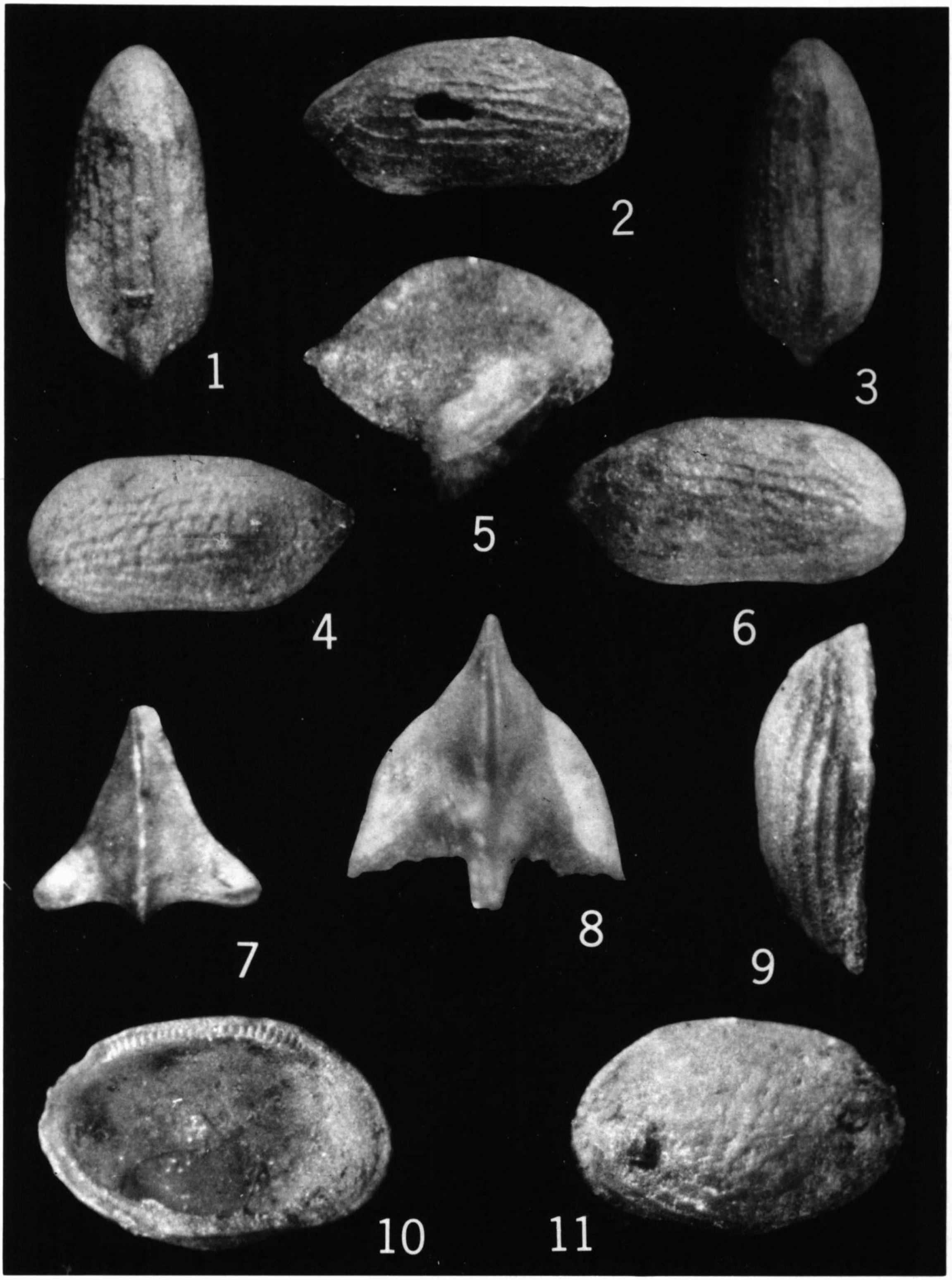
EXPLANATION OF PLATE 9
HEMICYTHERURA, CYTHERURA, EOCYTHEROPTERON

(All illustrated forms are from South Carolina)

FIGURE		PAGE
1-3.	—*Hemicytherura howei* (PURI);——*1*, exterior lateral view of right valve, ×120;——*3*, interior lateral view of right valve, ×110.	49
2,4-6.	—*Cytherura wardensis* HOWE & BROWN;——*2*, ventral view;——*4*, exterior lateral view of left valve of complete specimen;——*5*, exterior lateral view of right valve of complete specimen;——*6*, dorsal view, all ×100.	46
7-11.	—*Eocytheropteron blackmingoense* POOSER, n. sp.;——*7*, ventral view, ×75;——*8*, exterior lateral view of left valve, ×70;——*9*, dorsal view, ×70;——*10*, exterior lateral view of right valve of complete specimen, ×70;——*11*, interior lateral view of left valve, ×65.	48



POOSER—Cenozoic Ostracoda from South Carolina



POOSER—Cenozoic Ostracoda from South Carolina

(SWAIN, 1951, p. 44). BENSON (1964, personal communication) reports that this species is common within Recent sediments of Narragansett Bay, Rhode Island.

Family BYTHOCYTHERIDAE Sars, 1926

Genus MONOCERATINA Roth, 1928

Monoceratina ROTH, 1928, p. 16; ALEXANDER, 1934, p. 57; ———, 1934, p. 230; TRIEBEL & BARTENSTEIN, 1938, p. 502; TRIEBEL, 1941, p. 318; STEPHENSON, 1946, p. 312; MUNSEY, 1953, p. 17; SWAIN, 1955, p. 637; KEIJ, 1957, p. 165; SYLVESTER-BRADLEY, 1961, p. Q268.
Bythocytheremorpha MANDELSTAM, 1958.
Type-species. Monoceratina ventrale ROTH, 1928, p. 16, figs. 1a-c.

Diagnosis. Characterized by an elongate, subquadrate carapace; smooth, reticular, or spiniferous surface; dorsal margin long and straight; anterior end rounded; posterior end caudate and extended above; laterally or posteriorly projecting spines, alae, or swelling on posteroventral surface; median sulcus. Hinge consists of a simple groove and ridge which may be swollen posteriorly. *Dev.-Rec.*

MONOCERATINA ALEXANDERI Howe & Chambers, 1935

Pl. 8, figs. 5, 6

Monoceratina alexanderi HOWE & CHAMBERS, 1935, p. 21, pl. 3, fig. 19, pl. 4, fig. 21; MONSOUR, 1937, p. 94; BLAKE, 1950, p. 183, pl. 29, fig. 7; BROWN, 1958, p. 67, pl. 4, fig. 11.

Diagnosis. Characterized by four ridges on the prominent ventrolateral spine; marginal rim that parallels the anterior and dorsum, bending sharply downward just anterior to posterodorsal angle; and three short ridges originating at anterior and dorsal margins and coalescing along the median line of the carapace just anterior to middle. *M.-U.Eoc.*

Remarks. A single left valve was recovered from the South Carolina material on which the caudal process is broken just posterior to the posterodorsal angle. The interior of the valve is filled with matrix.

Dimensions. Length 0.64 mm, height 0.31 mm.
Material. Santee Limestone: 1 left valve.
Occurrence. Santee Limestone: Locality 9-54 (unit 1).

Reported from the Jackson Group of Louisiana (HOWE & CHAMBERS, 1935, p. 21) and Mississippi (MONSOUR, 1937, p. 94); the Gosport Formation of Alabama (BLAKE, 1950, p. 183); and the upper? Eocene of North Carolina (BROWN, 1958, p. 67).

Family CYTHERETTIDAE Triebel, 1952

Genus CYTHERETTA Müller, 1894

Cytheretta MÜLLER, 1894, p. 382; ———, 1912, p. 366; EDWARDS, 1944, p. 524; VAN DEN BOLD, 1946, p. 27; PURI, 1952a, p. 202; TRIEBEL, 1952, p. 16; PURI, 1953d, p. 281; KEIJ, 1957, p. 131; PURI, 1958b, p. 186; HOWE, 1961, p. Q270; BENSON & COLEMAN, 1963, p. 25.
Pseudocytheretta CUSHMAN, 1906, p. 382.
Cylindrus NEVIANI, 1928, p. 106.
Prionocytheretta MÉHES, 1941, p. 60.
Type-species. Cytheretta rubra MÜLLER, 1894 (=*Cytherina subradiosa* ROEMER, 1838, p. 517, pl. 6, fig. 20) (=*Cytheretta subradiosa* (Roemer) by RUGGIERI, 1950, p. 9).

Diagnosis. Recognized by its elongate-ovoid, smooth, punctate, or reticulate carapace. Hinge holamphidont; right valve consists of generally subtriangular anterior tooth, postjacent socket, smooth median groove, and large smooth posterior tooth. Duplicature broad with line of concresence coinciding with inner margin throughout and forming S-shaped curve anteriorly. Radial pore-canals numerous, thin, closely spaced, curved, and thickened in middle. Muscle-scar pattern consists of row of four scars, heart-shaped scar anterior, and mandibular scars near ventral inner margin. *Eoc.-Rec.*

CYTHERETTA ALEXANDERI Howe & Chambers, 1935

Pl. 12, figs. 1, 2, 4-6

Cytheretta alexanderi HOWE & CHAMBERS, 1935, p. 45, pl. 5, figs. 17-21, pl. 6, figs. 27, 28; GARRETT, 1936, p. 786; MONSOUR, 1937, p. 95; BERGQUIST, 1942, p. 109, pl. 11, fig. 20; BLAKE, 1950, p. 177, pl. 30, figs. 1-3; PURI, 1952a, p. 208, pl. 39, fig. 16; WILBERT, 1953, p. 125; PURI, 1957c, p. 195, pl. 7, figs. 1-4; BROWN, 1958, p. 67, pl. 6, fig. 14; VAN DEN BOLD, 1960, p. 171; KRUTAK, 1961, p. 785, pl. 91, figs. 5, 6.
Cythereis? catahoulana Howe & Pyeatt, 1935, *in* HOWE & CHAMBERS, 1935, p. 25, pl. 3, fig. 7, pl. 6, figs. 25, 26; MONSOUR, 1937, p. 90, 95.
Cythereis? catahoulana var. *pyeatti* HOWE & CHAMBERS, 1935, p. 26, pl. 3, figs. 20, 21; MONSOUR, 1937, p. 89, 95.

EXPLANATION OF PLATE 10

CYTHERURA, CYTHEROPTERON, EOCYTHEROPTERON

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1-4,6.—Cytherura johnsoni MINCHER;——*1,* dorsal view;——*2,* exterior lateral view of right valve; ——*3,* ventral view;——*4,* exterior lateral view of left valve of complete specimen;——*6,* exterior lateral view of right valve of complete specimen, all ×110.	45
5,7,8.—Cytheropteron sp. A;——*5,* exterior lateral view of right valve of complete specimen, ×100; ——*7,* anterior view, ×70;——*8,* dorsal view, ×100.	47
9-11.—Eocytheropteron spurgeonae HOWE & CHAMBERS;——*9,* ventral view of left valve (anterior towards bottom of plate), ×75;——*10,* interior lateral view of left valve, ×80;——*11,* exterior lateral view of left valve, ×75.	48

Cytheretta sp. cf. *C. alexanderi* SWAIN, 1951, p. 47, pl. 6, figs. 23-25.

Diagnosis. Characterized by an elongate-ovoid lateral outline with sharply upturned posterior. Surface ornamented with longitudinal ridges and intermediate pitted furrows that radiate from the posterior. *M.Eoc.-Oligo.*

Remarks. The surface ornamentation shows variation in both the intensity of the pitting and the strength of the longitudinal ridges. The original description of *Cytheretta alexanderi* by HOWE & CHAMBERS (1935, p. 45) made no mention of the crenulations on the median element. The specimens from South Carolina as well as those studied by BLAKE (1950, p. 177) from the Gosport Formation of Alabama show prominent crenulations on the median bar of the left valve. The inner margin is extremely irregular and forms the characteristic S-shaped curve in the anterior region.

Dimensions. Length 0.90 mm, thickness 0.44 mm, height 0.55 mm.

Material. Santee Limestone: 130 specimens. Cooper Marl: 112 specimens.

Occurrence. Santee Limestone: Localities 9-28, 9-54 (unit 1), 38-22, 38-103 and 18-1 (unit 1). Auger Holes 38-5 (80-100′), 38-11 (10-15′ and 20-25′), 38-13 (82-100′), 38-15 (70′), 38-17 (60-80′), 38-23 (25′ and 50′), 38-29 (14′), 38-35 (70-74′). Cooper Marl: Locality 18-1 (unit 4).

Reported from the Jackson Group throughout the Gulf states, the Gosport Formation of Alabama, the Ocala Group of Florida, and the middle and upper Eocene of North Carolina.

Genus PROTOCYTHERETTA Puri, 1958

Protocytheretta PURI, 1958b, p. 188; HOWE, 1961, p. Q271; BENSON & COLEMAN, 1963, p. 26.

Type-species. Cythere daniana BRADY, 1869, p. 124, pl. 14, figs. 13, 14.

Diagnosis. Carapace elongate-ovate with reticulate surface and three prominent longitudinal ribs; hinge like *Cytheretta. Oligo.-Rec.*

Remarks. PURI, who examined Paleocene material from Denmark which contained the type-species of *Paracytheretta,* differentiated *Protocytheretta* from *Paracytheretta* on the basis that the posterior right tooth of *Paracytheretta* is crenulate whereas that of *Protocytheretta* is noncrenulate. Some doubt exists as to the validity of PURI's genus *Protocytheretta* because neither TRIEBEL's description nor illustrations indicate a crenulate posterior tooth in the right valve of the type-species of *Paracytheretta* (*P. reticosa* TRIEBEL, 1941, p. 389, pl. 15, figs. 165-168).

PROTOCYTHERETTA KARLANA (Howe & Pyeatt, 1935) Puri, 1958

Pl. 12, figs. 3, 7-10

Cytheretta karlana Howe & Pyeatt, *in* HOWE AND OTHERS, 1935, p. 34, pl. 1, figs. 30, 34, pl. 3, figs. 3, 4; SMITH, 1941, p. 279; VAN DEN BOLD, 1946, p. 105, pl. 9, fig. 18; SWAIN, 1951, p. 46, pl. 6, fig. 19.

Cytheretta reticulata EDWARDS, 1944, p. 525, pl. 88, figs. 7-10; BROWN, 1958, p. 67, pl. 6, fig. 15; PURI, 1958b, p. 184, table 1.

Paracytheretta karlana (Howe & Pyeatt), PURI, 1952a, p. 209, pl. 40, figs. 3-5, text-fig. 8.

Protocytheretta karlana (Howe & Pyeatt), PURI, 1958b, p. 184, table 1.

Diagnosis. Characterized by a subrectangular lateral outline with a prominent convex swelling at posterodorsal angle of left valve. Surface ornamentation consists of rectangular pits separated by flattened ridges. Two prominent ridges originate near anteroventral angle and diverge posteriorly enclosing a deep reticulate depression. Uppermost ridge extends diagonally towards posterodorsal angle whereas lower ridge roughly follows ventral outline. *M.-U.Mio.*

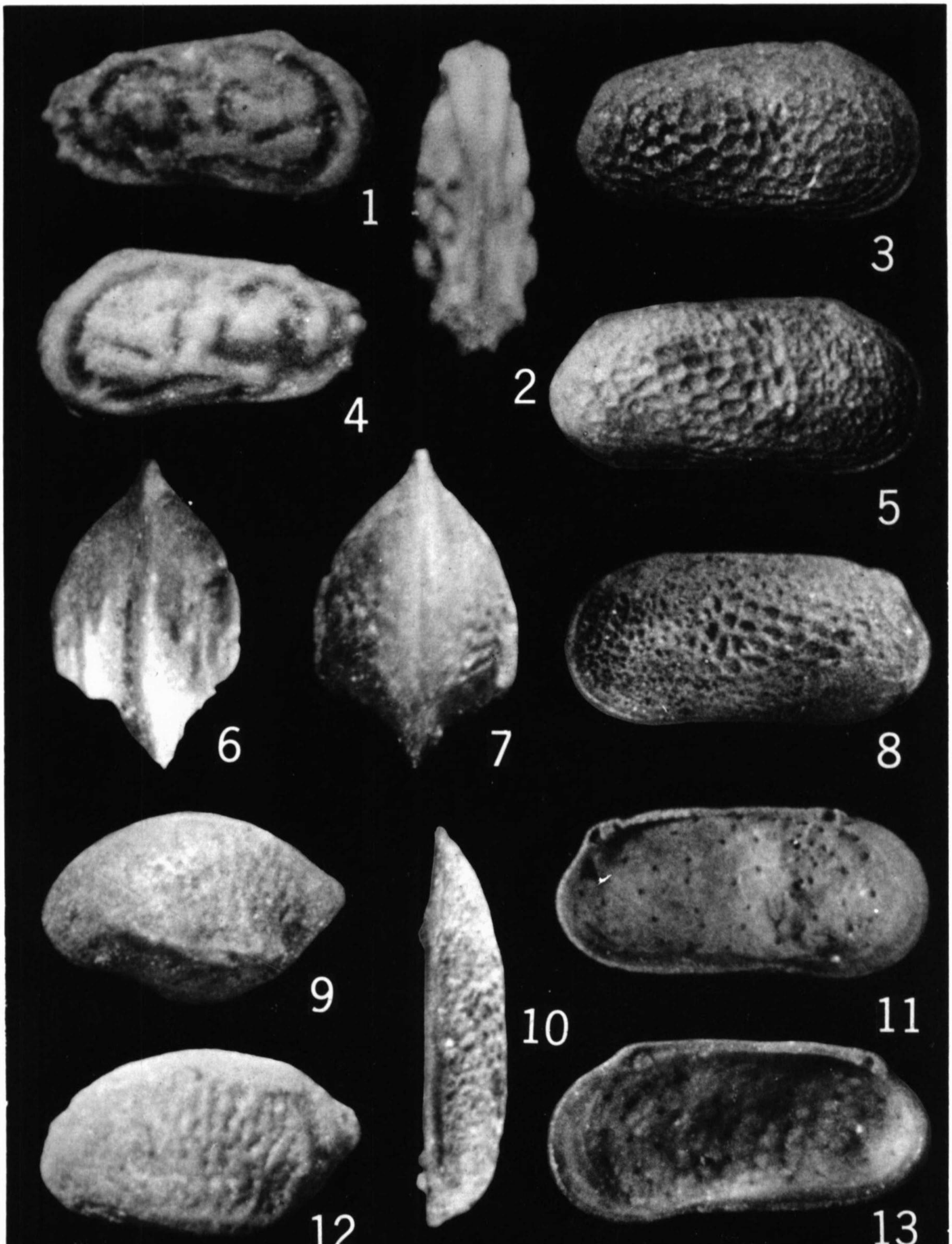
Remarks. The description and illustrations of *Cytheretta reticulata* (EDWARDS, 1944, p. 525) from the upper Miocene Duplin Marl of North Carolina resemble *P. karlana* (HOWE & PYEATT) so closely that they appear to be conspecific. *P. choctawatchiensis* (HOWE & TAYLOR) is very similar to *P. karlana* but differs in being smaller, much higher near the posterior end, particularly in the left valve, and the groove above the dorsal bar in the right valve is narrow instead of wide.

EXPLANATION OF PLATE 11

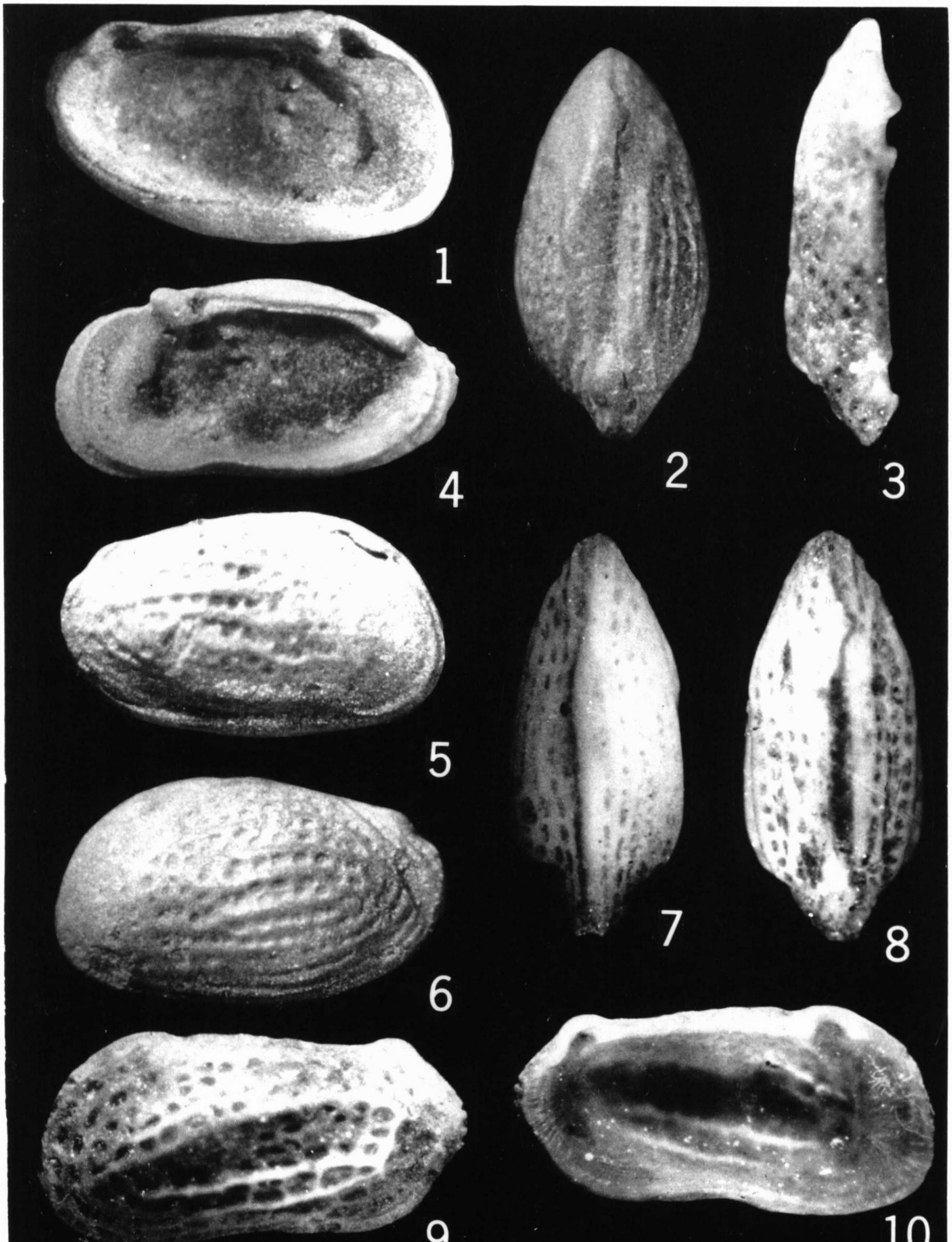
CYTHEROMORPHA, CYTHEROPTERON, MUNSEYELLA

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,2,4.—Munseyella subminuta (PURI);——*1,* exterior lateral view of right valve, ×140;——*2,* dorsal view, ×135;——*4,* exterior lateral view of left valve, ×140.	52
3,5,8,10,11,13.—Cytheromorpha warneri HOWE & SPURGEON;——*3,* exterior lateral view of right valve of female, ×95;——*5,* exterior lateral view of right valve of male, ×100;——*8,* exterior lateral view of left valve of male, ×100;——*10,* dorsal view of right valve of male, ×105;——*11,* interior lateral view of left valve of male, ×100;——*13,* interior lateral view of right valve of male, ×100.	51
6,7,9,12.—Cytheropteron variosum MARTIN;——*6,* ventral view, ×115;——*7,* dorsal view, ×115;——*9,* exterior lateral view of left valve of complete specimen, ×110;——*12,* exterior lateral view of left valve, ×125.	47



POOSER—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

The Miocene form *Protocytheretta karlana* is very similar to and in all probability is the ancestral form of the type-species *P. daniana* (BRADY), reported from the Pliocene and Recent by PURI (1958b) and the Recent of the eastern Gulf of Mexico by BENSON & COLEMAN (1963). *P. karlana* is most readily distinguished from *P. daniana* by its larger size and less compressed posterior. In addition the two central longitudinal ridges of *P. daniana* are connected posteriorly to form a loop, whereas the ridges of *P. karlana* are not joined posteriorly.

Dimensions. Length 1.07 mm, thickness 0.48 mm, height 0.54 mm.

Material. Duplin Formation: 5 specimens.

Occurrence. Duplin Formation: Localities 38-42, 38-45, and 21-1 (unit 2).

This species was originally reported from the Chipola facies of the Alum Bluff Stage of Florida (HOWE, 1935, p. 35). It has subsequently been reported from the middle Miocene, Chipola, Oak Grove, and Shoal River facies of the Alum Bluff Stage of Florida (PURI, 1952a, p. 209); the Miocene of Guatemala (VAN DEN BOLD, 1946, p. 105); the upper Miocene, Yorktown Formation of North Carolina (BROWN, 1958, p. 67); the upper Miocene, Duplin Marl of North Carolina (EDWARDS, 1944, p. 525); and the middle Miocene of North Carolina (SWAIN, 1951, p. 46).

Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEINAE Sars, 1925
Genus CLITHROCYTHERIDEA Stephenson, 1936

Cytheridea BOSQUET, 1852 (part), p. 37.
Cytheridea (Clithrocytheridea) STEPHENSON, 1936, p. 702; ———, 1942, p. 110; VAN DEN BOLD, 1946, p. 24.
Clithrocytheridea STEPHENSON, 1944b, p. 449; KEIJ, 1957, p. 57; HOWE, 1961, p. Q275; BENSON & KAESLER, 1963, p. 16.
Type-species. Cytheridea? garretti HOWE & CHAMBERS, 1935, p. 14, pl. 1, figs. 4, 5, pl. 2, figs. 11, 12, pl. 6, figs. 10, 11.

Diagnosis. Characterized by its subrhomboidal shape with a down-turned and obliquely truncated posterior, pitted to reticulate surface, and antimerodont hinge. *U.Cret.-Rec.*

CLITHROCYTHERIDEA GARRETTI
(Howe & Chambers, 1935), Stephenson, 1944
Pl. 8, figs. 8-11

Cytheridea? garretti HOWE & CHAMBERS, 1935, p. 14, pl. 1, figs. 4, 5, pl. 2, figs. 11, 12, pl. 6, figs. 10, 11.
Cytheridea (Clithrocytheridea) garretti (Howe & Chambers), STEPHENSON, 1936, p. 702, pl. 94, figs. 5, 6, 10, text-figs. 1, 1, o, p; ———, 1942, p. 104, 110, pl. 18, fig. 1.
Cytheridea (Cleithrocytheridea) garretti (Howe & Chambers), MONSOUR, 1937, p. 89, 94.
Clithrocytheridea garretti (Howe & Chambers), STEPHENSON, 1944b, p. 449, pl. 76, fig. 1; ———, 1946, p. 327, pl. 42, fig. 18; BLAKE, 1950, p. 175, pl. 29, figs. 9-11; GREKOFF, 1956, p. 44, pl. 7, figs. 127-129; KRUTAK, 1961, p. 778, pl. 92, fig. 8.
Cleithrocytheridea garretti (Howe & Chambers), WILBERT, 1953, p. 125.

Diagnosis. Characterized by its elongate shape and coarse pits that tend to parallel the margins of the carapace. *M.-U.Eoc.*

Remarks. The female is shorter, more tumid in proportion to length, and the dorsal and ventral margins converge toward the posterior more than in the male. The muscle-scar pattern, located just anterior to center, consists of a vertical row of four adductor scars, a V-shaped antennal scar, and an elongate mandibular scar.

Dimensions. Male: length 0.81 mm, thickness 0.37 mm, height 0.40 mm. Female: length 0.66 mm, thickness 0.37 mm, height 0.37 mm. The dimensions of the male carapace from South Carolina are almost identical to the holotype (length 0.83 mm, thickness 0.38 mm, height 0.40 mm).

Material. Warley Hill Formation: 24 specimens. Santee Limestone: 216 specimens.

Occurrence. Warley Hill Formation: Locality 8-3 (units 1 and 3). Santee Limestone: Localities 38-87 and 38-103. Auger Holes 38-5 (85-100′), 38-7 (17-23′), 38-11 (10-15′ and 20-25′), 38-15 (70′), 38-17 (60-80′), 38-18 (12-18′), 38-35 (70-74′), 38-37 (50-65′), and 38-40 (65-70′).

Clithrocytheridea garretti occurs throughout the Middle and Upper Eocene of the Gulf area.

EXPLANATION OF PLATE 12
CYTHERETTA, PROTOCYTHERETTA

(All illustrated forms are from South Carolina)

FIGURE PAGE

1,2,4-6.—*Cytheretta alexanderi* HOWE & CHAMBERS; *1,* interior lateral view of left valve, ×75;——*2,* dorsal view, ×70;——*4,* interior lateral view of right valve, ×75;——*5,* exterior lateral view of right valve of complete specimen, ×70;——*6,* exterior lateral view of left valve, ×70. 37

3,7-10.——*Protocytheretta karlana* (HOWE & PYEATT);——*3,* dorsal view of left valve, ×65;——*7,* ventral view, ×60;——*8,* dorsal view, ×60;——*9,* exterior lateral view of left valve, ×65;——*10,* interior lateral view of left valve, ×65... 38

CLITHROCYTHERIDEA HARRISI (Stephenson, 1938), Pooser, (n. comb.)

Pl. 4, figs. 1, 3, 5-10

Cytheridea (Haplocytheridea) harrisi STEPHENSON, 1938b, p. 571, pl. 67, figs. 11, 12, text-figs. 12, 24.

Diagnosis. Characterized by its distinct surface sculpture, consisting of rounded curvilinear ridges that tend to parallel the periphery. Furrows between ridges contain shallow but distinct pits of moderate size enclosed by short branches from the ridges. *L.Eoc.*

Remarks. Identical in all respects to *Cytheridea (Haplocytheridea) harrisi* as originally described by STEPHENSON except for the hinge. STEPHENSON described and illustrated a holomerodont hinge; however, all of the specimens examined from South Carolina have an antimerodont hinge in which the right valve consists of crenulate anterior and posterior elements with a crenulate median groove. The left valve is the antithesis of the right. The muscle-scar pattern is obscure but appears to consist of a vertical row of four adductor scars, a crescent-shaped antennal scar, and an elongate mandibular scar, which may consist of two components. The shape and hinge definitely place this form under the genus *Clithrocytheridea.*

This form closely resembles *Clithrocytheridea broussardi* (HOWE & GARRETT) from the lower Eocene of Alabama; however, the surface of *C. broussardi* is far more coarsely pitted and the slender ridges between the pits are shorter and do not parallel the periphery.

Dimensions. Length 0.65 mm, thickness 0.30 mm, height 0.32 mm.

Material. Black Mingo Formation: 41 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4).

Reported from the lower Eocene, Sabine, Nanafalia, and Tuscahoma formations of Alabama (STEPHENSON, 1938b, p. 572).

CLITHROCYTHERIDEA VIRGINICA Schmidt, 1948

Pl. 3, figs. 1-3

Clithrocytheridea virginica SCHMIDT, 1948, p. 429, pl. 64, figs. 21-23; SWAIN, 1951, p. 24, pl. 2, figs. 10-13.

Clithrocytheridea ruida (Alexander), MUNSEY, 1953, p. 15, pl. 2, figs. 14-18.

Cytheridea (Clithrocytheridea) virginica (Schmidt), BROWN, 1958, p. 58, pl. 5, fig. 15.

Diagnosis. Characterized by coarsely pitted carapace and an elongate depression below mid-line of valve, bordered above and below by rounded, pitted ridges. Ridge above depression accentuated by a small nodelike swelling. *Paleoc.-M.Eoc.*

Remarks. As noted by SCHMIDT (1948, p. 429) the width of the ridges and depressions varies because of the coarse pitting. Sexual dimorphism is pronounced, with the longer males having nearly parallel dorsal and ventral margins, whereas the dorsal and ventral margins of the females converge toward the posterior. The internal features have been well described by SWAIN (1951, p. 24). The South Carolina forms were compared with specimens that P. M. BROWN had compared with the holotype of *C. virginica.* This form is readily distinguished from *C. ruida* (ALEXANDER) by its nodelike swelling on the ridge above the depression and the absence of a short ridge that extends from the above mentioned ridge to the dorsal margin.

Dimensions. Male: length 0.76 mm, thickness 0.35 mm, height 0.37 mm. Female: length 0.72 mm, thickness 0.37 mm, height 0.39 mm.

Material. Black Mingo Formation: 67 specimens. Santee Limestone: 43 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4). Santee Limestone: Locality 18-1 (unit 3). Auger Holes 38-5 (85-100′), 38-7 (17-23′), 38-13 (82?-100′), 38-17 (60-80′), 38-18 (12-18′), 38-22 (70′), 38-23 (50′) 38-26 (25′), 38-27 (60′), and 38-37 (50-65′).

Reported from the lower Eocene, Aquia Formation of Maryland and Virginia (SCHMIDT, 1948, p. 400 and 429); middle Eocene of North Carolina (SWAIN, 1951, p. 24); the Paleocene, lower and middle Eocene of North Carolina (BROWN, 1958, p. 58); and the Paleocene, Coal Bluff Marl Member of the Naheola Formation of Alabama (MUNSEY, 1953, p. 15).

CLITHROCYTHERIDEA RUIDA (Alexander, 1934), Munsey, 1953

Pl. 4, figs. 2, 4; Pl. 5, figs. 1-3

Cytheridea ruida ALEXANDER, 1934, p. 224, pl. 33, fig. 7 (*non Clithrocytheridea ruida* MUNSEY, 1953, p. 15, pl. 2, figs. 14-18).

Diagnosis. Characterized by a coarsely pitted carapace and an elongate depression located just below mid-line of carapace, which is bounded above and below by rounded ridges. Just anterior to posterodorsal angle, a short vertical ridge connects dorsal margin with median longitudinal ridge. *Paleoc.-M.Eoc.*

Description. Carapace subrectangular; highest at anterocardinal angle with subparallel dorsal and ventral margins. Surface coarsely pitted; prominent ridge originates at anterocardinal angle, parallels anterior margin to just above anteroventral angle, trends posteroventrally to mid-length paralleling ventral margin, terminating slightly anterior to the posteroventer; a strong subcentral node present just anterior to center along mid-line of carapace; short ridge originates from anteroventral corner of subcentral node and trends posteroventrally for a short distance to ventral ridge; second longer ridge originates at upper edge of the subcentral node and trends posteriorly along mid-line of the carapace to just anterior to posterodorsal angle curving posteroventrally to join the ventral ridge. This ridge along mid-line of the carapace, together with ventral ridge and subcentral node, enclose an elongate pitted depression. Short vertical ridge connects median longitudinal ridge with dorsal margin.

Hinge antimerodont. Wide duplicature with very narrow vestibule at anterior. Left valve exhibits prominent selvage and selvage groove. Right valve has well-defined selvage around entire free margin and flange at antero- and posteroventral angles. Muscle-scar pattern consists of vertical row of four adductor scars and two additional anterior scars. Pronounced sexual dimorphism with males more elongate and rectangular than females.

Remarks. This species may readily be differentiated from *Clithrocytheridea virginica* by the lack of the nodelike swelling on the median longitudinal ridge and the presence of a short ridge that connects the median longitudinal ridge with the dorsal margin. The form illustrated by MUNSEY (1953, pl. 2, figs. 14-18) is clearly *C. virginica* and not *C. ruida.*

Dimensions. Male: length 0.58 mm, thickness 0.22 mm, height 0.30 mm. Female: length 0.54 mm, thickness 0.29 mm, height 0.30 mm.

Material. Warley Hill Formation: 5 specimens. Santee Limestone: 267 specimens.

Occurrence. Warley Hill Formation: Locality 9-33. Auger Hole 9-3 (62?'). Santee Limestone: Localities 9-28, 9-31, 9-32, 9-33, 9-54, 18-1 (unit 1), 38-10, and 38-103. Auger Holes 38-11 (10-15'), 38-15 (70'), 38-29 (14'), 38-35 (70-74' and 85'), and 38-40 (65-70').

Reported from the Paleocene, Kincaid Formation of Texas (ALEXANDER, 1934, p. 224).

Genus HAPLOCYTHERIDEA Stephenson, 1936

Cytheridea BOSQUET, 1852 (part), p. 37.
Cytheridea (Haplocytheridea) STEPHENSON, 1936, p. 700; EDWARDS, 1944, p. 507.
Cytheridea (Leptocytheridea) STEPHENSON, 1937 (part), p. 156.
Cytheridea (Phractocytheridea) SUTTON & WILLIAMS, 1939, p. 571.
Haplocytheridea STEPHENSON, 1944a, p. 159; ———, 1946, p. 321; SWAIN, 1955, p. 617; KEIJ, 1957, p. 59; BENSON, 1959, p. 48; HOWE, 1961, p. Q276, BENSON & COLEMAN, 1963, p. 27.
Type-species. Cytheridea montgomeryensis HOWE & CHAMBERS, 1935, p. 17, pl. 1, fig. 1, pl. 2, figs. 1-3, 7, 9, pl. 6, figs. 17, 18.

Diagnosis. Recognized by its subovate to subpyriform carapace; surface smooth, pitted, or with median subvertical weak furrows; hinge holomerodont. *U.-Cret.-Rec.*

HAPLOCYTHERIDEA MONTGOMERYENSIS (Howe & Chambers, 1935), Stephenson, 1946

Pl. 5, fig. 10; Pl. 6, figs. 1-4

Cytheridea montgomeryensis HOWE & CHAMBERS, 1935, p. 17, pl. 1, fig. 1, pl. 2, figs. 1-3, 7, 9, pl. 6, figs. 17, 18; GARRETT, 1936, p. 786; BERGQUIST, 1942, p. 106, pl. 11, fig. 5.
Cytheridea (Haplocytheridea) montgomeryensis (Howe & Chambers), STEPHENSON, 1936, p. 700, pl. 94, figs. 3, 4, 9, text-figs. 1 g, h, j, k; ———, 1937, p. 146, 153; ———, 1942, p. 109, pl. 18, figs. 17, 18; MONSOUR, 1937, p. 89; BROWN, 1958, p. 57, pl. 5, fig. 4.
Haplocytheridea montgomeryensis (Howe & Chambers), STEPHENSON, 1946, p. 322, pl. 42, fig. 29; BLAKE, 1950, p. 176, pl. 29, fig. 16; SWAIN, 1951, p. 20, pl. 1, fig. 18, pl. 2, figs. 1-4; WILBERT, 1953, p. 124; GREKOFF, 1956, p. 46, pl. 7, figs. 136-138; KRUTAK, 1961, p. 779, pl. 91, fig. 7.

