THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

STRATIGRAPHY AND PALEONTOLOGY OF THE JACKSON GROUP OF GEORGIA

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SUBMITTED TO THE GRADUATE FACULTY

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degree of

DOCTOR OF PHILOSOPHY

BY

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STRATIGRAPHY AND PALEONTOLOGY OF THE JACKSON GROUP OF GEORGIA

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STRATIGRAPHY AND PALEONTOLOGY OF THE JACKSON GROUP OF GEORGIA

CHAPTER I

INTRODUCTION

This report was prepared as an integral part of the requirements for the degree of Doctor of Philosophy at the University of Oklahoma. It entails a study of the stratigraphic position, facies relationships, and fauna of beds of Jackson age in the Coastal Plain of the State of Georgia.

The area studied includes an arc of thirty-three counties along the inner edge of the Coastal Plain, embracing an areal extent of 25,200 square miles, bounded on the southwest by the Florida-Georgia and Georgia-Alabama state lines, and on the northeast by the Savannah River.

The Jackson group of Georgia is composed of two formations, the Ocala limestone and the Barnwell sands and clays, strata equivalent in age to the Bartonian and most of the Ludian subseries or stages of the European section. A third unit, the Cooper marl, by some writers considered occurring above the Barnwell and included as such within the Jackson group, is not believed by the writer to be present in Georgia.

The Ocala limestone has at its base in central Georgia a tongue of soft, cream to white bryozoan limestone, and a bed of uncemented, tan, calcareous sand, thus constituting a unit known as the Tivola tongue of the Ocala. This limestone and sand sequence transgresses across the irregular Upper Cretaceous surface far into the area of outcrop of the Barnwell formation. The greater part of the Ocala is found in the southwestern part of the State, where it consists of bedded white to cream, very soft to hard limestone, which in places has become silicified.

The Barnwell formation consists of several members differentiated by many authors because of distinctive lithologies. The basal part of the Barnwell formation, extending from central Georgia to the Savannah River, is termed the Twiggs clay member. In extreme northeastern Georgia, this member has in its base a bed of large oyster shells, which has been termed the *Ostrea georgiana* Conrad zone.

Above the Twiggs clay member, stratigraphically, is the Irwinton sand member, overlain by a much localized unit known as the Sandersville limestone member. In a few areas near the overlap of Barnwell upon the Pre-Cambrian crystalline rocks the Upper Sand member is designated as part of the Barnwell formation.

In the writer's opinion, the argillaceous red sands composing the typical Barnwell, i. e., outside the area of outcrop of the Irwinton and Upper Sand members, should be termed the Uppermost Red Sand Member of the Barnwell formation. In extreme northeastern Georgia the sands occur higher in the section than the other members, whereas in Crawford, and possibly in Peach County, they occur conformably upon uppermost Twiggs clay. These beds are quite distinct from the Irwinton sands, which crop out essentially in Wilkinson and adjacent counties.

The Barnwell and Ocala formations are stratigraphic equivalents, intergrading in central Georgia, and thus indicating a change from littoral facies of predominantly red argillaceous sand and gray to green fuller's earth type clay to the north and northeast, to deeper water off-shore deposits of relatively pure, extremely fossiliferous limestone to the south and southwest.

Most of the fossil remains collected during this investigation were obtained from the Ocala formation, the fauna including a wide variety of pelecypods, several types of gastropods and echinoids, prolific bryozoans, and a few dwarfed foraminifers. The majority of the pelecypods and gastropods are represented by poorly preserved molds and casts. A few forms, such as <u>Ostrea</u>, <u>Pecten</u>, and <u>Chlamys</u>, yet retain the original shell material. The larger echinoids, such as

Periarchus and several others, likewise retain the original calcareous shell. Bryozoans occur in the original shell and as molds and casts.

The Barnwell sands contain a few bryozoan remains, with a limited number of molds and casts of gastropods. The Twiggs clay member is reported to have yielded a dwarfed foraminiferal assemblage similar to those of the Ocala formation.

The writer studied many of the exposures described by previous authors, and many others heretofore undescribed. During the present investigation outcrops of the Ocala were best exposed in quarries. At a few localities, complete sections including most of the members of the Barnwell, in association with the Tivola portion of the Ocala, were found cropping out above the Tuscaloosa formation of Upper Cretaceous age. The Barnwell is exposed predominantly in road cuts and deep gullies, north of central Georgia, and includes the Twiggs clay and Irwinton sand members in most areas studied.

No attempt was made to map in detail the outcrop area, since fairly recent mapping was done by F. Stearns MacNeil of the United States Geological Survey in 1947. MacNeil's map, and the Geologic Map of Georgia, prepared in 1939, by the Georgia Division of Mines, Mining, and Geology, was employed to trace the outcrops across the State.

The writer spent a year in studying the Jackson stage across the State of Georgia. Changes in lithology, both lateral and vertical, were discovered in central Georgia, especially in Peach, Houston, and Twiggs counties. The change from facies distinctly clastic (sand and clay) to that of an off-shore type (limestone) was noted in several complete sections, and such beds were traced northward and southward beyond the critical intertonguing areas, to the more typical deposits of each formation.

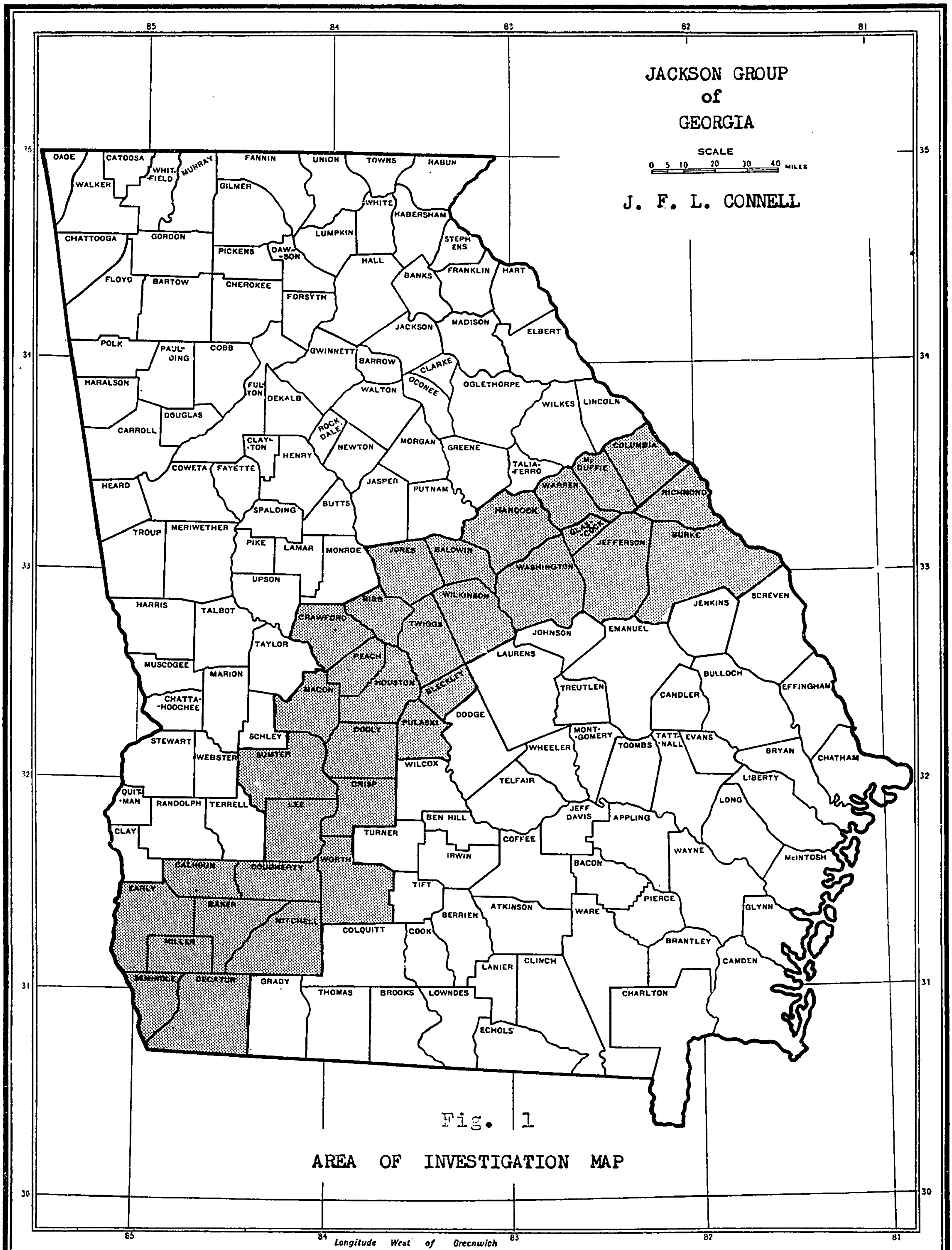


Fig. 1

AREA OF INVESTIGATION MAP

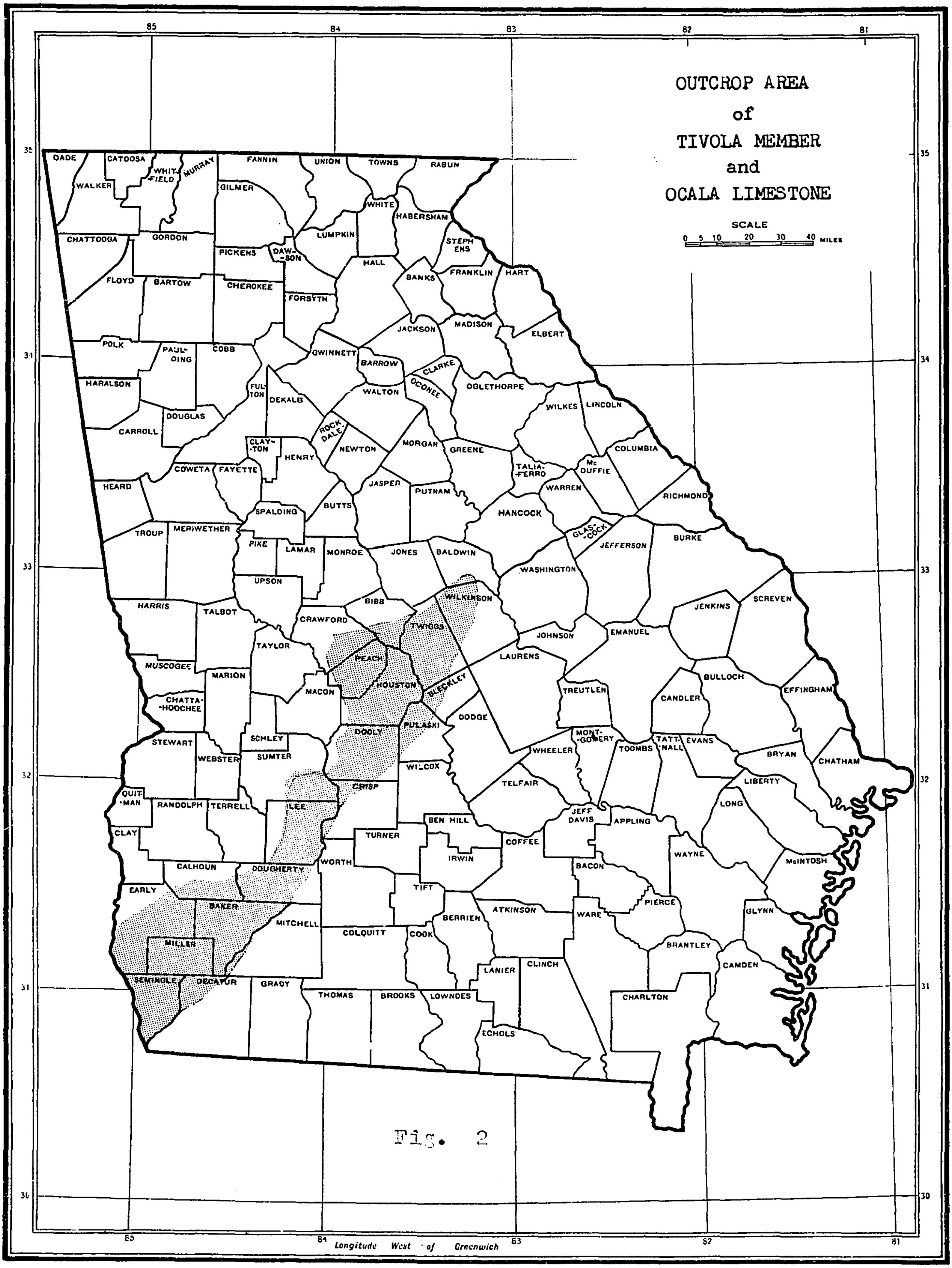

OUTCROP AREA
of
TIVOLA MEMBER
and
OCALA LIMESTONE
SCALE
0 5 10 20 30 40 MILES
DADE
CATOOSA
WHIT-FIELD
MURRAY
FANNIN
UNION
TOWNS
RABUN
WALKER
GILMER
WHITE
HABERSHAM
LUMPKIN
STEPHENS
CHATTOOGA
GORDON
PICKENS
DAW-SON
HALL
BANKS
FRANKLIN
HART
FLOYD
BARTOW
CHEROKEE
FORSYTH
JACKSON
MADISON
ELBERT
POLK
PAUL-DING
COBB
GWINNETT
BARROW
CLARKE
OCONEE
OGLETHORPE
HARALSON
FUL-TON
DEKALB
WALTON
WILKES
LINCOLN
DOUGLAS
CARROLL
ROCK DALE
CLAY-TON
HENRY
NEWTON
MORGAN
GREENE
TALIA-FERRO
Mc DUFFIE
COLUMBIA
COWETA
FAYETTE
JASPER
PUTNAM
WARREN
RICHMOND
HEARD
SPALDING
BUTTS
HANCOCK
TROUP
MERIWETHER
GLAS-COCK
JEFFERSON
BURKE
PIKE
LAMAR
MONROE
JONES
BALDWIN
WASHINGTON
UPSON
HARRIS
TALBOT
BIBB
WILKINSON
JENKINS
SCREVEN
CRAWFORD
TWIGGS
JOHNSON
EMANUEL
TAYLOR
PEACH
LAURENS
MUSCOGEE
MARION
HOUSTON
BLECKLEY
BULLOCH
EFFINGHAM
MACON
TREUTLEN
CANDLER
CHATTA-HOOCHEE
DODGE
PULASKI
DOOLY
SCHLEY
STEWART
MONT-GOMERY
TATT-NALL
EVANS
WEBSTER
SUMTER
WHEELER
TOOMBS
BRYAN
CHATHAM
WILCOX
CRISP
LIBERTY
QUIT-MAN
RANDOLPH
TERRELL
LEE
TELFAIR
JEFF DAVIS
APPLING
LONG
CLAY
BEN HILL
TURNER
COFFEE
WORTH
IRWIN
WAYNE
McINTOSH
CALHOUN
DOUGHERTY
BACON
EARLY
TIFT
PIERCE
BAKER
ATKINSON
WARE
GLYNN
MITCHELL
BERRIEN
COLQUITT
COOK
BRANTLEY
MILLER
LANIER
CLINCH
CAMDEN
SEMINOLE
DECATUR
GRADY
THOMAS
BROOKS
LOWNDES
CHARLTON
ECHOLS
Longitude West of Greenwich

Fig. 2

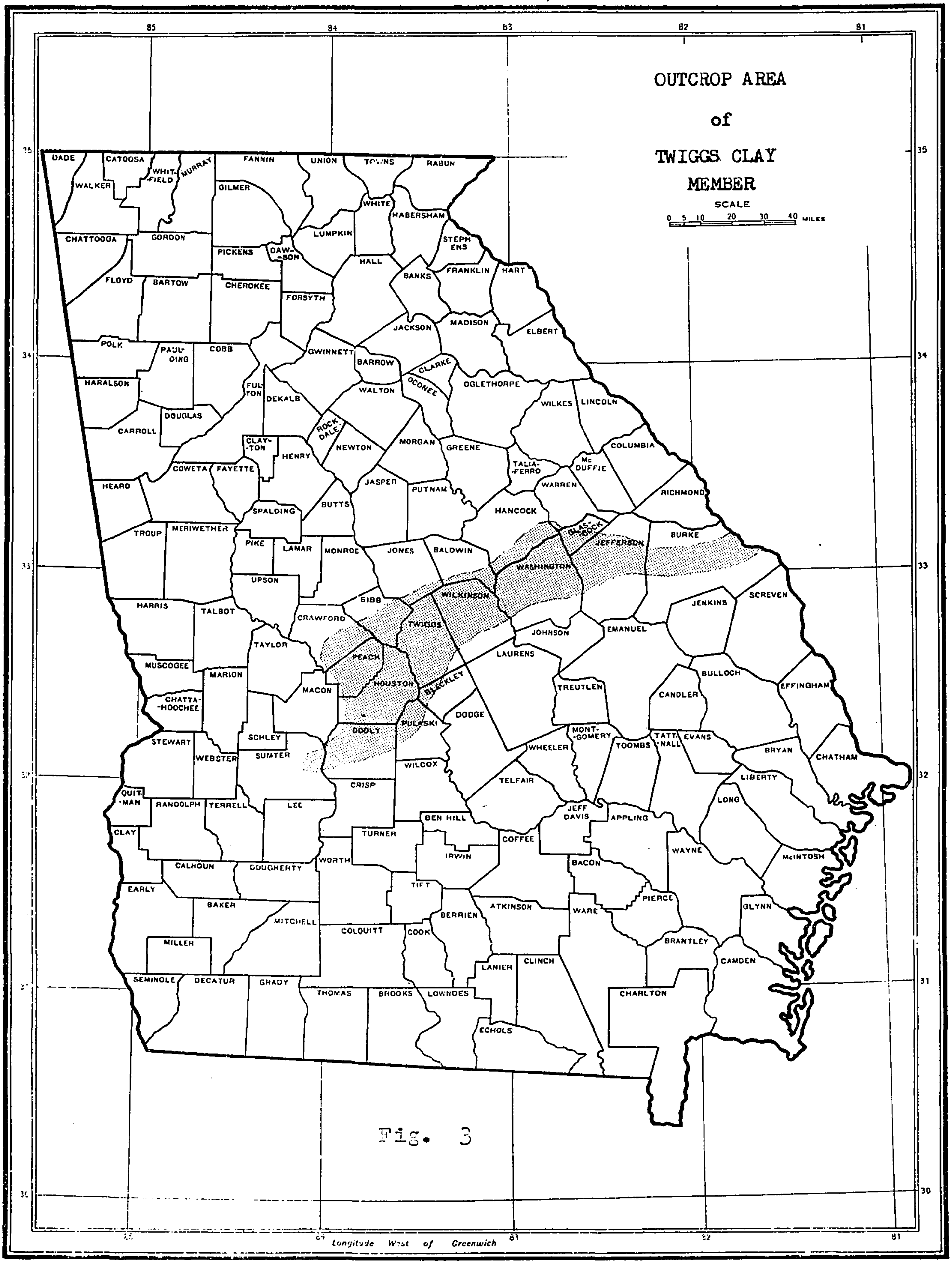
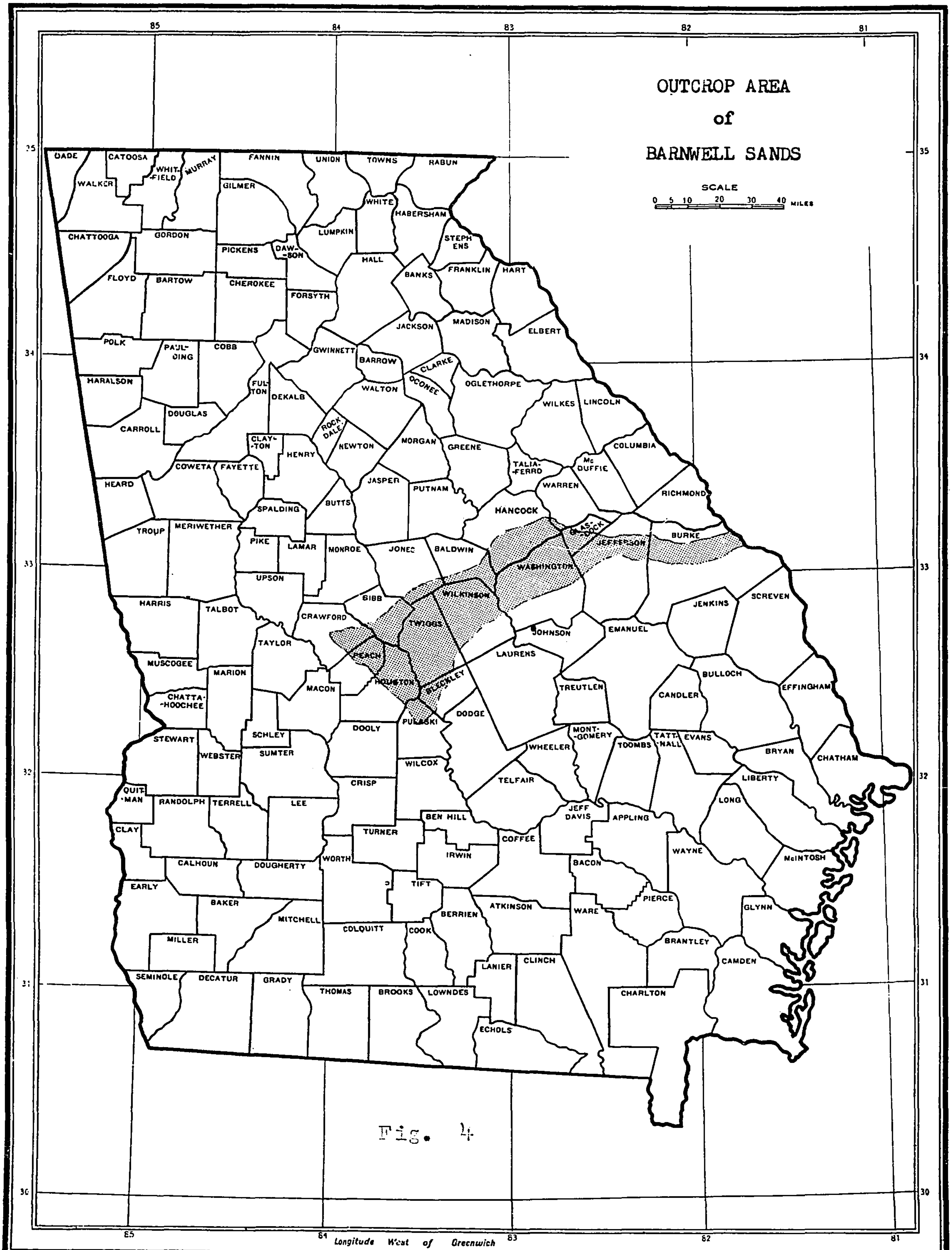

OUTCROP AREA
of
TWIGGS CLAY
MEMBER
SCALE
0 5 10 20 30 40 MILES
85
84
83
82
81
35
34
33
32
31
30
Longitude West of Greenwich
DADE
CATOOSA
WHITFIELD
MURRAY
FANNIN
UNION
TOWNS
RABUN
WALKER
GILMER
WHITE
HABERSHAM
LUMPKIN
CHATTOOGA
GORDON
PICKENS
DAWSON
STEPHENS
HALL
FRANKLIN
HART
BANKS
FLOYD
BARTOW
CHEROKEE
FORSYTH
JACKSON
MADISON
ELBERT
POLK
PAULDING
COBB
GWINNETT
BARROW
CLARKE
OCONEE
OGLETHORPE
HARALSON
FULTON
DEKALB
WALTON
WILKES
LINCOLN
DOUGLAS
CARROLL
ROCKDALE
CLAYTON
HENRY
NEWTON
MORGAN
GREENE
COLUMBIA
TALIAFERRO
McDUFFIE
COWETA
FAYETTE
HEARD
JASPER
PUTNAM
WARREN
RICHMOND
SPALDING
BUTTS
HANCOCK
GLASCOCK
TROUP
MERIWETHER
PIKE
LAMAR
MONROE
JONES
BALDWIN
JEFFERSON
BURKE
WASHINGTON
UPSON
HARRIS
TALBOT
BIBB
WILKINSON
CRAWFORD
TWIGGS
JENKINS
SCREVEN
JOHNSON
EMANUEL
TAYLOR
PEACH
LAURENS
MUSCOGEE
MARION
HOUSTON
BLECKLEY
BULLOCH
MACON
TREUTLEN
EFFINGHAM
CHATTAHOOCHEE
CANDLER
DODGE
PULASKI
DOOLY
SCHLEY
STEWART
WEBSTER
SUMTER
MONTGOMERY
WHEELER
TOOMBS
TATTNALL
EVANS
BRYAN
CHATHAM
WILCOX
LIBERTY
QUITMAN
CRISP
TELFAIR
RANDOLPH
TERRELL
LEE
LONG
JEFF DAVIS
APPLING
BEN HILL
CLAY
TURNER
COFFEE
WAYNE
IRWIN
McINTOSH
CALHOUN
DOUGHERTY
WORTH
BACON
EARLY
TIFT
PIERCE
BAKER
ATKINSON
WARE
GLYNN
MITCHELL
BERRIEN
COLQUITT
COOK
BRANTLEY
MILLER
LANIER
CLINCH
CAMDEN
SEMINOLE
DECATUR
GRADY
THOMAS
BROOKS
LOWNDES
CHARLTON
ECHOLS

Fig. 3


OUTCROP AREA
of
BARNWELL SANDS
SCALE
0 5 10 20 30 40 MILES
Longitude West of Greenwich
DADE
CATOOSA
WHIT-FIELD
MURRAY
FANNIN
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GLAS-COCK
BURKE
PIKE
LAMAR
MONROE
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BACON
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TIFT
PIERCE
BAKER
ATKINSON
WARE
GLYNN
MITCHELL
BERRIEN
COLQUITT
COOK
MILLER
BRANTLEY
CLINCH
CAMDEN
LANIER
SEMINOLE
DECATUR
GRADY
THOMAS
BROOKS
LOWNDES
CHARLTON
ECHOLS

Fig. 4

CHAPTER II

GEOGRAPHY

Physiographic Divisions

The area described in this report is included in the Coastal Plain Province. It is bounded on the northwest by the Piedmont Province, from whence the streams descend from the resistant Pre-Cambrian crystalline surface to the more easily eroded clay, sand, and limestone deposits of Cretaceous, Tertiary, and Quaternary age. At the juncture of these two distinct physiographic provinces, a decrease in the gradient of the streams results in a zone of falls and rapids, from whence the name Fall Zone is derived.

The Coastal Plain Province has been subdivided in Georgia into at least six topographic areas (Cooke, 1925, pp. 19-54), each distinctive in component topography and rock types. The differing lithologies and different erosional intervals of time involved in carving the respective areas constitute the fundamental factors which have produced the dissimilar types of topography.

At the juncture of the Coastal Plain and the Piedmont provinces is an area of hills and valleys which corresponds approximately to the outcrop of the Upper Cretaceous rocks. This area is known as the Fall Line Hills. In Peach County and immediately adjacent areas the Fort Valley Plateau is supported by the firm argillaceous sand of the Barnwell formation of Upper Eocene age. In southwest-central Georgia, the Dougherty Plain derives its low, flat karst topography from the readily soluble Ocala limestone (Upper Eocene) and the calcareous portions of the Flint River formation (Upper Oligocene). The Dougherty Plain is drained essentially by the Flint River, a prominent southward-flowing stream rising immediately south of Atlanta, Fulton County, and joining the Chattahoochee River in extreme southwestern Seminole County, Georgia.

The Louisville Plateau, termed the "Red Hill" (Veatch, 1911, pp. 28-30), overlooks the Fall Line Hills to the east of the Oconee River in Washington and Jefferson counties. This prominent topographic feature is underlain by the main body of the Barnwell formation, which in this area consists essentially of red argillaceous sand.

The Tifton Upland occurs coastward from the aforementioned topographic features, and is separated therefrom by a more or less continuous and conspicuous escarpment, consisting of more resistant sands and gravels of the Oligocene and Miocene residuum-bearing formations.

Extending eastward between the Tifton Upland and the

Atlantic Ocean is a broad band of seven distinct Coastal Terraces. These relatively unchanged Pleistocene sea floors were exposed by the gradual southeastward retreat of the sea to successively lower levels. The area occupied by these terraces, excepting that adjacent to the streams, is flat, and is at many places swampy. The flatness of the terrace surfaces is due in part to the brief time that they have been subjected to erosion, and in part to the lack of soluble rocks underlying them.

Drainage

At least six main rivers and numerous tributaries drain the area under discussion. Four of the streams flow southeastward across the area of outcrop of the main part of the Barnwell formation; the remaining two drain the area underlain by the Ocala limestone and flow southward into the Gulf of Mexico.

From northeast to southwest the main streams include first, the Savannah River, the boundary between South Carolina and Georgia. The Savannah is formed by the confluence of the Seneca and Tugaloo rivers in eastern Hart County, Georgia, flows southeastward between the two states, and discharges into the Atlantic Ocean at Savannah, Chatham County, Georgia.

The Ogeechee River rises in eastern Greene County, and flows southeastward into St. Catherine's Sound in Bryan County. Its main tributaries include Little Ogeechee, Williamson Swamp, Rocky, Buckhead, and Rocky Comfort creeks, all of which have dissected the main area of Barnwell outcrop.

The main channel of the Oconee River rises in eastern Morgan County, where its upper tributaries, Greenbrier, Hard Labor, and Sandy creeks, and the Appalachee River, combine southeast of the town of Swords. In the area of outcrop of the Barnwell formation, the Oconee is joined by such large tributaries as Buffalo, Big Sandy, Commissioners, Town, and Turkey creeks, all of which have cut into the thick Tuscaloosa kaolin deposits which underlie the Barnwell formation throughout this part of Georgia.

The Ocmulgee River, perhaps the largest stream in central Georgia, rises in Lloyd Shoals Reservoir, a large lake formed by the confluence of Alcovy, Yellow, and South rivers, and Tussahaw Creek, where Jasper, Butts, and Newton counties adjoin southeast of Worthville, Butts County. Below this juncture, the main feeder streams of the Ocmulgee River include Towaliga River, and Rum and Falling creeks north of Macon, Bibb County, and Rocky, Tobesofkee, Echeconnee, Stone, Mossy, Indian, Flat, Savage, Tenmile, Horse, and Little Ocmulgee creeks, south of Macon. The Ocmulgee and Oconee rivers join in the southeastern part of Wheeler County to form the larger Altamaha River, which continues to the Atlantic Coast, where it flows into Altamaha Sound north of St. Simon

Island.

The Flint River rises immediately south of Atlanta, Fulton County, and flows southward and southwestward across the State, to join the main channel of the Chattahoochee River in southwestern Seminole County. The main tributaries of Flint River which have dissected the outcrop area of the Ocala limestone in southwestern Georgia, north of Albany, Dougherty County, include Kinchafoonee, Muckaloochee, Muckalee, Lochochee, Piney Woods, Swift, and Cedar creeks. South of Albany, other main feeder streams include Chickasawatchee, Ichawaynochaway, Cooleewahee, Kiokee, Aycock, Dry, and Spring creeks.

The Chattahoochee River rises in White County, extreme northeastern Georgia, flows southwestward past Atlanta to the Alabama state line in Troup County, thence southward, forming the boundary between Alabama and Georgia, to the town of Chattahoochee, Florida, where, joining the Flint, it forms the Appalachicola River, which flows into the Gulf of Mexico at the town of its namesake. In the outcrop area under discussion the only noteworthy tributary flowing westward into the Chattahoochee River is Sowhatchee Creek in Early County.

Soils

The entire area occupied by the Coastal Plain of Georgia, from the Fall Line southeastward to the Atlantic Coast, is composed of soft to hard sands, clays, and limestones, most of which were deposited by marine waters which lapped upon the crystalline foundation rocks of the Piedmont. These sediments range in age from Upper Cretaceous to Recent, and extend coastward in concentric bands of outcrops. The strike or compass direction of the lines of outcrops of the various formations is northeast-southwest.

The Upper Cretaceous formations of the Coastal Plain of Georgia are represented mostly in the southwestern part of the State, in stratigraphic sequence consisting of the Tuscaloosa, Eutaw, Blufftown, Cusseta, Ripley, and Providence. All of these units have supplied much of the weathered mantle on which the fertile soils of the southwestern corner of the State have developed. The Tuscaloosa, which occupies most of the area of the Fall Line and "Sandhills," of this report, consists of white to pink to red quartz sands, and very thick deposits of kaolin. These rocks were derived from the weathering of the older gneisses and schists of the Piedmont to the northwest of the Coastal Plain. The disintegration of the Tuscaloosa sands has resulted in the formation of the deep sandy soils of the "Sandhills" district, which trends across the inner edge of the Coastal Plain.

The weathered red argillaceous sands of the Barnwell (Upper Eocene) formation are the source of the strata in the "Redhills" area, which includes such features as the Fort Valley and Louisville plateaus, and part of the Dougherty

Plain to the south and southeast. Most of the Dougherty Plain, however, is covered with sand, gravel, loam, and chert, derived from the weathering of the Clayton formation (Paleocene), Ocala limestone (Upper Eocene), and Flint River formation (Upper Oligocene).

To the east and southeast the Tifton Upland and many of the eroded river terraces are covered with sands and gravels derived from the Barnwell formation (Upper Eocene) and the Hawthorne formation (Lower Miocene).

The area under discussion in this report lies in that part of Georgia occupied by three of the eight major soil areas of the State (Soil Map, 1944), including the Sandhills Province, Upper Coastal Plain Province, and Middle Coastal Plain Province. Parts of Crawford, Bibb, Peach, Twiggs, Jones, Wilkinson, Baldwin, Washington, Hancock, Glascock, Columbia, and Richmond counties are included in the Sandhills Province. This province contains a narrow belt of deep sandy soils, extending across the inner edge of the Coastal Plain, as well as segments of several other soil series. The Kershaw Series is derived mainly from weathered Tuscaloosa sands, and forms a hilly, rolling topography. The Gilead and Vaucluse, in association with the Kershaw, occupy only small areas in the Sandhills Province. The Kershaw is a gray sand, occasionally loamy, extending to a depth of 72 inches. The Gilead is a gray sandy loam to loamy sand, and the Vaucluse is a yellow grayish-brown or brownish-yellow loamy sand to light sandy loam. All of these ara upland soils, covered essentially by pine, scrub oak, and turkey oak, and affording very small acreage for cultivation of cotton and corn.

East and southeast of the Sandhills Province is the Upper Coastal Plain Province, which embraces parts or all of several counties described in this report and occurs on or near the eastern boundary of the Province. From southwest to northeast, these counties include Early, Calhoun, Dougherty, Lee, Sumter, Dooly, Houston, Pulaski, Bleckley, Wilkinson, Washington, Jefferson, Richmond, and Burke. Counties on the inner edge, or those covered entirely by the soils of the Province, include Macon, Peach, Crawford, and Twiggs.

The Upper Coastal Plain Province contains several soil series within an area generally known as the "Redlands." These include Lakeland grayish-brown sand to loamy sand, Norfolk gray to pale yellow sand to sandy loam, Greenville dark-brown to reddish-brown sandy loam to clay loam, Magnolia grayish-brown to brown sandy loam to fine sandy loam, Faceville brownish-yellow to grayish-brown fine sandy loam, Carnegie dark-gray to brownish-gray sandy loam to fine sandy loam, with small iron concretions, Red Bay brown to reddish-brown sand to loam, Sumter light-yellowish gray or gray clay, Vaiden brownish-gray to brownish-yellow heavy clay, Eutaw light-gray clay mottled to brown and red, and Orangeburg grayish-brown sand to fine sandy loam. The Sumter, Vaiden, and Eutaw series constitute the "black belt" of central Georgia. These soils consist of badly weathered calcareous Twiggs clay and Tivola limestone, which become dark gray to black when completely decomposed. The "Redlands" are derived from the weathered materials of the red argillaceous sands of the Barnwell formation, and occupy quite flat to rolling topography. These Upper Coastal Plain soils are well adapted to mechanized farming, supporting extensive acreages of peach orchards and pecan groves. Macon, Peach, and the part of Crawford County occupied by the aforementioned soils, are the main peach-producing areas of the state. Other than fruit and nuts, considerable areas in central Georgia and the southcentral part of the Province under discussion support large acreages in corn, small grains, lespedeza, cotton, and peanuts. During the past several years, much of the former cotton-growing area has been converted into pasture land, supporting a profitable beef and dairy cattle industry.

The eastern and southernmost counties involved in this report occupy the western limits of the third major soil area in this part of the State, the Middle Coastal Plain Province. The soil series represented in these outermost counties include the already described Lakeland and Norfolk sandy soils, the Tifton grayish-brown sandy loam and fine sandy loam to loamy sand, both with concretions of iron, Ruston gray or grayish-brown loam to fine sandy loam, and Susquehanna gray to brownish-gray sandy loam to clay. Miscellaneous soils along the Savannah River, are here defined by soil scientists as undifferentiated alluvial and swamp soils.

The Middle Coastal Plain Province is characterized by an undulating to rolling topography. Norfolk and Tifton soils occur on the higher portions of the uplands, whereas the Lakeland occupies the lower slopes. The area of southwest and south-central Georgia is noted for heavy production of tobacco on these soils, Albany, Dougherty County, being the principal tobacco center in this part of the State. Other than tobacco, general crops such as peanuts, corn, cotton, and small grains, together with beef cattle, are produced in quantity. The counties discussed in this report which are occupied by the aforementioned soil series include, from southwest to northeast, Seminole, Decatur, Miller, Early, Baker, Mitchell, Dougherty, Crisp, Dooly, Pulaski, Bleckley, Washington, Jefferson, Burke, and Richmond.

Native Forest Vegetation

The Coastal Plain abounds in a great variety of native trees, particularly pines. The Upper Coastal Plain is characterized by both shortleaf (*Pinus echinata* Mill.) and loblolly pine (*Pinus taeda* Linne'), which occur in association with numerous oaks (*Quercus*) and black gum (*Nyssa sylvatica* Marsh). The middle and southerly areas of the Coastal Plain were once covered by immense stands of longleaf pine (*Pinus palustris* Mill.), but this species has been replaced by the faster-growing slash pine (*Pinus elliotii* Engelm.). Slash pine is the most important species in Georgia, supporting a large pulpwood, lumber, and naval stores industry. Along the many streams and in the swamps of southern and southeastern Georgia occur the moss-covered live oak (*Quercus virginiana* Mill.), baldcypress (*Taxodium distichum* Linne'), and the aforementioned black gum. The only remaining magnolia growing in the same habitat is *Magnolia grandiflora* Linne'.

Climate

The climate of Georgia involves long, relatively warm summers, with little variation in daily temperatures, and brief, mild winters. The southern and central parts of the State are especially warm, with mean temperatures for July ranging from 77° to 82° F. The highest temperatures, occurring from May to October, occasionally exceed 100°.

The higher elevations in the northern part of the State are responsible for much more moderate temperatures than would normally be expected. Maximum temperatures recorded at Atlanta, Fulton County, are in the vicinity of 100°, but this has occurred only twice within the past 50 years. Winters are mild throughout the State, the mean temperature for January seldom dropping below 40°. However, rare instances of sub-zero weather have been recorded for extreme northern

Georgia. Annual mean temperatures recorded (La Forge, et. al., 1925, pp. 3,4) at some of the larger cities include Atlanta, Fulton County, 61°; Gainesville, Hall County, 60°; Rome, Floyd County, 61°; Augusta, Richmond County, 64°; Savannah, Chatham County, 67°; and Brunswick, Glynn County, 68°.

Georgia has an average of 165 clear days per year, and 98 rainy days. The length of the growing season varies from 190 days in the north-central part of the State, to 300 on the extreme southeast coast.

The average annual precipitation ranges from 46 inches in northeast-central Georgia, from Twiggs County northeastward to the Savannah River, to 76 inches in the mountains of Towns and Rabun counties in northern Georgia, along the North and South Carolina state lines (see Rainfall Map). Between these two extremes, the average annual precipitation decreases from 54 inches in the north, to 50 inches over the central Georgia Piedmont, and from 54 inches in the southwestern part of the State, to 46 inches in the central and eastern parts of the State.

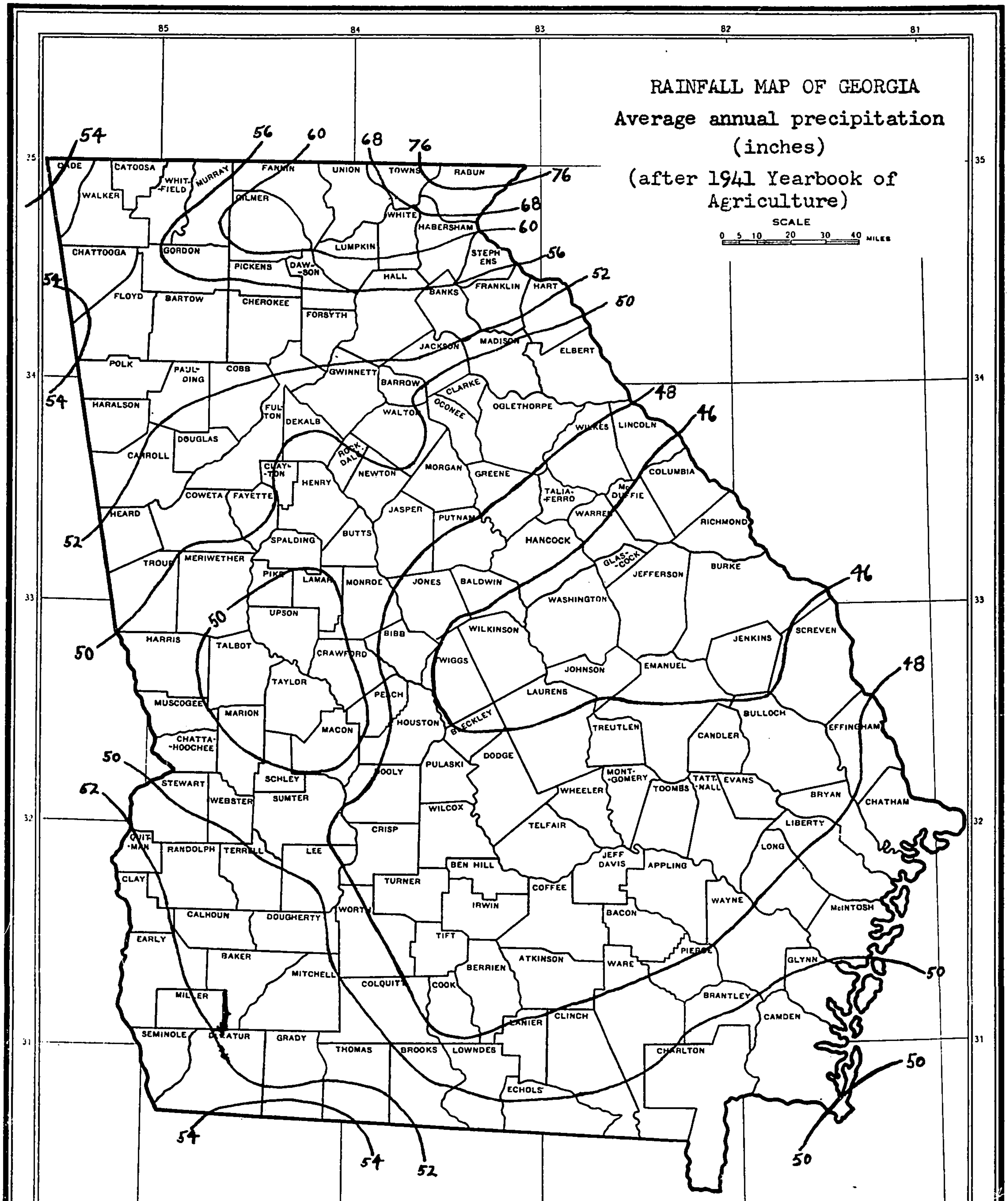
RAINFALL MAP OF GEORGIA
Average annual precipitation
(inches)
(after 1941 Yearbook of
Agriculture)
SCALE
0 5 10 20 30 40 MILES
85
84
83
82
81
35
34
33
32
31
30
Longitude West of Greenwich
54
56
60
68
76
76
68
60
56
52
50
48
46
46
48
50
50
52
54
54
54
52
50
50
52
54
54
52
50
50
DADE
CATOOSA
WHIT-FIELD
MURRAY
FANNIN
UNION
TOWNS
RABUN
WALKER
GILMER
WHITE
HABERSHAM
CHATTOOGA
GORDON
LUMPKIN
STEPHENS
PICKENS
DAWSON
HALL
BANKS
FRANKLIN
HART
FLOYD
BARTOW
CHEROKEE
FORSYTH
JACKSON
MADISON
ELBERT
POLK
PAULDING
COBB
GWINNETT
BARROW
CLARKE
OCONEE
OGLETHORPE
HARALSON
FULTON
DEKALB
WALTON
WILKES
LINCOLN
DOUGLAS
CARROLL
ROCKDALE
CLAYTON
HENRY
NEWTON
MORGAN
GREENE
COLUMBIA
TALIAFERRO
McDUFFIE
WARREN
COWETA
FAYETTE
HEARD
JASPER
PUTNAM
RICHMOND
SPALDING
BUTTS
HANCOCK
TROUP
MERIWETHER
GLASCOCK
JEFFERSON
BURKE
PIKE
LAMAR
MONROE
JONES
BALDWIN
WASHINGTON
UPSON
HARRIS
TALBOT
BIBB
WILKINSON
JENKINS
SCREVEN
CRAWFORD
TWIGGS
JOHNSON
EMANUEL
TAYLOR
PEACH
LAURENS
MUSCOGEE
MARION
MACON
HOUSTON
BLECKLEY
TREUTLEN
BULLOCH
CANDLER
EFFINGHAM
CHATTAHOOCHEE
DODGE
STEWART
SCHLEY
DOOLY
PULASKI
MONTGOMERY
WHEELER
TOOMBS
TATTNALL
EVANS
BRYAN
CHATHAM
WEBSTER
SUMTER
WILCOX
TELFAIR
LIBERTY
QUITMAN
RANDOLPH
TERRELL
LEE
CRISP
LONG
JEFF DAVIS
APPLING
BEN HILL
CLAY
TURNER
COFFEE
WAYNE
IRWIN
McINTOSH
CALHOUN
DOUGHERTY
WORTH
BACON
EARLY
TIFT
BAKER
PIERCE
MITCHELL
ATKINSON
WARE
GLYNN
BERRIEN
COLQUITT
COOK
BRANTLEY
MILLER
LANIER
CLINCH
CAMDEN
SEMINOLE
DECATUR
GRADY
THOMAS
BROOKS
LOWNDES
CHARLTON
ECHOLS

Fig. 5

CHAPTER III

EOCENE STRATIGRAPHY

The Eocene Series of Georgia

The Eocene series of Georgia consists of three distinct groups. From oldest to youngest, these are: Wilcox, Claiborne, and Jackson. Underlying the Wilcox is an older unit, the Clayton (Midway) formation of Paleocene age, which rests unconformably upon the Upper Cretaceous Providence sand in western Georgia, and extends eastward to Macon County.

The Wilcox group is represented by the Hatchetigbee formation, which crops out essentially west of southeastern Stewart County, with a few isolated remnants in Terrell, Webster, Clay, and Randolph counties.

The Claiborne group is represented by the McBean formation, mapped in easternmost Georgia only, and the Lisbon and Tallahatta formations, which are represented in western and subcentral Georgia.

The Jackson group, the sequence under discussion in this paper, consists of the Ocala limestone, which includes the Tivola tongue, and the equivalent Barnwell formation.

The latter consists of the Twiggs clay member, the Irwinton sand member, the Sandersville limestone member, and the Upper Sand member. The uppermost Jackson beds are believed to include the Cooper marl formation, a conception controversial for a number of years.

The Ocala limestone extends from the type locality at Ocala, Marion County, Florida, northwestward and northeastward across southern Alabama into southwestern and central Georgia, as far north as Twiggs and Wilkinson counties, where the lower part of the formation extends as a tongue of soft limestone and calcareous sand far into the area of Barnwell outcrop. This latter portion of the Ocala is termed in this report the Tivola member of the Ocala limestone. The Tivola is in turn conformably overlain at most localities studied in central Georgia, by the Twiggs clay member of the Barnwell formation, except in Pulaski County where the positions of the units are reversed.

In central Georgia the Ocmulgee River is considered arbitrarily as the boundary between the two main parts of the Jackson group, but several prominent lenses of sand and fuller's earth of the Barnwell have been observed in several counties south of the river indicating an encroachment of the clastic deltaic environment of the Barnwell into the deeper water, off-shore environment of the Ocala sea.

In areas of Jackson overlap upon older strata, it rests unconformably upon either the thick kaolin and sand deposits of the Tuscaloosa formation of Upper Cretaceous age, or upon the Pre-Cambrian crystalline rocks of the Piedmont, as in the northwesternmost areas of exposure of the Barnwell formation.

CHAPTER IV

ORIGIN OF TERMINOLOGY

Ocala Limestone

First valid use of the term Ocala as a formation name appears to have been by Dall (1892, pp. 103-104), who used it to describe a "yellowish friable rock containing many Foraminifera, notable among which were *Nummulites willcoxii* and *N. floridanus* Hp." Dall first described the unit as "Nummulitic beds, Ocala limestone." The formation, prior to Dall's use of the name Ocala, was considered by Heilprin (1883, pp. 189-193) to be of Oligocene age because of the association of numerous *Nummulites* with *Orbitoides ephippium*. On the basis of this evidence he correlated the unit with the "Nummulitic" of Europe. Prior to Heilprin's work, Eugene A. Smith (1881, pp. 292-309) published observations on large areas of limestone underlying western and peninsular Florida, correlating these strata with the Vicksburg limestone of Alabama and Mississippi, naming them the Vicksburg limestone.

Veatch and Stephenson (1911, p. 255) classified most of the Ocala limestone of Georgia as Vicksburgian, but interpreted the upper part of the unit as Jacksonian in age. Cooke

(1915, pp. 107-117) first employed the name Ocala in Georgia following a study of the formation at Bainbridge, Decatur County, on Flint River. Later, Cooke and Shearer (1918, pp. 41-81) made a comprehensive study of the outcrops of the Ocala limestone at many localities in the State, reclassifying what was formerly considered to be Claibornian, and establishing beyond doubt the Jackson age of the unit.

Barnwell Formation

The name Barnwell was first employed as a stratigraphic designation by Sloan (1908, p. 454), for a sequence of sands and clays in South Carolina. In his original description, he referred to the unit as the "Barnwell buhr sands," but cited no specific area as the type locality. Later, Vaughan (1911, p. 285) studied the Barnwell of Sloan in Barnwell County, South Carolina, and described a sequence consisting of silicified clays and fuller's earth overlain by glauconitic sandy marls, with local deposits of silicified shells, buhr rock, and calcareous beds.

Veatch and Stephenson (1911, pp. 285-296) included the Barnwell sand in the McBean formation of the Claiborne group, excluding a portion of the formation of definite Jackson equivalence.

Cooke and Shearer (1918, p. 52) in making a restudy of certain fossils on which Veatch and Stephenson had based the Claiborne affinity, discovered that these fossils also occurred in the overlying Jackson beds. They assigned the Barnwell in toto to the Jackson group, including a so-called Congaree clay member at its base, which they renamed the Twiggs clay member, with type locality at Pikes Peak Station, Twiggs County, Georgia.

Veatch and Stephenson (1911, pp. 253-255) discovered an isolated limestone outcrop in the vicinity of Sandersville, Washington County, which they also included in the McBean formation. Cooke and Shearer (1918, pp. 68-69) later transferred this unit to the upper part of the Barnwell formation upon the basis of several definite Upper Eocene (Jackson) fossils in it. Cooke (1943, p. 62) later designated this sequence the Sandersville limestone member of the Barnwell formation, with type locality at Sandersville, Washington County.

LaMoreaux (1946, p. 17) reported a persistent bed of fine to coarse uncemented sand lying upon the Twiggs clay in the vicinity of Irwinton, central Wilkinson County, and capping many of the hills in the northern part of the area of Jackson outcrop. In the same publication (1946, p. 21), he noted a red sand containing polished beach pebbles lying unconformably above the uncemented sand member. He designated the red sand the Irwinton sand member of the Barnwell formation, and the overlying pebbly unit, the Upper Sand member of the Barnwell formation.

CHAPTER V

LITHOLOGY

Ocala Limestone

The Ocala limestone, named from the type locality, Marion County, Florida, underlies large tracts of southwest-central Georgia, and traverses the State in a narrow band of outcrop in a northeastwardly direction. Typical exposures are few in the area underlain by the formation because of a thick cover of residuum composed of fragmental limestone, Flint River chert, and Pleistocene sands. Most of the southwestern part of the State is dissected by southward-flowing streams, whose alluvium has covered many otherwise ideal locations for study of the Ocala limestone. During the periods of reconnaissance and detailed study by the writer, the southwestern and south-central areas of exposure of the limestone were inundated by heavy summer rains, which brimmed the majority of the streams, notably the Flint and Chattahoochee, and their tributaries. Especially along the Flint, from the town of Flintside, Sumter County, southward, was difficulty encountered in locating the classical outcrops of the Ocala formation, because of a system of dams which has been erected to impound the waters of the Flint. Lake Blackshear is such an artificial lake formed by such impounding. Flooded terrain was encountered the length of Flint River southward, except at the Crisp County Power dam northwest of Warwick, Worth County, and at the Albany dam, Dougherty County. Below Albany, the entire section was likewise concealed, including the outcrops at Newton, Baker County, and Bainbridge, Decatur County. At Saffold, Early County, on the Chattahoochee River, an outcrop reported by MacNeil (1947, Geologic Map) was submerged by high water during investigations in that area by the writer.

Between the Flint and Chattahoochee rivers, however, several outcrops of Ocala limestone were studied, ranging from poorly exposed scattered blocks, to the thick section at Armena, southwestern Lee County.

Typical exposures of Ocala limestone consist of white or cream-colored to pink, pure limestone. The lower part of the formation, which crops out at few places, is commonly a massive bed of soft, fine-grained, tan, calcareous quartz sand, containing shark teeth. In the southwestern area of exposure the limestone is massive-bedded and essentially silicified. Beneath the bridge crossing Kinchafoonee Creek southwest of Leesburg, Lee County, on the county road to Byne Crossroads, the Ocala section is composed of equal amounts of coarse quartz grains and coarse calcite crystals, and is extremely fossiliferous. This is the only locality where such extremely quartzose content was noted.

Along Flint River in the vicinity of Albany, and again west of the town of Warwick, Worth County, are two localities displaying limestones ranging from an extremely friable and finely crystalline state, to compact and coarsely crystalline.

According to Cooke (1943, p. 72), the Ocala trends north and northeastward, crossing Flint River between Swift and Pennahatchie creeks in southwestern Dooly County, but strata at this crossing were not observed by the author, since artificial Lake Blackshear now inundates the former area of outcrop. West of Flint River, however, a bed of compact to soft, badly weathered, white to cream-colored, fossiliferous sandstone was encountered along Georgia Highway 49 north of Americus, Sumter County.

East of Flint River, the Ocala limestone crops out southeast of Lilly, Dooly County, along the north slope of Pennahatchie Creek, where it consists of soft to hard, silicified, sparsely fossiliferous, semi-crystalline limestone. At this locality the limestone displays a red surficial stain on an otherwise white surface.

North of Dooling, near the Macon-Dooly county line, the formation is again a dense to friable, red-stained, partly silicified, fossiliferous limestone.

The Ocala retains its silicified character to the northeast of Dooling, where, east of Hogcrawl Creek, it consists of large blocks of fossiliferous limestone strewn about the ground, and of bedded silicified limestone in the gullies.