Diagnosis. Characterized by its subtriangular carapace with straight dorsal and posterior slopes and ventrally acuminated posterior. Anterior margins of both valves spinose. Six to eight subvertical curvilinear pitted furrows separated by ridges that are wider than the furrows are located on the tumid portion of the carapace. *M.Eoc.-Oligo.*

Description of the interior. Specimens from South Carolina are exceptionally well preserved. Hinge holomerodont; left valve with terminal crenulate sockets connected by finely crenulate groove. Marginal area moderately wide with numerous long, simple, radial, pore-canals. Duplicature fused except at anterior and posterior where narrow vestibules are present. Muscle-scar pattern consists of vertical row of four adduction scars, V-shaped antennal scar located on level of uppermost adductor scar, and elongate mandibular scar anterior to and slightly below lowermost adductor scar.

Remarks. Haplocytheridea montgomeryensis is distinguished from *H. stuckeyi* STEPHENSON by its more fragile carapace, shorter height in proportion to length, much less overlap of left valve over right along the dorsum, a much narrower accommodation groove in the left valve, and a less arched dorsum.

The specimens of *Haplocytheridea montgomeryensis* from the middle Eocene, Warley Hill Formation and Santee Limestone and the overlying Oligocene, Cooper Marl appear to be identical in all respects.

Dimensions. Length 0.74 mm, thickness 0.35 mm, height 0.47 mm.

Material. Warley Hill Formation: 10 specimens. Santee Limestone: 581 specimens. Cooper Marl: 133 specimens.

Occurrence. Warley Hill Formation: Localities 9-28 and 9-33. Auger Hole 9-3 (62?'). Santee Limestone: Localities 9-28, 9-31, 9-32, 9-33 (unit 3), 9-54 (unit 1), 18-1 (unit 1), 38-10, 38-22, 38-26, 38-85, and 38-103. Auger Holes 5-1 (75-85'), 38-5 (70 and 85-100'), 38-7 (17-23') 38-11 (10-15' and 20-25'), 38-13 (82?-100'), 38-17 (60-80'), 38-18 (12-18'), 38-22 (70'), 38-23 (25 and 50'), 38-26 (25'), 38-29 (14'), 38-35 (70-74' and 85'), 38-37 (50-65'), and 38-40 (65-70'). Cooper Marl: Locality 18-1 (unit 4).

Reported from the Claiborne through the Jackson in the Gulf states (STEPHENSON, 1946, p. 322) and the middle Eocene of North

Carolina (SWAIN, 1951, p. 21). SWAIN (1951, p. 6) reports that *H. montgomeryensis* ranges from the middle Eocene to the Oligocene (Vicksburg) in the Gulf region, but has not been found in lower Eocene rocks.

HAPLOCYTHERIDEA STUCKEYI Stephenson, 1946

Pl. 2, figs. 5, 7-9

Haplocytheridea stuckeyi STEPHENSON, 1946, p. 324, pl. 42, fig. 31, pl. 44, figs. 7, 8.

Diagnosis. Carapace subtriangular with tumid portion ornamented by four to six vertically aligned pitted furrows, each separated by low ridges; peripheral area smooth; prominent accommodation groove above median element of left valve. *Paleoc.-M.Eoc.*

Remarks. *Haplocytheridea stuckeyi* may be readily confused with *H. montgomeryensis* HOWE & CHAMBERS (1935, p. 17) when viewed from the exterior; however, *H. stuckeyi* differs markedly from *H. montgomeryensis* in having a heavier carapace, greater height in proportion to length, and a wide and elongate accommodation groove in the left valve. *H. stuckeyi* may represent an ancestral form of *H. montgomeryensis;* however, possibly this is a case of homeomorphy in which the exterior of the two forms are almost identical.

Dimensions. Male: (Left Valve) length 0.92 mm, height 0.50 mm; (Right Valve) length 0.91 mm, height 0.45 mm; (Whole) thickness 0.36 mm. Female: (Left Valve) length 0.82 mm, height 0.48 mm; (Right Valve) length 0.76 mm, height 0.43 mm; (Whole) thickness 0.36 mm.

Material. Black Mingo Formation: 166 specimens.

Occurrence. Black Mingo Formation: Auger Hole 45-2 (21-29′).

Reported from the middle Eocene, Weches Formation of Texas (STEPHENSON, 1946, p. 324).

HAPLOCYTHERIDEA LEEI (Howe & Garrett, 1934), Schmidt, 1948

Pl. 7, figs. 1-5; Pl. 8, figs. 7, 12

Cytheridea leei HOWE & GARRETT, 1934, p. 33, pl. 1, figs. 22, 23.

Cytheridea (Haplocytheridea) leei (Howe & Garrett), STEPHENSON, 1938b, p. 572, pl. 67, figs. 4, 5, text-figs. 1, 2.

Haplocytheridea leei (Howe & Garrett), SCHMIDT, 1948, p. 424, pl. 63, figs. 8, 9; MUNSEY, 1953, p. 14, pl. 2, fig. 23.

Diagnosis. Distinguished by its subtriangular lateral outline, finely to coarsely pitted carapace, denticulate anteroventral margin, and denticulate posteroventer, especially in right valve. *Paleoc.-L.Eoc.*

Remarks. As originally defined and illustrated by HOWE & GARRETT (1934) the carapace is characterized by a smooth to very finely punctate surface; however, STEPHENSON (1938b) noted that, "The intensity of surface pitting exhibited by this species is quite variable, some specimens showing pronounced pits over the entire carapace, whereas on others there is an almost complete absence of pitting." The South Carolina specimens appear to be uniformly coarsely pitted.

Dimensions. Male: length 0.63 mm, thickness 0.27 mm, height 0.34 mm. Female: length 0.65 mm, thickness 0.33 mm, height 0.39 mm.

Material. Black Mingo Formation: 35 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4).

Described from the Nanafalia Formation of Louisiana and Alabama; Aquia Formation of Virginia and Maryland (SCHMIDT, 1948, p. 424); and the Coal Bluff Member of the Naheola Formation of Alabama (MUNSEY, 1953, p. 14).

HAPLOCYTHERIDEA MOODYI (Howe & Garrett, 1934), Stephenson, 1946

Pl. 5, figs. 4-9

Cytheridea moodyi HOWE & GARRETT, 1934, p. 35, pl. 2, figs. 2-6.

Cytheridea (Haplocytheridea) moodyi Howe & Garrett, STEPHENSON, 1938b, p. 573, pl. 67, fig. 3, text-figs. 3, 4; BROWN, 1958, p. 58, pl. 5, fig. 13.

Cytheridea (Haplocytheridea) subovata SUTTON & WILLIAMS, 1939, p. 569, pl. 64, figs. 26-28.

Cytheridea (Haplocytheridea) bastropensis SUTTON & WILLIAMS, 1940, p. 163.

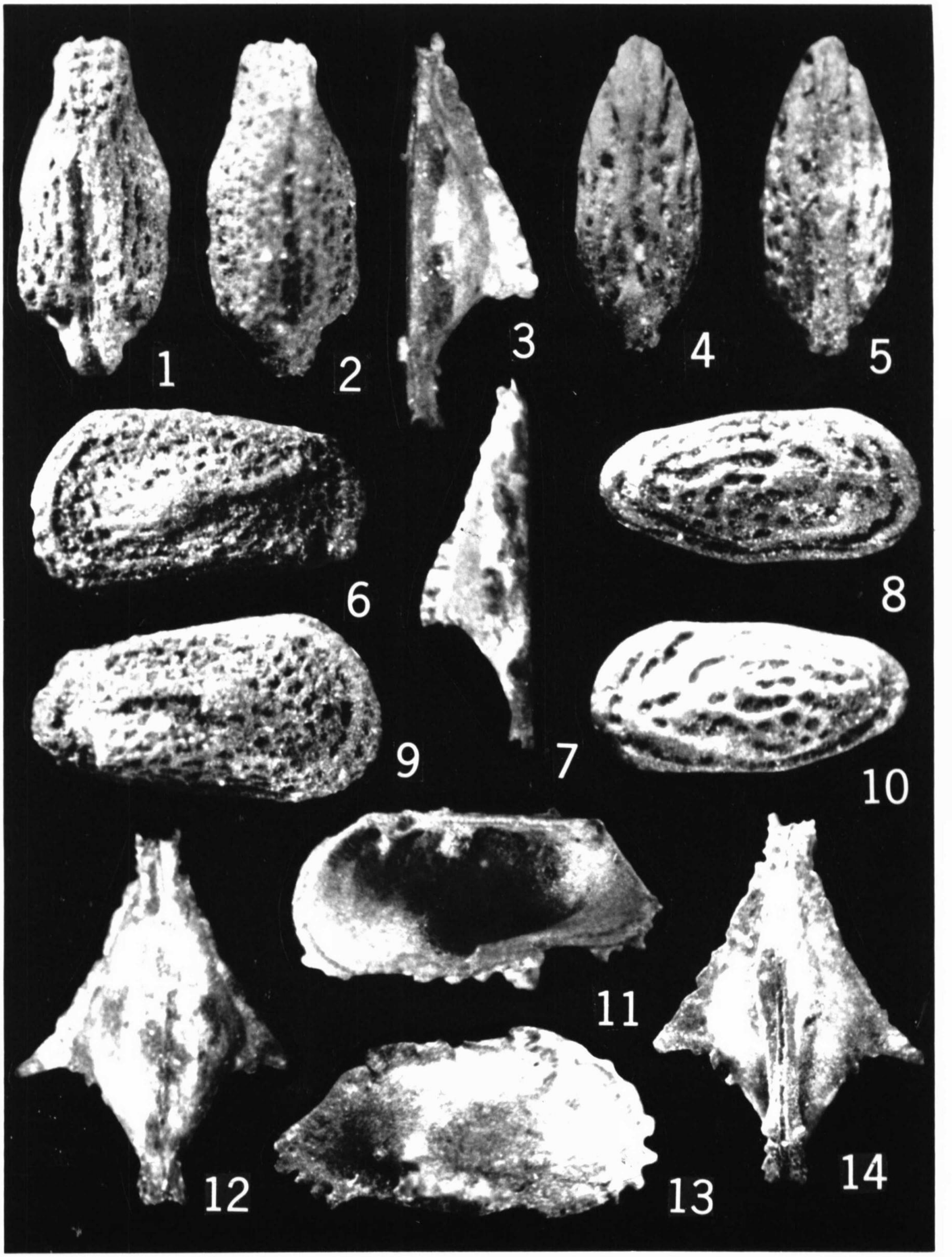
Haplocytheridea moodyi (Howe & Garrett), STEPHENSON, 1946, p. 323, pl. 42, fig. 25, pl. 44, fig. 15.

EXPLANATION OF PLATE 13

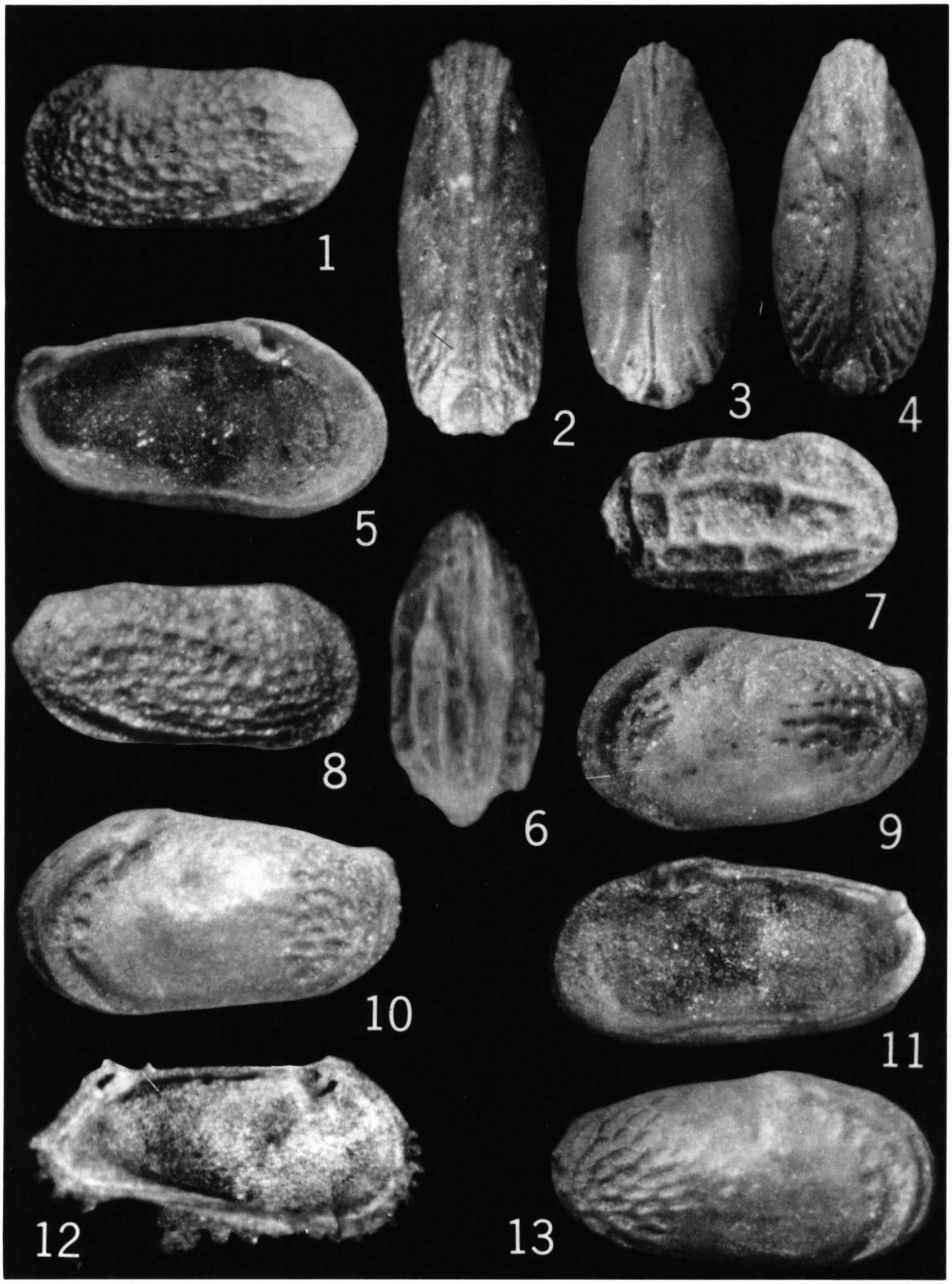
TRACHYLEBERIS, BUNTONIA, PTERYGOCYTHEREIS

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,2,6,9.—Trachyleberis? pauca (SCHMIDT);——*1,* ventral view;——*2,* dorsal view;——*6,* exterior lateral view of left valve of complete specimen;——*9,* exterior lateral view of right valve of complete specimen, all ×75.	55
4,5,8,10.—Buntonia howei (STEPHENSON);——*4,* dorsal view;——*5,* ventral view;——*8,* exterior lateral view of right valve of complete specimen;——*10,* exterior lateral view of left valve of complete specimen, all ×85.	57
3,7,11-14.—Pterygocythereis americana (ULRICH & BASSLER);——*3,* dorsal view of right valve, ×65;——*7,* dorsal view of left valve, ×60;——*11,* interior lateral view of right valve, ×60;——*12,* dorsal view, ×60;——*13,* exterior lateral view of right valve, ×60;——*14,* ventral view, ×60.	34



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

Diagnosis. Recognized by its subovate lateral outline; denticulate anterior margin; and vertical curvilinear furrows, each occupied by a series of pits. *Paleoc.-M.Eoc.*

Remarks. Haplocytheridea moodyi is very similar to *H. veatchi;* however, according to HOWE & GARRETT who identified both forms from the lower Eocene of Louisiana, the beaded ridges on the posterior of *H. veatchi* readily distinguish it from *H. moodyi.* In addition based on the illustrations by HOWE & GARRETT (1934) the lateral outline of *H. veatchi* appears to be considerably more rectangular than that of *H. moodyi.*

Dimensions. Length of adult specimen 0.78 mm, height 0.46 mm, thickness 0.37 mm.

Material. Black Mingo Formation: 10 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4).

Reported from the Weches, Reklaw, Cane River, Bashi, and Nanafalia formations of the Gulf Coast; and lower Eocene? and Paleocene, unnamed units of North Carolina (BROWN, 1958, p. 58).

HAPLOCYTHERIDEA BASSLERI Stephenson, 1943

Pl. 3, figs. 4-9

Cytheridea subovata ULRICH & BASSLER, 1904, p. 124, pl. 37, figs. 1-8, (*non Cythere subovata* Munster, 1830 later changed to *Cytheridea subovata* by Egger, 1858), (*non Cytheridea subovata* Sutton & Williams, 1939=*Haplocytheridea bastropensis* Sutton & Williams, *nom. nov.*, 1940).

Cytheridea (Haplocytheridea) subovata (Ulrich & Bassler), STEPHENSON, 1938a, p. 134, pl. 23, fig. 23, pl. 24, figs. 9, 10, text-fig. 3.

Haplocytheridea bassleri STEPHENSON, 1943, p. 206 (new name); PURI, 1953d, p. 230, pl. 3, figs. 1-4, text-figs. 4c-f; SWAIN, 1955, p. 617, pl. 59, figs. 9a, b; PURI & HULINGS, 1957, p. 187, fig. 11; PURI, 1960, p. 108, 110.

Haplocytheridea? sp. cf. *H.? subovata* (Ulrich & Bassler), SWAIN, 1951, p. 22, pl. 1, figs. 19, 20; PURI, 1953a, p. 750.

Haplocytheridea subovata (Ulrich & Bassler), MALKIN, 1953, p. 782, pl. 79, figs. 15-17.

Diagnosis. Characterized by its large subovate carapace, dorsal margin arcuate with greatest height approximately at mid-length, and surface covered with large circular pits that tend to assume vertical alignment. *M.Mio.-Rec.*

Remarks. Sexual dimorphism is pronounced with the females shorter and more ovoid than the males. The specimens from South Carolina appear to be identical to the Miocene forms illustrated by ULRICH & BASSLER (1904). The pits on the South Carolina forms are more circular than those of the forms illustrated by SWAIN (1955) from the Recent of San Antonio Bay, Texas; and show the same tendency toward vertical alignment as those illustrated by PURI (1953d) from the Miocene of Florida.

Dimensions. Length of male 0.94 mm, height 0.52 mm; length of female 0.93 mm, thickness 0.50 mm, height 0.60 mm.

Material. Duplin Formation: 64 specimens.

Occurrence. Duplin Formation: Localities 38-29 and 5-3. Auger Holes 43-7 (52') and 38-26 (12-19').

This species was originally reported from the middle Miocene, Calvert Formation of Maryland (ULRICH & BASSLER, 1904, p. 124) and was later reported from the Calvert and Choptank formations of Maryland by MALKIN (1953, p. 782). It also occurs in the Chipola, Oak Grove, and Shoal River facies of the middle Miocene, Alum Bluff Stage and the *Arca* and *Yoldia* facies of the upper Miocene, Choctawhatchee Stage of Florida (PURI, 1953d, p. 230), and the lower Miocene or Oligocene and upper Miocene? of North Carolina (SWAIN, 1951, p. 22). Also, it has been reported from the Recent in the lower part of San Antonio Bay and the marshes on Matagordo Island, Texas (SWAIN, 1955, p. 618); Pamlico Sound, North Carolina (GROSSMAN, 1964); and the west coast of Florida (PURI, 1960, p. 110).

Subfamily NEOCYTHERIDEIDINAE Puri, 1957
Genus CUSHMANIDEA Blake, 1933

Cytherideis JONES, 1857 (part), p. 46.

Cytherideis JONES, part of authors.

? *Sacculus* NEVIANI, 1928, p. 72.

Pontocythere DUBOVSKY, 1939, p. 29; OERTLI, 1956, p. 56.

Hemicytherideis RUGGIERI, 1952, p. 60; KEIJ, 1957, p. 80.

Cushmanidea BLAKE, 1933, p. 233; PURI, 1958a, p. 171; HOWE, 1961, p. Q290; BENSON & KAESLER, 1963, p. 21.

Type-species. Cytheridea seminuda CUSHMAN, 1906, p. 374, pl. 33, figs. 62-64, pl. 34, figs. 76, 77.

Diagnosis. Recognized by its elongate anterior, broadly rounded anterior and posterior ends, and smooth or reticulate surface with pattern tending to

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EXPLANATION OF PLATE 14
LOXOCONCHA, BUNTONIA, TRACHYLEBERIS, PTERYGOCYTHEREIS

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,8.—Loxoconcha mcbeanensis MURRAY;——*1,* exterior lateral view of left valve of complete specimen, ×120;——*8,* exterior lateral view of right valve of complete specimen, ×125.	50
2-5,9-11,13.—Buntonia reticulata POOSER, n. sp.;——*2,* dorsal view of male, ×80;——*3,* ventral view of female, ×80;——*4,* dorsal view of female, ×80;——*5,* interior lateral view of left valve of male, ×80;——*9,* exterior lateral view of left valve of female, ×75;——*10,* exterior lateral view of left valve of male, ×80;——*11,* interior lateral view of right valve of male, ×75;——*13,* exterior lateral view of right valve of male, ×80.	56
6,7.—Trachyleberis? johnsoni POOSER, n. sp.;——*6,* ventral view, ×120; *7,* exterior lateral view of right valve of complete specimen, ×110.	54
12.—Pterygocythereis americana (ULRICH & BASSLER); interior lateral view of left valve, ×65.	34

parallel margins. Hinge lophodont; right valve with elongate anterior tooth formed by enlargement of selvage, elongate median groove, and short posterior tooth extending posteriorly into selvage. *Jur.?-Rec.*

Remarks. The elongate anterior, broadly rounded posterior, and smooth to reticulate surface distinguish *Cushmanidea* from *Hulingsina* to which it is closely related.

CUSHMANIDEA MAYERI (Howe & Garrett, 1934), Puri, 1958

Pl. 7, figs. 6-9

Bythocypris? mayeri HOWE & GARRETT, 1934, p. 29, pl. 1, figs. 8-10.
Xestoleberis mayeri (Howe & Garrett), SCHMIDT, 1948, p. 410, pl. 63, fig. 10, text-fig. 2a.
Cytherideis mayeri (Howe & Garrett), BLAKE, 1950, p. 179; MUNSEY, 1953, p. 13, pl. 3, fig. 4.
Cushmanidea mayeri (Howe & Garrett), PURI, 1958a, p. 174, table 1.

Diagnosis. Distinguished by its reticulate carapace with smooth dorsal and ventral margins, denticulate anterior margin, and anteroventrally trending narrow sulcus located dorsal to mid-line and slightly anterior to middle. *Paleoc.-L.Eoc.*

Remarks. As originally described by HOWE & GARRETT (1934), "Just anterior to the middle on the elongate male valves, and at the middle on the shorter plumper female valves, a deep narrow trench leaves the dorsal margin, trends diagonally toward the anterior end, until it reaches the central axis, where it bifurcates, partially surrounds a circular area of 'lucid spots' and disappears." The South Carolina specimens have a well-incised nonbifurcated sulcus that originates just ventral to the dorsal margin and trends anteroventrally, anterior to which is a small, circular, nonreticulate area. This minor variation in ornamentation is not of sufficient significance to warrant designating the forms from South Carolina as a separate species.

Cushmanidea perforata (BLAKE) is similar to *C. mayeri* but lacks a sulcus and is less strongly reticulate.

Dimensions. Female: length 0.65 mm, thickness 0.25 mm, height 0.26 mm. Male: length 0.70 mm, thickness 0.25 mm, height 0.27 mm.

Material. Black Mingo Formation: 18 specimens.

Occurrence. Black Mingo Formation: locality 8-2 (units 2 and 4).

Previously reported from the Coal Bluff Member of the Naheola Formation of Alabama (MUNSEY, 1953, p. 13); Aquia Formation of Maryland (SCHMIDT, 1948, p. 410); Sabine Group at Sabinetown, Louisiana and Nanafalia, Alabama (HOWE & GARRETT, 1934, p. 29).

CUSHMANIDEA CALEDONIENSIS (Munsey, 1953), Puri, 1958

Pl. 6, figs. 6-11

Cytherideis caledoniensis MUNSEY, 1953, p. 13, pl. 3, fig. 5.
Cushmanidea caledoniensis (Munsey), PURI, 1958a, p. 174, table 1.

Diagnosis. Distinguished by its subrectangular shape, coarsely reticulate surface, bifurcated sulcus immediately below dorsal margin and slightly anterior to middle, and two longitudinal ridges originating just ventral to sulcus and terminating posteriorly at a vertical ridge. *Paleoc.-L.Eoc.*

Description of interior. The external features of *Cushmanidea caledoniensis* have been well described by MUNSEY (1953, p. 13); however, the internal features have not been previously described. Hinge of right valve consists of elongate anterior flange and postjacent groove which parallels posterodorsal slope of carapace. Selvage originates at posterior extremity of hinge and immediately departs from outer margin thus forming wide flange at posteroventer. Selvage parallels venter nearly to anteroventer where it merges with flange. Hinge of left valve antithesis of right with small socket at posterodorsal angle. Duplicature widest anteriorly with prominent anterior vestibule. Muscle-scar pattern obscure except for crescent-shaped antennal scar.

Remarks. This species is readily distinguished from other species of *Cushmanidea* by the unique arrangement of surface ridges. MUNSEY did not mention sexual dimorphism; however, the specimens from South Carolina indicate that the males are considerably more elongate and less tumid than the females.

EXPLANATION OF PLATE 15

TRACHYLEBERIS, TRIGINGLYMUS, ECHINOCYTHEREIS

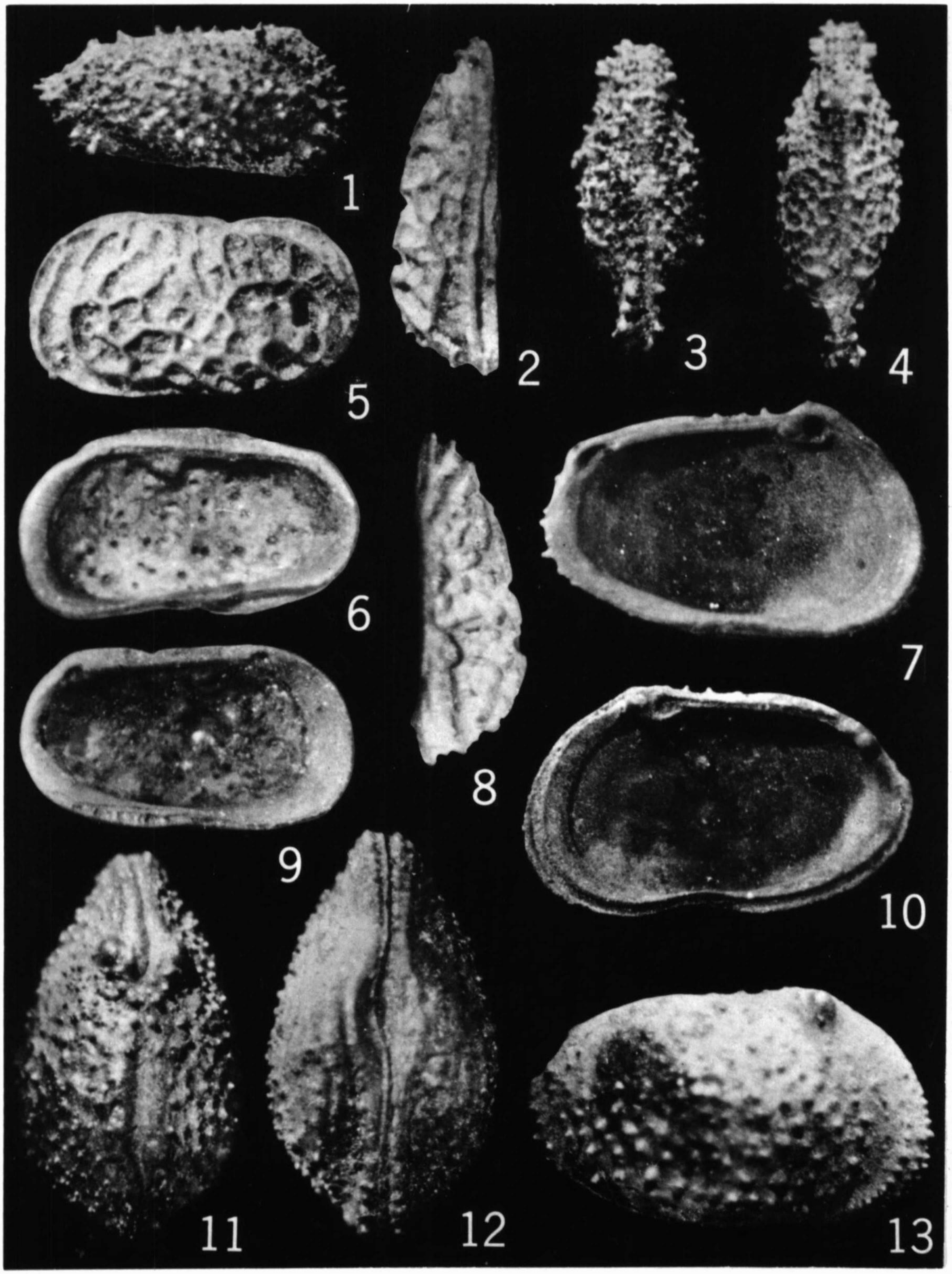
(All illustrated forms are from South Carolina)

FIGURE PAGE

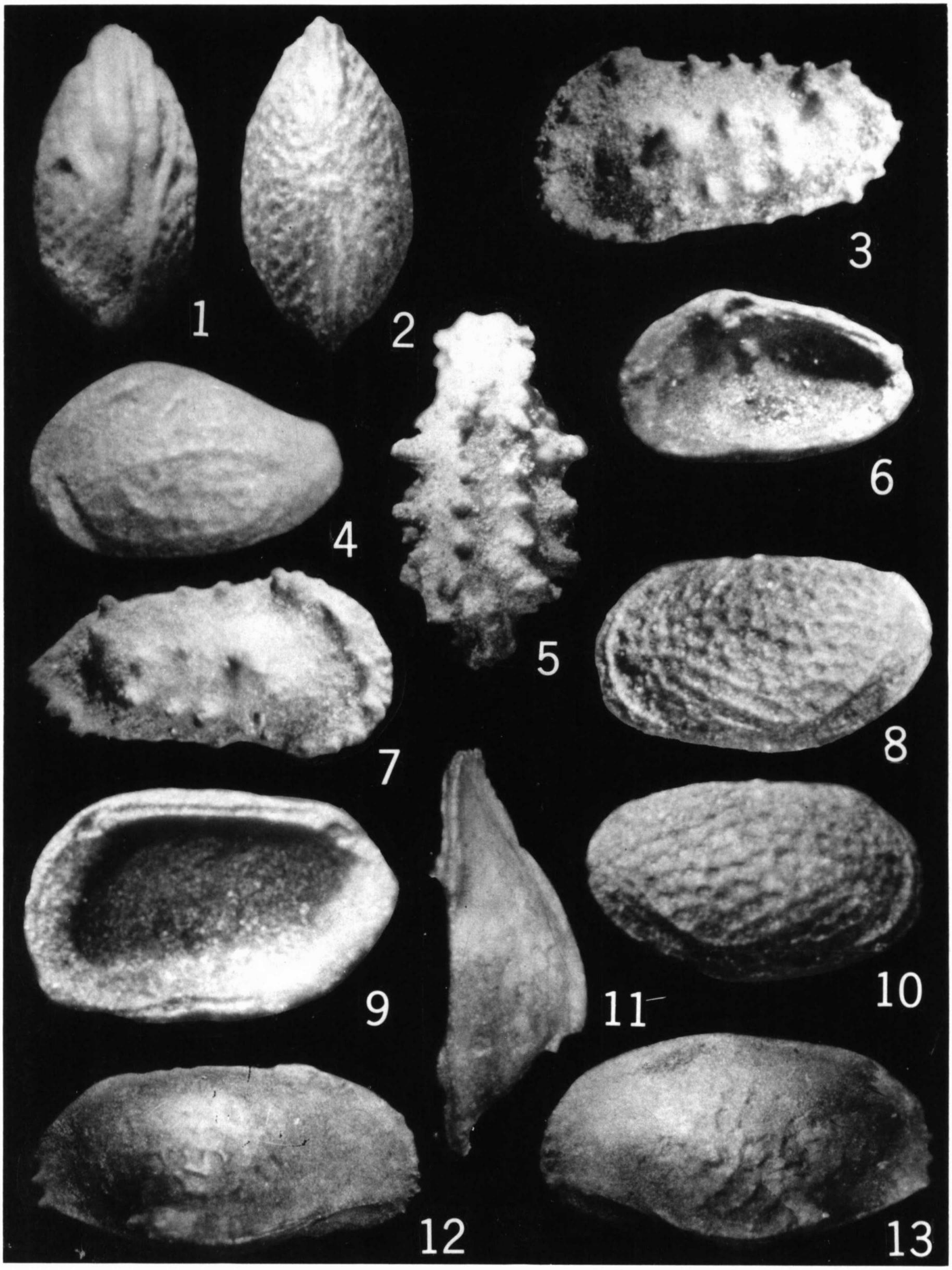
1,3,4.—Trachyleberis spinosissima (JONES & SHERBORN);——*1*, exterior lateral view of right valve of female whole specimen, ×60;——*3*, ventral view of female, ×60; *4*, dorsal view of male, ×65. 55

2,5,6,8,9.—Triginglymus whitei (SWAIN);——*2*, ventral view of right valve;——*5*, exterior lateral view of left valve;——*6*, interior lateral view of right valve;——*8*, dorsal view of right valve;——*9*, interior lateral view of left valve, all ×75. 36

7,10-13.—Echinocythereis jacksonensis (HOWE & PYEATT);——*7*, interior lateral view of left valve;——*10*, interior lateral view of right valve;——*11*, dorsal view;——*12*, ventral view;——*13*, exterior lateral view of right valve, all ×55. .. 58



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

Dimensions. Length 0.65 mm, thickness 0.23 mm, height 0.24 mm.

Material. Black Mingo Formation: 25 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4).

Reported from the Paleocene, Coal Bluff Marl Member of the Naheola Formation of Alabama (MUNSEY, 1953, p. 13).

Genus HULINGSINA Puri, 1958

Hulingsina PURI, 1958a, p. 173; HOWE, 1961, p. Q290; BENSON & COLEMAN, 1963, p. 30.

Type-species. Hulingsina tuberculata PURI, 1958a, p. 173, pl. 2, figs. 5-9.

Diagnosis. Anterior end rounded, posterior end subacute and angled obliquely in dorsal half of carapace. Surface tuberculate, coarsely reticulate, or coarsely pitted. Other features similar to *Cushmanidea. Mio.-Rec.*

HULINGSINA ASHERMANI (Ulrich & Bassler, 1904), Puri, 1958

Pl. 6, fig. 5; Pl. 8, figs. 1-3

Cytherideis ashermani ULRICH & BASSLER, 1904, p. 126, pl. 37, figs. 10-16; HOWE AND OTHERS, 1935, p. 14, pl. 3, figs. 8-10; EDWARDS, 1944, p. 514, pl. 86, figs. 1-4; SWAIN, 1948, p. 195, pl. 13, fig. 1; ———, 1951, p. 19; PURI, 1952b, p. 910, pl. 130, figs. 4-8, text-figs. 1, 2; ———, 1953d, p. 286, pl. 9, figs. 4-8; MALKIN, 1953, p. 778, pl. 78, figs. 1-13.

Cytherideis longula ULRICH & BASSLER, 1904, p. 128, pl. 37, figs. 21-27; SWAIN, 1948, p. 195, pl. 13, fig. 2; ———, 1951, p. 19.

Cytherideis semicircularis ULRICH & BASSLER, 1904, p. 127, pl. 37, figs. 18-20.

Cushmanidea ashermani (Ulrich & Bassler), MCLEAN, 1957, p. 77, pl. 8, figs. 5a-f; BROWN, 1958, p. 67, fig. 9.

Hulingsina ashermani (Ulrich & Bassler), PURI, 1958a, p. 173, table 2; BENSON & COLEMAN, 1963, p. 30, pl. 4, figs. 1-3, text-fig. 17.

Diagnosis. Characterized by its coarsely reticulate surface and highly arched dorsum. Selvage of right valve high and sharp anteriorly and set in from anterior margin. Along venter selvage lies almost at outer margin but swings sharply upward near posterior leaving broad, flat flange which is bordered by narrow, low posteroventral extension. *L.Mio.-Rec.*

Remarks. The marginal areas of the young molts are considerably narrower than those of the adults. The forms studied show considerable variation in lateral outline.

Dimensions. Length 0.78 mm, height 0.39 mm.

Material. Duplin Formation: 20 specimens.

Occurrence. Duplin Formation: Localities 38-42 and 38-45.

This species was originally described by ULRICH & BASSLER (1904, p. 126) and later reported by SWAIN (1948, p. 195) from the middle Miocene, Calvert Formation of Maryland. In addition MALKIN (1953, p. 778) has reported it from the middle and upper Miocene of Maryland. It has also been reported from North Carolina in the upper Miocene, Yorktown Formation (BROWN, 1958, p. 67); upper Miocene, Duplin Formation (EDWARDS, 1944, p. 514); and the lower Middle, and upper Miocene (SWAIN, 1951, p. 19). It occurs in the upper Miocene, Yorktown Formation of Virginia (MCLEAN, 1957, p. 76), and the Chipola, Oak Grove, *Arca, Ecphora,* and *Cancellaria* facies of Florida (PURI, 1953d, p. 286). *Hulingsina ashermani* has been reported from the Recent of the eastern Gulf of Mexico (BENSON & COLEMAN, 1963, p. 31) and Pamlico Sound, North Carolina (GROSSMAN, 1964).

Family CYTHERURIDAE G. W. Müller, 1894

Genus CYTHERURA Sars, 1866

Cytherura SARS, 1866, p. 60; ALEXANDER, 1936, p. 690; EDWARDS, 1944, p. 525; STEPHENSON, 1946, p. 316; HORNIBROOK, 1952, p. 50; SWAIN, 1955, p. 626; HANAI, 1957, p. 13, 17; KEIJ, 1957, p. 144; BENSON, 1959, p. 51; REYMENT, 1961, p. Q292; BENSON & COLEMAN, 1963, p. 31; BENSON & KAESLER, 1963, p. 22.

Type-species. Cythere gibba O. F. MÜLLER, 1785, p. 66, pl. 7, figs. 7-9.

Diagnosis. Distinguished by its subquadrate carapace and prominent caudal process. Surface smooth or with pits, reticulations, ridges, or spines. Duplicature wide with no vestibule. Hinge modified merodont; right valve with one or rarely two terminal knoblike teeth formed at proximal ends of the selvage, and overlying groove between hinge and flange; left valve with median bar and terminal sockets. *Cret.-Rec.*

CYTHERURA JOHNSONI Mincher, 1941

Pl. 10, figs. 1-4, 6

Cytherura johnsoni MINCHER, 1941, p. 343, pl. 47, fig. 1; SWAIN, 1955, p. 627, pl. 64, figs. 8a-c, text-figs. 35b and 38a, b and 39 1a-c; PURI & HULINGS, 1957, p. 187, fig. 11; PURI, 1960, p.

EXPLANATION OF PLATE 16

BUNTONIA, ACTINOCYTHEREIS, LOXOCONCHA, BRACHYCYTHERE

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,4,6.—Buntonia alabamensis (HOWE & PYEATT); ——*1,* dorsal view, ×90;——*4,* exterior lateral view of left valve, ×90;——*6,* interior lateral view of right valve, ×85.	57
3,5,7.—Actinocythereis davidwhitei (STADNICHENKO);——*3,* exterior lateral view of left valve, ×85;——*5,* dorsal view, ×80;——*7,* exterior lateral view of right valve, ×80.	55
2,8,10.—Loxoconcha sp. cf. *L. claibornensis* MURRAY; ——*2,* dorsal view;——*8,* exterior lateral view of left valve of complete specimen;——*9,* interior lateral view of right valve;——*10,* exterior lateral view of right valve of complete specimen, all ×110.	50
11-13.—Brachycythere martini MURRAY & HUSSEY; ——*11,* dorsal view of right valve;——*12,* exterior lateral view of right valve;——*13,* exterior lateral view of left valve, all ×55.	32

114, pl. 4, figs. 14, 15; BENSON & COLEMAN, 1963, p. 31, pl. 6, figs. 1-5, text-fig. 18. BENSON & KAESLER, 1963, p. 22, pl. 3, figs. 7, 9, text-fig. 11; VAN DEN BOLD, 1963b, p. 395, pl. 9, fig. 3.

Cytherura forulata EDWARDS, 1944, p. 526, pl. 88, figs. 17-20; MALKIN, 1953, p. 789, pl. 80, figs. 22-24; SWAIN, 1951, p. 50; ———, 1955, p. 628, pl. 64, figs. 10a-c, text-figs. 35c and 39-2a,b; PURI & HULINGS, 1957, p. 176, 183; PURI, 1960, p. 115, pl. 4, figs. 16, 17.

Cytherura elongata EDWARDS, 1944, p. 526, pl. 88, figs. 21-25; SWAIN, 1951, p. 50, pl. 7, figs. 24, 25; ———, 1955, p. 628, pl. 64, figs. 12a, b.

Diagnosis. Recognized by its elongate, subrectangular carapace, nearly straight to slightly arched dorsum, longitudinal ribs and delicate transverse ridges which form irregular rectangular pattern, and caudal process dorsal to mid-line. *U.Mio.-Rec.*

Remarks. Cytherura johnsoni MINCHER (1941), *C. elongata* EDWARDS (1944), and *C. forulata* EDWARDS (1944) have been described as separate species, but appear to be conspecific. EDWARDS (1944) indicated that the nearly straight dorsal margin differentiates *C. elongata* from *C. forulata;* however, the author experienced great difficulty in trying to differentiate the forms with a straight dorsum *(C. elongata)* from those with a slightly arched dorsum *(C. forulata)* in the samples collected from the Duplin Formation of South Carolina. There appears to be a complete transition from the slightly smaller forms with the gently arched dorsum to the more elongate forms with a straight dorsum. Possibly the smaller form represents the female or an earlier instar.

SWAIN (1955) had difficulty in distinguishing the molts of *C. elongata* from *C. johnsoni* in the samples from the Recent of San Antonio Bay, Texas. In addition he noted the similarity between *C. elongata* and *C. forulata* but indicated that *C. forulata* lacked a posterior caudal process and had a more convex dorsum. MALKIN (1953) noted that individuals classified as *C. forulata* are shorter in proportion to height than those of *C. elongata* but in other respects are similar and the two may be conspecific. BENSON & COLEMAN (1963), who based their work on living forms from the eastern Gulf of Mexico, are of the opinion that *C. johnsoni, C. forulata,* and *C. elongata* are conspecific.

Dimensions. Elongate form: length 0.50 mm, thickness 0.22 mm, height 0.25 mm.

Material. Duplin Formation: 40 specimens.

Occurrence. Duplin Formation: Locality 38-42. Auger Hole 38-38 (19 and 24′).

Originally described by MINCHER (1941) from the Miocene, Pascagoula Formation of Louisiana. It has subsequently been reported from the upper Miocene, Duplin Formation of North Carolina (EDWARDS, 1944 and SWAIN, 1951), Yorktown Formation of Virginia (MALKIN, 1953), Springvale Formation of Trinidad (VAN DEN BOLD, 1936b, p. 395); the Pleistocene of North Carolina (SWAIN, 1951); the Recent of Florida by PURI (1960) and BENSON & COLEMAN (1963), the Recent of San Antonio Bay, Texas by SWAIN (1955), the Recent of the Estero de Tastiota region, Sonora, Mexico (BENSON & KAESLER, 1963, p. 22), and the Recent of Trinidad (VAN DEN BOLD, 1963b, p. 395).

CYTHERURA WARDENSIS Howe & Brown, 1935

Pl. 9, figs. 2, 4-6

Cytherura wardensis Howe & Brown, *in* HOWE AND OTHERS, 1935, p. 36, pl. 1, figs. 23, 27, pl. 4, fig. 7; EDWARDS, 1944, p. 525, pl. 88, figs. 11, 12; SWAIN, 1951, p. 50; MALKIN, 1953, p. 769, table 1; PURI, 1953d, p. 241, pl. 4, figs. 1-4, text-fig. 6f; ———, 1960, p. 109, table 1.

Diagnosis. Recognized by its elongate subquadrate outline and uniform height throughout length of carapace. Surface ornamented by fine longitudinal reticulations, low sulcus just anterior to middle, small eye tubercle immediately below anterior cardinal angle, and longitudinal striae on flattened ventral surface. Ventral margin with posterior keel forming sharp ridge where valves meet. *U.Mio.-Rec.*

Remarks. Cytherura wardensis is readily distinguished from the other species of *Cytherura* that are usually found with it by the posterior swelling and prominent posteroventral keel.

Dimensions. Length 0.54 mm, thickness 0.25 mm, height 0.28 mm.

EXPLANATION OF PLATE 17
AURILA, ORIONINA, PURIANA

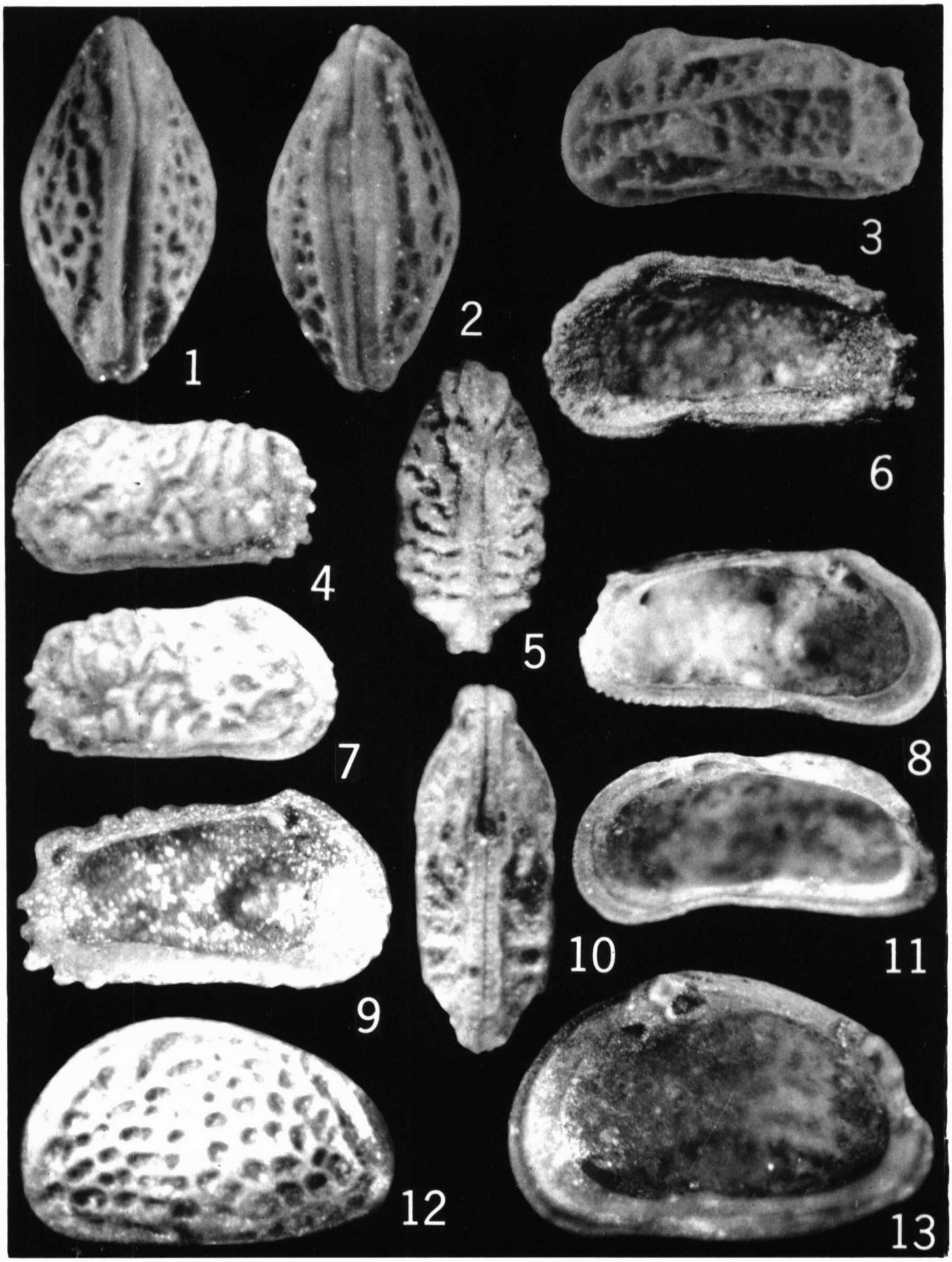
(All illustrated forms are from South Carolina)

FIGURE — PAGE

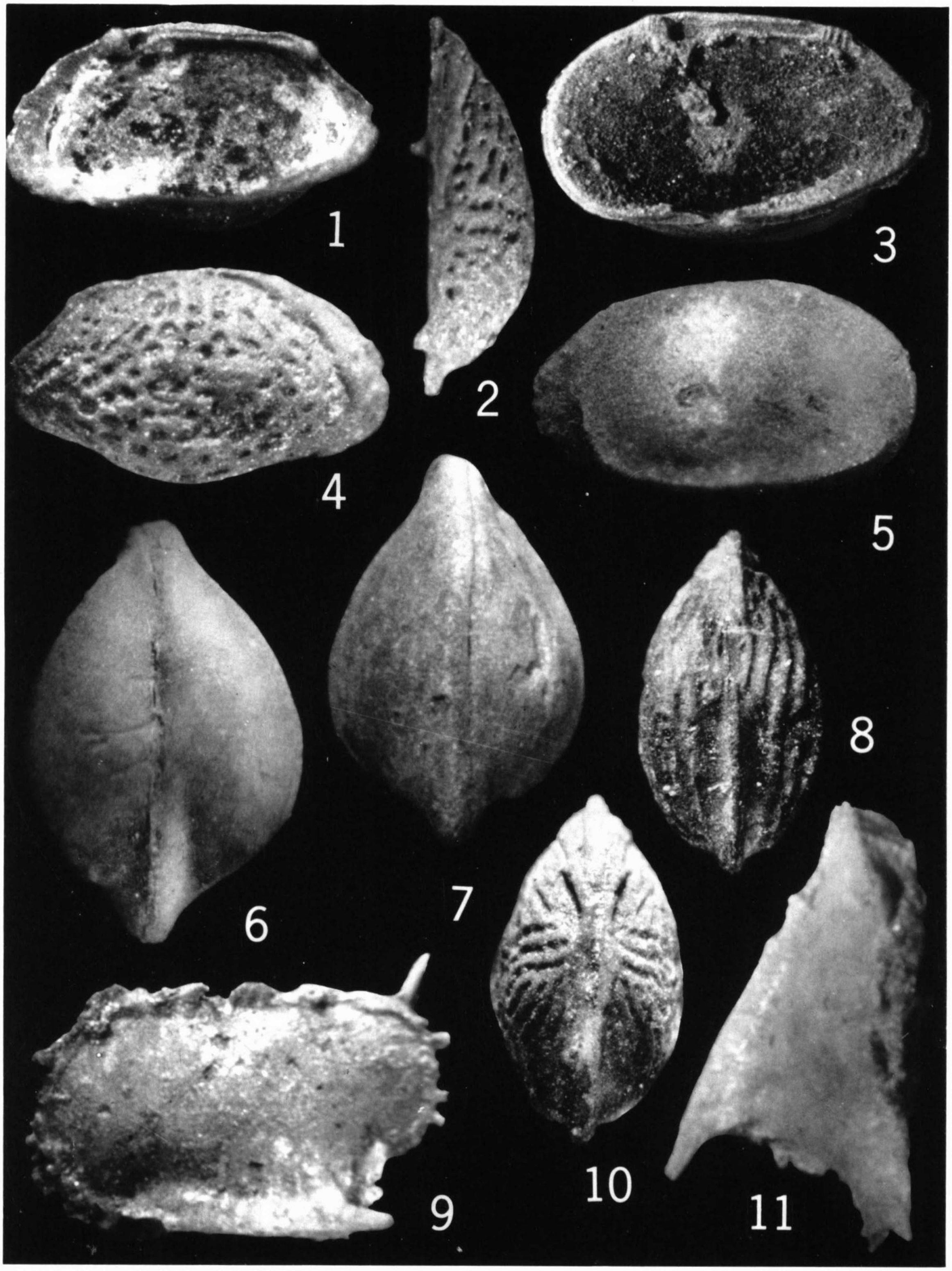
1,2,12,13.—Aurila conradi conradi (HOWE & McGUIRT);——*1,* dorsal view, ×100;——*2,* ventral view, ×100;——*12,* exterior lateral view of left valve, ×100;——*13,* interior lateral view of right valve, ×115. 48

3,8,10,11.—Orionina bermudae (BRADY);——*3,* exterior lateral view of left valve;——*8,* interior lateral view of left valve;——*10,* ventral view;——*11,* interior lateral view of right valve, all ×70. 61

4-7,9.—Puriana rugipunctata (ULRICH & BASSLER);——*4,* exterior lateral view of left valve of complete specimen, ×70;——*5,* dorsal view, ×80;——*6,* interior lateral view of right valve, ×90; *7,* exterior lateral view of right valve of complete specimen, ×75;——*9,* interior lateral view of left valve, ×90. 62



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

Material. Duplin Formation: 36 specimens.

Occurrence. Duplin Formation: Locality 38-42. Auger Holes 38-26 (12-19') and 38-38 (19 and 24').

Originally described from the upper Miocene, *Arca* facies of the Choctawhatchee Stage of Florida (HOWE AND OTHERS, 1935, p. 36). It has also been reported from the *Arca, Ecphora,* and *Cancellaria* facies of the Choctawhatchee Stage of Florida (PURI, 1953d, p. 241); the upper Miocene, Duplin Marl of North Carolina (EDWARDS, 1944, p. 525); the upper Miocene of North Carolina (SWAIN, 1951, p. 50); the upper Miocene, Yorktown Formation of Virginia (MALKIN, 1953); and the Recent of Florida (PURI, 1960).

Genus CYTHEROPTERON Sars, 1866

Cytheropteron SARS, 1866, p. 779; SARS, 1926, p. 232; ALEXANDER, 1933, p. 181; MARTIN, 1939, p. 176; STEPHENSON, 1946, p. 318; HANAI, 1957, p. 26; BENSON, 1959, p. 54; REYMENT, 1961, p. Q292.

Type-species. Cythere latissima NORMAN, 1865, p. 19, pl. 6, figs. 5-8 (=*Cytheropteron convexum* SARS, 1866).

Diagnosis. Distinguished by its smooth, pitted, or reticulate carapace with caudal extension and winglike lateral projection (ala). Hinge merodont; right valve with crenulate terminal teeth at each end of hingement and crenulate groove between. *U.Jur.-Rec.*

Remarks. Eocytheropteron is similar to *Cytheropteron* in lateral outline but is readily distinguished from *Cytheropteron* by the lack of the winglike lateral projection and the somewhat indistinct differentiation of the terminal teeth from the median element.

CYTHEROPTERON VARIOSUM Martin, 1939

Pl. 11, figs. 6, 7, 9, 12

Cytheropteron variosum MARTIN, 1939, p. 178, pl. 22, figs. 7-9; BLAKE, 1950, p. 180, pl. 30, figs. 13, 14; SWAIN, 1951, p. 48, pl. 7, figs. 12, 14, 15.

Diagnosis. Characterized by a gently convex ventral margin and by a strongly and evenly arched dorsum. Surface ornamentation variable with some forms smooth, whereas others have vertically aligned, elongate pits extending from ala almost to dorsal margin. Prominent ala parallels ventral margin. *M.Eoc.*

Remarks. MARTIN (1939, p. 178) made no mention of two short *en echelon* ridges on the venter; however, the ridges are well developed on the material studied by the author and on the forms illustrated by SWAIN (1951). The posterolateral ridge of the venter of each valve appears as a small spine when viewed from the dorsum or venter. *Cytheropteron variosum* is similar to *C. montgomeryense* HOWE & CHAMBERS (1935, p. 19) in shape, but is more strongly ornamented. *C. lisbonense* MARTIN (1939, p. 177) is distinguished from *C. variosum* by its unique surface ornamentation. MARTIN (1939) reports that *C. variosum* is the most common Claiborne species. It is also very abundant in the Claiborne of South Carolina.

Dimensions. Length 0.44 mm, thickness 0.26 mm, height 0.26 mm.

Material. Warley Hill Formation: 8 specimens. Santee Limestone: 41 specimens.

Occurrence. Santee Limestone: Localities 9-28, 9-31, 9-32, 9-33 (unit 3), 9-54 (unit 1), 38-85, 38-87, 38-103. Auger Holes 5-1 (75-85'), 38-7 (27'), 38-11 (10-15'), 38-22 (70'), 38-23 (25'), 38-35 (70-74'), 38-37 (50-65'), 38-40 (65-70'). Warley Hill Formation: Localities 9-28, 9-33 (unit 1), and 9-34.

Reported from the Cook Mountain Formation of Louisiana (MARTIN, 1959, p. 178), Gosport Formation of Alabama (BLAKE, 1950, p. 182), middle Eocene of North Carolina (SWAIN, 1951, p. 48), and the McBean Formation of Georgia.

CYTHEROPTERON, sp. A.

Pl. 10, figs. 5, 7, 8

A single whole specimen of this very alate form was recovered from Auger Hole 8-39 (25-30'). Length 0.50 mm, thickness 0.45 mm, height 0.47 mm.

Genus EOCYTHEROPTERON Alexander, 1933

Cytheropteron (Eocytheropteron) ALEXANDER, 1933, p. 195; KEIJ, 1957, p. 149; POKORNÝ, 1958, p. 288.

Eocytheropteron HOWE & GARRETT, 1934, p. 45; HANAI, 1957, p. 15; REYMENT, 1961, p. Q292.

Type-species. Cytheropteron bilobatum ALEXANDER, 1929, p. 104, pl. 10, fig. 14-15.

Diagnosis. Like *Cytheropteron* but devoid of side wings. Differentiation of terminal teeth from medial element indistinct. *Cret.-Rec.*

EXPLANATION OF PLATE 18

LEGUMINOCYTHEREIS, DIGMOCYTHERE, ALATACYTHERE

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,2,4,8,10.—Leguminocythereis scarabaeus HOWE & LAW;——*1*, interior lateral view of right valve, ×75;——*2*, dorsal view of right valve, ×75;——*4*, exterior lateral view of right valve, ×80;——*8*, ventral view, ×65;——*10*, dorsal view, ×65.	35
3,5-7.—Digmocythere russelli (HOWE & LEA);——*3*, interior lateral view of right valve, ×60;——*5*, exterior lateral view of right valve, ×60;——*6*, ventral view, ×65; *7*, dorsal view, ×60.	33
9,11.—Alatacythere ivani HOWE;——*9*, exterior lateral view of left valve;——*11*, dorsal view of left valve, all ×60.	32

EOCYTHEROPTERON BLACKMINGOENSE Pooser, n. sp.
Pl. 9, figs. 7-11

Diagnosis. Distinguished by its subovate lateral outline and reticulate surface. Tumid venter with longitudinal ridges, one or two of which are visible from lateral view. Strongly compressed anterior and posterior margins. *L.Eoc.*

Description. General shape tumid; dorsal outline ovate; lateral outline subovate; venter swollen but lacking any indication of alae; subtriangular to subovate in end view. Greatest height in middle; greatest thickness in middle and near venter. Dorsal margin strongly and evenly arched; ventral margin evenly convex; anterior end broadly to obliquely rounded. Short caudal process along median line. Left valve slightly larger than right and overreaches right along dorsal margin and posterior portion of ventral margin. Ventral sinuation just anterior to middle in both valves. Dorsal portion of surface smooth or sparsely reticulate, remainder of carapace coarsely reticulate, reticulations becoming more conspicuous toward venter. Longitudinal ridges along tumid venter, one or two of which are visible from lateral view. Narrow compressed anterior and posterior margins.

Hinge typical of genus. Left valve with terminal crenulate sockets; right valve antithesis of left. Median elements of both valves not differentiated into ridge and groove as in *Cytheropteron* but rather teeth of one valve fit into sockets of other valve. Small anterior vestibule. Left valve with strong flange groove and weakly developed selvage. Radial pore-canals not observed. Normal pore-canals expressed as large scattered pits on interior. Muscle-scar pattern consists of vertical row of four elongate adductor scars and V-shaped antennal scar anterior to uppermost adductor scar.

Males longer than females and with more obliquely rounded anterior.

Remarks. Eocytheropteron blackmingoense differs from *Cytheropteron (Cytheropteron) midwayense* ALEXANDER in being larger, and in having a more arched dorsum and coarser reticulations. ALEXANDER (1934, p. 230) reports that *C. (C.) midwayense* has a densely and finely punctate surface thus giving the shell a finely granular appearance. The form reported by SCHMIDT (1948, p. 414) as *C. (C.) midwayense* is similar to *E. blackmingoense* in lateral outline but differs in surface texture and overall size.

Dimensions. Female: length 0.80 mm, thickness 0.48 mm, height 0.50 mm. Male: length 0.88 mm, thickness 0.51 mm, height 0.46 mm.

Material. Black Mingo Formation: 20 specimens. Holotype deposited in the U.S. National Museum, Smithsonian Institution, Washington, D.C.; WKP821622.

Occurrence. Lower Eocene, Black Mingo Formation: Locality 8-2 (units 2 and 4).

EOCYTHEROPTERON SPURGEONAE Howe & Chambers, 1935
Pl. 10, figs. 9-11

Eocytheropteron spurgeonae HOWE & CHAMBERS, 1935, p. 20, pl. 3, fig. 18, pl. 4, fig. 2, pl. 6, figs. 12, 13; GARRETT, 1936, p. 786; MONSOUR, 1937, p. 89, 93.
Konarocythere spurgeonae (Howe & Chambers), KRUTAK, 1961, p. 776, pl. 92, fig. 4.

Diagnosis. Characterized by its very faintly reticulate surface with longitudinal ridges and grooves along ventrolateral and ventral surfaces. *U.Eoc.-Oligo.*

Remarks. Eocytheropteron spurgeonae differs from *E. blackmingoense* in that *E. spurgeonae* is less coarsely reticulate, less ovate in lateral outline, and the venter is considerably more tumid.

Eocytheropteron spurgeonae is similar to *E. fiski* HOWE & LAW (1936) of the Vicksburg Oligocene; however, *E. fiski* is considerably more coarsely reticulate than *E. spurgeonae.*

Dimensions. Left valve (female): length 0.75 mm, thickness 0.26 mm, height 0.52 mm.

Material. Cooper Marl: 2 single valves.

Occurrence. Cooper Marl: Locality 8-1 (unit 4).

This species was originally described from the lower Jackson of Alabama. HOWE & CHAMBERS (1935, p. 21) reported that *E. spurgeonae* is fairly common in the basal Jackson from Alabama to Texas. Also it has been reported from the upper Eocene, Ocala Limestone at Claiborne Bluff, Alabama (GARRETT, 1936, p. 786); the Jackson of Mississippi (MONSOUR, 1937, p. 89 and 93); and the Cocoa Sand of Alabama (KRUTAK, 1961, p. 776).

Family HEMICYTHERIDAE Puri, 1953

Genus AURILA Pokorný, 1955

Cythereis JONES, 1849 (part), p. 14; AUCTT.
Hemicythere SARS, 1925 (part), p. 182; AUCTT.
Cythereis gruppo, Auris NEVIANI, 1928 (part), p. 72.
Cythereis (Eucythereis) ELOFSON, 1941 (part), p. 283.
Aurila POKORNÝ, 1955, p. 17; KEIJ, 1957, p. 114; HOWE, 1961, p. Q302. BENSON & COLEMAN, 1963, p. 34; BENSON & KAESLER, 1963, p. 23.
Type-species. Cythere convexa BAIRD, 1850, p. 174, pl. 21, fig. 3.

Diagnosis. Characterized by its almond shape and pitted to reticulate carapace. Hinge holamphidont; right valve consists of conical, stepped, anterior tooth; postjacent socket; finely serrate groove; and posterior tooth with incision in middle of ventral wall. *Mio.-Rec.*

AURILA CONRADI CONRADI (Howe & McGuirt, 1935), McLean, 1957
Pl. 17, figs. 1, 2, 12, 13

Hemicythere conradi Howe & McGuirt, *in* HOWE AND OTHERS, 1935, p. 27, pl. 3, figs. 31-34, pl. 4, fig. 17; EDWARDS, 1944, p. 518. pl. 86, figs. 17, 18; SWAIN, 1951, p. 42, pl. 6, figs. 9-12;

MALKIN, 1953, p. 796, pl. 82, figs. 16-18; PURI, 1953c, p. 176, pl. 2, figs. 1, 2; ———, 1953d, p. 266; BROWN, 1958, p. 65, pl. 6, fig. 17.
Aurila conradi (Howe & McGuirt), MCLEAN, 1957, p. 94, pl. 11, figs. 7a, b. PURI, 1960, p. 129, pl. 3, figs. 9, 10.
Aurila conradi conradi Howe & McGuirt, 1935, *nom. trans.* herein.

Diagnosis. Characterized by coarse linear reticulations, large eye tubercle and prominent ridge paralleling ventral, posterior, and posterodorsal margins. Second ridge, originating at dorsal margin just posterior to anterior cardinal angle, trends anteroventrally and terminates at anterior margin just dorsal to anteroventral angle. *Mio.*

Remarks. *Aurila conradi* is readily distinguished from *Hemicythere schmidtae* MALKIN (1953, p. 796) in that the reticulations of *H. schmidtae* tend to be arranged in a more radial pattern than those of *A. conradi*. *Hemicythere confragosa* EDWARDS (1944, p. 518) has a much coarser surface ornamentation and the arrangement of the reticulations are strikingly different from those of *A. conradi*.

BENSON & COLEMAN (1963, p. 35) identified a new subspecies, *Aurila conradi floridana,* from the Recent of the eastern Gulf of Mexico in which the surface depressions match those of *A. conradi conradi* in location but those of *A. conradi conradi* are more robust, have thicker confining ridges, and are rounded instead of well-defined and polygonal. In addition, the subcentral region of the surface in the area of the adductor scars is thickened and smooth, with a few punctae in *A. conradi conradi,* but the open reticulations of *A. conradi floridana* continue to the rest of the carapace. BENSON & COLEMAN consider the Recent forms identified as *Hemicythere conradi* by SWAIN (1955) and *H.* cf. *H. cymba* by CURTIS (1960) to be *A. conradi floridana,* and those identified by PURI (1960) as *A. conradi* and *Hemicythere cymba* probably also *A. conradi floridana.*

BENSON & KAESLER (1963, p. 23) distinguished *Aurila conradi californica,* a Recent form from the Estero de Tastiota region of Baja California, from *A. conradi conradi* by its more vaulted dorsum, smaller circular more pitlike reticulations, and the lack of a clearly defined ventral and anterior rim.

Dimensions. Length 0.60 mm, thickness 0.32 mm, height 0.36 mm.

Material. Duplin Formation: 68 specimens.

Occurrence. Duplin Formation: Localities 38-42, 38-29, 18-9 (unit 4), and 21-1 (unit 2). Auger Hole 38-38 (19 and 24′).

Aurila conradi conradi has been reported from the upper Miocene, Choctawhatchee Stage of Florida (HOWE AND OTHERS, 1935, p. 27 and PURI, 1953d, p. 266); upper Miocene, Duplin Marl (EDWARDS, 1944, p. 518) and Yorktown Formation (BROWN, 1958, p. 65) of North Carolina; Yorktown Formation of Virginia (MALKIN, 1953, p. 796 and MCLEAN, 1957, p. 95); and the lower, middle, and upper Miocene of North Carolina (SWAIN, 1951, p. 42).

Genus HEMICYTHERURA Elofson, 1941

Hemicytherura ELOFSON, 1941, p. 314; HORNIBROOK, 1952, p. 58; HANAI, 1957, p. 23, WAGNER, 1957, p. 75; POKORNÝ, 1958, p. 286; REYMENT, 1961, p. Q293.
Type-species. Cythere cellulosa NORMAN, 1865, p. 22, pl. 5, figs. 17, 20, pl. 6, fig. 17.

Diagnosis. Characterized by a small, subrhomboidal, heavily reticulate or ridged carapace with prominent caudal process. Hinge of right valve consists of terminal teeth separated by groove that is open to the interior and overlain by a flange groove. Marginal area wide and generally lacks vestibules. Muscle-scar pattern consists of four vertically arranged posterior scars and one anterior scar. Radial pore-canals tends to be grouped. *Mio.-Rec.*

HEMICYTHERURA HOWEI (Puri, 1953), Pooser (n. comb.)

Pl. 9, figs. 1,3

Kangarina howei PURI, 1953d, p. 246, pl. 4, fig. 7, text-figs. 6i, j.

Diagnosis. Characterized by its minute size, strongly arched dorsum, and acute, triangular, compressed posterior. Carapace ornamented with ten to eleven ridges separated by rows of pits, and three prominent depression; one below anterior cardinal angle, another separated from anteroventral depression by raised ridge, and a third at posteroventer. *U.Mio.*

Remarks. The specimens from the upper Miocene, Duplin Formation of South Carolina are identical to the illustrations and description of *Hemicytherura howei* (PURI) from the *Ecphora* facies of the upper Miocene, Choctawhatchee Stage of Florida. The interior of a single poorly preserved right valve was examined and the hinge appears to consist of terminal teeth formed from the extension of the selvage, separated by a groove that is open to the interior, and overlain by a flange groove that is developed between the hinge and the flange. The small size, surface ornamentation, subrhomoboidal shape, and hinge indicate that this species should be placed under the genus *Hemicytherura.*

Dimensions. Length 0.37 mm, thickness 0.18 mm, height 0.23 mm.

Material. Duplin Formation: 13 specimens.

Occurrence. Duplin Formation: Auger Hole 38-38 (19 and 24′).

The only other reported occurrence of this form is by PURI, (1953d, p. 246) from the upper Miocene, *Ecphora* facies of Florida.

Family LOXOCONCHIDAE Sars, 1925
Genus LOXOCONCHA Sars, 1866

Loxoconcha Sars, 1866, p. 61; ———, 1926, p. 217; Alexander, 1936, p. 693; Murray, 1938, p. 586; Elofson, 1941, p. 322; Edwards, 1944, p. 526; Keij, 1957, p. 139; Benson, 1959, p. 51; Howe, 1961, p. Q313; Benson & Coleman, 1963, p. 36; Benson & Kaesler, 1963, p. 26.
Type-species. Cythere impressa Baird, 1850, (*non* M'Coy, 1844) (=*C. rhomboidea* Ficher, 1855).

Diagnosis. Distinguished by its subrhomboidal carapace; surface pitted or reticulate; hinge gongylodont with crenulate median element. *Cret.-Rec.*

LOXOCONCHA MCBEANENSIS Murray, 1938
Pl. 14, figs. 1, 8

Loxoconcha mcbeanensis Murray, 1938, p. 591, pl. 68, figs. 7, 10.
Loxoconcha sp. cf. *L. mcbeanensis* Murray, Swain, 1951, p. 26, pl. 2, figs. 22, 23.

Diagnosis. Characterized by its elongate form, rounded to angular pits arranged in rows roughly parallel to margins separted by irregular ridges, and one or more well-developed ridges on the venter. The most prominent of which converges anteriorly toward the ventral marginal rim leaving depressed area between prominent converging ridge and ventral marginal rim. *M.Eoc.*

Remarks. The specimens from South Carolina are identical in all respects to the original description by Murray (1938, p. 591) except for the arrangement of the prominent ventral ridge. Murray indicated that the, ". . . carapace, viewed ventrally, is characterized by convergence of most prominent ridge on either valve with marginal rim." Study of topotypes from the McBean Formation at McBean Creek, Georgia indicate that the most prominent ventral ridge converges anteriorly with the anterior portion of the ventral marginal rim but never quite meets it; however, a second, shorter, ventral ridge, originating just anterior to the middle and between the ventral marginal rim and the above mentioned prominent ventral ridge, does converge and join the anterior portion of the ventral marginal rim.

Dimensions. Length 0.46 mm, thickness 0.17 mm, height 0.21 mm.

Material. Santee Limestone: 7 specimens.

Occurrence. Santee Limestone: Localities 38-85 and 38-87. Auger Holes 38-22 (70′) and 38-23 (25′).

Reported from the middle Eocene, McBean Formation of Georgia (Murray, 1938, p. 592) and the middle Eocene of North Carolina (Swain, 1951, p. 26).

LOXOCONCHA sp. cf. L. CLAIBORNENSIS Murray, 1938
Pl. 16, figs. 2, 8-10

Loxoconcha claibornensis Murray, 1938, p. 588, pl. 69, figs. 2, 19; Stephenson, 1946, p. 315, pl. 43, fig. 13; Brown, 1958, p. 66, pl. 6, fig. 5.
Loxoconcha sp. aff. *L. claibornensis* Murray, Swain, 1951, p. 26, pl. 2, figs. 16, 17.