Macon County contains no outcrops of the Ocala limestone so far as determined by the author. An exposure, however, has been reported by MacNeil (1947, Geologic Map) south of Winchester, but the writer finds no evidence to corroborate the report.

The Ocala formation trends eastward into Houston County, where there are several excellent thick exposures in active and abandoned quarries. In Houston County the formation is soft, with a few resistant ledges occurring at intervals. The limestone is cream to white, and is extremely fossiliferous. This part of the formation was designated the Tivola tongue of the Ocala limestone by Cooke and Shearer (1918, p. 51), but in this report it is termed the Tivola member of the Ocala limestone.

This soft, friable, exceedingly fossiliferous member extends from Houston County in not too widely separated outcrops northeastward into Twiggs, Wilkinson, and Bleckley counties. The northernmost exposure is immediately south of Gordon, northwestern Wilkinson County, where ten feet of limestone and two feet of sand are exposed in the lower part of the unit. Somewhere between the Gordon locality and the Stevens Pottery clay mine, 5.6 miles to the north in Baldwin

County, the Ocala must pinch out, since it is absent at the latter locality. The Twiggs clay member of the Barnwell formation is the oldest Jackson unit at Stevens Pottery, lying with notable unconformity upon the eroded surface of the Tuscaloosa kaolin of Upper Cretaceous age.

East of the main areas of outcrop of the Tivola member exposures of the member occur along the east slope of Ocmulgee River, north of Hawkinsville, Pulaski County, and in extreme southeastern Twiggs County, on the Macon, Dublin, and Savannah Railroad. North of Hawkinsville, a massive bed of dense limestone, overlain by soft to medium dense, white, argillaceous limestone, well-stained with red iron oxide, is identified as the Tivola member, upon the basis of the fossil assemblage of lower upper Ocala age.

In extreme southeastern Twiggs County, the Tivola member consists of ledges of hard, crystalline, white to red-stained, silicified limestone, interbedded with dark red, argillaceous quartz sand. At this locality, the fossils are also of definite lower upper Ocala age.

Far to the west of the main areas of outcrop of the Tivola member is a prominent thick outlier of the member unconformably overlying the eroded Tuscaloosa surface. The lower bed of light tan, fine-grained, soft, calcareous quartz sand, containing numerous shark teeth, is well-exposed at this locality. The limy portion of the Tivola is composed of soft, white to cream to yellow, friable to hard limestone, occurring as resistant ledges, impregnated with typical Ocala bryozoans, pelecypods, gastropods, and echinoids. Such an exposure occurs at the highest point in Crawford County, six miles northeast of Roberta, thirty miles from the nearest Tivola outcrops to the east.

The Tivola member of the Ocala limestone merges laterally into the Twiggs clay member of the Barnwell formation as far south as the vicinity of Dooling, Dooly County, where the two members are present along Georgia Highway 90. Farther to the southwest, the Twiggs clay member is exposed along Georgia Highway 49 north of Americus, Sumter County, but only the lower sand of the Tivola is present. Farther to the south (east of Americus), the Twiggs clay member is present though the Tivola is absent altogether, the Twiggs being overlain by the Flint River chert of Oligocene age.

The northeasternmost exposures of the Tivola member have been reported heretofore in Twiggs, Bleckley, and parts of central Wilkinson County, the former county containing the thick Dry Branch exposure reported by innumerable previous authors. In this report, the known outcrop area of the Tivola is extended as far north as Gordon, northwestern Wilkinson County.

Heretofore, the southernmost exposures of the Barnwell formation have been placed arbitrarily at the Dooly-Houston county line (Cooke and Shearer, 1918, p. 55). Investigations induce the present writer to extend the Twiggs clay member of the Barnwell formation at least twenty-five miles southwestward to a locality northeast of Americus, Sumter County.

The lithology and fauna of the Ocala limestone suggest deposition in a shallow sea which deepened to the south and southeast. Bryozoan, pelecypod, gastropod, and echinoid remains are quite prolific throughout most localities studied, suggesting warm, clear waters quite beyond the shore. The occurrence of the lower Tivola member of the Ocala limestone as far north as northern Wilkinson County, represents a temporary advance of the Ocala sea far into the present area of outcrop of the clastic facies of the Barnwell formation, bringing with it the distinctive assemblages of Ocala marine life. As Tivola time closed, the streams flowing from the source area located to the north and northwest, brought fine clays farther southward to be deposited on the older tongue of limestone, in turn succeeded by the fine to coarse sands of the middle and upper Barnwell, which encroached on and interfingered with it, pushing the deeper water environment farther to the south, where the thicker limestone section was developed.

It can be deduced that the major parts of the Ocala and the Barnwell were deposited contemporaneously, the Barnwell representing the littoral facies of coarser material deposited adjacent to the upper Jackson strand line. Laterally, the Barnwell merges gradually to the south and southwest into the deeper-water limestone of the main part of the Ocala. Vertically it grades downward from the fine clays of the Twiggs member into the typical limy deposits of the Tivola member.

Barnwell Formation

Typical Barnwell lithology consists chiefly of fine to coarse-grained, dark red to yellow, argillaceous quartz sand. This unit can be traced almost continuously from Barnwell and Aiken counties, South Carolina, across Savannah River, southwestward into east-central Georgia, where it becomes differentiated into several distinct lithologies. In east-central Georgia, the Barnwell is divided into a much localized Channel Sand at the base, the Twiggs clay member, the Irwinton sand member, a local calcareous unit known as the Sandersville limestone member, and another unnamed coarse red sand and pebbly unit, known as the Upper Sand member, at the top of the section.

The Barnwell and its several facies appears to represent nearshore to deltaic conditions, the deposits interfingering with the off-shore materials of the Ocala limestone. Cross-bedding in the Barnwell at some localities, coarse angular grains of quartz sand, streaks of carbonaceous material, and polished beach pebbles, serve to verify this assignment to littoral and deltaic conditions which existed during Barnwell time.

Channel Sands

At several localities, the lower part of the Barnwell formation consists of pink to white, cross-bedded, fine to coarse quartz sand, containing clay balls of kaolinitic and bauxitic materials, lying with unconformity upon eroded Tuscaloosa kaolin and sand, and, where the Barnwell has overlapped upon the irregular crystalline surface of the Piedmont. This bed has been termed Channel Sand by LaMoreaux (1946, p. 7), who considers it (lowermost Barnwell) possibly Upper Eocene in age.

The Channel Sand crops out in northern Twiggs, Wilkinson, Washington, and at scattered localities in Hancock, Jones, and Baldwin counties. These sands were suggested by Stephenson and Thompson (pp. 26-28) to be derived from an older Eocene unit, older than any formation of Jackson age now present, and that some of the material composing these sands was not destroyed by the encroaching Jackson sea, because of its position in channels in the pre-Jackson surface below the zone of active cutting. Because of the limited area of outcrop, LaMoreaux (1946, p. 7) maps the exposures of the Channel Sands as Upper Eocene, noting the possibility of their relationship to the Upper Jackson deposits. Their position in the stratigraphic sequence suggests equivalence to the Gosport (Claiborne) sand of the Alabama section.

Twiggs Clay Member

The Twiggs clay member of the Barnwell formation lies conformably upon the Tivola member of the Ocala limestone in most of the sections where these beds are associated, except in Pulaski County where the Twiggs is overlain unconformably by the Tivola, suggesting a temporary transgression of the Ocala sea over the eroded Twiggs surface. Elsewhere the Twiggs overlies the kaolin or sand of the Tuscaloosa formation with notable unconformity.

Typical deposits of the Twiggs clay member consist of pale-green to gray, hackly, blocky, fuller's earth type clay, which in turn grades downward into gray blocky fossiliferous marl and sand. At a few localities the lower part of the Twiggs consists of several feet of light, greenish-gray, glauconitic sand which fills the channeled Cretaceous surface, or lies with conformity upon the Channel Sands of the basal Barnwell.

At three localities, Postell, Jones County, Stevens Pottery, Baldwin County, and an exposure 5.75 miles north of Warthen, Washington County, the basal part of the Twiggs member consists of dark blue, blocky clay of the fuller's earth type. The first two aforementioned localities expose the blue clay with prolific molluscan remains. Elsewhere, the typical pale green to gray hue persists, except where mottled by red or purple surficial stains.

The area of outcrop of the Twiggs clay member extends from the vicinity of Andersonville and Americus, Sumter County, northeastward across central and east-central Georgia, approximately to the Savannah River, where it is exposed along the Shell Bluff-McBean road in Burke County. Most of the outcrops are in Twiggs, Wilkinson, and Washington counties, where the fuller's earth is mined commercially. The typical hackly, blocky character and pale green to gray color of Twiggs lithology persists throughout the extent of its exposure, except for the aforementioned few blue clay localities. In Burke County, Along Savannah River, and at Keys Mill (now Red's Pond), the lower part of the Twiggs is characterized by a bed of large oyster shells enclosed in a matrix of hard white limestone and green clay. This is the *Ostrea georgiana* Conrad zone which occurs at the base of the Barnwell formation beyond the Savannah River in Barnwell County, South Carolina.

Irwinton Sand Member

The Irwinton sand member consists of fine to medium-grained, cross-bedded, quartz sand, ranging from yellow to light-gray to white in color. The lower part of the member exhibits a gradation of mixed laminae of typical Irwinton quartz sand, and pale gray to yellow Twiggs clay. At the type locality at Irwinton, Wilkinson County, the unit consists of yellow to gray, loose, micaceous, quartz sand, interbedded with tough yellow clay. A bed of coarse white quartz sand containing carbonaceous particles occurs at intervals in several sections studied.

The thickest portion of the Irwinton sand member is exposed in Washington, Wilkinson, and Twiggs counties, where approximately fifty feet of typical Irwinton sand crops out. It thins northward to approximately 10 feet along the northern margin of the area of outcrop of the Barnwell formation in Burke County. Southward from the typical areas of outcrop, the member thins to 6 feet at the Penn-Dixie quarry at Clinchfield, Houston County.

The unit extends to the north and west into Baldwin and Jones counties, and southward into Bleckley County, where it persists as a massive, red, argillaceous, fine to coarse-grained quartz sand, with occasional layers of tough weathered fuller's earth and scattered quartz pebbles occurring near the base.

Sandersville Limestone Member

Southwest of Sandersville, Washington County, an abandoned quarry exposes a much-localized, soft, white, fossiliferous limestone, known as the Sandersville limestone member of the Barnwell formation. The explanation of this calcareous member within an entirely clastic environment is problematical. In other scattered localities of southern and east-central Washington County, thin laminae of siliceous limestone occur within the Irwinton sand member, and are related undoubtedly to the Sandersville material. The limestone at Sandersville might conceivably represent a second temporary advance of the Ocala sea into the area of Barnwell deposition, much later than the Tivola advance. However, there is no evidence of continuous limestone deposition from this local outcrop southward into the upper part of the Ocala section, with which it is equivalent. The Sandersville member might otherwise represent a local sagging of the southern portion of the Barnwell deltaic environment, with accompanying influx of the Ocala sea with attendant marine faunas, consisting of such forms as Periarchus quinquefarius (Say), Pecten sp., and a few poorly preserved gastropod and pelecypod molds. However, the strata referred to the Irwinton sand member in and around the Sandersville locality exhibit no such sagging as would have been necessary to change the environment to one of deeper water. Where exposed, the Sandersville and the upper part of the Irwinton seem to interfinger, indicating that the two units are contemporaneous in such portions of the section. If such an inundation by the upper Ocala sea did occur, evidence of continuity between the Ocala limestone and the Sandersville member has been obliterated, the missing beds to the south having been replaced by the typical red sands and sandy clays of the Irwinton. The siliceous limestone laminae present in other parts of Washington County might possibly represent other remnants of such an encroachment by the upper Ocala sea into the Barnwell environment.

Stratigraphically, the Sandersville is equivalent to the Irwinton sand member, which occurs near the upper part of the Barnwell sequence. It is considered a yet younger deposit of Jackson age by LaMoreaux (1946, p. 18). The Sandersville and Irwinton are equivalent to the upper middle portion of the Ocala limestone, which crops out to the south.

CHAPTER VI

LITHOLOGIC DESCRIPTIONS BY COUNTIES

Ocala Limestone

The Ocala limestone lies at or near the surface in southwestern Georgia, occurring at most places as badly weathered or silicified fragments of limestone mixed with rubble derived from the overlying Flint River chert of Oligocene age. MacNeil (1947, Geologic Map) maps all of the material on either side of Flint River as "residuum of Jackson and Oligocene limestones."

This part of the State is marked by extensive solution of the Ocala limestone, with subsequent silicification of the formation by materials derived from the Flint River chert. The former outcrops of the Ocala along Flint and Chattahoochee rivers were inundated during the present investigation by high water due to impounding by dams following heavy rains, as in Decatur, Seminole, Early, Baker, and Mitchell counties.

Cooke (1943, p. 71) describes the basal beds of the Ocala limestone along Chattahoochee River at Saffold, Early County as "hard gray to yellow-brown, calcareous sandstone containing many large *Periarchus lyelli*, bryozoans, foraminifers, and other fossils." Again, "on U. S. 84 from Bainbridge to Dothan, about a mile below the railroad bridge," he reports "the Ocala rises 18 feet above water, and contains innumerable Discocyclina sp., large broad-hinged oysters, and Crassatella alta."

Brantly (1916, p. 132) reports the Ocala limestone "on Spring Creek, 1½ miles above the trestle of the Central of Georgia Railway, four miles west-northwest of Arlington, Calhoun County. The limestone rises 15 feet above the swamp level and is said to extend to a depth of at least 60 feet."

Cooke (1943, p. 72) also describes the Ocala exposures "on Flint River near Bainbridge at several places between Red Bluff, 6 miles above Bainbridge, and Blue Spring." At those localities he reports "white to cream-colored limestone composed chiefly of a loose, or case-hardened mass of marine organisms of many kinds. Orbitoid foraminifers are abundant. Echinoids are represented by Cidaris mortoni Conrad, Peronella crustuloides (Morton), Oligopygus haldemani (Conrad), Eupatagus curvus Cooke, Eupatagus ocalanus Cooke, Agassizia floridana De Loriol, and Fibularia vaughani (Twitchell). Mollusks include Pecten spillmani Gabb, P. indecisus Dall, P. suwaneensis Dall, Amusium ocalanum Dall, and others."

Good exposures of Ocala limestone in any part of southwestern Georgia are rare at this writing, for the aforementioned reasons. However, where the unit occurs in situ and is measurable, its typical characteristics may be observed. Such characteristics include the abundance of fossil remains, and the white to cream to pink limestone, which is silicified in most places in this part of the State.

Miller County

In the vicinity of Colquitt, Miller County, two poorly exposed sections of the Ocala limestone were studied. At the highway bridge, where U. S. Highway 27 crosses Spring Creek 0.2 mile southwest of Colquitt, the following section was observed in the east bank of the stream, at an elevation of 147 feet above sea level:

	Feet
Ocala limestone:	
White to pink, compact, silicified limestone, occurring as large blocks on either side of highway......................	6

At Pilgrim's Rest Church, on the county road which crosses Spring Creek 7.1 miles southwest of Colquitt, the Ocala was observed on the east bank of the stream:

Ocala limestone:	
White to pink, very dense, silicified, sparsely fossiliferous limestone, occuring as layers up to 10 inches thick, and as large blocks up to 12 feet square from creek level to level of church and cemetery....................................	20

Calhoun County

In a lime sink on the R. C. Singletary property, 4 miles northwest of Arlington, Calhoun County the following section was measured:

	Feet
Ocala limestone:	
White to red-stained, dense, partly crystalline, sparsely fossiliferous limestone occurring in layers from 5 to 12 inches thick, extending from floor of sink to level of plowed field....................	15

Four miles east of Arlington, along Georgia Highway 62, between the highway and the tracks of the Central of Georgia Railroad, the following section was observed:

	Feet
Ocala limestone:	
Large blocks (3 to 8 ft. wide) of white to cream-colored, siliceous to very soft, rotten, fossiliferous limestone, excavated from railroad and highway rights-of-way. Height of largest block............	4

In a road cut along Georgia Highway 62, 3.6 miles east of Leary, the following exposure was observed on either side of the highway:

	Feet
Ocala limestone:	
White to cream-colored, soft to very hard,	

silicified, rotten, fossiliferous limestone occurring in place and as large (2 to 5 ft.) angular blocks........ 5

Dougherty County

Several exposures of typical Ocala limestone are present in Dougherty County, along Flint River and the southern extremities of Kinchafoonee Creek. Two localities along Flint River occur immediately northeast of Albany, on the south side of the Georgia Power Company dam. On Kinchafoonee Creek, an exposure occurs at the junction of the stream with Fowltown Creek, north of Albany in southern Lee County, and again at the junction of the stream with Flint River northeast of Albany.

In these exposures only the upper three to fifteen feet of the formation were observed during the present investigation.

Immediately below the Georgia Power Company dam, 2 miles northeast of Albany, the following section was observed on Flint River during flood stage, at an elevation of 200 feet above sea level:

	Feet
River sand..................................	15
Ocala limestone:	
Hard to medium soft, pure white to cream-colored to pink, very fossiliferous limestone occurring as weathered ledges on both banks of river...........	3

Fig. 6

Large blocks of silicified Ocala limestone along Georgia Highway 62, 4 miles east of Arlington, Calhoun County.

Fig. 7

Close-up view of pitted, silicified Ocala limestone along Georgia Highway 62, 4 miles east of Arlington, Calhoun County.

Fig. 8

Extremely weathered Ocala limestone exposed on south side of Georgia Highway 62, 3.6 miles east of Leary, Calhoun County.

Fig. 9

Close-up view of hard, white, rotten Ocala limestone exposed along north side of Georgia Highway 62, 3.6 miles east of Leary, Calhoun County.

A previously reported seven-foot section was submerged.

At the junction of Flint River and Kinchafoonee Creek, 1 3/4 miles northeast of Albany, the following section was observed during the high water stage of the streams:

	Feet
River sand....................................	12
Ocala limestone:	
Compact to very soft, white to cream-colored to pink, very fossiliferous limestone occurring as badly weathered ledges on both banks of river...........	15

Lee County

At the junction of Fowltown and Kinchafoonee creeks, 3 miles northwest of Albany city limits, and one mile north of Palmyra Springs, the following section was observed east of Georgia Highway 3A:

	Feet
River sand....................................	10
Ocala limestone:	
White to cream-colored to pink, soft to medium hard, fossiliferous limestone....	15

The strata occurring in beds up to 10 inches in thickness, are exposed in a bend of Kinchafoonee Creek, approximately 50 feet south of the intersection of the two aforementioned streams. The lower part of the section forms rapids across the mouth of Fowltown Creek as it flows into Kinchafoonee Creek. The south bank of Fowltown Creek forms a 45° slope which is supported by various layers of weathered limestone, and by the soil cover. The east bank of Kinchafoonee Creek displays a foot of Ocala limestone and 10 feet of white river sand.

On both sides of the bridge spanning Kinchafoonee Creek, on the county road from Leesburg to Byne Crossroads, one mile southwest of Leesburg, the following section was observed at an elevation of 254 feet above sea level:

	Feet
River sand....................................	12
Ocala limestone:	
Very soft to very hard, coarsely arenaceous, very friable, finely to coarsely crystalline, white to cream-colored, badly weathered, very fossiliferous limestone occurring in irregular layers from 8 to 12 inches thick to water's edge on both sides of creek............	3

At the abandoned quarry of the Armena Lime Company, Armena, two miles northeast of U. S. Highway 82, and 8.8 miles northwest of Albany, the following section was observed at an elevation of 245 feet above sea level:

	Feet
Ocala limestone:	
White to cream-colored, compact to soft,	

partly silicified, fossiliferous limestone occurring as vertical walls in the quarry, and as gentle slopes to quarry floor. Individual beds 2 to 10 inches thick from top of working face to level of pond on quarry floor......................... 25

Crisp County

North and east of Dougherty County, a single Ocala limestone locality was discovered above water level along Flint River. This section occurs on the south side of the Crisp County Power dam, 2 miles west of Georgia Highway 257 and west of Warwick, Worth County. At this locality, as at Albany, the River was in flood stage, covering all excepting the upper part of the formation.

	Feet
River sand..................................	12
Ocala limestone:	
White to light gray, soft to medium hard, highly weathered, fossiliferous limestone occurring in layers from 8 to 12 inches thick, and as small to large well-rounded cobbles to water's edge.......................	10

Brantly (1916, p. 159) and other authors report that the Ocala outcrops across Flint River between Pennahatchie and Swift creeks, in Crisp County. Brantly reports the following section 2 miles south of Coney, in a bluff along Flint River, currently submerged beneath Lake Blackshear:

Fig. 10

Practically submerged Ocala limestone in Flint River, south side of Georgia Power Company dam, 2 miles north of Albany, Dougherty County.

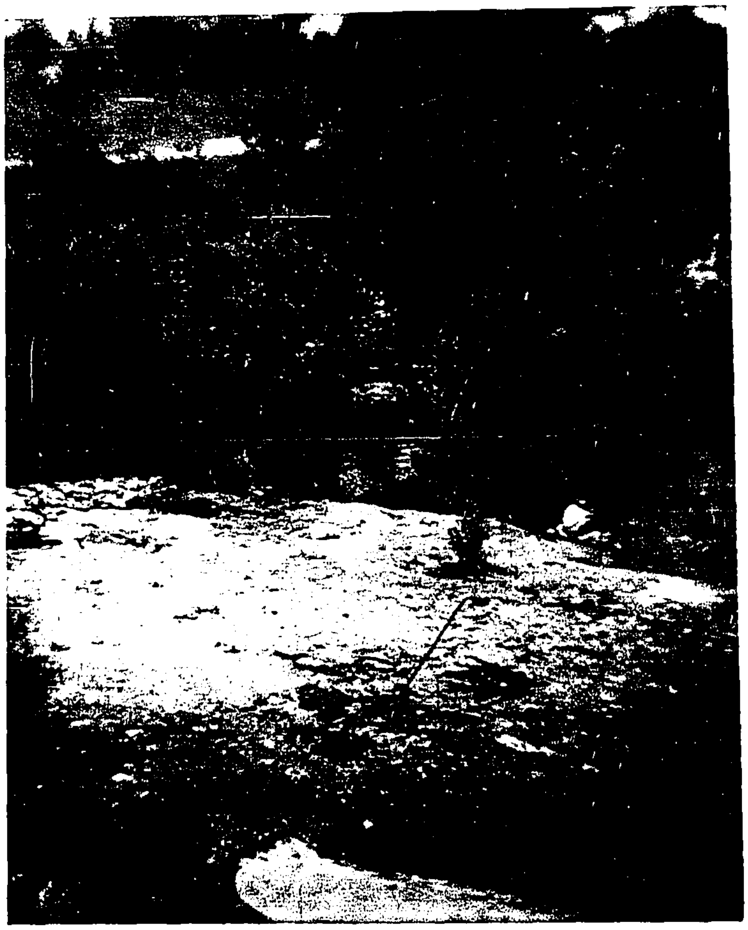

Fig. 11

Ocala limestone exposed on east side of Flint River, south side of Georgia Power Company dam, 2 miles north of Albany.

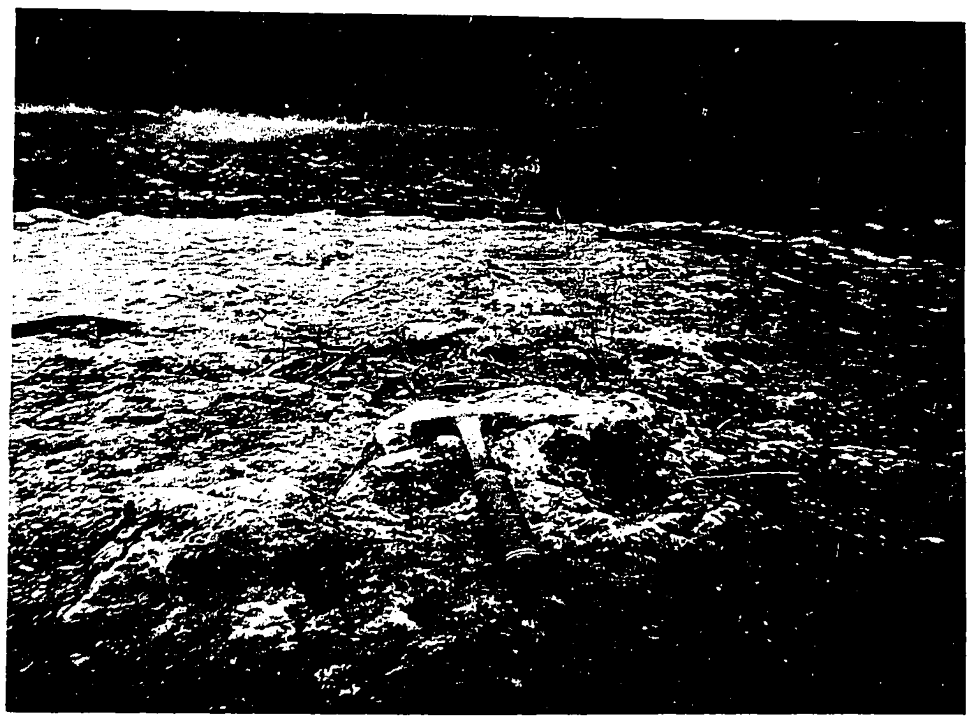

Fig. 12

Ocala limestone at water level, south side of Georgia Power Company dam, 2 miles north of Albany.

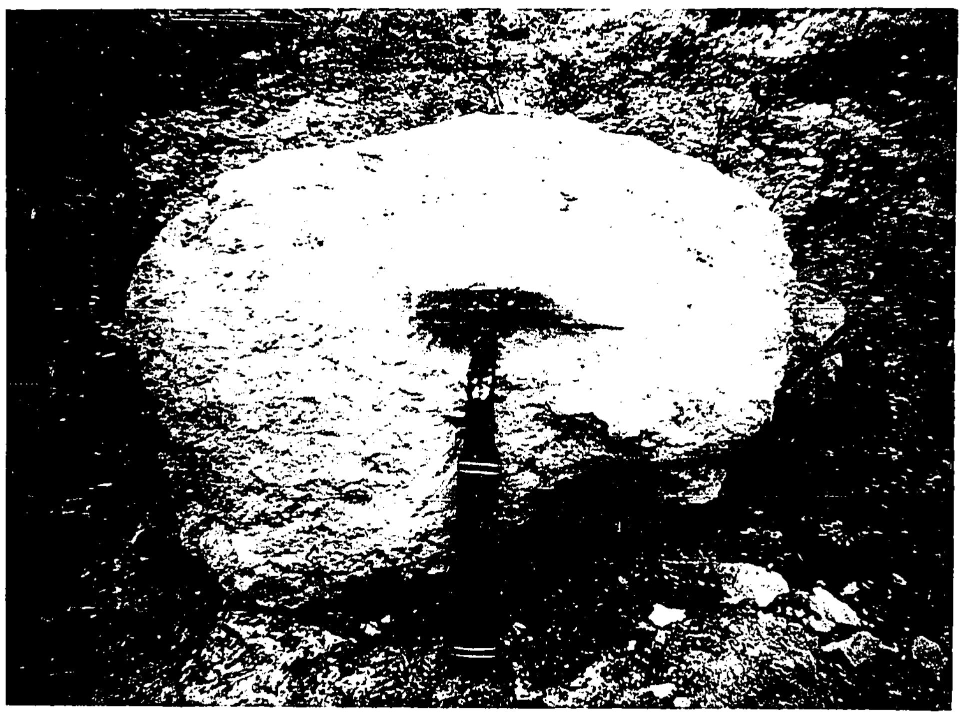

Fig. 13

Boulder of hard, fossiliferous Ocala limestone, south side of Georgia Power Company dam, Albany

Fig. 14

Tree-covered, practically submerged Ocala limestone at junction of Kinchafoonee Creek with Flint River, 1.75 miles north of Albany.

Fig. 15

Extremely weathered, fossiliferous Ocala limestone on east bank of Flint River, at junction of Kinchafoonee Creek with Flint River, 1.75 miles north of Albany.

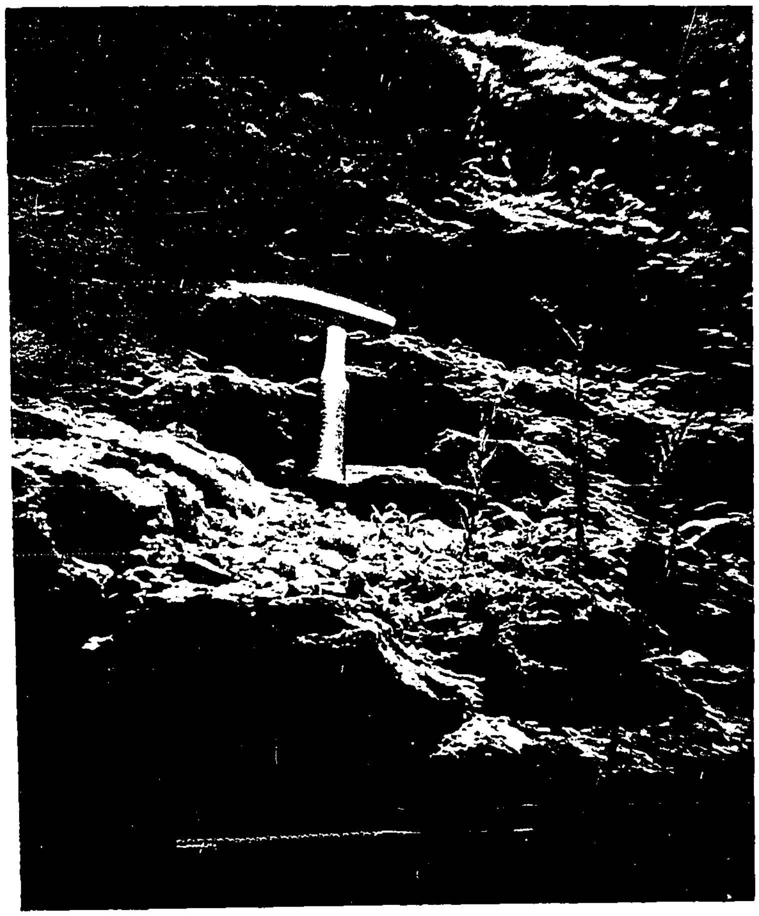

Fig. 16

Soft to very hard, fossiliferous Ocala limestone exposed along east bank of Flint River, at junction of Kinchafoonee Creek with Flint River, 1.75 miles north of Albany.

Fig. 17

Ocala limestone exposed on west bank of Kinchafoonee Creek, 1 mile southwest of Leesburg, Lee County.

Fig. 18

Hard, massive Ocala limestone in south face of abandoned quarry, Armena, Lee County.

Fig. 19

Hard, massive Ocala limestone exposed immediately north of grinding mill, Armena, Lee County.

Fig. 20

Exposure (25 feet) of hard, white to cream-colored Ocala limestone in south face of abandoned quarry, Armena, Lee County.

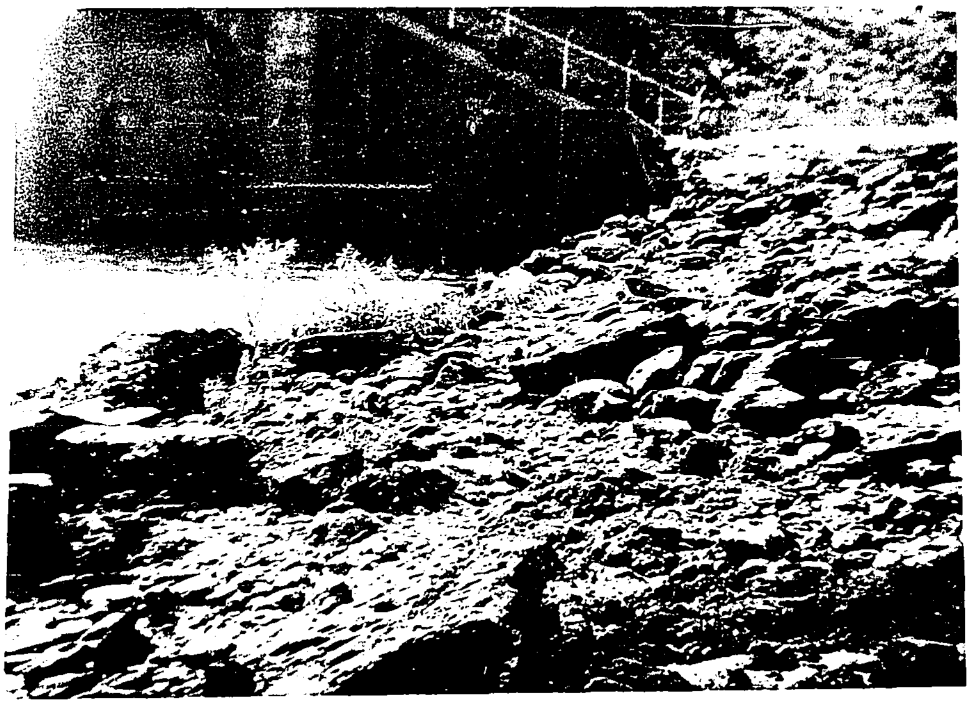

Fig. 21

Ledges and angular blocks of soft to very hard Ocala limestone, exposed along east bank of Flint River, south side of Crisp County power dam, 2 miles west of Warwick, Worth County.

Section of Limestone on Armstrong Place

	Ft.	In.
11. Pleistocene sands and gravel, surface second terrace.................	7	
Jackson Group:		
10. Mostly concealed, but with several small exposures of soft, white granular limestone and hard, partly crystalline, light gray limestone.......	8	
9. Hard, light gray, crystalline limestone................................	0	3
8. Alternating 6 to 10 inch layers of soft to slightly harder, white granular limestone..................	1	6
7. Hard, light gray, crystalline limestone................................	0	3
6. Alternating 6 to 10 inch layers of soft and slightly harder white, granular limestone..................	7	6
5. Medium hard, white, partly crystalline limestone.....................	4	
4. Soft, white, granular limestone.....	4	
3. Medium hard, white limestone, containing Bryozoa.....................	4	
2. Soft, light gray, granular limestone containing flint nodules......	8	
1. Hard, white, partly crystalline, limestone, irregularly weathered. <u>Lunulites</u>, <u>Flabellum</u>, and Bryozoa...	2	
River................................	0	
	47	

Sumter County

The writer reports a section including sand of Jackson age west of Flint River in Sumter County, in a road cut at the junction of Georgia Highway 49 and the county road to New Era, 3.9 miles north of Americus, at an elevation of 350 feet above sea level:

	Feet
Oligocene:	
Flint River formation:	
2. Yellow to white to red-streaked, unconsolidated, fine-grained quartz sand to top of road cut.............	3
Eocene:	
Ocala limestone:	
1. Very dense to unindurated, white to cream-colored to red-stained, sparsely fossiliferous, saccharoidal sandstone to level of road......	7

Bed No. 1 of the section is similar to the lower sand of other localities of more complete Ocala exposure, except for the paucity of fossils. In other localities this sandy zone contains abundant shark teeth.

Elsewhere in Sumter County, other beds of Jackson age occur, but do not include the Ocala limestone. In a road cut on Georgia Highway 49, 5 miles south of Andersonville National Cemetery, the following section was observed near the top of a hill, at an elevation of 397 feet above sea level:

	Feet
Oligocene:	

Fig. 22

Road cut at junction of Georgia Highway 49 and New Era road, 3.9 miles north of Americus, Sumter County, exposing hard, basal sand of Tivola member, overlain by sand of Flint River formation.

Fig. 23

Close-up view of basal sand of Tivola member, at junction of Georgia Highway 49 and New Era road, 3.9 miles north of Americus, Sumter County.

Fig. 24

Exposure of Twiggs clay member along Georgia Highway 49, 5 miles south of Andersonville, Sumter County. One to 3 feet of sand of Flint River formation overlies Twiggs clay. Sand in gully is probably Gosport formation.

Flint River formation:

3. Yellow to tan, fine-grained, unconsolidated sand to top of road cut.................................. 1-3

Eocene:

Barnwell formation:

Twiggs clay member:

2. Dark red to gray to white, blocky, plastic, sandy clay, with irregular lenses of carbonaceous material well-distributed throughout the bed.................................. 1-10

Claiborne Group:

Gosport formation?

1. Unindurated, dark brown to red, fine-grained quartz sand, with irregular nodules of sandy clay to level of road........................ 1-8

In a road cut 5.2 miles east of Americus on Georgia Highway 27, the following section was observed at an elevation of 397 feet above sea level:

Feet

Oligocene:

Flint River formation:

2. Compact, blocky, white to brown, fossiliferous chert to top of road cut.................................. 7

Eocene:

Barnwell formation:

Twiggs clay member:

Fig. 25

Exposure of blocky Flint River chert overlying dark red to gray, blocky Twiggs clay, along Georgia Highway 27, 5.2 miles east of Americus, Sumter County.

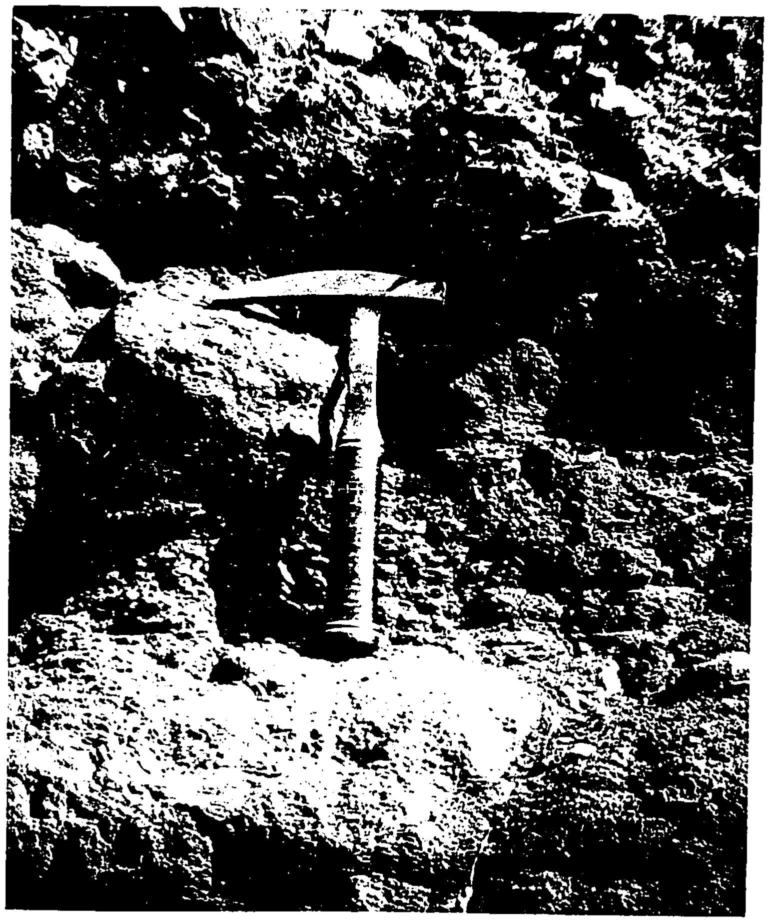

Fig. 26

Contact between dark red, blocky Twiggs clay, and overlying Flint River chert on Georgia Highway 27, 5.2 miles east of Americus, Sumter County.

1. Dark red to gray, blocky, plastic, sandy clay, with thin laminae of carbonaceous material well-distributed throughout the bed to level of road........................ 8

Dooly County

East of Flint River, exposures of Ocala limestone associated with the basal member of the Barnwell become more abundant. Traced northward from Dooly County, both formations are typically exposed in Houston, Pulaski, Bleckley, Twiggs, and Wilkinson counties.

In a plowed field on the H. H. Hutchins property, 1.5 miles southeast of Lilly, and immediately east of Georgia Highway 90, along the north slope of Pennahatchie Creek, the following section was observed at an elevation of 350 feet:

Feet

Ocala limestone:

Soft to very hard, white to red-stained, partly crystalline limestone boulders, strewn over plowed field, and as irregular, poorly exposed ledges occurring on terrace rims, and in gully. Few very poorly preserved fossils................ 20

The following section was observed in a road cut on the southwestern side of Georgia Highway 90, 4.6 miles southeast of Montezuma, Macon County, and 0.2 mile within Dooly County, on the southeast slope of Hogcrawl Creek, at an elevation of 325 feet:

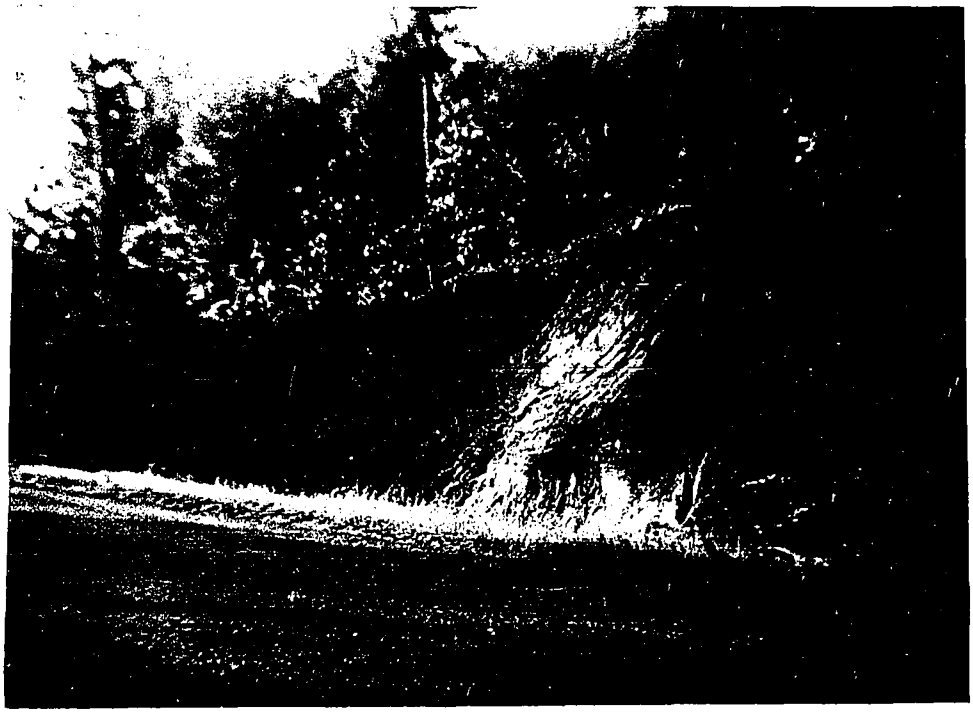

Fig. 27

Exposure of Twiggs clay member overlain by thin, sub-silicified Tivola limestone, 0.2 mile within Dooly County, along Georgia Highway 90.

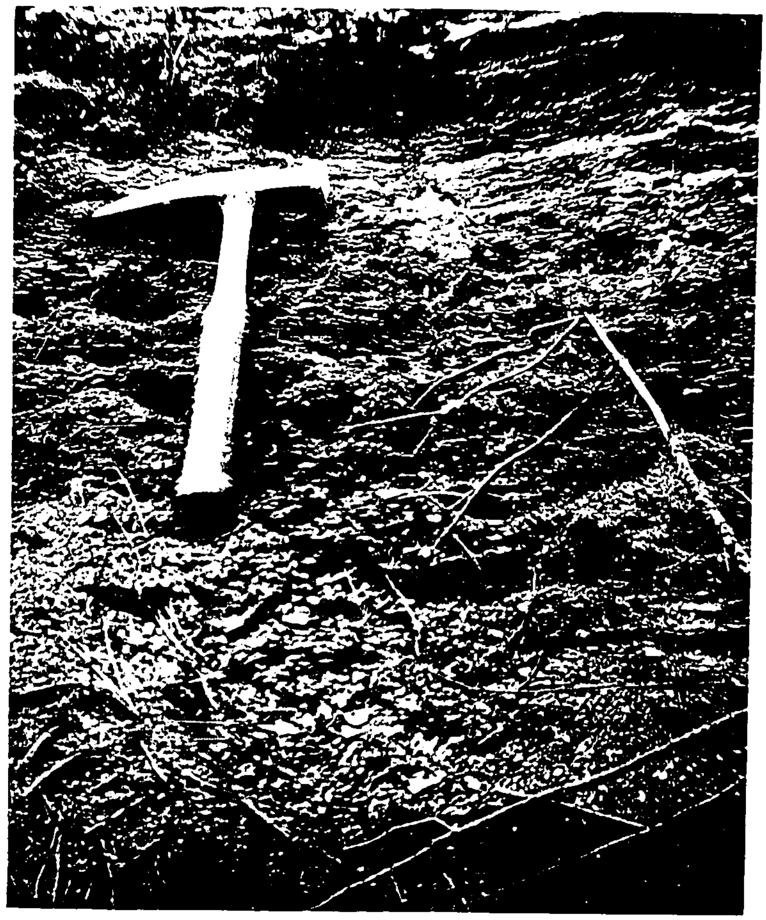

Fig. 28

Red-stained Twiggs clay 0.2 mile within Dooly County, along Georgia Highway 90.

	Feet
Ocala limestone:	
Tivola member:	
2. White to cream-colored to red-stained, soft to very hard, partly silicified, sparsely fossiliferous limestone to top of road cut....	4
Barnwell formation:	
Twiggs clay member:	
1. Greenish-yellow, sandy, blocky clay, with red surface stains to bottom of gully..............................	15

On the eastern boundary of the McKenzie property, along the north-south county road 2.5 miles east of Hogcrawl Creek, the following section was observed at an elevation of 327 feet. This locality is situated 10 miles east of Montezuma, and 2.5 miles within Dooly County.

	Feet
Ocala limestone:	
White to gray, very hard, partly crystalline, red-stained limestone, occurring mostly as great blocks up to 12 feet in length strewn over ground surface. In a few instances, material occurs in situ in shallow gully bordering road. Limestone is abundantly fossiliferous, but only molds and casts of pelecypods and gastropods are preserved..............................	10

Pulaski County

Cooke (1943, p. 73) reports a few exposures of Ocala

Fig. 29

Blocks of partially silicified Ocala limestone on McKenzie Property, 2.5 miles east of Hogcrawl Creek, Dooly County.

limestone along Ocmulgee River. If present, the limestone is well covered by Recent alluvium and vegetation.

In a road cut 2.7 miles north of Hawkinsville, ¼ mile east of a prominent bluff on the east bank of Ocmulgee River, immediately south of the Henry Wilcox property, the following section was observed at an elevation of 250 feet:

	Feet
Ocala limestone:	
Tivola member:	
3. Soft to medium hard, white to red-stained, argillaceous, fossiliferous limestone. Lower 2 feet consist of a hard massive yellow layer of arenaceous limestone..........	25
Unconformity:	
Barnwell formation:	
Twiggs clay member:	
2. Green to reddish-brown, hackly, fuller's earth type clay............	1-3
1. Unconsolidated, white to gray, fine-grained quartz sand with red surface stain to level of road......	5

In a road cut 6.3 miles northwest of Hawkinsville, on U. S. Highway 341 (Georgia Highway 7), and 7.7 miles southeast of the main Penn-Dixie quarry at Clinchfield, Houston County, the following section was observed on the north side of the highway at an elevation of 320 feet:

Feet

Fig. 30

Tivola limestone overlying Twiggs clay and lower Barnwell sands, 2.7 miles north of Hawkinsville, Pulaski County.

Fig. 31

Unconformity between Tivola member (above) and Twiggs clay, 2.7 miles north of Hawkinsville, Pulaski County.

Fig. 32

Extremely weathered Tivola limestone, 2.7 miles north of Hawkinsville, Pulaski County.

Barnwell formation:

Twiggs clay member:

Gray to reddish-brown, sandy, hackly, fuller's earth type clay to level of road, containing in the lower two feet rounded and irregularly-shaped nodules of soft to partly silicified, white to pinkish fossiliferous Ocala limestone.........................	6

Houston County

Exposures of the Tivola member, Twiggs clay member, and the upper sandy portions of the Barnwell formation crop out in the prominent northeast-southwestward trending escarpment which bisects Houston County. Notable exposures occur in abandoned or active quarries, or in road cuts in several localities, especially along U. S. Highway 341 (Georgia Highway 7) southeast of Perry.

In most of these localities, the dominant lithology is the typical white to cream-colored, soft to very compact, exceedingly fossiliferous Tivola member of the Ocala limestone.

In the main quarry of the Penn-Dixie Cement Company at Clinchfield, 6 miles southeast of Perry, the following section was observed in the east face of the escarpment on the north side of U. S. Highway 341, at an elevation of 350 feet above sea level:

Feet

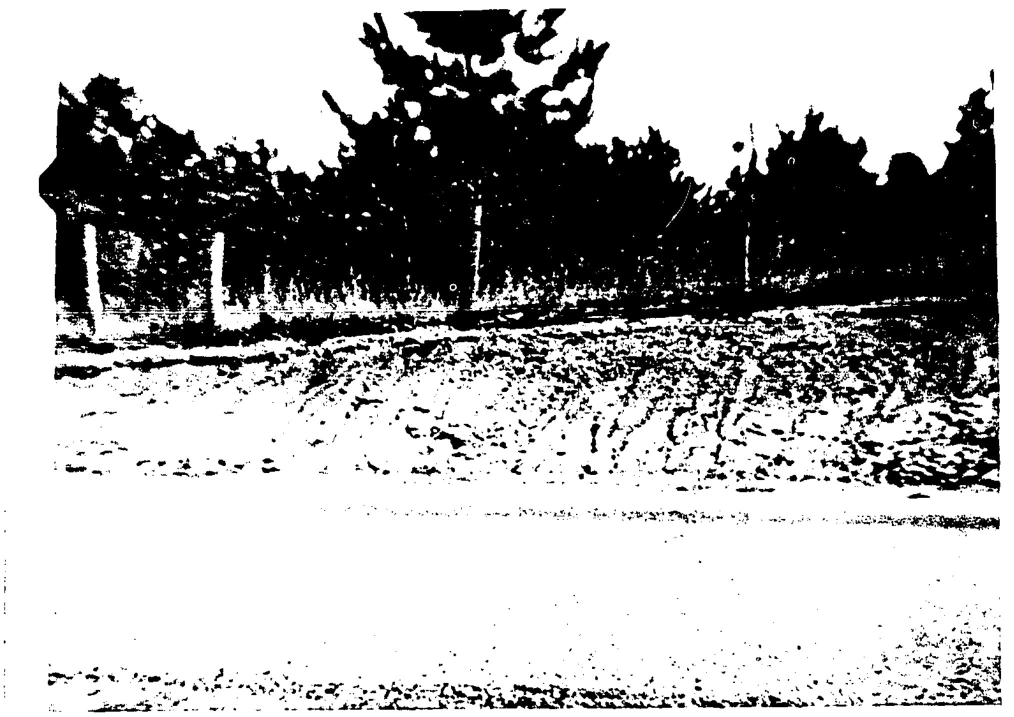

Fig. 33

Road cut along U. S. Highway 341, 6.3 miles northwest of Hawkinsville, Pulaski County, exposing 6 feet of Twiggs clay with nodules of partially silicified Ocala limestone in lower portion.

Fig. 34

Gray to reddish-brown Twiggs clay containing silicified nodules of Ocala limestone, along U. S. Highway 341, 6.3 miles northwest of Hawkinsville, Pulaski County.

Fig. 35

Blocky, fuller's earth type clay of Twiggs clay member, exposed along U. S. 341, 6.3 miles northwest of Hawkinsville, Pulaski County.

Barnwell formation:

Twiggs clay member:

5. Massive, cream-colored to greenish, blocky, hackly, plastic clay, with stringers and nodules of white chalky limestone. This bed grades upward into brilliant to dark red, argillaceous quartz sand to top of quarry..............................	20

Ocala limestone:

Tivola member:

4. Massive, soft to hard, white to cream-colored, fossiliferous limestone..............................	7
3. Cream-colored to grayish-green, hackly, plastic, fuller's earth type clay..............................	3
2. Massive, soft to very hard, white to cream-colored "bryozoan" limestone..............................	4
1. Massive, white to yellowish, soft to medium hard, highly fossiliferous limestone to floor of quarry....	40

On the south side of U. S. Highway 341, ½ mile south of the main Penn-Dixie Cement Company quarry, another recently opened exposure was observed at the same elevation, immediately east of the tracks of the Southern Railroad:

Feet

Ocala limestone:

Tivola member:

2. Soft to very hard, white to cream-colored, fossiliferous limestone,

Fig. 36

Clinchfield Quarry, Clinchfield, Houston County, exposing hard and soft ledges of white to cream-colored Tivola limestone. Twiggs clay exposed in left background, overlain by dark red Barnwell sand.

Fig. 37

Twiggs clay member overlain by dark red Barnwell sand exposed in upper part of Clinchfield Quarry. Tivola limestone in foreground.

Fig. 38

Large, angular blocks of exceedingly fossiliferous Tivola limestone near quarry floor, Clinchfield Quarry.

which in places has become recrystallized and cavernous......... 8

1. Dark bluish, hackly clay containing much carbonaceous material. 7

In an abandoned limestone quarry at Ross Hill, 3 miles south of Perry, on both sides of the Perry to Elko road, along the south slope of Flat Creek, the following section was observed at an elevation of 366 feet:

	Feet
Oligocene:	
Flint River formation:	
7. Thin layer of wooded soil, strewn with lumps of pink to red chert....	2
Eocene:	
Barnwell formation:	
6. Soft, gray, hackly, sandy, red-stained clay merging upward with bed No. 7.........................	2
5. Reddish, sandy, weathered limestone containing molds of fossils..	4
Twiggs clay member:	
4. Hackly, cream-colored, calcareous fuller's earth type clay containing limy nodules..................	4
Ocala limestone:	
Tivola member:	
3. Soft, cream-colored to white, fossiliferous limestone, with a hard similar ledge at base of bed.......	7

2. Soft, yellow limestone, with locally indurated nodules and ledges. Also contains soft, irregular limestone concretions.......... 7

1. Pale, cream-colored, soft limestone, with abundant bryozoans, Pecten, Chlamys, and echinoids (Periarchus). weathered ledges of much harder limestone near top of bed............................ 20

In the aforementioned section, Bed No. 1 was observed on the west side of the county road only. Beds Nos. 2 through 7 crop out on the east side of the road for a distance of 180 feet southward to the top of the hill.

Along U. S. Highway 341, 4.5 miles southeast of Clinchfield, in a road cut and on the side of a hill south of the highway, the following section was observed at an elevation of 338 feet above sea level:

Feet

Oligocene:

Flint River formation:

2. Scattered cobbles and smaller fragments of pink chert within overburden of soil to top of hill.......... 15

Eocene:

Ocala limestone:

Tivola member:

1. Irregular ledges and large blocks of weathered, white to yellow to cream-colored, soft to very hard, silicified, extremely fossiliferous

Fig. 39

South face of quarry exposing ledges of soft Tivola limestone, Ross Hill, 3 miles south of Perry, Houston County.

Fig. 40

East wall of Ross Hill quarry, exposing soft Tivola limestone.