Diagnosis. Characterized by its ovate-elongate lateral outline and rounded to subangular pits. Those pits near edges of carapace tend to parallel margins, whereas those nearer center show less of an orderly arrangement. *M.-U.? Eoc.*

Remarks. Murray (1938, p. 588), Stephenson (1946, p. 315), and Swain (1951, p. 26) noted the extreme variation in ornamentation shown by this form; consequently, its value as a time-stratigraphic indicator is doubtful. In all probability several species have been included under this form. Neither Murray nor Stephenson mentioned a prominent anterior marginal rim; however, it is well-developed on the South Carolina forms and on those illustrated by Swain (1951, pl. 2, figs. 16, 17) from North Carolina. The hinge is clearly gongylodont but the other internal features are so poorly preserved that it is impossible to describe them accurately. *Loxoconcha* sp. cf. *L. claibornensis* is similar to *L. mornhinvegi* Howe

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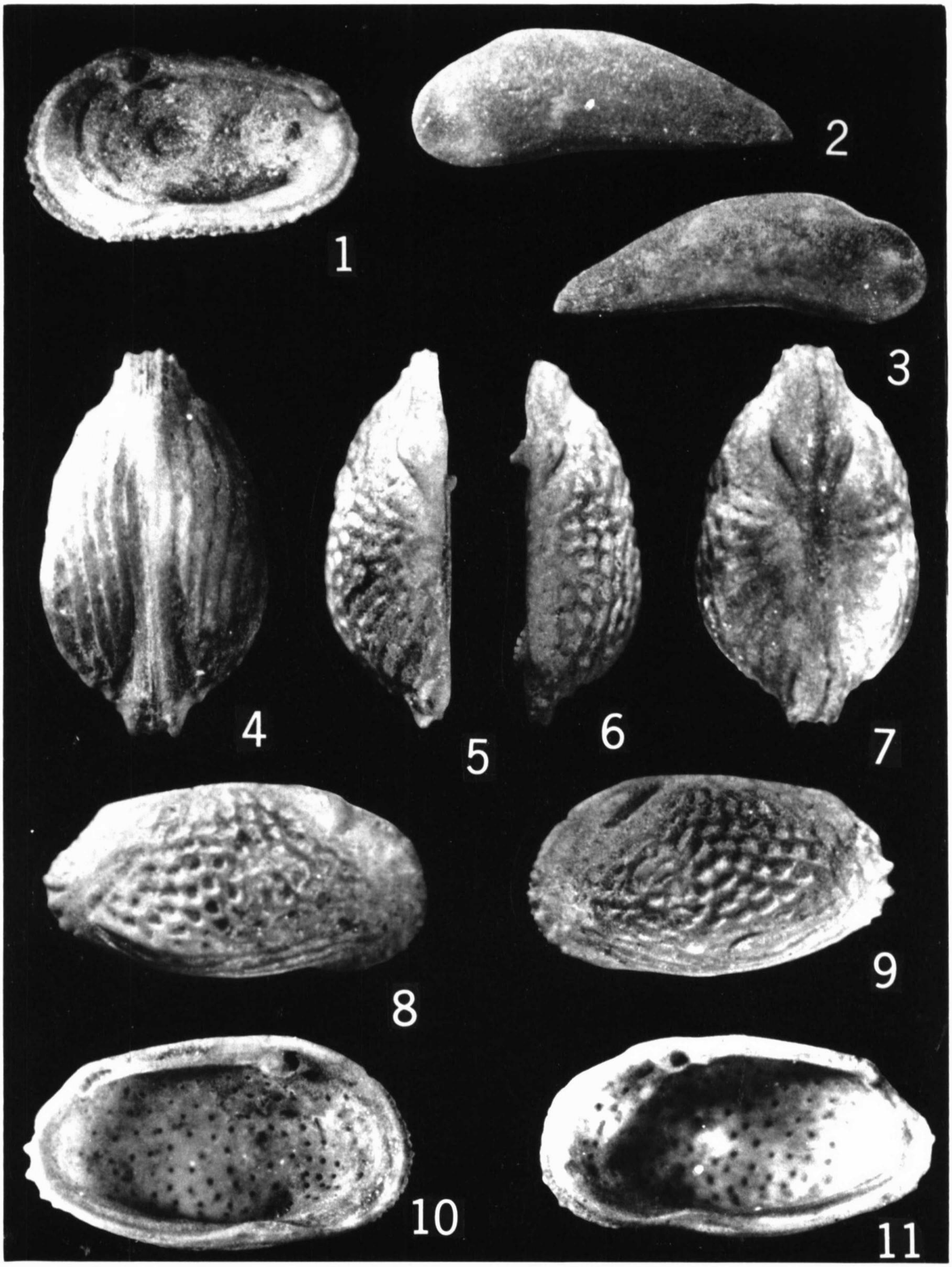
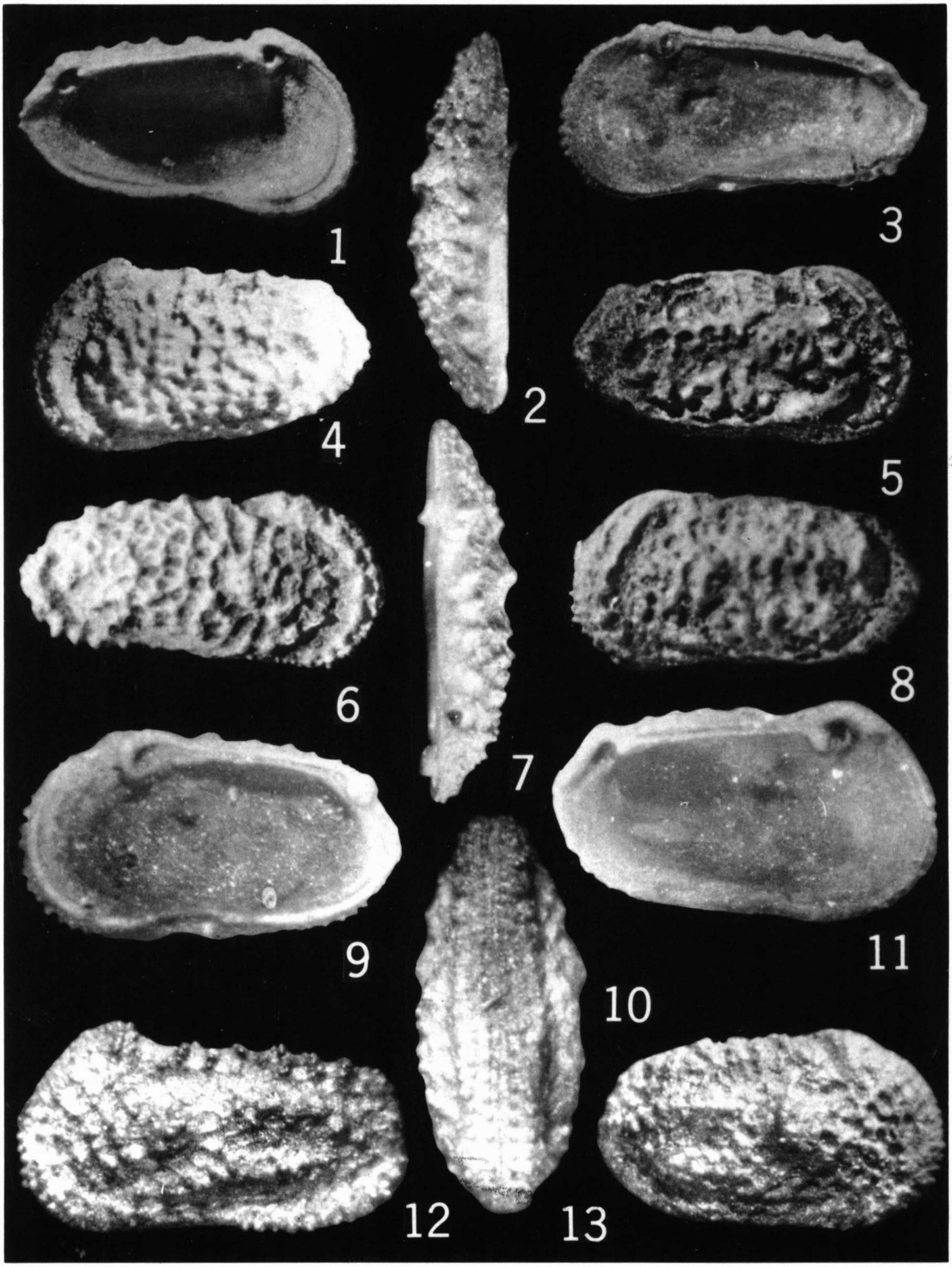
EXPLANATION OF PLATE 19
HENRYHOWELLA, PARACYPRIS, BRACHYCYTHERE

(All illustrated forms are from South Carolina)

Figure	Page
1.—Henryhowella evax (Ulrich & Bassler); interior lateral view of right valve, ×75.	59
2,3.—Paracypris kaesleri Pooser, n. sp.;——*2,* exterior lateral view of left valve;——*3,* exterior lateral view of right valve, all ×45.	30
4-11.—Brachycythere marylandica (Ulrich);——*4,* ventral view, ×55; *5,* dorsal view of left valve, ×55;——*6,* dorsal view of right valve, ×55;——*7,* dorsal view, ×55;——*8,* exterior lateral view of right valve, ×55;——*9,* exterior lateral view of left valve, ×55;——*10,* interior lateral view of left valve, ×60;——*11,* interior lateral view of right valve, ×60.	31



Pooser—Cenozoic Ostracoda from South Carolina



POOSER—Cenozoic Ostracoda from South Carolina

& CHAMBERS (1935) from the Jackson in the arrangement of the pits and the presence of a faint keel that originates near the ventral margin and swings upward toward the posterodorsum; however, *L. mornhinvegi* possesses a compressed, wide, anterior margin that is lacking on *L. claibornensis*.

Dimensions. Length 0.51 mm, thickness 0.26 mm, height 0.29 mm.

Material. Warley Hill Formation: 10 specimens. Santee Limestone: 90 specimens.

Occurrence. Warley Hill Formation: Localities 8-3 (unit 3), 9-28 and 9-34. Santee Limestone: Localities 9-28, 9-31, 9-32, 8-3 (unit 4), 18-1 (units 1 and 3), 38-22, 38-26, 38-85, and 38-87. Auger Holes 5-1 (75-85′), 38-7 (27′), 38-11 (20-25′), 38-15 (70′), 38-18 (12-18′), 38-22 (70′), 38-23 (25′), 38-29 (14′), and 38-35 (70-74′).

Reported from the middle Eocene, Lisbon Formation of Alabama (MURRAY, 1938, p. 588); Weches, Reklaw, and Cook Mountain formations of Texas (STEPHENSON, 1946, p. 316); the middle Eocene of North Carolina (SWAIN, 1951, p. 26); and the upper? and middle Eocene, Castle Hayne Limestone of North Carolina (BROWN, 1958, p. 66).

Genus CYTHEROMORPHA Hirschmann, 1909

Cytheromorpha HIRSCHMANN, 1909, p. 292; SARS, 1925, p. 177; KLIE, 1938, p. 170; OERTLI, 1956, p. 72; KEIJ, 1957, p. 88; SWAIN, 1955, p. 630; WAGNER, 1957, p. 49; HOWE, 1961, p. Q313.

Type-species. Cytheromorpha albula HIRSCHMANN, 1909, p. 290 (=*Cythere fuscata* BRADY, 1869, p. 47, pl. 7, figs. 5-8), SD SARS, 1925.

Diagnosis. Recognized by its small ovate carapace with upturned posterior end; surface ornamented with pits, reticulations or ridges; marginal areas of moderate size, with anterior and posterior vestibules, and few, straight radial pore-canals; hinge gongylodont. *Paleoc.-Rec.*

CYTHEROMORPHA WARNERI Howe & Spurgeon, 1935

Pl. 11, figs. 3, 5, 8, 10, 11, 13

Cytheromorpha warneri Howe & Spurgeon, *in* HOWE AND OTHERS, 1935, p. 11, pl. 2, figs. 5, 8, 9, pl. 4, fig. 4; VAN DEN BOLD, 1946, p. 105; MALKIN, 1953, p. 787, pl. 80, figs. 18, 19; PURI, 1953d, p. 277, pl. 6, figs. 5-7, text-figs. 11f, g; PURI & HULINGS, 1957, p. 187, fig. 11; PURI, 1960, p. 114, pl. 3, figs. 11, 12, text-fig. 36.

Cytheromorpha sp. cf. *C. warneri* Howe & Spurgeon, SWAIN, 1951, p. 49, pl. 7, figs. 18, 19; MCLEAN, 1957, p. 70, pl. 7, figs. 3a, b.

Diagnosis. Characterized by faint median sulcus and reticulations arranged in rows more or less parallel to margins. Reticulations roughly hexagonal in outline in posterior half of carapace but more irregular in anterior half. *M.Mio.-Rec.*

Remarks. Compared to the females, the males are longer, the dorsal and ventral margins are more nearly parallel, and exhibit the greatest variation in the size of the reticulations on the anterior portion of the carapace. The reticulations on the anterior portion of some of the male carapaces are approximately the same size as those on the posterior, whereas other male specimens exhibit much finer reticulations anteriorly. None of the specimens are considered to be *Cytheromorpha warneri okaloosaensis* HOWE & SPURGEON. This latter form is distinguished by fine circular pits on the anterior one-third to one-half of the carapace.

Cytheromorpha laevigata PURI (1953d, p. 275) is very similar to *C. warneri* in lateral outline and the presence of a sulcus just anterior to middle, but differs in having a smooth carapace.

Dimensions. Male: length 0.61 mm, thickness 0.24 mm, height 0.27 mm. Female: length 0.58 mm, thickness 0.26 mm, height 0.31 mm.

Material. Duplin Formation: 62 specimens.

Occurrence. Duplin Formation: Localities 38-29 and 5-3. Auger Holes 38-26 (12-19′) and 38-38 (19 and 24′).

This species was originally described from the upper Miocene, Choctawhatchee Stage of Florida (HOWE AND OTHERS, 1935, p. 11). It has also been reported from the middle Miocene, Calvert Formation through the upper Miocene, Yorktown Formation of Virginia (MALKIN, 1953, p. 787); Yorktown Formation of Virginia (MCLEAN, 1957, p. 70); *Ecphora* and *Cancellaria* facies of the Choctawhatchee

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EXPLANATION OF PLATE 20
ACTINOCYTHEREIS, HENRYHOWELLA

(All illustrated forms are from South Carolina)

FIGURE PAGE

1,3-6,8.—Actinocythereis stenzeli STEPHENSON;——*1,* interior lateral view of left valve of female, ×75; ——*3,* interior lateral view of right valve of male, ×75;——*4,* exterior lateral view of left valve of female, ×75;——*5,* exterior lateral view of right valve of complete female specimen, ×60; ——*6,* exterior lateral view of right valve of male, ×75;——*8,* exterior lateral view of left valve of complete female specimen, ×65. 56

2,7,9-13.—Henryhowella evax (ULRICH & BASSLER); ——*2,* dorsal view of left valve of male, ×75; ——*7,* dorsal view of right valve of male, ×75; *9,* interior lateral view of right valve of male, ×75;——*10,* ventral view of male, ×75;——*11,* interior lateral view of left valve of male, ×75; *12,* exterior lateral view of left valve of male, ×75;——*13,* exterior lateral view of right valve of female, ×80. 59

Stage of Florida (PURI, 1953d, p. 277); upper Miocene of North Carolina (SWAIN, 1951, p. 49); Miocene of Cuba (VAN DEN BOLD, 1946, p. 105); Recent of Florida (PURI & HULINGS, 1957, p. 187 and PURI, 1960, p. 114); and the Recent of Pamlico Sound, North Carolina (GROSSMAN, 1964).

Family PECTOCYTHERE Hanai, 1957

Genus MUNSEYELA van den Bold, 1957

Toulminia MUNSEY, 1953, p. 6 (*non Toulminia* ZITTEL, 1878).
Munseyella VAN DEN BOLD, 1957, p. 7; ———, 1958, p. 401-402; HANAI, 1961, p. Q320, figs. 246,3 and 246A.
Type-species. Toulminia hyalokystis MUNSEY, 1953, p. 6-7, pl. 2, figs. 26-27, text-fig. 1.

Diagnosis. Carapace small, compressed, subquadrangular; maximum height in anterior third; widest slightly behind middle. Anterior end broadly rounded, dorsal margin nearly straight, ventral margin sinuate, posterior margin straight and almost perpendicular to dorsal margin. Surface heavily ornamented. Anterior end and usually posterior end heavily rimmed. Hinge of right valve consists of rounded terminal teeth between which extends a long denticulate groove in which small sockets occur at both ends. Left valve has open terminal sockets and a crenulate bar which broadens at both ends and carries small knob-like teeth. Anterior marginal area broad with deep mid-anterior vestibule. Radial pore-canals straight and few. Normal pore-canals few, widely scattered, and of sieve-type. Muscle-scar pattern consists of a vertical row of four with one in front. *U.Cret.-Rec.*

MUNSEYELLA SUBMINUTA (Puri, 1953), van den Bold, 1958

Pl. 11, figs. 1, 2, 4

Cytheromorpha subminuta PURI, 1953d, p. 276, pl. 6, figs. 9, 10, text-figs. 11 i,j.
Munseyella subminuta (Puri), VAN DEN BOLD, 1958, pl. 5, fig. 3; ———, 1963b, p. 379, pl. 5, fig. 3.

Diagnosis. Characterized by its small, elongate carapace with dorsal and ventral margins converging posteriorly. Dorsal margin straight; ventral margin concave near middle. Anterior end broadly rounded; posterior end compressed and spinose. Surface ornamentation consists of two circular ridges; anterior ridge encloses elongate node, whereas posterior ridge encircles large rounded node. Duplicature wide with large anterior vestibule. *U.Mio.*

Remarks. The internal features of the specimens from South Carolina are poorly preserved; however, externally they appear to be identical to the description and illustrations by PURI (1953) of the holotype from the upper Miocene of Florida.

Dimensions. Length 0.39 mm, thickness 0.17 mm, height 0.21 mm. These dimensions compare favorably with those of the holotype: length 0.354 mm, height 0.202 mm.

Material. Duplin Formation: 10 specimens.

Occurrence. Duplin Formation: Auger Hole 38-38 (19 and 24′).

This species has been previously reported from the upper Miocene *Arca, Ecphora,* and *Cancellaria* facies of the Choctawhatchee Stage of Florida (PURI, 1953d, p. 276) and the upper Miocene, Epringvale Formation of Trinidad (VAN DEN BOLD, 1963b, p. 379).

Family TRACYHYLEBERIDIDAE Sylvester-Bradley, 1948

Genus TRACHYLEBERIS Brady, 1898

Trachyleberis BRADY, 1898; emend. HARDING & SYLVESTER-BRADLEY, 1953.
Type-species. Cythere scabrocuneata BRADY, 1880, p. 103, pl. 17, figs. 5a-f, pl. 23, figs. 2a-c.

Diagnosis. Recognized by its subrectangular carapace with broadly rounded anterior and compressed triangular posterior; ornamentation consists of spines, tubercles, or blades and prominent subcentral tubercle; hinge holamphidont. *U.Cret.-Rec.*

TRACHYLEBERIS BASSLERI (Ulrich, 1901), Brown, 1958

Pl. 22, figs. 2, 3

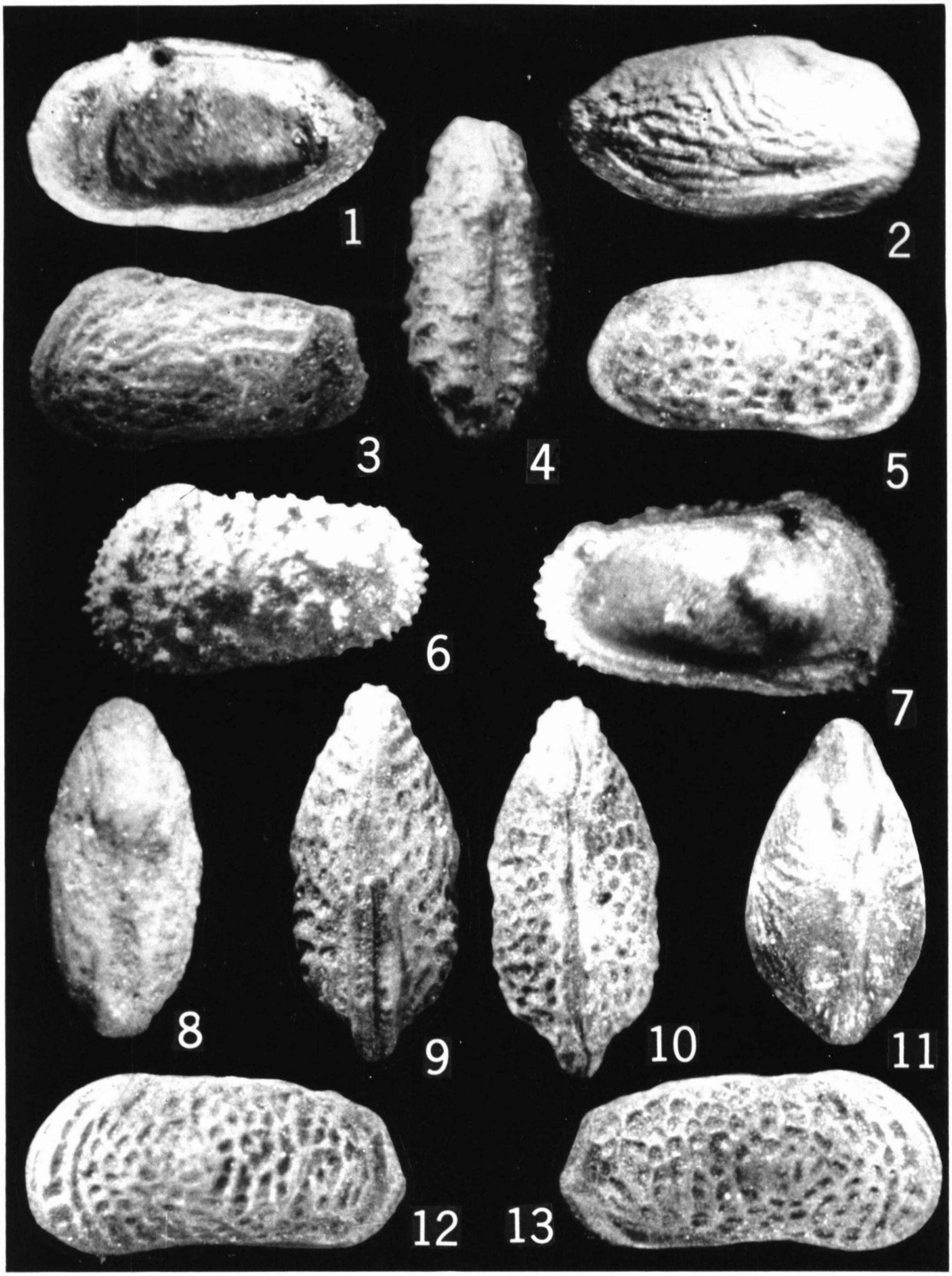
Cythereis bassleri ULRICH, 1901, p. 120, pl. 16, figs. 19-21; WELLER, 1907, p. 843, pl. 110, figs. 1-3; ?CUSHMAN, 1925, p. 302, pl. 8, figs. 3a-c; ALEXANDER, 1934, p. 219; ?JENNINGS, 1936, p. 51, pl. 7, figs. 1 a, b; ?VAN DEN BOLD, 1946, p. 94, pl. 6, fig. 20; SCHMIDT, 1948, p. 422, pl. 64, fig. 13; SWAIN, 1948, p.

EXPLANATION OF PLATE 21

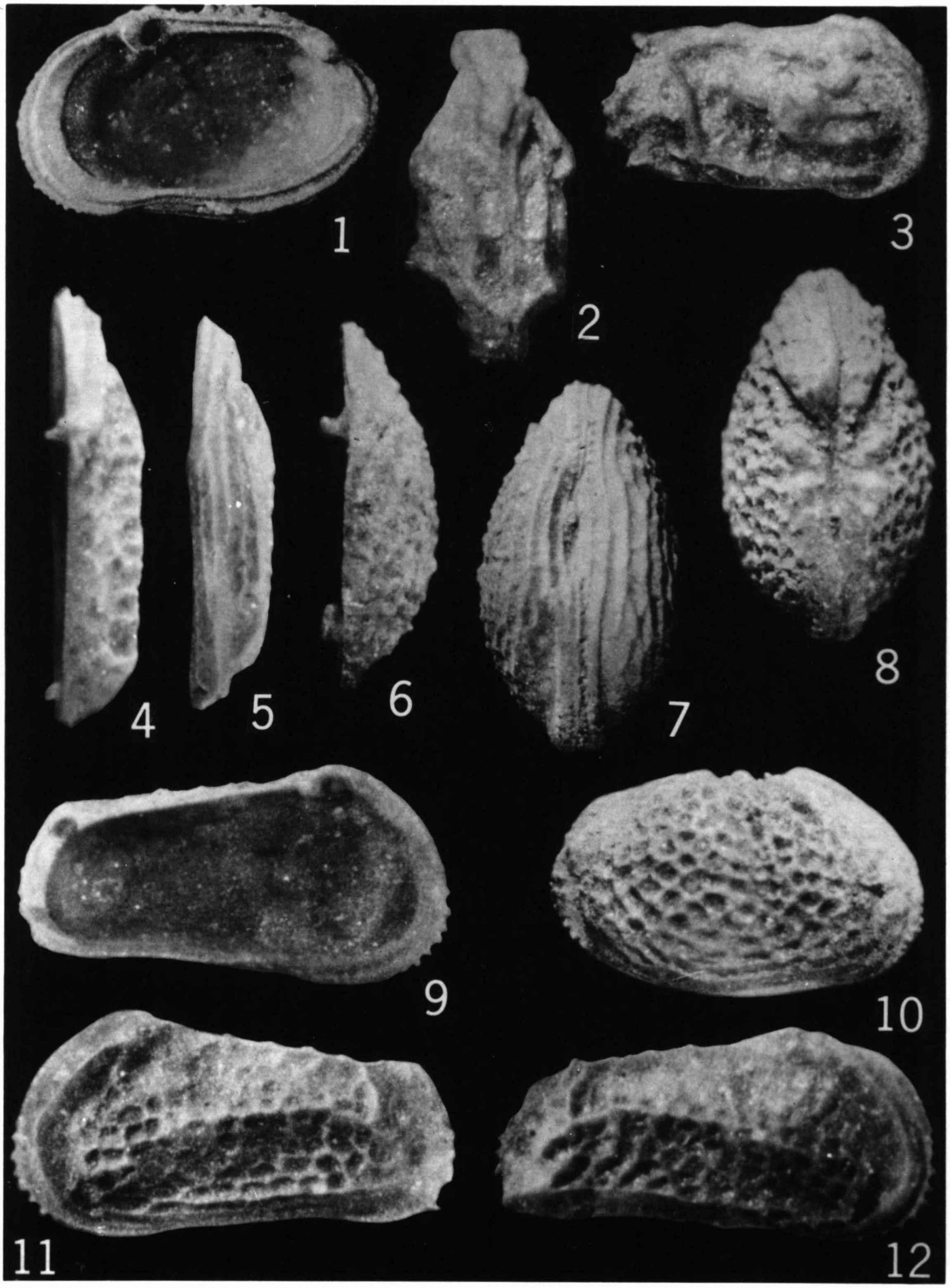
BRACHYCYTHERE, MURRAYINA, TRACHYLEBERIS

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,2,11.—Brachycythere interrasilis ALEXANDER;—*1,* interior lateral view of right valve, ×55;—*2,* exterior lateral view of right valve, ×55; *11,* dorsal view, ×50.	31
3,5,8.—Murrayina martini (ULRICH & BASSLER);—*3,* exterior lateral view of left valve;—*5,* exterior lateral view of right valve;—*8,* dorsal view, all ×80.	60
4,6,7.—Trachyleberis florienensis (HOWE & CHAMBERS);—*4,* dorsal view, ×65;—*6,* exterior lateral view of left valve, ×65; *7,* interior lateral view of left valve, ×75.	53
9,10,12,13.—Murrayina dictyolobus (MUNSEY);—*9,* ventral view;—*10,* dorsal view;—*12,* exterior lateral view of left valve;—*13,* exterior lateral view of right valve, all ×80.	59



Pooser—Cenozoic Ostracoda from South Carolina



Pooser—Cenozoic Ostracoda from South Carolina

197, pl. 13, fig. 7; MUNSEY, 1953, p. 8, pl. 4, figs. 6, 7, 12-14.
Cythereis bassleri lata JENNINGS, 1936, p. 52, pl. 7, figs. 2a, b.
Cythereis claibornensis GOOCH, 1939, p. 581, pl. 67, figs. 5, 6, 10; STEPHENSON, 1946, p. 336, pl. 45, fig. 4.
Cythereis bassleri reticulolira SCHMIDT, 1948, p. 423, pl. 64, figs. 14, 15.
Cythereis plusculmenis SCHMIDT, 1948, p. 422, pl. 64, figs. 2-4.
Paracythereis potomaca SCHMIDT, 1948, p. 419, pl. 64, figs. 18, 19.
Cythereis? collei Gooch, BLAKE, 1950, p. 178, pl. 30, figs. 30-32.
Trachyleberis? bassleri (Ulrich), SWAIN, 1951, p. 34, pl. 5, figs. 8, 11-15; BROWN, 1958, p. 13, pl. 7, figs. 10-14.
Trachyleberis bassleri (Ulrich), BROWN, 1958, p. 62, pl. 3, fig. 15.

Diagnosis. Characterized by its reticulate surface, prominent subcentral tubercle from which three small ridges extend anteriorly, and main ridge that parallels the venter from the anteroventer to just anterior to posteroventer, trends obliquely to posterodorsum, and parallels dorsal margin terminating just posterior and ventral to eye tubercle. *U.Cret.-Oligo.*

Remarks. Trachyleberis bassleri shows considerable variation in surface sculpture, particularly within the various molt stages; consequently, numerous new species and varieties have been designated. The characteristics given by SCHMIDT (1948, p. 422) for *Cythereis bassleri reticulolira* and *C. plusculmenis* are not considered to be of sufficient significance to designate them as separate species. *Paracythereis potomaca* (SCHMIDT, 1948, p. 419) apparently is an immature molt of *T. bassleri. Cythereis collei* (GOOCH, 1939, p. 585) is very similar to *T. bassleri* in lateral view; however, they differ in dorsal outline.

Dimensions. Length 0.59 mm, thickness 0.31 mm, height 0.32 mm.

Material. Warley Hill Formation: 18 specimens. Santee Limestone: 310 specimens. Cooper Marl: 31 specimens.

Occurrence. Warley Hill Formation: Localities 8-3 (unit 3), 9-33 and 9-28. Auger Hole 9-3 (62?'). Santee Limestone: Localities 9-28, 9-31, 9-32, 9-33 (unit 3), 9-54 (unit 1), 38-10, 38-85, 38-103, and 18-1 (unit 1). Auger Holes 38-5 (85-100'), 38-11 (10-15' and 20-25'), 38-15 (70'), 38-18 (12-18'), 38-29 (14'), 38-35 (70-74' and 85'), 38-37 (50-65'), and 38-40 (65-70'). Cooper Marl: Locality 18-1 (unit 4).

Reported from the lower Eocene, Aquia Formation of Maryland and Virginia (ULRICH, 1901, p. 121; SCHMIDT, 1948, p. 419, 422, and 423; SWAIN, 1948, p. 197); Claiborne Group of Texas and Louisiana (GOOCH, 1939, p. 581; STEPHENSON, 1946, p. 336); Gosport Formation of Alabama (BLAKE, 1950, p. 178); middle Eocene of North Carolina (SWAIN, 1951, p. 35); upper Cretaceous, Paleocene, lower Eocene, and middle Eocene of North Carolina (BROWN, 1958, p. 62); and sediments of Oligocene age in Alabama (SWAIN, 1951, p. 35). VAN DEN BOLD (1946, p. 94) tentatively identified *T. bassleri* from the Paleocene and lower Eocene of Guatemala and Honduras.

TRACHYLEBERIS FLORIENENSIS
(Howe & Chambers, 1935), Pooser (n. comb.)

Pl. 21, figs. 4, 6, 7

Cythereis florienensis HOWE & CHAMBERS, 1935, p. 28, pl. 1, fig. 14, pl. 6, figs. 14, 15; MONSOUR, 1937, p. 89; WILBERT, 1953, p. 125, pl. 1, fig. 16.
Cythereis deusseni HOWE & CHAMBERS, 1935, p. 27, pl. 1, fig. 15, pl. 6, figs. 2, 3; HOWE & LAW, 1936, p. 58; MONSOUR, 1937, p. 89.
Henryhowella florienensis (Howe & Chambers), KRUTAK, 1961, p. 784, pl. 91, fig. 8.

Diagnosis. Characterized by its subrectangular lateral outline with dorsal and ventral margins converging slightly toward posterior; surface coarsely reticulate and with coarse spines, five of which project above the dorsal margin of either valve; prominent spinose subcentral tubercle bordered posteriorly and ventrally by narrow arcuate sulcus; and wedge-shaped, non-reticulate depression immediately posterior and ventral to eye tubercle. *U.Eoc.-Oligo.*

Description. This species has been well described by HOWE & CHAMBERS (1935, p. 28); however, the following observations based on the study of specimens from South Carolina are offered to better qualify the description.

Sexual dimorphism pronounced with males longer and narrower than females. Anterior margin bears three rows of spines, those of innermost row considerably stouter, fewer in number, and more widely spaced. Muscle-scar pattern consists of vertical row of four adductor scars situated on posterior slope of depression that forms external subcentral tubercle, and V-shaped antennal scar on anterior slope of depres-

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EXPLANATION OF PLATE 22
ECHINOCYTHEREIS, TRACHYLEBERIS, MURRAYINA

(All illustrated forms are from South Carolina)

FIGURE	PAGE
1,6-8,10.—Echinocythereis clarkana (ULRICH & BASSLER);——*1*, interior lateral view of right valve of female;——*6*, dorsal view of right valve of female;——*7*, ventral view of female;——*8*, dorsal view of female;——*10*, exterior lateral view of right valve of female, all ×50.	58
2,3.—Trachyleberis bassleri (ULRICH);——*2*, dorsal view;——*3*, exterior lateral view of right valve of complete specimen, all ×90.	52
4,5,9,11,12.—Murrayina barclayi; MCLEAN;——*4*, dorsal view of right valve, ×95;——*5*, ventral view of left valve, ×90;——*9*, interior lateral view of left valve, ×100;——*11*, exterior lateral view of left valve, ×100;——*12*, exterior lateral view of right valve, ×100.	60

sion immediately anterior to second adductor scar located from top. Conspicuous flange groove in left valve. Line of concrescence coincides with inner margin throughout. Radial pore-canals numerous, short, and simple. Hinge holamphidont.

Remarks. KRUTAK (1961, p. 784) placed this species under the genus *Henryhowella;* however, both the illustrations of the holotype by HOWE (1935) and those of KRUTAK as well as the specimens from South Carolina fail to show the three longitudinal spinose plications on the posterior half of the carapace that characterize *Henryhowella.*

Dimensions. Male: length 0.86 mm, thickness 0.31 mm, height 0.44 mm. Female: length 0.81 mm, thickness 0.33 mm, height 0.46 mm.

Material. Cooper Marl: 41 specimens.

Occurrence. Cooper Marl: Locality 8-4. Auger Holes 8-39 (12?-21?' and 25-30') and 8-40 (4-7').

This species was originally described from the Jackson of Louisiana (HOWE & CHAMBERS, 1935, p. 29). It has subsequently been reported from the Jackson of Mississippi (MONSOUR, 1937, p. 89) and Arkansas (WILBERT, 1953, p. 125), and the Cocoa Sand of Alabama (KRUTAK, 1961, p. 784).

TRACHYLEBERIS? JOHNSONI Pooser, n. sp.

Pl. 14, figs. 6, 7

Trachyleberis pidgeoni SWAIN, 1951, p. 36 pl. 6, fig. 1.

Diagnosis. Characterized by three distinct longitudinal ridges which together with shorter and weaker anastomosing ridges give a reticulate, lattice-like appearance to the carapace. *M.Eoc.*

Description. Carapace small and of moderate strength; subrectangular in dorsal view with parallel sides and compressed posterior; in lateral view rectangular with pointed posterior; greatest height at anterior cardinal angle; greatest width posterior to middle. Anterior broadly rounded with denticulate anteroventral margin; posterior end compressed and slightly acuminate at middle. Left valve larger than right and overlaps right at anterior cardinal angle and along venter. Surface ornamentation latticed and consisting of three prominent, rounded, subparallel, raised ridges, one of which originates at anteroventral angle, parallels anterior and dorsal margin and bends sharply at posterodorsal angle terminating at posteroventer. Second longitudinal ridge just dorsal to median line of carapace originates at posterior vertical ridge and terminates slightly short of anterior marginal ridge. Third bifurcated longitudinal ridge parallels ventral margin and coalesces just anterior to middle terminating short of anterior ridge. In addition to these three main ridges entire surface is covered with anastomosing small ridges that accentuate lattice appearance. Prominent eye tubercle at anterior cardinal angle.

Hinge holamphidont; right valve with high pointed anterior tooth, rimmed postjacent socket, deep groove, and large smooth ovate posterior tooth. Left valve antithesis of right. Duplicature moderately broad with simple, long, widely spaced, normal pore-canals and narrow anterior and posterior vestibules. Muscle-scar pattern obscured. Subcentral tubercle, which is not readily discernable from exterior, is expressed as depression on interior of carapace.

Remarks. The generic position of this species is in doubt. The eye tubercle, subcentral tubercle, and hinge indicate that this species is closer to *Trachyleberis* than to any other established genus; however, it may be best to establish a new genus to include forms with a surface ornamentation as that of *T.? johnsoni.* SWAIN (1951, p. 36) reports that this form was obtained from the Naval Auxiliary Air Station well, Washington, N. C. at a depth of 115-120 feet, where it is associated with *Haplocytheridea montgomeryensis* (HOWE & CHAMBERS), *Trachyleberis? rukasi* (GOOCH) and other characteristic Eocene ostracodes. However, SWAIN identified the present form as *T. pidgeoni* (BERRY) which occurs in the Upper Cretaceous of Maryland and North Carolina and assumed that its occurrence in association with Eocene ostracodes was a result of reworking. The external features of the form illustrated by SWAIN (1951, pl. 6, fig. 1) are identical to those of *T.? johnsoni*; consequently, the form illustrated by SWAIN is considered conspecific with *T.? johnsoni.*

Trachyleberis? johnsoni is readily distinguished from *T. pidgeoni* by the presence of the ventrally located depressed area enclosed by the bifurcated ventrolateral ridge. *T.? johnsoni* is named in honor of HENRY S. JOHNSON, JR., South Carolina State Geologist.

Dimensions. Holotype; Length 0.42 mm, thickness 0.19 mm, height 0.24 mm.

Material. Warley Hill Formation: 1 specimen. Santee Limestone: 19 specimens. Holotype from Auger Hole 38-35 (70-74') deposited in the U.S. National Museum, Smithsonian Institution, Washington, D.C.; WKP821623.

Occurrence. Warley Hill Formation: Auger Hole 9-3 (62?'). Santee Limestone: Localities 9-32, and 38-103. Auger Holes 38-22 (70'), 38-23 (25'), 38-26 (25'), and 38-35 (70-74').

Reported from the middle Eocene of North Carolina (SWAIN, 1951, p. 36).

TRACHYLEBERIS? PAUCA (Schmidt), 1948

Pl. 13, figs. 1, 2, 6, 9

Cythereis pauca SCHMIDT, 1948, p. 420, pl. 64, fig. 20.

Diagnosis. Characterized by its subquadrate lateral outline; coarsely reticulate carapace; denticulate anterior and posteroventral margins; and three rounded longitudinal ridges. Ventral ridge is continuation of anterior marginal rim terminating just anterior to posteroventer as accentuated node. Median ridge originates at subcentral tubercle, extends posteriorly and slopes posterodorsally to join dorsal ridge near posterodorsal angle. *L.-M.Eoc.*

Remarks. This species is doubtfully referred to the genus *Trachyleberis*. SCHMIDT (1948, p. 420) reports that, "This species is larger than *C. communis aquia* but about the same size as *C. communis*. It differs from *C. communis aquia* as follows: Ridges more subdued; dorsal and median ridges joined by definite slanting connections; spines on anterior and posterior margins more prominent; posterior area gradually compressed; surface coarsely punctate to slightly reticulate along dorsal and ventral margin."

Dimensions. Length 0.72 mm, thickness 0.33 mm, height 0.39 mm.

Material. Warley Hill Formation: 45 specimens. Santee Limestone: 2 specimens.

Occurrence. Warley Hill Formation: Locality 8-3 (units 1 and 3). Auger Hole 14-3 (50′). Santee Limestone: Locality 8-3 (unit 4).

Reported from the lower Eocene, Aquia Formation of Maryland (SCHMIDT, 1948, p. 420).

TRACHYLEBERIS SPINOSISSIMA
(Jones & Sherborn, 1887), Pooser (n. comb.)

Pl. 15, figs. 1, 3, 4

Cythereis spinosissima JONES & SHERBORN, 1887, p. 452, text-fig. 2 (*non Cythere spinosissima* BRADY, 1865, p. 386=*Cythereis mucronata* SARS, 1866,=*Pterygocythereis*).

Cythereis spiniferrima JONES & SHERBORN, 1889, p. 34, text-fig. 3; ALEXANDER, 1934, p. 220, pl. 32, fig. 11; KLINE, 1943, p. 68, pl. 8, fig. 6; VAN DEN BOLD, 1946, p. 93, pl. 11, fig. 3.

Trachyleberis? spinosissima (Jones & Sherborn), VAN DEN BOLD, 1957b p. 9, pl. 3, figs. 4a, b.

Trachyleberis spiniferrima (Jones & Sherborn), BROWN, 1958, p. 62, pl. 3, fig. 17.

Diagnosis. Characterized by a strongly rimmed anterior margin bearing double row of short stout spines, strongly compressed and triangular posterior, and coarsely reticulate carapace with numerous spines arising from junctions of the reticulations. *Paleoc.-M.Eoc.*

Remarks. The South Carolina forms were compared with specimens of *Trachyleberis spinosissima* from the Wills Point Formation of Texas and differ only in being more elongate. The South Carolina specimens, those studied by the author from the Wills Point Formation of Texas, and the illustrations by ALEXANDER (1934, pl. 33, fig. 11) and KLINE (1943, pl. 95, fig. 6) show a third row of spines on the ventral portion of the anterior margin which has not been mentioned in any of the previous descriptions. The males are longer and slightly less tumid than the females.

Dimensions. Male: length 0.91 mm, thickness 0.33 mm, height 0.39 mm. Female: length 0.83 mm, thickness 0.34 mm, height 0.38 mm.

Material. Warley Hill Formation: 6 whole specimens.

Occurrence. Warley Hill Formation: Locality 8-3 (unit 3).

Trachyleberis spinosissima has been reported from the Eocene, London Clay of England (JONES & SHERBORN, 1889, p. 34); the Paleocene, Kincaid and Wills Point formations of Texas (ALEXANDER, 1934, p. 220); the Paleocene, Porters Creek and Clayton formations of Mississippi (KLINE, 1943, p. 69); a Paleocene, unnamed unit of North Carolina (BROWN, 1958, p. 63); and the Paleocene of Guatemala, British Honduras, and Trinidad (VAN DEN BOLD, 1957b, p. 9).

Genus ACTINOCYTHEREIS Puri, 1953

Actinocythereis PURI, 1953b, p. 178; ———, 1953d, p. 252; SWAIN, 1955, p. 634; SYLVESTER-BRADLEY, 1961, p. Q334; BENSON & COLEMAN, 1963, p. 47.

Type-species. Cythere exanthemata ULRICH & BASSLER, 1904, p. 117, pl. 36, figs. 1-5.

Diagnosis. A trachyleberidid with three longitudinal rows of spines; hinge holamphidont. *Eoc.-Rec.*

ACTINOCYTHEREIS DAVIDWHITEI (Stadnichenko, 1927), Puri, 1953

Pl. 16, figs. 3, 5, 7

Cythereis davidwhitei STADNICHENKO, 1927, p. 240, pl. 39, fig. 24; STEPHENSON, 1946, p. 336, pl. 44, fig. 5, pl. 45, fig. 12; VAN DEN BOLD, 1950a, table 1.

Cythereis gibsonensis HOWE & CHAMBERS, 1935, p. 29, pl. 1, fig. 22, pl. 6, figs. 21, 22; GARRETT, 1936, p. 786; MONSOUR, 1937, p. 89; BERQUIST, 1942, p. 107, pl. 11, figs. 9, 10.

Cythereis quinquespinosa SUTTON & WILLIAMS, 1939, p. 566, pl. 63, figs. 10, 11.

Trachyleberis davidwhitei (Stadnichenko), BLAKE, 1950, p. 180, pl. 30, fig. 27; SWAIN, 1951, pl. 4, fig. 19, pl. 5, figs. 6, 7.

Actinocythereis quinquespinosa (Sutton & Williams), PURI, 1953b, p. 183, pl. 2, fig. 13.

Actinocythereis davidwhitei (Stadnichenko), PURI, 1953b, p. 182, pl. 2, fig. 10, BROWN, 1958, p. 64, pl. 3, fig. 14.

Actinocythereis gibsonensis (Howe & Chambers), PURI, 1953b, p. 182, pl. 2, figs. 11, 12; KRUTAK, 1961, p. 782, pl. 91, fig. 4.

Diagnosis. Characterized by compressed ends; spinose anterior margin; bladelike anterior rim originating at eye tubercle, paralleling anterior margin to just dorsal of median line of carapace then becoming series of stout nodes that extend to anteroventral margin; and three longitudinal rows of spines. *L.-U.-Eoc.*

Remarks. Actinocythereis gibsonensis and *A. davidwhitei* have been considered as separate species by numerous workers; however, the author is of the opinion that they are the same. BLAKE (1950, p. 180) arrived at this same conclusion and stated that, "A close comparison of the Gosport species with the types of *Cythereis gibsonensis* Howe and Chambers and the hypotypes of *C. davidwhitei* Stadnichenko of Stephenson, revealed that no constant difference exists. All apparently fit the description of *C. davidwhitei* Stadnichenko." STEPHENSON (1946, p. 337) indicated that the holotype of *C. quinquespinosa* is the right valve of the female carapace of *C. davidwhitei*.

Dimensions. Length 0.72 mm, thickness 0.37 mm, height 0.37 mm.

Material. Santee Limestone: 51 specimens, mostly poorly preserved.

Occurrence. Santee Limestone: Localities 9-28, 9-31, 9-32, 9-33 (unit 3), 9-54 (unit 1), 38-26, 38-85, 38-103, and 18-1 (unit '). Auger Holes 38-5 (70 and 85-100'), 38-11 (20-25'), 38-22 (70'), 38-23 (25'), 38-29 (14'), 38-35 (70-74'), 38-37 (50-65'), 38-40 (65-70').

Reported from the Gosport Formation of Alabama (BLAKE, 1950, p. 180); Yegua Formation of Texas (STADNICHENKO, 1927, p. 240); Jackson Group of Louisiana, Mississippi, and Alabama (HOWE & CHAMBERS, 1935, p. 30); Weches Formation of Texas, Cook Mountain Formation of Louisiana, and the Lisbon Formation of Alabama (STEPHENSON, 1946, p. 337); Yazoo Formation of Alabama (KRUTAK, 1961, p. 783); Yazoo Formation of Mississippi (BERQUIST, 1942, p. 107); lower and middle Eocene of North Carolina (SWAIN, 1951, p. 33); lower, middle, and upper? Eocene of North Carolina (BROWN, 1958, p. 64); and the lower Eocene of Cuba (VAN DEN BOLD, 1950a, table 1).

ACTINOCYTHEREIS STENZELI (Stephenson, 1946), Brown, 1958

Pl. 20, figs. 1, 3-6, 8

Cythereis hilgardi Howe & Garrett, STEPHENSON, 1944b, p. 450, pl. 76, fig. 11.
Cythereis stenzeli STEPHENSON, 1946, p. 340, pl. 45, fig. 5.
Trachyleberis stenzeli (Stephenson), SWAIN, 1951, p. 32, pl. 4, figs. 17, 18, 22, pl. 5, fig. 1.
Actinocythereis stenzeli (Stephenson), BROWN, 1958, p. 65, pl. 3, fig. 13.

Diagnosis. Characterized by a heavily reticulate, spinose, carapace; marginal spines; and a spinose short ridge that extends downward from posterodorsal angle to median ridge. *L.-M.Eoc.*

Remarks. This species is readily confused with *Actinocythereis hilgardi* (HOWE & GARRETT), and in fact they may be conspecific. STEPHENSON (1944 and 1946) and SWAIN (1951) had great difficulty in distinguishing *A. stenzeli* from *A. hilgardi*. STEPHENSON indicated that ". . . *hilgardi* is much more weakly ornamented, and the strong, angular, spinose dorsal ridge which angles downward from the vicinity of the posterocardinal angle on *C. stenzeli* is very weak on Wilcox material." He considered these differences sufficiently diagnostic to separate the two forms. SWAIN (1951) assigned forms to *A. hilgardi* that were, ". . . not so spinose as *T. stenzeli* and their two longitudinal ridges bear spurlike projections on each side, rather than spines on the ridges themselves." In addition SWAIN indicated that the short postdorsal subvertical ridge on *A. stenzeli* was more strongly elevated than that of *A. hilgardi*. The forms from the lower and middle Eocene of South Carolina do not show sufficient differences in ornamentation and strength of the posterodorsal ridge to warrant differentiating them into two species; consequently, only *A. stenzeli* is recognized; however, possibly some of the less ornate lower Eocene forms may be *A. hilgardi*.

Dimensions. Male: length 0.83 mm, thickness 0.36 mm, height 0.43 mm. Female: length 0.78 mm, thickness 0.39 mm, height 0.44 mm.

Material. Black Mingo Formation: 80 specimens. Warley Hill Formation: 27 specimens. Santee Limestone: 576 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4). Auger Hole 45-2 (21-29'). Warley Hill Formation: Localities 8-3 (units 1 and 3), 9-33 and 9-34. Auger Holes 14-3 (50') and 9-3 (62?'). Santee Limestone: Localities 9-28, 9-31, 9-32, 9-33, 9-54, 18-1 (units 1 and 3), 38-10, 38-26, 38-85, 38-87, and 38-103. Auger Holes 38-5 (70' and 85-100'), 38-7 (17-23' and 27'), 38-11 (10-15' and 20-25'), 38-13 (82?-100'), 38-17 (60-80'), 38-18 (12-18'), 38-22 (70'), 38-23 (25' and 50'), 38-27 (60'), 38-29 (14'), 38-35 (70-74' and 85'), 38-37 (50-65'), and 38-40 (65-70').

Reported from the middle Eocene, Reklaw and Weches formations of Texas (STEPHENSON, 1944b, p. 450 and 1946, p. 340); lower and middle Eocene of North Carolina (SWAIN, 1951, p. 31 and BROWN, 1958, p. 65).

Genus BUNTONIA Howe, 1935

Cythereis? Howe & Pyeatt, *in* HOWE & GARRETT, 1934, p. 50; Howe & Pyeatt, *in* HOWE & CHAMBERS, 1935, p. 33.
Buntonia Howe, *in* HOWE & CHAMBERS, 1935, p. 22; STEPHENSON, 1947, p. 579; HOWE, 1947, p. 50; SYLVESTER-BRADLEY, 1961, p. Q336.
Pyricythereis Howe, *in* HOWE & LAW, 1936, p. 65; SUTTON & WILLIAMS, 1939, p. 569; STEPHENSON, 1944, p. 453; VAN DEN BOLD, 1946, p. 30, 103; STEPHENSON, 1946, p. 329.
Semicythereis ELOFSON, 1944, p. 16.
Type-species. Buntonia shubutaensis Howe, *in* HOWE & CHAMBERS, 1935, p. 23, pl. 4, figs. 4, 5; pl. 5, fig. 7, juvenile. (=*Cythereis? israelskyi* HOWE & PYEATT, 1935, adult.)

BUNTONIA RETICULATA Pooser, n. sp.

Pl. 14, figs. 2-5, 9-11, 13

Diagnosis. Characterized by its subpyriform lateral outline with dorsal and ventral margins converging posteriorly; anterior end broadly rounded; posterior end sharply upturned. Posterior one-third coarsely reticulate; remainder of carapace smooth except for single row of reticulations immediately posterior to anteromarginal rim. Prominent sulcus dorsal to the median line and slightly anterior of middle. *Oligo.*

Description. Carapace strong, large, and subpyriform to subrectangular. Dorsal outline subrectangular with blunt posterior end, female more tumid than the male. In lateral outline dorsum and venter converge posteriorly with greatest convergence in female carapaces. Greatest height at anterior cardinal angle and greatest width slightly posterior to middle. Anterior end broadly rounded; posterior end sharply upturned with margin extended at posterior cardinal angle. Left valve larger than right valve with greatest overreach along venter and posterior cardinal angle. Posterior one-third of carapace coarsely reticulate. Remainder of carapace smooth except for single row of reticulations immediately posterior to anteromarginal rim. Rounded anteromarginal rim originating at eye tubercle, parallels anterior margin, and terminates just posterior to anteroventer. Anterior to this rim are two shallow, narrow depressions separated by slender ridge. Wide depression posterior to rim. Vertically elongated sulcus dorsal to the median line of the carapace and slightly anterior to middle.

Hinge holamphidont; right valve with high, smooth, rounded anterior tooth, deep circular socket, finely crenulated groove widest at the anterior and posterior extremities, and very large, smooth, rounded, posterior tooth. Left valve antithesis of right with anterior socket enclosed ventrally. Duplicature fused and widest anteriorly. Radial pore-canals numerous, long, and simple. Left valve with prominent selvage and selvage groove. Muscle-scar pattern consisting of vertical row of four adductor scars and crescent-shaped antennal scar directly anterior to two center adductor scars. Sexual dimorphism pronounced with females shorter, higher, and more tumid.

Remarks. *Buntonia reticulata* is very similar to *B. huneri* (HOWE & LAW) from the Vicksburg Group of Louisiana, but *B. huneri* differs in that it has a smooth carapace and two sulci below the anterodorsum. *B. reticulata* differs from *B. shubutaensis* (HOWE & PYEATT) in that *B. reticulata* is more subrectangular and has a row of coarse reticulations immediately posterior to the anteromarginal rim.

Dimensions. Female: length 0.72 mm, thickness 0.33 mm, height 0.42 mm. Male: length 0.78 mm, thickness 0.27 mm, height 0.39 mm.

Material. Cooper Marl: 28 specimens. Holotype deposited in the U.S. National Museum, Smithsonian Institution, Washington, D.C.; WKP821624.

Occurrence. Cooper Marl: Localities 18-9 (units 1 and 2) and 8-4. Auger Holes 8-39 (12?-21?' and 25-30'), and 8-40 (4-7').

BUNTONIA HOWEI (Stephenson, 1946), Stephenson, 1947

Pl. 13, figs. 4, 5, 8, 10

Pyricythereis howei STEPHENSON, 1946, p. 330, pl. 42, figs. 16, 17.
Buntonia howei (Stephenson), STEPHENSON, 1947, p. 579; SWAIN, 1951, p. 38, pl. 2, figs. 25-27; BROWN, 1958, p. 68, pl. 6, fig. 11.

Diagnosis. Characterized by an elongate, subrectangular shape, and surface ornamentation consisting of longitudinally elongated pits which are best developed near center of carapace. *M.Eoc.*

Remarks. The internal features were not observed; however, the external features are identical to those of *Buntonia howei* (STEPHENSON). *B. howei* is distinguished from *B. alabamensis* (HOWE & PYEATT) by the lack of ridges across the central portion of the carapace.

Dimensions. Length 0.62 mm, thickness 0.24 mm, height 0.32 mm.

Material. Warley Hill Formation: 7 specimens. Santee Limestone: 7 specimens.

Occurrence. Warley Hill Formation: Locality 8-3 (units 1 and 3). Santee Limestone: Auger Holes 38-5 (85-100'), and 38-18 (12-18').

Reported from the Claiborne, Weches Formation of Texas (STEPHENSON, 1946, p. 330); middle Eocene, lower part of the Castle Hayne Limestone of North Carolina (BROWN, 1958, p. 68); and the middle Eocene of North Carolina (SWAIN, 1951, p. 38).

BUNTONIA ALABAMENSIS (Howe & Pyeatt, 1934), Stephenson, 1947

Pl. 16, figs. 1, 4, 6

Cythereis? alabamensis Howe & Pyeatt, *in* HOWE & GARRETT, 1934, p. 50, pl. 4, figs. 2, 5, 7-10.
Pyicythereis alabamensis (Howe & Pyeatt), STEPHENSON, 1944b (part), p. 453; ———, 1946, p. 330, pl. 42, fig. 12; VAN DEN BOLD, 1946, p. 103, pl. 11, fig. 6.
Buntonia alabamensis (Howe & Pyeatt), STEPHENSON, 1947, p. 579; VAN DEN BOLD, 1957b, p. 8; ———, 1960, p. 168.

Diagnosis. Characterized by its subpyriform lateral outline and reticulate surface with low, rounded longitudinal ridges between which are prominent pits. Ridges tend to parallel dorsal and ventral margins and exhibit closer spacing toward venter. *Paleo.-M.Eoc.*

Description. Carapace subpyriform in lateral outline and ornamented with longitudinal ridges and reticulations. Two of the longitudinal ridges, one slightly above median line of carapace and the other just dorsal to venter, enclose a slightly depressed reticulate area. Vertical sulcus just posterior to eye tubercle and terminating slightly above median line. Sharp keel-like anteromarginal rim originating at eye tubercle parallels anterior margin terminating at anteroventer.

Interior of valves characterized by small vestibules, anterior vestibule being wider than that of posterior. Radial pore-canals simple, long, and closely spaced. Ocular pits prominent on both valves. Hinge holamphidont: right valve consists of a strong, elongate, pointed, anterior tooth; deep, postjacent socket; coarsely crenulate groove that parallels dorsal margin of carapace; and large, ovate posterior tooth. Left valve antithesis of right. Muscle-scar pattern consisting of short vertical row of four adductor scars and V-shaped antennal scar anterior and slightly ventral to uppermost adductor scar. Sexual dimorphism pronounced; males longer, having more pointed posterior, and thinner, thus giving rectangular appearance when viewed from dorsum.

Remarks. Buntonia alabamensis differs from *B. subtriangularis* (SUTTON & WILLIAMS) in having much coarser pitting. *B. alabamensis* is readily distinguished from *B. howei* (STEPHENSON) by the presence of longitudinal ridges across the central portion of the carapace.

Dimensions. Male: length 0.58 mm, thickness 0.26 mm, height 0.33 mm. Female: length 0.55 mm, thickness 0.31 mm, height 0.34 mm.

Material. Santee Limestone: 92 specimens.

Occurrence. Santee Limestone: Auger Holes 38-5 (70′ and 85-100′), 38-7 (17-23′ and 27′), 38-18 (12-18′), 38-22 (70′), 38-23 (25′), 38-26 (25′), 38-29 (14′), 38-37 (60-65′), 38-40 (65-70′).

Reported from the lower Eocene, Sabine Group of Texas, Louisiana and Alabama (HOWE & GARRETT, 1934, p. 51); middle Eocene, Weches Formation of Texas (STEPHENSON, 1946, p. 330); lower Eocene and Paleocene of Guatemala and British Honduras VAN DEN BOLD, 1946, p. 103); and the lower or middle Eocene of Trinidad (VAN DEN BOLD, 1957b, p. 8).

Genus ECHINOCYTHEREIS Puri, 1953

Echinocythereis PURI, 1953d, p. 259; SYLVESTER-BRADLEY, 1961, p. Q336; BENSON & COLEMAN, 1963, p. 46.

Type-species. Cythereis garretti Howe & McGuirt, *in* HOWE AND OTHERS, 1935, p. 20, pl. 3, figs. 17-19, pl. 4, figs. 5, 15.

Diagnosis. Recognized by its inflated subovate to subrectangular lateral outline; anterior end broadly rounded, denticulate; posterior end obliquely rounded; surface covered by numerous small rounded spines superimposed on reticulations. Hinge holamphidont. *Eoc.-Rec.*

ECHINOCYTHEREIS CLARKANA (Ulrich & Bassler, 1904), McLean, 1957

Pl. 22, figs. 1, 6-8, 10

Cythere clarkana ULRICH & BASSLER 1904, p. 98, pl. 35, figs. 1-10.
Cythere clarkana var. *minuscula* ULRICH & BASSLER, 1904, p. 99, pl. 35, figs. 11-14.
Leguminocythereis clarkana (Ulrich & Bassler), SWAIN, 1948, p. 207, pl. 13, fig. 6; ———, 1951, p. 43, pl. 6, fig. 18.
Trachyleberis clarkana (Ulrich & Bassler), MALKIN, 1953, p. 792, pl. 82, figs. 1-3.
Echinocythereis clarkana (Ulrich & Bassler), MCLEAN, 1957, p. 84, pl. 10, figs. 3a-c.

Diagnosis. Characterized by its coarsely and deeply reticulate surface with spines at junction of intersecting ridges. Reticulate network arranged somewhat concentrically about subcentral point. *Oligo.-Mio.*

Remarks. MALKIN (1953, p. 792) considered *Echinocythereis clarkana minuscula* (ULRICH & BASSLER) a molt of *E. clarkana* (ULRICH & BASSLER). *E. clarkana* is closely related to *E. jacksonensis* (HOWE & PYEATT) of the upper Eocene and Oligocene from which it may be distinguished by its coarser reticulations, wider hinge depression, and the very irregular dorsal outline immediately posterior to the eye tubercle.

Dimensions. Male: (left valve) length 1.35 mm, height 0.75 mm. Female: length 1.17 mm, thickness 0.64 mm, height 0.72 mm.

Material. Cooper Marl: 76 specimens.

Occurrence. Cooper Marl: Localities 18-3, 18-8 (unit 1), 18-9 (unit 2), and 38-13. Auger Holes 8-40 (4-7′), 8-49 (13′), and 18-4 (14-15′).

This distinctive form was originally described from the middle Miocene, Calvert Formation of Maryland (ULRICH & BASSLER, 1904, p. 99), and later reported by SWAIN (1948, p. 208) from the Calvert Formation of Maryland. It has subsequently been reported by MALKIN (1953, p. 792) from the Calvert and Kirkwood formations of Maryland; and the lower, middle, and upper Miocene of North Carolina (SWAIN, 1951, p. 43). MCLEAN (1957, p. 85) reports that he considers this species diagnostic of the pre-Yorktown in the area of the York-James Peninsula of Virginia.

ECHINOCYTHEREIS JACKSONENSIS (Howe & Pyeatt, 1935), Puri, 1953

Pl. 15, figs. 7, 10-13

Cythereis? jacksonensis Howe & Pyeatt, *in* HOWE & CHAMBERS, 1935, p. 35, pl. 1, figs. 23, 24, pl. 6, fig. 31; MONSOUR, 1937, p. 90; BERQUIST, 1942, p. 108, pl. 11, fig. 14.
Cythereis jacksonensis Howe & Pyeatt, GARRETT, 1936, p. 786; VAN DEN BOLD, 1946, p. 89, pl. 10, fig. 9; WILBERT, 1953, p. 125, pl. 1, fig. 14.
Echinocythereis jacksonensis (Howe & Pyeatt), PURI, 1953d, p. 260; KRUTAK, 1961, p. 783, pl. 91, fig. 9.

Diagnosis. Characterized by an elongate, subrectangular, tumid carapace. Surface very faintly reticulate with well-developed spines at intersections of the reticulations. *M.Eoc.-Oligo.*

Remarks. This form is very similar to and closely related to *Echinocythereis clarkana* (ULRICH & BASSLER, 1904). *E. jacksonensis* differs from *E. clarkana* in the extent of ornamentation. The reticulations on *E. jacksonensis* are not as well developed, the hingeline depression is narrower, the anterior marginal area is more compressed, and the depression posterior to and below the eye tubercle is not as well developed as in *E. clarkana*. Viewed laterally, the dorsal outline of *E. clarkana* is very irregular just posterior to the eye tubercle, whereas the dorsal margin of *E. jacksonensis* is essentially straight.

Echinocythereis garretti (HOWE & MCGUIRT) is very similar to *E. jacksonensis* but differs in having a more rounded posterior, more quadrate lateral outline, and greater spinosity.

Dimensions. Length 1.10 mm, thickness 0.59 mm, height 0.57 mm.

Material. Warley Hill Formation: 4 specimens. Santee Limestone: 92 specimens. Cooper Marl: 67 specimens.

Occurrence. Warley Hill Formation: Locality 9-28. Auger

Hole 9-3 (62?'). Santee Limestone: Localities 9-28, 9-31, 9-32, 9-33 (unit 3), 9-54 (unit 1), 18-1 (unit 1), 38-10, and 38-103. Auger Holes 38-35 (70-74') and 38-40 (65-70'). Cooper Marl: Localities 18-1 (unit 4), 18-3, 18-8 (unit 1), 18-9 (unit 2), 18-10 (unit 1), and 8-4. Auger Holes 8-39 (12-21?' and 25-30') and 8-40 (4-7').

HOWE & PYEATT *in* HOWE & CHAMBERS, 1935, p. 37) report that, "This species and its varieties are probably the commonest large ostracodes in the Jackson and Vicksburg of the Gulf Coast, and is subject to great variation." It is also reported from the lower Oligocene of Cuba (VAN DEN BOLD, 1956, p. 89).

Genus HENRYHOWELLA Puri, 1957

Howella PURI, 1956, p. 274.

Henryhowella PURI, 1957d, p. 982 [*pro Howella* PURI, 1956 (*non* OGILBY, 1899)]; SYLVESTER-BRADLEY, 1961, p. Q336.

Type-species. Cythere evax ULRICH & BASSLER, 1904, p.119, pl. 36, figs. 6-8.

Diagnosis. Like *Actinocythereis* but the three well-developed longitudinal rows of spines do not continue into the anterior half of carapace, where spines are concentrically arranged. *U.Eoc.-Mio.*

HENRYHOWELLA EVAX (Ulrich & Bassler, 1904), Puri, 1957

Pl. 19, fig. 1; Pl. 20, figs. 2, 7, 9-13

Cythere evax ULRICH & BASSLER, 1904, p. 119, pl. 36, figs. 6-8.

Cythere evax oblongula ULRICH & BASSLER, 1904, p. 119, pl. 36, figs. 9, 10.

Cythereis evax (Ulrich & Bassler), VAN DEN BOLD, 1946, p. 90, pl. 10, fig. 19; SWAIN, 1948, p. 204, pl. 12, figs. 19, 20.

Trachyleberis evax (Ulrich & Bassler), SWAIN, 1951, p. 28, pl. 3, figs. 1-3; MALKIN, 1953, p. 792, pl. 82, figs. 4, 5.

Echinocythereis evax (Ulrich & Bassler), PURI, 1953d, p. 260, pl. 12, fig. 1, text-fig. 9c; BROWN, 1958, p. 65, pl. 2, fig. 15.

Howella evax (Ulrich & Bassler), PURI, 1956, p. 275, pl. 35, figs. 1-8.

Howella echinata PURI, 1956, p. 275, pl. 35, figs. 9-14, pl. 36, figs. 1-4.

Henryhowella evax (Ulrich & Bassler), SYLVESTER-BRADLEY, 1961, p. Q336, fig. 261, 4.

Diagnosis. Characterized by its subrectangular to subovate lateral outline; faintly reticulate surface with spines or nodes concentrically arranged in anterior half and three well-developed longitudinal spinose rows in posterior; and prominent subcentral tubercle with cluster of closely spaced spines. Sexual dimorphism pronounced with females shorter than males and with more arched dorsal outline. Hinge holamphidont with right valve consisting of bilobed anterior tooth, deep postjacent socket, straight, narrow, finely crenulate groove, and smooth, large, rounded posterior tooth. Duplicature moderately broad, of uniform width throughout its extent, and with small anterior and posterior vestibules. Well-defined, deep flange groove extends around entire free margin. *U.Eoc.-Mio.*

Remarks. Henryhowella evax oblongula (ULRICH & BASSLER) is apparently the male dimorph of *Henryhowella evax* (ULRICH & BASSLER), and differs from *H. evax* only in its greater length. PURI (1956, p. 275) designated *Henryhowella echinata* (PURI) as a new species from the Cooper Marl near Charleston, South Carolina. He indicated that *H. echinata* was more thickly and closely ornamented than *H. evax*, and that the posterior end in *H. evax* has a tendency towards angulation while *H. echinata* tends to be subrounded. The author does not believe that these differentiating features are sufficiently diagnostic to separate the two forms; consequently, *H. evax* and *H. echinata* are considered conspecific.

VAN DEN BOLD (1960, p. 169) considered *Henryhowella evax* as a junior synonym of *Henryhowella asperrima* (REUSS).

Dimensions. Male: length 0.84 mm, thickness 0.35 mm, height 0.45 mm. Female: length 0.79 mm, thickness 0.38 mm, height 0.46 mm.

Material. Cooper Marl: 101 specimens.

Occurrence. Cooper Marl: Localities 18-1 (unit 4), 18-8 (unit 1), 18-9 (unit 2), 18-10 (unit 1), and 8-4. Auger Holes 8-39 (12?-21' and 25-30'), 8-40 (4-7'), 8-49 (13'), and 18-5 (31').

This species was originally described from the middle Miocene, Calvert Formation of Maryland (ULRICH & BASSLER, 1904, p. 119). It has subsequently been reported from the middle Miocene, Calvert Formation of Maryland (SWAIN, 1948, p. 188, 204); the Oligocene?, lower and middle Miocene of North Carolina (SWAIN, 1951, p. 28); the upper Miocene of Florida (PURI, 1953d, p. 261); middle Miocene, Calvert and Kirkwood formations of Maryland (MALKIN, 1953, p. 793); and the upper Miocene, Yorktown Formation and unnamed Miocene? unit of North Carolina (BROWN, 1958, p. 65). VAN DEN BOLD (1946, p. 90) reported this species from the Oligocene of Cuba but the author is unable to verify his identification because only interior views are illustrated. In addition, VAN DEN BOLD (1960, p. 169) reported this form as *Henryhowella asperrima* from the upper Eocene and Oligocene of Trinidad.

Genus MURRAYINA Puri, 1953

Murrayina PURI, 1953d, p. 255; MCLEAN, 1957, p. 85; SYLVESTER-BRADLEY, 1961, p. Q339.

Type-species. Murrayina howei PURI, 1953d, p. 255, pl. 12, figs. 9, 10, text-figs. 8g, h.

Diagnosis. Distinguished by an elongate, subrectangular, reticulate carapace; well-defined anterior and posterior marginal rims and subcentral tubercle. Hinge holamphidont; right valve with smooth or stepped anterior tooth, postjacent socket, serrate groove, and smooth posterior tooth. *Paleo.-Rec.?*

MURRAYINA DICTYOLOBUS (Munsey, 1953), Pooser (n. comb.)

Pl. 21, figs. 9, 10, 12, 13

Cythereis dictyolobus MUNSEY, 1953, p. 9, pl. 4, figs. 9-11.

Diagnosis. Carapace elongate, subrectangular, and with anterior and posterior marginal rims. Entire surface coarsely reticulate, those anterior to subcentral node aligned so as to form ridges which parallel anterior margin; those posterior to subcentral node show random arrangement. *Paleo.-L.Eoc.*

Remarks. The hinge of the only right valve observed consists of a high conical anterior tooth, a postjacent shallow narrow socket, and a long straight groove that appears to be finely crenulate and widens just anterior to a small oval posterior tooth. Muscle-scars obscured. A deep flange groove borders the free margin of the right valve. Anterior duplicature is moderately wide with a small vestibule.

Munsey placed this form under *Cythereis;* however, the shape, subcentral node, anterior and posterior marginal rims, and hinge indicate that it should be placed under the genus *Murrayina.*

Dimensions. Length 0.78 mm, thickness 0.34 mm, height 0.35 mm.

Material. Black Mingo Formation: 20 specimens.

Occurrence. Black Mingo Formation: Locality 8-2 (units 2 and 4).

Reported from the Paleocene Coal Bluff Member of the Naheola Formation of Alabama (Munsey, 1953, p. 9).

MURRAYINA MARTINI (Ulrich & Bassler, 1904), Puri, 1953

Pl. 21, figs. 3, 5, 8

Cythere martini Ulrich & Bassler, 1904, p. 112, pl. 36, figs. 11-15.
Cythere micula Ulrich & Bassler, 1904, p. 116, pl. 36, figs. 18-20.
Cythereis martini (Ulrich & Bassler), Swain, 1948, p. 196, pl. 12, figs. 16, 17.
Trachyleberis? martini (Ulrich & Bassler), Swain, 1951, p. 29, pl. 3, figs. 8, 15.
Trachyleberis? sp. cf. *T.? micula* (Ulrich & Bassler), Swain, 1951, p. 29, text-fig. 31.
Trachyleberis martini (Ulrich & Bassler), Malkin, 1953 (part) p. 793.
Murrayina martini (Ulrich & Bassler), Puri, 1953d, p. 256, pl. 12, figs. 11-13, text-figs. 8e, f; McLean, 1957, p. 86, pl. 11, figs. 1a-e, 2a, b, 3a, d.

Diagnosis. Characterized by its subrectangular lateral outline, coarsely reticulate carapace, and moderately broad anterior marginal rim. *Mio.*

Remarks. Murrayina martini is very similar and closely related to *M. howei* Puri. Malkin (1953, p. 793) considers *M. howei* (identified as *Cythereis producta*) as an elongated phenotypic variant, conforming in all particulars with *M. martini* (identified as *Trachyleberis martini*). Ulrich & Bassler (1904, p. 115) who originally described the two forms recognized their similarity but distinguished *M. howei* (identified as *Cythere producta*) from *M. martini* (identified as *Cythere martini*) by its much greater proportional length, more nearly parallel ventral and dorsal edges, marginal spines at both ends of the left valve as well as the right, in being at least one-fifth larger, posterior extremity much more produced and compressed, and having coarser marginal spines.

Dimensions. Length 0.72 mm, thickness 0.30 mm, height 0.39 mm.

Material. Duplin Formation: 33 specimens.

Occurrence. Duplin Formation: Localities 38-29, 38-42, 38-45, 18-9 (unit 4), and 21-2 (unit 2). Auger Hole 38-38 (19′).

This sepecies occurs in the Choptank and Calvert Formations of Maryland, and the Chesapeake Group at Yorktown, Virginia (Ulrich & Bassler, 1904, p. 113), and in the Calvert Formation of the subsurface of Maryland (Swain, 1948, p. 196). It has also been reported from the upper Miocene, Yorktown Formation of Virginia (McLean, 1957, p. 87); the lower through upper Miocene of North Carolina (Swain, 1951, p. 29); and the *Arca, Ecphora,* and *Cancellaria* facies of the Choctawhatchee Stage of Florida (Puri, 1953d, p. 256).

MURRAYINA BARCLAYI McLean, 1957

Pl. 22, figs. 4, 5, 9, 11, 12

Murrayina barclayi McLean, 1957, p. 87, pl. 11, figs. 4a-f.

Diagnosis. Characterized by an elongate, subrectangular lateral outline; obliquely rounded and distinctly rimmed anterior end bearing stout anteroventral spines; posterior slightly rounded and bears several spines in ventral half; surface ornamented with coarse reticulations, prominent subcentral node, ventrolateral ridge, and longitudinal median ridge. *U.Mio.*

Remarks. The South Carolina specimens appear to be identical to *Murrayina barclayi* with the exception that the anterior duplicature is narrower. *M. barclayi* is closely related to *M. howei* Puri from which *M. barclayi* is distinguished by its unique ornamentation and more elongate carapace.

Dimensions. Length 0.72 mm, height 0.39 mm.

Material. Duplin Formation: one left and one right valve.

Occurrence. Duplin Formation: Locality 38-29.

Originally reported from the upper Miocene, Yorktown Formation of Virginia (McLean, 1957, p. 88).

Genus OCCULTOCYTHEREIS Howe, 1951

Occultocythereis Howe, 1951a, p. 19; Sylvester-Bradley, 1961, p. Q339.

Type-species. Occultocythereis delumbata Howe, 1951a, p. 20, pl. 1, figs. 7-10.

Diagnosis. Recognized by its very small, compressed, carapace; anterior end with prominent rim and strong marginal spines; surface smooth to very finely pitted; radial pore-canals divide into two or more branches midway along length; hinge holamphidont. *Eoc.*

OCCULTOCYTHEREIS DELUMBATA Howe, 1951

Occultocythereis delumbata Howe, 1951a, p. 20, pl. 1, figs. 7-10; Puri, 1957c, p. 207, pl. 7, figs. 5-8; Sylvester-Bradley, 1961, p. Q339, fig. 367, 2.

Diagnosis. Carapace small, compressed, and very elongate with dorsal and ventral margins converging strongly toward posterior. Anterior margin broadly rounded and with marginal spines; posterior strongly compressed, acuminate, and with stout spines on the posteroventral margin. Surface finely pitted and ornamented with prominent angular tubercles trending diagonally from the posterior cardinal angle and intersect venter just anterior to middle of carapace. *Eoc.*

Remarks. A single whole specimen was recovered from the Santee Limestone of South Carolina. The internal features were not observed; however, based on the external features the specimen appears to be *Occultocythereis delumbata.*

Dimensions. Length 0.56 mm, thickness 0.16 mm, height 0.24 mm.

Material. A single whole specimen was recovered from the Santee Limestone.

Occurrence. Santee Limestone: Locality 18-1 (unit 1).

Reported from the middle Eocene, Avon Park Limestone of Florida (Howe, 1951a, p. 21), and the upper Eocene, Crystal River Formation of the Ocala Group of Florida (Puri, 1957, p. 207).

Genus ORIONINA Puri, 1953

Orionina Puri, 1953d, p. 253; Pokorný, 1958, p. 264; Sylvester-Bradley, 1961, p. Q339; Benson & Coleman, 1963, p. 45.

Type-species. Cythere vaughani Ulrich & Bassler, 1904, p. 109, pl. 38, figs. 25-27 [=*C. serrulata* Brady, 1869, p. 153, pl. 18, figs. 11, 12 (non *C. serrulata* Bosquet, 1854) =*C. bermudae* (Brady) by Brady, 1880, p. 90].

Diagnosis. Characterized by its large, elongate carapace; surface reticulate with two to four well-developed longitudinal ridges; hinge of right valve with anterior lobate tooth, postjacent socket, median groove, and smooth posterior tooth. *Eoc.-Rec.*

ORIONINA BERMUDAE (Brady, 1880), van den Bold, 1952
Pl. 17, figs. 3, 8, 10, 11

Cythere serrulata Brady, 1869, p. 153, pl. 18, figs. 11, 12 (*non Cythere serrulata* Bosquet, 1854).