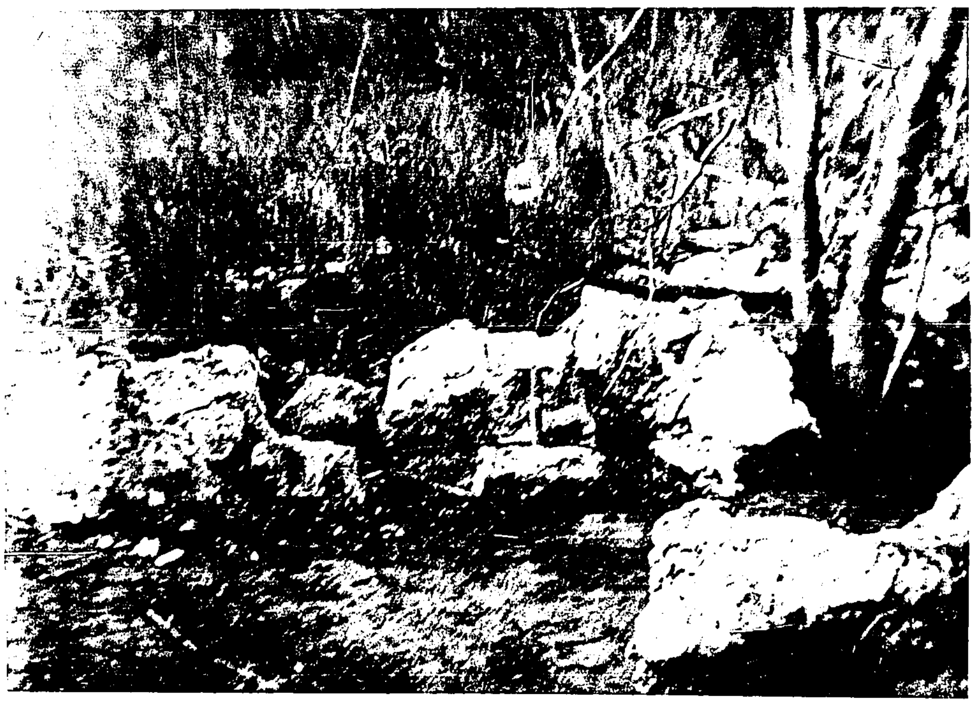

Fig. 41

Angular blocks of fossiliferous Tivola limestone exposed along U. S. Highway 341, 4.5 miles southeast of Clinchfield, Houston County.

limestone from level of road up the hillside and in road cut........	12

Peach County

North of Fort Valley, the summits of the highest hills are capped by a predominantly dark red, argillaceous quartz sand, which, appears to be a remnant of a once more extensive deposit of Barnwell sand, lying with imperceptible unconformity upon the sands of the underlying Tuscaloosa formation. In a sand pit on the west side of Georgia Highway 49 at Powersville, Peach County, on the north slope of Mule Creek, the following incomplete section was observed at an elevation of 514 feet:

	Feet
Eocene?	
Barnwell formation?	
2. Fine to medium-grained, unconsolidated, pink to dark red, argillaceous quartz sand to top of pit..........................	6
Unconformity (imperceptible)	
Upper Cretaceous:	
Tuscaloosa formation:	
1. Yellow to brown, coarse, cross-bedded quartz sand to floor of pit	4

The differentiation of the sandy units of the section is based solely upon abrupt changes in color, grain size, re-

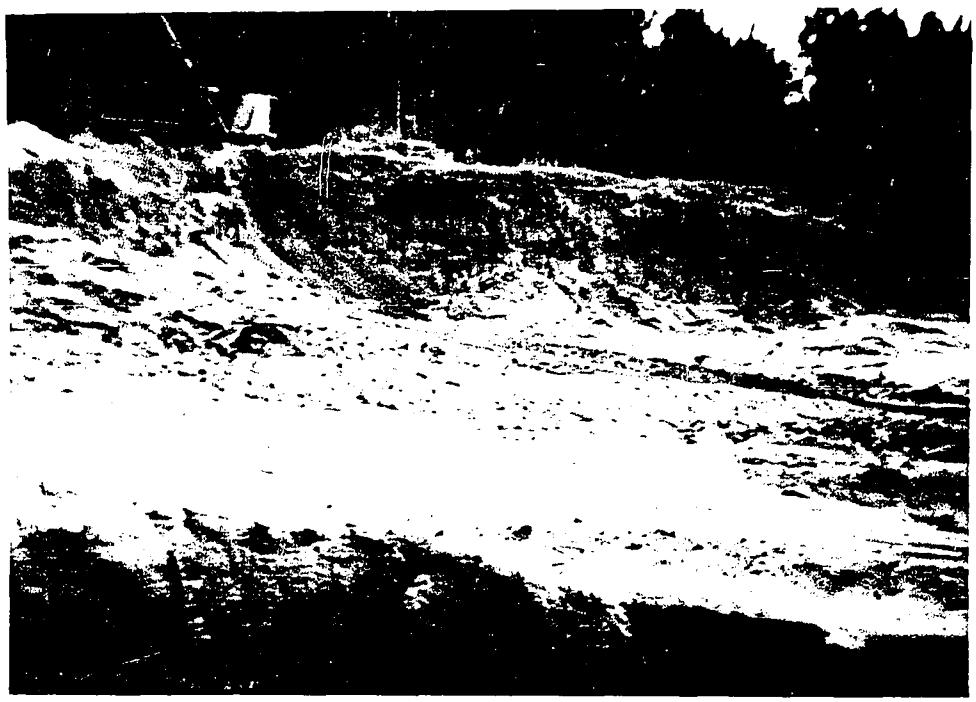

Fig. 42

Sand pit on west side of Georgia Highway 49, Powersville, Peach County, exposing thick Tuscaloosa sand and probable thin upper Barnwell sand.

Fig. 43

Probable upper Barnwell red sand overlying Tuscaloosa sand, Powersville, Peach County.

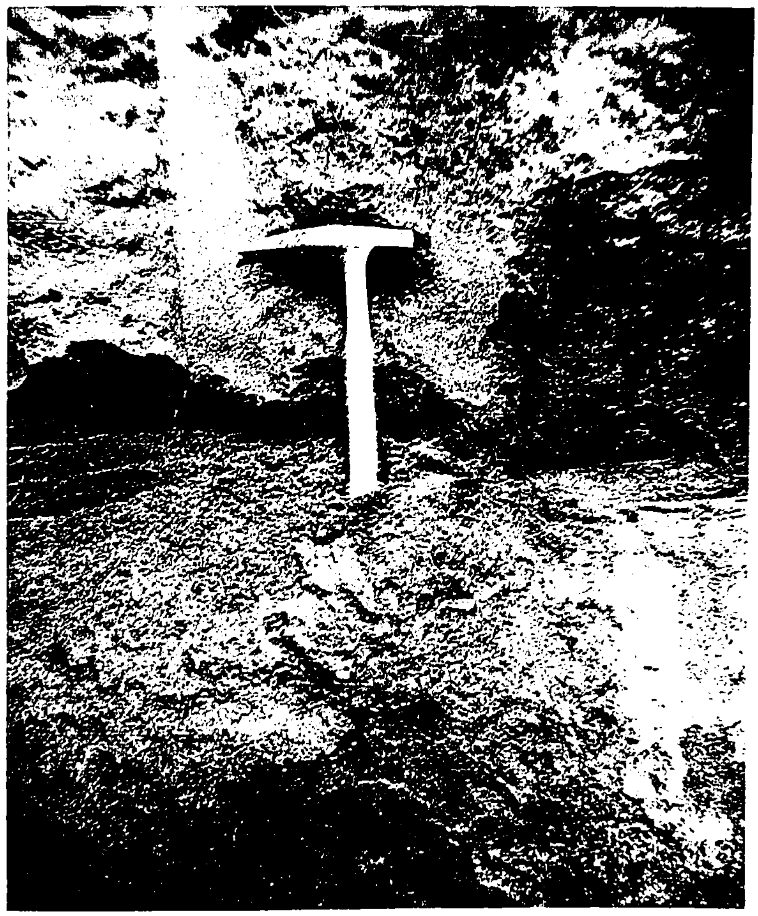

Fig. 44

Boundary between yellow to brown Tuscaloosa sand (below) and probable pink to dark red Barnwell sand, Powersville, Peach County.

semblance of the No. 2 bed to typical Barnwell of known localities, and definite Tuscaloosa lithology of cross-bedded sand within a short distance of this outcrop.

Crawford County

An interesting exposure of the Jackson group occurs at Rich Hill, an imposing topographic feature situated south of Georgia Highway 42, 6 miles east of Roberta, Crawford County.

The exposure is unique in that it represents a complete Jackson section deposited much farther to the west than any known Jackson outcrop, being separated by a distance of at least thirty miles. The area between this locality and that at Powersville, Peach County, seems to have been completely denuded of all Jackson strata. The nearest practically complete section is at Ross Hill, south of Perry, Houston County. The rocks which are exposed in the intervening area include the sands and kaolin deposits of the Tuscaloosa, and erratic exposures of Gosport, Lisbon, and Tallahatta sands and clays of Claiborne age. None of the latter units has been found in association with the Jackson beds.

In the deep gully on the south side of Rich Hill, the following section was observed at an elevation of 518 feet:

	Feet
Eocene:	
Barnwell formation:	

8. Deeply eroded, dark red to yellow, fine to medium-grained quartz sand, with thin beds of plastic, greenish-gray clay near the base........................ 40

Twiggs clay member:

7. Light-green to yellow, blocky, plastic, fuller's earth type clay............................... 10

Ocala limestone:

Tivola member:

6. Massive, soft to medium hard, white, nodular, argillaceous limestone......................... 3

5. Grayish-green, hackly, fuller's earth type clay.................. 3

4. White, soft to medium hard, nodular limestone...................... 3

3. Soft, yellowish to cream-colored, arenaceous limestone. Molds and casts of pelecypods and gastropods prolific. Echinoids (_Periarchus_) abundant...................... 5

2. Massive, unconsolidated, light yellow to tan, calcareous sand, with hard ledges of fossiliferous limestone at top; shark teeth abundant throughout remainder of bed........ 25

Unconformity:

Upper Cretaceous:

Tuscaloosa formation:

1. Massive kaolinic sand at base, ranging from fine to coarse-grained, white quartz sand, and massively-bedded, pure white kaolin to bottom of gully................. 100

Fig. 45

South slope of Rich Hill, 6 miles east of Roberta, Crawford County, exposing complete section of Jackson Group overlying Tuscaloosa kaolin (foreground).

Fig. 46

Massively bedded, very fossiliferous limestone of Tivola member, Rich Hill.

Fig. 47

Massively bedded, basal sand in lower part of Tivola member, Rich Hill.

Fig. 48

White fuller's earth type clay in lower part of Twiggs clay member, Rich Hill.

Fig. 49

Green, hackly, fuller's earth type clay in upper part of Twiggs clay member, Rich Hill.

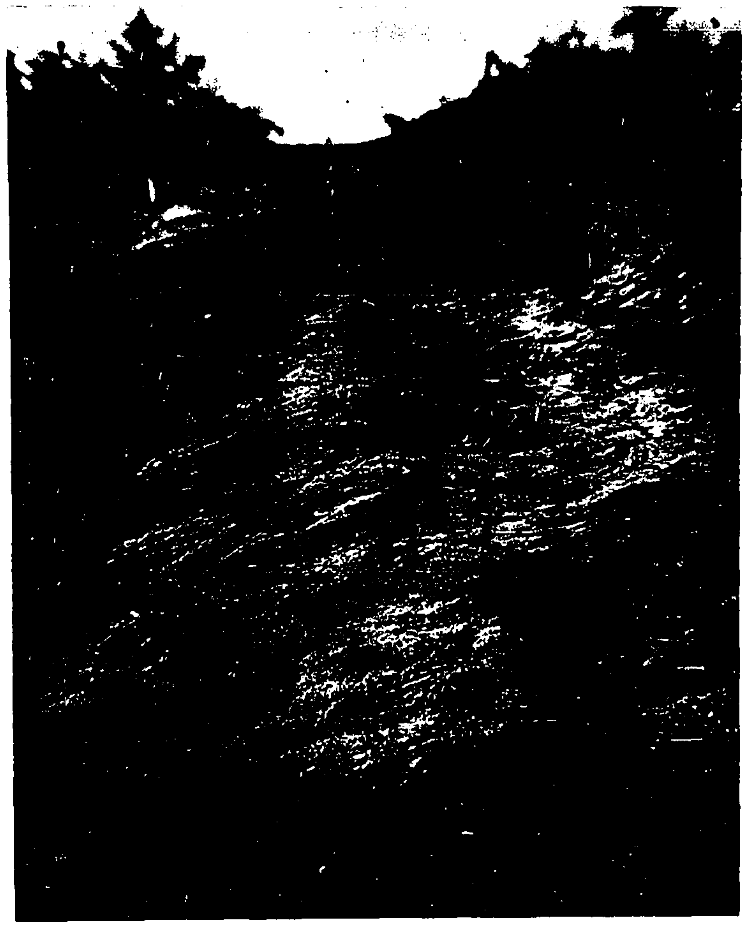

Fig. 50

Extremely eroded, dark red, massively bedded, uppermost Barnwell sand, top of Rich Hill.

Bibb County

During the present investigation only the uppermost sands of the Barnwell formation were observed in Bibb County. Previous authors (Cooke and Shearer, 1918, pp. 47-48) describe an exposure in the vicinity of Browns Mountain, 9 miles southeast of Macon, on the Macon-Marion road. At the present writing this exposure was inaccessible:

Section reported at Browns Mountain on the Macon-Marion road, 9 miles southeast of Macon

	Feet
Eocene:	
6. Hard sandstone and quartzite, to top of hill..................................	7
5. Mottled plastic clay..................	3
4. Red sand...............................	4
3. Soft, fossiliferous sandstone........	0-4
2. Basal conglomerate. White kaolin pebbles in cross-bedded sand. Contact with Cretaceous not precisely located because of lithologic similarity................................	55
Cretaceous:	
1. Coarse white kaolinic sand to stream level.................................	65

In a sand pit of the W. C. Scott Sand and Gravel Company, one mile south of the city limits of Macon, along the east side of U. S. Highway 41 (Georgia Highways 11 and 49), and east of the tracks of the Central of Georgia Railroad, the following section was observed at an elevation of 330 feet above sea level:

	Feet
Eocene:	
Barnwell formation:	
3. Fine to very coarse, dark red, argillaceous quartz sand to top of pit. Chert pebbles occur at base of bed attaining three inches in diameter, extending to contact with underlying Cretaceous..........	2-8
Unconformity:	
Upper Cretaceous:	
Tuscaloosa formation:	
2. Massive, medium-grained, reddish-pink to white, cross-bedded quartz sand................................	12
1. Massive white kaolin with medium to coarse-grained quartz sand and kalinic sand at base..................	75

Twiggs County

In northwestern Twiggs County, at the mine of the Georgia Kaolin Company, 2 miles east of Dry Branch, south of U. S. Highway 80 (Georgia Highway 19), the following complete section of the Jackson stage was observed at an elevation of 585 feet above sea level:

	Feet
Eocene:	

Fig. 51

Dark red, argillaceous Barnwell sand overlying reddish-pink, cross-bedded Tuscaloosa sand and massive kaolin, 1 mile south of Macon, Bibb County.

Fig. 52

Disconformity separating Tuscaloosa sand (below) from Barnwell sand, 1 mile south of Macon, Bibb County.

Barnwell formation:

Irwinton sand mamber:

7. Unindurated to medium hard, fine-grained, white to dark red quartz sand with clay partings to top of quarry.............................. 65

Twiggs clay member:

6. Massive, blocky, hackly, greenish-gray, plastic fuller's earth type clay................................ 15

Ocala limestone:

Tivola member:

5. Massive white, argillaceous, fossiliferous limestone, grading upward into fuller's earth................. 3

4. Yellow to brown, unindurated to medium hard, fine-grained, calcareous quartz sand, with abundant molds and casts of pelecypods and gastropods...................... 8

3. Hard, massive, white, partly crystalline limestone forming a persistent ledge about quarry face........ 2

2. Unindurated to medium hard, light brown to yellow, calcareous quartz sand, with abundant molds and casts of gastropods and pelecypods, and shark teeth........................ 8

Unconformity:

Upper Cretaceous:

Tuscaloosa formation:

1. Massive, pure white kaolin to level of pond on quarry floor............. 2

In southeastern Twiggs County, 5 miles southeast of

Fig. 53

South face of main quarry of Georgia Kaolin Company, 2 miles east of Dry Branch, Bibb County, exposing complete section of Jackson beds.

Fig. 54

Tivola limestone and sand overlain by Twiggs clay member, in south face of Georgia Kaolin Company quarry, 2 miles east of Dry Branch.

Fig. 55

Twiggs clay member overlying Tivola member, in east face of Georgia Kaolin Company quarry, 2 miles east of Dry Branch.

Fig. 56

Massively bedded and crumbly Twiggs clay
in east face of Georgia Kaolin Company
quarry, 2 miles east of Dry Branch.

Jeffersonville, in the creek bank at the old county bridge across Turkey Creek, and in the road cut 100 feet west of the bridge at old Gallemore Mill, 4 miles northeast of Danville and one mile east of U. S. Highway 80, the following section was observed at an elevation of 380 feet above sea level:

	Feet
Barnwell formation:	
Irwinton sand member:	
5. Brilliant red to dark red, argillaceous quartz sand to top of hill. Lower part of bed consists of basal conglomerate of coarse red sand and quartz pebbles attaining two inches in diameter........................	16
Unconformity:	
Twiggs clay member:	
4. Greenish-gray, hackly, blocky, fuller's earth type clay, containing laminae of red to yellow, fine-grained quartz sand.................	9
Ocala limestone:	
Tivola member:	
3. Dark red quartz sand containing ledges of hard, crystalline, partly silicified, white to red-stained limestone at top of bed............	10
2. Concealed interval from creek level to tracks of Macon, Dublin, and Savannah Railroad..................	7
1. Soft, yellow, sandy marl exposed in creek bed.........................	1

Beds Nos. 4 and 5 of the aforementioned section are

Fig. 57

Greenish-gray Twiggs clay, Gallemore Mill, 4 miles northeast of Danville, Twiggs County.

Fig. 58

Massively bedded Twiggs clay, Gallemore Mill, Twiggs County.

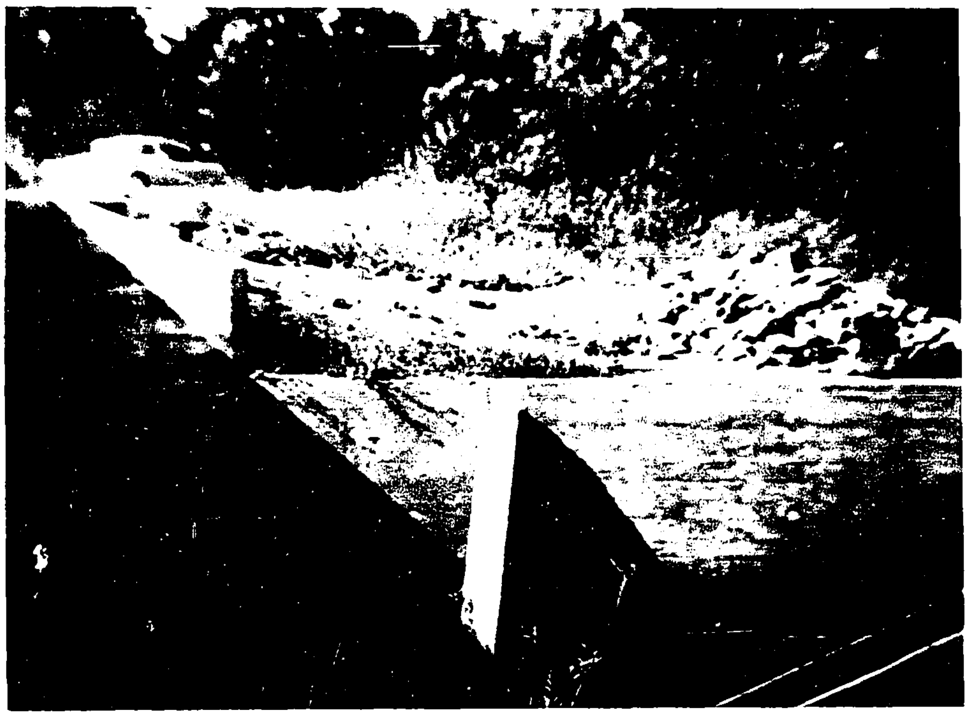

Fig. 59

West bank of Turkey Creek, Gallemore Mill, exposing very hard, silicified Tivola limestone.

exposed 100 feet west of Turkey Creek on either side of the road leading down to the creek.

Bleckley County

In an abandoned limestone quarry on the Weatherly Farms property, 1¼ miles east of Ainslie, on the east bank of Shellstone Creek, 71 feet of section are exposed in the westward-facing escarpment across northwestern Bleckley County. This locality is located 5.5 miles west of U. S. Highway 129 (Georgia Highway 87 and U. S. Highway 23), and 5.5 miles northwest of Cochran, the County seat.

The following section was observed at an elevation of 335 feet above sea level:

	Feet
Eocene:	
Barnwell formation:	
Irwinton sand member:	
5. Massively-bedded, brilliant to dark red, argillaceous quartz sand to top of hill....................	30
Twiggs clay member:	
4. Cream-colored to greenish-gray, weathered fuller's earth type clay, with local sandy ledges. This bed grades upward into Bed No. 5............................	15
Ocala limestone:	
Tivola member:	

3. Soft to medium hard, well-pitted, white to cream-colored, fossiliferous limestone..................	10
2. Soft, white to yellow, very porous, friable, highly fossiliferous limestone......................	13
Recent:	
1. Creek bottom land..................	3

Wilkinson County

Beds of Jackson age crop out essentially in the southern and southeastern parts of Wilkinson County. To the north, these beds cap the higher northwest-southeastward trending "Red Hills," which owe their origin and relief to such deep-cutting streams as Commissioners, Slash, Black, and Big Sandy creeks. These streams have removed most of the Jackson deposits in this part of the County, exposing the deeply-eroded clays, sands, and gravels of the underlying Tuscaloosa formation.

LaMoreaux (1946, p. 58) reports the type locality of the Irwinton sand member at the "Hatfield Place, 150 yards west of a cemetery which is 0.3 mile south of the courthouse at Irwinton, along Georgia Highway 29." The following section is that of LaMoreaux:

	Thickness (feet)
Colluvium:	
4. Red coarse clay............	14+

Fig. 60

West face of abandoned limestone quarry on Weatherly Farms property, 1.25 miles east of Ainslie, Bleckley County.

Fig. 61

Basal 5 feet of soft, exceedingly fossiliferous Tivola limestone, Weatherly Farms, 1.25 miles east of Ainslie, Bleckley County.

Tertiary (upper Eocene)

Barnwell formation:

Irwinton sand member:

3. Clay, gray, waxy, mottled red........................	3
2. Sand, yellow and gray, loose, fine to medium-grained, interbedded with many tough yellow clay layers. Many fine dark particles scattered throughout sand..................	41

Twiggs clay member:

1. Clay, pale-green, hackly, fuller's earth type with thin beds of fine angular quartz sand................	20+

The aforementioned section occurs at an elevation of 467 feet above sea level.

From the bridge spanning Big Sandy Creek, 3 miles south of Irwinton on U. S. Highway 441 (Georgia Highway 29), extending southward to a point up the hill, the following poorly exposed section of Jackson beds was observed at an elevation of 345 feet above sea level:

Feet

Eocene:

Barnwell formation:

Irwinton sand member:

5. Brilliant to dark red to mottled yellow, argillaceous,

fine-grained quartz sand, with thin laminae of gray plastic clay in lower part.......... 20

Twiggs clay member:

4. Plastic, greenish-yellow, blocky, hackly, fuller's earth type clay...................... 10

3. Plastic, bluish sandy clay, with red surface stains......... 5

2. Grayish-green, hackly fuller's earth type clay................. 5

Unconformity:

Upper Cretaceous:

Tuscaloosa formation:

1. Massive, pure white to yellow kaolin.......................... 5

Bed No. 1 of the section occurs on the south side of the bridge; beds Nos. 2 through 5 occur in succession to the south, up the hill along the Highway.

In a road cut on Georgia Highway 57, 1 mile east of Toombsboro, the following Jackson section was observed at an elevation of 233 feet above sea level:

Feet

Barnwell formation:

Irwinton sand member:

3. Dark red, fine-grained, massively-bedded, argillaceous quartz sand to top of road cut......... 5

2. Fine-grained, reddish-yellow quartz sand, with laminae of

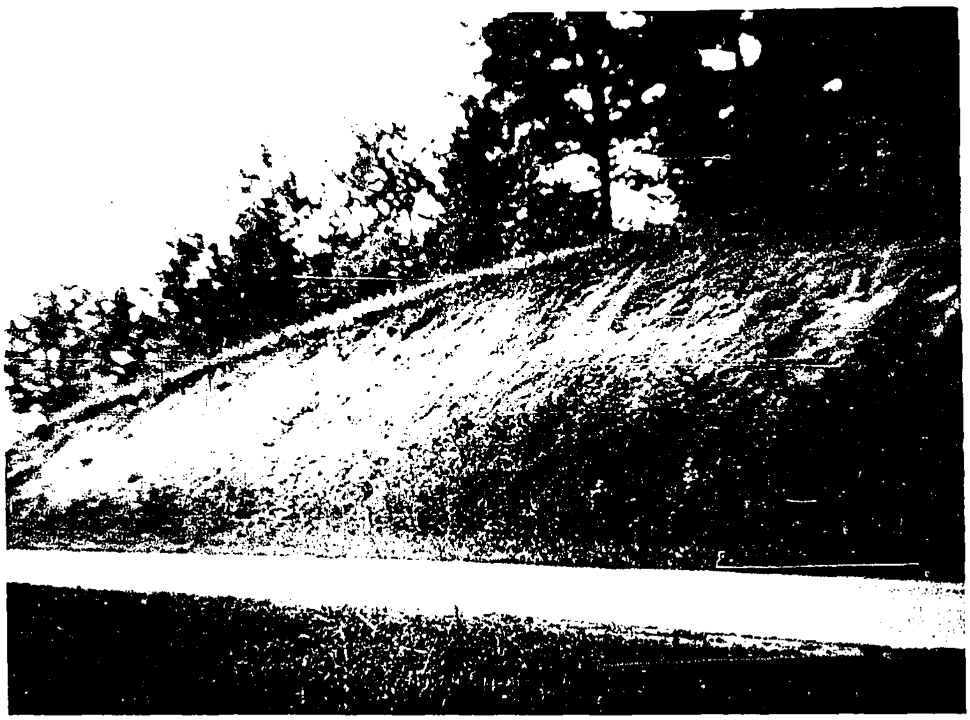

Fig. 62

Road cut along U. S. Highway 441, 3 miles south of Irwinton, Wilkinson County, exposing Twiggs clay and Irwinton sand member.

Fig. 63

Extremely weathered Twiggs clay, 3 miles south of Irwinton, on U. S. Highway 441.

gray clay near base............. 10

Twiggs clay member:

1. Grayish-green, hackly, plastic, fuller's earth type clay to road level. This bed becomes sandy near top.................. 5

At the kaolin mine of the Southern Clays Company, 1 mile south of Gordon and 1 mile east of Georgia Highway 18, the following section is exposed at an elevation of 347 feet above sea level:

	Feet
Eocene:	
Barnwell formation:	
Irwinton sand member:	
5. Massive, dark red to mottled yellow, fine-grained, argillaceous quartz sand to top of hill.........................	60
Twiggs clay member:	
4. Greenish-yellow, blocky, plastic fuller's earth type clay, containing white chalk nodules at base..................	10
Ocala limestone:	
Tivola member:	
3. Massively-bedded, sandy, white to cream-colored limestone, with abundant bryozoans and molds and casts of pelecypods and gastropods. The bed is essentially a friable limestone, but it contains several hard coquinid	

Fig. 64

Road cut along south side of Georgia Highway 57, 1 mile east of Toombsboro, Wilkinson County, exposing grayish-green Twiggs clay, overlain by massive Irwinton sand.

ledges with fossils occurring as molds and casts......... 10

2. Massive, fine to medium-grained, light yellow to tan, argillaceous, glauconitic, quartz sand, containing shark teeth; it fills depressions on irregular Cretaceous surface.......... 2

Unconformity:

Upper Cretaceous:

Tuscaloosa formation:

1. Massive, pure white kaolin to floor of quarry................. 30

Other rocks of Jackson age formerly exposed in Wilkinson County were once located at McIntyre, 3 miles north of Irwinton on Georgia Highway 29, and at Ivey, a mile northeast of Gordon on Georgia Highway 243. The outcrops have either been removed to expose the kaolin deposits, or have been covered by an overburden of waste from the kaolin mills.

Jones County

Only the southern part of Jones County was found to contain Jackson exposures. These occur between the upper reaches of Slash and Big Sandy creeks, and where present, the beds either overlap the Tuscaloosa to rest unconformably upon the crystalline surface of the Piedmont, or occur in unconformable contact with the Tuscaloosa sands.

In a railroad a mile northeast of Postell (formerly Roberts), at the underpass of the Central of Georgia Railroad,

Fig. 65

Abandoned kaolin quarry of Southern Clays Company, 1 mile south of Gordon, Wilkinson County, exposing thick Tuscaloosa kaolin overlain by Tivola limestone and Twiggs clay.

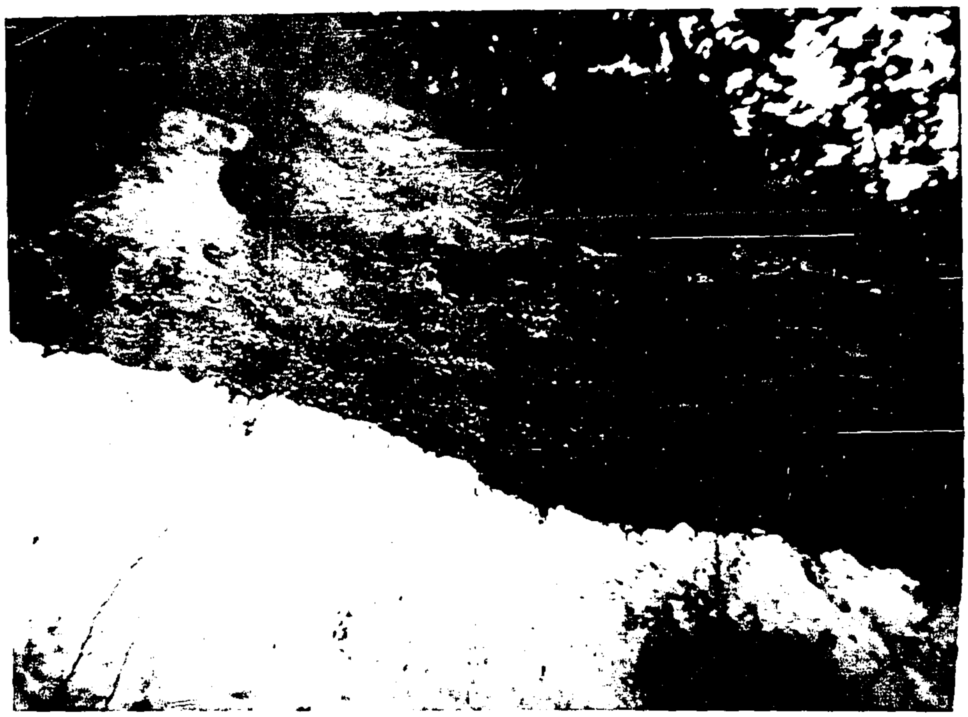

Fig. 66

Disconformity separating white Tuscaloosa kaolin and white to gray, weathered Tivola limestone, 1 mile south of Gordon, Wilkinson County.

Fig. 67

Crumbly Tivola limestone, 1 mile south of Gordon, Wilkinson County.

the following section is exposed ½ mile west of Georgia Highway 49, at an elevation of 626 feet:

	Feet
Eocene:	
Barnwell formation:	
Irwinton sand member:	
5. Loosely consolidated, brilliant red to dark red, fine to coarse-grained, argillaceous quartz sand, with scattered quartz pebbles attaining two inches in diameter at base....................	8
Twiggs clay member:	
4. Greenish-gray, blocky, plastic, fuller's earth type clay, with local sandy laminae..............	10
3. Greenish-gray, sandy, fuller's earth type clay, with white chalk nodules. Top 2 feet extremely fossiliferous............	6
2. Dark blue, calcareous, blocky clay, containing abundant pelecypods and gastropods with original, but very fragile shell material.........................	7
Unconformity (imperceptible)	
Upper Cretaceous:	
Tuscaloosa formation:	
1. Massive, white to reddish-yellow, fine kaolinic sand..........	10

Beds Nos. 2 through 5 in the aforementioned exposure are present north and south of the railroad bridge. The base

Fig. 68

Twiggs clay member exposed along tracks of Georgia Railroad, 1 mile northeast of Postell, Jones County.

Fig. 69

Blocky, blue, fossiliferous, fuller's earth type clay exposed at track level, 1 mile northeast of Postell, Jones County.

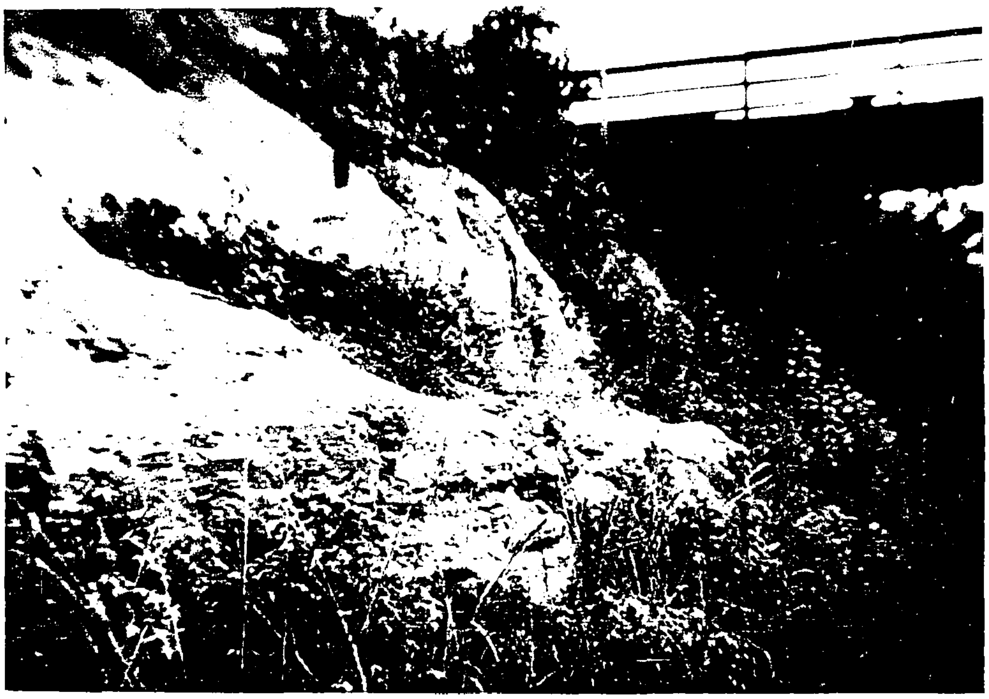

Fig. 70

Hard, massively bedded Tuscaloosa sandstone exposed along tracks of Georgia Railroad, 1.25 miles northeast of Postell, Jones County.

of Bed No. 2 is exposed to the level of the railroad tracks. Bed No. 1 is exposed ¼ mile northeast of the railroad bridge, beneath the wagon bridge overpass.

Baldwin County

A well-exposed section of Jackson beds crops out in southwestern Baldwin County, 1½ miles southeast of Stevens Pottery, and 5.7 miles northeast of Gordon, Wilkinson County, in the kaolin quarry of the General Refractories Company, ½ mile east of Georgia Highway 243.

In the eastern face of the quarry, the following section was observed at an elevation of 330 feet:

	Feet
Eocene:	
Barnwell formation:	
Irwinton sand member:	
5. Massive, dark red, angular, argillaceous, fine-grained quartz sand to top of quarry. Lower part of bed contains laminae of weathered fuller's earth type clay........................	6
Twiggs clay member:	
4. Sandy, cream-colored to red-stained fuller's earth type clay............................	18
3. Dark blue, calcareous, blocky clay or marl, containing abundant pelecypods and gastropods with original but very fragile shell material (equivalent of	

Bed No. 2 at Postell)............ 23

2. Light greenish-gray, glauconitic quartz sand, filling irregularities in Cretaceous surface... 2

Unconformity:

Upper Cretaceous:

Tuscaloosa formation:

1. Massive, pure white kaolin to floor of quarry.................. 21

Hancock County

Cropping out in a road cut culvert on Georgia Highway 248, 3.5 miles south of Jewell in eastern Hancock County, the following section was observed at an elevation of 525 feet above sea level:

Feet

Eocene:

Barnwell formation:

Irwinton sand member:

4. Brownish to reddish, fine to medium-grained, cross-bedded, argillaceous quartz sand with green clay balls at base......... 5

Twiggs clay member:

3. Yellow to green, hackly, plastic, sandy clay of fuller's earth type...................... 5

Channel Sands:

2. Orange to red, coarse, angular, cross-bedded, arkosic sand, with

Fig. 71

Kaolin quarry of General Refractories Company, 1.5 miles southeast of Stevens Pottery, Baldwin County, exposing massively bedded Tuscaloosa kaolin, overlain by thick section of gray to blue Twiggs clay, and massive Irwinton sand.

Fig. 72

South face of Stevens Pottery quarry, revealing disconformity between thick Tuscaloosa kaolin and massive Twiggs clay.

Fig. 73

North face of Stevens Pottery quarry, exposing massive Twiggs clay overlain by thin Irwinton sand. Tuscaloosa kaolin practically covered by Twiggs clay talus at base of exposure.

pebbles attaining four inches in diameter...................... 1

Unconformity:

Pre-Cambrian:

1. Fresh to highly weathered, gray, medium to coarsely crystalline granite......................... 3

Washington County

The Barnwell formation underlies the major part of Washington County, but exposures of complete sections are few, due to concealment by overburden, or due to miners' stripping the Barnwell cover to expose the Tuscaloosa kaolin. The Twiggs clay and Irwinton sand members are readily recognized where exposed in road cuts and kaolin quarries.

The rocks of Jackson age in Washington County have been well-dissected by such streams as Buffalo and Williamson Swamp creeks, and Ogeechee River, and their tributaries, which in places have cut into the underlying Tuscaloosa kaolin.

An isolated outcrop of limestone, a mile south of the courthouse at Sandersville, was reported by Veatch and Stephenson (1911, pp. 253-255) as part of the McBean formation. Cooke and Shearer (1918, pp. 68-69) later described the same bed at the head of Limestone Creek as Barnwell in age. In a later publication, Cooke (1943, p. 62) named the seventeen-foot limestone section the Sandersville limestone member of the Barnwell formation, with type locality at Sandersville,

Fig. 74

Twiggs clay member in contact with pre-Cambrian granite along Georgia Highway 248, 3.5 miles south of Jewell, Hancock County.

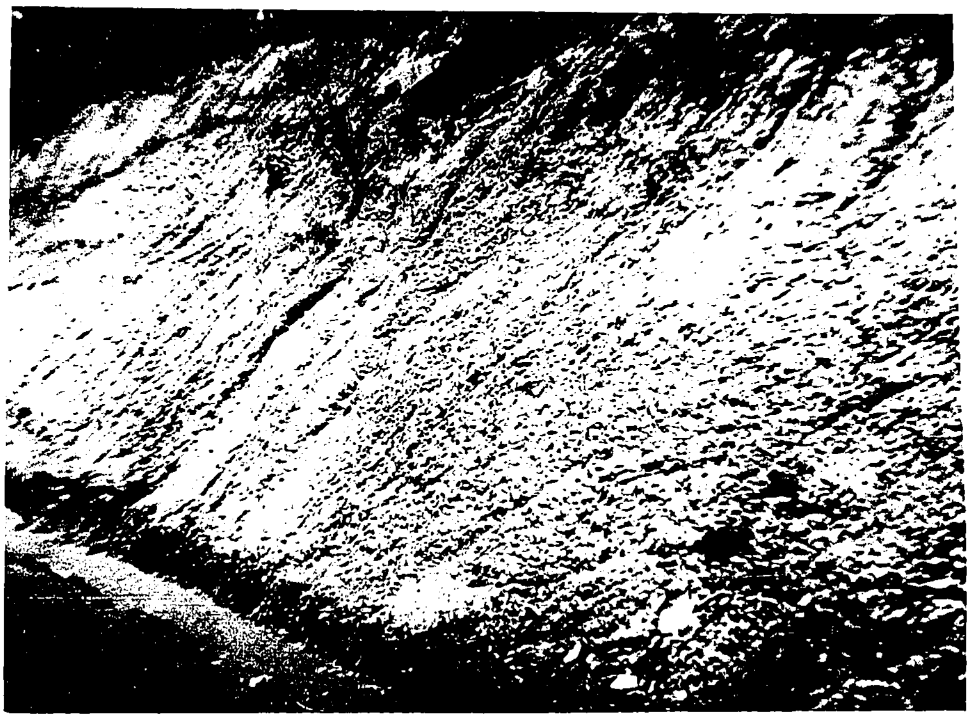

Fig. 75

Weathered Twiggs clay along Georgia Highway 248, 3.5 miles south of Jewell, Hancock County.

Fig. 76

Twiggs clay member overlain by Irwinton sand member along Georgia Highway 248, 3.5 miles south of Jewell, Hancock County.

Washington County.

The writer visited the old Champion Clay Mine, a mile south of Sandersville, as well as other areas where this sequence has been reported, but discovered only a small amount of limestone, with a few fossil remains including *Ostrea georgiana* Conrad, bryozoans, and a possible *Periarchus quinquefarius* (Say).

The following section described by Cooke (1918, p. 69) occurs at an elevation of 450 feet above sea level:

	Feet
Barnwell formation:	
6. Red sand to top of hill..............	10+
5. Coarse gray sandstone, irregularly indurated and terminating laterally in red sand.........................	6
4. Gray sand, oxidized red and yellow, exposed along road..................	15
3. Light-gray chalky limestone; contains *Mortonella quinquefaria* (Say) in abundance and casts of other fossils; *Ostrea georgiana* is reported here. Exposed in sink.......	12
2. Gray, very sandy limestone with obscure fossils.....................	5±
1. Bright blue incoherent sand, apparently grading into gray sandy limestone. Exposed in stream below sink............................	2

In a road cut on Georgia Highway 248, 5.75 miles north of Warthen, the following section was observed at an elevation of 502 feet above sea level:

	Feet
Barnwell formation:	
Irwinton sand member:	
2. Brilliant to dark red to yellow, fine to medium-grained, argillaceous, cross-bedded quartz sand to top of cut......................	15
Twiggs clay member:	
1. Gray to blue, blocky, plastic, fuller's earth type clay to level of road......................	15

Barnwell outcrops also occur in a road cut on Georgia Highway 102, a mile northeast of Warthen, at an elevation of 500 feet above sea level:

	Feet
Barnwell formation:	
Irwinton sand member:	
2. Dark red, fine to medium-grained, argillaceous quartz sand to top of cut.............................	10
Twiggs clay member:	
1. Light gray to rusty brown, blocky, plastic, fuller's earth type clay to level of road..................	10

On the Otis Parker property, 6 miles north of Sandersville, and 2 miles west of Georgia Highway 15, on the pine covered south slope of Little Keg Creek, the following sec-

Fig. 77

Weathered Twiggs clay overlain by massive Irwinton sand along Georgia Highway 248, 5.75 miles north of Warthen, Washington County.

Fig. 78

Blocky, light-gray to brown Twiggs clay exposed along Georgia Highway 102, 1 mile northeast of Warthen, Washington County.

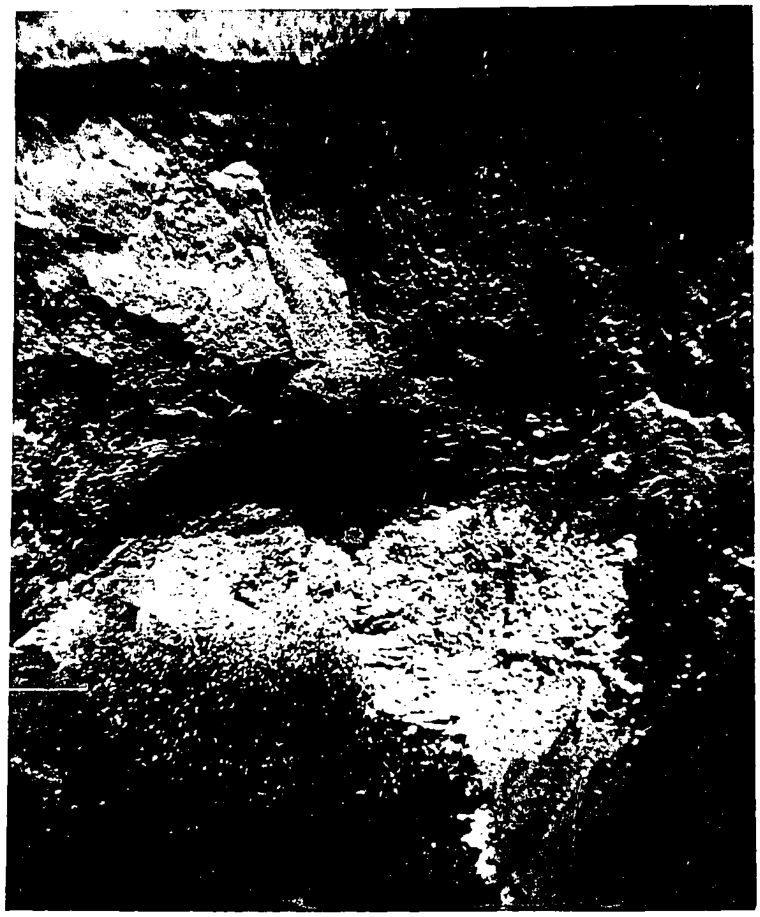

Fig. 79

Gray to yellowish Twiggs clay overlain by massive, brilliant red Irwinton sand in gully on Otis Parker property, 6 miles north of Sandersville, Washington County.

tion is exposed in a deeply eroded gully at an elevation of 250 feet:

	Feet
Barnwell formation:	
Irwinton sand member:	
2. Brilliant to dark red, fine to medium-grained quartz sand, with thin laminae of yellow sandy clay at base..........................	18
Twiggs clay member:	
1. Gray to yellowish, blocky, plastic clay of fuller's earth type to bottom of gully.....................	10

In an abandoned quarry of the Hale Brothers Kaolin Company, 14.5 miles west of Sandersville, and 1.5 miles north of Georgia Highway 24 on the Deepstep Road, west of Buffalo Creek, the following section was observed at an elevation of 237 feet:

	Feet
Eocene:	
Barnwell formation:	
Irwinton sand member:	
3. Dark red to lavender, brown to dark yellow, very fine-grained, argillaceous, micaceous quartz sand, with thin streaks of plastic gray clay attaining an inch in thickness in lower part, and a layer of ferruginous nodules at top........................	20

Twiggs clay member:

2. Gray to yellow, blocky, plastic, fuller's earth type clay......... 1

Unconformity:

Upper Cretaceous:

Tuscaloosa formation:

1. Massive white kaolin to quarry floor.............................. 12

On Georgia Highway 68, the following section was observed in a road cut 8 miles southwest of Tennille, at an elevation of 380 feet above sea level:

	Feet
Barnwell formation:	
Irwinton sand member:	
3. Brilliant to dark red to yellow, fine-grained, argillaceous quartz sand to top of cut...............	6
Twiggs clay member:	
2. Grayish-green, hackly, blocky, plastic fuller's earth type clay, interbedded in lower part with layers of red, argillaceous sand from ¼ to 3 inches in thickness..	6
1. Yellow, fine-grained, argillaceous quartz sand, with lenses of overlying gray clay..................	1

A mile west of Sandersville city limits, on the east slope of Limestone Creek, a road cut on Georgia Highway 24 exposes the following section at 458 feet above sea level:

Fig. 80

Hale Brothers Kaolin Mine, 14.5 miles west of Sandersville, Washington County, exposing massive Tuscaloosa kaolin overlain by thin Twiggs clay and massive, red Irwinton sand.

Fig. 81

Massively bedded, pitted Irwinton sand, Hale Brothers Kaolin Mine, 14.5 miles west of Sandersville, Washington County.

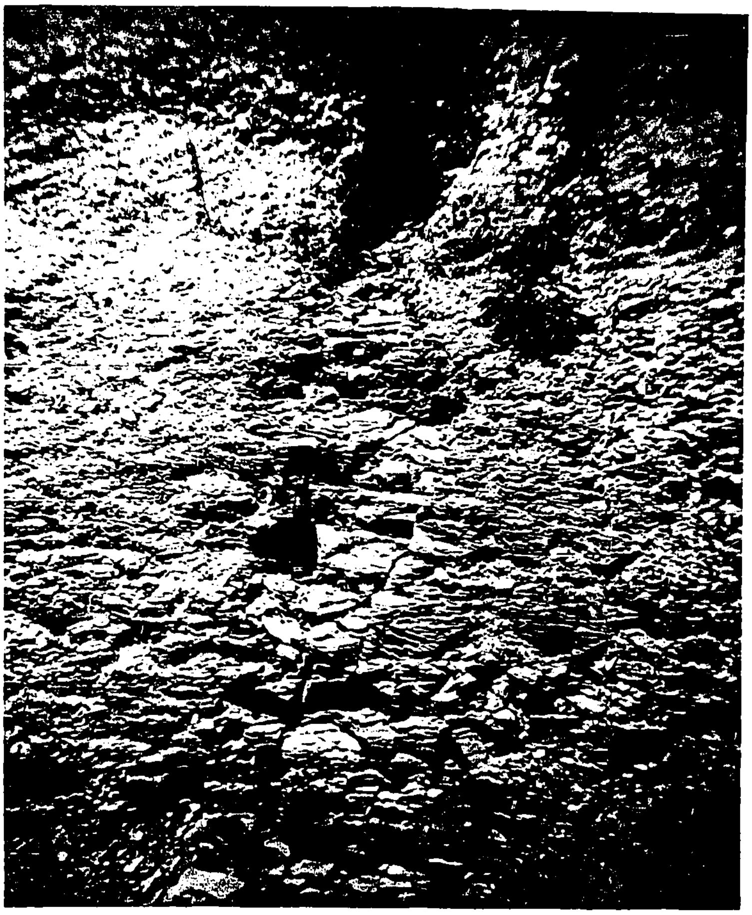

Fig. 82

Blocky Twiggs clay exposed along Georgia Highway 68, 8 miles south of Tennille, Washington County.

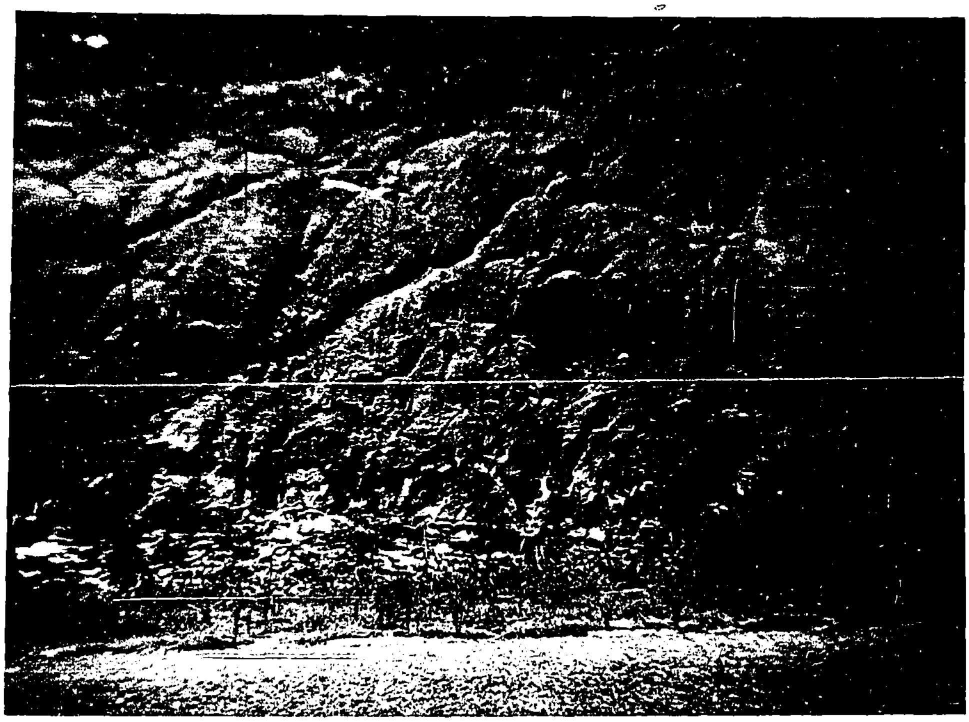

Fig. 83

Exposure of Twiggs clay member (below) and massively bedded, red Irwinton sand, along Georgia Highway 24, 1 mile west of Sandersville, Washington County.

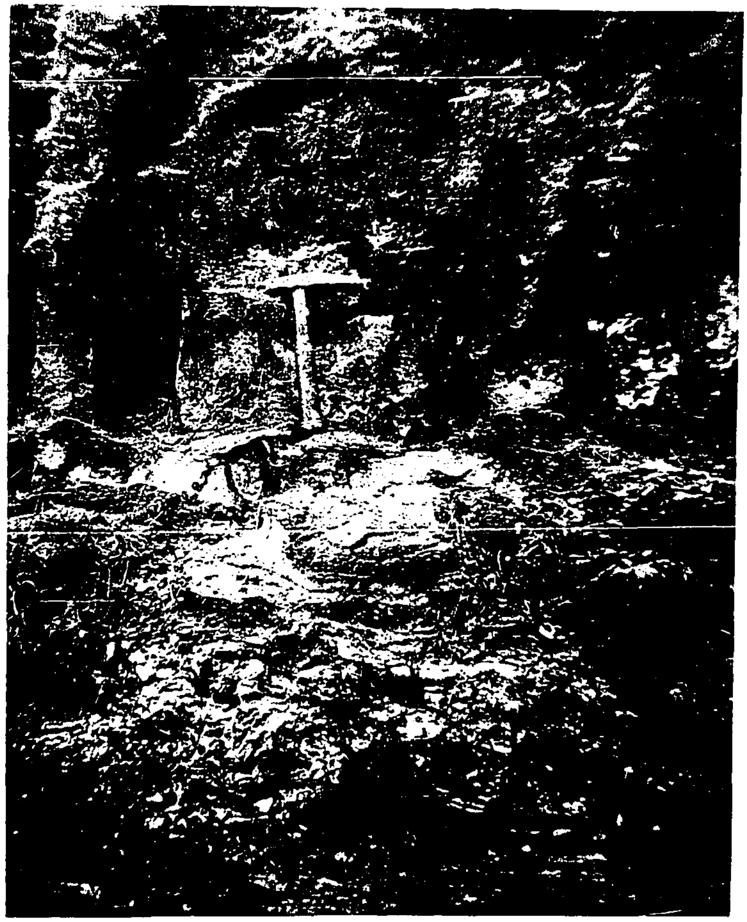

Fig. 84

Weathered, blocky Twiggs clay overlain by massive, pitted Irwinton sand, along Georgia Highway 24, 1 mile west of Sandersville, Washington County.

	Feet
Barnwell formation:	
Irwinton sand member:	
2. Brilliant to dark red to yellow, fine-grained, argillaceous, quartz sand to top of cut................	15
Twiggs clay member:	
1. Gray to yellowish-white, plastic, blocky, fuller's earth type clay, interbedded with thin laminae of yellow, fine-grained quartz sand, from 1/8 to 2 inches in thickness..	4

Glascock County

Glascock County is underlain by the Barnwell formation. Several of the members of the Barnwell are recognizable, including the Twiggs clay, the Upper Sand member, and the topmost yellow to brown argillaceous quartz sand member. The Irwinton and Sandersville members are not recognized thus far northwest.