Cythere bermudae Brady, 1880, p. 90, pl. 21, figs. 2a-d (new name for *Cythere serrulata* Brady).

Cythereis rambohri Müller, 1912, p. 358.

Cythere vaughani Ulrich & Bassler, 1904, p. 109, pl. 38, figs. 25-27.

Cythereis vaughani (Ulrich & Bassler), Howe and others, 1935, p. 25, pl. 3, figs. 24, 25, pl. 4, fig. 13; Coryell & Fields, p. 9, fig. 10a; Edwards, 1944, p. 522, pl. 87, figs. 27, 28; van den Bold, 1946, p. 88, pl. 10, fig. 1; ———, 1950b, p. 83.

Trachyleberis vaughani Swain, 1951, p. 37, pl. 6, figs. 6, 7; Malkin, 1953, p. 794, pl. 82, fig. 14.

Orionina vaughani (Ulrich & Bassler), Puri, 1953d, p. 254, pl. 12, figs. 15, 16, text-figs. 8a-c; McLean, 1957, p. 88, pl. 11, figs. 6a, b; Brown, 1958, p. 65, pl. 3, fig. 2.

Orionina bermudae (Brady), van den Bold, 1952a, p. 242; Puri & Hulings, 1957, p. 187, fig. 11; Puri, 1960, p. 123, 126, pl. 1, figs. 15, 16; Benson & Coleman, 1963, p. 45, pl. 8, fig. 7, text-fig. 29.

Diagnosis. Characterized by a prominent anterior marginal rim and three somewhat oblique longitudinal ridges, lowermost of which bifurcates below subcentral tubercle. These longitudinal ridges together with numerous transverse ridges form reticulate pattern. *Mio.-Rec.*

Remarks. The specimens of *Orionina bermudae* from the upper Miocene of South Carolina were compared with Recent forms collected by Benson & Coleman from the eastern Gulf of Mexico and were found to be identical in surface ornamentation but considerably longer. The adult specimens from South Carolina average 0.83 mm in length; whereas, the specimens from the eastern Gulf of Mexico measure 0.58 mm, and those reported by Puri (1960, p. 123) from Florida Bay are 0.551 mm in length.

Dimensions. Length 0.83 mm, thickness 0.31 mm, height 0.41 mm.

Material. Duplin Formation: 36 specimens.

Occurrence. Duplin Formation: Localities 38-45, 38-42, 18-9 (unit 4), and 21-1 (unit 2). Auger Hole 38-38 (19′).

This species was originally described from the middle Miocene, Chesapeake Group of Virginia (Ulrich & Bassler, 1904, p. 110). It has also been reported from the upper Miocene, Yorktown Formation of Virginia (McLean, 1957, p. 89 and Malkin, 1953, p. 794), and the Duplin Marl of North Carolina (Edwards, 1944, p. 552); middle and upper Miocene of North Carolina (Swain, 1951, p. 37); middle Miocene of Panama (Coryell & Fields, 1937, p. 10); Miocene of Cuba, Guatemala, and the British Honduras (van den Bold, 1946, p. 88); upper Miocene Yorktown Formation of North Carolina (Brown, 1958, p. 65); upper Miocene and Pliocene of Florida (Puri, 1953d, p. 254); and the Recent of Florida (Benson & Coleman, 1963, p. 45 and Puri, 1960, p. 126). Van den Bold (1957a, p. 242) reports this form throughout the Miocene of Trinidad.

Genus PURIANA Coryell, *in* Puri, 1953

Favella Coryell & Fields, 1937, p. 8; Edwards, 1944, p. 523 (*non Favella* Jorgensen, 1925).

Puriana Coryell *in* Puri, 1953a, p. 751; Swain, 1955, p. 634; Benson, 1959, p. 60; Sylvester-Bradley, 1961, p. Q341; Benson & Coleman, 1963, p. 42; Benson & Kaesler, 1963, p. 30.

Type-species. Favella puella Coryell & Fields, 1937, p. 8, figs. 8a-c, juvenile [=*Cythereis rugipunctata gatunensis* Coryell & Fields, 1937, p. 10, fig. 11a].

Diagnosis. Characterized by its small, subquadrate carapace; ornamentation consists of ridges and nodes, subcentral tubercle, prominent rim around anterior margin, prominent spines on posterior margin, and subvertical ridges extending from posterodorsum to median line. Hinge holamphidont. *Mio.-Rec.*

PURIANA RUGIPUNCTATA (Ulrich & Bassler, 1904), Puri, 1953
Pl. 17, figs. 4-7, 9

Cythere rugipunctata Ulrich & Bassler, 1904, p. 118, pl. 38, figs. 16, 17.

Cythereis rugipunctata (Ulrich & Bassler), *in* Howe and others, 1935, p. 23, pl. 1, figs. 18, 20-22, pl. 4, figs. 22, 23.

Favella rugipunctata (Ulrich & Bassler), Edwards, 1944, p. 524, pl. 88, figs. 5, 6; van den Bold, 1946, p. 100, pl. 10, fig. 3; ———, 1950b, p. 86; Malkin, 1953, p. 797, pl. 82, fig. 25.

Trachyleberis? rugipunctata (Ulrich & Bassler), Swain, 1951, p. 38, pl. 6, fig. 8.

Puriana rugipunctata (Ulrich & Bassler), PURI, 1953a, p. 750; ———, 1953d, p. 257, pl. 12, figs. 18, 19, text-fig. 8k; MCLEAN, 1957, p. 89, pl. 11, figs. 5a-d; PURI & HULINGS, 1957, p. 174, 176, 183; BROWN, 1958, p. 63, pl. 4, fig. 10; VAN DEN BOLD, 1958, p. 404; PURI, 1960, p. 126; BENSON & COLEMAN, 1963, p. 43.

Diagnosis. Characterized by its subquadrate lateral outline and prominent rugose ornamentation. Posterior portion of carapace bears 4 or 5 oblique, flat-topped ridges that ventral to middle become nodes. *Mio.-Rec.*

Remarks. The specimens of *Puriana rugipunctata* from the upper Miocene, Duplin Formation differ from Recent forms from the eastern Gulf of Mexico only in that the Miocene forms are slightly longer.

Dimensions. Length 0.70 mm, thickness 0.30 mm, height 0.36 mm.

Material. Duplin Formation: 40 specimens.

Occurrence. Duplin Formation: Localities 38-42, 18-19 (unit 4), and 21-1 (unit 2). Auger Hole 38-38 (19' and 24').

This species was originally described from the middle Miocene, Chesapeake Group of Virginia (ULRICH & BASSLER, 1904, p. 118). It has subsequently been reported from the upper Miocene, Choctawhatchee Stage of Florida (HOWE AND OTHERS, 1935, p. 23), Duplin Marl of North Carolina (EDWARDS, 1944, p. 524), Yorktown Formation of North Carolina (BROWN, 1958, p. 63), Yorktown Formation of Virginia (MCLEAN, 1957, p. 89 and MALKIN, 1953, p. 797); Miocene of Cuba, Guatemala, and British Honduras (VAN DEN BOLD, 1946, p. 100); and the lower, middle, and upper Miocene of North Carolina (SWAIN, 1951, p. 38). In addition it has been reported from the Recent in the Alligator Harbor and Panama City Regions of Florida and in Florida Bay (PURI & HULINGS, 1957); eastern Gulf of Mexico (BENSON & COLEMAN, 1963, p. 44); Pamlico Sound, North Carolina (GROSSMAN, 1964); and the west coast of Florida (PURI, 1960, p. 126).

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APPENDIX

SELECTED MEASURED SECTIONS

Locality 2-1

Location: Roadcut on County Highway 394; 0.3 miles east of Dean Swamp Creek; 1.0 miles west of Salley.

	Thickness (Feet)
Pleistocene?	
surficial material	
7. Sand, quartzose, fine- to coarse-grained, gritty, argillaceous, brick-red	20-25
Unconformity	
Middle Eocene	
Congaree Formation	
6. Clay, silty, mottled light-green, olive, and rusty-red	5
5. Sand, quartzose, fine- to coarse-grained argillaceous, with interbedded layers 0.2 to 2 inches thick of yellowish-ocher clay; small pockets of silicified fossil shells	18
4. Pebble Marker Bed; clay, very arenaceous, olive, weathers to yellowish ocher; contains well-rounded quartz pebbles up to 0.5 inches in diameter; (Alt. elev.=278 feet)	0.5
3. Sandstone, ferruginous, argillaceous	3
2. Sandstone, quartzose, silicia-cemented, gray, weathers dark-brown to black	1.5
1. Sand, quartzose, fine- to medium-grained, yellow	10

Remarks: Units 1 and 2 are exposed on the north side of the road. SLOAN (1908, p. 344) found numerous specimens of *Ostrea johnsoni* ALDRICH at this locality.

Reference: COOKE (1936, p. 59, loc. 102); COOKE & MACNEIL (1952, p. 22).

Locality 2-2

Location: Roadcut on unpaved county road; 0.1 miles southeast of Abrams Branch; 1.2 miles N. 24° W. from Salley.

	Thickness (Feet)
Pleistocene?	
surficial material	
6. Sand, quartzose, fine- to very coarse-grained, gritty, brick-red numerous well-rounded quartz pebbles	10-12
Unconformity	
Middle Eocene	
Congaree Formation	
5. Sand, quartzose, very argillaceous, yellowish-red	3
4. Pebble Marker Bed; clay, very arenaceous, green, weathers to yellowish-ocher, contains well-rounded quartz pebbles. (Alt. elev.=283 feet)	0.5-2
3. Sand, quartzose, fine- to coarse-grained, with thin layers of light-green clay	2
2. Sandstone, quartzose, silica-cemented, gray	0.5
1. Sand, quartzose, fine-grained, well-sorted, yellow, worm borings; base concealed in ditch	6

Locality 2-3

Location: Roadcut on County Highway 732; 0.1 miles east of Goodland Creek; 1.2 miles N. 45° E. from Salley.

	Thickness (Feet)
Pleistocene?	
surficial material	
6. Sand, quartzose, medium- to coarse-grained, slightly argillaceous, brick-red	3
Unconformity	
Middle Eocene	
Congaree Formation (Alt. elev.=310 feet)	
5. Clay, silty to sandy, olive with rusty stain	2-3
4. Sand, quartzose, medium- to coarse-grained with thin layers of cherty clay and some sandstone layers from 1 to 2 inches thick	12
3. Sand, quartzose, fine- to very coarse-grained, yellowish-rust, with pockets of broken and small whole shells (beach deposit)	3
2. Sandstone, fine- to medium-grained, whitish-gray, with interbedded layers of loose quartzose sand	6
1. Sand, quartzose, medium-grained, well-sorted, rusty-yellow; base concealed in ditch	4

Locality 2-4

Location: Roadcut on County Highway 270; 0.1 miles south of Abrams Branch; 1.3 miles N. 45° W. from Salley.

	Thickness (Feet)
Pleistocene?	
surficial material	
5. Sand, quartzose, medium- to very coarse-grained, gritty, brick-red	6-8
Unconformity	
Middle Eocene	
Congaree Formation	
4. Sand, quartzose, fine-grained, very argillaceous, mottled yellow and ocher, contains nodules of cherty clay	6-7
3. Pebble Marker Bed; clay, light-green to ocher, with well-rounded quartz pebbles up to 1 inch in diameter (Alt. elev. =287 feet)	2-2.5
2. Sand, quartzose, fine-grained, yellow, with thin layers of light-green clay	1
1. Sandstone, quartzose, fine-grained, silicia cemented, yellow and white; base concealed in ditch	0.5

Locality 5-1

Location: Spring just east of U.S. Highway 301 bridge over Lemon Creek and immediately north of creek; 2.3 miles S. 43° W. from Bamberg.

Light-green, very fine-grained, quartzose marl of the Oligocene, Cooper Marl can be seen at a depth of 1 to 2 feet below the water surface in a small spring-fed pond.

References: TUOMEY (1884, p. 159); SLOAN (1908, p. 274, Sur. No. 339); COOKE (1936, p. 89, loc. 179).

Locality 5-3

Location: Hand auger hole on property of Mr. E. E. Crow, Box 298, Bamberg; 5.5 miles N. 25° W. from Ehrhardt.

A hand auger hole drilled to a depth of 3 feet penetrated the Upper Miocene, Duplin Formation consisting of bluish-gray, plastic, arenaceous, calcareous mud with numerous broken pelecypod shell fragments. The following ostracodes were identified from this locality: *Cytheromorpha warneri* HOWE & SPURGEON and *Haplocytheridea bassleri* STEPHENSON.

Locality 8-1

Location: Spoil-bank on south side of diversion canal, immediately southeast of S.C. Highway 45; 2.1 miles S. 11° E. from Eadytown.

Numerous large boulders of light-yellow to white limestone of the middle Eocene, Santee Limestone, derived from construction of the Santee-Cooper Diversion Canal, occur on the south bank of the canal.

Locality 8-2

Location: South bank of Santee River, 2.4 miles N. 8° W. from Eadytown or 0.6 miles east of junction of County Highway 31 and unpaved road leading to Wilson's Landing. Alt. elev. at river level=29.5 feet.

	Thickness (feet)
Lower Eocene	
Black Mingo Formation	
5. Limestone, same as unit 3 but more olive-green	0.5-1
4. Marl, light-gray to olive-green; numerous small broken shell fragments of pelecypods and gastropods	1
3. Limestone, well-indurated, light-gray; forms ledge. Contact with underlying unit sharp and undulates up to 2 feet	1-2
2. Marl, bluish-green; numerous small broken shell fragments of pelecypods and gastropods	2-3
1. Sand, quartzose, fine- to medium-grained, gray. Base concealed at river level	1

Remarks: Units 3, 4, and 5 contain *Ostrea compressirostra* SAY and *Turritella mortoni* sp. cf. *T. mortoni postmortoni* HARRIS.

Locality 8-3

Location: South bank of Santee River at Wilson's Landing; 0.5 miles downstream from Santee Dam or 2.5 miles N. 17° W. from Eadytown. Alt. elev. at river level=29.5 feet.

	Thickness (Feet)
Pleistocene?	
surficial material	
5. Sand, quartzose, fine- to very coarse-grained, argillaceous, light-gray to white in lower portion and mixed light-gray and yellowish-brown (limonite stained) in upper portion; contains subangular quartz grains and sparse to moderate muscovite flakes and slightly rounded feldspar cleavage fragments up to about 0.2 inches in diameter	15
Unconformity	
Middle Eocene	
Santee Limestone	
4. Limestone, fine-grained, granular, yellowish-brown; contains sparse to moderate amount of megafossils up to about 1 inch in diameter (pelecypods, corals, echinoderms); no glauconite noted	4
Warley Hill Formation	
3. Limestone, fine- to medium-grained, granular; cream-colored matrix with sparse to abundant light- to dark-green grains of glauconite; contains sparse rounded quartz grains; sparse to moderate amount of small megafossils (pelecypods, corals, echinoderms). Between units 3 and 4 a brown plastic clay layer ranges from a knife edge to 1-foot thick. It has an undulatory layering with interbedded seams of fine- to coarse-grained quartzose and glauconitic sand and lignitic material	3
2. Limestone, slightly arenaceous, light-yellow to white fragmental matrix with moderate amount of light- to dark-green grains of glauconite; abundant large megafossils (pelecypods, echinoderms, corals); strongly cemented and forms ledge; considerably more arenaceous than unit 3	1
1. Limestone, fine- to medium-grained, granular, light-yellow matrix with moderate to abundant light- to dark-green grains of glauconite; contains sparse rounded quartz grains and sparse to moderate amount of small megafossils (pelecypods, corals, echinoderms). Base concealed at river level	5

Remarks: Approximately midway between Localities 8-3 and 8-2, large boulders and ledges of ironstone occur within the river and on the south bank. It appears to represent the oxidized glauconitic sand of the Warley Hill Formation.

Locality 8-4

Location: Ditch exposure on U.S. Highway 52; 0.2 miles south of the southern town limit of Moncks Corner.

Approximately 5 feet of olive-drab to dark-green, glauconitic marl of the Oligocene, Cooper Marl is exposed in a ditch on the east side of S.C. Highway 52.

Locality 9-6

Location: Roadcut on unnumbered county road 0.9 miles south of Sandy Run Church; 13 miles northwest of St. Matthews; 1.55 miles S. 24° E. of junction of U.S. Highways 21 and 176.

	Thickness (Feet)
Lower Eocene	
Black Mingo Formation	
6. Soil and weathered fullers earth to top of hill	4
5. Fuller's earth, buff to gray	4
4. Medium-grained glauconitic, quartzose sand with clay lenses 1.5 feet thick	9
3. Buhrstone containing some poorly preserved unidentifiable fossils	5
2. Fullers earth and fine-grained, quartzose, sand	3
Unconformity	
Upper Cretaceous	
Tuscaloosa Formation	
1. Clay, arenaceous, white to gray, kaolinitic. Base concealed in ditch	5

Locality 9-10

Location: Roadcut southeast of Little Beaver Creek on County Highway 173; 9.4 miles N. 60° W. from St. Matthews or 2.95 miles N. 75° W. from Hammond Crossroads.

	Thickness (Feet)
Pleistocene?	
surficial material	
8. Sand, quartzose, medium- to coarse-grained, white, unconsolidated, with scattered pebbles throughout; lower surface irregular with relief up to 3 feet.	0-5
7. Clay, arenaceous, well-oxidized, scattered pebbles and clay balls, reticulate mottling at base; thickness variable because of irregular collapse of underlying units	2-12
Unconformity	
Lower Eocene	
Black Mingo Formation	
6. Sand, quartzose, medium-grained, white to rusty-red, unconsolidated; interbedded with laminated clay. This unit is highly contorted due to collapse of the overlying unit. Iron oxide cementation of the sand is common	3-8
5. Fuller's earth, porous, light-tan, liesegang rings of iron stain common. The fuller's earth occurs as pods and irregular shaped bodies within a clay residuum. Upper surface irregular because of destruction of the fuller's earth and consequent collapse of the overlying beds	
4. Sand, quartzose, coarse-grained, oxidized, with some glauconite; clay layers in upper part; shell hash forms indurated layers in lower part. Down the cut this unit grades into medium-scale, cross-bedded sand. Thickness of unit variable; on the east side of the cut 10.5 feet to the base of unit (5) and on the west side of the cut 5.5 feet to the base of the fuller's earth	5.5-10.5
3. Mudrock, grayish-black, thin-bedded and oxidized, moderate yellowish-brown sand. The sand layers are generally 2 cm. thick and the clay layers are 8 cm. thick	8.5
2. Sand, quartzose, medium- to coarse-grained, dark-gray, with irregular layers of grayish-black clay. Scattered pebble-size balls of white argillaceous sand and angular feldspar grains concentrated towards base. Lower surface irregular and undulates from 1 to 2 feet	1.1-3.2
Unconformity	
Upper Cretaceous	
Tuscaloosa Formation (Alt. elev.=206 feet)	
1. Sand, quartzose, argillaceous, mottled white, yellow, brown, and purple; angular feldspar pebbles common in more sandy portion of unit. Thin pebble bands of quartz and feldspar scattered throughout. Medium-scale, high-angle (30°) cross-bedding occurs near top of unit on west side of cut. Base concealed in ditch.	15

Locality 9-11

Location: Roadcut on southeast side of Little Beaver Creek; 9.2 miles N. 64° W. from St. Matthews or 2.1 miles southwest of Bethel Church.

The lower Eocene, Black Mingo Formation is overlain unconformably by the middle Eocene, Congaree Formation. The unconformity is marked by numerous quartz pebbles and pisolitic, kaolinitic pebbles and boulders. Alt. elev. at the unconformity=237 feet.

Locality 9-13

Location: Roadcut on north side of U.S. Highway 21; 0.12 miles southeast of Big Beaver Creek.

	Thickness (Feet)
Middle Eocene	
Congaree Formation	
9. Sand, quartzose, coarse- to very coarse-grained, angular to subangular, yellow- to rusty-red.	5
8. Clay, thinly-bedded, silty, light-green and sand, quartzose, medium- to very coarse-grained, angular to sub-angular, yellow.	1.5
7. Sand, quartzose, coarse- to very coarse-grained, angular to subangular, yellow to rusty-red; some thin- to very thinly-bedded, light-green, silty clay. Lower portion of unit contains bauxitized, pisoltic, kaolinitic boulders up to 1.5 feet in diameter embedded in a medium- to very coarse-grained, yellow and brown, quartzose sand. Numerous well-rounded, quartzose pebbles.	14
Unconformity	
Lower Eocene	
Black Mingo Formation (Alt. elev.=251 feet)	
6. Clay, silty to arenaceous, black, weathers light- to medium-gray; contains discontinuous and irregular shaped layers, generally 0.3 inches thick, and pockets of fine- to medium-grained, quartzose sand.	2.5
5. Sand, quartzose, medium- to coarse-grained, yellow to rusty-red, cross-bedded in places. Some glauconite and other dark minerals. Silty, light-green, clay seams generally 0.2 to 0.4 inches thick are scattered throughout the unit.	5
4. Coquina, siliceous with numerous shell fragments of pelecypods, gastropods, and solitary corals. This in all probability represents a littoral deposit.	1.5
3. Sand, quartzose, fine- to medium-grained, rusty-yellow, with layers of medium-gray, silty clay that ranges in thickness from 0.2 to 3 inches.	5
Covered interval.	7.5
2. Fuller's earth, slightly silty, dark-gray, weathers light-gray; numerous thinly-bedded seams of yellow to gray, fine- to medium-grained, quartzose sand and numerous muscovite flakes.	5
Covered interval.	2
Unconformity	
Upper Cretaceous	
Tuscaloosa Formation	
1. Clay, silty to arenaceous; mottled light-gray and rusty-yellow. Base concealed in ditch.	1.5

Locality 9-14

Location: Roadcut on southeast side of Congaree Spring Branch; 1.5 miles N. 64° E. from Bethal Church or 8.0 miles N. 47° W. from St. Matthews.

	Thickness (Feet)
Lower Eocene	
Black Mingo Formation	
3. Fuller's earth, very arenaceous; contains a considerable amount of glauconite.	8
Covered interval.	5
2. Sand, quartzose, fine- to very coarse-grained glauconitic, poorly sorted, light-olive, with hard and soft layers.	5
Unconformity	
Upper Cretaceous	
Tuscaloosa Formation (Alt. elev.=232 feet)	
1. Clay, very arenaceous, kaolinitic, gray. Base concealed at stream level.	±50

Locality 9-17

Location: Roadcut on County Highway 24; 0.22 miles southeast of Bates Mill Creek; 3.86 miles north of the center of St. Matthews; 0.1 miles southeast of Mt. Carmel Church.

	Thickness (Feet)
Pleistocene?	
surficial material	
4. Sand, quartzose, medium- to very coarse-grained, rusty-red, gritty, with some small quartzose pebbles.	15
Unconformity	
Middle Eocene	
Congaree Formation	
3. Sand, quartzose, medium- to very coarse-grained, red and yellow with thin layers of silty, olive-drab clay.	20
Unconformity	
Lower Eocene	
Black Mingo Formation	
2. Fuller's earth, well-bedded, with coarse, to very coarse-grained quartzose sand grains along bedding planes.	25
Covered interval.	5
Unconformity	
Upper Cretaceous	
Tuscaloosa Formation (Alt. elev.=171 feet)	
1. Clay, kaolinitic, sandy to silty. Base concealed at creek level.	±15

Locality 9-18

Location: Roadcut on County Highway 21; 0.1 miles southeast of Bates Mill Creek or 3.6 miles N. 30° W. from St. Matthews.

	Thickness (Feet)
Middle Eocene	
Congaree Formation	
2. Sand, quartzose, predominately coarse-grained, yellow; some small- to medium-scale, tabular, cross-bedding. Numerous irregular beds of coarse-grained, quartzose sandstone with a white, chalky matrix. The sandstone is friable, well-indurated, forms ledges up to 1-inch thick, and contains numerous fragments of fossils. Interspersed within the sand section are numerous thin layers of light-green to olive, silty, clay.	±60
Unconformity	
Lower Eocene	
Black Mingo Formation (Alt. elev.=192 feet)	
1. Fuller's earth, beige to dark-gray; weathers light gray. Base concealed in ravine.	20

Remarks: The Tuscaloosa Formation is exposed adjacent to a pond dam to the north of this exposure near Bates Mill Creek.

Reference: SLOAN (1908, p. 353, Sur. No. 676); COOKE (1936, p. 53, loc. 97).

Locality 9-19

Location: Roadcut on County Highway 42; 2.6 miles north of St. Matthews or 0.25 miles northwest of junction of County Highway 42 and 24.

Pleistocene? — Thickness (Feet)
surficial material
5. Sand, quartzose, medium- to very coarse-grained, poorly sorted, rusty-red, numerous well-rounded quartz pebbles up to 2 inches in diameter. — 10

Unconformity
Middle Eocene
McBean Formation
4. Sand, quartzose, fine-grained, very argillaceous, light-olive to rusty-red. Lower 1 foot contains numerous chert-like nodules with impressions of fossils and grains of manganese. — 6

Unconformity
Warley Hill Formation (Alt. elev.=253 feet)
3. Sand, quartzose, fine- to medium-grained, olive, very glauconitic; numerous grains of manganese. Boundary with underlying unit is transitional with grains of the glauconitic olive sand interspersed within the yellow sand of unit 2. — 5

Congaree Formation
2. Sand, quartzose, medium-grained, yellow, angular; no glauconite except in upper 1 foot. — 18
Covered interval. — 15
1. Alternating beds of light-green, silty clay and coarse-grained, yellow quartzose sand. The arenaceous portion of the unit contains small-scale crossbeds and very thin layers of silty, light-green clay. The clay portions of the unit range up to 3 feet thick and contain well-indurated, silicified, siltstone layers that generally average 3 inches in thickness. Several specimens of *Anodontia? augustana* GARDNER and impressions of echinoids were collected from the light-green clay layers. Base concealed in ravine. — 22

Locality 9-21

Location: Roadcut on S.C. Highway 6; 0.2 miles southeast of Lyons Creek or 3.9 miles S. 65° E. from St. Matthews.

Pleistocene? — Thickness (Feet)
surficial material
4. Clay, very arenaceous, mottled red, gray, and yellow; numerous well-rounded and fractured quartz pebbels. Thickness on south side of road approximately one-foot; however approximately 3 feet of surficial material is exposed on the north side of the road. — 1-3

Unconformity
Middle Eocene
Warley Hill Formation
3. Sand, quartzose, medium- to coarse-grained, dark-olive, very glauconitic. Boundary with underlying unit is transitional with small irregular inclusions of the yellow sand of the underlying unit interspersed within the glauconitic sand. Boundary shows no evidence of unconformity but rather indicates a change of regimen. — 5

Congaree Formation (Alt. elev.=198 feet)
2. Sand, quartzose, medium- to coarse-grained, slightly glauconitic, yellow to light-green becoming slightly more glauconitic in upper portion; numerous light-green, silty clay lami nations. — 13
1. Clay, silty, light-green, thin- to medium-bedded, with 0.2 to 0.5 inch, fine-grained, gray, sand layers. The clay contains well-indurated siltstone layers 1 to 2 inches thick. This unit is lithologically identical to the Congaree Formation at its type locality (loc. 9-26). — 5

Locality 9-23

Location: Roadcut on northeast side of S.C. Highway 267; 4.6 miles N. 22° W. from Lone Star or 0.1 miles southeast of Squirrel Creek.

Middle Eocene — Thickness (Feet)
Congaree Formation
4. Sand, quartzose, fine- to medium-grained, yellowish-red, numerous muscovite flakes, very slightly glauconitic. Sparse 0.5 inch thick layers of gray to light-green, silty clay. Contact with underlying unit marked with a 1.5 to 2 inch thick ironstone layer. — 11

Unconformity
Lower Eocene
Black Mingo Formation (Spot elev.=126 feet)
3. Claystone, slightly silty, black, thinly bedded, unctuous. Contains minute grains of pyrite and numerous thin layers of yellow to rusty-red, coarse- to very coarse-grained, quartzose sand that pinch and swell within short horizontal distances. Some of the sand layers are bounded above and below by ironstone. (Euxenic environment.) — 3
2. Sand, quartzose, fine- to medium-grained, very argillaceous, dark-gray to black; contains numerous muscovite flakes. — 5.5
Covered interval. — 2.5
1. Fuller's earth, medium- to dark-gray on fresh tsurface, light-gray upon weathering; thin- to medium-bedded with interbedded fine- to medium-grained, yellow to rusty-red quartzose sand layers that vary from 0.2 to 0.5 inches in thickness; muscovite flakes abundant. Base concealed in ditch. — 8

Reference: COOKE (1936, p. 70, loc. 130).

Locality 9-24

Location: Roadcut on S.C. Highway 267; 3.1 miles N. 24° W. from Lone Star or 0.1 miles southeast of crossing of S.C. Highway 267 over Warley Creek.

Pleistocene? — Thickness (Feet)
surficial material
5. Sand, quartzose, coarse-grained, very argillaceous, gray, with well-rounded quartz pebbles forming pebble lines. — 1-3

Middle Eocene
Warley Hill Formation
4. Sand, quartzose, fine- to medium-grained, yellow to olive-drab, very glauconitic. — 18
3. Sand, quartzose, fine- to medium-grained, dark-gray to dark-green on fresh surface, yellow to rusty-olive upon weathering; very glauconitic; matrix between sand grains consists of clay from underlying unit. The lower 1 foot of this unit is transitional with the underlying unit and contains thin stringers of the underlying Congaree clay. — 6

Congaree Formation
2. Claystone, slightly silty, light-green, with casts of pelecypods. SLOAN (1908) and COOKE & MACNEIL (1952) found casts of *Anodontia? augustana* GARDNER within this unit. — 10
Covered interval. — 6.5

Unconformity
Lower Eocene
Black Mingo Formation (Spot elev.=120 feet)
1. Fuller's earth, medium- to dark-gray on fresh surface, light-gray on weathered surface; coarse- to very coarse-grained, yellow sand layers 0.2 to 0.5 inches thick. Base concealed in ditch. — 2

Remarks: Unit 1 is exposed on the south side of the road.

Reference: SLOAN (1908, p. 300, Sur. No. 684); COOKE (1936, p. 71, loc. 131); COOKE & MACNEIL (1952, p. 22).

Locality 9-26

Location: Roadcut on S.C. Highway 33; 0.7 miles N. 25° E. from Creston.

Middle Eocene — Thickness (Feet)
Warley Hill Formation
3. Sand, quartzose, fine- to coarse-grained, very glauconitic, olive, weathers brick-red. Boundary with underlying unit is transitional. — 6

Congaree Formation (Spot elev.=125 feet)
2. Alternating thin beds of light-green, silty clay and yellow, fine-grained quartzose sand. — 5
1. Alternating thin beds of light-green to gray, silty clay and well-indurated, arenaceous, siltstone; *Anodontia? augustana* GARDNER Base concealed in ditch. — 14

Reference: COOKE & MACNEIL (1952, p. 22).

Locality 9-28
(See also Auger Hole 9-7)

Location: Lower pond on farm of Earl Edwards; 0.4 miles N. 55° E. from Creston.

Approximately 20 feet of buff. slightly arenaceous Santee Limestone containing numerous whole and broken pelecypod shells is exposed on the south side of the pond.

Approximately 100 feet east of the above exposure, at the level of the stream draining the pond, an underground spring issues from a small cave. The limestone surrounding the opening of the cave constitutes the calcareous facies of the Warley Hill Formation and is gray to green and very glauconitic with numerous pelecypod shells including *Ostrea* sp. This glauconitic Warley Hill limestone grades upward into buff-colored Santee Limestone within a vertical distance of 10 feet. The actual contact of the two units is not exposed.

Locality 9-31

Location: Abandoned limestone quarry on farm of Robert Edwards between S.C. Highway 6 and Halfway Swamp Creek; approximately 0.75 miles east of railroad crossing at Creston.

Approximately 20 feet of the middle Eocene, Santee Limestone is exposed in the quarry walls and consists of a light-yellow to buff, calcarenite to calcirudite.

Locality 9-32
(See also Auger Hole 9-4)

Location: Roadcut on unnumbered, unpaved road; 0.2 miles south of where road crosses Halfway Swamp; 1.9 miles S. 78° E. from railroad crossing at Creston.

The Santee Limestone and an overlying unit that apparently represents a residuum derived from the leaching of the Santee Limestone are exposed in the roadcut. The Warley Hill Formation does not crop out but was encountered beneath the Santee Limestone by means of a hand auger at a depth of 1 foot.

The Warley Hill Formation consists of a medium- to coarse-grained, very glauconitic, non-calcareous quartzose sand. The Santee Limestone crops out with a thickness of 5 feet and consists of a creamy calcirudite with numerous pelecypod shells and bryozoans. The Santee Limestone is overlain by 10 to 15 feet of orange to pink, friable, massive sand that exhibits many small slump structures. The hypothesis that this unit represents a residuum derived from the leaching of the Santee Limestone is supported by heavy mineral studies by CAZEAU (personal communication) in which he found that both the Santee Limestone and the overlying sand unit have almost the same order of abundance and very close similarity of percentages of transparent heavy minerals.

Locality 9-33

Location: Deep ravine on north bank of tributary to Halfway Swamp Creek; 4.3 miles S. 85° E. from Creston or 0.1 miles southeast of where S.C. Highway 267 crosses Halfway Swamp Creek.

Middle Eocene — Thickness (Feet)
Santee Limestone
2. Calcarenite, light-yellow, moderately glauconitic in lower few feet, grades upward into buff-colored calcarenite with less than 1 per cent glauconite. Lower 1 foot transitional with underlying unit; numerous fragments 1 to 3 inches in diameter consisting of olive-drab glauconitic limestone are incorporated within the cream-colored, slightly glauconitic limestone. — 9
Warley Hill Formation (Alt. elev.=105 feet)
1. Calcarenite, olive-drab, very glauconitic; contains well-indurated layers 2 to 3 inches thick with numerous casts and shells of pelecypods. This unit represents the calcareous facies of the Warley Hill Formation. Base concealed. — 3

Remarks: A hand auger hole placed 4 feet below the above section encountered 5.5 feet of glauconitic limestone and an additional 5 feet of very slightly calcareous, very argillaceous, fine-grained, olive sand that represents the transition to the non-calcareous, arenaceous facies of the Warley Hill Formation.

Locality 9-34

Location: Cave Hall, a deep ravine that empties into Lake Marion; 1.1 miles south of the embayed mouth of Halfway Swamp Creek or 5.8 miles S. 87° E. from Creston.

The strata exposed consist of 5 feet of dark-green to olive, very glauconitic limestone of the Warley Hill Formation. The upper 2 feet of which are well-indurated to form a ledge. SLOAN (1908, p. 302) obtained specimens of *Ostrea lisbonensis* HARRIS (reported as *O. sellaeformis*) from this unit.

Higher up the bank of the ravine buff-colored, non-glauconitic limestone of the Santee Limestone is exposed; however, the boundary between the two formations was not observed. Near the mouth and on the west side of the ravine numerous boulders of well-indurated, glauconitic limestone of the Warley Hill Formation are exposed. A hand auger hole indicated that the boulders are underlain by a non-calcareous, very glauconitic, olive-drab to dark-green, quartzose sand. This underlying sand unit represents the non-calcareous, arenaceous facies of the Warley Hill Formation.

Reference: SLOAN (1908, p. 302, Sur. No. 699); COOKE & MACNEIL (1952, p. 23).

Locality 9-35

(See also Auger Hole 9-1)

Location: Roadcut on west side of County Highway 22; 0.2 miles southwest of Caw Caw Swamp; 7.3 miles S. 66° W. from St. Matthews.

Pleistocene? — Thickness (Feet)
surficial material
5. Sand, quartzose, medium- to very coarse-grained, argillaceous, gritty, brick-red, with numerous, well-rounded, quartz pebbles up to 1 inch in diameter. — 6

Unconformity
Middle Eocene
McBean Formation
4. Sand, quartzose, fine- to medium-grained very argillaceous, yellowish-red. — 2
Covered interval. — 2
3. Clay, silty, light-green, weathers mottled light-green and rusty-red; irregular chert-like nodules. — 2

Unconformity
Warley Hill Formation (Alt. elev.=233 feet)
2. Sand, quartzose, fine- to medium-grained, angular, very glauconitic; 2 to 3 inch thick bed of white, well-indurated, silicia-cemented, medium-grained, quartzose sand. — 2
Congaree Formation
1. Sand, quartzose, medium-grained, angular, yellow and white, well-sorted. Upper 1 foot is transitional with the overlying unit and contains 0.2 to 0.5 inch thick seams of glauconitic sand that pinch, swell, and terminate abruptly. Base concealed in ditch. — 6

Reference: COOKE (1936, p. 66, loc. 120).

Locality 9-36

Location: Roadcut on southeast side of County Highway 22; 0.25 miles southwest of junction of County Highway 22 and U.S. Highway 21 or 6.9 miles S. 67° W. from St. Matthews.

Pleistocene? — Thickness (Feet)
surficial material
4. Sand, quartzose, fine- to very coarse-grained, argillaceous, poorly sorted, gritty, brick red, with some small quartzose pebbles. — 5
3. Basal conglomerate of well-rounded quartzose pebbles, many of which are discoidal; gritty, arenaceous matrix. — 2.5

Unconformity
Middle Eocene
Warley Hill Formation
2. Sand, quartzose, fine-grained, very glauconitic; transitional with underlying unit. — 1.5
Congaree Formation
1. Sand, quartzose, fine- to medium-grained, angular, yellow with brown banding. Base concealed in ditch. — 6

Locality 9-38

Location: Escarpment approximately 50 yards north of S.C. Highway 6; 0.1 miles east of crossing of S.C. Highway 6 over Murph Mill Creek or 6.05 miles N. 84° W. from St. Matthews.