The exposed Barnwell beds in Glascock County are dissected by Ogeechee River and Rocky Comfort and Deep creeks. Only between the two latter streams, 4 miles east of Gibson, and ½ mile south of Georgia Highway 80, was a typical section exposed during this investigation. At the fire-clay mine of the Harbison-Walker Refractories Company, southeast of Gibson, the following section was observed at an elevation of 346 feet above sea level:

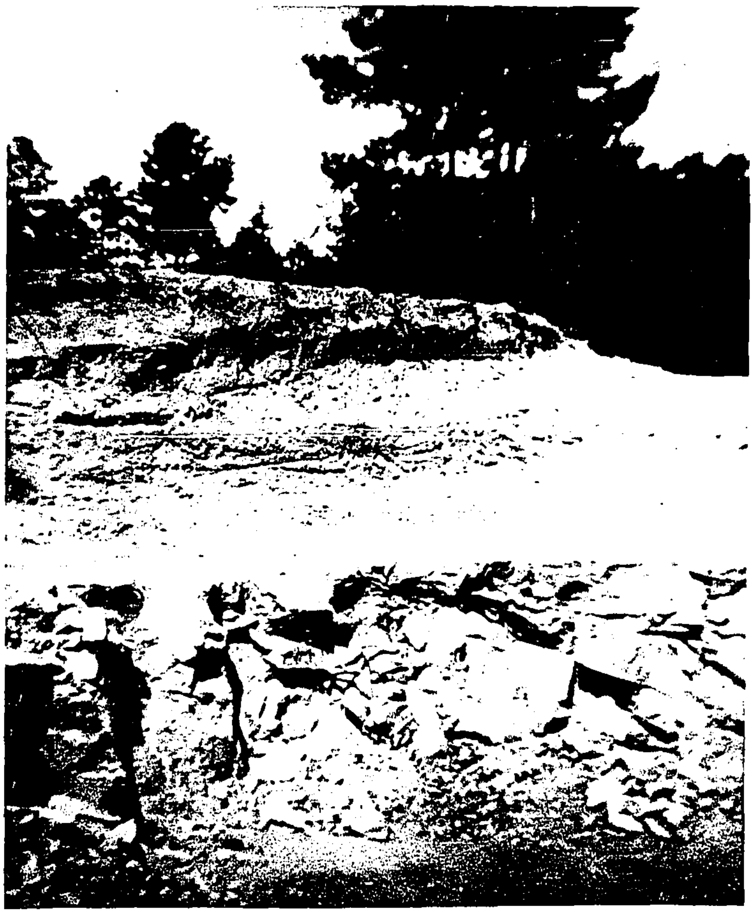

Fig. 85

Harbison-Walker fireclay mine, 4 miles east of Gibson, Glascock County, exposing massive Tuscaloosa kaolin overlain by Twiggs clay member and sands of Upper Sand member, and uppermost Barnwell sands.

	Feet
Eocene:	
Barnwell formation:	
Topmost Sand member:	
4. Fine-grained, yellow to brown, unindurated, massive, argillaceous quartz sand to top of quarry........................	7
Upper Sand member:	
3. Hard, conglomeratic layer of yellow to brown quartz sand and pebbles......................	3
Twiggs clay member:	
2. Massive, grayish-green, hackly, blocky, fuller's earth type clay, with lignite partings at base, filling irregularities on Cretaceous surface..................	2
Unconformity:	
Upper Cretaceous:	
Tuscaloosa formation:	
1. Bluish-gray to white, massive kaolin to floor of quarry........	10

Jefferson County

The sands and clays of the Barnwell formation extend southward from Glascock into Jefferson County, underlying practically all of the latter county.

On the east bank of Rocky Comfort Creek on Georgia Highway 171, a road cut 3/4 mile west of Louisville exposes the following section east of the old wagon bridge which cros-

Fig. 86

Road cut .75 mile west of Louisville, Jefferson County, exposing sands and fuller's earth of Twiggs clay member, and Irwinton sand member.

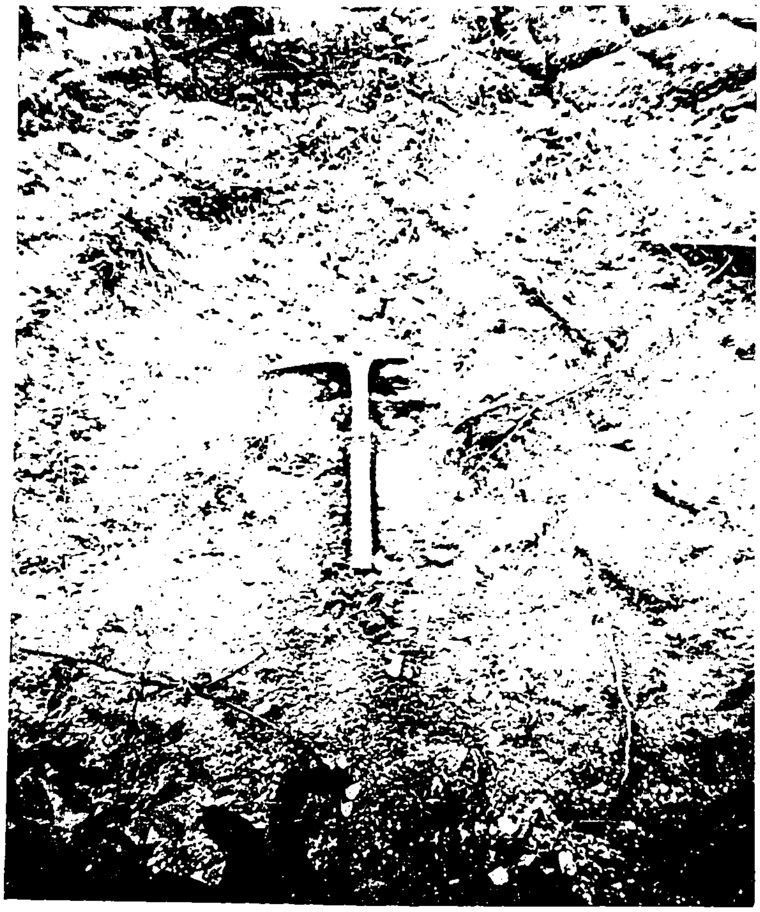

Fig. 87

Hackly Twiggs clay, .75 mile west of Louisville, Jefferson County.

ses the creek at an elevation of 320 feet above sea level:

	Feet
Barnwell formation:	
Topmost Sand member:	
6. Massive, brilliant to dark red, fine-grained, argillaceous, unconsolidated quartz sand...........	15
Irwinton sand member:	
5. Massive, brown to yellow, fine-grained, unconsolidated quartz sand...............................	6
Twiggs clay member:	
4. Green, hackly, blocky, plastic, fuller's earth type clay...........	3
3. Fine-grained, dark yellow to brown quartz sand..................	4
2. Fine to medium-grained, dark red, argillaceous quartz sand...........	7
1. Gray to white and yellow, fine-grained quartz sand to level of road...............................	6

A mile south of Wrens on U. S. Highway 1 (Georgia Highways 4 and 17), the following section is exposed on the north slope of Brushy Creek at an elevation of 423 feet above sea level:

	Feet
Barnwell formation:	
Irwinton sand member:	
3. Dark red, argillaceous, fine to	

Fig. 88

Road cut on west side of U. S. Highway 1, 1 mile south of Wrens, Jefferson County, exposing Twiggs clay member overlain by dark red Irwinton sand.

medium-grained quartz sand, with thin laminae of light-green fuller's earth type clay near base.... 20

Twiggs clay member:

2. Slightly indurated, porous, hackly, green clay of fuller's earth type.. 7

1. Concealed interval to creek level.. 5

Burke County

Only three exposures of Jackson strata were discovered in Burke County during the present investigation, two near Savannah River in the eastern part of the County, and a third at Keys Mill in the northwestern corner of the county, 3 miles north of St. Clair. In Burke County the writer observed the first occurrence of the basal part of the Twiggs clay member, the Ostrea georgiana Conrad zone.

At Red's Pond (formerly Keys Mill), 3 miles southeast of Keysville and 3 miles north of St. Clair, the following exposure occurs on the east slope of the mill pond on Reedy Creek 320 feet above sea level:

Feet

Barnwell formation:

Irwinton sand member:

5. Dark red, argillaceous, fine-grained quartz sand containing laminae of greenish-yellow, plastic, hackly clay near base...................... 35

4. Coarse yellow quartz sand with lignite partings at base............ 10

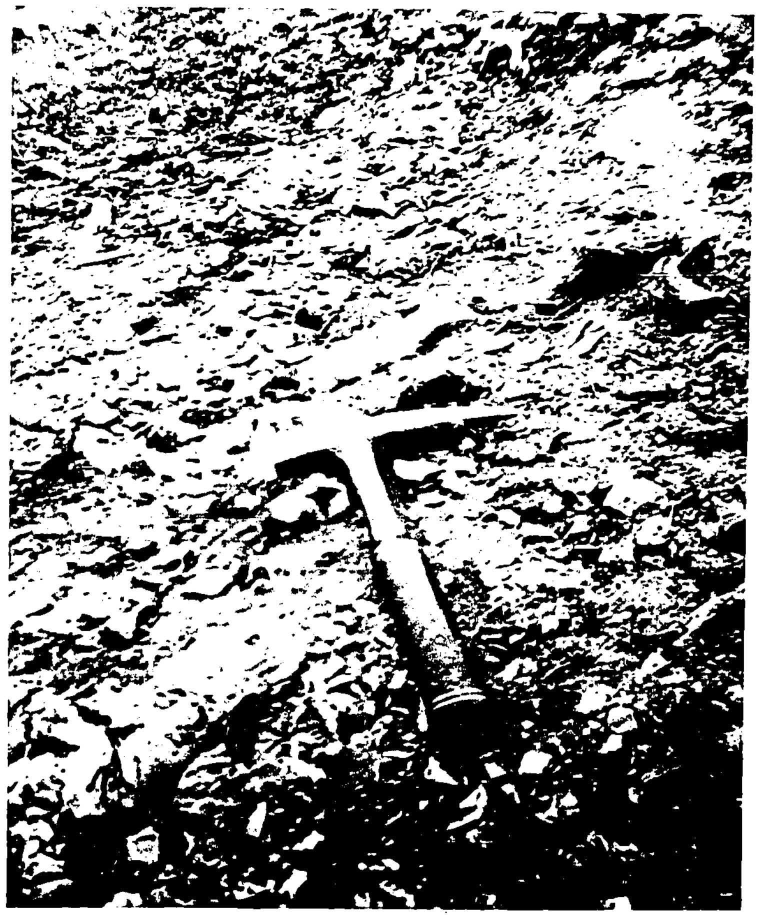

Fig. 89

Top of Ostrea georgiana Conrad zone, Red's Pond (Keys Mill), 3 miles southeast of Keysville, Burke County.

Fig. 90

Massively bedded Twiggs clay, Red's Pond, 3 miles southeast of Keysville, Burke County.

Fig. 91

Blocky Twiggs clay, Red's Pond, 3 miles southeast of Keysville, Burke County.

Twiggs clay member:

3. Pale-green, hackly, fuller's earth type clay along narrow road above pond..................... 4

2. Bed of large oyster shells (<u>Ostrea georgiana</u> Conrad zone) in a matrix of hard, white to reddish limestone and green plastic clay. (New water well reported to penetrate this bed at depth of forty-five feet).............observed..... 7

1. Concealed interval to pond level.... 5

The majority of the earlier writers report the presence of Barnwell lithology at Shell Bluff on Savannah River. All of the beds at this locality were formerly assigned to the Claiborne group, the contact between the Barnwell and McBean formations being considered as the top of the <u>Ostrea georgiana</u> Conrad zone. A study of the faunas at this locality by Vaughan (1911, p. 240), however, revealed the presence of a distinct Jackson assemblage, which necessitated raising the <u>Ostrea georgiana</u> Conrad zone so as to include it in the lower part of the Barnwell.

During the present investigation, the Shell Bluff locality was inaccessible to the writer. The following section is that of Cooke and Shearer (1918, p. 61):

<u>Feet</u>

Barnwell formation:

7. Apparently all red argillaceous sand to level of upland plain. The

surface of the plain is covered by several feet of loose gray sand, but clayey sand for road building is obtained from shallow trenches along the roads...... 35

6. _Ostrea georgiana_ zone. The base of the oyster bed is 80 feet above zero water level in the river, and although exposures are not continuous, oysters are found up to 110 feet above water level. The oyster bed at the base of the zone contains very large shells in a matrix of yellowish sand. Above this is a bed of calcareous conglomerate containing quartz pebbles. Above the conglomerate bed the oysters are in a matrix of yellowish marl or hard calcareous clay, having some of the characteristics of fuller's earth. The matrix of the oyster shells contains Bryozoa of the Rich Hill facies of the Jackson fauna....... 30

McBean formation:

5. Concealed interval between upper and lower bluffs. Covered by talus from the _Ostrea georgiana_ zone and other overlying formations but probably is a bed of sand............................. 10

4. Moderately hard to hard light-colored marl, with few fossils.... 9

3. Ledge of hard brown coquina-like rock, with numerous hollow casts of fossils.................. 6

2. White to purplish sandy limestone, made up largely of fossils. This is the most important fossiliferous stratum of the McBean formation, and Vaughan collected from it a total of 35 species. It is characterized by large specimens of _Ostrea sellaeformis_........... 6

1. Sandy and argillaceous marl, not abundantly fossiliferous; in layers differing considerably in color, hardness, and chemical composition. A number of analyses show calcium carbonate content ranging from 50 to 90 per cent, but the actual local variation is even greater, for these are thin ledges of comparatively pure limestone and other beds of slightly calcareous sand and clay. The color, as a whole, appears light gray, but individual beds have various shades of white, yellow, buff, gray, and greenish-yellow. This bed is exposed as an almost vertical cliff, rising from water level, in which the harder layers form projecting ledges........................... 50

In a road cut on the Shell Bluff-McBean road, 1.5 miles northwest of Shell Bluff Community, the following section was observed on the east side of the road at an elevation of 256 feet above sea level:

	Feet
Barnwell formation:	
Irwinton sand member?	
3. Dark red, argillaceous, fine to medium-grained quartz sand to top of cut..............................	15
Twiggs clay member:	
2. Yellow to greenish-gray and red-stained, hackly, blocky, sandy clay of fuller's earth type containing bryozoa......................	3

1. Hard to very soft, red quartz sand, containing layers of hematitic material from ½ to 2 inches thick to bottom of cut.............	3

This section is at least 6 miles from the classical Shell Bluff exposure, and in some respects appears equivalent to Beds Nos. 6 and 7 of the classic section.

In a road cut on Georgia Highway 56, ½ mile southeast of the town of McBean, the following section was observed at an elevation of 240 feet above sea level:

	Feet
Barnwell formation:	
Irwinton sand member?	
3. Dark red, argillaceous, fine to medium-grained quartz sand to top of road cut.........................	6
2. Very hard, gray to white, silicified, fossiliferous limestone or marl................................	8
1. Dark red to lavender, fine-grained, argillaceous quartz sand, streaked with thin laminae of gray, sandy clay................................	3-10

Richmond and Burke Counties

During the present investigation, the writer endeavored to visit several localities mentioned by previous authors in the northeasternmost areas of outcrop of Jackson beds, but these were either inaccessible or obliterated.

In Richmond County, according to Cooke and Shearer

Fig. 92

Gully along Shell Bluff-McBean road, 1.5 miles northwest of Shell Bluff Community, exposing red sand and green to red Twiggs clay, and probable Irwinton sand (above).

Fig. 93

Sparsely fossiliferous Twiggs clay overlain by probable Irwinton sand, along Shell Bluff-McBean road.

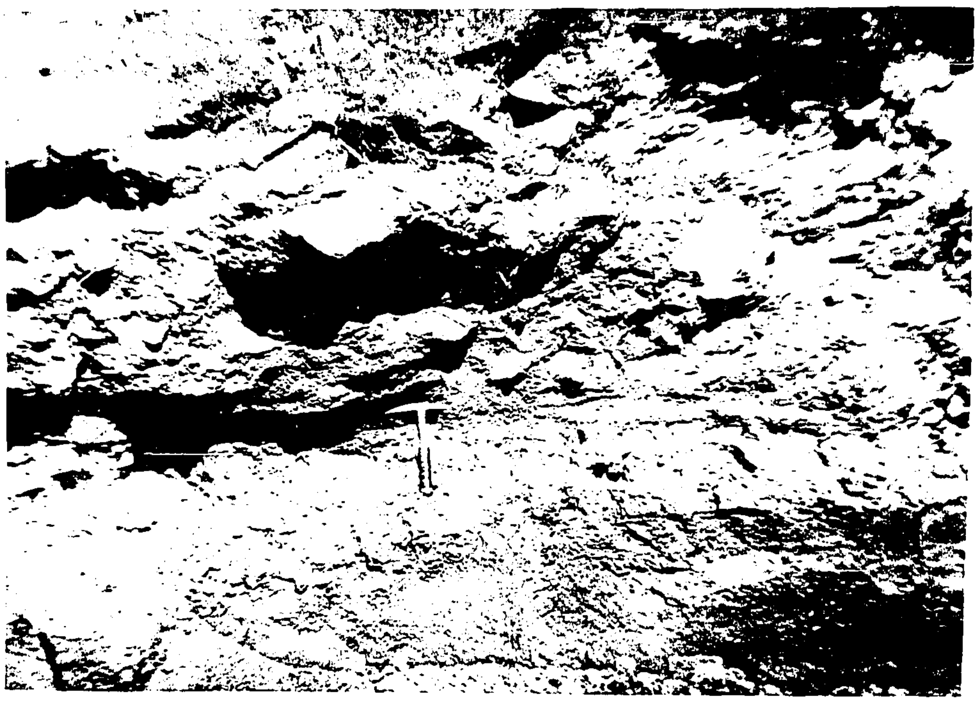

Fig. 94

Dark red to lavender, lower Barnwell sand, overlain by blocky, fuller's earth type clay and limestone of Twiggs clay member, along Georgia Highway 56, .5 mile southeast of McBean, Burke County.

(1918, pp. 63-65), "the Barnwell formation caps the hills north of McBean Creek, where it overlies the McBean formation, but in the absence of characteristic beds it is almost impossible to distinguish one formation from another. In the vicinity of Bath and in the western part of the county, the Barnwell formation contains at its base beds of indurated fuller's earth which directly overlie the Cretaceous."

Following is a section measured by Cooke and Shearer (1918, p. 64) on the north slope of Mount Enon, near Dean's Bridge Road, 14 miles southwest of Augusta and 3 miles northeast of Bath, Richmond County, at an elevation of 400 feet above sea level:

	Feet
Eocene:	
Barnwell formation:	
8. Apparently all red sand to top of hill. Near the top are fragments of dense banded cherty limestone........................	60
Twiggs clay member:	
7. Soft white fuller's earth; as the top of the bed is not exposed, the thickness may be greater than indicated..........	3
6. Argillaceous sandstone with abundant but poorly preserved fossils and rounded quartz pebbles an inch in maximum diameter............................	1

5. Coarse yellow sand..............	11
4. Light-drab claystone, with angular and conchoidal fracture on weathering. Has a high SiO_2-Al_2O_3 ratio and is a silicified fuller's earth, exactly like that at Hatcher's Mill and at Wrens, Jefferson County.........	11
3. Gray plastic clay................	1
Unconformity:	
Lower Cretaceous:	
2. Indurated sandy kaolin or flint clay............................	10
1. Kaolinic sand, etc., not measured	
	97

The sandy kaolin and kaolinic sand are now known to be members of the Tuscaloosa formation of Upper Cretaceous age.

The Phinizy Gully locality, in Columbia County, a mile northeast of Grovetown was also studied by Cooke and Shearer (1918, p. 64), but was inaccessible during the present investigation. This is the locality from which Berry (1914, pp. 130-131) described Eocene plants collected from the Twiggs clay member.

Following is the section measured and described by previous writers (1918, p. 64) in Phinizy Gully, on the old Augusta-Wrightsboro road, one mile northeast of Grovetown, Columbia County:

Feet

Eocene:

Barnwell formation:

6.	Yellow to red argillaceous sand, coarse and pebbly near base. Caps hill to east of gully, to an altitude of 540 feet................	50+
5.	Laminated plastic greenish clay.....	0-3
4.	Conglomerate of varicolored kaolin pellets in red sand. Contains some fragments of lignitized wood.........	0-2

Unconformity (?)

Twiggs clay member:

3.	Laminated shaly fuller's earth containing local leaf impressions. The bedding dips west at a smaller angle than the unconformity below. Pinches out toward the east.........	0-6

Lower Cretaceous:

2.	Silicified white sandy kaolin or flint clay; has been described as "argillaceous sandstone." The bedding dips 10° east: the unconformity above dips 15° west in the head of the gully.......................	12
1.	Soft plastic white kaolin, interbedded with white and yellow sand, with some kaolin conglomerate near the bottom of the exposure..........	12

As in Richmond County, at the Mount Enon locality, the kaolin beds recorded as Lower Cretaceous are now an established part of the Tuscaloosa formation of Upper Cretaceous age.

CHAPTER VII

STRATIGRAPHY, CORRELATION, AND STRUCTURE

Stratigraphy and Correlation

In the present interpretation the Jackson group of Georgia includes the Ocala limestone (with its lower or Tivola member) and its deltaic equivalent equivalent, the Barnwell formation. The Barnwell section includes the Twiggs clay, Irwinton sand, Sandersville limestone, and Upper Sand members, all correlative with the upper part of the Jackson group at the type locality in Jackson, Mississippi.

In Florida, the upper part of the Ocala limestone has been designated Ocala "restricted" (Vernon, 1951, p. 111), the formation having been subdivided into two units and correlated with two such corresponding beds at the type locality. The former term "lower Ocala" is now termed the Moodys Branch formation, and consists of two members, the lower or Inglis member, and the upper or Williston member. The Moodys Branch formation in Florida comprises an 80-foot section of limestone lying unconformably upon the Avon Park limestone of Upper Claiborne age. No part of the Jackson group of Georgia has been proven equivalent to the Moodys Branch formation.

The Ocala and Barnwell formations of Georgia are equivalent to the upper or Ocala "restricted" of the Florida section. The lithologies and faunas of the two limestone sections are quite similar. The Ocala of both areas is marine, extremely fossiliferous, very soft to very hard, massive, white to cream-colored, consisting of a spongy mass of fossil remains in a matrix of fairly pure calcium carbonate. Large foraminifers, echinoids, and molds and casts of pelecypods and gastropods are abundant. Bryozoans are the most prolific remains, constituting much of the rock mass in both areas. Such forms as *Amusium ocalanum* Dall, *Periarchus lyelli* (Conrad) and its conical variety *P. pileus-sinensis* (Ravenel), *Rumphia archerensis* (Twitchell), *Lepidocyclina ocalana* Cushman, *Pecten spillmani* Gabb, *Pecten perplanus* Morton, and many others, are quite numerous, and serve as useful guide fossils in the formation.

Several species discovered in the Ocala of Georgia during the present investigation are reported also from the Inglis member of the Moodys Branch formation, including *Cassidulus ericsoni* Fischer, *Eupatagus mooreanus* Pilsbry, and *Agassizia floridana* de Loriol. Fossils from the Ocala of Georgia which occur in the Williston member of the Moodys Branch of Florida include *Schizaster armiger* Clark, *Peronella cubae* Weisbord, and *Eupatagus dixie* Cooke.

In Georgia the Ocala limestone is overlain by the Suwannee limestone (Flint River formation) of Upper Oligocene age. At none of the outcrops studied is there any evidence of an unconformity separating the two units.

The beds of upper Jackson age in Georgia are correlative with upper Jackson units in Alabama. The Alabama Jackson section consists of the upper part of the Ocala limestone and three members of the Yazoo clay, lower and upper clay, and the Cocoa sand. The Moodys Branch formation of Alabama is equivalent to the lower part of the Jackson of Florida. In central Alabama, a sequence to noncalcareous sands and shales of lower and middle Yazoo age interfingers eastwardly with the Ocala. These beds are considered by some (MacNeil, 1947, Correlation Chart) a part of the Ocala. Possibly they should be considered as Ocala members in Alabama.

In Mississippi, the entire upper Jackson is composed of the Yazoo clay and the Cocoa sand member, the latter extending westward from Tombigbee River across the state line into the lower upper part of the Yazoo.

From east-central Georgia, the Barnwell formation extends northeastward into South Carolina, beyond the type locality in Barnwell County. Other Jackson units in South Carolina are the Santee limestone, which, according to Cooke (1936, p. 72), appears to be equivalent to the basal Barnwell, and the Cooper marl, which may be equivalent to the upper Barnwell. The Santee fauna contains many species of Bryozoa and echinoids occurring in beds of equivalent age to the southwest in Georgia and Alabama. The limestone at the base of the Barnwell in South Carolina contains such forms as Lepidocyclina ocalana Cushman, which occurs in the Tivola member at various localities in Georgia. Foraminifers and other remains in the Cooper marl of South Carolina suggest an age equivalent with Jackson beds in the Georgia section. Following a study of outcrops in Georgia where the Cooper marl has been reported, the writer is of the opinion that the unit does not occur in the State. Beds referred to the Cooper are considered a part of the Irwinton sand member, and should be designated as such, as at the Penn-Dixie Quarry at Clinchfield, Houston County.

The Castle Hayne marl of North Carolina is the stratigraphic equivalent of the Santee limestone, the Twiggs clay, and the Tivola limestone members to the south and southwest. Several characteristic Castle Hayne species were discovered in the Tivola member of the Ocala limestone of Georgia, including many of the bryozoans in the Rich Hill, Crawford County section, and Periarchus pileus-sinensis (Ravenel).

The Ocala limestone in Georgia is the remnant of a marine sequence deposited by a transgressive sea in upper Jackson time. Evidently, the preceding deposits of Claiborne age were being removed from the exposed land surface in Georgia, while the lower Jackson beds (Moodys Branch formation) of Florida, Alabama, and Mississippi were being deposited. This erosion proceeded until it laid bare the deeply-dissected Tuscaloosa surface, removing the Claiborne from all except the extreme northeastern and southwestern parts of the State.

Surface evidence indicates that the oldest beds of Ocala in central Georgia (Tivola member) were deposited as a thin tongue of soft fossiliferous limestone and calcareous sand upon the dissected Tuscaloosa surface, as far north as the vicinity of Gordon, Wilkinson County. At Stevens Pottery, 5.6 miles to the northeast, in Baldwin County, the lowest beds of Jackson age are Twiggs clay strata resting directly upon the eroded Tuscaloosa surface. Somewhere between this exposure and that at Gordon, the Tivola must pinch out, since that member is present at Gordon and absent at Stevens Pottery.

Immediately following Tivola time, the clastic materials of the Barnwell formation began to accumulate in the former limestone environment. These materials were derived from the Tuscaloosa and the exposed Pre-Cambrian crystalline rocks to the north and northwest. These lowermost Barnwell beds are the fine, green, hackly clays of the Twiggs clay member, which were deposited as a continuous sheet of fuller's earth from central Sumter County to and beyond the Savannah River. The trans-Savannah portion of the Twiggs clay is the Ostrea georgiana Conrad zone, which occurs in the lower part of the member, and is present in Burke County, Georgia.

Coarser materials comprising the overlying Irwinton sand member of the Barnwell formation, later encroached upon the Twiggs surface, possibly as far south as Peach and Houston counties, Georgia. In many places in its lower portion the Irwinton contains thin laminae of weathered fuller's earth and scattered quartz pebbles.

The origin of the Sandersville limestone member has not been explained sufficiently by previous authors. Sandersville lithology and fauna closely resemble those of the Ocala to the south, but its presence in an area surrounded by the clastic facies of the Irwinton sand member is problematical. The Sandersville limestone outcrop at the type locality, and several isolated lenses of siliceous limestone in southern Washington County, could represent possibly a second advance of the upper Ocala sea from the south and southeast into the clastic environment of the Barnwell. However, these beds cannot be retraced continuously on the ground to the south, since any strata intervening between the widely separated outcrops of the Sandersville and Ocala have been obliterated and supplanted by the red sands of the upper part of the Irwinton.

At a few localities near the source area of the Barnwell sediments, coarse sands and polished beach pebbles unconformably overlie the Irwinton, but such erosional surface is not everywhere evident. In some areas the Upper Sand member, as these beds are termed, lies directly upon the Irwinton without evidence of unconformity.

In northeastern Georgia, the Barnwell lies unconformably upon the McBean formation of Claiborne age. In most of its area of outcrop, the Barnwell lies unconformably upon either the Tuscaloosa kaolin or sand of Upper Cretaceous age, or upon the eroded Pre-Cambrian rocks of the Piedmont, thereby having overlapped the Tuscaloosa. From Pulaski, Bleckley, and Twiggs counties northeastward, the Barnwell is overlain by the Suwannee limestone (Flint River chert) of Upper Oligocene age, and the Hawthorn formation of upper Lower Miocene age.

Structure

The regional dip of the Barnwell and Ocala formations of Georgia is exceedingly gentle, approximating 3 to 12 feet per mile to the south and southeast. The regional dip of the sediments has its origin in the gentle southeastward inclination of the underlying beds on which they were deposited. No inclination of strata at any particular outcrop is discernible, rather, they appear horizontal. The strike of the formations is N. 40° E., paralleling that of the underlying Cretaceous and the overlying Oligocene and Miocene.

Subsurface studies of the Jackson group of Georgia were made by Toulmin (1952, p. 1164) and Richards (1945, pp. 920-926). The following depths were recorded by Toulmin in central and southeastern Georgia:

	Depth
Base of upper Jackson at Sandersville.......	266'
" " " " in Treutlen County....	695'
" " " " in Montgomery County..	695'
" " " " in Appling County.....	885'
" " " " in Pierce County......	945'

From these given depths, the writer computes a dip of 3.03 feet to the mile to the south-southeast.

Richards (1945, pp. 920-926) made a study of oil-test well samples from 18 counties in southeastern and southern Georgia, and reported the Ocala limestone or its equivalents at depths ranging from 205 to 1120 feet. He assembled the following data from a study of core samples on file at the Georgia Geological Survey:

At Albany, Dougherty County, the J. R. Sealy's Reynolds Bros.-Lumber Co. No. 1 encountered the Ocala limestone between) and 205 feet, with total depth in the Tuscaloosa sandstone at 5,013 feet. In a test well approximately 10 miles south of Waycross, Ware County the Waycross Oil Company encountered the Ocala at a reported of 1,120 feet with total depth in the Midway (Paleocene) at 2,978 feet. The distance between the two aforementioned wells is approximately 110 miles, thus, indicating a dip of 8.3 feet per mile to the southeast.

Near McRae, Wheeler County, the Dixie Oil Company encountered the top of the Ocala at 680 feet in a well whose depth totalled 3,389 feet in the Upper Cretaceous. In a well twelve miles west of Hazelhurst, Jeff Davis County, the Ocala was encountered at 1,115 feet, with total depth in lower Eocene or Upper Cretaceous at 1,975 feet. The distance between the two aforementioned wells is 20 miles, with a resultant dip of 2.1 feet per mile to the southeast.

Glen Rose Oil Co.-Fowler No. 1, 6 miles west of Soperton, Treutlen County, was abandoned in the Eutaw sand of Upper Cretaceous age at 2,125 feet. The Ocala limestone was encountered therein at 695 feet. Near Brunswick, Glynn County, Hercules Powder Company drilled to a total depth of 1,063 feet, where it encountered beds of Ocala or Claiborne age. At 795 feet, limestone with bryozoans and foraminifers of Ocala age were found in the samples. The distance between the two wells is 105 miles, resulting in a southeastward dip of 0.95 feet per mile.

At Rich Hill, Crawford County, at an elevation of 518 feet above sea level, occurs 89 feet of Barnwell and Ocala sediments. With the base of the Jackson here as a datum, the dip of the beds from this point to a well at the Naval Air Station, 6.2 miles north of Brunswick, Glynn County, where the Ocala was encountered at a depth of 986 feet, is estimated at 5.01 feet per mile to the southeast.

Cooke and Shearer (1918, p. 56) reported the base of the Barnwell formation at 500 feet above sea level at Grovetown, Columbia County, and at 80 feet above sea level at Griffin's Landing, Burke County, on Savannah River. The distance between the two points is approximately 36 miles, thus, indicating a southeastward dip of 11.06 feet per mile.

In Twiggs County, at the mine of the Georgia Kaolin Company, 2 miles east of Dry Branch, the base of the Jackson section is 464 feet above sea level. At Gallemore Mill, 17 miles southeast of the aforementioned locality, and 4 miles northeast of Danville, Twiggs County, the basal Jackson beds occur at 337 feet above sea level. The beds dip southeastward between the two outcrops at the rate of 7.04 feet per mile.

MacNeil (1947, Geologic Map) reports an east-northeastward trending fault extending eastward from a point immediately south of Andersonville, Sumter County, to a point immediately east of Dooling, Dooly County, with down-thrown side on the north, but the writer finds no field evidence to substantiate the report. Throughout the entire area of outcrop of Ocala and Barnwell formations, these Jackson beds appear not to have been disturbed by any diastrophic movements.

TABLE I

REGISTER OF LOCALITIES

1. Rich Hill - 6 miles east of Roberta, Crawford County, two hundred yards south of Georgia Highway 42.

2. Ross Hill - 3 miles south of Perry, Houston County, on Perry-Elko road.

3. Clinchfield - Penn-Dixie Cement Co. quarry, 6 miles southeast of Perry on U. S. Highway 341 (Georgia Highway 7).

4. Hawkinsville - 2.7 miles north of Hawkinsville, Pulaski County, along river road ¼ mile east of Ocmulgee River.

5. Dry Branch - Georgia Kaolin Co. quarry, 2 miles east of Dry Branch, in Twiggs County, on U. S. Highway 80.

6. Postell - Railroad cut 1 mile northeast of Postell (formerly Roberts), Jones County, and ½ mile west of Georgia Highway 49.

7. Stevens Pottery - Fireclay mine of General Refractories Co., 1½ miles southeast of Stevens Pottery, Baldwin County.

8. Gordon - Kaolin mine of Southern Clays Co., 1 mile south of Gordon, Wilkinson County, and 1 mile east of Georgia Highway 18.

9. Ainslie - Abandoned limestone quarry on Weatherly Farms property, 1¼ miles east of Ainslie, Bleckley County, and 5½ miles west of U. S. Highway 129.

10. Gallemore Mill - Creek bank along Macon, Dublin, and Savannah Railroad, 4 miles northeast of Danville, Twiggs County, and 1 mile east of U. S. Highway 80.

11. Irwinton - 3 to 3¼ miles south of Irwinton, Wilkinson County, south of Big Sandy Creek, along U. S. Highway 441.

12. McKenzie Property - eastern boundary of McKenzie property

on north-south county road, 2 miles east of Hogcrawl Creek, Dooly County.

13. Lilly - H. H. Hutchins property, 1½ miles southeast of Lilly, Dooly County, east of Georgia Highway 90.

14. Macon-Dooly county line - Road cut 0.2 mile within Dooly County, on Georgia Highway 90, and 4.6 miles southeast of Montezuma, Macon County.

15. Macon - Sand pit of W. C. Scott Sand and Gravel Co., 1 mile south of city limits, Macon, Bibb County, on east side of U. S. Highway 41.

16. Powersville - Sand pit on west side of Georgia Highway 49 at Powersville, Peach County.

17. Gibson - Fireclay mine of Harbison-Walker Refractories Co., 4 miles east of Gibson, and ¼ mile south of Georgia Highway 80, Glascock County.

18. Jewell - 3½ miles south of Jewell, along Georgia Highway 248, Hancock County.

19. Warthen - Road cut on Georgia Highway 248, 5.75 miles north of Warthen, Washington County.

20. Warthen - Road cut on Georgia Highway 102, 1 mile northeast of Warthen, Washington County.

21. Sandersville - Otis Parker property, 6 miles north of Sandersville, and 2 miles west of Georgia Highway 15, Washington County.

22. Sandersville - Hale Brothers Kaolin Co. mine, 14.5 miles west of Sandersville, and 1.5 miles north of Georgia Highway 24, on Deepstep road, Washington County.

23. Shell Bluff Community - Road cut on Shell Bluff-McBean road, 1.5 miles northwest of Shell Bluff Community, Burke County.

24. McBean - Road cut on Georgia Highway 56, ½ mile southeast of McBean, Burke County.

25. Red's Pond - 3 miles southeast of Keysville, and 3 miles north of St. Clair, along Reedy Creek, Burke County. Formerly termed Keys Mill.

26. Wrens - Road cut on U. S. Highway 1, 1 mile south of Wrens, along Brushy Creek, Jefferson County.

27. Louisville - East bank of Rocky Comfort Creek along Georgia Highway 171, .75 mile west of Louisville, Jefferson County.

28. Tennille - Road cut on Georgia Highway 68, 8 miles southwest of Tennille, Washington County.

29. Sandersville - Road cut 1 mile west of city limits, on Georgia Highway 24, Washington County.

30. Toombsboro - Road cut on Georgia Highway 57, 1 mile east of Toombsboro, Wilkinson County.

31. Albany - South side of Georgia Power Company dam, 2 miles northeast of Albany, Dougherty County.

32. Albany - Junction of Flint River and Kinchafoonee Creek, 1.75 miles northeast of Albany, Dougherty County.

33. Palmyra Springs - Junction of Fowltown and Kinchafoonee creeks, 3 miles northwest of Albany, and 1 mile north of Palmyra Springs, Lee County.

34. Leesburg - Bridge across Kinchafoonee Creek, 1 mile southwest of Leesburg, Lee County.

35. Warwick - South side of Crisp County Power Company dam across Flint River, 2 miles west of Georgia Highway 257 and Warwick, Worth County (exposure is in extreme southwestern corner of Crisp County).

36. Armena - Abandoned quarry of Armena Lime Company, 2 miles northeast of U. S. Highway 82, Lee County.

37. Arlington - Lime sink on R. C. Singletary property, 4 miles northwest of Arlington, Calhoun County.

38. Colquitt - Bridge across Spring Creek along U. S. Highway 27, 0.2 mile west of Colquitt, Miller County.

39. Colquitt - Pilgrim's Rest Church, 7.1 miles southwest of Colquitt, along east slope of Spring Creek, Miller County.

40. Arlington - Road cut along Georgia Highway 62, 4 miles

east of Arlington, Calhoun County.

41. Leary - Road cut along Georgia Highway 62, 3.6 miles east of Leary, Calhoun County.

42. Andersonville - Road cut on Georgia Highway 49, 5 miles south of Andersonville National Cemetery, Sumter County.

43. Americus - Road cut at junction of Georgia Highway 49 and county road to New Era, 3.9 miles north of Americus, Sumter County.

44. Americus - Road cut on Georgia Highway 27, 5.2 miles east of Americus, Sumter County.

45. Hawkinsville - Road cut on U. S. Highway 341 (Georgia Highway 7), 6.3 miles northwest of Hawkinsville, Pulaski County, and 8 miles southeast of Clinchfield, Houston County (outcrop is in Pulaski County).

46. Clinchfield - Road cut on U. S. Highway 341 (Georgia Highway 7), 4.5 miles southeast of Clinchfield, Houston County.

CHAPTER VIII

PALEONTOLOGY

The fauna of the Ocala and Barnwell formations of Georgia includes typical species of Jackson age occurring elsewhere along the Atlantic and Gulf Coastal Plains of the United States. The majority of the fossil remains described in this report have been recorded previously from rocks of upper Jackson age in the Carolinas, Florida, Alabama, Mississippi, and Louisiana. A few, however, have been reported from the lower Jackson Moodys Branch formation of Florida, Alabama, and Mississippi.

The great majority of the fossil remains described herein are in a poor state of preservation, consisting of badly weathered molds and casts, making specific identification difficult. A few forms including Pecten,Mueller, Chlamys, Bolten, and Periarchus, Conrad from the Tivola member of the Ocala limestone, and many fragile specimens from the Twiggs clay member of the Barnwell formation, yet retain the original shell nacre.

Palmer (1951) reports forty-seven species of pelecypods from the Ocala and its lower member. The present paper describes sixty-six species distributed through nineteen families, two of the species being recorded as new. Many of these sixty-six species are not reported by Palmer from Georgia or Florida, but Harris (1946) records them from the upper Eocene of the Gulf Coastal Plain. The Tivola member of the Ocala limestone contains the majority of the Jackson pelecypods described in the present paper; the Twiggs clay member of the Barnwell formation contains practically all of the others. Gastropod remains include twenty-one species representing thirteen families, the majority of which occur in the Tivola and Twiggs clay members. Only in the latter unit is the original shell preserved.

Bryozoans are prolific at all localities where the Tivola member is well exposed. In some areas the Tivola is practically a bryozoan coquina. The majority of the bryozoa, however, occur as shattered, unidentifiable, interlaced, permineralized masses, composing the major part of hard and soft strata. A total of twenty species representing fifteen families are identified in the present report.

Echinoids are restricted to the Tivola member and the Ocala limestone proper. Representatives of the genus _Periarchus_ Conrad are most prolific in central Georgia. _Periarchus quinquefarius_? (Say), previously described from the Sandersville limestone member in Washington County, is tentatively identified in the present paper on the basis of one small, weathered specimen from a small outcrop south of Sandersville, Washington County. In this report fourteen species of echinoids, distributed among six families, are described.

Shark teeth, numbering ten species, rank second in abundance to the bryozoa. With the exception of two specimens, the shark teeth described in this report were collected from the basal sand of the Tivola member. Several excellent specimens of fish vertebrae and other bony materials were collected from the Rich Hill, Crawford County, site. No attempt has been made in this paper to describe either the fish bones or the shark teeth.

One species of scaphopod, Dentalium sp., is recorded from two widely separated localities in the Twiggs clay and Tivola limestone members. A single species of crab claw, Callianassa inglisestris Roberts, is described from two localities. This species has been recorded previously from the lower member of the Moodys Branch formation of the Florida section.

Other remains described in this report include one coral, Flabellum cuneiforme Lonsdale, two worm-like structures, Serpulorbis sp. and Vermetina? sp., and a single, large protozoan, Lepidocyclina georgiana? Cushman. It is not the purpose of this report to describe the smaller Foraminifera of the Jackson Group of Georgia; Cushman (1945, pp. 1-11) has described the Foraminifera of the Twiggs clay member. In the present investigation, the writer noted a paucity of small Foraminifera in the Tivola and Twiggs members. In the Tivola member the planispiral types predominate, but they appear, along with the other types, to be dwarfed forms, such as Cushman described from the Twiggs clay member.

Several botryoidal masses of calcareous material, tentatively described as coprolites, are recorded in the present investigation from a locality in southwestern Georgia. Previously described zeuglodont remains, Basilosaurus cetoides (Owen), reported by Cooke (1943, p. 70) from Houston County, were observed by the writer in the collections of the Penn-Dixie Cement Company, Clinchfield, Houston County. Several vertebrae, measuring fourteen inches in diameter, were collected by the aforementioned producers from the Tivola member.

Several invertebrate species collected from the Ocala limestone and its lower Tivola member are sufficiently abundant to be used in correlating the several outcrops from central to southwestern Georgia. Among the pelecypods, Amusium ocalanum Dall, Chlamys spillmani (Gabb), Chlamys spillmani var. clinchfieldensis (Gabb), Glycymeris sp. cf. G. anteparilis Kellum, Ostrea georgiana Conrad, Pecten perplanus Morton, Protocardia (Nemocardium) nicolletti Harris, Tellina perovata n. sp., and "Venus" jacksonensis Meyer, are generally present at localities where fossil remains occur. Among the gastropods, Calyptraea aperta (Solander), Pseudocrommium brucei Palmer, and Turritella arenicola (Conrad) are quite abundant in the Tivola member and the Ocala limestone proper from central to southwestern Georgia. Periarchus lyelli (Conrad) and its highly-conical relative P. pileus-sinensis (Ravenel), are the only abundant echinoids in both units in the southern half of the State. The larger spatangids, such as Macropneustes mortoni (Conrad), and such hemiasterids as Schizaster armiger Clark, seem to be limited to the Ocala limestone in southern and south-central Georgia.

The orbitoid Foraminifera, Lepidocyclina georgiana? Cushman generally occurs in limestone outcrops from central to southern Georgia. Shark teeth are generally abundant where the lower sand stratum of the Tivola is exposed in central and east-central Georgia.

Several species of pelecypods and gastropods occur in both the Twiggs clay and Tivola members, a fact suggesting an equivalence in age. These forms seem to have adapted themselves to life in an environment dominantly argillaceous (Twiggs clay), after having thrived previously in a calcareous habitat (Tivola limestone). It is to be noted, however, that the individuals of the Twiggs clay macrofaunas are much smaller, even though fully developed, than those of the Tivola member.

In the more clastic environment of the Barnwell sand,

and in the sandy portions of the Twiggs clay in the northernmost areas of outcrop, the only recognizable remains reported in the present paper are Mesalia georgiana Bowles; Ostrea georgiana Conrad; two structures of worm-like organisms, Serpulorbis sp., and Vermetina? sp.; and a few scattered weathered remains of bryozoans. Only a single species of the latter, Hincksina jacksonica Canu and Bassler, retains sufficient diagnostic recognizable features.

At several exposures in central and east-central Georgia the Tivola member is completely silicified. The limestone at Gallemore Mill, 4 miles northeast of Danville, Twiggs, County; the road cut on Georgia Highway 90, 0.2 mile within Dooly County; and the locality on the McKenzie Property, 10 miles east of Montezuma, Macon County, and 2 miles east of Hogcrawl Creek, Dooly County, are especially notable. The beds at these localities, including fossil content, are completely silicified and are coated with red oxide stain. As in southwestern Georgia, the limestone has been dissolved and replaced by silica derived from the weathering of the overlying Flint River chert of Oligocene age.

The presence of the original calcareous material in but a few of the fossil remains in the Tivola member and the Ocala limestone proper, is due probably to the lesser resistance of that material in the great majority of the forms. The majority of the pelecypods possess rather thin shells, a criterion possibly indicating a quiet water environment. The oysters constitute an exception to this observation. The same condition obtains for the gastropods: the shells of those in the Twiggs clay being extremely weak and powdering at the slightest touch. At such localities as Postell, Jones County, and Stevens Pottery, Baldwin County, the clay of the Twiggs member is quite damp and "sticky" on freshly exposed surfaces. The moisture in this material is possibly chemically basic which has caused the decomposition of the shell. Such ordinarily substantial forms as representatives of Venericardia Lamarck readily disintegrate unless extreme care be exercised in handling them. The lower beds at the two aforementioned localities contain more fossil remains than any other strata in the Twiggs clay member. Between Stevens Pottery and Savannah River, the only other fossils collected from this unit were the aforementioned Mesalia georgiana Bowles, the worm-like structures, and Ostrea georgiana Conrad.

Ostrea georgiana Conrad is quite prolific in the lower part of the Twiggs clay member in northeastern Georgia; where, indeed, this part of the unit is known as the Ostrea georgiana zone. This zone was encountered in Burke County at Keys Mill (now Red's Pond), 3 miles north of St. Clair.

The Twiggs clay member and the Barnwell sand north of Baldwin County are practically barren of organic remains. The sedimentary clastic environments in which these units were deposited were not conducive to invertebrate marine habitation, a condition probably resulting from the coarseness of the inflowing material and the turbidity of the water. Only the oysters seem to have thrived along the margins of the upper Jackson sea. Farther to the south, the abundance of organic remains indicates a more conducive environment in quiet and clear water that teemed with invertebrate as well as vertebrate life.

Faunules collected from the various localities of the Jackson Group of Georgia described in the present report are listed in Table II, Faunal Distribution Chart.

Systematic Descriptions

Phylum PROTOZOA

Class SARCODINA

Family ORBITOIDIDAE

Genus Lepidocyclina Gumbel, 1870

Lepidocyclina georgiana? Cushman

Plate 1, figures 1-7

Lepidocyclina cf. L. georgiana CUSHMAN, 1920, U. S. Geol. Survey, Prof. Paper 125-D, pp. 60-63, pl. XVI, fig. 1, pl. XVII, figs. 1-3, pl. XVIII, figs. 1, 2.

Test large, flat to undulating or sellaeform; central region prominently umbonate; surface scrobiculate near margins, becoming strongly papillate toward embryonic region, marking distal ends of internal pillars; umbo rather small, low, rounded, one millimeter high; internal structure obliterated by filling and recalcification; diameter of largest specimen 25 mm., thickness 0.5 mm.

Specimens of the form are plentiful in several localities, and appear to be quite similar to previously described material. Identification is based on surface characteristics only.

Occurrence: Ocala limestone and Tivola member.

Phylum COELENTERATA

Class ANTHOZOA

Family TURBINOLIDAE

Genus Flabellum Lesson, 1831

Flabellum cuneiforme Lonsdale

Plate 1, figures 8-10

Flabellum cuneiforme LONSDALE, 1944, Index Fossils of North America, p. 122, pl. 46, fig. 4.

Internal casts of strongly costate, compressed wedge: costae

longest and thickest towards center; first three cycles of septa form the columella by fusion of inner margins; columella blade-like; fifty-two large septa bifurcate towards apex of corallum into smaller, secondary septa; length 19 mm., height 10 mm., width 11 mm.
Occurrence: Tivola member and Ocala limestone.

Phylum ECHINODERMATA

Class ECHINOIDEA

Family LAGANIDAE

Genus _Peronella_ Gray, 1855

Peronella _cubae_ Weisbord

Plate 2, figures 20-25

Peronella _cubae_ WEISBORD, 1934, Bull. Amer. Paleont., vol. 20, p. 217, pl. 24, figs. 4-6.
Peronella _quinquenodulata_ WEISBORD, 1934, idem, p. 214, pl. 24, figs. 1-3.
Peronella _caribbeana_ WEISBORD, 1934, idem, p. 216, pl. 24, figs. 7-9.
Peronella _cubae_ Weisbord, COOKE, 1942, Jour. Paleont., vol. 16, pp. 25, 26, pl. 2, figs. 15-21.

Corona small, oval; aboral surface slightly convex; apical system central, slightly tumid; four minute genital pores very obscure; petals wide, short, pointed, extending half the distance to the periphery of shell, closed or approximately so at distal ends; poriferous areas of petals narrow, incurved at apical end, practically touching adjacent petals; peristome small, central, rounded to pentagonal, situated in central depression; oral surface flattened at margins, but sloping gently inward toward peristome; periproct circular to transversely oval, approximately one-fourth the distance from margin to peristome; aboral surface with small, widely spaced, low, rounded tubercles; oral surface with larger, closely spaced tubercles; length 9 mm., width 8 mm., height 3 mm.
Occurrence: Tivola member.

Genus _Rumphia_ Desor, 1857

Rumphia archerensis (Twitchell)

Plate 2, figures 9-11

Laganum archerensis TWITCHELL, 1915, U. S. Geol. Survey, Mon. 54, p. 161, pl. 75, figs. 1a-d.
Echinodiscus archerensis (Twitchell), LAMBERT AND THIERY, 1925, Nomenclature raissonee des echinides, fasc. 9, p. 581.
Laganum archerensis (Twitchell), COOKE AND MOSSOM, 1929, Florida Geol. Survey, Ann. Rept. 20, pl. 3, figs. 6a-b.
?Scutella camagueyana WEISBORD, 1934, Bull. Amer. Paleont., vol. 20, p. 220, pl. 24, figs. 13, 14.
Rumphia archerensis (Twitchell), COOKE, 1942, Jour. Paleont., vol. 16, p. 27, pl. 2, figs. 11-13.

Corona small, subdiscoidal, aboral surface very low, with a slightly concave ring involving most of the ambulacral areas between the slightly tumid apical region and the thickened periphery; highest portion of shell occurs anteriorly; oral surface flattened, with peristomal area much excavated by weathering; apical system obliterated, but original descriptions report four genital pores set unusually far apart; ambulacral areas simple, consisting of five elongate, elliptical petals, the distal ends of which terminate on the rounded, raised periphery; periproct small, ovate, approximately 2 mm. within edge of shell; length 22 mm., width 20 mm., height 4 mm.

Occurrence: Tivola member.

Family SCUTELLIDAE

Genus Periarchus Conrad, 1866

Periarchus lyelli (Conrad)

Plate 4, figures 8-10
Plate 5, figures 1-3

Scutella lyelli CONRAD, 1834, Acad. Nat. Sci. Philadelphia, Jour., ser. 1, vol. 7, p. 152.
Scutella pileus-sinensis RAVENEL, 1844, Acad. Nat. Sci., Philadelphia, Proc., vol. 2, p. 97.
Scutella sp. EMMONS, 1858, Agriculture of the eastern counties, p. 308, figs. 247, 248.
Sismondia alta CONRAD, 1865, Acad. Nat. Sci. Philadelphia, Proc., ser. 2, vol. 9, p. 74.

Periarchus pileus-sinensis (Ravenel), STEFANINI, 1911, Soc. geol. italiana, Boll., vol. 30, p. 688, pl. 22, figs. 4a-b, 5a-b.
Periarchus altus (Conrad), CLARK AND TWITCHELL, 1915, U. S. Geol. Survey, Mon. 54, p. 130, pl. 58, figs. 1a-e.
Periarchus lyelli (Conrad), CLARK AND TWITCHELL, 1915, idem, p. 131, pl. 61, figs. 2a-f; pl. 62, figs. 1a-c, 2a-d.
Periarchus pileus-sinensis (Ravenel), CLARK AND TWITCHELL, 1915, idem, p. 135, pl. 63, figs. 1a-e, 2a-d.
Periarchus lyelli (Conrad), COOKE, 1942, Jour. Paleont., vol. 16, pp. 14, 15, no figure.

Corona variable in size, subdiscoidal to subovate in outline; aboral surface much depressed except centrally, where it rises to a low, gently rounded, convex mound of variable height; oral surface flattened except in peristomal region, which is convex to a variable degree; ambulacral petals subelliptical to suboblong, extending half the distance to the shell margin, and becoming wide in central portion of petal and bluntly rounded at distal end; food groove areas elongate, lanceolate; odd petal slightly longer than remaining four; interambulacral areas large, relatively wide, subuniform, consisting of approximately four rows of large, polygonal, low, tubercle-bearing plates; apical system somewhat flat to low, rounded; madreporite large, gently convex; peristome small (3 mm. in diameter), circular, central, slightly eccentric anteriorly; ambulacral furrows fairly straight, approximately one-half the distance to the shell margin, becoming bifurcate at an angle of 45°, and continuing practically to shell margin; periproct small (1 mm. in diameter), subcircular, situated one-third the distance between the peristome and the posterior periphery of the shell; length 70 mm., width 68 mm., height 10 mm.

P. lyelli (Conrad) is closely related to P. pileus-sinensis (Ravenel), the latter having a much higher, conical, central tumid area.

Occurrence: Tivola member and Ocala limestone.

Periarchus pileus-sinensis (Ravenel)

Plate 4, figures 1-6

Scutella pileus-sinensis RAVENEL, 1844, Acad. Nat. Sci. Philadelphia, Proc., vol. 2, pp. 97-98, no figure.
Scutella pileus-sinensis RAVENEL, 1850, Am. Assoc. Adv. Sci., Proc., vol. 3, p. 160.
Sismondia pileus-sinensis (Ravenel), CONRAD, 1865, Acad. Nat. Sci. Philadelphia, Proc., p. 74, no figure.