Middle Eocene — Thickness (Feet)
McBean Formation
3. Clay, silty to arenaceous, rusty-red, numerous chert-like nodules containing molds of pelecypods. — 5

Unconformity (Alt. elev.=272 feet)
Warley Hill Formation
2. Sand, quartzose, medium-grained, angular, olive, very glauconitic; transitional boundary with underlying unit. — 1
Congaree Formation
1. Sand, quartzose, medium-grained, angular, yellow. Base concealed in open field. — 8

Locality 9-40

Location: Roadcut on County Highway 155; 0.1 miles east of Bates Mill Creek or 2.8 miles N. 53° W. from St. Matthews.

Approximately 20 feet of the Congaree Formation is exposed in a roadcut on the north side of County Highway 155. The strata consist of interbedded light-green clays and medium- to coarse-grained, angular, quartzose sand. The sand contains tabular, small-scale cross-beds; 0.2 to 0.5 inch thick layers of light-green clay; and 0.5 to 3 inch layers of silicified shell fragments of gastropods, pelecypods, and corals. DRUID WILSON (personal communication) identified one of the pelecypods as *Pholas* sp.

Locality 9-41

Location: Roadcut on U.S. Highway I-26, station 1210; 0.1 miles southeast of Big Beaver Creek or 11.4 miles N. 59° W. from St. Matthews.

Pleistocene? — Thickness (Feet)
surficial material
4. Sand, quartzose, coarse-grained, very argillaceous, gritty, brick red. — 14

Unconformity
Middle Eocene
Congaree Formation
3. Alternating layers of medium- to very coarse-grained, angular, quartzose, yellow sand and light-gray to light-green, silty clay. Much of the sand section shows small-scale cross-bedding. The base of this unit is marked by an unconformity that consists of bauxitized, pisolitic, clay boulders up to 0.5 feet in diameter; a 1 inch thick ironstone layer; and numerous, well-rounded, quartz pebbles, many of which are discoidal. — 54

Unconformity
Lower Eocene
Black Mingo Formation (Highway profile elev.=278 feet)
2. Fuller's earth, black, weathers light-gray, very thickly-bedded; contains small pockets, generally less than one inch in diameter, of medium-grained, quartzose, sand. — 13
1. Fuller's earth, black, weathers light-gray, conchoidal to hackly fracture; contains laminae, very thin beds, and small pockets of medium-grained, quartzose sand. Base concealed in ditch. — 5

Locality 9-43

Location: Roadcut on U.S. Highway 21; 6.9 miles S. 71° W. from St. Matthews; 0.15 miles from crossing of U.S. Highway 21 over Murph Mill Creek.

Pleistocene? — Thickness (Feet)
surficial material
3. Sand, quartzose, medium- to very coarse-grained, gritty, very argillaceous, with well-rounded, quartzose pebbles occurring as channel fill; much scour and fill. — 10

Unconformity
Middle Eocene
McBean Formation (Spot elev.=261 feet)
2. Sand, quartzose, fine- to coarse-grained, yellow, white, and tan, interbedded with yellowish-green, silty clay. Near the base of this unit is a 0.5 foot layer of buhrstone containing silicified shell fragments of pelecypods and gastropods. — 20
1. Clay, silty, light-green to yellow. Base concealed in ditch. — 3

Reference: COOKE (1936, p. 66, loc. 121).

Locality 9-44

Location: Roadcut on County Highway 155; 0.15 miles southeast of tributary to Bates Mill Creek; 3.9 miles S. 50° W. from St. Matthews.

Middle Eocene — Thickness (Feet)
McBean Formation
4. Clay, silty to arenaceous, light-green and rusty-red; grades upward into yellowish-olive, fine-grained, quartzose, sand; lower two feet with numerous chert-like nodules with molds of fossils. — 5

Unconformity
Warley Hill Formation
3. Sand, quartzose, fine-grained, very glauconitic, argillaceous, olive. — 3
Congaree Formation
2. Sand, fine- to coarse-grained, quartzose, yellow, banded with dark buff layers. Upper one foot transitional with above formation and consists of very fine- to fine-grained, white sand with inclusions of the overlying glauconitic sand. — 16
Covered interval. — 6
1. Clay, pale-olive, alternating with rusty-red, quartzose sand layers. Base concealed in ditch. — 5

Remarks: A hand auger hole indicated an additional 4 feet of pale-olive clay.

Locality 9-46

Location: Artificial exposure on west side of Rast's Pond near dam; 1.2 miles S. 18° W. from U.S. Highway 21 crossing of Big Beaver Creek or 11.7 miles N. 70° W. from St. Matthews.

Lower Eocene — Thickness (Feet)
Black Mingo Formation
2. Fuller's earth, black on fresh surface, light-gray on weathered surface. — 6
1. Sand, quartzose, fine- to medium-grained, olive, glauconitic. Base concealed at pond level. — 2

Locality 9-47

Location: Roadcut on southeast side of County Highway 172; 0.1 miles northeast of Caw Caw Swamp; 1.6 miles N. 77° E. from Staley Crossroads.

Pleistocene? — Thickness (Feet)
surficial material
3. Sand, quartzose, coarse-grained, gritty, rounded to angular, mottled, with a well-developed basal conglomerate that consists of rounded to angular quartz and feldspar pebbles. Lower contact undulates from 1 to 3 feet. — 8

Unconformity
Middle Eocene
McBean Formation
2. Clay, silty, green to ocher, weathers rusty-red; basal 2 to 3 feet contains chert-like nodules. — 20

Unconformity
Congaree Formation
1. Sand, quartzose, fine-to coarse-grained, olive, glauconitic, with well-indurated, light-gray, silicia-cemented, quartzose, sand layers. Base concealed in ditch. — 2

Locality 9-49

Location: South bank of Lake Marion: 1.55 miles N. 78° W. from crossing of S.C. Highway 267 over Halfway Swamp Embayment; 5.85 miles N. 85° E. from Creston.

Approximately 5 feet of the Warley Hill Formation crops out above water level on the south bank of Lake Marion. The formation consists of rusty-red, glauconitic, argillaceous, quartzose sand with thin ironstone layers.

Locality 9-50

Location: Roadcut on unnumbered county road 0.1 miles southwest of tributary draining into Halfway Swamp; 4.15 miles S. 97° E. from Creston.

Pleistocene? — Thickness (Feet)
surficial material
3. Sand, quartzose, poorly sorted, gritty, argillaceous, rounded and fractured pebbles throughout the unit; channel scouring; basal conglomerate of rounded quartz pebbles. — 5

Unconformity
Middle Eocene
Warley Hill Formation (Alt. elev.=96 feet)
2. Sand, quartzose, fine-grained, more argillaceous than unit 1, very glauconitic, olive on fresh surface, rusty-red on weathered surface; non-calcareous; contains numerous 0.2 to 2 inch layers of ironstone in lower 2 feet of unit. — 4
1. Sand, quartzose, fine-grained, very glauconitic, olive, slightly argillaceous, non-calcareous. Base concealed in ditch. — 1

Locality 9-53

Location: Roadcut on County Highway 158; 0.1 miles west of tributary draining into Halfway Swamp; 3.05 miles S. 74° E. from Creston.

Pleistocene? — Thickness (Feet)
surficial material
2. Sand, quartzose, medium- to very-coarse grained, mottled yellowish-red, gritty; small rounded, quartzose pebbles throughout. — 15

Unconformity
Middle Eocene
Warley Hill Formation (Alt. elev.=124 feet)
1. Sand, quartzose, fine- to medium-grained, angular, olive, very glauconitic, slightly argillaceous, weathers rusty-olive. Base concealed in ditch. — 9

Locality 9-54

Location: Artificial exposure on east side of pond; 4.65 miles S. 82° E. from Creston; due west of sharp bend in S.C. Highway 267.

Pleistocene? — Thickness (Feet)
surficial material
2. Sand, quartzose, fine- to coarse-grained, yellow to rusty-red; numerous muscovite flakes. — 15

Unconformity
Middle Eocene
Santee Limestone
1. Calcarenite, buff, less than 1 per cent glauconite; base concealed at pond level. — 9

Locality 9-62

Location: Roadcut on S.C. Highway 419; 0.6 miles S. 57° E. from Fort Motte.

Pleistocene? — Thickness (Feet)
surficial material
3. Sand, quartzose, fine- to medium-grained, rusty-red, very argillaceous; lower contact undulates up to 3 feet. — 14

Unconformity
Middle Eocene
Warley Hill Formation
2. Clay, silty, mottled rust, yellow, white, and gray, well-oxidized, lower contact undulates up to 2 feet. — 2-4
1. Sand, quartzose, fine- to medum-grained, very argillaceous, very glauconitic, olive and rusty-red, well-oxidized; base concealed in ditch. — 7
(Alt. elev. at base of section=242 feet).

Locality 9-63

Location: Roadcut on County Highway 73; 0.45 miles north of Warley Creek; 4.05 miles N. 45° W. from Lone Star.

Pleistocene? — Thickness (Feet)
surficial material
1. Sand, quartzose, fine- to medium-grained, very argillaceous, brick-red, basal conglomerate 0.5 feet thick of well-rounded quartz pebbles up to 2 inches in diameter. — 3

Unconformity
Middle Eocene
Warley Hill Formation (Alt. elev.=198 feet)
1. Sand, quartzose, fine- to medium-grained, very glauconitic, olive and rusty-red, slightly argillaceous; contains ironstone layers up to 0.5 inches thick; base concealed in ditch. — 5

Locality 9-64

Location: Bluff on south side of Congaree River; 2.5 miles N. 88° W. from U.S. Highway 601 bridge crossing over Congaree River.

Lower Eocene — Thickness (Feet)
Black Mingo Formation
6. Sand, quartzose, fine- to medium-grained; thin seams of black fullers earth; molds and casts of pelecypods as well as shark teeth; more arenaceous in lower 6 feet; grades upward to gray fullers earth at top of exposure. — 12-15
5. Sand, similar to unit 1 but without the fullers earth; contains small unidentifiable shell fragments and shark teeth; 8-inch thick fairly coarse-grained glauconitic sand layer at base. — 8
4. Clay, dark-gray, flaky, becomes more thickly laminated towards base; contains clean sand in the form of layers, and irregular masses; sand content increases towards base; weathered shale surfaces are iron stained; penecontemporaneous slumping is evidenced by contorted bedding, local intraformational breccia (clay fragments), and minor faults with 3-foot displacement; faulting appears to start and end on the bedding planes in "S-shaped" curves; thickness of unit variable. — 8-12
3. Sand, quartzose, coarse- to very coarse-grained and contains scattered quartz and fairly fresh feldspar pebbles interbedded with dark-gray to olive clay layers; small- to medium-scale cross-bedding; unit consists of about 20 percent clay in all; 1- to 2-foot thick layer of gravel and coarse-grained sand at base of unit. — 16-20
2. Sand and dark-gray silty clay; poorly laminated; some slumped bedding; layers of fine-grained sand and occasional pockets of grit and small quartz gravel; sands and gravels contain partially decomposed feldspar crystals up to 0.5 inches in length. — 1-2

Unconformity
Upper Cretaceous
Tuscaloosa Formation (Elev. estimated from contours=130 feet)
1. Sand, quartzose, coarse-grained, white, kaolinitic; very stiff clay; exposure to cover at base of slope about 8 feet above river level. — 50

Remarks: Section modified from files of Division of Geology, South Carolina State Development Board.

Locality 18-1

Location: Limestone quarry of Carolina Giant Cement Corporation; 2.2 miles N. 11° E. from Harleyville.

Pleistocene? — Thickness (Feet)
surficial material
6. Clay, mottled gray and red with sub-angular quartzose pebbles at base. — ±10

Upper Miocene?
Duplin Formation?
5. Sand, quartzose, fine-grained, angular, with black grains and some glauconite. — 8

Oligocene
Cooper Marl
4. Calcarenite, arenaceous, light-gray to olive, massive, with large whole fossils, small pectens being especially common. Glauconite grains make up about 5 percent of the rock and phosphate grains about 1 percent. Contact with underlying unit is sharp and essentially horizontal. — 8

Middle Eocene
Santee Limestone
3. Calcirudite, light-yellow to gray with a matrix of fine- to medium-grained calcium carbonate grains with varying percentages of whole and broken shells of pectens, echinoderms, oysters, etc. Hard layers a foot or so thick occur within this unit and consist of large shells and molds. Toward the top of the unit are discontinuous zones up to 9 feet thick that stand out on the pit faces because of their pronounced yellow color; these zones contain a large percent of broken and whole shells. — 25
2. Calcarenite, yellowish-gray, with sand size shell fragments and lime grains, and a few larger whole shells. Lower contact with underlying unit is sharp and can be traced throughout the pit. Upper contact with overlying unit is not visible because of mining bench but the contact may be gradational with only an increase in number and size of shell fragments. — 8

1. Calcarenite, yellowish-gray with about 1 percent glauconite; fossils rare except for echinoid plates; very massive with no cross-bedding or other sedimentary structures. Upper 4 to 9 feet is an irregular slabby zone. Base concealed at pit floor. — 15

Locality 18-2

Location: North bank of Edisto River; 7.8 miles S. 74° W. from St. George; 1.0 miles West of Cattle Creek.

Olive-drab, glauconitic marl of the Oligocene, Cooper Marl occurs at a depth of 1 foot below stream level.

Locality 18-3

Location: Stream bed of Cattle Creek under wooden bridge; 7 miles S. 70° W. from St. George.

Olive-drab, glauconitic marl of the Oligocene, Cooper Marl occurs at a depth of 0.5 feet below stream level.

Locality 18-4

Location: Dug-pond on property of Mr. J. S. Connelly at town of Dorange where U.S. Highway 78 crosses Orangeburg-Dorchester County line.

The Upper Miocene, Duplin Formation is exposed on the spoil-bank of a dug-pond in the form of thousands of broken and whole pelecypod shells.

Locality 18-6

Location: North bank of Edisto River; 7.8 miles S. 4° W. from St. George or 4.1 miles S. 84° W. from Grover.

This locality is known as the Raysor Bridge locality and constituted the type-locality of the "Raysor Marl" of COOKE (1936, p. 116). The "Raysor Marl" is now considered part of the Duplin Formation. At the time of the authors' visit to this locality, both the 'Raysor Marl" and the Cooper Marl that were reported by COOKE were inundated by the waters of the Edisto River. COOKE (1936, p. 116) listed the megafossils recovered from the Duplin Formation at this locality.

Locality 18-8

Location: Roadcut on north side of County Highway 19; 0.1 miles east of County Highway 19 bridge over Four Hole Swamp; 5.7 miles S. 5° W. from Dorchester.

	Thickness (Feet)
Pleistocene? surficial material	
2. Interbedded quartzose sand and light-green clay.	15
Oligocene Cooper Marl	
1. Sand, quartzose, medium-grained, yellowish-tan, very calcareous.	3

Locality 18-9

Location: East bank of Edisto River near Givhans Ferry, about one-quarter mile upstream from old ferry road.

	Thickness (Feet)
Pleistocene? surficial material	
5. Surficial sand.	12
Upper Miocene Duplin Formation	
4. Limestone, massive, white or pale-yellow; abundant mollusks; lower 3 feet sandy; 6 inch bed at base consisting of pebbles of quartzite, phosphate rock, limestone, bone, and oyster shells. Contact with layer below abrupt and flat with one inch of relief.	12
Lower Miocene?	
3. Limestone, pale-yellow, sandy, fossiliferous; fine grains of phosphate; top riddled with borings of marine animals.	1
Oligocene Cooper Marl	
2. Marl, sandy, pale-yellow; friable and soft; lumps of hard marlstone; grades into layer below.	8
1. Marl, olive-brown, compact; granular texture. Base concealed at river level.	6

Remarks: Section modified after MALDE (1959, p. 30).

Locality 18-10

Location: West bank of Four Hole Swamp at U.S. Highway 78 bridge crossing; 2.5 miles N. 85° E. from Dorchester.

	Thickness (Feet)
Pleistocene? surficial material	
3. Sand, quartzose, fine-grained, white but weathers yellow, cross-bedded; beach or river deposit; altitude at top of hill=85 feet above sea level.	15
2. Sand, pebbly, dark-gray at base passing upward into fine-grained black carbonaceous sand.	4.5
Oligocene Cooper Marl	
1. Marl, granular, brown, soft; containing shark teeth, casts of corals and mollusks, *Pecten calvatus* MORTON, *Terebratulina* sp., and many phosphate nodules.	23

Remarks: Section modified after COOKE (1936, p. 148).

Locality 21-1

Location: Bostick Landing on the west side of the Pee Dee River; 9.5 miles northwest of the mouth of Lynches River.

	Thickness (Feet)
Pleistocene? surficial material	
5. Sand and loam.	7
Unconformity	
Upper Miocene Duplin Formation	
4. Marl, sandy, dirty-buff, granular and friable; mass of loose fragments of shells at base.	16
3. Marl, indurated, dirty-yellow, contains *Pecten eboreus, Natica duplicata,* etc.	4
2. Marl, granular, porous, buff, contains numerous casts in the upper part; *Amusium mortoni* is prominent in the lower part.	21
Unconformity	
Upper Cretaceous Peedee Formation	
1. Not exposed along the river; bluish-black sticky marl beneath shell rock struck in well at Bostick, half a mile west of the landing.	187

Remarks: Section modified after COOKE (1936, p. 119). Sample from which the ostracodes were obtained was collected by R. M. MITTERER from what he thought was bed 2 of COOKE's measured section.

Locality 38-1

Location: Roadcut 0.2 miles south of Early Branch on U.S. Highway 21; 2.9 miles S. 65° W. from railroad crossing at Jamison.

	Thickness (Feet)
Middle Eocene McBean Formation	
2. Clay, very arenaceous, mottled rusty-red and olive-drab, weathers brick-red, contains pockets of sand with numerous silicified shells; transitional contact with underlying unit.	18
1. Siltstone, porous, light-weight, olive; contains molds of mollusks among which is *Kymatox lapidosus* (CONRAD); appears to be a marl from which the lime has been leached; base concealed at road level. (Alt. elev. to base of section=199 feet).	14

Reference: SLOAN (1908, p. 276, Sur. No. 344); COOKE (1936, p. 63, loc. 117).

Locality 38-5

Location: Roadcut on U.S. Highway 21, 0.1 miles south of Turkey Hill Branch; 3.75 miles S. 43° W. from railroad crossing at Jamison.

	Thickness (Feet)
Middle Eocene McBean Formation	
1. Clay, arenaceous, mottled light-green and rusty-red; grades upward into golden yellow, medium-grained, slightly argillaceous, quartzose sand; numerous silicified fossils occur within pockets of sand. Base concealed in ditch. Alt. elev.=200 feet at base of section.	15

Locality 38-7

Location: Roadcut on south side of U.S. Highway 176, immediately east of Limestone Creek; 2.7 miles S. 42° E. from Wolfton.

	Thickness (Feet)
Pleistocene? surficial material	
4. Sand, quartzose, coarse-grained, conglomeratic, red, somewhat finer grained near top, mottled red and white on exposed surfaces; to top of hill.	15
Unconformity	
Middle Eocene McBean Formation	
3. Sand, quartzose, red, massive.	7
2. Sand, quartzose, and clay; mottled red, purple, and green; gradational with bed 1.	5
1. Sand, quartzose, very fine-grained, greenish-yellow, partly silicified; *Venericardia claiboplata* GARDNER & BOWLES; weathers bright-red; lenses and stringers of chert.	23

Remarks: Section modified after COOKE (1936).

Reference: COOKE (1936, p. 62, loc. 112).

Locality 38-8

Location: Roadcut on County Highway 77, immediately east of Little Limestone Creek; 2.5 miles N. 25° E. of Wolfton.

	Thickness (Feet)
Pleistocene? surficial material	
4. Sand, quartzose, medium- to very coarse-grained, argillaceous, gritty, brick-red, numerous rounded quartz pebbles at base.	6
Unconformity	
Middle Eocene McBean Formation	
3. Sand, quartzose, very fine- to fine-grained, very argillaceous, mottled tan and olive, contains many chert-like nodules throughout; numerous coiled gastropods near top; transitional contact with unit 2.	17
2. Clay, silty, blocky, olive.	3
Unconformity?	
Warley Hill Formation? (Alt. elev.=245 feet)	
1. Sandstone, quartzose, very fine- to fine-grained indurated, gray with scattered grains of glauconitic; base concealed in ditch.	1

Reference: COOKE (1936, p. 65, loc. 118).

Locality 38-10

Location: South bank of small stream draining to Bull Swamp; 0.1 miles east of County Highway 29; 2.25 miles S. 43° E. from railroad crossing at Jamison.

Numerous small pits from which limestone was formerly obtained are located on the south side of the small stream a few hundred yards southeast of County Highway 29. The pits are now overgrown with vegetation and filled with water; however, the presence of the middle Eocene, Santee Limestone is indicated by scattered lumps of white to cream-colored, calcarenite on the spoil-dumps. Numerous poorly preserved specimens of *Ostrea* sp. occur scattered about the ground, some of which appear to be *O. sellaeformis* CONRAD.

Reference: SLOAN (1908, p. 277, Sur. No. 349); COOKE (1936, p. 81, loc. 147).

Locality 38-13

Location: Dug-pond 100 feet north of County Highway 135 on the west side of Cattle Creek; 5.3 miles east of Branchville.

Strata of the Cooper Marl can be seen on the spoil-bank of a small dug-pond just west of Cattle Creek. The dark-gray to olive marl, which has been contaminated by the overlying fluvial sands, contains numerous shark teeth and shell fragments.

Locality 38-14

Location: Roadcut on U.S. Highway 21; 0.05 miles southeast of Burke Creek; 0.3 miles S. 26° E. from U.S. Highway 21 crossing of Orangeburg-Calhoun County line.

	Thickness (Feet)
Middle Eocene	
McBean Formation	
2. Clay, silty to arenaceous, light-green, weathers rusty-red; contains numerous chert-like nodules, 0.2-inch thick layers of ironstone, and ironstone concretions.	3
Unconformity	
Warley Hill Formation (Alt. elev.=230 feet)	
1. Sand, quartzose, fine- to medium-grained, olive, very glauconitic; base concealed in ditch.	5

Locality 38-15

(See also Auger Hole 38-9)

Location: Roadcut on south side of County Highway 190, just east of bridge over Long Branch; 1.65 miles southwest of Wolfton.

	Thickness (Feet)
Pleistocene?	
surficial material	
4. Sand, quartzose, medium- to coarse-grained, argillaceous, gritty, brick-red, prominent basal conglomerate of rounded quartz pebbles at base.	6
Unconformity	
Middle Eocene	
McBean Formation	
3. Alternating beds of silty to very fine-grained, mottled light-green to rusty-red clay and medium-grained, yellow and orange, quartzose sand.	5
2. Sand, quartzose, medium- to coarse-grained, well-sorted, yellow and orange, with a few 0.2-inch thick layers of light-green, silty clay near top of unit; small-scale cross-bedding.	15
1. Clay, arenaceous, mottled light-green to ocher, contains pockets of silicified mollusks; base concealed at road level. (Alt. elev. at top of unit 1=224 feet.)	9

Locality 38-19

Location: Dug-pond; 0.3 miles west of Enterprise School; 3.2 miles N. 17° E. from U.S. Highway 178 crossing of Orangeburg-Dorchester County line.

Fragments of the Santee Limestone occur on the spoil-bank and consist of white calcarenite with numerous specimens of pelecypods.

Locality 38-21

Location: Dug-pond at northeast corner of intersection of U.S. Highway 178 and unnumbered county road; 1.2 miles N. 30° W. from U.S. Highway 178 crossing of Orangeburg-Dorchester County line.

The Santee Limestone is exposed on the spoil-bank and consists of a white to buff calcirudite with numerous bryozoa and shells of mollusks.

Locality 38-22

Location: Lime pit 0.2 miles west of Four Hole Station; 3.3 miles S. 25° W. from Holly Hill.

The Santee Limestone is exposed on the spoil-bank and along the edge of a large quarry, now filled with water, that was formerly used as a source for limestone. The limestone is a white, calcarenite with numerous echinoderms and pelecypods. COOKE & MACNEIL (1952, p. 26) obtained specimens of *Periarchus lyelli* (CONRAD) and *Chlamys cookei* (KELLUM) from this locality.

Reference: COOKE & MACNEIL (1952, p. 26).

Locality 38-24

Location: South shore of Lake Marion, on east side of small inlet; 2.05 miles N. 4° E. from Vance.

White to buff calcarenite (Santee Limestone) forms the bluffs along the south shore of Lake Marion at this locality. No megafossils were observed.

Locality 38-26

Location: South shore of Lake Marion within Eutaw Springs Battle Monument enclosure; 2.75 miles N. 72° E. from Eutawville.

This exposure is the type-locality of the Santee Limestone. Backwaters from Lake Marion have inundated all but approximately 2 feet of the exposure. The limestone consists of a yellow to white, well-indurated, calcirudite with numerous bryozoa and mollusks. COOKE & MACNEIL (1952, p. 24) obtained *Ostrea sellaeformis* CONRAD and *Eurhodia raveneli* (TWITCHELL) from this exposure.

Reference: COOKE & MACNEIL (1952, p. 24).

Locality 38-29

Location: Dug-pond on farm of Mr. A. W. AUSTIN on northeast side of Bull Swamp; 0.2 miles southeast of County Highway 65; 3.8 miles S. 15° W. from railroad crossing of U.S. Highway 176 in Cameron.

Green to gray, marl (Duplin Formation) occurs on the spoil-bank of a small dug-pond. The marl contains numerous large specimens of pelecypods and gastropods.

Locality 38-42

Location: Dug-pond; 3.1 miles N. 22° E. from crossing of U.S. Highway 21 bridge over Edisto River; 0.7 miles north of junction of County Highways 528 and 102.

The Duplin Formation occurs on the spoil-bank and consists of a yellow to light-gray marl with numerous large pelecypod and gastropod shells. Some of the pelecypods are still hinged.

Locality 38-45

Location: Dug-pond approximately 1.1 miles east of Wells Crossing; the pond is in a wooded area and is extremely difficult to locate.

Gray marl of the Duplin Formation is exposed on a spoil-bank and contains numerous shark teeth, gastropods, and pelecypods. *Ecphora quadricostata* (SAY), a gastropod apparently restricted to upper Miocene strata, was obtained from this locality.

Locality 38-50

Location: 2.15 miles S. 5° E. from Holly Hill; 1.2 miles S. 31° E. from junction of S.C. Highway 453 and County Highway 68.

The Santee Limestone is exposed in a shallow ditch behind the house of Mr. D. W. BAKER. The limestone is white and contains many ehinoids.

Locality 38-56

Location: 3.05 miles S. 34° W. from Norway; just east of Willow Swamp.

Numerous chert-like boulders with molds of pelecypods occur within an arenaceous, rusty-yellow, clay matrix in an artificial exposure on the east side of Willow Swamp. This unit appears to be the middle Eocene, McBean Formation.

Reference: COOKE (1936, p. 61, loc. 108).

Locality 38-57

Location: East bank of Rocky Swamp Creek; immediately north of junction of S.C. Highway 332 and County Highway 162; 4.4 miles S. 70° E. from Springfield.

The McBean Formation is exposed along the east bank of Rocky Swamp Creek in the form of a 5-foot thick fossiliferous, silicified, buhrstone ledge. COOKE (1936, p. 61) identified *Venericardia claiboplata* GARDNER & BOWLES from this buhrstone.

Reference: COOKE (1936, p. 61, loc 109).

Locality 38-58

Location: Stream bed of Rocky Swamp Creek where dirt road crosses creek; 4.7 miles S. 50° E. from Springfield.

Fossiliferous, silicified buhrstone of the McBean Formation, similar to that at Loc. 38-57, crops out in the stream bed of Rocky Swamp Creek and forms rapids.

Locality 38-64

Location: East bank of Bolen Mill Creek; approximately 50 feet north of S.C. Highway 4; 3.4 miles S. 65° W. from Neeses.

	Thickness (Feet)
Pleistocene?	
surficial material	
3. Sand, quartzose, fine- to very coarse-grained, poorly sorted, very argillaceous, gritty, brick-red, numerous rounded and broken quartz pebbles.	8
Unconformity	
Middle Eocene	
McBean Formation	
2. Sand, quartzose, fine- to medium-grained, angular, rusty-yellow, with numerous muscovite flakes.	7
1. Clay, silty to sandy, light-green to gray, base concealed at stream level.	2.5

Locality 38-65

Location: East bank of Tampa Creek; approximately 10 feet north of S.C. Highway 132; 3.6 miles N. 43° E. from Springfield.

	Thickness (Feet)
Pleistocene?	
surficial material	
2. Sand, quartzose, medium- to coarse-grained, gritty, argillaceous, with numerous quartzose pebbles.	5-6
Unconformity	
Middle Eocene	
McBean Formation	
1. Clay, silty, mottled light-green to rusty-red; very sandy in upper 2 feet; numerous chert-like nodules in upper portion; many coiled gastropods and pelecypods, *Venericardia* sp., *Turritella* sp., and *Venericardia (Venericor)* sp.; base concealed at stream level.	8

Locality 38-71

Location: Roadcut on unpaved road immediately east of Goodland Creek; 2.8 miles N. 8° E. from Springfield.

	Thickness (Feet)
Pleistocene?	
surficial material	
5. Sand, quartzose, coarse- to medium-grained, gritty, argillaceous, brick-red with clastic dikes.	5
Unconformity	
Middle Eocene	
Congaree Formation	
4. Sand, quartzose, coarse-grained, light-green, silty clay matrix	2.5
3. Sand, same as unit 1.	20
2. Sandstone, quartzose and silicified buhrstone boulders and lenses with silicified pelecypods within red, rust, and orange, medium-grained, argillaceous, quartzose sand.	6
1. Sand, quartzose, medium- to coarse-grained, argillaceous, red, rust, and orange; base concealed in ditch.	5.5
(Alt. elev. at top of unit 2=265 feet.)	

Remarks: Section begins at break in slope just west of Oak Branch Church and continues nearly to stream level.

Locality 38-77

Location: Southeast bank of Harleys Millpond; 3 miles N. 38° W. from Livingston.

	Thickness (Feet)
Pleistocene?	
surficial material	
4. Sand, quartzose, medium- to very coarse-grained, gritty, yellowish-red.	10-12
Unconformity	
Middle Eocene	
McBean Formation	
3. Sand, quartzose, very fine- to fine-grained, very argillaceous, yellow and light-green, numerous silicified fossils; boundary with underlying unit transitional.	4-6
2. Clay, silty, blocky, mottled light-green and rusty-red; lower 2 feet consists of alternating layers of loose and well-indurated, medium- to coarse-grained, white and green quartzose sand (Alt. elev. to the indurated sand=236 feet.)	14
Unconformity?	
Congaree Formation?	
1. Sand, quartzose, medium-grained, white and yellow, loose, well-sorted; base concealed at pond level.	3

Locality 38-78

Location: Roadcut on S.C. Highway 58 just south of crossing of Big Beaver Creek; 3.9 miles N. 52° W. from Livingston.

	Thickness (Feet)
Pleistocene?	
surficial material	
4. Sand, quartzose, coarse,grained, slightly silty, rusty-red; small-scale cross-beds near base; basal conglomerate of rounded quartz pebbles and very coarse-grained, quartzose sand.	10
Unconformity	
Middle Eocene	
McBean Formation	
3. Sand, quartzose, fine- to medium-grained, argillaceous, yellow to rusty-red; numerous, buff and light-green, silty layers up to 1 inch thick; pockets of small silicified shell fragments.	7
2. Clay, silty to arenaceous, mottled green and ocher, numerous silicified pelecypods and gastropods as well as small pockets of silicified shell fragments.	9
1. Clay, blocky, light-green; base concealed in ditch.	1

Remarks: Cooke (1936, p. 62) reported *Venericardia claiboplata* Gardner & Bowles from the McBean Formation at this locality.

Reference: Cooke (1936, p. 62, loc. 112).

Locality 38-80

Location: Roadcut on County Highway 397; 0.1 miles south of crossing of Bull Swamp; just south of Midway Mill Pond; 3.5 miles N. 25° E. from North.

	Thickness (Feet)
Pleistocene?	
surficial material	
6. Sand, quartzose, fine- to very coarse-grained, poorly sorted, gritty, argillaceous, mottled gray and red, contains gray clay in the form of clay balls and stringers.	8
Unconformity	
Middle Eocene	
McBean Formation	
5. Clay, arenaceous, light-green, olive, and purple.	2
4. Sand, quartzose, medium-grained, yellowish-white.	3
3. Clay, silty, mottled light-green to rusty-red.	7
2. Sand, quartzose, very coarse-grained, well-indurated, greenish-yellow.	1
1. Sand, quartzose, predominately medium-grained but some very coarse-grained, white and yellow; base concealed in ditch.	2

Remarks: This section is very similar in lithology to Loc. 38-77.

Locality 38-81

Location: Spoil-bank of dug-pond in field immediately to west of unpaved road that parallels west bank of Caw Caw Swamp; 5.1 miles S. 51° W. from Jamison.

Mottled rusty-yellow, silty, plastic clay of the McBean Formation occurs on the spoil-bank and contains specimens of *Venericardia* sp., *Turritella* sp., and *Kymatox lapidosus* (Conrad).

Locality 38-83

Location: Wannamaker Plantation on east bank of Caw Caw Swamp; 0.5 miles north of U.S. Highway 178 bridge crossing over Caw Caw Swamp or 5.15 miles S. 46° W. from Jamison.

	Thickness (Feet)
Pleistocene?	
surficial material	
4. Sand, quartzose, fine- to coarse-grained, slightly argillaceous, buff; banded (darker rusty-brown layers average 0.5 inches in thickness whereas the light-buff layers average 3 to 4 inches in thickness); either soil profile or eolian.	3
3. Sand, quartzose, fine- to coarse-grained, gritty, slightly argillaceous, brick-red; loess-like deposit; lower contact sharp with well-developed basal conglomerate of well-rounded quartz pebbles.	7.5
Unconformity	
Middle Eocene	
McBean Formation	
2. Clay, arenaceous, mottled rust, yellow, and olive, plastic; numerous silicified mollusks occur in sandy pockets; *Kymatox lapidosus* (Conrad) occurs as molds.	10.5
1. Siltstone, light-olive; contains molds of *Kymatox lapidosus* (Conrad) and *Venericardia (Venericor)* sp.; base concealed at pond level.	3.5

Remarks: This section is very similar to that at Loc. 38-1.

Locality 38-85

Location: South shore of Lake Marion; 2.4 miles S. 69° E. from Santee.

The Santee Limestone forms the bluffs on the south shore of Lake Marion and consists of a yellow to buff calcarenite with numerous broken shells and large *Ostrea* sp., and *Venericardia (Venericor)* sp.

Locality 38-86

Location: Dug-pond near center of Polk Swamp (a Carolina Bay); 5.2 miles S. 2° E. from Bowman.

The Duplin Formation is exposed on the spoil-bank and consists of gray marl with numerous whole and broken pelecypod shells.

Locality 38-87

Location: South shore of Lake Marion; 0.1 miles east of Francis Marion Bridge; 1.4 miles N. 49° E. from Santee.

Large boulders of Santee Limestone are visible above water level along the south shore of Lake Marion.

Locality 38-91

Location: Roadcut on U.S. Highway I-26; 0.2 miles southeast of Early Branch; I-26 station No. 1894; 1.4 miles S. 79° W. from Jamison.

	Thickness (Feet)
Pleistocene?	
surficial material	
3. Sand, quartzose, fine- to medium-grained argillaceous, mottled red and yellow.	10-12
Unconformity	
Middle Eocene	
McBean Formation	
2. Clay, silty to arenaceous, mottled yellow, light-green and gray; 1 to 3 inch thick layers of sandstone and siltstone with molds of pelecypods; silicified gastropods and pelecypods in sandy pockets.	8
1. Clay, silty to arenaceous, mottled yellow, light-green, and brick-red, numerous silicified mollusks in sandy pockets; base concealed in ditch.	6

Remarks: Units 2 and 3 are exposed on the north side of U.S. Highway I-26; unit 1 is exposed on the south side. (I-26 profile elev. to top of unit 1=242 feet.)

Locality 38-93

Location: Roadcut on unnumbered county road; 0.1 miles east of Tampa Creek; 5.9 miles N. 69° W. from Neeses; 5.9 miles N. 83° W. from Livingston.

	Thickness (Feet)
Pleistocene?	
surficial material	
3. Sand, quartzose, fine- to medium-grained, gritty, argillaceous, brick-red; rounded quartz pebbels in basal portion.	12-15
Unconformity	
Middle Eocene	
McBean Formation	
2. Sand, quartzose, fine- to medium-grained, rusty-red; upper 2 feet very argillaceous.	5
1. Clay, silty, light-green to ocher, blocky, with laminae of fine-grained, quartzose sand near base of exposure; base concealed in ditch.	15
(Alt. elev. to top of unit 1=288 Feet.)	

Locality 38-96

Location: East bank of Hutto Mill Pond on Gibson Branch; 3.7 miles N. 85° E. from Livingston.

Approximately 5 feet of the McBean Formation is exposed on the east bank of Hutto Pond and consists of interbedded medium- to very coarse-grained, poorly sorted, slightly argillaceous, mottled rusty-red and yellow, quartzose sand and silty, light-green to ocher clay. The sand contains pockets of poorly preserved, silicified shell fragments.

Locality 38-97

Location: Drainage ditch; 0.4 miles east of County Highway 74 bridge crossing of North Fork Edisto; 5 miles S. 27° E. from Wolfton.

Light-green siltstone of the McBean Formation is exposed on the spoil-bank of a drainage ditch emptying into the North Fork Edisto. The siltstone is identical to that at Loc. 38-1 and contains molds of numerous pelecypods.

Locality 38-100

Location: East bank of Limestone Creek immediately downstream from dam; 3.1 miles S. 29° E. from Wolfton.

Dark-green, blocky, well-indurated shale of the McBean Formation is exposed at stream level. A hand auger hole indicated that it is underlain by a greenish-black, fine- to medium-grained, very glauconitic quartzose sand of the Warley Hill Formation.

Locality 38-101

(See also Auger Hole 38-34)

Location: Ditch exposure on south side of U.S. Highway I-26; 0.2 miles southeast of Saddler Swamp; I-26 station No. 1819 plus 00; 2.4 miles N. 64° W. from Jamison.