Mortonia (Periarchus) pileus-sinensis (Ravenel), CONRAD, 1866, Smithsonian Misc. Coll., vol. 7, (200), p. 21, no figure.
Periarchus pileus-sinensis (Ravenel), GREGORY, 1891, Geol. Soc. America, Bull., vol. 3, p. 105, no figure.
?Scutella caput-linensis KENNEDY, 1891, Texas Geol. Survey, Third Ann. Rept., pp. 55, 56.
?Scutella caput-sinensis KENNEDY, 1895, Acad. Nat. Sci. Philadelphia, Proc., pp. 113, 114, 115.
Periarchus pileus-sinensis (Ravenel), STEFANINI, Soc. geol. italiana, Boll., vol. 30, p. 688.
Periarchus pileus-sinensis (Ravenel), CLARK AND TWITCHELL, 1915, U. S. Geol. Survey, Mon. 54, pp. 135-136, pl. LXIII, figs. 1a-e, 2a-d.

Corona subcircular in outline; aboral surface much depressed except for high, well-defined, conical, central area with straight to concave slopes; marginal area thin, undulating, rounded; ambulacral areas elongate to subelliptical, extending more than one-half the distance to the shell margin, distal ends bluntly rounded, proximal ends tapering; food grooves elongate, lanceolate; oral surface flattened; peristome subcentral, small; ambulacral furrows straight to gently curved, bifurcating half the distance to the margin at an angle of 45°, and continuing practically to shell margin; periproct circular, one-third the size of the peristome, and one-third the distance between shell margin and peristome; apical system to acutely rounded, pentagonal in outline; apical pores widely separated, madreporite large, flattened; length of largest specimen 72 mm., width 69 mm., height of most typical specimen 17 mm.

Occurrence: Tivola member.

Periarchus quinquefarius? (Say)

Plate 2, figures 17-19

Scutella 5-faria SAY, 1825, Acad. Nat. Sci. Philadelphia, Jour., ser. 1, vol. 5, p. 228.
Scutella rogersi Morton, AGASSIZ (not Morton), 1841, Mon. d'echinodermes, Mon. 2, p. 85, pl. 19a, figs. 1-4.
Mortonia rogersi (Morton), DESOR (not Morton), 1858, Synopsis des echinoides fossiles, p. 231.
Mortonia quinquefaria (Morton), CONRAD, 1866, Smithsonian Misc. Coll., vol. 7 (200), p. 32.
Mortonella rogersi (Morton), POMEL, 1883, Classification methodique et genera des echinides, p. 70.

Scutella (Mortonia) rogersi of De Gregorio, 1890, Ann. Geol. Paleont., p. 250, pl. 43, figs. 17-20 (not fig. 16).
Mortonella rogersi (Agassiz, not Morton), STEFANINI, 1911, Soc. geol. italiana Boll., vol. 30, p. 685, p. 22, figs. 2, 3.
Mortonella quinquefaria CLARK AND TWITCHELL, 1915, U. S. Geol. Survey, Mon. 54, p. 128, pl. 60, figs. 2a-f; pl. 61, figs. 1a-b.
Periarchus quinquefarius (Say), COOKE, 1942, Jour. Paleont., vol. 16, pp. 15, 16, (no figure).

Single, isolated, adolescent corona, which bears resemblance to P. quinquefarius (Say); discoidal, circular in marginal outline; aboral surface somewhat tumid centrally, much depressed elsewhere; petals large, broadly lanceolate, extending half the distance to the periphery of the shell; apical system subcentral; oral surface flat to concave approaching peristome; peristome round, anteriorly eccentric; periproct diminutive, situated one-third the distance between peristome and margin of shell; ambulacral furrows straight to undulating, becoming indistinct midway toward shell margin; length 9 mm., width 9 mm., height 2 mm.
Occurrence: Sandersville limestone member.

Family CASSIDULIDAE

Genus Cassidulus Lamarck, 1801

Cassidulus ericsoni Fischer

Plate 2, figures 1-4

Cassidulus ericsoni FISCHER, 1951, Florida Geol. Survey, Bull. 34, pp. 65-67, figs. 6, 7, 8; pl. 2, figs. 1, 2; pl. 3, figs. 1-3.

Internal cast of corona: subpentagonal to subhexagonal, wider posteriorly; aboral surface high, swollen, conical, uniformily covered with small scrobicules; apical system eccentric, slightly anterior; periproct situated immediately above a broad sulcus which extends to margin of shell; periproct with prominent overhanging hood which begins 15 mm. behind the apex, i. e., where posterior angle commences; oral oral surface flattened, rounded at margins; peristome eccentric, well forward, situated in a slight depression; shallow sulcus anterior to peristome, continuing onto anterior surface; oral surface scrobiculate; petal areas lanceolate, open distally; interambulacral areas about three times as broad as petals; length of corona 33 mm., width 29 mm., height 20 mm.
Occurrence: Tivola member and Ocala limestone.

Cassidulus (Paralampas) carolinensis (Twitchell)

Plate 2, figures 9-16

Cassidulus (Pygorhynchus) carolinensis TWITCHELL, 1915, U. S. Geol. Survey, Mon. 54, p. 146, pl. 67, figs. 2a-g.
Cassidulus (Paralampas) carolinensis (Twitchell), COOKE, 1942, Jour. Paleont., vol. 16, p. 34, no figure.

Corona oval in outline, thin-walled, posterior end truncated; anterior and ambital margins rounded; aboral surface low, convex, slightly higher posteriorly, with low, rounded ridge above periproctal region; oral surface somewhat flattened, becoming concave toward peristome; apical system eccentric anteriorly; madreporite slightly tumid in well preserved specimens; peristome situated antero-central directly below apical system, pentagonal, with floscelle; ambulacral areas rather long, narrow, practically closed distally, posterior pair slightly longer; shell covered with rounded pits with weathered spinal tubercles; length 30 mm., width 28 mm., height 18 mm.
Occurrence: Ocala limestone and Tivola member.

Cassidulus (Paralampas) globosus? Fischer

Plate 2, figures 5-8

Cassidulus (Paralampas) globosus FISCHER, 1951, Florida Geol. Survey, Bull. 34, pp. 71-72, figs. 8, 9, 10; pl. 4.

Internal cast: corona highly inflated, well rounded orally and ambitally, widest in posterior third; posterior flattened; oral surface flattened to gently rounded; anterior abruptly rounded; peristome and apex anteriorly eccentric; periproct situated situated high on posterior margin, upper margin slightly arched over orifice; specimen too badly weathered to observe petal areas or other diagnostic features; length 14 mm., width 13 mm., height 11 mm.
Occurrence: Ocala limestone.

Family CIDARIDAE

Genus Phyllacanthus Brandt, 1835

Phyllacanthus mortoni? (Conrad)

Plate 5, figure 9

?*Cidaris alabamensis* MORTON, 1846, Acad. Nat. Sci. Philadelphia, Proc., vol. 3, p. 51.
Cidarites mortoni CONRAD, 1850, idem, Jour., ser. 2, vol. 2, p. 40, pl. 1, fig. 13.
Cidaris carolinensis EMMONS, 1858, Agriculture of the eastern counties, p. 305, fig. 238.
?*Cidaris mitchelii* EMMONS, 1858, idem, p. 305, fig. 237.
?*Cidaris blandus* De GREGORIO, 1890, Ann. Geol. Paleont., p. 253, pl. 44, fig. 5.
?*Cidaris modestus* De GREGORIO, 1890, idem, p. 253, pl. 43, fig. 26.
?*Cidaris moerens* De GREGORIO, 1890, idem, p. 252, pl. 43, figs. 22, 23.
?*Cidaris ordinatus* De GREGORIO, 1890, idem, p. 252, pl. 44, fig. 1.
?*Cidaris perdubius* De GREGORIO, 1890, idem, p. 253, pl. 44, fig. 2.
Cidaris mortoni Conrad, CLARK AND TWITCHELL, 1915, U. S. Geol. Survey Mon 54, p. 157, pl. 73, fig. 1.
?*Cidaris alabamensis* Conrad, CLARK AND TWITCHELL, 1915, idem, p. 116.
Cidaris carolinensis Conrad, CLARK AND TWITCHELL, 1915, idem, p. 113, pl. 55, figs. 2a-c.
?*Cidaris mitchelii* Conrad, CLARK AND TWITCHELL, 1915, idem, p. 113, pl. 55, figs. 1a-c.
?*Cidaris blandis* De Gregorio, CLARK AND TWITCHELL, 1915, idem, p. 116.
?*Cidaris modestus* De Gregorio, CLARK AND TWITCHELL, 1915, idem, p. 115.
?*Cidaris moerus* De Gregorio, CLARK AND TWITCHELL, 1915, idem, p. 115.
?*Cidaris ordinatus* De Gregorio, CLARK AND TWITCHELL, 1915, idem, p. 115.
?*Cidaris perdubius* De Gregorio, CLARK AND TWITCHELL, 1915, idem, p. 116.
Cidaris georgiana CLARK, 1915, idem, p. 158, pl. 73, fig. 4.
Leiocidaris carolinensis Conrad, LAMBERT AND THIERY, 1925, Essai de nomenclature raissonee des echinides, fasc. 8, p. 560.
?*Leiocidaris mitcheli* Conrad, LAMBERT AND THIERY, 1925, idem, p. 560.
Cidaris (Dorocidaris) georgiana Conrad, LAMBERT AND THIERY, idem, p. 560.
Phyllacanthus mortoni (Conrad), COOKE, 1941, Jour. Paleont., vol. 15, pp. 3-5, pl. 1, figs. 16-18.

Two fragments of well preserved, flattened subglobose coronas: ambulacra straight, pore openings distinct; interambulacral areas consisting of two rows of large, very well developed tubercles separated by large plates; each plate has a smooth, well rounded tubercular base, surmounted by a perforated secondary tubercle (one base displays two spines); bases of tubercles ringed by secondary nodes; areas among the principal rows of large tubercles sloping toward center, and marked by well-defined sutures; many fine, transverse rows of minute nodes mark the plates in the area among the principal tubercles; length 25 mm., height 30 mm.

Occurrence: Ocala limestone.

Family SPATANGIDAE

Genus Eupatagus Agassiz, 1847

Subgenus Plagiobrissus Pomel, 1883

Eupatagus (Plagiobrissus) ocalanus? Cooke

Plate 4, figure 7

Eupatagus (Plagiobrissus) ocalanus COOKE, 1942, Jour. Paleont., vol. 16, p. 57, pl. 6, figs. 4-8.

Well preserved fragment of oral and ambital surface of large specimen: surface covered with rows of short, rounded nodes which converge and become indistinct toward edge of corona as the ambital surface is approached; length 27 mm., width 15 mm.

Specimen is probably from right side, since the two rows trend across the plate posteriorly at an angle of 45° from the horizontal, and the individual nodes become larger in that direction.

Occurrence: Tivola member.

Genus Macropneustes Agassiz, 1847

Macropneustes mortoni (Conrad)

Plate 3, figures 1-7

Holaster mortoni CONRAD, 1850, Acad. Nat. Sci. Philadelphia, Jour., ser. 2, vol. 2, p. 40, pl. 1, fig. 10.

Macropneustes cubensis COTTEAU, 1875, K. svenska vetensk.-akad., Handl., vol. 13, No. 6, p. 6.

Macropneustes cubensis COTTEAU, 1876, Soc. geol. France., Bull., ser. 3, t. 5, p. 130.

Macropneustes cubensis COTTEAU, 1881, Soc. geol. Belgique, Annales, t. 9, p. 48, pl. 4, fig. 7.
Macropneustes cubensis Cotteau, EGOZCUE, 1897, Com. mapa, geol. Espana, Bol., vol. 22, p. 91, pl. 23, figs. 1-4, pl. 25, fig. 7.
Macropneustes mortoni (Conrad), CLARK AND TWITCHELL, 1915, U. S. Geol. Survey Mon. 54, pl. 72, figs. 1a-d.
Mauritanaster cubensis (Cotteau), LAMBERT, 1923, Soc. cubana historia nat. "Felipe Poey" Mem., vol. 5, No. 1, p. 44 (1924), Reprint, p. 42.)
Antillaster castroi LAMBERT, 1923, idem, p. 44, (1924, Reprint, p. 42.)
Trachypatagus castroi LAMBERT, 1923, idem, p. 48, (1924, Reprint, p. 46.)
Mauritanaster cubensis (Cotteau), SANCHEZ ROIG, 1923, idem, p. 38, (1924, Reprint, p. 36.)
Macropneustes mortoni (Conrad), COOKE, 1926, Alabama Geol. Survey Special Rept. 14, pl. 96, figs. 1a-b.
Macropneustes mortoni (Conrad), COOKE, 1942, Jour. Paleont., vol. 16, p. 51, no figure.

Corona very large, elevated, tumid, round to ovate; apex and apical system eccentric anteriorly; ambulacral areas broad. elongate, petaloid, flush, or situated in shallow, elongate depressions, extending far down the sloping sides; interambulacral areas broad, three times that of ambulacra; surface of both ambulacral and interambulacral areas covered with numerous small, irregularly dispersed tubercles, interambulacral areas each consisting of two rows of wide curved plates, separated by a well-defined suture; petals with numerous, very distinct, pore pairs;; peristome well anterior, arc-shaped, posterior portion covered by well-defined lip, which is reflected posteriorly the length of the shell in a low, gently sloping to distinctly carinate ridge, immediately below the anal opening; periproct large, ovate to triangular, situated a short distance above the posterior margin; length 97 mm., width 80 mm., height 53 mm.
Occurrence: Ocala limestone.

Family HEMIASTERIDAE

Genus Schizaster Agassiz, 1832

Schizaster armiger Clark

Plate 5 figures 4-8

Schizaster armiger HARRIS, 1894, Alabama Geol. Survey, Ann.

Rept. for 1892, vol. 2, p. 172, pl. 6, fig. 11.
Schizaster armiger CLARK, 1915, U. S. Geol. Survey, Mon. 54, p. 152, pl. 70, figs. 1a-d.
Schizaster floridanus CLARK, 1915, idem, p. 175, pl. 82, figs. 1a-e.
Schizaster armiger (Harris), LAMBERT AND THIERY, 1925, Nomenclature des echinides, fasc. 8, p. 524.
Schizaster armiger Clark, COOKE, 1942, Jour. Paleont., vol. 16, pp. 39, 40, no figure.

Corona large; aboral surface depressed, sloping abruptly anteriorly, but more gently posteriorly to apex, beyond which an elevated carinate ridge continues to truncated posterior margin; ambulacral areas in deep furrows, the paired petals in moderately depressed furrows; antero-lateral furrows slightly longer than the post-lateral; the single anterior ambulacrum longer than others, and set in much deeper furrow which becomes shallow as it traverses the anterior margin onto the oral surface; interambulacral areas somewhat flattened, slightly inflated, the posterior portion much elevated, forming a distinct ridge; apical system slightly behind the center; periproct round to subovate, situated at base of keel high on truncated posterior margin; peristome arc-shaped, one-third the distance within the anterior margin; peristome partly covered by raised, rimmed lip which forms a triangular, flattened ridge extending posteriorly and bounded by smooth, shallow depressions; surface thickly covered with small, low, rounded tubercles; length 57 mm., width 51 mm., height 35 mm.
Occurrence: Ocala limestone.

WORMS

Family VERMETIDAE

Genus Serpulorbis Sasso, 1827

Serpulorbis sp.

Plate 24, figure 18

Mass of numerous, contorted tubes with circular openings: surface ornamented with numerous, roughened, concave, imbricate, growth markings; two prominent carinae on each tube situated 180° apart, marking point of attachment between adjacent tubes; shell wall thin; interior smooth; length of longest tube 20 mm., diameter of openings 1 mm.
Occurrence: Twiggs clay member.

In the Twiggs clay bed along the Shell Bluff-McBean road, 1.5 miles northwest of Shell Bluff Community, Burke County, several specimens resembling large worm tubes occurred with Serpulorbis sp. Most of these specimens are coiled in a trochoid manner, are hollow, and the surface is encrusted with several types of bryozoans in a very poor state of preservation. Only one species, Hincksina jacksonica Canu and Bassler, is tentatively identified. The remainder of the bryozoans have had most of the diagnostic structures destroyed. One author (Pierson, 1950) reports this material from the same area in northeast Georgia, and identifies it as "Cassidaria carinata," but it can readily be seen that these are not the remains of gastropods. In this paper, the name Vermetina sp. is tentatively assigned to these "worm tubes." Dimensions of largest figured specimen 50 mm. long and 27 mm. in diameter.

Phylum BRYOZOA

Class ECTOPROCTA

Family PORINIDAE

Genus **Beisselina** Canu, 1913

Beisselina implicata Canu and Bassler

Plate 9, figure 2

Beisselina implicata CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 325, pl. 44, figs. 1-4.

Aperture circular, surrounded by raised, rounded peristome; zooecia very distinct; ascopore indistinct; approximately 10 zooecia in 5 mm.

Occurrence: Ocala limestone.

Beisselina trulla Canu and Bassler

Plate 9, figures 1, 3-11

Beisselina trulla CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 324, pl. 43, figs. 19-21.

Zoaria ramose, covered with rounded zooecia, encircled by thin, rounded, raised peristome; peristome surrounded by 6 or 7 pores, one of which may be the ascopore; approximately 22 zooecia in 5 mm.; length of largest specimen 65 mm.

Occurrence: Tivola member.

Family STEGANOPORELLIDAE

Genus _Steganoporella_ Smitt, 1873

Steganoporella _jacksonica_ Canu and Bassler

Plate 8, figures 5, 6

Steganoporella _jacksonica_ CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, pp. 262-263, pl. 39, figs. 9-16.

Zoarium bilamellar, formed of two calcareous layers back to back; zooecia dimorphic, elongate, narrow, distinct, arc-shaped in upper portion; large or B-zooecia (avicularia) taper toward base, and contain a tooth in lower portion of opening, to which a large operculum was attached; distinct arc-shaped rimule overhanging all apertures; apertures ovate to elliptical, modified by prominent, flat-edged tooth which forms a hinge for attachment of operculum; approximately 10 zooecia in 5 mm.; length of zoarium 20 mm.

Occurrence: Tivola member.

Family SCHIZOPORELLIDAE

Genus _Schizopodrella_ Canu and Bassler, 1917

Schizopodrella _linea_ Lonsdale

Plate 8, figure 1

Eschara _linea_ LONSDALE, 1845, Account of twenty-six species of Polyparia obtained from the Eocene Tertiary formation of North America, Quarterly Journal Geological Society London, vol. 1, p. 530, fig.

Escharinella? _linea_ GABB AND HORN, 1862, Monograph of the fossil Polyzoa of the Secondar and Tertiary formations of North America, Journal of the Academy of Natural Sciences of Philadelphia, ser. 2, vol. 5, p. 140.

Schizopodrella _linea_ Lonsdale, CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 340, pl. 45, figs. 10-18.

Zoarium bilamellar; zooecia large, distinct, elliptical; frontal convex; aperture round to semilunar, bordered by narrow rimule; small avicularium on border of a few apertures; 7 zooecia in 5 mm.; length of zoarium 15 mm.
Occurrence: Tivola member.

Schizopodrella viminea Lonsdale

Plate 8, figures 2-4

Eschara viminea LONSDALE, 1845, Quarterly Journal Geological Society London, vol. 1, p. 520, fig.
Eschara incumbens LONSDALE, 1845, op. cit., p. 529.
Eschara viminea Lonsdale, GABB AND HORN, 1862, Academy of Natural Sciences of Philadelphia, Journal, ser. 2, vol. 5, p. 116.
Eschara incumbens Lonsdale, GABB AND HORN, op. cit., p. 116.
Eschara texta GABB AND HORN, 1862, op. cit., pl. 17, pl. 19, fig. 1.
Schizopodrella viminea Lonsdale, CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 342, pl. 45, figs. 1-9.

Zoarium bilamellar, formed of two layers back to back; fronds wide, flat, undulating; zooecia long, fusiform, or cylindrical; frontal portion convex, with numerous very faint pores; aperture subrounded, transverse, with very small rimule; peristome low, thin; approximately 9 zooecia in 5 mm.; length of largest zoarium 39 mm.
Occurrence: Tivola member.

Family HINCKSINIDAE

Genus Hincksina Norman, 1903

Hincksina jacksonica Canu and Bassler

Plate 6, figures 6, 7
Plate 7, figures 1, 2

Hincksina jacksonica CANU AND BASSLER, 1917, U. S. Nat. Mus., Bull. 96, p. 15, pl. 1, fig. 6.
Hincksina jacksonica CANU AND BASSLER, 1920, U. S. Nat. Mus., 106, p. 113, pl. 22, figs. 4-9.

Zoarium free, bilamellar; zooecia elongate, distinct, elliptical; mural rim elevated, distinct, ringed by faint knobs;

8 zooecia in 5 mm.; length of longest specimen 23 mm.
Occurrence: Tivola member.

Family LUNULITIDAE

Genus Lunulites Lamarck, 1816

Lunulites distans Lonsdale

Plate 6, figures 1-5

Lunulites distans LONSDALE, 1845, Quarterly Journal Geological Society London, vol. 1, p. 531, fig.
Lunulites distans Lonsdale, GABB AND HORN, 1862, Journal Academy Natural Sciences, Philadelphia, ser. 2, vol. 5, p. 119.
Lunulites distans Lonsdale, De GREGORIO, 1890, Annales de Geologie et de Paleontologie, Livraisons 7, 8, p. 250, pl. 42, fig. 29.
Lunulites contigua EMMONS, 1858, Geological Survey of North Carolina, Paleontology, p. 311, figs. 250, 251 (not L. contigua Lonsdale, 1845).
Lunularia distans Lonsdale, CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, pp. 245-247, pl. 38, figs. 1-20.
Lunulites distans Lonsdale, BASSLER, 1953, Treatise on Invertebrate Paleontology, Part G, Bryozoa, pp. 171-172, fig. 131,3.

Zoarium large, conical; rows of zooecia alternate with rows of vibracula; vibracula elongate, narrow, with two lateral condyles, and situated at zooecial angles; zooecia rounded to elongate; mural rim rounded, thin finely granulated; when stripped away zooecia reveal thin, blade-like partitions among individuals, and numerous tuberosities among the walls; 10 zooecia in 5 mm.; height of largest zoarium 21 mm., diameter 33 mm.
Occurrence: Tivola member.

Family TUBULIPORIDAE

Genus Tretonea Canu and Bassler, 1920

Tretonea levis Canu and Bassler

Plate 9, figures 12, 13

<u>Tretonea levis</u> CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 769, pl. 141, figs. 20-27.
<u>Tretonea levis</u> Canu and Bassler, BASSLER, 1953, Treatise on Invertebrate Paleontology, Part G, Bryozoa, p. 48, fig. 17-8a-b.

Zoarium free, ramose, triangular in cross-section; zooecia occur in horizontal groups or fascicles, with subrounded to rectangular peristomes which are conspicuously raised; fascicles on each side of frontal portion offset from the other; number of zooecia in each fascicle approximately 6; reverse side of zoarium with minute, scattered zooecia; length of largest zoarium 16 mm.

Occurrence: Tivola member.

Family OPESIULIDAE

Genus <u>Rectonychocella</u> Canu and Bassler, 1917

<u>Rectonychocella semiluna</u> Canu and Bassler

Plate 7, figures 3-8

<u>Rectonychocella semiluna</u> CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, pp. 210-211, pl. 33, figs. 9-13.

Weathered zoarium free, ramose; zooecia rounded to slightly elongate, separated by a faint furrow; 11 zooecia in 5 mm.; length of largest specimen 21 mm.

Occurrence: Tivola member.

Family PHYLACTELLIDAE

Genus <u>Perigastrella</u> Canu and Bassler, 1917

<u>Perigastrella elegans</u> Canu and Bassler

Plate 7, figure 9

<u>Perigastrella elegans</u> CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 579, pl. 73, fig. 1.

Encrusting zoarium; zooecia distinct, elongate, cylindrical; frontal convex, with faint rounded pores; aperture deep, rectangular; peristome thin, salient, rounded, smooth, some with faint denticle in center of inferior lip; 8 zooecia in

5 mm.; length of zoarium 6 mm.
Occurrence: Tivola member.

Family HORNERIDAE

Genus Hornera Lamouroux, 1821

Hornera polyporoides Canu and Bassler

Plate 7, figures 10, 11

Hornera polyporoides CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 799, pl. 144, figs. 9-13.

Ramose zoarium smoothed by weathering; zooecia not crowded, situated in wide sulci which are separated by low nervi; zooecia rounded, with low, smooth peristome; characteristic trabeculae missing; length of zoarium 11 mm.
Occurrence: Tivola member.

Family CELLEPORIDAE

Genus Holoporella Waters, 1909

Holoporella damicornis Canu and Bassler

Plate 10, figures 1, 2

Holoporella damicornis CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 609, pl. 77, figs. 1-7.

Zoarium massive, consisting of irregular masses ornamented with "horns" of greater or less length; zooecia somewhat erect, crowded; aperture rounded to semilunar; specimens well weathered; length of largest zoarium 50 mm.
Occurrence: Tivola member.

Genus Schismopora MacGillivray, 1888

Schismopora globosa Canu and Bassler

Plate 11, figures 9-11

Schismopora globosa CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 598, pl. 75, figs. 7-15.

Zoarium massive, globular; zooecia distinct, somewhat erect, ovate; frontal smooth, convex, with faint avicularium; aperture circular, with wide rimule; maximum diameter of zoarium 11 mm.
Occurrence: Tivola member.

Family STOMACHETOSELLIDAE

Genus Ochetosella Canu and Bassler, 1917

Ochetosella robusta Canu and Bassler

Plate 10, figures 4-7

Ochetosella robusta CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 453, pl. 57, figs. 11-17.

Zoarium free, ramose, cylindrical; zooecia large, somewhat elongate, with low, rounded peristome; specimen exceedingly weathered; length of largest zoarium 18 mm.
Occurrence: Sandersville limestone member.

Family DIASTOPORIDAE

Genus Stomatopora Bronn, 1825

Stomatopora cornu Canu and Bassler

Plate 10, figure 3

Stomatopora cornu CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 657, pl. 130, fig. 14.

Zoaria elongate, tubular, encrusting in the form of a horn; aperture circular; peristome thick, salient; zooecia widely separated; length of zoarium 5 mm.
Occurrence: Tivola member.

Genus Spiropora Lamx., 1821

Spiropora majuscula Canu and Bassler

Plate 11, figures 1-3

Spiropora majuscula CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 675, pl. 128, figs. 8-13.

Zoarium cylindrical, ramose, with fascicles of rectangular to ovate apertures; fascicles form annular, salient verticells which become offset and incomplete toward point of bifurcation of zoarium; interzooecial areas ribbed and sulcate; length of zoarium 7 mm.
Occurrence: Tivola member.

Family ONCOUSOECIIDAE

Genus Filisparsa d'Orbigny, 1853

Filisparsa ingens Canu and Bassler

Plate 11, figure 4

Filisparsa ingens CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 694, pl. 142, figs. 12-21.

Zoarium compressed, dichotomous; zooecia distinct, convex, salient, ringed by smooth, rounded peristome; area among zooecia longitudinally sulcate; length 5 mm.
Occurrence: Tivola member.

Family LEIOSOECIIDAE

Genus Parleiosoecia Canu and Bassler, 1920

Parleiosoecia jacksonica Canu and Bassler

Plate 11, figures 5-8

Parleiosoecia jacksonica CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, pp. 824-825, pl. 148, figs. 1-13.
Parleiosoecia jacksonica Canu and Bassler, BASSLER, 1953, Treatise on Invertebrate Paleontology, Part G, Bryozoa, p. 72, fig. 37-4a, b.

Zoarium free, ramose, solid or hollow, irregularly cylindrical, club-shaped; zooecia numerous, exceedingly crowded, with thin, orbicular, somewhat salient peristome; maximum length 24 mm.
Occurrence: Tivola member.

Family CALLOPORIDAE

Genus Membraniporidra Canu and Bassler, 1917

Membraniporidra porrecta Canu and Bassler

Plate 12, figure 1

Membraniporidra porrecta CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 135, pl. 26, figs. 6-13.

Zoarium free, noticeably thin; zooecia large, oval, elongate, with thin, rounded, salient mural rim; length of zoarium 2 mm.
Occurrence: Tivola member.

Membraniporidra spissimuralis Canu and Bassler

Plate 12, figure 2

Membraniporidra spissimuralis CANU AND BASSLER, 1920, U. S. Nat. Mus., Bull. 106, p. 136, pl. 27, figs. 1-19; pl. 28, figs. 1-7.

Zoarium free, consisting of two lamellae back to back; zooecia elongate, oval, distinct, separated by a thin, raised line; mural rim flattened; 12 zooecia in 5 mm.; entire zoarium 10 mm. long.
Occurrence: Tivola member.

Phylum MOLLUSCA

Class PELECYPODA

Family OSTREIDAE

Genus Gryphaeostrea Conrad, 1865

Gryphaeostrea vomer (Morton)

Plate 13, figure 6

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

Gryphaea vomer MORTON, 1830, Amer. Jour. Sci., vol. 18, pl. 3, figs. 1, 2; WHITFIELD, 1885, U. S. Geol. Survey, Mon. 9, pl. 26, figs. 11, 12; WELLER, 1907, New Jersey Geol. Survey, Paleont., vol. 4, pl. 44, figs. 10, 11.
Gryphaeostrea vomer (Morton), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 14, pl. 1, fig. 1-4.

Shell oblong, concave, thick; surface with heavy, roughened deposit traversed by widely spaced growth lines; beak small, indistinct, umbo well-rounded; length 19 mm., height 39 mm.
Occurrence: Ocala limestone.

Gryphaeostrea vomer var. plicatella (Morton)

Plate 13, figures 7, 8

Gryphaea plicatella MORTON, 1833, Amer. Jour. Sci., vol. 23, p. 293; idem, 1833, vol. 24, pl. 9, fig. 4.
Gryphaea plicatella MORTON, 1834, Synopsis Organic Remains, Cret. Group, p. 55, pl. 9, fig. 4.
Gryphaeostrea vomer var. plicatella (Morton), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 16, pl. 1, figs. 5, 7-13.

Shell thick, elongate, coarsely ornamented with narrow to widely spaced, concentric growth lines; muscle scar deep, rather high, and near posterior margin; length 42 mm., height 74 mm.
Occurrence: Tivola member.

Ostrea georgiana Conrad

Plate 13, figures 9, 10

Ostrea georgiana CONRAD, 1834, Acad. Nat. Sci. Philadelphia, Jour., vol. 7, p. 156.
Ostrea contracta CONRAD, 1855, Acad. Nat. Sci. Philadelphia, Proc., p. 269, U. S. and Mexican Boundary Survey, Rept., 1 (2): pl. 18, fig. 1.
Ostrea blandpiedi HOWE, 1937, Jour. Paleont., vol. 11, p. 362, pl. 44, figs. 1-4.
Ostrea gigantissima HOWE, 1937, Jour. Paleont., vol. 11, p. 362, pl. 44, figs. 5, 6.
Ostrea georgiana CONRAD, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 6, pl. 1, figs. 3-5; pl. 2, figs. 1-3.

Shell very large, thick, rounded to elliptical in shape; surface very rough, composed of coarse, roughly imbricate growth lines covered with shallow to deep, circular depressions penetrating first and second layers of shell; pallial line distinct; muscle scar large, deep, subrounded, situated in center of shell; hinge area 40 mm. long, 24 mm. high; ligamental groove deep, tapering toward beak; beak opisthogyre; height of shell 117 mm., length 111 mm., thickness 50 mm.
Occurrence: Tivola member.

Ostrea trigonalis Conrad

Plate 13, figures 3-5

Ostrea trigonalis CONRAD, 1854, Rept. and Geol. Mississippi, pl. 14, fig. 10; 1855, Acad. Nat. Sci. Philadelphia, Proc., p. 259; 1865, Amer. Jour. Conch., vol. 1, p. 15.
Ostrea pandaeformis GABB, 1861, Acad. Nat. Sci. Philadelphia, Proc., p. 328.
Ostrea tuoymeyi CONRAD, 1865, Acad. Nat. Sci. Philadelphia, Proc., p. 184.
Ostrea mortoni ALDRICH, 1887, Cincinnati Soc. Nat. Hist., Jour., vol. 10, p. 79.
Ostrea trigonalis Conrad, HARRIS, 1898, Wagner Free Inst. Sci., Trans., vol. 3, p. 681.
Ostrea trigonalis Conrad, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 21, pl. 4, figs. 1-6; pl. 5, figs. 1-3.
Ostrea trigonalis Conrad, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 7, pl. 2, figs. 4, 5.

Shell triangular, shallow, surface roughened, with distinct fine to coarse growth lines, and additional faint radiating lines; muscle scar shallow, obliquely suboval, situated nearer dorsal surface than ventral, and left of median line; shell margin irregular, somewhat ascending, crenulated; hinge line narrow, resilifer shallow, triangular, hinge area 6 mm. high; beak and umbo flattened on left valve, pointed on right valve; pallial line distinct; height of shell 51 mm., length 47 mm., thickness 19 mm.
Occurrence: Tivola member.

Family PECTINIDAE

Genus Amusium Bolten, 1798

Amusium ocalanum Dall

Plate 15, figures 14-17

Pecten (*Amusium*) *ocalanus* DALL, 1895, Wagner Free Inst. Sci., Trans., vol. 3, p. 756, pl. 29, fig. 2.
Amusium ocalanum Dall, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 10, pl. 5, figs. 3-5.

Shell thin, orbicular, equivalve; outer layer smooth except for closely spaced, faint to coarse growth lines; next underlying layer ribbed as in *Pecten* Mueller and *Chlamys* Bolten; beak small, orthogyre, umbo somewhat inflated; hinge line straight, alate; byssal notch distinct on well preserved specimens; height of shell 38 mm., length 39 mm.
Occurrence: Ocala limestone and Tivola member.

Subgenus *Chlamys* Bolten, 1798

Chlamys spillmani (Gabb)

Plate 15, figures 6, 7

Pecten spillmani GABB, 1860, Acad. Nat. Sci. Philadelphia, Jour., vol. 4, p. 402, pl. 68, fig. 3.
Pecten spillmani CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 14.
Pecten perplanus HEILPRIN, 1881, Acad. Nat. Sci. Philadelphia, Proc., p. 417.
Pecten (*Aequipecten*) *perplanus* of DALL (not Heilprin), 1895, Wagner Free Inst. Sci., Trans., vol. 3, p. 732.
Chlamys (*Aequipecten*) *perplanus* of TUCKER-ROWLAND (not Heilprin), 1938, Mus. roy. hist. nat. Belgique, Mem., 2 ser., fasc. 13, p. 29, pl. 6, fig. 12.
Chlamys spillmani (Gabb), HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 9, pl. 4, figs. 1-7; pl. 5, figs. 1, 1'.

Shell thin, equivalved; orbicular; surface marked by 23 prominent, radiating ribs, each with 2 very small ribs on either side; all ribs minutely imbricate and beaded, except earlier ones which are smooth; intercostal spaces imbricate except earlier portions; hinge line straight, alate, ears beaded; beak prominent, orthogyre; resilifer and muscle scar prominent; length of shell 37 mm., height 37 mm., thickness 6 mm.
Occurrence: Tivola member and Ocala limestone.

Chlamys spillmani var. clinchfieldensis Harris

Plate 15, figures 1-5

Chlamys spillmani var. clinchfieldensis HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, pp. 9, 10, pl. 4, figs. 4-7.

Shell equivalved; orbicular; surface marked by 23 radiating ribs, which are either smooth or ornamented with closely spaced, imbricate markings, which extend into the intercostal areas; hinge line straight, alate; umbo rounded, extending into pointed beak; beak orthogyre; hinge line with minute spines on dorsal edge; resilifer small, shallow; height of shell 38 mm., length 40 mm., thickness 7 mm.

These forms differ from C. spillmani (Gabb) in not having subribs or rows of beads so characteristic of that species.

Occurrence: Tivola member and Ocala limestone.

Genus Pecten, Mueller, 1776

Pecten choctavensis Aldrich

Plate 15, figures 8, 9

Pecten choctavensis ALDRICH, 1895, Bull. Amer. Paleont., vol. 1, No. 2, p. 16, pl. V, fig. 7.

Pecten choctavensis Aldrich, CLARK AND MARTIN, 1901, Maryland Geol. Survey, vol. 1, (Eocene), p. 188, pl. XLIV, figs. 4-6.

Shell subcircular, thin, convex, ribbed with rounded, imbricate costae, which bifurcate one-third the distance from the beak toward the ventral edge; number of ribs thirty-eight after bifurcation; distinct but low imbricate rib separating most of the larger pairs of ribs; hinge line straight, beaded, alate; byssal notch prominent, deep; ears with five beaded ribs extending outward from beak; umbo flattened, beak pointed, orthogyre; muscle scar situated dorsal and posterior to median line; resilifer triangular, shallow; height of shell 24 mm., length 24 mm., thickness 4 mm.

Occurrence: Tivola member and Ocala limestone.

Pecten perplanus Morton

Plate 15, figure 12

Pecten perplanus MORTON, 1833, Amer. Jour. Sci., vol. 23, p. 293, pl. 5, fig. 5; 1834, Synop. Organic Remains, Cret. Group, p. 58, pl. 5, fig. 5; pl. 15, fig. 8.
Pecten perplanus Morton, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 27, pl. 7, figs. 5-11.
Pecten perplanus Morton, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 8, pl. 3, figs. 5-8.

Shell large, flat; ribs coarse, subangular, finely ventricose, attaining 1 mm. in thickness, with equally wide intercostal spaces; 23 ribs on largest specimen; hinge line strongly alate, covered with fine ridges radiating from beak; byssal notch conspicuous but not deep; height of shell 50 mm., width 53 mm., width of hinge line 24 mm.

Differs from Chlamys spillmani (Gabb) and C. spillmani var. clinchfieldensisHarris in having coarser, higher ribs, and in the absence or lack of high degree of ornamentation in the latter species.

Occurrence: Tivola member and Ocala limestone.

Pecten pulchricosta Aldrich and Meyer

Plate 15, figure 13

Pecten pulchricosta ALDRICH AND MEYER, 1886, Jour. Cinn. Soc. Nat. Hist., vol. 9, p. 45, pl. 2, fig. 23, 23a.
Pecten pulchricosta Aldrich and Meyer, DALL, 1898, Wagner Free Inst. Sci., Trans., p. 730.
Pecten pulchricosta Aldrich and Meyer, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 24, pl. 14, figs. 9, 10.

Internal cast: robust, convex; beak orthogyre; surface with 7 smooth, broad, rounded, radiating ribs, which become indistinct dorsally; intercostal spaces broad, shallow, rounded; height of shell 35 mm., length 31 mm.

Occurrence: Ocala limestone.

Pecten wautubbeanus Dall

Plate 15, figure 10

Pecten (Chlamys) wautubbeanus DALL, 1898, Trans. Wagner Free Inst., vol. 3, p. 736, pl. 34, fig. 9.
Pecten wautubbeanus Dall, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 21, pl. 14, figs. 1-4.

Shell small, broad, orbicular, convex, thin; surface ornamented with at least 16 narrow, rounded, dichotomous ribs, with closely spaced, imbricate structures; imbricate subribs between each larger pair in intercostal spaces; concentric growth lines occur near ventral margin of shell; height 20 mm., length 18 mm., thickness 5 mm.

Specimen is without most of dorsal portion, except for posterior ear of valve.

Occurrence: Tivola member.

Genus Plicatula Lamarck, 1801

Plicatula filamentosa Conrad

Plate 13, figures 1, 2

Plicatula filamentosa CONRAD, 1897, Bull. Amer. Paleont., vol. 2, No. 9, p. 233.
Plicatula filamentosa Conrad, DALL, 1898, Trans. Wagner Free Inst. Sci., p. 762.
Plicatula filamentosa Conrad, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 18, pl. 12, figs. 3-8.
Plicatula filamentosa Conrad, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 25, pl. 6, figs. 1, 1a.
Plicatula filamentosa Conrad, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 7, pl. 2, figs. 6-9.

Internal cast of convex, subovate shell: with 10 strong, low, rounded, radial ridges extending to margins; intercostal areas narrow, rounded; strongly marked, closely spaced, concentric growth lines, effecting appearance of imbricate, radiating lines; hinge line narrow; beak pointed, orthogyre; height of specimen 22 mm., length 18 mm.

Occurrence: Ocala limestone.

Genus Spondylus Linnaeus, 1758

Spondylus hollisteri? Harris

Plate 15, figure 11

Spondylus hollisteri HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 8, pl. 12, figs. 10, 11; pl. 3, figs. 1-4.

Shell thin, coarsely ribbed; ribs rounded, covered by small rounded nodes from beak to ventral edge; 7 ribs in 10 mm.; hinge line alate; beak orthogyre; height of specimen 22 mm., length 19 mm.

Occurrence: Ocala limestone and Tivola member.

Family MYTILIDAE

Genus Modiolus Lamarck, 1799

Modiolus texanus Gabb

Plate 14, figure 14

Perna texana GABB, 1861, Proc. Phila. Acad. Sci., p. 371.
Modiola texana Gabb, HARRIS, 1895, Proc. Phila. Acad. Sci., p. 46, pl. 1, fig. 2.
Modiolus texanus Gabb, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 32, pl. 17, figs. 6, 7.

Shell very small, elongate, subtriangular; beaks anterior, terminal, minute, prosogyre; anterior margin rounded, narrow; umbo prominent; ventral margin broad, sinuous; post-ventral margin abruptly rounded; posterior edge broadly convex, merging with a regular curve with hinge line; umbonal ridge high, continuing diagonally across shell surface to post-ventral margin; surface with numerous, flattened, bifurcating, radial ridges, separated by deep intercostal spaces; radial ridges become finer anteriorly, becoming indistinct on anterior umbonal slope; length of shell 10 mm., height 6 mm.

Occurrence: Twiggs clay member.

Family PTERIIDAE

Genus Atrina Gray, 1840

Atrina sp. cf. A. jacksoniana Dall

Plate 14, figure 1

Atrina jacksoniana DALL, 1895, Wagner Free Inst. Sci., Trans., vol. 3, p. 662.
Pinna (Atrina) jacksoniana (Dall), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 39, pl. 10, figs. 5, 6.
Atrina jacksoniana Dall, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 13, pl. 6, fig. 5.

Internal cast of shell: displays evidence of having been thin, fragile, widening abruptly toward posterior extremity; somewhat compressed along ventral border; ornamentation absent, but Dall reports numerous, feeble, more or less wavy, longitudinal, elevated lines which become less distinct laterally, and are obsolete over greater portion of shell; figured specimen 96 mm. long, 55 mm. wide, entire aspect rounded, spatulate.
Occurrence: Tivola member.

Genus Pteria Scopoli, 1777

Pteria limula var. vanwinkleae Harris

Plate 14, figures 15-17

Avicula limula CONRAD, 1833, Foss. Shells Tert. Form., p. 39.
Avicula claibornensis LEA, 1833, Contr. to Geol., p. 86, pl. 3, fig. 65.
Avicula claibornensis Lea, De GREGORIO, 1890, Ann. Geol. Paleont., p. 183, pl. 22, fig. 4.
Avicula cardincrassa De GREGORIO, 1890, Ann. Geol. Paleont., p. 184, pl. 22, figs. 1, 2.
Pteria limula (Conrad), HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 29, pl. 16, figs. 3-7.
Pteria limula var. vanwinkleae HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 37, pl. 10, figs. 1-4.

Shell convex, distinctly oblique; umbo tapers gradually toward acute apex; wing large, most oblique; posterior sinus shallow, reflected in growth lines; anterior margin acute, ventral margin rounded to posterior extremity; surface markings consist of fine to coarse, concentric, imbricate, growth lines, crossed by very faint radial ridges; height 57 mm., length 49 mm.
Occurrence: Tivola member.

Genus Pinna Linnaeus, 1758

Pinna sp. cf. P. quadrata Dall

Plate 14, figure 18

Pinna quadrata DALL, 1895, Wagner Free Inst. Sci., Trans., vol. 3, p. 660, pl. 29, fig. 7.
Pinna quadrata Dall, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 12, pl. 6, figs. 2-4.

Very poorly preserved internal cast of dorsal portion of shell exhibiting lateral angle and faint radii; height 6 mm., length 7 mm.

Occurrence: Ocala limestone.

Family NUCULIIDAE

Genus Nucula Lamarck, 1799

Nucula spheniopsis Conrad

Plate 22, figures 2-4

Nucula spheniopsis CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 140, pl. 10, fig. 13.
Nucula meridionalis ALDRICH AND MEYER, 1887, Sonder-Abdr. Ber. Senckenberg. Naturf. Gesell., p. 10, pl. 2, fig. 2.
Nucula spheniopsis Conrad, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 63, pl. 14, figs. 24-30.

Shell obliquely ovate-triangular, slightly ventricose; posterior extremity cuneiform, acutely rounded; inner margin finely crenulate; dorsal surface long, sloping, becoming rounded at anterior extremity; beaks minute, opisthogyre; dentition taxodont, 9 simple teeth behind beak, 24 teeth anterior to beak; surface with fine to coarse, concentric growth markings, crossed by extremely fine radial markings; length 14 mm., height 11 mm., thickness 3.5 mm.

Occurrence: Twiggs clay member and Ocala limestone.

Genus Nuculana Link, 1807

Nuculana albirupina (Harris)

Plate 21, figures 16-21

Leda albirupina HARRIS, 1894, Arkansas Geol. Survey, Ann. Rept. for 1892, vol. 2, p. 148, pl. 6, fig. 1.
Leda albirupina Harris, DALL, 1898, Wagner Free Inst. Sci., Trans., vol. 3, p. 578.
Nuculana albirupina (Harris), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 57, pl. 13, figs. 15, 16.

Shell extremely small, tapering posteriorly; anterior margin abruptly rounded; posterior extremity truncate; widest portion of shell below beak; dorsal surface behind beak flattenned, triangular; prominent fold leading posteriorly from beak to extremity; surface markings consisting of very fine, rounded growth lines, becoming truncate at post-dorsal fold, then projected onto flattened, dorsal side; beak minute, opisthogyre; hinge line long; height of shell 4 mm., length 9 mm.

Occurrence: Twiggs clay member and Tivola member.

Nuculana sp.

Plate 21, figure 15

Internal cast of long, narrow shell: tapering to point at posterior end; anterior end somewhat rounded; surface with faint growth markings; beak low, rounded, somewhat opisthogyre; dentition taxodont, well preserved, 10 teeth and 9 sockets preserved anterior to beak, approximately 11 teeth and corresponding sockets present behind beak; length of figured specimen 16 mm., height 6 mm.

Occurrence: Tivola member.

Genus Yoldia Moller, 1842

Yoldia psammotaea? var. rubamnis Harris

Plate 22, figure 1

Yoldia (Nuculana) psammotaea DALL, 1898, Wagner Free Inst. Sci., Trans., vol. 3, p. 596, pl. 34, fig. 20.
Yoldia psammotaea Dall, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, p. 72, pl. 25, figs. 25-31.
Orthoyoldia psammotaea(Dall), STEWART, 1930, Acad. Nat. Sci. Philadelphia, Spec. Publ., No. 3, p. 61.
Yoldia psammotaea? var. rubamnis HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 58, pl. 14, fig. 1.

Shell very thin, porcelaneous, elongate; beak well ahead of median line, slightly opisthogyre; dentition taxodont; area between beak and ventral margin rather broad, gibbous; posterior portion elongate, narrow, and truncated; anterior portion abruptly rounded; surface with many coarse to fine growth lines; height 8 mm., length 14 mm.

Occurrence: Twiggs clay member.

Yoldia sp.

Plate 21, figure 22

Internal casts of large *Yoldia*-like forms: with long, tapering posterior portion abruptly truncated at posterior extremity; closely resemble *Y. psammotaea* Dall from Jackson of Alabama and Mississippi, and Lisbon (Claiborne) of same areas; specimens measure 10 and 20 mm. in length respectively, and 5 and 8 mm. in width; surface with faint, regularly spaced, growth lines; beak minute, opisthogyre; hinge line long.

Occurrence: Twiggs clay member.

Family ARCIDAE

Genus *Arca* Linnaeus, 1758

Arca sp. cf. *A. rhomboidella* Lea

Plate 17, figure 11

Arca rhomboidella LEA, 1833, Contributions to Geology, p. 74, pl. 2, fig. 52.
Anomalocardia rhomboidella (Lea), CONRAD, 1865, Jour. Amer. Conch., vol. 1, p. 11.
Arca (*Cucullaearca*) *cuculloides* De GREGORIO, non CONRAD, 1890, Ann. Geol. Paleont., p. 195, pl. 24, figs. 17-20.
Arca rhomboidella (Lea), **COSSMAN** (in part), 1893, Notes Compl., p. 17.
Arca (*Scapharca*) *rhomboidella* (Lea), DALL, 1895, Trans. Wagner Free Inst. Sci., vol. III, p. 625.
Arca rhomboidella (Lea), SHELDON, 1916, Paleont. Amer., vol. 1, p. 30, pl. VII, figs. 6-10.
Arca rhomboidella (Lea), HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 51, pl. 21, figs. 11-17; pl. 22, figs. 1-4.
Arca cf. *rhomboidella* (Lea), HARRIS, 1951, Bull. American Paleont., vol. 33, No. 138, p. 14, pl. 6, fig. 8.

Internal cast of rhomboidal shell: compressed on ventral margin; faintly **ribbed**; ventral margin crenulate; growth lines faintly visible; umbo rounded, situated in anterior third of shell; dorsal edge sloping gently posteriorly and becoming rounded; beak small, becoming opisthogyre; length of figured specimen 8.5 mm., height 5 mm.

Occurrence: Ocala limestone

Genus Glycymeris Da Costa, 1778

Glycymeris sp. cf. G. anteparilis Kellum

Plate 17, figure 10

Glycymeris anteparilis KELLUM, 1926, U. S. Geol. Survey, Prof. Paper 143, p. 35, pl. 8, figs. 4-6.
Glycymeris cf. anteparilis Kellum, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 16, pl. 7, figs. 4-7.

Internal cast of suborbicular, convex shell: umbo pronounced, rounded; beak rostrate, orthogyre; hinge line long; dentition taxodont, 8 simple teeth on either side of beak; muscle scars deep, elongate; pallial line pronounced; ventral marginal area flattened, ventral edge extremely rounded; height 28 mm., length 26 mm.

Occurrence: Tivola member and Ocala limestone.

Glycymeris arctatus var. cookei Dall

Plate 17, figures 5, 6

Pectunculus arctatus CONRAD, 1848, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 1, p. 125, pl. 13, fig. 24.
Axinea arctata CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 12.
Glycymeris cookei DALL, 1917, U. S. Nat. Mus., Proc., vol. 51, p. 490, pl. 84, figs. 1-4.
Glycymeris arctatus var. cookei Dall, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 17, pl. 7, fig. 12.

Internal cast of small, erect, inflated shell: umbo rounded, beak orthogyre; surface markings include 10 raised, practically flat, ribs, which tend to display a mesially depressed, thread-like line, intercostal areas display faint riblet; near ventral margin ribs appear to subdivide; concentric markings include at least 3 strongly depressed lines; height of largest specimen 16 mm., length 16 mm.

Occurrence: Ocala limestone.

Glycymeris idonea (Conrad)

Plate 17, figures 7-9

Pectunculus idoneus CONRAD, 1833, Fossil Shells of the Tertiary Formation, p. 39.
Axinea idonea CONRAD, 1865, Amer. Jour. Conch., vol. I, p. 12.
Pectunculus broderipii var. radiatus De GREGORIO, 1890, Ann. Geol. Paleont., p. 194, pl. 2, figs. 15, 16.
Glycymeris idoneus DALL, 1895, Trans. Wagner Free Inst. Sci., vol. 3, p. 607.
Pectunculus idoneus HARRIS, 1895, Bull. Amer. Paleont., vol. 1, p. 22.
Glycymeris idonea (Conrad), HARRIS, 1919, Bull. Amer. Paleont., vol. 6, pp. 47-48, pl. 20, figs. 9-11.

Internal cast of inflated shell: ribbing faint, 8 in 5 mm. in nepionic forms; beak prominent, pointed, orthogyre, sloping 45° toward anterior and posterior median margins; anterior and posterior muscle scars prominent; prominent taxodont dentition; length 29 mm., height 29 mm.
Occurrence: Tivola member and Ocala limestone.

Glycymeris tivolensis n. sp.

Plate 16, figures 1-7
Plate 17, figures 1-4

Internal cast of extremely large, trigonal to subrounded shell: valves inflated; beaks extremely high, opisthogyre, arched over hinge line (attitude 11 mm. above escutcheon); anterior and posterior muscle scars large, deep, triangular; ventral margin wide (5 mm.), coarsely serrate; anterior edge of shell round, truncated; posterior edge of shell sloping less sharply; dentition coarse, taxodont, approximately 20 teeth and sockets on best preserved specimen; surface ornamentation coarse, consisting of widely spaced growth lines, traversed by finer radial ridges, resulting in reticulate pattern of squares and rectangles.

Specimens are larger, more robust than G. idonea (Conrad); beaks opisthogyre instead of orthogyre as in G. idonea (Conrad) and G. arctatus var. cookei Dall; radial ridges not pronounced as in latter species. All three inflated, rounded, rostrate, with taxodont dentition.

Specimens appear to be the largest, most rostrate forms found belonging to this species; named for the Tivola member of the Ocala limestone, but also present in the Ocala limestone.

Dimensions of largest specimen 76 mm. long, 69 mm. high, thickness of most complete specimen 27 mm., probable maximum thickness 45 mm.
Occurrence: Tivola member and Ocala limestone.

Family LIMIDAE

Genus Lima Bruguiere, 1797

Lima vicksburgiana? Dall

Plate 17, figure 13

Lima vicksburgiana DALL, 1895, Wagner Free Inst. Sci., Trans., vol. 3, p. 765, pl. 35, fig. 20.
Lima vicksburgiana Dall, HARRIS, 1946, Bull. Amer. Paleont., vol. 33, No. 138, p. 11, pl. 5, figs. 7, 8.

Internal cast of triangular shell: ventral margin rounded, somewhat oblique; umbo inflated; ornamentation consists of 25 to 30 rounded, radial ribs ribs extending to ventral margin, traversed by 3 widely spaced, concentric growth lines; height of specimen 17 mm., length 16 mm.

Occurrence: Ocala limestone.

Family LUCINIDAE

Genus Diplodonta Bronn, 1831

Diplodonta ungulina var. yazoocola Harris

Plate 20, figure 9

Astarte ungulina CONRAD, 1833, Amer. Jour. Sci., vol. 23, p. 342.
Egeria rotunda LEA, 1833, Contr. to Geol., p. 50, pl. 1, fig. 17.
Diplodonta astartiformis CONRAD, 1860, Jour. Phila. Acad. Nat. Sci., vol. 4, p. 296.
Diplodonta deltoidea CONRAD, 1860, Jour. Phila. Acad. Nat. Sci., vol. 4, p. 296.
Mysia astartiformis CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 147, pl. 11, fig. 15.
Mysia deltoidea CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 147, pl. 11, fig. 10.
Diplodonta ungulina Dall, HARRIS, 1900, Trans. Wagner Free Inst. Sci., vol. III, p. 1181.
Diplodonta ungulina Conrad, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, pp. 127-128, pl. 40, figs. 10-14.
Diplodonta ungulina var. yazoocola HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 85, pl. 19, figs. 9, 10, 10a.

Shell subrounded to triangular, somewhat inflated; very finely ornamented with narrow, evenly spaced growth lines, and finer radial lines; shell substance thin; beak somewhat elevated, prosogyre; length 10 mm., height 14 mm.
Occurrence: Twiggs clay member.

Genus Here Gabb, 1866

Here sp. cf. H. wacissana (Dall)

Plate 20, figure 10

Phacoides (Here) wacissanus DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, p. 1365, pl. 50, fig. 15.
Here cf. wacissana (Dall), HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 21, pl. 10, fig. 6.

Internal cast of shell: height exceeds length, moderately deep; surface with conspicuous, rounded, concentric growth lines, traversed by finer radial ornamemtation, dividing each growth line into many subcircular rectangles; length 11 mm., height 15 mm.
Occurrence: Ocala limestone.

Genus Lucina Bruguiere, 1797

Lucina (Myrtea?) curta (Conrad)

Plate 20, figure 5

Cyclas curta CONRAD, 1865, Amer. Jour. Conch., vol. 1, pp. 139, 212, pl. 20, fig. 14.
Lucina curta CONRAD, 1866, Smithsonian Misc. Coll., vol. 7, Check List, No. 200, p. 24.
Myrtaea Curta DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, p. 1358.
Lucina (Myrtea?) curta (Conrad), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 89, pl. 19, figs. 19-23.

Shell small, equilateral, suborbicular; surface ornamentation consisting of fine, closely spaced, concentric growth lines; posterior margin truncated; area anterior to beaks crescentic; anterior margin truncated to rounded; beak low, pointed, orthogyre; length 12 mm., height 11 mm.
Occurrence: Twiggs clay member.

Lucina (Plastomiltha) gaufia Harris

Plate 20, figures 6, 7

Lucina (Plastomiltha) gaufia HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 91, pl. 20, figs. 9-13.

Shell thin, circular; beak prominent, prosogyre; umbo flattened; growth lines prominent; anterior and posterior cardinal margins alate; length 25 mm., width 25 mm.
Occurrence: Twiggs clay member.

Lucina (Eophysema) ozarkana? Harris

Plate 20, figure 8

?Lucina dartoni CLARK, 1896, U. S. Geol. Survey, Bull. 141, p. 79, pl. 20, figs. 2a-c.
Lucina ozarkana HARRIS, 1897, Bull. Amer. Paleont., vol. 2, No. 9, pl. 20, figs. 7a-b.
Lucina convexa DALL, partim, 1903, Trans. Wagner Free Inst. Sci., vol. III, p. 1352.
Lucina ozarkana HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 118, pl. 38, figs. 24-26.
Lucina (Eophysema) ozarkana? HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 90, pl. 20, figs. 6, 7.

Shell much inflated, oval; anterior margin truncated; beak prosogyre; lunular area small, shallow; teeth not visible, but reported to be lucinoid; umbo rounded, convex; beak low; posterior margin truncated at hinge line; surface with numerous, fine, closely spaced, concentric growth lines, traversed by very fine radial ridges extending from beak to ventral margin; posterior portion of shell with wide, shallow sinus from beak to ventral margin; height 15 mm., length 16 mm.
Occurrence: Twiggs clay member.

Genus Miltha Adams, 1857

Miltha ocalana Dall

Plate 20, figure 11

Phacoides (Miltha) ocalanus DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, p. 1375, pl. 50, fig. 14.

Miltha ocalana Dall, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 21, pl. 10, figs. 7-9.

Internal cast of thin, shallow, suborbicular, lucinoid shell: surface with fine radial lines traversed by coarse, concentric growth lines; beaks high, pointed, orthogyre; anterior margin abrupt, rounded to ventral extremity; area posterior to beaks more gently sloping to edge of hinge line, truncated at posterior margin of shell; height 19 mm., length 18 mm., thickness 6 mm.
Occurrence: Tivola member.

Family CARDIIDAE

Genus *Cardium* Linne, 1758

Cardium sp.

Plate 18, figure 14

Internal cast of long, inflated shell: beak prominent, orthogyre; ribs prominent, flat to rounded, 8 in 10 mm. at mid-ventral margin; approximately 24 ribs in entire specimen; ribs lack spines of *C. cabezai* (Gardner); anterior and posterior margins sharply sloping; length 28 mm., height 25 mm.
Occurrence: Tivola member.

Genus *Gari* Schumacher, 1817

Gari jacksonense Harris

Plate 17, figure 12

Gari jacksonense HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 97, pl. 21, figs. 12-14.

Internal cast of elongate, inequilateral shell: anterior portion shorter, more rounded, posterior end slopes backward at sharp angle from beak, truncated; beak inconspicuous; teeth faintly visible, cyclodont; surface covered with alternating coarse and fine concentric growth lines; length 23 mm., height 12 mm.
Occurrence: Tivola member and Twiggs clay member.

Genus Protocardia Beyrich, 1845

Protocardia (Nemocardium) nicolletti (Conrad)

Plate 18, figures 1-9

Cardium nicolletti CONRAD, 1841, Acad. Nat. Sci. Philadelphia, Proc., vol. 1, p. 33; 1842, idem., Jour., 1st ser., vol. 8, p. 190; 1854, Wailes Rept. Agric. and Geol. Mississippi, pl. 14, fig. 6; 1855, Acad. Nat. Sci. Philadelphia, Proc., p. 258.
Protocardia lima CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 139, pl. 10, fig. 3.
Not Cardium nicolletti (Conrad), ALDRICH, 1886, Alabama Geol. Survey, Bull. No. 1, p. 48.
Protocardia nicolletti (Conrad), DALL, 1890, Wagner Free Inst. Sci., Trans., vol. 3, p. 113.
Protocardia nicolletti (Conrad) HARRIS, 1897, Bull. Amer. Paleont., vol. 2, p. 251; 1919, vol. 6, pl. 42, fig. 4.
Protocardia (Nemocardium) nicolletti (Conrad), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 92, pl. 20, figs. 16-19.
Protocardia nicolletti (Conrad), HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 23, pl. 12, figs. 1, 2.

Internal cast of robust shell: well preserved specimens exhibit crowded, minute, impressed, radial ornamentation over major part of shell; posterior quarter with strong, papillate costae; growth lines smooth to coarse; beaks central, rostrate, well-rounded, orthogyre; anterior margin rounded, posterior margin subdirect, slightly emarginate; length 38 mm., height 31 mm., thickness 22 mm., largest specimen 55 mm. long, 60 mm. high.
Occurrence: Tivola member and Twiggs clay member.

Family CARDITIDAE

Genus Venericardia Lamarck, 1801

Venericardia (Venericor) apodensata Gardner and Bowles

Plate 18, figure 12

Venericardia (Venericor) apodensata GARDNER AND BOWLES, 1937, U. S. Geol. Survey, Prof. Paper 189-F, pp. 192-193, pl. 37, fig. 13; pl. 43, fig. 8; pl. 45, figs. 15, 16.

Shell of small size for the genus (height 20 mm., width 21 mm.), inflated, rounded, trigonal in outline; umbo prominent; beak turned inwardly, prosogyre; surface marked by 27 flattened, angular, but distinct, finely imbricate ribs; intercostal areas and ribs of equal width.
Occurrence: Twiggs clay member.

Venericardia sp. cf. *V.* (*Venericor*) *nodifera* Kellum

Plate 18, figure 10

Venericardia nodifera KELLUM, 1926, U. S. Geol. Survey, Prof. Paper No. 143, p. 36, pl. 9, figs. 1-3.
Venericardia cf. *nodifera* Kellum, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 16, pl. 7, figs. 9-11.

Fragment of internal cast of right valve: surface displaying 25 narrow ribs with numerous, rounded nodes which become larger toward ventral edge of shell; anterior edge rounded, posterior edge gently sloping; umbo rounded, prominent; beak orthogyre; height 11 mm., length 19 mm.
Occurrence: Ocala limestone.

Venericardia planicosta Lamarck

Plate 19, figure 5

Venericardia planicosta Lamarck, HARRIS, Bull. Amer. Paleont., vol. 30, No. 117, p. 65, pl. 15, figs. 8, 9.

Internal cast of deep, rounded shell: ventral edge serrate; umbo most prominent; beak prosogyre; anterior muscle scar distinct, elliptical; hinge line long, cardinal teeth prominent (teleodont), laterals distinct; height 23 mm., length 33 mm., thickness 8 mm.
Occurrence: Ocala limestone.

Venericardia (*Venericor*) *densata* Conrad

Plate 18, figure 13

Cardita densata CONRAD, 1845, Acad. Nat. Sci. Philadelphia, Proc., vol. 2, p. 173.
Cardita densata Conrad, LEA, 1848, Catalogue of Tertiary

Testacea of the United States, p. 5.

Cardita densata CONRAD, 1848, Acad. Nat. Sci. Philadelphia, Jour., 2nd ser., vol. 1, pt. 2, p. 130, pl. 14, fig. 24.

Cardita densata CONRAD, 1848, Acad. Nat. Sci. Philadelphia, Proc., vol. 4, p. 97.

Cardita densata CONRAD, 1850, Alabama Geol. Survey, 1st. Bienn. Rept., p. 153.

Venericardia planicosta Lamarck, EMORY, 1857, Mexican Boundary Survey Rept., p. 161, pl. 19, figs. 2a, 2b.

Not Venericardia planicosta Lamarck, OWEN, 1860, Geol. Reconnaissance of Arkansas, 2d Rept., pl. 39, figs. 2, 2a, 2b.

Not Cardita densata Conrad, OWEN, 1860, Geol. Reconnaissance of Arkansas, 2d Rept., p. 35.

Venericardia (Cardita) densata CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 8.

Venericardia densata CONRAD, 1866, Smithsonian Misc. Coll., No. 200, p. 5.

Venericardia mooreana CONRAD, 1867, Amer. Jour. Conch., vol. 3, p. 190.

Venericardia densata CONRAD, 1867, Amer. Jour. Conch., vol. 3, p. 190.

Cardita (Venericardia) densata Conrad, De GREGORIO, 1890, Ann. Geol. Paleont., p. 214, pl. 32, fig. 11.

Cardita densata Conrad, HEILPRIN, 1891, Acad. Nat. Sci. Philadelphia, Proc., for 1890, p. 402.

Venericardia mooreana Conrad, HARRIS, Acad. Nat. Sci., Philadelphia, Proc., for 1890, p. 402.

Cardita dorsata Conrad, COSSMAN, 1894, (obviously intended for densata), Notes complementaires sur le faune eocenique d'Alabama, p. 14.

Cardita densata Conrad, HARRIS, 1896, Bull. Amer. Paleont., vol. 1, No. 4, p. 58. Not Cardita densata Conrad, HARRIS, 1894, Arkansas Geol. Survey, Ann. Rept. for 1892, vol. 2, p. 150, 1894.

Venericardia mooreana Conrad, HARRIS, 1896, Bull. Amer. Paleont., vol. 1, No. 4, p. 58.

Cardita densata Conrad, HARRIS, 1897, Bull. Amer. Paleont., vol. 2, No. 9, pp. 54, 55.

Venericardia densata Conrad, COSSMAN, 1901, Soc. Geol. France, Bull., 4th ser., vol. 1, pp. 652-656, 2 text figs.

Venericardia densata Conrad, DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, pp. 1420-1422.

Venericardia mooreana Conrad, DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, p. 1422.

Venericardia "densata" Conrad, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 77.

Venericardia mooreana Conrad, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 77.
Venericardia densata Conrad, WOODS, 1922, Geology of Northwest Peru, pp. 69, 70.
Cardita densata Conrad, ABRARD, 1925, Le Lutetien du bassin de Paris, pp. 450-451.
Venericardia densata Conrad, STEWART, 1930, Acad. Nat. Sci. Philadelphia, Special Pub. 3, pp. 154, 157, 158.
Venericardia mooreana Conrad, STEWART, 1930, Acad. Nat. Sci., Philadelphia, Special Pub. 3, p. 158.
Venericardia densata Conrad, PLUMMER, 1933, Univ. Texas Bull. 3232, p. 625.
Venericardia densata Conrad, RUTSCH, 1936, Eclogae Geol. Helvetiae, vol. 29, pp. 163, 164, 170, 180.
Venericardia mooreana Conrad, RUTSCH, 1936, Eclogae Geol. Helvetiae, vol. 29, pp. 161, 164.
Venericardia (*Venericor*) *densata* Conrad, GARDNER AND BOWLES, 1937, U. S. Geol. Survey, Prof. Paper 189-F, pp. 189-192, pl. 37, fig. 7; pl. 45, figs. 1-11, 14.

Shell heavy, obliquely cordate, with approximately 20 flattened costae, which become obsolete toward ventral margin; umbo rounded, prominent; beak pointed, prosogyre; posterior extremity truncated; anterior margin less truncated; extremely fine, concentric growth lines intersecting costae; intercostal areas narrow, shallow; height 21 mm., length 21 mm., thickness 8 mm.

Occurrence: Twiggs clay member.

Venericardia planicosta var. *ocalaedes* Harris

Plate 19, figures 1-4

Venericardia planicosta LAMARCK, 1894, Report on the Geology of the Coastal Plain of Alabama, p. 242, pl. 12, fig. 3.
Venericardia planicosta LAMARCK (part), HARRIS, 1896, Bull. Amer. Paleont., vol. 1, No. 4, p. 58, pl. 4, fig. 13.
Venericardia mooreana Conrad (part), DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, p. 1422.
Venericardia planicosta Lamarck (part), GRABAU AND SHIMER, 1909, North American Index Fossils, Invertebrates, vol. 1, p. 545, fig. 747.
Venericardia planicosta Lamarck, SHIMER AND SHROCK, 1944, Index Fossils of North America, p. 419, pl. 167, figs. 22-24.
Venericardia planicosta var. *ocalaedes* HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 16, pl. 7, fig. 8.

Internal cast of large, robust shell: beaks rostrate, prosogyre (15 mm. above long, wide hinge line); ribs flat, wide (4 mm. wide at ventral margin); muscle scars prominent, the anterior more so than the posterior; distinct ridge on each valve from median portion to tip of beaks; pallial line distinct; ventral margin serrate; height 85 mm., width 78 mm., thickness 40 mm.

Occurrence: Twiggs clay member.

Venericardia sp.

Plate 18, figure 11

Internal cast of robust shell: beak rostrate, arched above hinge line; umbo inflated; muscle scars distinct, subovate; surface markings consisting of 23 coarse, flattened ribs, preserved only on ventral margin; height 27 mm., length 24 mm., thickness 8.5 mm.

Occurrence: Tivola member and Ocala limestone.

Family VENERIDAE

Genus Macrocallista Meek, 1876

Macrocallista annexa (Conrad)

Plate 17, figures 19-21

Dione annexa CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 137, pl. 10, fig. 5.

Callista annexa (Conrad), PALMER, 1929, Paleont. Amer., vol. 1, p. 283, pl. 45, figs. 17, 20.

Callista annexa (Conrad), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 95, pl. 21, figs. 6-9.

Macrocallista annexa (Conrad), RICHARDS, 1953, Florida Geol. Survey, Bull. 35, p. 53, pl. 12, fig. 5.

Shell ovate, convex; anterior margin short, obtusely rounded; posterior margin long, cuneate, abruptly rounded at extremity; ventral margin rounded; umbo broad, inflated; beak small, prosogyre; surface with fine to coarse growth lines; height 18 mm., length 17 mm.

Occurrence: Ocala limestone, Tivola member, Twiggs clay member.

Genus Meretrix Lamarck, 1799

Meretrix ovata var. pyga Conrad

Plate 21, figure 10

Cytherea pyga CONRAD, 1848, Jour. Acad. Sci. Philadelphia, 2d ser., vol. 1, p. 131, pl. XIV, fig. 18.
Cytherea pyga Conrad, H. C. LEA, 1848, Acad. Nat. Sci. Philadelphia, Proc., vol. 4, p. 99.
Meretrix pyga CONRAD, 1854, Acad. Nat. Sci. Philadelphia, Proc., vol. 7, p. 30.
Dione pyga CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 6.
Cytherea ovata CLARK, 1895, Johns Hopkins Univ., Circ., vol. XV, p. 5. (In part)
Cytherea ovata CLARK, 1896, U. S. Geol. Survey, Bull. 141, p. 76 (In part.)
Meretrix ovata var. pyga Conrad, CLARK, 1901, Maryland Geol. Survey, vol. I (Eocene), p. 169, pl. 34, figs. 2-5.

Shell suboval, ventricose, thick, with distinct, closely spaced, concentric growth lines traversed by finer radial ridges; umbo wide, rounded; dorsal margin oblique, rounded; anterior margin more acutely rounded; height 24 mm., length 25 mm.

Occurrence: Tivola member.

Genus Pitar Roemer, 1857

Pitar sp. cf. P. cornelli Harris

Plate 21, figures 1-3

Pitar cornelli HARRIS, 1895, Bull. Amer. Paleont., vol. 1, pl. 1, fig. 5.
Pitar cf. cornelli HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 22, pl. 11, figs. 4, 5.

Internal cast of large, inflated, well-rounded left valve: umbo prominent, rounded; beak large, prosogyre, well forward; dentition teleodont; ligamental area opisthodetic; lunule deep, elliptical; anterior and posterior muscle scars large, faintly preserved; length 46 mm., height 41 mm., thickness 9 mm.

Occurrence: Tivola member.

Pitar sp. cf. P. nuttali Conrad

Plate 21, figure 4

Cytherea nuttali CONRAD, 1834, Jour. Phila. Acad. Nat. Sci., vol. 6, p. 149.
Dione nuttali CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 6.
Meretrix nuttali Conrad, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 143, pl. 45, figs. 4-8.
Pitar nuttali Conrad, HARRIS, 1927, Palaeont. Amer., vol. 1, No. 45, p. 14.
Pitar sp. cf. nuttali Conrad, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 22, pl. 11, figs. 1, 2.

Internal cast of robust, inequilateral shell: beak arched, prosogyre, well ahead of median line; umbo prominent, rounded; hinge line long truncated anteriorly; anterior and posterior margins well-rounded, the ventral edge gently so; anterior muscle scar prominent; pallial line faintly preserved; length 39 mm., height 30 mm., thickness 22 mm.

Occurrence: Tivola member.

Pitar securiformis (Conrad)

Plate 21, figure 5

Dione securiformis CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 137, pl. 10, fig. 1.
Pitar (Pitaria) securiformis (Conrad), PALMER, 1929, Palaeont. Amer., vol. 1, p. 225, pl. 33, figs, 14-16.
Pitar securiformis (Conrad), HARRIS, Bull. Amer. Paleont., vol. 30, No. 117, p. 94, pl. 21, figs. 1-3.

Internal casts of robust, subcordate, ventricose shell; umbo prominent, rounded; beak pointed, rostrate, prosogyre, well ahead of median line; anterior extremity acutely rounded, subtruncated; dorsal surface long, gently sloping; muscle scar very faint, subrounded; lunule faint, cordate, defined by slightly impressed groove; surface with faint, concentric, closely spaced growth lines; length 25 mm., height 23 mm.

Occurrence: Tivola member.

Pitar trigoniata (Lea)

Plate 21, figure 6

<u>Cytherea</u> <u>trigoniata</u> LEA, 1833, Contr. to Geol., p. 67, pl. 2, fig. 44.
<u>Dione</u> <u>discoidalis</u> CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 6 (Not <u>C</u>. <u>discoidalis</u> CONRAD, Foss. Shells of the Tertiary Formations).
<u>Cytherea</u> <u>trigoniata</u> De GREGORIO, 1890, Ann. Geol. Paleont., p. 218, pl. 34, fig. 15-22.
<u>Meretrix</u> <u>trigoniata</u> LEA, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 146, pl. 47, figs. 1-3.
<u>Pitar</u> <u>trigoniata</u> (Lea), HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 22, pl. 11, fig. 9.

Internal cast of somewhat inflated, triangular shell: beaks anterior, prosogyre; anterior edge practically vertical, becoming rounded toward ventral margin; posterior edge abruptly rounded; faint evidence of 3 concentric growth lines; length 14 mm., height 21 mm., thickness 12 mm.
Occurrence: Tivola member.

Genus <u>Venus</u> Linnaeus, 1758

"<u>Venus</u>" <u>jacksonensis</u> Meyer

Plate 21, figures 7-9

<u>Venus</u> <u>jacksonensis</u> MEYER, 1887, Sonder-Abdruck, Ber. Senkenberg. Naturf. Gesell., p. 12, pl. 2, fig. 4.
<u>Venus</u> <u>jacksonensis</u> Meyer, PALMER, 1929, Palaeont. Amer., vol. 1, p. 403, pl. 64, fig. 9.
"<u>Venus</u>" <u>jacksonensis</u> Meyer, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, pp. 96-97, pl. 21, fig. 9a.

Internal cast of robust, elongate specimen: beaks well forward, prosogyre; hinge line long, gently sloping, truncated at posterior extremity; anterior margin rounded, truncated at hinge line; ventral margin crenulate; anterior muscle scar prominent, subovate; lunule deep, elongate; ligamental groove deep, occupying uppermost half of dorsal surface; pallial line distinct, located 3 millimeters above ventral margin; faint ornamentation suggests coarse, concentric growth markings traversed by finer radial ridges; dimensions of largest of several specimens 44 mm. long, 35 mm. high, 8 mm. thick; dimensions of smallest specimen 19 mm. long, 9 mm. high., 5 mm. thick.
Occurrence: Tivola member and Ocala limestone.

Family FIMBRIIDAE

Genus *Fimbria* Megerle von Muhlfelt, 1811

Fimbria olssoni Richards

Plate 21, figs. 11-14

Fimbria olssoni RICHARDS, 1953, Florida Geol. Survey Bull. 35, p. 51, pl. 11, fig. 1.

Internal cast of elliptical, robust shell: beaks elevated, prosogyre; surface reticulate where visible; margins crenulate; dentition lucinoid; differs from *F. vernoni* Richards in having wider, less numerous radial ribs; length 44 mm., height 31 mm.
Occurrence: Ocala limestone.

Family CRASSATELLIDAE

Genus *Crassatella* Lamarck, 1801

Crassatella eutawacolens (Harris)

Plate 19, figures 6, 7

Crassatella eutawacolens HARRIS in Van Winkle and Harris, 1919, Bull. Amer. Paleont., vol. 8, No. 33, p. 14, pl. 2, fig. 4.
Crassatella eutawacolens (Harris), RICHARDS, 1953, Florida Geol. Survey Bull. 35, p. 46, pl. 10, fig. 4.

Internal cast of highly inflated, obese, essentially quadrate shells: muscle scars prominent; beaks rostrate, prosogyre; margins crenulated; pallial line deep; height 53 mm., width 62 mm., thickness 12 mm.
Occurrence: Tivola member and Ocala limestone.

Crassatella flexura Conrad

Plate 20, figure 3

Crassatella flexura CONRAD, 1854, Rept. Agric. and Geol. Mississippi, pl. 14, fig. 7; 1855, Acad. Nat. Sci. Philadelphia, Proc., p. 259 (Reprinted: Bull. Amer. Paleont., vol. 24, pp. 343-359, pls. 23, 26).

Crassatella producta CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 139, pl. 10, fig. 6.
Crassatella flexura Conrad, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 8, pl. 18, figs. 22-29, 35-38; pl. 19, figs. 1-4.

Internal cast of elongate, inequilateral shell: slightly contracted anteriorly, more so posteriorly; umbonal slope angulated and prominent; beak opisthogyre, arching above extended hinge line; ideal specimens corrugated with prominent, concentric growth lines; length 13 mm., height 5 mm.
Occurrence: Twiggs clay member and Tivola member.

Genus *Crassatellites* Krueger, 1823

Crassatellites protextus Conrad

Plate 20, figures 1, 2

Crassatella protexta CONRAD, 1832, Foss. Sh. Tert. Form., p. 22, pl. 8, fig. 2.
Crassatella protexta De GREGORIO, 1890, Ann. Geol. Paleont., p. 198, pl. 24, figs. 31-37; pl. 25, figs. 2-11.

Shell elongate, inequilateral, anterior end shorter, well-rounded; posterior portion long, obliquely descending; beak pointed, subrostrate, with marked carina extending from umbo to posterior angle; lunule and escutcheon subequal, impressed, lanceolate; beak low, orthogyre; umbo flattened; resilifer small, triangular, deep; dentition diagenodont; muscle scars distinct, subrounded; ventral edge fairly straight, crenulate; surface with fine, closely spaced, concentric growth lines; faint radial striations visible on part of shell; length 35 mm., height 16 mm., thickness 5 mm.
Occurrence: Tivola member.

Family ASTARTIIDAE

Genus *Astarte* Sowerby, 1816

Astarte triangulata Meyer

Plate 17, figures 14, 15

Astarte triangulata MEYER, 1886, Alabama Geol. Survey Bull. No. 1, p. 80, pl. 3, figs. 21, 21a.

Astarte triangulata Meyer, DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, p. 1488.
Astarte triangulata Meyer, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 76, pl. 18, figs. 11-14.

Internal cast of subtriangular shell: muscle scars distinct, elliptical; lunular depression long, narrow, flat; hinge line long, sloping to anterior edge, truncated; hinge area behind beak short, abruptly truncated; anterior, posterior, and ventral margins well-rounded; umbo prominent; beak prosogyre; surface with fine, closely spaced, radial ridges visible near ventral edge; a prominent concentric growth line visible near ventral edge; height 14 mm., length 16 mm.

Occurrence: Tivola member and Ocala limestone.

Astarte triangulatoides Harris

Plate 17, figure 16

Astarte triangulatoides HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 91, pl. 32, figs. 12, 12a.

Internal cast of shell that is more broadly ovate and less triangular than A. triangulata Meyer: umbo somewhat rounded; beak pointed, prosogyre; posterior margin with deep, rounded sulcus extending from beak practically to post-ventral edge; surface ornamentation consisting of distinct, equally spaced growth lines, traversed by faint radial lines; height 9 mm., length 9 mm.

Occurrence: Tivola member.

Genus Lirodiscus Conrad, 1869

Lirodiscus jacksonensis (Meyer)

Plate 17, figure 18

Astarte parilis CONRAD, 1854, Wailes Rept. Agric. and Geol. Mississippi, p. 289, pl. 14, fig. 2; not A. parilis CONRAD, 1853, Acad. Nat. Sci. Philadelphia, Jour., vol. 2, p. 276, pl. 24, fig. 216.
Astarte sulcata var. jacksonensis MEYER, 1885, Amer. Jour. Sci., vol. 29, p. 460.
Lirodiscus wailesii DALL, 1903, Wagner Free Inst. Sci., Trans., vol. 3, p. 1483, pl. 57, fig. 21.

Lirodiscus jacksonensis Meyer, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 77, pl. 18, figs. 1-5, 8-10.
Lirodiscus jacksonensis (Meyer), HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 20, pl. 10, fig. 5.

Internal cast of subovate shell: high, prominent, rounded, practically smooth umbo; hinge line broad; beak rounded, prosogyre; surface with at least 9, flattened, prominent, concentric growth lines; faint sinus near anterior and posterior margins reflected in growth lines; very fine, closely spaced, radial markings extending from beak to ventral edge; lunular area practically smooth, sublanceolate; length 17 mm., height 16 mm.

Occurrence: Tivola member.

Family TELLINIDAE

Genus Tellina Linne, 1758

Tellina perovata n. sp.

Plate 20, figure 20

Internal casts of several distinctly ovate shells: umbo rounded, distinct; beak pointed, prosogyre; anterior muscle scar long, subspatulate; posterior muscle scar small; pallial line distinct, situated 2 millimeters from ventral margin; surface marked by wide, evenly spaced, rounded, concentric, growth lines, with very shallow interspaces; hinge line 29 mm. long, marked by an anterior lateral tooth and socket, and a posterior lateral socket; cardinal teeth consist of 2 prominent teeth and sockets; anterior and posterior margins well-rounded, posterior margin more abrupt, ventral margin gently so; length 39 mm., height 31 mm., thickness 4 mm.

Beak more forward than T. vaughani Cooke or T. eburneopsis Conrad, and approaching size of latter species; posterior margin more rounded, not truncated, as in T. eburneopsis Conrad; more ovate.

This species is named for its more ovate character.

Occurrence: Tivola member and Ocala limestone.

Tellina vaughani Cooke

Plate 20, figure 19

Tellina vaughani COOKE, 1926, Washington Acad. Sci., Jour., vol. 16, p. 138, figs. 16a-b.
Tellina vaughani Cooke, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, pp. 102-103, pl. 22, figs. 13-16.

Shell thin elliptical; beaks slightly behind median line, orthogyre, somewhat inflated; posterior margin the more acutely rounded; surface with faint, closely spaced, concentric growth lines; dentition schizodont; area in front of beaks long, gently sloping, becoming rounded at anterior extremity; length 12 mm., height 8 mm.
Occurrence: Twiggs clay member.

Family ANATIDAE

Genus Pholadomya Sowerby, 1823

Pholadomya sp. cf. P. claibornensis Aldrich

Plate 14, figs. 11-13

Pholadomya claibornensis ALDRICH, 1886, Geol. Surv. Ala., Bull. 1, p. 38, pl. 4, fig. 5.
Pholadomya claibornensis Aldrich, DALL, 1903, Trans. Wagner Free Inst. Sci., vol. III, p. 1531.
Pholadomya claibornensis Aldrich, HARRIS, 1919, Bull. Amer. Paleont., vol. 6, No. 31, p. 197, pl. 59, figs. 6-10.

Shell extremely thin, fragile, distorted, pearly; growth lines very fine but distinct, traversed by extremely fine radial lines; beaks high, well forward of shell center, orthogyre; anterior margin abruptly truncated and rounded; posterior margin produced and rounded; lunule long, narrow, smooth; dorsal surface wide, hinge raised; height 12 mm., length 18 mm., thickness 18 mm.
Occurrence: Twiggs clay member.

Family MYIDAE

Genus Gastrochaena Spengler, 1783

Gastrochaena mississippiensis Harris

Plate 14, figures 7-10

Gastrochaena mississippiensis HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 120, pl. 25, figs. 7-11.

Internal cast of long, elliptical shell: anterior margin truncated; posterior margin rounded; beak well forward, prosogyre; dorsal surface long, flattened, becoming rounded posteriorly; hinge line short; umbonal ridge extending from beak practically to posterior edge; prominent, concentric growth markings occurring as distinct ridges and fine, rounded depressions; faint radial lines preserved on anterior quarter of shell; height 21 mm., length 14 mm., thickness 7.5 mm.

Occurrence: Tivola member and Ocala limestone.

Genus Panope Menard, 1807

Panope oblongata (Conrad)

Plate 14, figures 2-6

Panopaea oblongata CONRAD, 1847, Acad. Nat. Sci. Philadelphia, Proc., p. 290; 1848, idem, Jour., 2d ser., vol. 1, p. 121, pl. 13, fig. 12.
Panopea oblongata DALL, 1898, Wagner Free Inst. Sci., Trans., vol. 3, p. 828.
Panope oblongata (Conrad), HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 119, pl. 25, fig. 6.
Panope oblongata (Conrad), HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 25, pl. 13, figs. 6, 7?, 8.

Internal cast of large, elongate, notably inequilateral, oblong shell, gaping widely behind; anterior and posterior margins rounded; umbo rounded, prominent, low and long; beaks low, orthogyre; surface ornamentation marked by thickened, rounded, concentric growth lines; ligament external on prominent ridge; dimensions of largest specimen 92 mm. long, 41 mm. high, greatest thickness 25 mm.

Occurrence: Tivola member and Twiggs clay member.

Family CORBULIDAE

Genus Corbula Bruguiere, 1797

Corbula wailesiana Harris MS in Dall

Plate 20 figures 12-18

Corbula bicarinata CONRAD, 1854, (homonym of Sowerby, 1833), Rept. Agric. and Geol. Mississippi, p. 289, pl. 14, fig. 3; 1855, Acad. Nat. Sci. Philadelphia, Proc., vol. 7, p. 258.

Corbula wailesiana HARRIS (MS), DALL, 1898, Wagner Free Inst. Sci., Trans., vol. 3, p. 846.
Corbula bicarinata Conrad (Reprint), HARRIS, 1939, Bull. Amer. Paleont., vol. 24, p. 344, pl. 23, fig. 3.
Corbula wailesiana Dall, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 113, pl. 23, figs. 27, 28; pl. 24, figs. 1-8.

Shell thin, triangular, small, slightly oblique, robust; umbo prominent; beaks incurved, orthogyre; posterior slope biangulated; surface covered with regularly spaced growth lines, reflecting robust character of shell; distinct carina on posterior portion of shell, extending from point of beak to ventral edge of shell; height 7 mm., length 10 mm., thickness 5 mm.

Occurrence: Twiggs clay and Tivola member.

Family MACTRIDAE

Genus Spisula Gray, 1837

Spisula praetenuis Conrad

Plate 17, figure 17

Mactra praetenuis CONRAD, 1833, Fossil Shells Tertiary Form., p. 42, pl. 19, fig. 9 of Harris Reprint.
Mactra praetenuis CONRAD, 1846, Amer. Jour. Sci., vol. 1, p. 217, pl. 2, fig. 4.
Mactrella praetenuis CONRAD, 1865, Amer. Jour. Conch., p. 4.
Spisula praetenuis Conrad, DALL, 1895, Trans. Wagner Free Inst. Sci., vol. III, p. 896.
Spisula praetenuis Conrad, HARRIS, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 106, pl. 23, fig. 1.
Spisula praetenuis Conrad, HARRIS, 1951, Bull. Amer. Paleont., vol. 33, No. 138, p. 26, pl. 13, figs. 10, 11?

Internal cast of subtriangular, compressed, equilateral shell: umbonal slope submarginal, subrectilinear; beaks prominent; hinge line long sloping; anterior and posterior extremities abruptly rounded; prominent, widely spaced, concentric growth lines; height 23 mm., length 33 mm.

Occurrence: Twiggs clay member, Tivola member, and Ocala limestone.

Class GASTROPODA

Family CALYPTRAEIDAE

Genus *Calyptraea* Lamarck, 1799

Calyptraea aperta (Solander)

Plate 22, figures 18-21

Trochus apertus SOLANDER, 1766, in Bander, Fossilia Hantoniensis, p. 9, pl. 1, figs. 1, 2.
Trochus opercularis SOLANDER, 1766, in Bander, Fossilia Hantoniensia, p. 9, pl. 1, fig. 3.
Calyptraea aperta (Solander), HARRIS, 1899, Bull. Amer. Paleont., vol. III, No. 11, pt. II, p. 84, pl. 11, figs. 13-16; MAURY, 1912, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. XV, p. 99, pl. XIII, fig. 5 Midway (Paleocene), Trinidad; PALMER, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 145, pl. 16, figs. 1, 2, 3, 5; OLSSON, 1944, Bull. Amer. Paleont., vol. XXVIII, No. 111, p. 90, pl. 9, figs. 10-13.
Calyptraea (Trochatella) aperta (Solander), OLSSON, Bull. Amer. Paleont., vol. XIV, No. 52, p. 62, upper Eocene, Peru.
Calyptraea aperta (Solander), PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 260, pl. 31, figs. 2, 4-12.

Internal cast of 2 whorls of incomplete specimen: orbicular, obtusely conical; apex subcentral; surface smooth, except for wide, rounded carina along inner and outer edges of body whorl; height 14 mm., diameter 25 mm.

Occurrence: Tivola member and Ocala limestone.

Family BUCCINIDAE

Genus *Buccitriton* Conrad, 1865

Buccitriton jacksonensis? (Cooke)

Plate 23, figure 16

Alectrion jacksonensis COOKE, 1926, Washington Acad. Sci., Jour., vol. 16, No. 5, p. 136, fig. 7.
Buccitriton jacksonensis (Cooke), PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 353, pl. 45, fig. 14.

Shell small, robust, apical angle approximately 50 degrees;

nucleus crushed, apparently consisted of 3 whorls; only 2 whorls of entire shell remain intact; suture impressed; surface of upper whorl with coarse, ribbed, growth lines terminating in 13 spines or beads on shoulder; spines on shoulder of body whorl coarse; spiral ornamentation consisting of fine, closely spaced lirae; outer lip thick; columella short, straight; aperture ovate; length 9 mm., diameter 6 mm.

Occurrence: Twiggs clay member.

Genus *Cornulina* Conrad, 1853

Cornulina louisianae Palmer

Plate 24, figure 3

Cornulina louisianae PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 365, pl. 48, figs. 7, 8.

Shell medium stout, 2.5 whorls preserved (4 to 5 whorls on complete specimen); 12 prominent, longitudinal folds with wide interspaces; folds with prominent node in upper third of each whorl; approximately 25 fine, well-preserved, spiral lirae on each whorl; suture and whorls somewhat oblique; suture impressed; aperture ovate; outer lip thin; canal short, curved; length 18 mm., diameter 14 mm.

Occurrence: Twiggs clay member.

Genus *Pseudoliva* Swainson, 1840

Pseudoliva vetusta var. *perspectiva* Conrad

Plate 23, figures 17, 18
Plate 24, figure 1

Gastridium vetustum CONRAD, 1854, WAILES, Agric. Geol. Mississippi, p. 289, pl. XVII, fig. 4; CONRAD, 1855, Acad. Nat. Sci. Philadelphia, Proc., vol. VII, p. 262; 1939, Reprint, Bull. Amer. Paleont., vol. XXIV, No. 86, pp. 8, 19, pl. 4, fig. 4.

Pseudoliva perspectiva CONRAD in Gabb, 1860, Acad. Nat. Sci. Philadelphia, Jour., n. s., vol. IV, p. 381, pl. 67, fig. 29.

Pseudoliva carinata CONRAD in Gabb, 1860, *loc. cit.*, pl. 67, fig. 32.

Sulcobuccinum (*Buccinorbis*) *carinata* CONRAD, 1865, *loc. cit.*

Pseudoliva (Buccinorbis) perspectiva CONRAD, 1866, Smithsonian Misc. Coll., vol. VII, No. 200, p. 25.
Pseudoliva (Buccinorbis) carinata CONRAD, 1886, Smithsonian Misc. Coll., vol. VII, No. 200, p. 17.
Pseudoliva pyruloides var. perspectiva CONRAD, 1885, Amer. Jour. Sci., vol. 79, p. 468.
Pseudoliva vetusta Conrad, De GREGORIO, 1890, Ann. Geol. Paleont., 7 liv., p. 109, partim, pl. 8, pl. 35, 36, 39, 40.
Pseudoliva (Buccinorbis) perspectiva Conrad, COSSMAN, 1901, Essais Paleoconch. comp., 4 liv., p. 193, pl. VIII, figs. 19-20.
Pseudoliva vetusta perspectiva Conrad in Gabb, PALMER, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 313, pl. 42, figs. 1-6; pl. 85, fig. 4, (pl. 42, figs. 1, 2 Jackson shells).
Pseudoliva vetusta perspectiva Conrad in Gabb, PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, pp. 356-357, pl. 46, figs. 7-15; pl. 47, figs. 1, 3-5.

Shell ovate, spire missing, short in other reported specimens; suture channeled; channel revolving, deep, 7 millimeters above base; columella callous; umbilicus large, long, with at least 3 plaits; surface with numerous, fine, closely spaced, revolving lirae to top of body whorl; body whorl with rounded, somewhat nodose carina; length 23 mm., diameter 25 mm.

Occurrence: Twiggs clay member.

Family TURRITELLIDAE

Genus Mesalia Gray, 1842

Mesalia georgiana Bowles

Plate 23, figures 7, 8

Mesalia vetusta Conrad, McCALLIE, 1908, ex parte, Georgia Geol. Survey, Bull. 15, pp. 338, 340, 342, 346, 347. (Not p. 337 = Mesalia claibornensis Harris, nor pp. 345, 348 = M. sp.?).
Mesalia vetusta Conrad, VEATCH AND STEPHENSON, 1911, ex parte, Georgia Geol. Survey, Bull. 26, pp. 286, 289, 292. (Not pp. 246, 256, 259, 276, 282, 295 = M. claibornensis Harris).
Mesalia vetusta Conrad, STEPHENSON AND VEATCH, 1915, U. S. Geol. Survey, Water-Supply Paper 341, p. 80.

Mesalia georgiana BOWLES, 1939, Jour. Paleont., vol. 13, p. 333, pl. 34, figs. 12, 13.

Spire high, robust, abruptly tapering; sutures linear, distinct, not noticeably impressed; sutures more comparable with *M. claibornensis* Harris than *M. vetusta* Conrad; whorls ornamented with at least 12 extremely fine spiral lirae; incrementals very fine, gently arcuate; outer lip thin, fragile, practically entire on figured specimen; columella becoming spoon-shaped basally; number of preserved whorls 9; height 34 mm., maximum diameter 8 mm.

Occurrence: Twiggs clay member.

Genus *Turritella* Lamarck, 1799

Turritella arenicola (Conrad)

Plate 23, figures 1-5

M.? arenicola CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 141, pl. 10, fig. 11.

Turritella arenicola (Conrad), BOWLES, 1939, Jour. Paleont., vol. 13, p. 275, pl. 31, figs. 5-7.

Turritella arenicola (Conrad), STENZEL AND TURNER, 1942, Type Invertebrate Fossils of North America, Eocene, Gastropoda 17, Card No. 45, figs. 11, 1-3.

Turritella arenicola (Conrad), PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 281, pl. 34, figs. 8-11.

Internal cast containing 11 whorls: 6 acute, prominent, revolving lirae; sutures impressed; whorls angular, rounded; height 29 mm., approximate diameter 8 mm.

Occurrence: Twiggs clay member, Tivola member, and Ocala limestone.

Turritella clevelandia Harris

Plate 23, figure 6

Turritella perdita? DALL, 1891, in Call, Ann. Rept. Geol. Survey Arkansas for 1889, vol. II, p. 8, fide Harris, 1894, p. 92.

?*Turritella mortoni* CALL, 1891, Ann. Rept. Geol. Survey Arkansas for 1889, vol. II, p. 8, fide Harris, 1894, p. 92.

Turritella clevelandia HARRIS, 1894, Ann. Rept. Geol. Survey Arkansas for 1892, vol. II, p. 170, pl. VI, fig. 9; PALMER, 1937, Bull. Amer. Paleont., vol. VII, No. 32, p. 202, pl. 26, figs. 6, 7; BOWLES, 1930, Jour. Paleont., vol. 13, No. 3, p. 308, pl. 31, figs. 9, 12; STENZEL AND TURNER, 1942, Type Invertebrate Fossils of North America, Eocene, Gastropoda 28, Card No. 56, figs. 1, 9, 12.
Turritella clevelandia Harris, PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 290, pl. 36, figs. 1-6.

Nepionic shell with 7 whorls, generally ornamented with 3 prominent, revolving lines, and a few subordinate ones; suture and whorls oblique; whorls rounded; sutures impressed; height 12 mm., diameter 4 mm.
Occurrence: Twiggs clay member.

Turritella sp.

Plate 23, figure 11-13

Internal cast of shell fragment with 4 rounded whorls preserved: sutures noticeably impressed; whorls and sutures oblique; height 19 mm., maximum diameter 10 mm.
Occurrence: Twiggs clay member and Tivola member.

Family CONIDAE

Genus Conus Morch, 1852

Conus (Lithoconus) sauridens (Conrad)

Plate 24, figures 12-14

Conus sauridens CONRAD, 1833, Foss. Tert. Form., p. 33; CONRAD, 1835, Foss. Tert. Form., p. 38, pl. 15, fig. 7.
Conus tortilis Conrad, 1854, Wailes, Rept. Agric. Geol. Mississippi, p. 289, pl. XV, fig. 5; CONRAD, 1855, Acad. Nat. Sci. Philadelphia, Proc., vol. VII, p. 260; 1939, Reprint, Bull. Amer. Paleont., vol. XXIV, No. 86, pp. 6, 19, pl. 2, fig. 5; CONRAD, 1865, Amer. Jour. Conch., vol. I, p. 29; CONRAD, 1866, Smithsonian Misc. Coll., vol. VII, No. 200, p. 25; DALL, 1895, U. S. Nat. Mus., Proc., vol. 18, p. 41.
Conus jacksonensis MEYER, 1885, Amer. Jour. Sci., vol. 129, p. 466; TOMLIN, 1937, Malacol. Soc. London, Proc., vol. XXII, pt. IV and pt. V, p. 263.

Conus tortilis Conrad, PALMER, 1937, Bull. Amer. Paleont., vol. VII, No. 32, pp. 458-463, pl. 71, figs. 1-14; pl. 90, fig. 3.
Conus (Lithoconus) sauridens (Conrad), PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 444, pl. 62, figs. 15-18, 20.

Internal cast of shell with 9 smooth whorls with rounded shoulders and deeply impressed sutures: nuclear whorls 4 in number; apical angle 45 degrees; body whorl long, sloping inwardly toward basal portion; aperture narrow (3 mm. wide) and long; length of shell 31 mm., maximum diameter 23 mm.
Occurrence: Ocala limestone.

Family NATICIDAE

Genus Sinum Roeding in Bolten, 1798

Sinum danvillense Palmer

Plate 22, figures 5-7

Sinum danvillense PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 253, pl. 30, figs. 6, 7.

Shell of medium size; earlier whorls worn, but 2 are visible; post-nuclear whorls sharply sloping, with fine, spiral striations traversed by equally fine growth lines; body whorl well-rounded, inflated, oblique; umbilicus deep, narrow; aperture ovate; height 24 mm., maximum diameter 22 mm.
Occurrence: Ocala limestone.

Family STROMBIDAE

Genus Strombus Linnaeus, 1758

Strombus sp.

Plate 23, figures 14, 15

Internal cast of large shell (minus spire): body whorl long, gently rounded, the basal third tapering and concave; outer lip wing-like and deeply grooved; aperture long, narrow, widening at lower extremity; inner lip smooth; surface with faint spiral lirae, traversed by distinct, longitudinal, rounded carinae; body whorl with coarse, rounded shoulder, with traces of several short, rounded spines and a pointed spine; inside of uppermost portion of shell exhibits 4 deep plait markings, alternating with high, straight-sided, rounded ridges, which in the aperture become wide and flattened on outer lip; height of figured specimen 43 mm., maximum diameter 26 mm.

Occurrence: Ocala limestone.

Family AMPULLOSPIRIDAE

Genus Pseudocrommium Clark, 1946

Pseudocrommium brucei Palmer

Plate 22, figures 8-17

Pseudocrommium brucei PALMER, 1953, Florida Geol. Survey, Bull. 35, p. 27, pl. 4, figs. 2-8.

Internal casts of large and small shells: high, sharp spires numbering 4 or 5; nuclear portion consisting of 1.5 whorls; body whorl well-rounded; whorls with broad, smooth shoulders; sutures slightly oblique, impressed, rounded at margin of shoulder; umbilicus open, deep, oval; margin of callus recurved and flaring; faint trace of growth lines; height of most complete specimen 31 mm., maximum diameter of largest specimen 40 mm.

Occurrence: Tivola member and Ocala limestone.

Genus Levifusus Conrad, 1865

Levifusus fulguriparens Maury

Plate 24, figure 4

Levifusus fulguriparens MAURY, 1909, Amer. Jour. Sci., vol. 177, p. 335, fig.

Levifusus fulguriparens Maury, PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 370, pl. 49, figs. 7, 8.

Nuclear whorls not present; post-nuclear whorls sharply carinate, nodose; body whorl long, finely lirate, carina sharply spinose, sharply truncated below carina; differs from L. branneri Harris in having only one row of nodes or spines on body whorl; outer lip thin; inner lip with approximately 3 sharp plaits visible; length 17 mm., maximum diameter 9 mm.

Occurrence: Twiggs clay member.

Levifusus? sp.

Plate 24, figures 5, 6

Internal cast of body whorl: fusiform; outer lip fringed with at least 8 coarse, rounded crenulations extending from top of whorl practically to end of canal; aperture long, narrow; suture oblique; body whorl with coarse, longitudinal, somewhat nodose, transverse ridges; length 25 mm., diameter 18 mm.

Occurrence: Ocala limestone.

Family VOLUTIDAE

Genus Athleta Conrad, 1853

Athleta petrosa (Conrad)

Plate 24, figures 7, 8

Voluta petrosa CONRAD, 1833, Foss. Shells Tert. Form., p. 29; CONRAD, 1835, Foss. Shells Tert. Form., p. 41, pl. 16, fig. 2.
Volutalithes symmetrica CONRAD, 1854, Wailes, Rept. Agr. Geol. Mississippi, p. 289, pl. XV, fig. 6; CONRAD, 1855, Acad. Nat. Sci. Philadelphia, Proc., vol. VII, p. 260; 1939, Reprint, Bull. Amer. Paleont., vol. XXIV, No. 86, pp. 6, 19, pl. 2, fig. 6; CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 24; CONRAD, 1866, Smithsonian Misc. Coll., vol. 7, No. 200, p. 25.
Volutalithes dumosa CONRAD, 1854, Wailes, Rept. Agr. Geol. Mississippi, p. 289, pl. XVI, fig. 1; Reprint, op. cit., pl. 3, fig. 1; CONRAD, 1865, op. cit., p. 23.
Volutilithes petrosus (Conrad), SMITH, 1906, Acad. Nat. Sci. Philadelphia, Proc., vol. LVIII, p. 67, text fig. 7, pl. II, fig. 4, 7.
Athleta petrosa (Conrad), SMITH, 1907, Acad. Nat. Sci. Philadelphia, Proc., vol. LIX, p. 234.
Athleta petrosa (Conrad), PALMER, 1937, Bull. Amer. Paleont., vol. VII, No. 32, pp. 372-375, pl. 58, figs. 1-14; pl. 88, figs. 1, 7, 11.
Athleta petrosa (Conrad), PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 391, pl. 53, figs. 1-4.

Nuclear and greater portion of post-nuclear portions missing: body whorl complete except for upper two-thirds of outer lip; shell long, tapering; shoulders with very large, subpointed spines (5 on body whorl, 7 on superjacent whorl);

surface ornamented by prominent, evenly spaced, revolving lirae, which become finer toward apex of shell; finer transverse markings preserved on body whorl shoulder; columella straight, tapering toward base; columella with 3 high, sharp to subrounded plaits, which completely encircle shell to appear on outer lip half-way within edge; secondary plaits among major ones, the coarsest below; upper minoe plait very fine; aperture narrow, elongate; length of specimen 46 mm., diameter 19 mm.

Occurrence: Tivola member.

Genus Caricella Conrad, 1835

Caricella subangulata Conrad

Plate 24, figures 9, 10

Caricella subangulata CONRAD, 1854, Wailes, Rept., Agr. Geol. Mississippi, p. 289, pl. XV, fig. 8; CONRAD, 1855, Acad. Nat. Sci. Philadelphia, Proc., vol. VII, p. 261; 1939, Reprint, Bull. Amer. Paleont., vol. XXIV, No. 86, pp. 7, 19, pl. 2, fig. 8; CONRAD, 1865, Amer. Jour. Conch., vol. 1, p. 24; CONRAD, 1866, Smithsonian Misc. Coll., vol. VII, No. 200, p. 25; COSSMAN, 1899, Essais Paleoconch. comp., 3 liv., p. 130.

Scaphella (Caricella) subangulata Conrad, DALL, 1890, Wagner Free Inst. Sci., Trans., vol. 3, pt. 1, p. 87, pl. 6, fig. 11.

Caricella subangulata Conrad, PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 395, pl. 54, figs. 10, 12, 13, 15.

Shell turbinate; outer lip expanded; shoulder subangulated; body whorl flattened above; spire low, consisting of 4.5 volutions; ornamentation consisting of very faint lirae near apex of spire; body whorl with numerous, narrow, evenly spaced growth lines; aperture long, narrow; columella curved, callous, with 3 coarse, flat-edged plaits; length 42 mm., diameter 31 mm.; diameter of largest specimen 43 mm., length 43 mm.

Occurrence: Tivola member and Ocala limestone.

Genus Voluticella Palmer, 1953

Voluticella levensis Palmer

Plate 24, figure 11

Voluticella levensis PALMER, 1953, Florida Geol. Survey, Bull. 35, p. 37, pl. 5, figs. 4-8.

Internal cast of small shell (minus spire): body whorl pyriform, with reticulate sculpture of coarse, narrowly spaced, spiral lirae, and finer growth lines, forming squares, which in this specimen appear as nodes; shoulder rounded; suture somewhat impressed, oblique; aperture appears to have been narrow, elongate; length of specimen 16 mm., diameter 7 mm.
Occurrence: Tivola member.

Family ACTEONIDAE

Genus Acteon? Montfort, 1810

Acteon? idoneus? Conrad

Plate 24, figure 17

Acteon idoneus CONRAD, 1833, Nov., Fossil Shells Tert. Form., vol. 1, No. 3, p. 45.
Acteon pomilius CONRAD, 1894, Ann. Rept. Geol. Survey Arkansas for 1892, p. 158.
Acteon idoneus Conrad, PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 453, pl. 63, figs. 14, 15.

Internal cast of narrow, elliptical shell with only body whorl and a single nuclear whorl preserved, both with faint, spiral lirae: suture and whorls slightly oblique; whorls well-rounded; suture impressed; lower part of body whorl tapering; length 20 mm., diameter 12 mm.
Occurrence: Tivola member.

Family OLIVIDAE

Genus Agaronia Gray, 1839

Agaronia mississippiensis (Conrad)

Plate 24, figure 2

Oliva mississippiensis CONRAD, 1847, Acad. Nat. Sci. Philadelphia, Proc., vol. III, p. 289; CONRAD, 1848, Acad. Nat. Sci. Philadelphia, Jour., vol. I, 2d ser., p. 119, pl. 13, figs. 6, 38.

Lamprodoma Mississippiensis CONRAD, 1865, Amer. Jour. Conch., vol. I, p. 22.
Agaronia mississippiensis (Conrad), PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 410, pl. 63, figs. 17-19.

Shell subelliptical; 2 of 6 volutions preserved on entire specimen; slightly impressed equatorial line in body whorl; length 7 mm., diameter 3 mm.
Occurrence: Twiggs clay member.

Family ARCHITECTONICIDAE

Genus Architectonica Roeding in Bolten, 1798

Subgenus Stellaxis Dall, 1892

Architectonica (Stellaxis) alveata (Conrad)

Plate 22, figures 22-24

Solarium alveatum CONRAD, 1833, Sept., Foss. Shells Tert. Forms., p. 31; CONRAD, 1835, Foss. Shells Tert. Forms., p. 47, pl. 17, fig. 3.
Architectonica alveata (Conrad), PALMER, Bull. Amer. Paleont., vol. VII, No. 32, p. 173, pl. 19, figs. 8-18.
Architectonica (Stellaxis) alveata (Conrad), PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, pp. 276-277, pl. 32, figs. 9-11.

Fragments of several well-rounded whorls: upper surface with a prominent ridge preserved on inner edge above suture; lower portion somewhat compressed, flattened; maximum diameter 11 mm.
Occurrence: Twiggs clay member.

Family CERITHIIDAE

Genus Bittium Leach in Gray, 1847

Bittium koeneni Meyer

Plate 24, figures 15, 16

Bittium koeneni MEYER, 1886, Geol. Survey Alabama, Bull. No. 1, pt. II, p. 70, pl. 2, fig. 12; DALL, 1892, Wagner

Free Inst. Sci., Trans., vol. 3, pt. II, pp. 275-276; COSSMAN, 1893, Ann. Geol. Paleont., 12 liv., p. 30.
Bittium koeneni Meyer, PALMER, 1946, Bull. Amer. Paleont., vol. 30, No. 117, p. 301, pl. 39, figs. 7-9.

Internal cast with some shell material preserved: 6.5 volutions preserved; the 2 upper volutions with reticulate ornamentation, consisting of 4 coarse, spiral ribs, traversed by coarse, transverse ribs, forming prominent nodes at intersections; aperture ovate to circular; whorls convex; suture impressed, oblique; length 24 mm., diameter 11 mm.
Occurrence: Tivola member.

Class SCAPHOPODA

Family DENTALIIDAE

Genus Dentalium Linnaeus, 1758

Dentalium sp.

Plate 25, figures 1-4

Internal casts and original shell material consisting of tusk-like, tubular, slightly curved, regularly tapering shells, with ends open in well-preserved specimens; maximum length 9 mm., anterior end 4 mm. in diameter, posterior end 2 mm. in diameter.
Occurrence: Twiggs clay member and Tivola member.