A ditch on the south side of U.S. Highway I-26 exposes approximately 11 feet of the McBean Formation. The mottled light-green and yellow, silty to arenaceous clay contains many fragments of chert-like material and sandstone. A hand auger hole placed at the bottom of the ditch passed through 8 feet of the same lithology as exposed in the ditch prior to encountering 0.5 feet of Santee Limestone. The limy unit consisted of a yellow, calcarenite with pelecypod fragments up to 1 inch in diameter. (I-26 profile elev. at bottom of ditch=205 feet.)

Locality 38-103

Location: 50 yards west of County Highway 29; 2.3 miles S. 42° E. from railroad crossing at Jamison.

A hand auger hole penetrated 3 feet of cream-colored Santee Limestone.

Locality 38-106

Location: Ditch exposure on south side of U.S. Highway I-26; 60 yards east of U.S. Highway 601 overpass; 1.65 miles S. 16° W. from Jamison.

	Thickness (Feet)
Pleistocene?	
surficial material	
2. Sand, quartzose, fine- to very coarse-grained, very argillaceous, mottled gray, yellow, and tan, gritty, well-rounded quartz pebbles, clay dikes.	10
Unconformity	
Middle Eocene	
McBean Formation	
1. Sand, quartzose, fine- to medium-grained, very argillaceous, mottled red, green, and tan; base concealed in ditch.	4

Locality 38-108

(See also Auger Hole 38-40)

Location: Ditch exposure on south side of U.S. Highway I-26; approximately 50 feet northwest of County Highway 29 overpass; I-26 station No. 2090 plus 00; 3.05 miles S. 12° E. from Jamison.

	Thickness (Feet)
Pleistocene?	
surficial material	
2. Sand, quartzose, fine- to very coarse-grained, poorly sorted, very argillaceous, well-rounded quartz pebbles; lower contact shows considerable evidence of scour and fill; stream deposit.	6-8
Unconformity	
Middle Eocene	
McBean Formation (I-26 Profile elev.=212 feet).	
1. Sand, quartzose, fine- to medium-grained, very argillaceous, mottled light-yellow and brick-red, contains pockets of silicified gastropods and pelecypods; base concealed in ditch.	3

SELECTED LOGS OF AUGER HOLES

Auger Hole 5-1

Location: On unpaved road 0.2 miles southeast of junction of County Highways 20 and 42; 4.0 miles N. 79° E. from Bamberg.

Collar elev.: 132 ft. (Contours). Total depth: 85 ft.

	Depth (Feet)
Floodplain deposit	
Clay, silty.	0-5
Sand, quartzose, medium- to very coarse-grained, tan, angular, some organic material; very coarse-grained at about 60 feet.	5-75
Middle Eocene	
Santee Limestone	
Calcilutite, light-olive.	75-85

Auger Hole 8-2

Location: 6.6 miles southeast of St. Stephens on County Highway 63.

Collar elev.: 52 ft. (Spot elev.). Total depth: 23 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Roadfill.	0-2
Clay, very arenaceous.	2-5
Sand, quartzose, coarse- to very coarse-grained, argillaceous.	5-15
Middle Eocene	
Santee Limestone	
Limestone, pale-yellow; becomes light-gray with depth.	15-23

Auger Hole 8-39

Location: 150 feet east of road intersection 24 at a point 0.82 miles S. 57° E. from Casey Church and 0.8 miles S. 14° W. from St. Paul's Church.

Collar elev.: 24 ft. (Spot elev.). Total depth: 40 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Soil.	0-1
Clay, very plastic, mottled red, yellow, and brown.	1-5
Clay, very arenaceous, gritty, yellowish-brown quartz pebbles up to 0.5 inches in diameter.	5-12?
Oligocene	
Cooper Marl	
Marl, yellowish-brown, contains abundant amber-colored grains of phosphate?; reworked Cooper Marl.	12?-21
Marl, brownish-green grading downward into typical olive-green Cooper Marl.	21-40

Auger Hole 8-40

Location: Mount Holly Quadrangle, southwest quarter; at road intersection 21 on east edge of Huckhold Swamp; 0.65 miles S. 75° E. from Driggerstown and 1.15 miles S. 10° W. from Grove Hall.

Collar elev.: 21 ft. (Spot elev.). Total depth: 25 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand and clay.	0-4
Marl, cream-colored, very calcareous.	4-7
Oligocene	
Cooper Marl	
Marl, olive-green.	7-25

Auger Hole 8-45

Location: 150 feet northeast of U.S. Highway 176; 3.0 miles northwest of junction of U.S. Highways 176 and 17A; south end of Black Tom Bay.

Collar elev.: 88 ft. (Contours). Total depth: 50 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, medium- to fine-grained.	0-21
Clay, buff, with thin quartzose sand layers.	21-22
Sand, quartzose, very argillaceous, olive-blue.	22-29
Sand, quartzose, very argillaceous, grayish-blue; thin, well-indurated, clay layers.	29-39
Upper Miocene?	
Duplin Formation?	
Marl, grayish-blue, plastic clay layers up to 2 feet in thickness; very fossiliferous; *Mulina congesta*.	39-44
Oligocene	
Cooper Marl	
Marl, olive, shark tooth.	44-50

Auger Hole 8-49

Location: Intersection of S.C. Highway 27 and U.S. Highway I-26; 0.1 miles southwest of Pisgah Church.

Collar elev.: 60 ft. (Contours). Total depth: 16 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, fine-grained, very argillaceous, buff to yellowish-brown.	0-10
Oligocene	
Cooper Marl	
Marl, grayish-green; upper 2 feet reworked and consists of loose, fine- to coarse-grained, calcareous, phosphatic, quartzose sand with shark teeth.	10-16

Auger Hole 8-55

Location: Junction of S.C. Highway 27 and U.S. Highway 176; 0.9 miles northwest of Ebenezer Church and School.

Collar elev.: 87 ft. (Spot elev.). Total depth: 44 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Clay with sparse fine-grained, quartzose sand from 2 to 7 feet; medium-brown from 1 to 7 feet; medium-brown and light-gray from 7 to 11 feet; light-gray from 11 to 19 feet; very plastic in lower portion.	0-19
Sand, quartzose, coarse-grained, slightly argillaceous, pink.	19-27
Oligocene	
Cooper Marl	
Marl, olive-green, discoidal quartz pebbles up to 1 inch in diameter and *Ostrea* sp. near base.	27-36
Middle Eocene	
Santee Limestone	
Limestone, light-gray, slightly arenaceous, sparse pelecypod fragments.	36-44

Auger Hole 8-66

Location: On S.C. Highway 311; 0.35 miles west of junction of S.C. Highway 311 and County Highway 135; 11.2 miles N. 57° W. from Moncks Corner.

Collar elev.: 81 ft. (Spot elev.). Total depth: 37 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, medium- to coarse-grained in upper portion, becoming fine-grained with depth; slightly argillaceous; brownish-yellow.	0-27

Middle Eocene
Santee Limestone
Marl, bluish-gray, argillaceous, slightly to moderately calcareous; weathered and reworked; contains *Claiborne foraminifera* (SIPLE, personal communication); bottomed at 37 feet in cream-colored calcarenite. 27-37

Auger Hole 9-1

(See also Locality 9-35)

Location: Southwest bank of Caw Caw Swamp; on S.C. Highway 117, 0.4 miles southwest of intersection of S.C. Highway 117 and U.S. Highway 21.

Collar elev.: 238 ft. (Alt. elev.). Total depth: 100 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, medium- to coarse-grained, argillaceous.	0-4
Middle Eocene	
McBean Formation	
Clay, yellowish-green.	4-7
Warley Hill-Congaree Transition	
Sand, quartzose, medium-grained, glauconitic, silicified? layer 1 to 2 inches thick at depth of 7 feet.	7-8
Sand, quartzose, medium- to coarse-grained, yellow, green, and brown, sparsely to moderately glauconitic.	8-12
Sand, quartzose, fine-grained, light-yellow.	12-32
Sand, quartzose, fine- to medium-grained, yellowish-green, moderate to abundant glauconite; sparse to no glauconite in lower 30 feet.	32-100

Auger Hole 9-2

Locaton: 3.1 miles S. 40° E. from St. Matthews on S.C. Highway 20 at Lyon's Creek.

Collar elev.: 180 ft. (Contours). Total depth: 49 ft.

	Depth (Feet)
Middle Eocene	
McBean Formation	
Clay, plastic, rusty-brown. with thin layers of silicified sandstone or coquina; very hard drilling.	0-5
Warley Hill Formation	
Sand, quartzose, argillaceous, yellowish-brown to green; green is predominant color below 25 feet; glauconite content increases downward with little or none in upper portion and moderate to abundant glauconite in lower portion; sand is fine- to coarse-grained and becomes very coarse-grained and conglomeratic in lowermost 10 feet; sparse muscovite flakes and occasional fragments of silicified coquina or sandstone throughout the section; non-calcareous.	5-49

Auger Hole 9-3

Location: Road intersection 2.1 miles east of Creston; 0.6 miles north of Hutto Pond.

Collar elev.: 163 ft. (Spot elev.). Total depth: 75 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, medium- to coarse-grained, argillaceous, angular; some quartz pebbles.	0-15
Sand, quartzose, coarse- to very coarse-grained, argillaceous, angular, rusty-brown.	15-25?
Middle Eocene	
Warley Hill Formation	
Sand, quartzose, fine-grained, argillaceous, yellowish-orange, slightly glauconitic at depth of 38 feet.	25?-47
Sand, as above but with small calcareous fragments.	47-60
Sand, quartzose, fine-grained, grayish-olive, glauconitic, calcareous; effervesces slightly more than the 47 to 60 foot unit.	60-?
Sand, quartzose, non-calcareous, very fine- to medium-grained, dark-gray.	?-75

Auger Hole 9-4

Location: Approximately 200 feet south of Hutto's Pond on County Highway 72; 2.1 miles S. 75° E. from Creston.

Collar elev.: 130 ft. (Alt. elev.). Total depth: 50 ft.

	Depth (Feet)
Roadfill	
Sand, quartzose, fine-grained, argillaceous.	0-7
Middle Eocene	
Santee Limestone	
Calcirudite, buff.	7-15
Warley Hill Formation	
Sand, quartzose, fine- to coarse-grained, very glauconitic, greenish-black; less glauconite at a depth of 22 feet.	15-23
Sand, quartzose, glauconitic as above but containing small fragments of white micaceous siltstone.	23-27
Congaree Formation	
Siltstone, micaceous, white.	27-33
Lower Eocene	
Black Mingo Formation	
Mudrock, grayish-black, non-calcareous, micaceous.	33-50

Auger Hole 9-5

Location: Daniel's 4-H Camp on southwest side of Lake Marion, 25 yards from lake; 8.6 miles S. 70° E. from Creston.

Collar elev.: 80 ft. (Contours). Total depth: 61 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, fine- to very coarse-grained, well-rounded quartz pebbles.	0-7
Clay, very plastic, mottled green, red, and yellow.	7-11
Middle Eocene	
Santee Limestone	
Calcarenite, grayish-yellow; well-indurated layer at 35 to 37 feet.	11-40
Warley Hill Formation	
Calcarenite, grayish-olive, glauconitic, nodules of phosphate at 61 feet, well-indurated layer from 44 to 45 feet.	40-61

Auger Hole 9-6

Location: 0.7 miles N. 32° W. from Calvery Church; 1.0 miles S. 2° W. from Mt. Carmel Church; 3.0 miles north of St. Matthews.

Collar elev.; 262 ft. (Alt. elev.). Total depth: 105 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, medium-grained, argillaceous, red.	0-33
Middle Eocene	
McBean, Warley Hill, and Congaree Formations	
Clay, plastic, green and fine- to coarse-grained, quartzose sand.	33-94
Lower Eocene	
Black Mingo Formation	
Mudrock, silty, black.	94-105

Auger Hole 9-7

Location: 0.3 miles N. 20° E. from railroad crossing at Creston; 100 feet south of Dam on Earl Edward's farm.

Collar elev.: 160 ft. (Contours). Total depth: 70 ft.

	Depth (Feet)
Sink hole	
Sand, quartzose, coarse-grained and silty clay. This footage represents sediments from a sink hole because the Santee Limestone crops out only 20 feet from the auger hole.	0-20
Middle Eocene	
Warley Hill and Congaree Formations	
Clay, plastic, light-green with quartzose sand and glauconite.	20-60
Lower Eocene	
Black Mingo Formation	
Mudrock, black.	60-70

Auger Hole 9-8

Location: 30 feet south of S.C. Highway 172; 0.9 miles west of U.S. Highway 21; just east of Caw Caw Swamp floodplain; 10.2 miles east of Woodford.

Collar elev.: 272 ft. (Alt. elev.). Total depth: 30 ft.

	Depth (Feet)
Middle Eocene	
McBean Formation	
Sand, quartzose, fine- to coarse-grained, argillaceous, yellowish-brown; angular chert fragments.	0-3
Congaree Formation	
Sand, quartzose, fine- to coarse-grained, mostly medium-grained, yellowish-orange, angular, no glauconite.	3-27
Siltstone, greenish-yellow, chips of grayish-black well-indurated sandstone and green claystone; very hard drilling.	27-30

Auger Hole 9-9

Location: On unnumbered, unpaved county road between County Highways 35 and 30; 0.8 miles south-east of Little Beaver Creek.

Collar elev.: 302 ft. (Alt. elev.) Total depth: 90 ft.

	Depth (Feet)
Middle Eocene	
McBean Formation	
Sand, quartzose, fine- to very coarse-grained, argillaceous; numerouse chert fragments.	0-5
Congaree Formation	
Sand, quartzose, fine- to medium-grained, very sligthtly argillaceous, rusty-yellow, coarse grained with depth.	5-80
Lower Eocene	
Black Mingo Formation	
Mudrock, black, unctuous.	80-90

Auger Hole 9-10

Location: 2.0 miles N. 29° E. from Wiles Crossroads; at intersection of U.S. Highway 601 and unnumbered dirt road.

Collar elev.: 231 ft. (Spot elev.). Total depth: 69 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, medium- to coarse-grained, very argillaceous, brick-red.	0-22
Middle Eocene	
Congaree Formation	
Sand, quartzose, medium- to very coarse-grained, poorly sorted, very angular, yellow.	22-40
Lower Eocene	
Black Mingo Formation	
Mudrock, plastic, black, with interbedded dark-gray, medium grained, quartzose sand.	40-69

Auger Hole 9-12

Location: On County Highway 45 at intersection 291; 2.8 miles N. 80° E. from Jamison.

Collar elev.: 291 ft. (Spot elev.). Total depth: 75 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, fine- to very coarse-grained, conglomeratic, light-gray to reddish-brown; rounded quartz pebbles.	0-2

Middle Eocene
McBean Formation
Clay, silty, red down to 24 feet, yellowish-brown from 24 to 45 feet, pale-green from 45 to 70 feet; interbedded medium- to coarse-grained, quartzose sand from 55 to 65 feet; lower 5 feet is moderately to slightly calcareous and contains yellowish-white chert fragments up to 0.3 inches in diameter; large pelecypod fragments and *Turritella* sp. near base. — 2-70
Santee Limestone
Limestone, light-buff, contains sparse medium- to coarse-grained quartz grains and white chert-like fragments; very calcareous, non-glauconitic. — 70-75

Auger Hole 9-20

Location: Junction of County Highways 22 and 122; 4.9 miles S. 61° W. from St. Matthews.

Collar elev.: 290 ft. (Spot elev.) Total depth: 75 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand, quartzose, fine- to medium-grained, slightly argillaceous, golden-yellow. — 0-3
Sand, quartzose, coarse-grained, argillaceous, purplish-red. — 3-7
Middle Eocene
McBean Formation
Clay, arenaceous, muscovite flakes, purplish-red. — 7-19
Sand, quartzose, coarse- to very coarse-grained, argillaceous purplish-red to yellowish-brown. — 19-24
Sand, quartzose, coarse- to very coarse-grained, argillaceous, golden-yellow. — 24-62
Warley Hill-Congaree Transition
Clay, slightly arenaceous, glauconitic, yellowish-green becoming darker-green and more glauconitic with depth; contains muscovite flakes and chert-like fragments. — 62?-75

Auger Hole 14-3

Location: 2.05 miles southeast of Davis Crossroads on unnumbered county road; at New Zion Church.

Collar elev.: 95 ft. (Contours). Total depth: 55 ft. — Depth (Feet)
Tertiary?
Sand, quartzose, yellowish-orange, argillaceous. — 0-34
Middle Eocene
Warley Hill Formation
Limestone, glauconitic, pale-olive; basal portion very glauconitic and contains phosphate grains. — 34-50
Lower Eocene?
Black Mingo Formation?
Sand, quartzose, very fine-grained to silty, light-gray. — 50-55

Auger Hole 18-4

Location: Ridgeville Quadrangle; on U.S. Highway I-26 at junction with County Highway 51; 3.0 miles N. 60° E. from Dorchester.
Collar elev.: 101 ft. (Contours). Total depth: 39 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand, quartzose, fine-grained, light-buff. — 0-29
Sand, quartzose, fine- to coarse-grained, grayish-blue, slightly calcareous. — 29-34
Oligocene
Cooper Marl
Marl, olive-green. — 34-39

Auger Hole 18-5

Location: Ridgeville Quadrangle; on U.S. Highway I-26 at junction with County Highway 39; 4.0 miles S. 62° E. from Harleyville.

Collar elev.: 90 ft. (I-26 profile elev.). Total depth: 39 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand and clay. — 0-31
Oligocene
Cooper Marl
Marl, olive-green. — 31-39

Auger Hole 18-8

Location: 200 feet west of Pee Dee Branch on U.S. Highway I-26; 0.3 miles northwest of U.S. Highway 15; 2.5 miles N. 10° E. from Rosinville.

Collar elev.: 92 ft. (Contours). Total depth: 19 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand, quartzose, fine- to medium grained. — 1-4
Sand, quartzose, medium- to very coarse-grained, very argillaceous, gray. — 4-12
Middle Eocene
Santee Limestone
Calcarenite, medium-gray. — 12-19

Auger Hole 18-9

Location: On County Highway 28 at Bench Mark 81; 3.85 miles N. 69° E. from Harleyville.
Collar elev.: 81 ft. (Bench Mark). Total depth: 50 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand, quartzose, fine- to very coarse-grained, yellowish-brown. — 0-6
Clay, plastic, slightly arenaceous, gray. — 6-7
Sand, quartzose, fine- to very fine-grained, yellowish-brown. — 7-8
Clay, arenaceous, very plastic, mottled blue, red, and gray. — 8-11
Sand, quartzose, fine- to very coarse-grained, yellowish-brown. — 14-31
Oligocene
Cooper Marl
Marl, olive-green. — 31-45
Middle Eocene
Santee Limestone
Limestone, granular, white. — 45-50

Auger Hole 18-11

Location: Town of Pregnall on U.S. Highway 78.

Collar elev.: 85 ft. (Bench Mark). Total depth: 30 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand, quartzose, fine-grained, very argillaceous, yellowish-brown. — 0-4
Sand, quartzose, fine- to very coarse-grained, argillaceous, red, plastic; more argillaceous with depth. — 4-15
Upper Miocene?
Duplin Formation?
Sand, quartzose, fine-grained, slightly argillaceous, contains moderate amount of tiny calcareous fragments that may be shell fragments. — 15-25
Oligocene
Cooper Marl
Marl, olive-green. — 25-30

Auger Hole 18-13

Location: Road junction 99; 3.2 miles N. 61° W. from Harleyville.

Collar elev.: 99 ft. (Spot elev.). Total depth: 29 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand, quartzose, fine-grained, very argillaceous, yellowish-brown. — 0-3
Sand, quartzose, fine- to coarse-grained, very argillaceous, mottled brown, red, and white. — 3-6
Sand, quartzose, fine- to very coarse-grained, very argillaceous, yellowish-brown. — 6-15?
Upper Miocene?
Duplin Formation?
Sand, quartzose, fine-grained, light-yellow. — 15?-21
Oligocene
Cooper Marl
Marl, olive-green, quartz pebbles up to 1 inch in diameter in upper 1 to 3 feet. — 21-29

Auger Hole 38-1

Location: Sandy Island; 3.8 miles south of Branchville; floodplain of the Edisto River.

Collar elev.: 100 ft. (Contours). Total depth: 65 ft.

Depth (Feet)
Floodplain deposit. — 0-35
Oligocene
Cooper Marl
Marl, arenaceous, olive-green. — 35-54
Middle Eocene
Santee Limestone
Limestone, creamy-white, with large fragments of pelecypods. — 54-65

Auger Hole 38-5

(See also Locality 38-1)

Location: 2.8 miles S. 62° W. from Jamison; 0.3 miles southeast of where U.S. Highway 21 crosses Early Branch.

Collar elev.: 237 ft. (Alt. elev.) Total depth: 100 ft.

Pleistocene? — Depth (Feet)
surficial material
Clay, arenaceous, brick-red, quartz pebbles. — 0-3
Middle Eocene
McBean Formation
Clay, silty, yellowish-tan. — 3-9
Clay, silty to arenaceous, light-green. — 9-18
Siltstone, light-green, well-indurated; this lithology is exposed in the roadcut at Loc. 38-1. — 18-35
Santee Limestone
Limestone, greenish-yellow; looks very much like 18 to 35 footage except it is strongly calcareous. — 35-95
Santee Limestone-Warley Hill Transition
Limestone, arenaceous, glauconitic, olive-drab. — 95-100

Auger Hole 38-7

Location: First unpaved road west of Caw Caw Swamp; 1.5 miles north of U.S. Highway 178.

Collar elev.: 200 ft. (Contours). Total depth: 30 ft.

Pleistocene? — Depth (Feet)
surficial material
Sand, quartzose, fine- to coarse-grained, angular, grayish-yellow. — 0-6
Middle Eocene
McBean Formation
Clay, arenaceous, plastic, rusty-red. — 6-13
Clay, arenaceous, plastic, mottled red, green, gray, and yellow. — 13-17

Santee Limestone
Calcilutite, arenaceous, sparse glauconite, greenish-yellow. 17-23
Santee Limestone-Warley Hill Transition
Calcilutite, slightly more glauconitic than above unit, arenaceous. 23-30

Auger Hole 38-9

(See also Locality 38-15)

Location: Culler Millpond; 1.8 miles southwest of Wolfton.

Collar elev.: 215 ft. (Contours). Total depth: 55 ft.

	Depth (Feet)
Middle Eocene	
McBean Formation	
Clay, silty to very fine-grained, arenaceous, greenish-yellow, slightly glauconitic; silicified mollusks.	0-10
Warley Hill-Congaree Transition	
Sand, quartzose, fine- to coarse-grained, very angular, yellowish-white, slightly glauconitic.	10-25
Sand, quartzose, fine- to coarse-grained, angular, olive-drab, glauconitic; color changes to greenish-black at about 35 feet and becomes olive-drab at 50 feet.	25-55

Auger Hole 38-10

(See also Locality 38-7)

Location: East bank of Limestone Creek on U.S. Highway 178; 6 miles northwest of Orangeburg.

Collar elev.: 227 ft. (Alt. elev.). Total depth: 55 ft.

	Depth (Feet)
Fill material.	0-12
Middle Eocene	
McBean Formation	
Sand, quartzose, fine- to medium-grained, argillaceous, rusty-red; fragments of chert.	12-22
Warley Hill Formation	
Clay, silty to arenaceous, glauconitic, greenish-yellow.	22-32
Sand, quartzose, fine- to medium-grained, glauconitic, olive-yellow.	32-42
Sand, fine- to medium-grained, glauconitic, greenish-black.	42-55

Auger Hole 38-11

(See also Locality 38-10)

Location: South bank of small stream draining to Bull Swamp; 0.1 miles east of County Highway 29; 2.25 miles S. 43° E. from railroad crossing at Jamison.

Collar elev.: 200 ft. (Contours). Total depth: 25 ft.

	Depth (Feet)
Soil.	0-4
Middle Eocene	
Santee Limestone	
Limestone, slightly arenaceous, greenish-gray.	4-25

Auger Hole 38-13

Location: 2.5 miles S. 7° W. from Rowesville on County Highway 117.

Collar elev.: 150 ft. (Bench Mark). Total depth: 100 ft.

Floodplain deposit.	0-65?
Middle Eocene	
Santee Limestone	
Calcarenite, greenish-yellow.	65?-100

Auger Hole 38-14

Location: 3.4 miles northwest of Branchville on County Highway 63.

Collar elev.: 112 ft. (Bench Mark). Total depth: 95 ft.

	Depth (Feet)
Floodplain deposit.	0-60?
Middle Eocene	
Santee Limestone	
Calcarenite to calcirudite, light-green, arenaceous, shell fragments.	60?-95

Auger Hole 38-15

Location: Polk Swamp, 1.1 miles N. 10° E. from Mt. Tabor Church; 4.5 miles S. 4° W. from Bowman.

Collar elev.: 130 ft. (Contours). Total depth: 75 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, fine- to medium-grained, angular, argillaceous, olive-gray.	0-5
"Carolina Bay Deposit"	
Clay, arenaceous, yellowish-orange.	5-12
Clay, silty, very plastic, grayish-blue.	12-15
Upper Miocene	
Duplin Formation	
Sand, quartzose, fine-grained, bluish-gray, numerous calcareous shell fragments and some whole pelecypods; lower few feet consists of fine- to medium-grained, yellowish-green, quartzose, sand with numerous shell fragments.	15-35?
Middle Eocene	
Santee Limestone	
Calcarenite, grayish-green, numerous shell fragments.	35?-75

Auger Hole 38-16

Location: 1.3 miles north of Dorange on County Highway 164; 6.0 miles S. 85° E. from Branchville.

Colar elev.: 130 ft. (Contours). Total depth: 42 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, fine- to medium-grained, argillaceous, grayish-orange.	0-7
Clay, very arenaceous, rusty-red.	7-12
Clay, silty, mottled yellow and pale-green.	12-16
Upper Miocene	
Duplin Formation	
Sand, quartzose, fine-grained, olive-brown, shell fragments.	16-30
Oligocene	
Cooper Marl	
Calcarenite, light-olive, numerous shell fragments, phosphate nodules on drill bit.	30-42

Auger Hole 38-17

Location: 3.2 miles northeast of Rowesville; on north bank of Sandy Creek where County Highway 64 crosses the stream.

Collar elev.: 180 ft. (Contours). Total depth: 80 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, fine-grained, angular, slightly argillaceous, dusty-yellow.	0-18?
Upper Miocene	
Duplin Formation	
Clay, arenaceous, medium-gray.	18?-19
Sand, quartzose, fine-grained, slightly argillaceous, gray, numerous calcareous shell fragments.	19-60?
Middle Eocene	
Santee Limestone	
Calcarenite, pale-olive, shell fragments.	60?-80

Auger Hole 38-18

Location: Tyler's Landing; north bank of South Fork Edisto where U.S. Highway 321 crosses river; 3.6 miles S. 10° W. from Norway.

Collar elev.: 185 ft. (Contours). Total depth: 18 ft.

	Depth (Feet)
Floodplain deposit.	0-6
Middle Eocene	
Santee Limestone	
Calcilutite, pale-olive, very hard drilling.	12-18

Auger Hole 38-19

Location: 5.0 miles N. 73° W. from Norway; 50 feet west of where S.C. Highway 332 crosses Rocky Swamp.

Collar elev.: 195 ft. (Contours). Total depth: 100 ft.

	Depth (Feet)
Floodplain deposit.	0-15
Middle Eocene	
Congaree Formation	
Sand, quartzose, fine- to very coarse-grained, yellowish-brown, numerous fragments of chert-like clay.	15-100

Auger Hole 38-22

Location: 4.3 miles S. 83° E. of Norway; 10 feet north of Roberts Swamp on unnumbered County Highway.

Collar elev.: 180 ft. (Contours). Total depth: 85 ft.

	Depth (Feet)
Floodplain deposit.	0-22
Middle Eocene	
Santee Limestone	
Sand, medium- to very coarse-grained, yellowish-brown, very calcareous, numerous shell fragments.	22-60?
Sand, fine-grained, greenish-gray, very calcareous.	60?-85

Auger Hole 38-23

Location: South bank of North Fork Edisto River; 4.0 miles N. 70° W. from Orangeburg; 1.4 miles southeast of where S.C. Highway 74 crosses North Fork Edisto River.

Collar elev.: 175 ft. (Contours). Total depth: 62 ft.

	Depth (Feet)
Floodplain deposit.	0.11
Middle Eocene	
Santee Limestone-Warley Hill Transition	
Calcarenite, light-olive to gray, shell fragments.	11-30?
Calcilutite, light-olive to gray, shell fragments, slightly glauconitic.	30?-55?
Calcarenite, darker green and more glauconitic than above units.	55?-62

Auger Hole 38-26

Location: 6.5 miles east of Orangeburg; north bank of Little Bull Swamp where S.C. Highway 155 crosses stream.

Collar elev.: 150 ft. (Contours). Total depth: 25 ft.

	Depth (Feet)
Floodplain deposit	0.12
Upper Miocene	
Duplin Formation	
Sand, quartzose, fine- to coarse-grained, light-olive and gray, calcareous, numerous shell fragments.	12-19
Middle Eocene	
Santee Limestone	
Calcilutite, greenish-gray, some whole pelecypod shells.	19-25

Auger Hole 38-27

Location: 3.8 miles S. 83° E. from Cope; southwest bank of Cooper Swamp; 0.6 miles southwest of Edisto Church.

Collar elev.: 160 ft. (Contours). Total depth: 65 ft.

	Depth (Feet)
Roadfill.	0-7
Upper Miocene?	
Duplin Formation?	
Sand, quartzose, fine- to very coarse-grained, light-gray, argillaceous.	7-45?
Sand, quartzose, medium-grained, yellowish-orange with small shell fragments.	45?-50
Middle Eocene	
Santee Limestone	
Limestone, arenaceous, greenish-gray.	50-65

Auger Hole 38-29

Location: 0.25 miles east of Saddler Swamp on County Highway 166; 7.0 miles north of Orangeburg.

Collar elev.: 218 ft. (Alt. elev.). Total depth: 75 ft.

	Depth (Feet)
Middle Eocene	
McBean Formation	
Clay, arenaceous, mottled light-green, yellow, and rusty-red.	0-13
Santee Limestone	
Calcilutite, cream-colored, slightly glauconitic, numerous shell fragments.	13-25?
Warley Hill Formation	
Calcilutite to calcarenite, arenaceous, olive, very glauconitic.	25?-40?
Sand, quartzose, fine- to medium-grained, olive, very calcareous, very glauconitic; between 60 and 65 feet becomes non-calcareous.	40?-65
Sand, quartzose, fine- to coarse-grained, very glauconitic, non-calcareous, slightly coarser than above unit.	65-75

Auger Hole 38-34

(See also Locality 38-101)

Location: 150 feet west of Saddler Creek on U.S. Highway I-26, south side; 2.5 miles N. 67° W. from Jamison.

Collar elev.: 210 ft. (I-26 Profile elev.). Total depth: 79 ft.

	Depth (Feet)
Floodplain deposit.	0.10
Middle Eocene	
Warley Hill-Congaree Transition	
Sand, quartzose, fine- to medium-grained, yellow.	0-17
Sand, quartzose, fine- to medium-grained, greenish-yellow; at 25 feet becomes darker-green and very glauconitic; at 65 feet very, very glauconitic, dark-olive.	17-71
Clay, light-green, very arenaceous; drills like interbedded clay and sand.	71-79

Auger Hole 38-35

Location: South side of burrow pit at intersection of U.S. Highway I-26 and S.C. Highway 33; 2.9 miles S. 68° E. from Stilton.

Collar elev.: 215 ft. (I-26 Profile elev.). Total depth: 85 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Soil.	0-2
Sand, quartzose, fine-grained, argillaceous, rusty-brown.	2-10
Sand, quartzose, coarse-grained, slightly argillaceous, light-gray.	10-16?
Upper Miocene?	
Duplin Formation?	
Sand, quartzose, fine- to very coarse-grained, yellow; yellowish-pink with depth.	16?-65
Middle Eocene	
Santee Limestone	
Solution cavity.	65-68
Calcilutite, light-green, shell fragments; well-rounded quartz pebbles up to 2 inches in diameter on rods from 77 to 85 feet.	68-85

Auger Hole 38-36

Location: Intersection of S.C. Highway 121 and U.S. Highway I-26; 5.5 miles N. 80° E. from Bowman.

Collar elev. 106 ft. (I-26 Profile elev.). Total depth: 49 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Soil.	0-3
Sand, quartzose, fine- to medium-grained, argillaceous, yellow, red, and orange.	3-14
Clay, slightly arenaceous, light-gray and yellow.	14-20
Upper Miocene	
Duplin Formation	
Sand, quartzose, fine- to coarse-grained, argillaceous, buff.	20-22
Clay and golden-yellow, quartzose sand.	22-25
Sand, quartzose, fine- to very coarse-grained, yellow; minute calcareous shell material near base; ribbed pelecypod shell.	25-49

Auger Hole 38-37

Location: Intersection of U.S. Highway I-26 and County Highway 45; 4.7 miles N. 6° E. from Bowman.

Collar elev.: 160 ft. (Contours). Total depth: 64 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, fine-grained, argillaceous, brick-red.	0-12
Clay, arenaceous, mottled gray and pink.	12-14
Sand, quartzose, fine-grained, argillaceous, muscovite flakes; 14 to 24 feet buff; 24 to 34 feet pink; 34 to 49 feet rusty-red.	14-49?
Middle Eocene	
Santee Limestone	
Marl, bluish-gray.	49?-64

Auger Hole 38-38

Location: On U.S. Highway I-26, 0.4 miles northwest of U.S. Highway 301 overpass; burrow pit 50 feet north of U.S. Highway I-26, station No. 2430.

Collar elev.: 153 ft. (I-26 Profile elev.). Total depth: 43 ft.

	Depth (Feet)
Upper Miocene?	
Duplin Formation?	
Sand, quartzose, fine- to very coarse-grained, angular golden-yellow; interbedded clays and sands at a depth of about 5 feet.	0-16
Upper Miocene	
Duplin Formation	
Sand, quartzose, fine- to coarse-grained, olive; minute calcareous shell? fragments.	16-19
Marl, bluish-green, shell fragments up to 1.5 inches in diameter.	19-37
Middle Eocene	
Santee Limestone	
Limestone, light-gray.	37-43

Auger Hole 38-39

Location: North side of U.S. Highway I-26; I-26 station No. 2098; 3.4 miles S. 13° E. from Jamison.

Collar elev.: 205 ft. (I-26 Profile elev.). Total depth: 74 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Soil.	0-1
Sand, quartzose, fine- to medium-grained, argillaceous, rusty-tan.	1-5
Clay, arenaceous, light-gray.	5-13
Upper Miocene?	
Duplin Formation?	
Sand, quartzose, fine- to coarse-grained, angular, yellowish-tan.	13-26
Sand, quartzose, fine- to very coarse-grained, rose.	26-27
Middle Eocene	
Santee Limestone	
Limestone, olive, glauconitic; may represent Santee-Warley Hill facies change; well-rounded quartz pebbles on rods from 40 to 74 feet.	27-74

Auger Hole 38-40

(See also Locality 38-108)

Location: 300 feet south of U.S. Highway I-26; I-26 station No. 2090; 50 feet northwest of S.C. Highway 29 overpass; 3.3 miles S. 12° E. from Jamison.

Collar elev.: 215 ft. (I-26 Profile elev.) Total depth: 74 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Soil.	0-1
Sand, quartzose, fine- to coarse-grained, poorly sorted, very argillaceous, tan.	1-7
Middle Eocene	
McBean Formation	
Clay, arenaceous, rusty-red.	7-14
Clay, silty, mottled light-green and red.	14-26
Santee Limestone	
Limestone, greenish-buff, large shell fragments; well-indurated layer at 65 feet.	26-74

Auger Hole 38-68

Location: At road junction 111; 1.5 miles N. 56° E. from Holly Hill.

Collar elev.: 111 ft. (Spot elev.). Total depth: 74 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Soil.	0-2
Sand, quartzose, medium- to coarse-grained, very argillaceous, sparse quartz pebbles and feldspar fragments.	2-12
Sand, quartzose, very coarse-grained, angular to subangular, yellow; feldspar fragments.	12-34
Upper Miocene	
Duplin Formation	
Sand, quartzose, medium- to coarse-grained, very slightly argillaceous, light-green to olive, calcareous.	34-66
Middle Eocene	
Santee Limestone	
Calcilutite, light-gray to light-pink.	66-74

Auger Hole 38-80

Location: 5.3 miles S. 19° E. from Jamison; on County Highway 65; 3.7 miles N. 60° E. from Orangeburg.

Collar elev.: 195 ft. (Spot elev.). Total depth: 60 ft.

	Depth (Feet)
Upper Miocene?	
Duplin Formation?	
Sand, quartzose, fine- to coarse-grained, argillaceous, yellowish-brown to golden-yellow; reddish tint at 29 feet; thin clay layers; may be oxidized portion of underlying unit.	0-45?
Upper Miocene	
Duplin Formation	
Sand, quartzose, very fine-grained, very argillaceous, black; mica flakes; slightly calcareous.	45?-55
Middle Eocene	
Santee Limestone	
Calcilutite, white, well-indurated layers.	55-60

Auger Hole 38-91

Location: U.S. Highway I-26 crossing of Southern Railroad tracks; 1.5 miles S. 12° W. from Jamison.

Collar elev.: 316 ft. (Railroad profile). Total depth: 52 ft.

	Depth (Feet)
Middle Eocene	
McBean Formation	
Sand, quartzose, fine-grained, argillaceous, bluish-gray interbedded with mottled white, blue, and gray arenaceous clay; sparse quartz pebbles.	0-15
Same as unit 0-15 but olive-green in upper portion becoming bluish-gray in lower portion.	15-46
Sand, quartzose, fine-grained, argillaceous, grading downward into bluish-gray marl with rounded to subangular quartz pebbles.	46-52

Auger Hole 45-2

Location: Town of Lane; 0.3 miles south of Lane Chapel.

Collar elev.: 70 ft. (Spot elev.). Total depth: 29 ft.

	Depth (Feet)
Pleistocene?	
surficial material	
Sand, quartzose, coarse-grained, very argillaceous, mottled red and yellow; soil at top; no samples from 10 to 21 feet.	0-21
Lower Eocene	
Black Mingo Formation	
Marl, gray to grayish-black; poorly sorted; coarse-grained; subrounded to subangular quartz grains; very calcareous; numerous microfossils and small fish teeth.	21-29

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