Phylum ARTHROPODA

Class CRUSTACEA

Family CALLIANASSIDAE

Genus Callianassa Leach, 1814

Callianassa inglisestris Roberts

Plate 25, figures 5-7

Callianassa inglisestris ROBERTS, 1953, Florida Geol. Survey, Bull. 35, pp. 64-67, pl. 13, figs. 1-12.

Left major manus of female, with stump for six digits; fixed digit approximately one-fourth as wide as total width of claw; outer surface more concave than inner; posterior margin concave; inner and outer surfaces of palm marked with minute, polygonal areas, enclosed by raised, flattened ridges; length 15 mm., height 11 mm., thickness 2 mm.

Occurrence: Tivola member and Ocala limestone.

Phylum CHORDATA

The following species of shark and bony fish remains have been described adequately by Leriche (1942) in an imposing work on the fish faunas of the Atlantic Coastal Plain. It is not the purpose of the present paper to redescribe these forms, but only to list them as integral components of the Jackson Group of Georgia. The major portion of the remains occur in the lower sand bed of the Tivola member; a single fossil was derived from the Twiggs clay member and another from the Ocala limestone.

Class CHONDRICHTHYES

Aetobatis irregularis Agassiz
Galeocerdo alabamensis Leriche
Lamna obliqua Agassiz
Myliobatis sp.
Odontaspis macrota Agassiz
Odontaspis sp.
Oxyrhina hastalis Agassiz
Oxyrhina nova Winkler
Oxyrhina praecursor var. *americanus* Leriche
Sphyrna gilmorei Leriche

Class OSTEICHTHYES

Pristis? *aquitanicus*? Delfortrie
Various fish vertebrae (genus and species indet.)

PLATES

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9, 10. Side views of 8 and another specimen, illustrating limestone replacement of interseptal areas, and bifurcation of septa. (x1)

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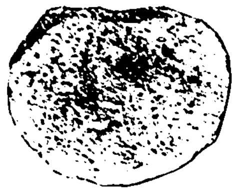

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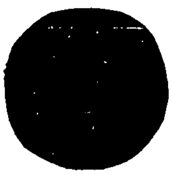

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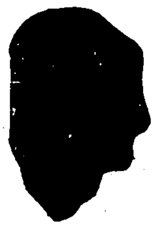

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17. Aboral view showing faint, short, blunt ambulacral petals. (x3)

EXPLANATION OF PLATE 2 (cont'd)

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19. Oral view showing centrally located peristome, and faint ambulacral furrows. (x3)

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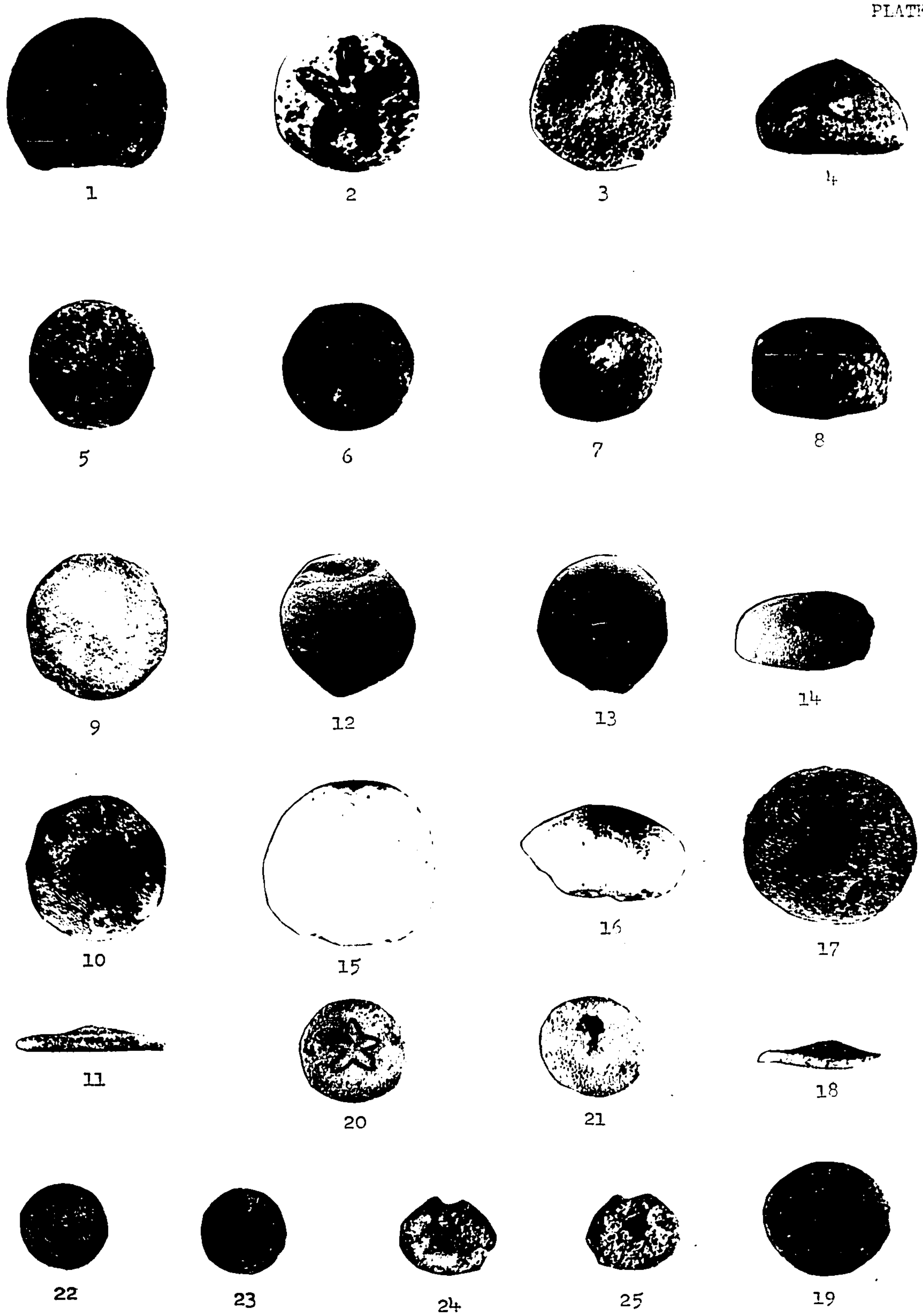
PLATE 2



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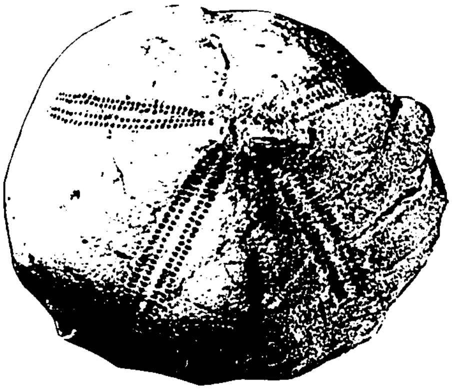

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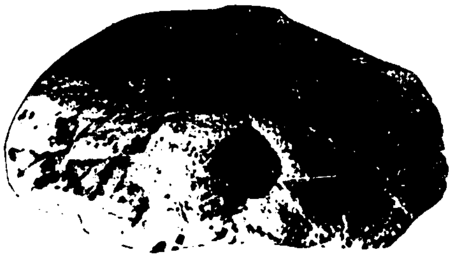

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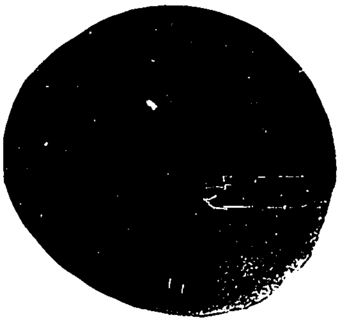

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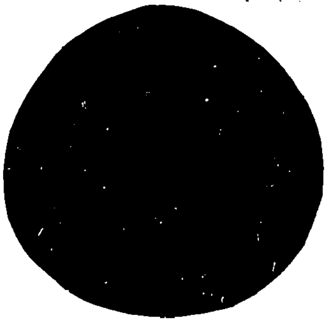

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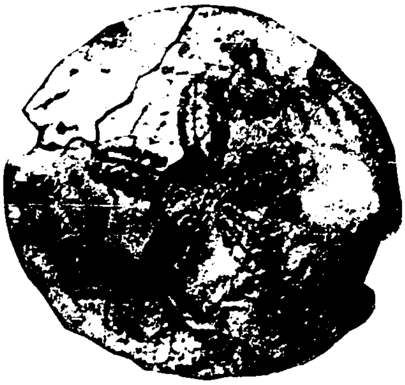

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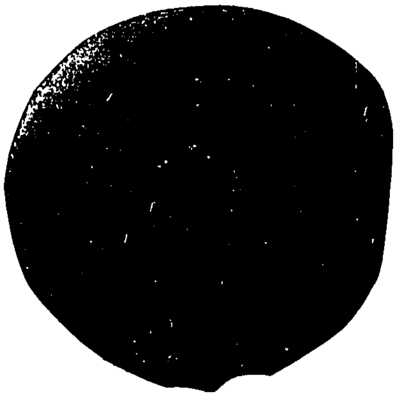

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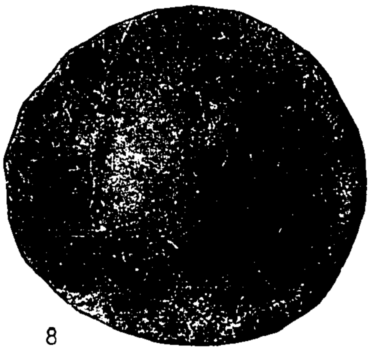

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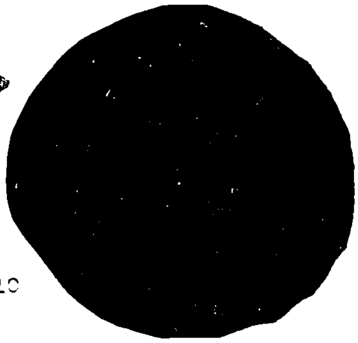

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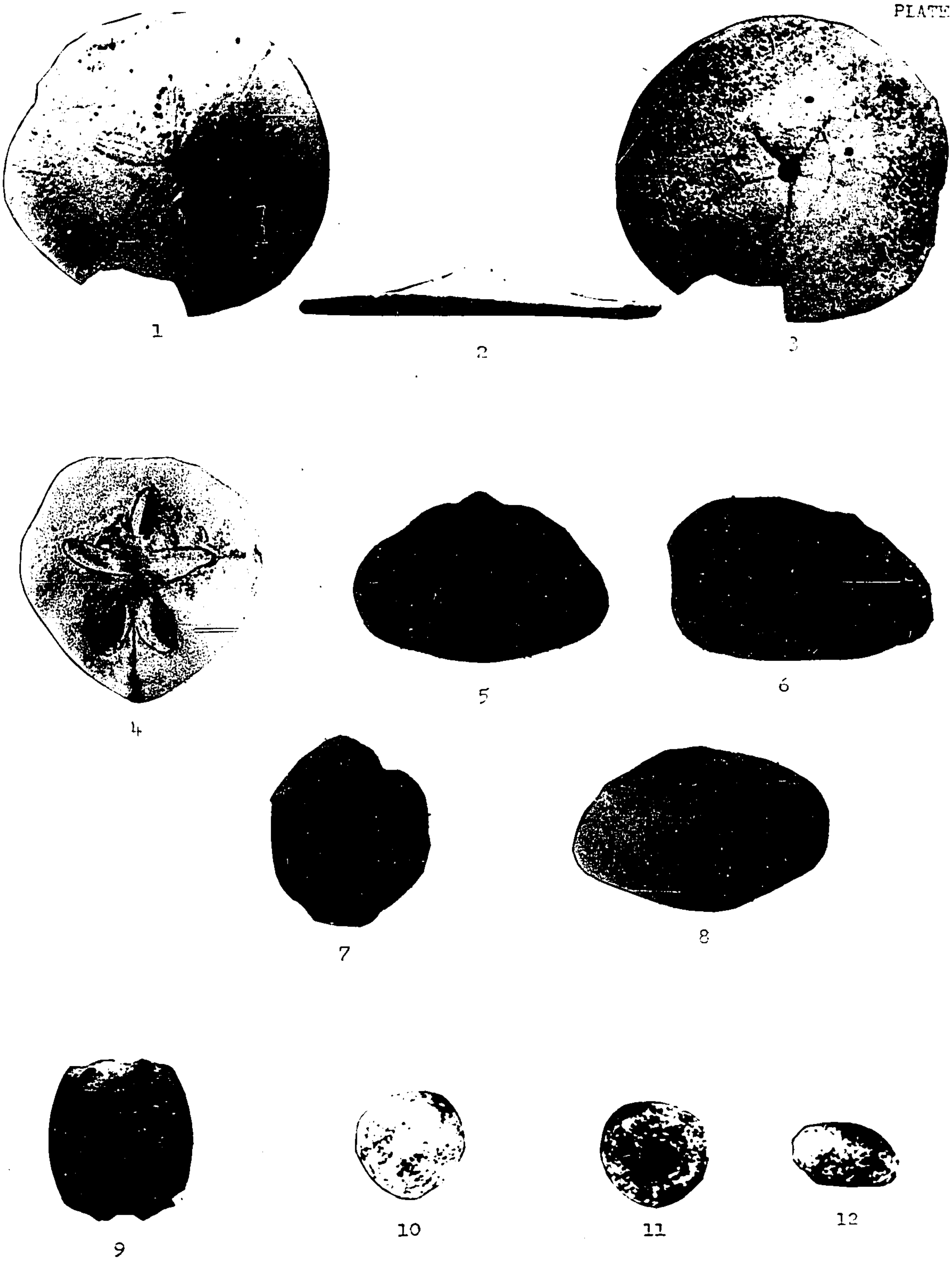

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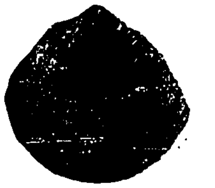

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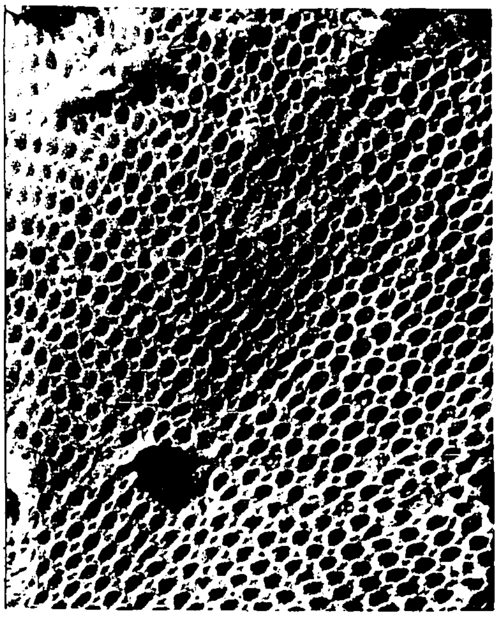

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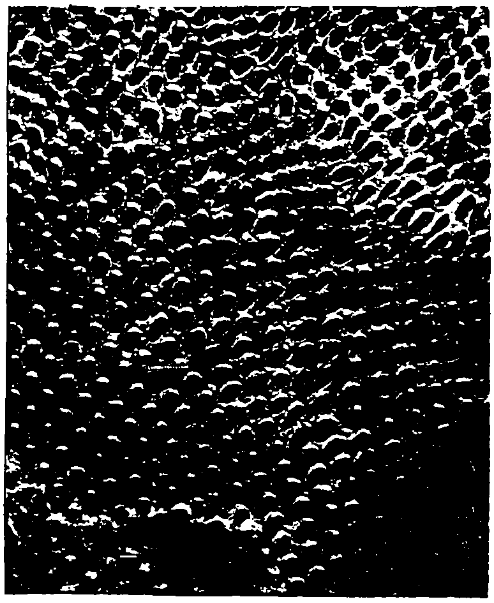

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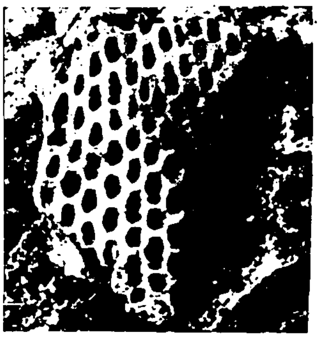

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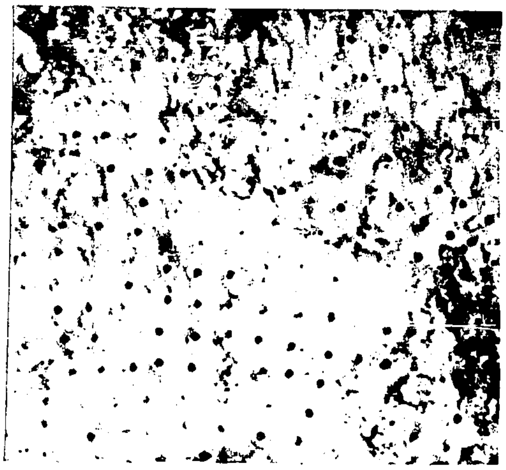

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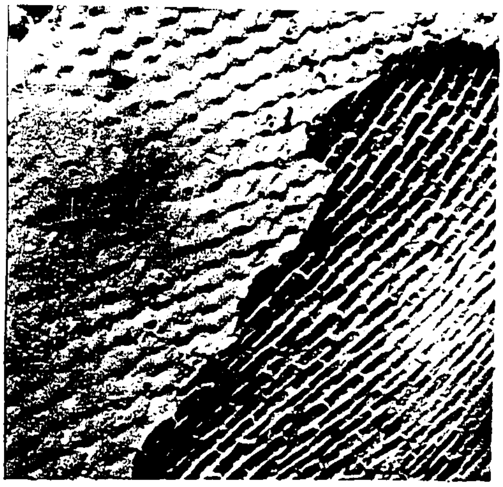

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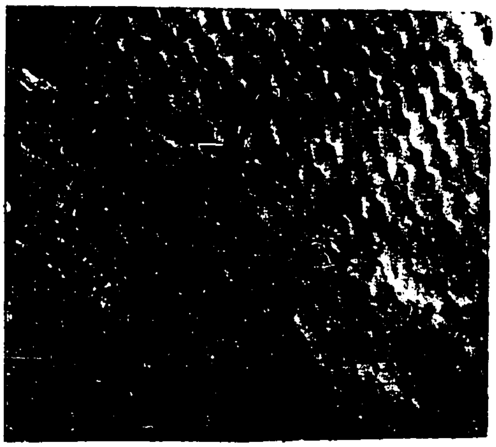

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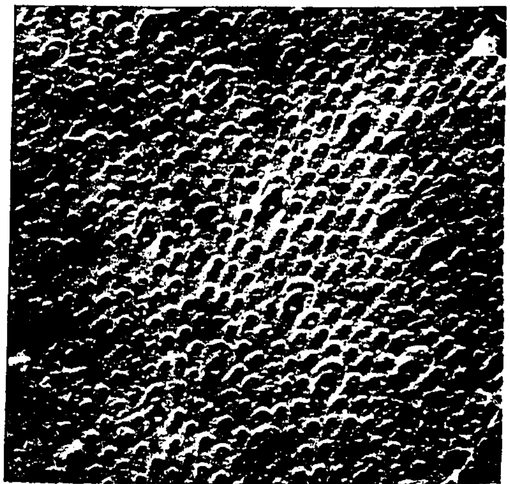

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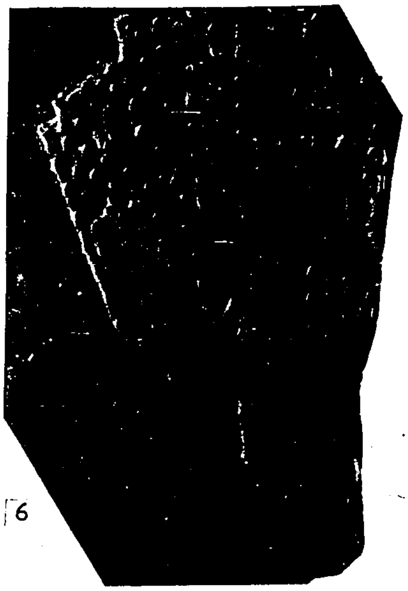

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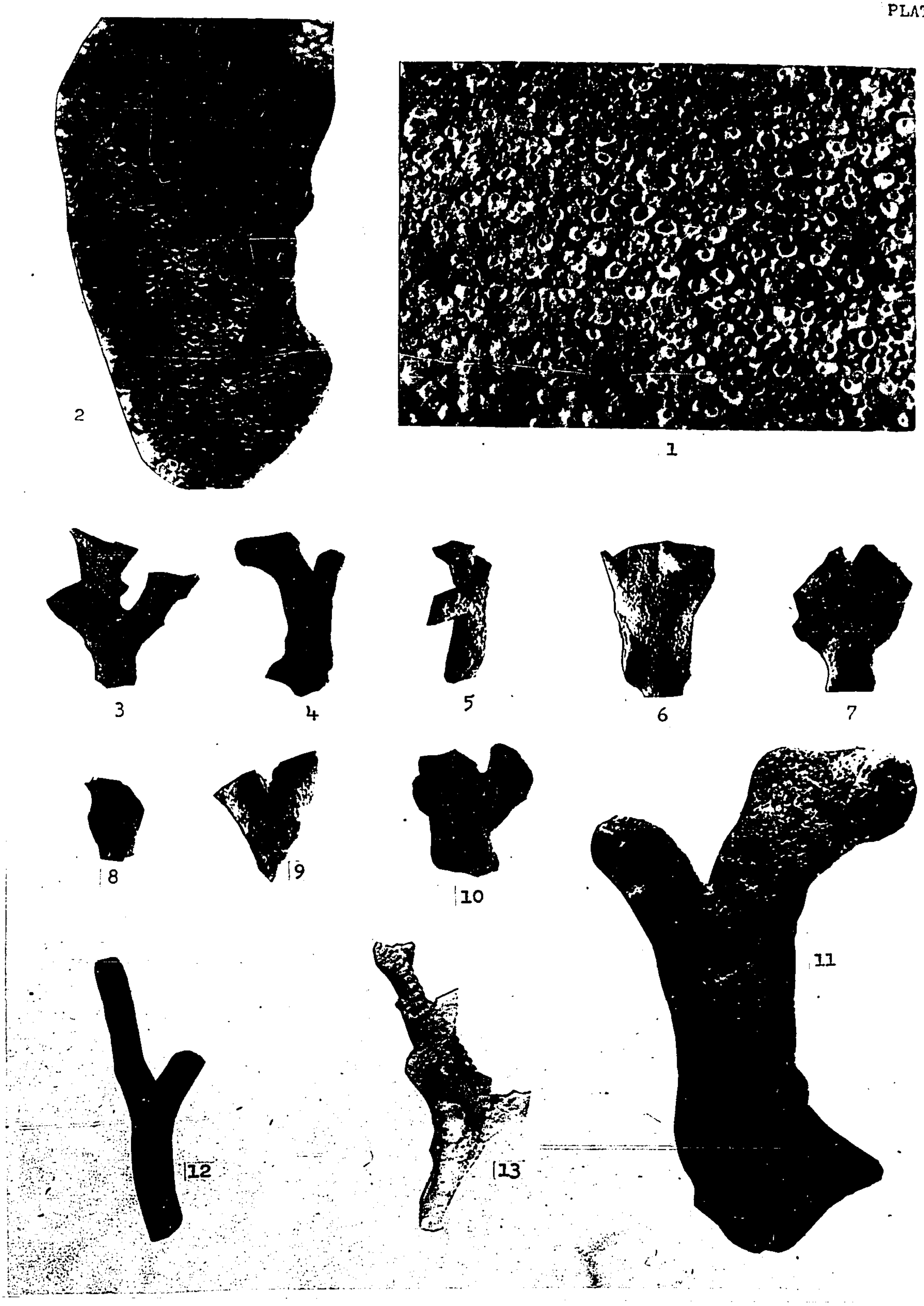

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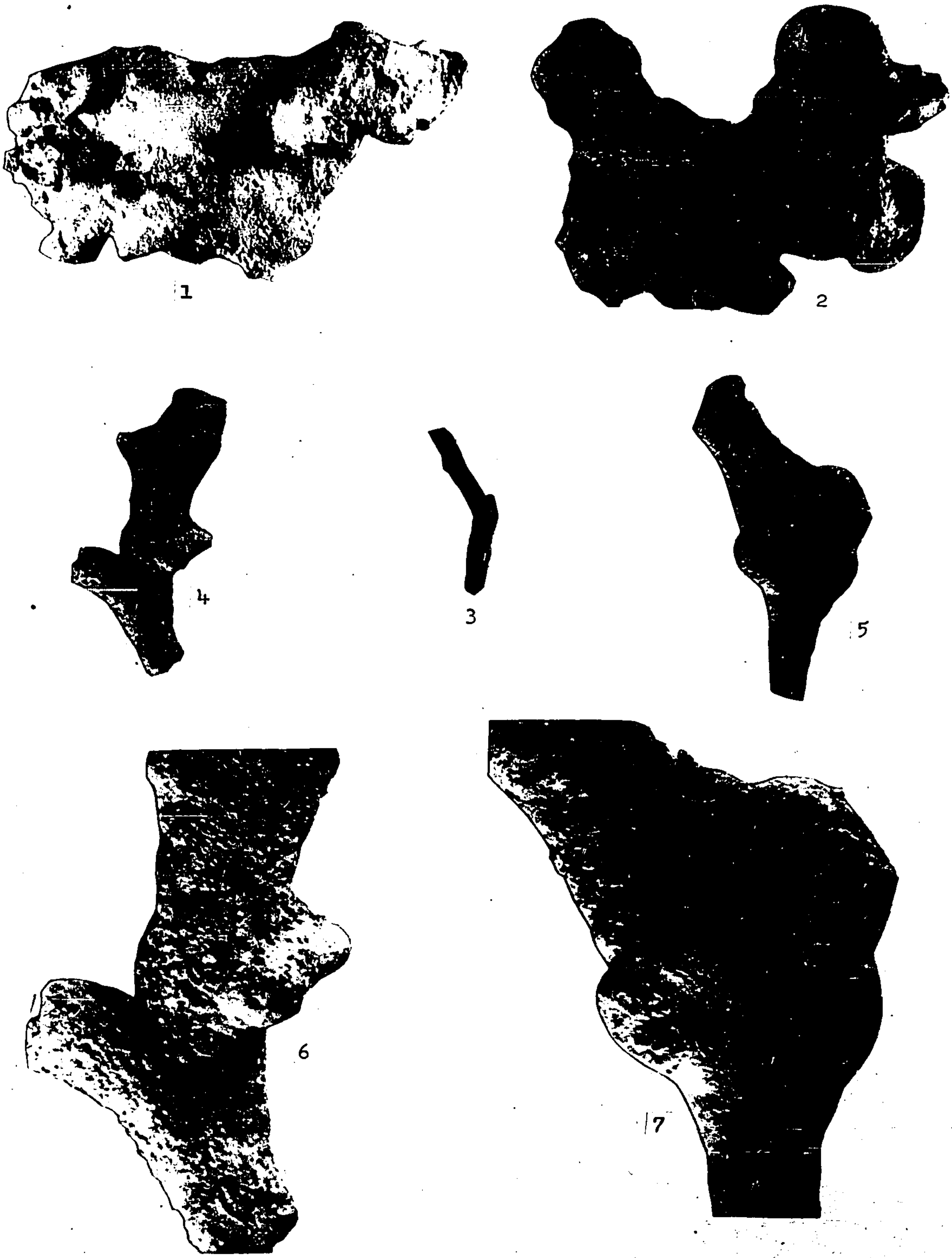

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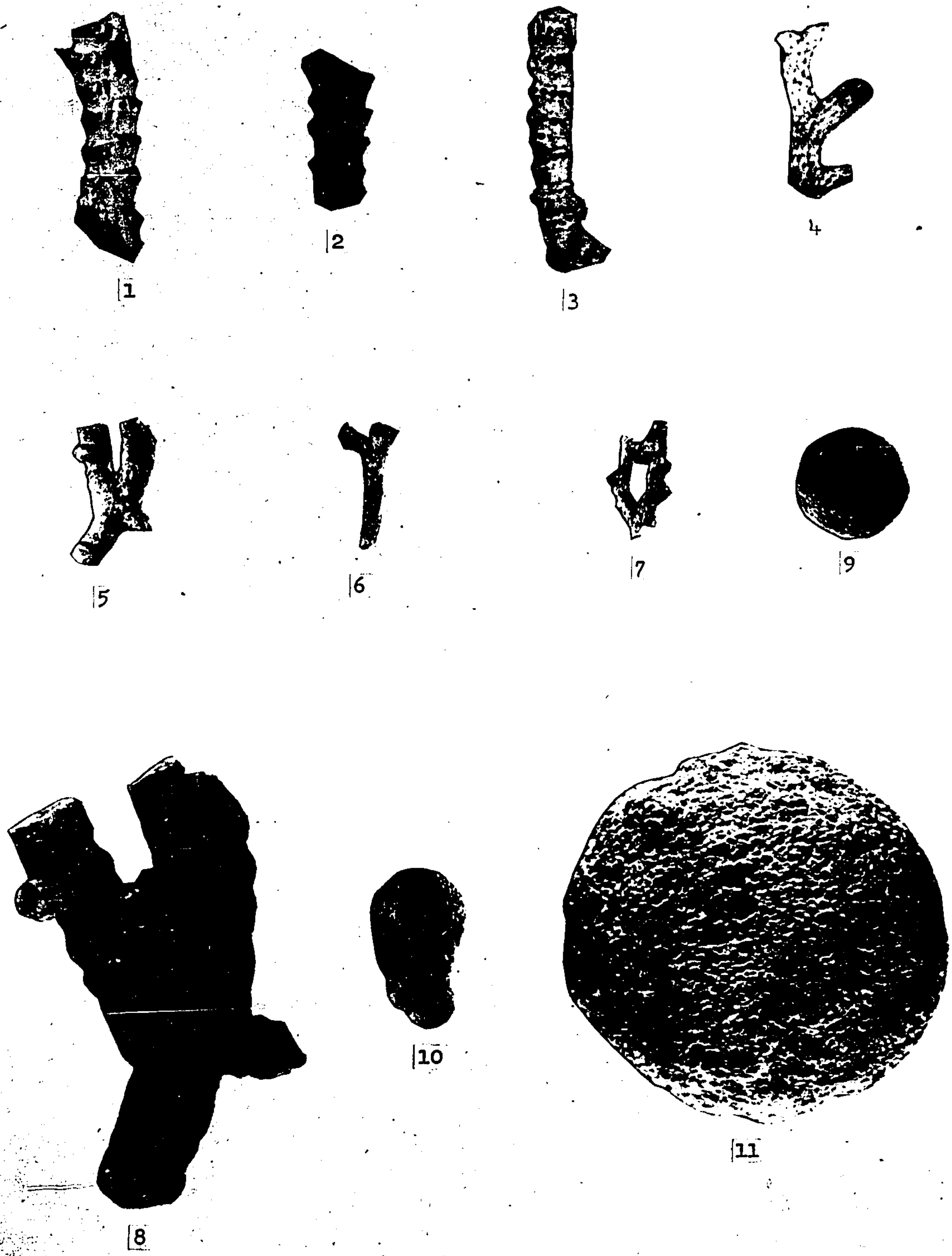

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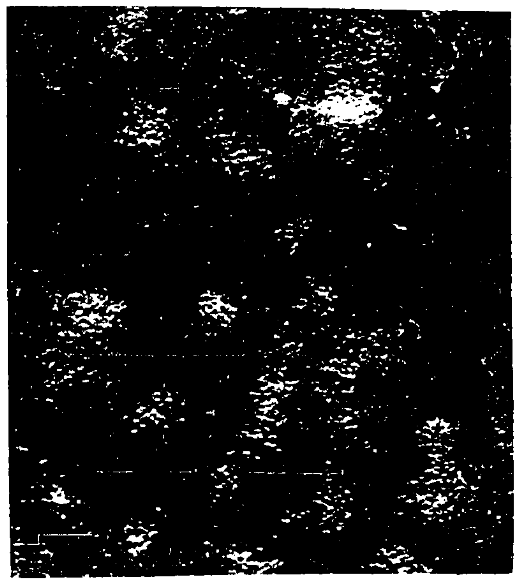

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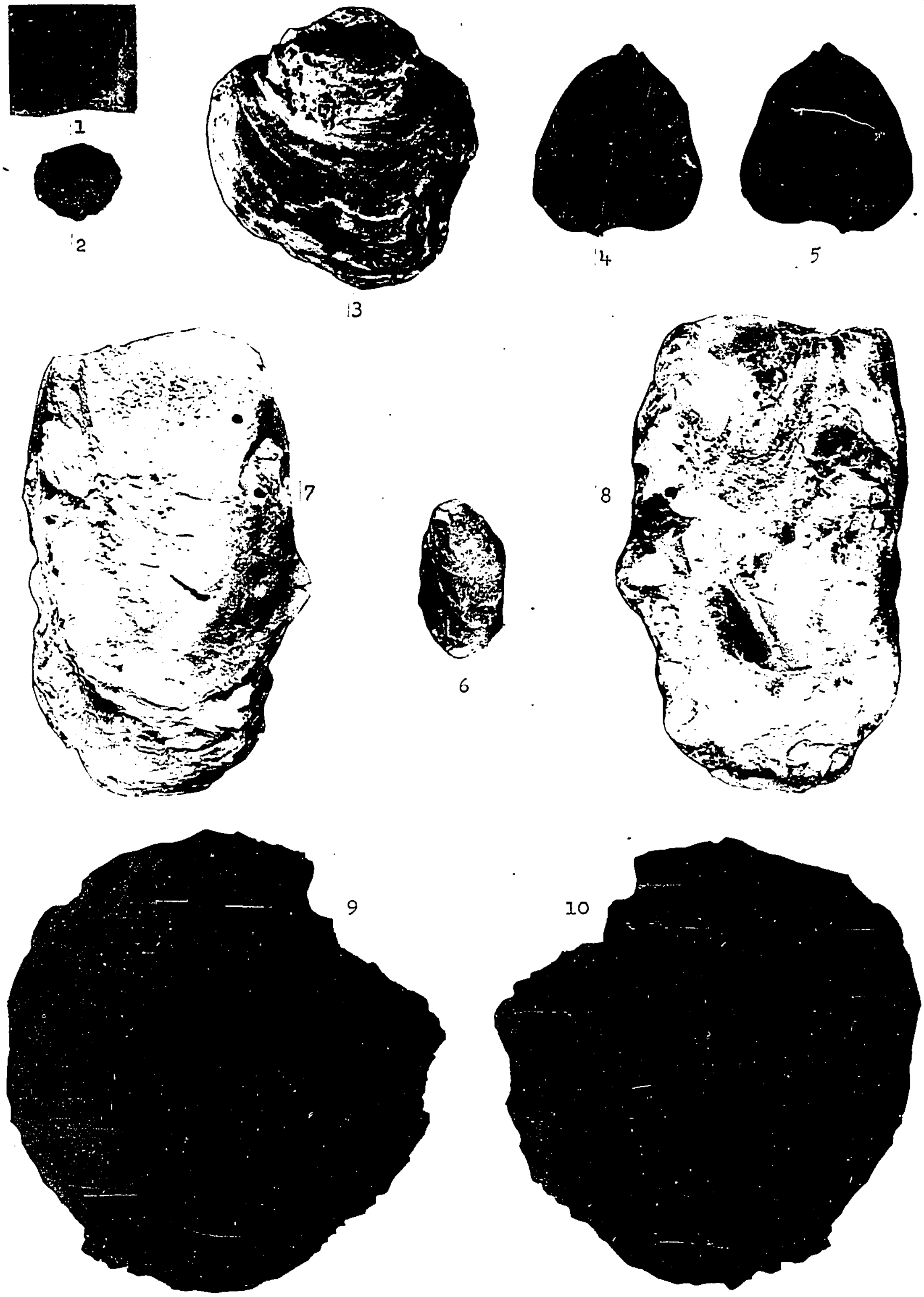

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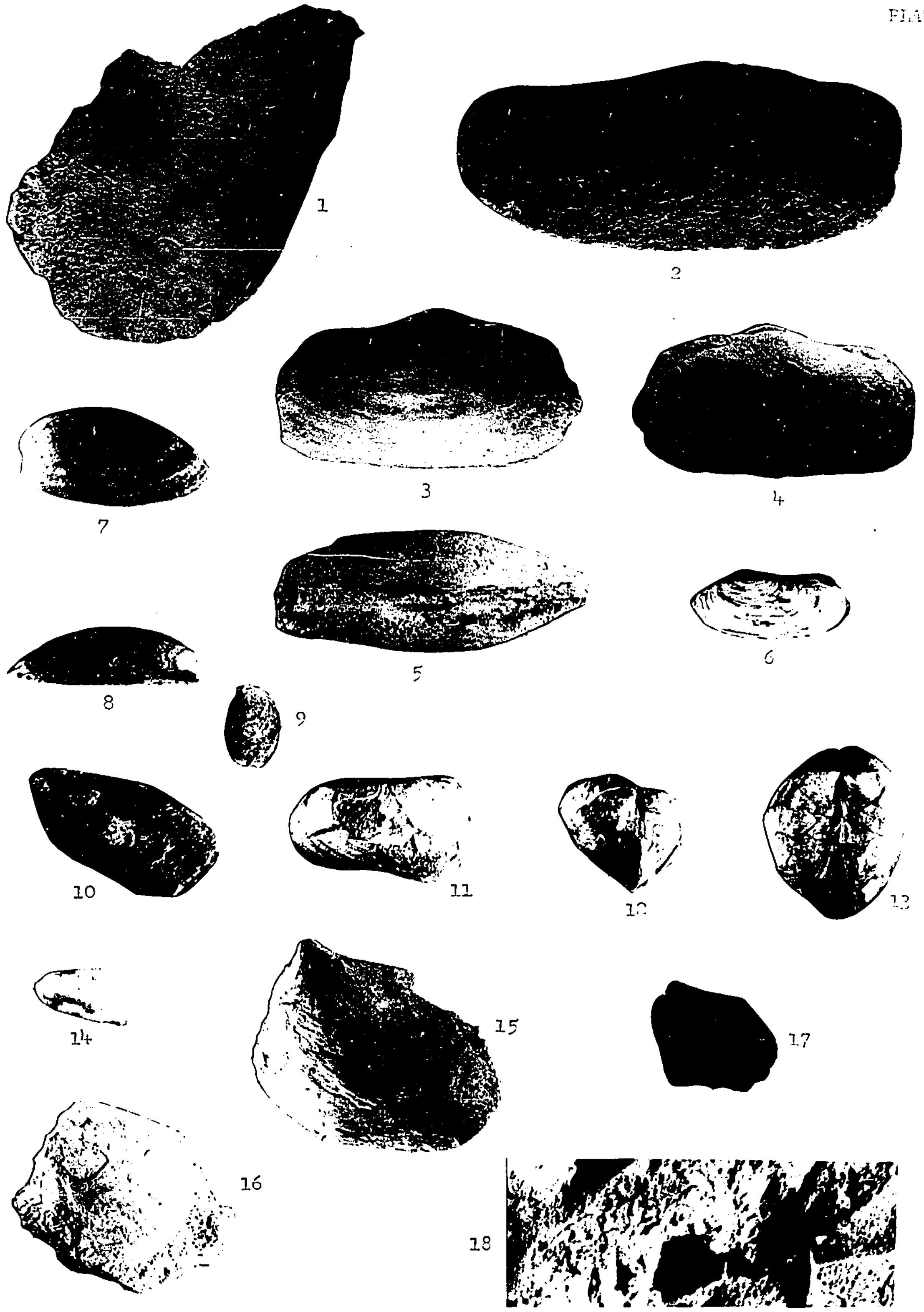

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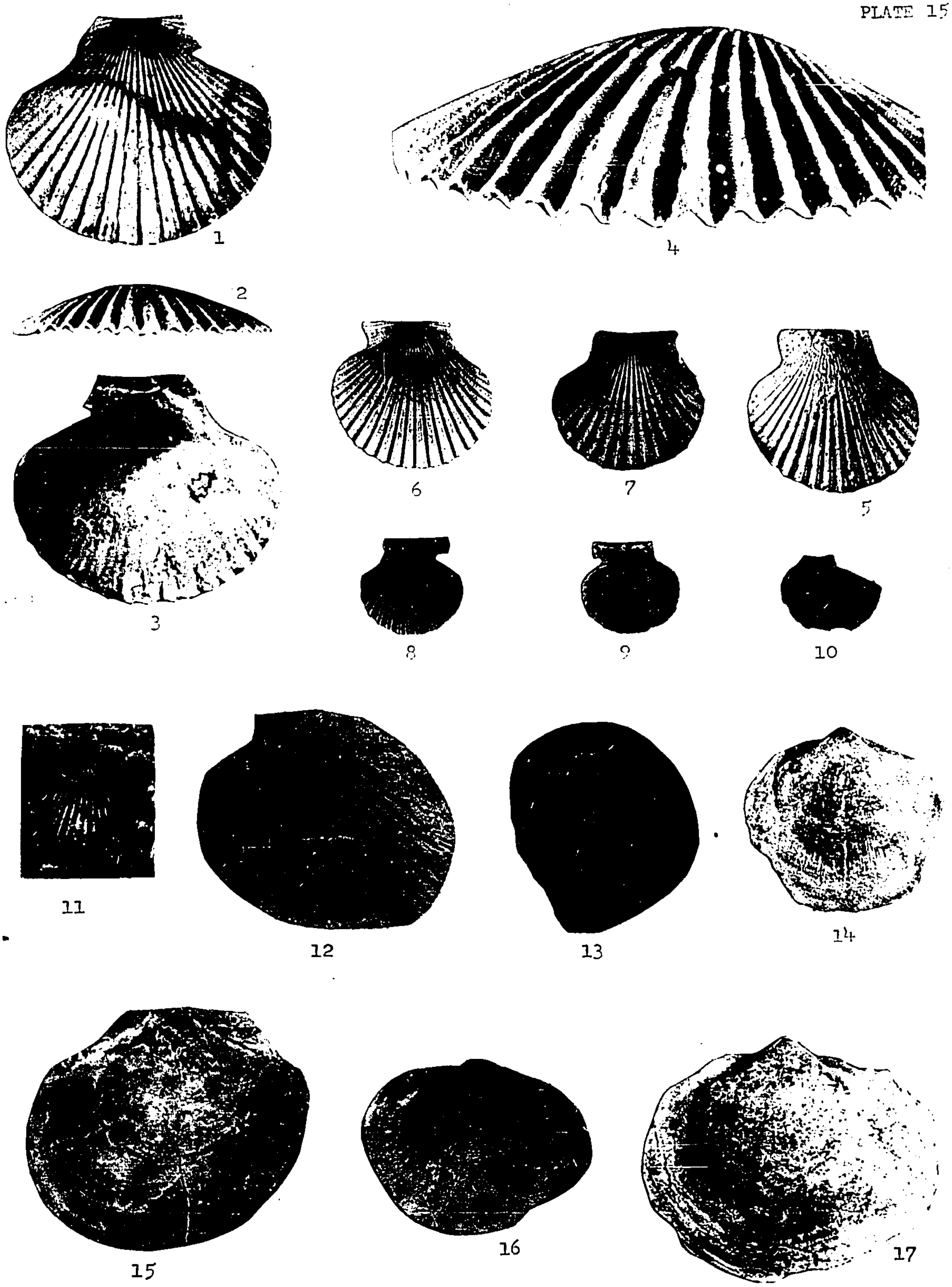

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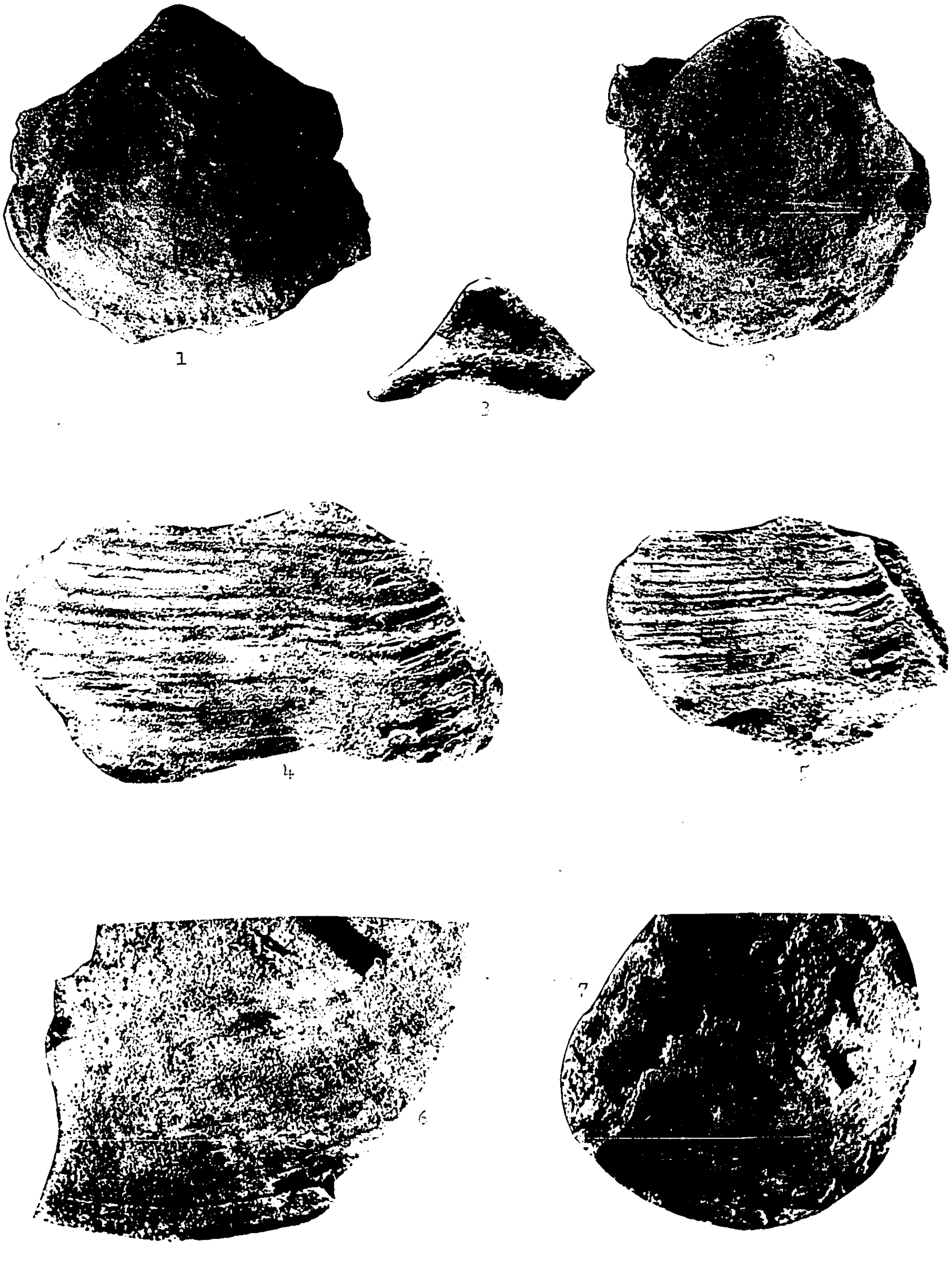
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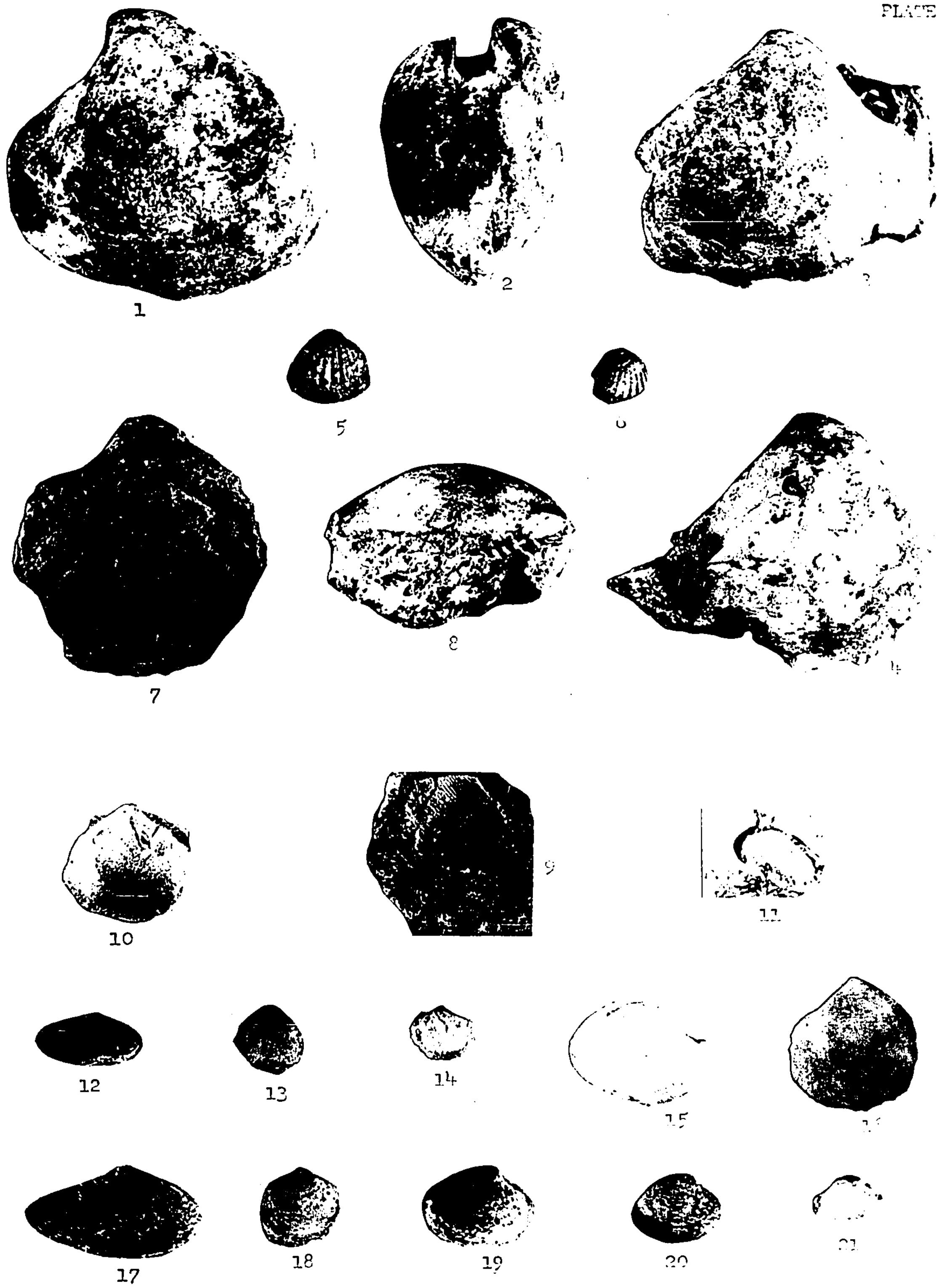

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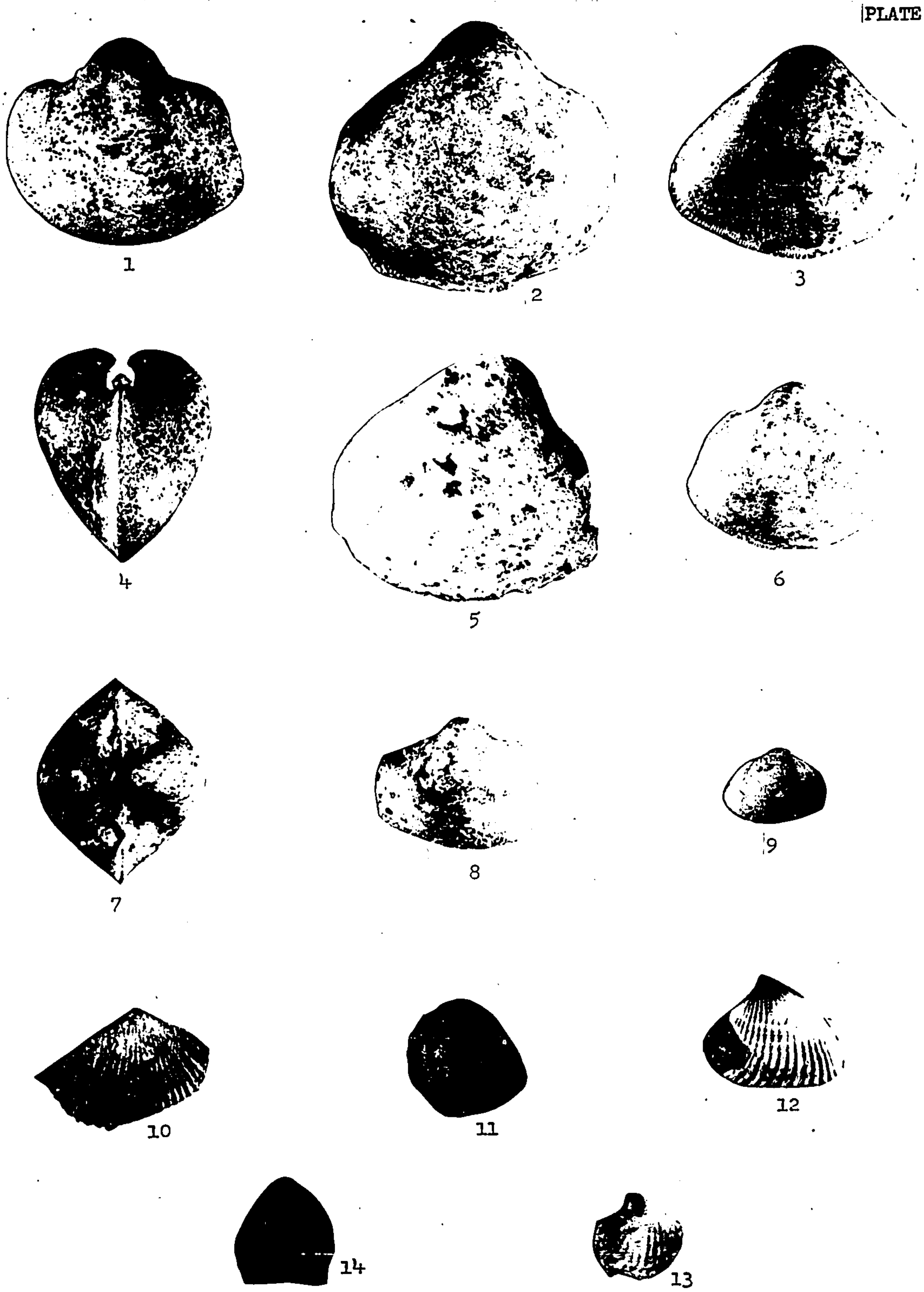

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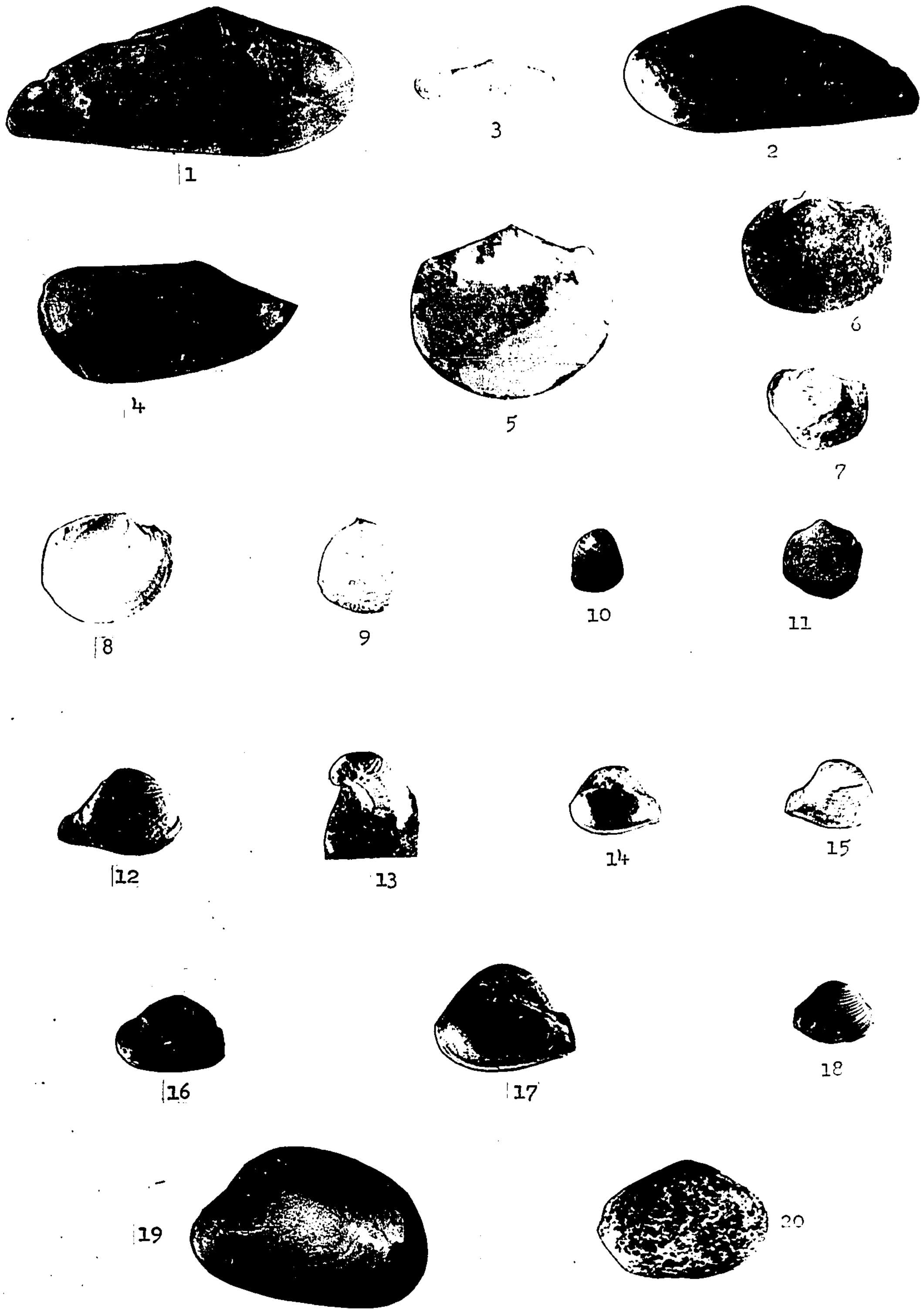

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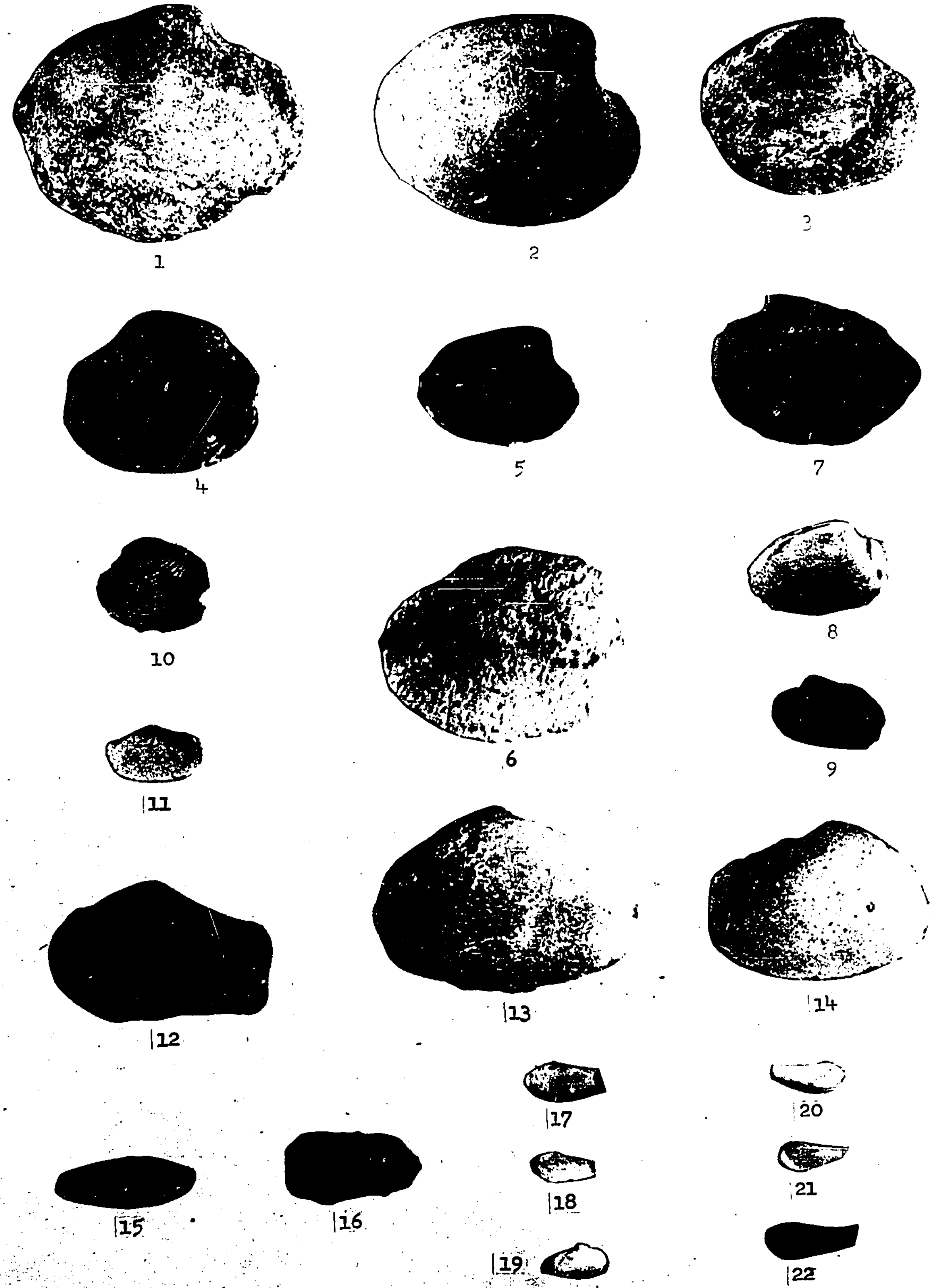

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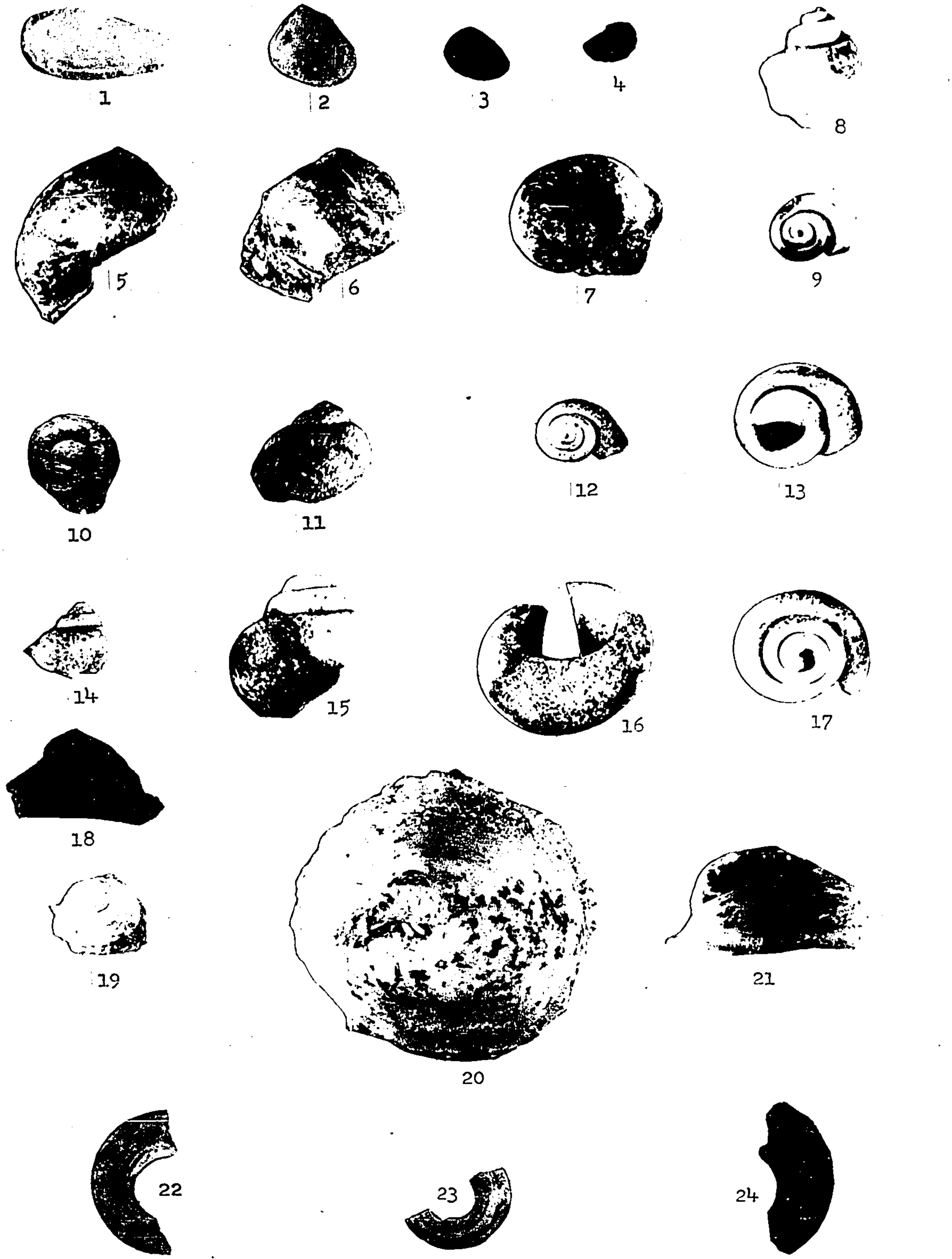

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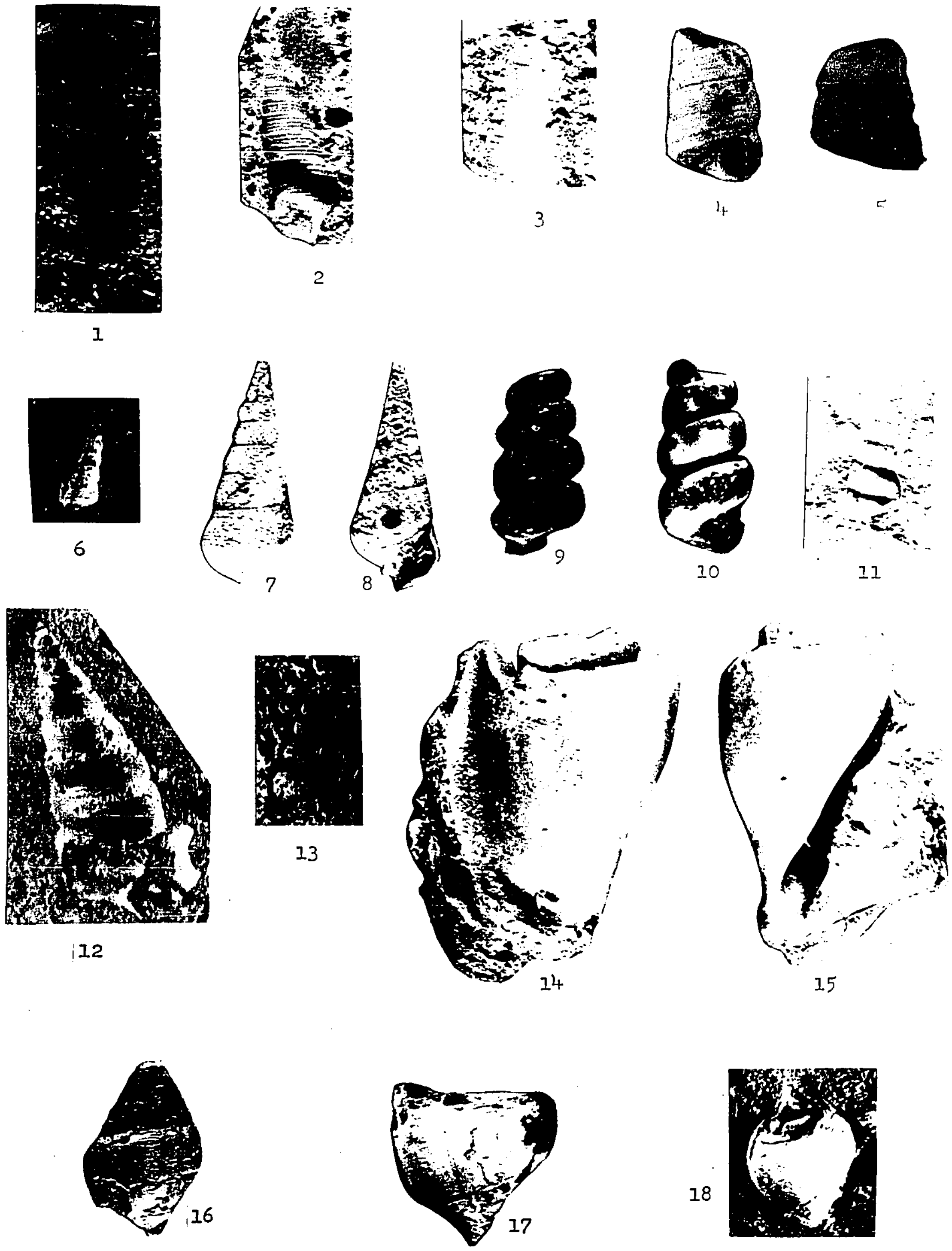
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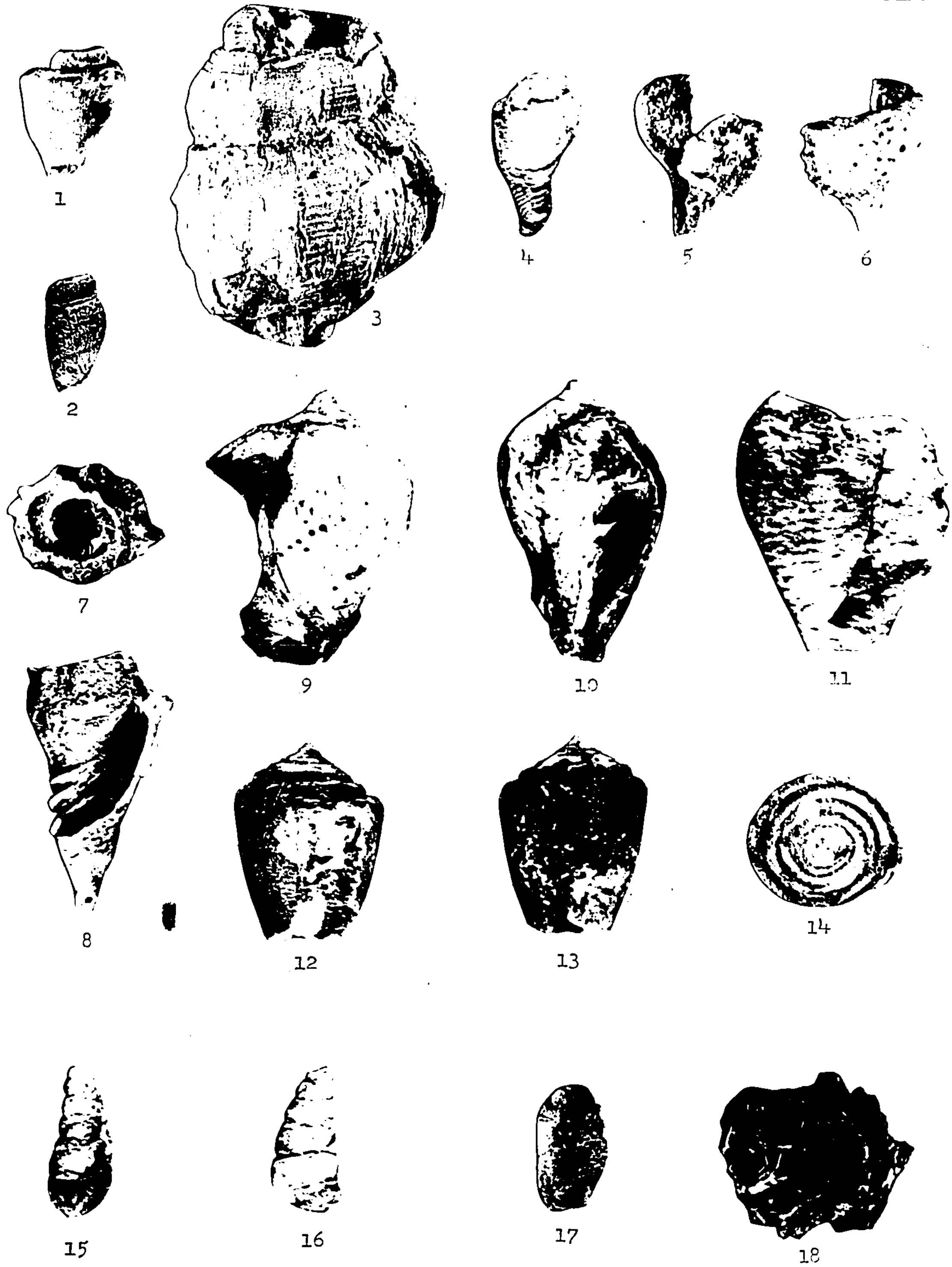

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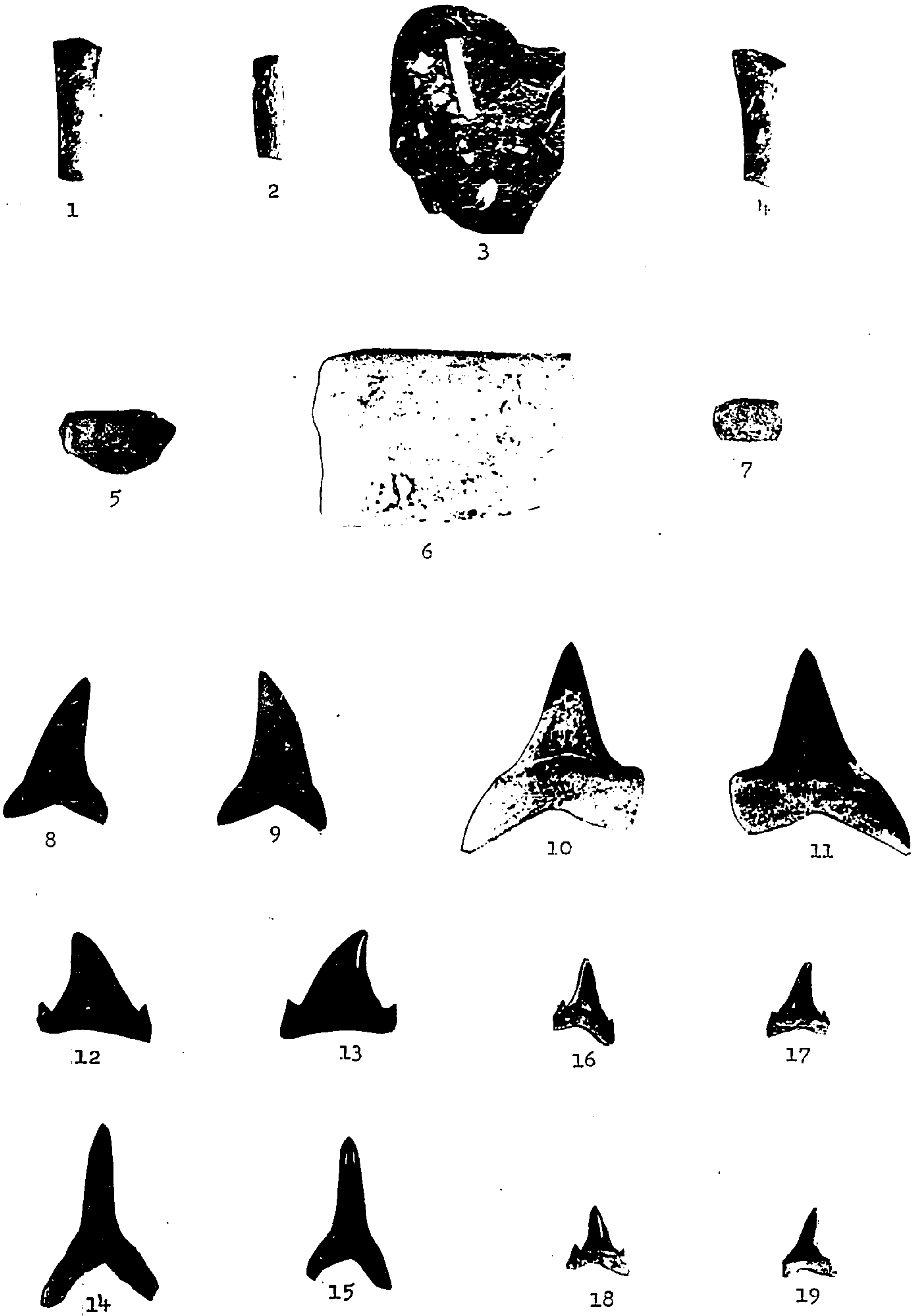

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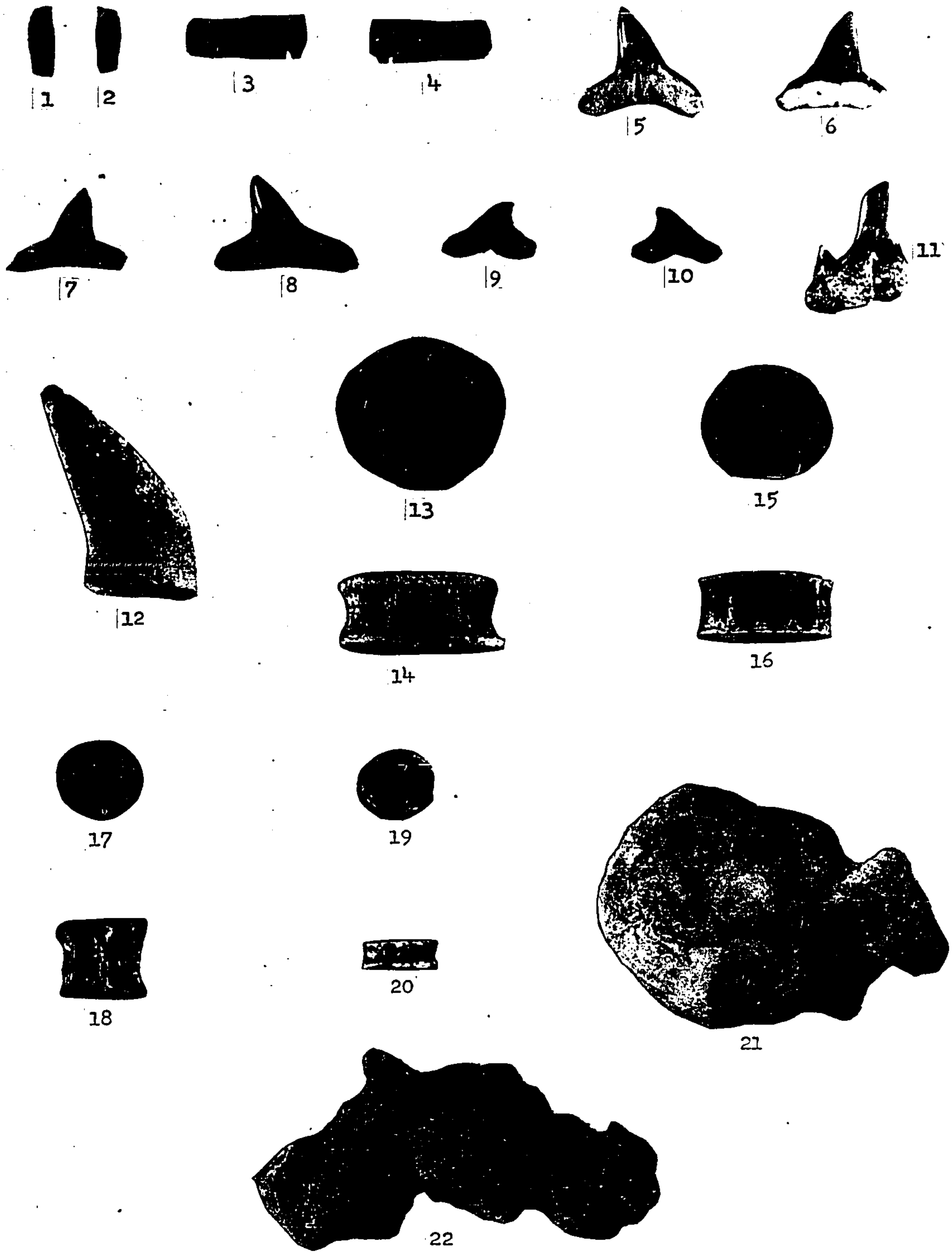

CHAPTER IX

ECONOMIC GEOLOGY

Several of the stratigraphic units within the Jackson Group of Georgia have been exploited for commercially valuable mineral resources. The Ocala and its lower member have yielded a high calcium limestone suitable for the manufacture of Portland cement; the Twiggs clay member is quarried for its fuller's earth content; and the Irwinton sand member is a notable aquifer in east-central Georgia.

Ocala limestone

Where it has not been silicified, the relatively pure Ocala limestone has been extensively quarried for the manufacture of Portland cement. This is especially true of the Tivola member, which is a soft, crumbly rock averaging from 85 to 90 percent calcium carbonate. The Penn-Dixie Cement Company, Clinchfield, Houston County, the largest producer of Portland cement in Georgia, requires approximately 77 percent calcium carbonate in the raw mixture of limestone before the process of cement-making begins. At Clinchfield, the aggregate of raw materials used in the manufacture of this product includes limestone, fuller's earth, iron slag, and sand.

The limestone, fuller's earth, and sand are all mined locally in one of the thickest Jackson exposures in the State. The kaolin is derived from a thick section of the Tuscaloosa formation at Kathleen, 9 miles north of Clinchfield, and the slag iron is shipped from Copper Hill, Tennessee.

These five components are mixed with approximately 40 percent water, and ground to a fineness which will permit passing through a 200 mesh sieve in tube mills. The resultant slurry is fed into rotary kilns 175 feet long and 10 feet in diameter. These rotary kilns are inclined at one-half inch per foot, and are lined with fire brick. They rotate approximately 25 times per hour.

As the slurry is fed into the high end of the kiln, pulverized coal is fired into the lower end, and the slurry is burned into what is termed a cement clinker. The temperature attained at the discharge end of the kilns is 2800° F.

The major compounds formed during this burning process are tri-calcium silicate, di-calcium silicate, tri-calcium aluminate, and tetra-calcium aluminum ferrite. The clinker is next mixed with approximately 4 percent gypsum and ground to cement in tube mills. Approximately 140 pounds of coal are required to burn one barrel (365 pounds) of clinker. The Penn-Dixie Cement Company produces and ships approximately 3,000,000 barrels of Portland cement per year.

Limestone from the Tivola member of the Ocala limestone is quarried by a few processors for use as road material. The Georgia Lime Rock Company, Dry Branch, Georgia, derives its raw material from the thick Upper Jackson exposure in the northwestern corner of Twiggs County, approximately 3 miles east of Dry Branch, Bibb County. Here the material is a high calcium stone with little impurity, analyzing from 92 to 97 percent calcium carbonate.

As a road base the material has a natural cementing value. It is crushed from 3½ inches to dust, and is laid in thicknesses of 11 to 8 inches and rolled and compacted to thicknesses of 6 to 8 inches. When the material is rolled and thoroughly wet, it sets up a bond and becomes quite hard. After the road has been shaped for smoothness, a topping of asphalt is applied. The material will not stand long exposure to weather, but makes an excellent road when properly topped.

When used for agriculture purposes, the limestone is ground to a fineness which will permit passing through a 20 mesh sieve, and is usually applied by truck spreaders.

At Armena, Lee County, the Ocala limestone was formerly quarried for use as a soil additive. The rock here consists of approximately 55 percent CaO, and contains less than 3% impurities. Average analysis approximates 97 percent calcium carbonate.

Other than its use as a soil additive, the Ocala was mined at Armena for rock aggregate in cement, and in concrete blocks. It has also been used as chicken grit, paint filler, road base, for correcting acidity in the manufacture of certain chemicals, and in the processing of pulp wood for the manufacture of paper.

The processing at Armena involved the crushing of the material into various sizes to meet certain specifications in the use of rock aggregate, and processing the fine particles through a dryer to remove the moisture, then crushing to a minus 69 mesh for use as a fertilizer filler, and soil conditioner.

Twiggs clay member

The Twiggs clay member of the Barnwell formation is noted for its extensive fuller's earth deposits which are mined chiefly in Twiggs County.

Fuller's earth, derived from the Twiggs clay member, is a green, hackly, blocky, locally calcareous, clay, so named because of its use by fullers to remove or full grease from cloth. Its absorptive powers are high, and it is widely used as a filter. It is used also to decolor fats, oils, and greases. According to the U. S. Bureau of Mines (Minerals Yearbook, 1951), the highest quality fuller's earth type clays are found essentially in the southeastern United States. These clays possess certain natural bleaching powers and no further activating is necessary.

Bleaching clays are included in two main categories, those that are naturally active and those which require artificial activation through acid treatment. The majority of bleaching clays are non-plastic, but the Twiggs clay, where it has been observed during the present investigation, is quite plastic when damp. Fuller's earth is characteristically high in water content, has a foliated structure, and adheres to the tongue when dry. The origin of its decolorizing quality has not been determined definitely. A possible replacement of a base by the hydrogen of water on the mineral surface, resulting in an open bond, would be necessary to create an active absorbing surface. On the other hand, the union of positive and negative charges in the acidoid particles with the basic colored ions in oil, might be the basis of the bleaching action in active clays (Bateman, 1950, pp. 768-770). Heating a clay to a high temperature to drive off the water content results in the loss of its absorptive powers. Used fuller's earth can be treated by heat and used again as many as twenty times.

Approximately 70 percent of the fuller's earth mined is used in the petroleum industry in refining, filtering, and clarifying petroleum products, principally lubricating oils. Approximately 1 percent is used in refining vegetable oils and animal fats. Its importance as a filter in domestic water purification is increasing, as well as its use in the removal of odors, putrescence, and coliform bacteria present in oil waste waters. In recent years, considerable fuller's earth has been used in the preparation of dusting powder for insecticides, and as a base for the manufacture of drilling mud for oil wells. A small proportion of the material is used in floorsweep preparations, abrasives, and for the detection of coloring agents in cosmetics and food products.

Fuller's earth is thought to have originated from the weathering of volcanic ash. The chief constituents are montmorillonite and attapulgite, montmorillonite being characteristic of bentonite. According to Bateman (1950, pp. 768-770), fuller's earth is derived from bentonite by natural leaching by surface waters, possibly assisted by plant acids and bacteria. Several occurrences of bentonite have been reported at the base of the fuller's earth deposits in Florida and Georgia, the fuller's earth having resulted from the leaching of grain surfaces in the bentonite. If fuller's earth is further weathered it may yield kaolin.

The presence of marine fossils in at least two localities in the Twiggs clay member suggests a sedimentary origin for the fuller's earth in central Georgia. These beds have all the characteristics of deposits forming today in shallow coastal embayments, wherein thrive many forms of invertebrate life, especially those with fragile shells, inferring a quiet lagoonal type of environment.

According to Petersen (1955, p. 16), attapulgite is a type of fuller's earth occurring in the Tampa limestone of lower Miocene age in Florida, and containing fresh water fossil remains. These deposits occur with montmorillonite in the Tampa. The upper 30 to 40 feet of the overlying Hawthorn formation (Miocene) contain attapulgite associated with dolomite. Petersen (1955, p. 16) cites a lacustrine environment as necessary for the accumulation of the attapulgite.

The fuller's earth of the Twiggs clay member is mined by the open pit method, wherein a power shovel or scraper is employed. It is dried to approximately 15 percent moisture, crushed, ground, and screened. If used in percolation processes, absorption granules are used. If used in contact, powder is agitated with the oil and later filtered off.

At present, there are three producers of fuller's earth in Georgia. The Diversey Corporation (formerly General Reduction Company), Macon, Bibb County, has installations at Pikes Peak, Twiggs County, producing from a thick exposure of the Twiggs clay member. The other two producers derive fuller's earth from stratigraphically younger beds in southern Georgia. The Attapulgus Clay Company, Attapulgus, Decatur County, and the Cairo Production Company, Grady County, derive raw materials from the Chipola formation of upper, lower Miocene age. Total production of fuller's earth from all sources in Georgia is approximately 145,000 tons per year.

Barnwell sands

The best source of ground water in most of the counties under discussion in this report is the thick sands and gravels of the Tuscaloosa formation. These beds are quite porous and are noted for the absence of readily soluble minerals. Discharge in the great majority of wells penetrating the Tuscaloosa averages about 600 gallons per minute. The quality of the water is high, ranging from 1 to 30 parts per million of bicarbonate, 1 to 10 parts per million of chloride, 0.1 part per million or less of fluoride, 1 to 17 parts per million of sulfate, and less than 6 parts per million of nitrate (LaMoreaux, 1946, p. 47).

In east-central Georgia, many domestic and industrial wells are drilled to shallower depths into the fine to coarse, unconsolidated sands of the Irwinton sand member of the Barnwell formation. Surface water percolating downward through the Irwinton is arrested by the impervious underlying Twiggs clay, causing the ground water to flow laterally through the Irwinton sand member, making it an excellent aquifer in this area. Although its discharge is not of great volume (2 to 300 gallons per minute), it yields a sufficient supply of water for domestic and stock use. In several areas in southern Washington County, and in Wilkinson and Twiggs counties, the larger volumes are sufficient to supply small industry and municipal demands.

The depth of the wells drilled into the Irwinton sand ranges from 50 to 130 feet, and analyses of the water reveal the aquifer to be low in dissolved solids, generally containing less than 30 parts per million of bicarbonate, 2 parts per million of sulfate, 6 parts per million of chloride, 0.1 part per million of fluoride, and 30 parts per million of total hardness (LaMoreaux, 1946, pp. 62-63).

The Upper Sand member, which overlies the Irwinton sand member in the southern and central parts of the area of Barnwell outcrop, is responsible for only a minor amount of ground water, because of its thinness and its advanced stage of weathering. Dug wells penetrating this aquifer are very shallow (the thickest part of the unit being only 20-25 feet). Volume of water ranges from 2 to 10 gallons per minute, and samples reveal 36 to 108 parts per million of total hardness, 51 to 136 parts per million of bicarbonate, with minor percentages of iron, sulfate, fluoride, nitrate, and chloride.

Wells in the Sandersville area, Washington County, have penetrated solution cavities in the Sandersville limestone member, yielding up to 150 gallons of water per minute, but the water is unsuitable for use without treatment, because of its hardness and dissolved solids content. Samples of the water from these calcareous strata range from 82 to 303 parts per million of bicarbonate, 29.5 parts per million of silica, 70 parts per million of calcium, 4.1 parts per million of sodium and potassium combined, 2 to 27 parts per million of sulfate, and hardness from 72 to 252 parts per million (LaMoreaux, 1946, p. 57).

In several places where the Twiggs clay member crops out in central and east-central Georgia, ground water issues from it as springs. This water percolates downward through the sands of the Barnwell (Upper Sand and Irwinton sand members), and flows laterally along the impervious upper portion of the Twiggs clay until it encounters an outcrop, where it discharges at the surface.

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Name	Location: Station 1	2	3	4	5	6	7	8	9	10	1
PROTOZOA											
Lepidocyclina georgiana? Cushman		X	X						X		
COELENTERATA											
Flabellum cuneiforme Lonsdale		X									
ECHINODERMATA											
Cassidulus (Paralampas) carolinensis (Twitchell)											
C. (Paralampas) globosus? Fischer											
C. ericsoni Fischer				X							
Eupatagus (Plagiobrissus) ocalanus? Cooke			X								
Macropneustes mortoni (Conrad)											
Periarchus sp.											
P. lyelli (Conrad)	X	X	X					X	X		
P. pileus-sinensis (Ravenel)	X	X	X						X		
P. quinquefarius? (Say)											
Peronella cubae Weisbord		X									
Phyllacanthus mortoni? (Conrad)											
Rumphia archerensis (Twitchell)		X									
Schizaster armiger Clark											
Echinoid spines (gen. & sp. indet.)										X	
WORMS											
Serpulorbis sp.											
Vermetina? sp.											
BRYOZOA											
Beisselina implicata Canu & Bassler											
B. trulla Canu & Bassler	X	X						X	X		
Filisparsa ingens Canu & Bassler		X									
Hincksina jacksonica Canu & Bassler		X	X						X		
Holoporella damicornis Canu & Bassler		X									
Hornera polyporoides Canu & Bassler									X		
Lunulites distans Lonsdale		X	X						X		
Membraniporidra porrecta Canu & Bassler			X								
M. spissimuralis Canu & Bassler									X		
Ochetosella robusta Canu & Bassler											
Perigastrella elegans Canu & Bassler											
Parleiosoecia jacksonica Canu & Bassler	X	X									
Rectonychocella semiluna Canu & Bassler	X							X			
Schismopora globosa Canu & Bassler	X	X	X								
Schizopodrella linea Lonsdale		X									
S. viminea Lonsdale	X		X					X	X		
Spiropora majuscula Canu & Bassler	X	X						X	X		
Steganoporella jacksonica Canu & Bassler	X		X						X		
Stomatopora cornu Canu & Bassler		X									
Tretonea levis Canu & Bassler	X	X						X	X		

X--known occurrence
Number refers to locality as listed in Registry

TABLE 11

FAUNAL DISTRIBUTION CHART

10	11	12	13	14	15	16	18	19	20	21	22	23	24	25	26	27	28	29	30
				X															
		X																	
		X																	
X																			
													X						
												X							
				X															
												X							

II

TION CHART

22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	4
											X	X		X	X	X		
										X				X				
									X	X								
																X		
									X	X								
												X						
									X	X								
									X									
									X									
		X																
	X																	
	X								X									
																X		
											X						X	

Location: Station

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ana? Cushman		X	X						X					X		
Lonsdale		X														
as) carolinensis (Twitchell)																
osus? Fischer												X				
				X								X				
ssus) ocalanus? Cooke			X													
(Conrad)																
	X	X	X					X	X							
Ravenel)	X	X	X						X							
ay)																
oord		X														
? (Conrad)																
Twitchell)		X														
ark																
& sp. indet.)										X						
Canu & Bassler														X		
ler	X	X						X	X							
u & Bassler		X														
Canu & Bassler		X	X						X							
s Canu & Bassler		X														
Canu & Bassler									X							
nsdale		X	X						X							
octa Canu & Bassler			X													
& Bassler									X							
anu & Bassler																
Canu & Bassler																
lica Canu & Bassler	X	X														
una Canu & Bassler	X							X								
anu & Bassler	X	X	X													
Lonsdale		X														
anu & Bassler	X		X					X	X							
nica Canu & Bassler	X	X						X	X							
nu & Bassler	X		X						X							
Bassler		X														
	X	X						X	X							

lity as listed in Registry

TABLE II

FAUNAL DISTRIBUTION CHART

5	16	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
																	X	X	
																X			
															X	X			
															X	X			
																		X	
															X	X			
															X				
															X				
								X											
							X												
							X								X				
																	X		

31	32	33	34	35	36	37	38	39	40	41	42	43	44
		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				X	

Name	Location: Station 1	2	3	4	5	6	7	8	9
MOLLUSCA (Pelecypoda)									
Amusium ocalanum Dall		X	X		X				
Arca sp. cf. A. rhomboidella Lea									
Astarte triangulata Meyer					X		X		
A. triangulatoides Harris			X						
Atrina jacksoniana Dall		X							
Cardium sp.				X					
Chlamys spillmani (Gabb)		X	X	X				X	X
C. spillmani var. clinchfieldensis Harris	X	X						X	X
Crassatella eutawacolens (Harris)			X					X	
C. flexura Conrad						X			
Crassatellites protextus Conrad									
Corbula waileslana Harris					X	X	X		
Diplodonta ungulina var. yazoocola Harris						X			
Fimbria olssoni Richards									
Gari jacksonense Harris						X	X		
Gastrochaena mississippiensis Harris	X	X	X						
Glycymeris sp. cf. G. anteparilis Kellum	X				X				
G. arctatus var. cookei Dall									
G. idonea (Conrad)				X					
G. tivolensis n. sp.			X		X				
Gryphaeostrea vomer (Morton)									
G. vomer var. plicatella (Morton)					X				
Here sp. cf. H. wacissana (Dall)									
Lima vicksburgiana? Dall									
Lirodiscus jacksonensis (Meyer)			X						X
Lucina (Myrtea?) curta (Conrad)							X		
L. (Plastomiltha) gaufia Harris						X	X		
L. (Eophysema) ozarkana? Harris							X		
Macrocallista annexa (Conrad)			X	X			X		
Meretrix ovata var. pyga Conrad				X					
Miltha ocalana Dall	X							X	
Modiolus texanus Gabb							X		
Nucula spheniopsis Conrad						X	X		
Nuculana albirupina (Harris)						X	X		
Nuculana sp.									
Ostrea georgiana Conrad	X	X			X				
O. trigonalis Conrad		X	X		X			X	
Ostrea sp.		X							
Panope elongata (Conrad)	X		X		X		X		
Panope? sp.									
Pecten choctavensis Aldrich					X				
P. perplanus Morton	X	X	X					X	X
P. pulchricosta Aldrich and Meyer									
P. wautubbeanus Dall	X				X			X	
Pholadomya sp. cf. P. claibornensis Aldrich						X			
Pinna quadrata? Dall									
Pitar sp. cf. P. cornelli Harris			X						X
P. sp. cf. P. nuttalli Conrad	X				X				
P. securiformis (Conrad)									
P. trigoniata (Lea)	X								

X--known occurrence
Number refers to locality as listed in Registry

TABLE II

2

8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	2
					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														
X																			
	X																		

25	26	27	28	29	30	31	32	33	34	35	36	37	3
						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				
										X	X		
						X	X	X			X		

	Location: Station																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
oda)																				
Dall		X	X		X								X	X						
homboidella Lea																				
ta Meyer					X		X													
s Harris			X																	
a Dall		X																		
				X																
(Gabb)		X	X	X				X	X											
clinchfieldensis Harris	X	X						X	X											
acolens (Harris)			X					X												
						X														
otextus Conrad										X										
a Harris					X	X	X													
na var. yazoocola Harris.						X														
ichards																				
Harris						X	X													
issippiensis Harris	X	X	X									X								
. G. anteparilis Kellum	X				X							X		X						
cookei Dall												X		X						
				X																
sp.			X		X															
er (Morton)																				
catella (Morton)					X															
acissana (Dall)												X								
a? Dall																				
ensis (Meyer)			X						X											
curta (Conrad)							X													
gaufia Harris						X	X													
rkana? Harris							X													
xa (Conrad)			X	X			X					X								
. pyga Conrad				X										X						
ll	X							X												
abb							X													
Conrad						X	X													
a (Harris)						X	X													
onrad	X	X			X															
ad		X	X		X			X												
		X								X										
nrad)	X		X		X		X													
s Aldrich					X															
n	X	X	X					X	X			X	X							
drich and Meyer													X							
ll	X				X			X												
P. claibornensis Aldrich						X														
ll																				
ornelli Harris			X						X											
ali Conrad	X				X															
onrad)																				
)	X																			

e
locality as listed in Registry

TABLE II

2

8	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
													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	X			X	

33	34	35	36	37	38	39	40	41	42	43	44	45
	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							
X			X		X		X					
					X							

Name	Location: Station 1	2	3	4	5	6	7	8	9	10	11	12	13
MOLLUSCA (Pelecypoda cont'd)													
Plicatula filamentosa Conrad													
Protocardia (Nemocardium) nicolletti (Conrad)	X	X	X		X		X	X	X				
Pteria limula var. *vanwinkleae* Harris			X		X								
Spisula praetenuis Conrad		X			X	X			X				X
Spondylus hollisteri? Harris		X											
Tellina perovata n. sp.		X	X					X	X				X
Tellina vaughani Cooke						X							
Venericardia (Venericor) apodensata Gardner & Bowles						X							
V. (Venericor) densata Conrad							X						
V. (Venericor) sp. cf. V. nodifera Kellum												X	
V. (Venericor) planicosta Lamarck												X	
V. (Venericor) planicosta var. *ocalaedes* Harris	X												
Venericardia sp.					X					X			
"Venus" jacksonensis Meyer		X	X		X				X			X	
Yoldia psammotaea? var. *rubamnis* Harris						X							
Yoldia sp.						X							
MOLLUSCA (Gastropoda)													
Agonaria mississippiensis (Conrad)						X							
Acteon? idoneus? Conrad		X											
Architectonica (Stellaxis) alveata (Conrad)						X							
Athleta petrosa (Conrad)										X			
Bittium koeneni Meyer										X			
Buccitriton jacksonensis (Cooke)						X							
Calyptraea aperta (Solander)	X	X			X		X						
Caricella subangulata Conrad										X			
Conus (Lithoconus) sauridens (Conrad)												X	
Cornulina louisianae Palmer						X							
Levifusus fulguriparens Maury						X	X						
Levifusus? sp.												X	
Mesalia georgiana Bowles													
Pseudocrommium brucei Palmer		X			X					X			X
Pseudoliva vetusta var. *perspectiva* Conrad							X						
Sinum danvillense Palmer												X	
Strombus sp.													
Turritella arenicola (Conrad)			X			X				X		X	X
T. clevelandia Harris						X							
Turritella sp.		X			X		X			X			
Voluticella levensis Palmer													
MOLLUSCA (Scaphopoda)													
Dentalium sp.						X							
ARTHROPODA (Crustacea)													
Callianassa inglisestris Roberts			X									X	
CHORDATA (Chondrichthyes)													
Aetobatis irregularis Agassiz	X					X		X					

X--known occurrence
Number refers to locality as listed in Registry

TABLE II

3

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
																					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																				

3	24	25	26	27	28	29	30	31	32	33	34	35	36	37	3
								X	X				X		
													X	X	
													X	X	
													X		
											X				
											X		X		
														X	
											X				
											X		X		
											X				
	X										X		X		

Location: Station

(cont'd)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Conrad														
ium) nicolletti (Conrad)	X	X	X		X		X	X	X					
nwinkleae Harris			X		X									
nrad		X			X	X			X				X	
Harris		X												
p.		X	X					X	X				X	
e						X								
or) apodensata Gardner & Bowles						X								
a Conrad							X							
V. nodifera Kellum												X		
sta Lamarck												X		
sta var. ocalaedes Harris	X													
					X					X				X
eyer		X	X		X				X			X		X
. rubamnis Harris						X								
						X								
sis (Conrad)						X								
		X												
xis) alveata (Conrad)						X								
d)										X				
										X				
is (Cooke)						X								
ander)	X	X			X		X							
Conrad										X				
ridens (Conrad)												X		
Palmer						X								
Maury						X	X							
												X		
s														
Palmer		X			X					X			X	
perspectiva Conrad							X							
er												X		
onrad)			X			X				X		X	X	
						X								
		X			X		X			X				
lmer														
						X								
s Roberts			X									X		
es)														
gassiz	X					X		X						

y as listed in Registry

TABLE II

3

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
																	X	X		
X																				X
X																				X
																				X
								X												
																				X
																				X
									X											X

7	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
				X	X				X			X	X				
									X	X							
									X	X							
									X								
							X										
							X		X		X						
										X							
							X										
							X		X								
							X										
							X		X			X					

Name	1	2	3	4	5	6	7
CHORDATA (Chondrichthyes cont'd)							
Galeocerdo alabamensis Leriche	X						
Lamna obliqua Agassiz							
Myliobatis sp.	X						
Odontaspis macrota Agassiz	X				X		
Odontaspis sp.	X						
Oxyrhina hastalis Agassiz	X						
O. nova Winkler							
O. praecursor var. *americanus* Leriche	X						
Sphyrna gilmorei Leriche	.X				X		
CHORDATA (Osteichthyes)							
Pristis? aquitanicus? Delfortrie	X						
Fish vertebrae (gen. & sp. indet.)	X						
Coprolites?							

X--known occurrence
Number refers to locality as listed in Registry

TA

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
			X														
			X														
X			X														
			X														
			X														
			X														
X			X	X													

TABLE II

4

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35

29	30	31	32	33	34	35	36	37	38	39	40	41
						X					

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
(Chondrichthyes cont'd)																	
) alabamensis Leriche	X							X									
qua Agassiz								X									
sp.	X																
macrota Agassiz	X				X			X									
sp.	X																
astalis Agassiz	X							X									
nkler								X									
sor var. americanus Leriche	X							X									
lmorei Leriche	.X				X			X	X								
(Osteichthyes)																	
quitanicus? Delfortrie	X																
brae (gen. & sp. indet.)	X																
?																	

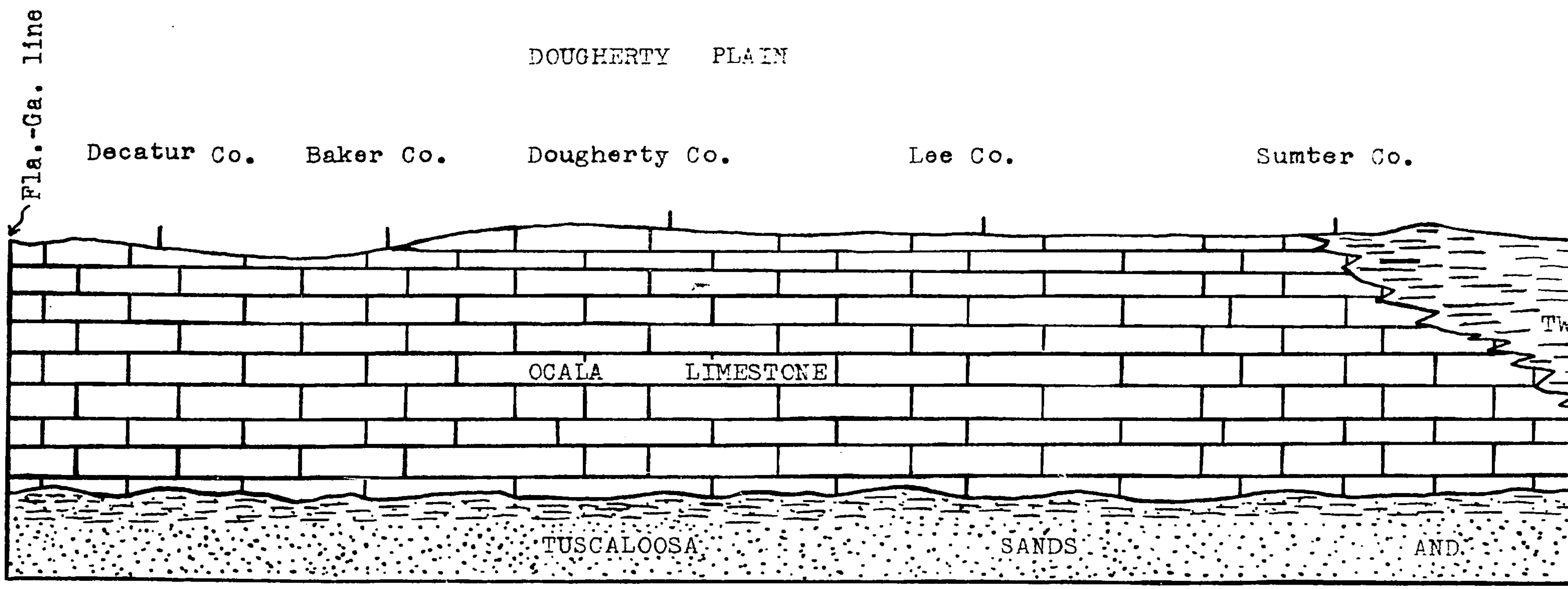
ccurrence
ers to locality as listed in Registry

TABLE II

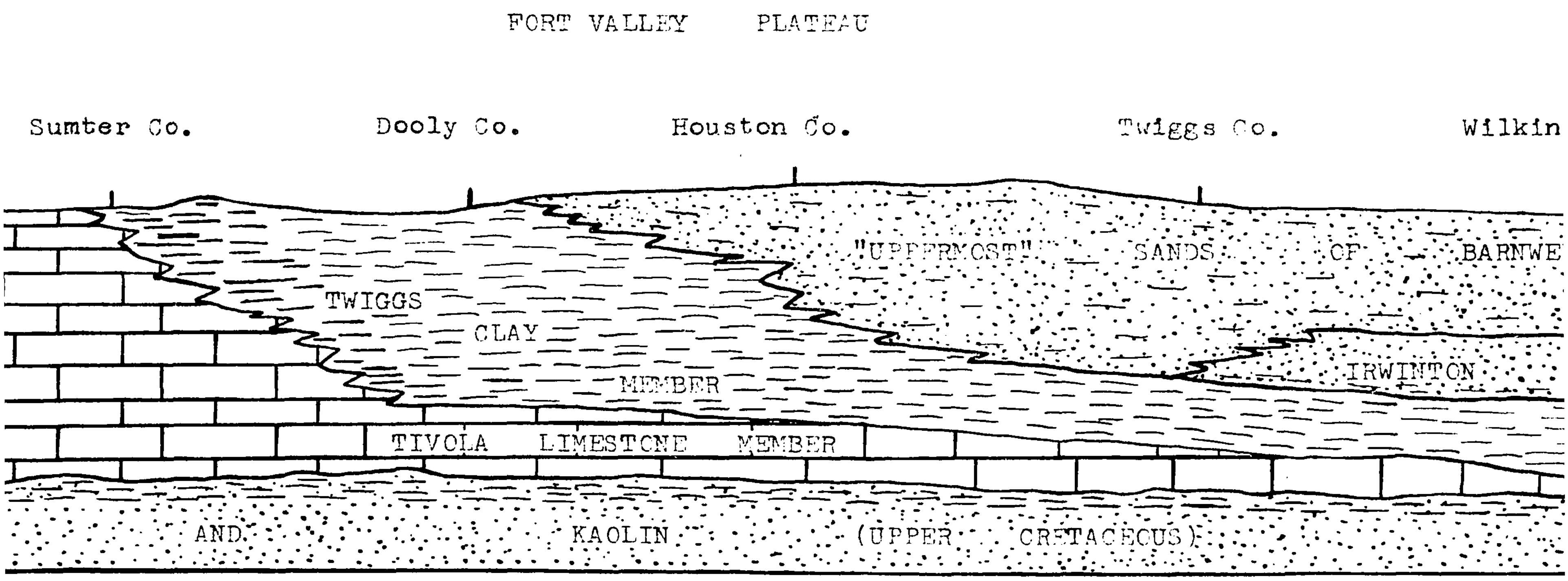
4

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35

31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	4
					X										

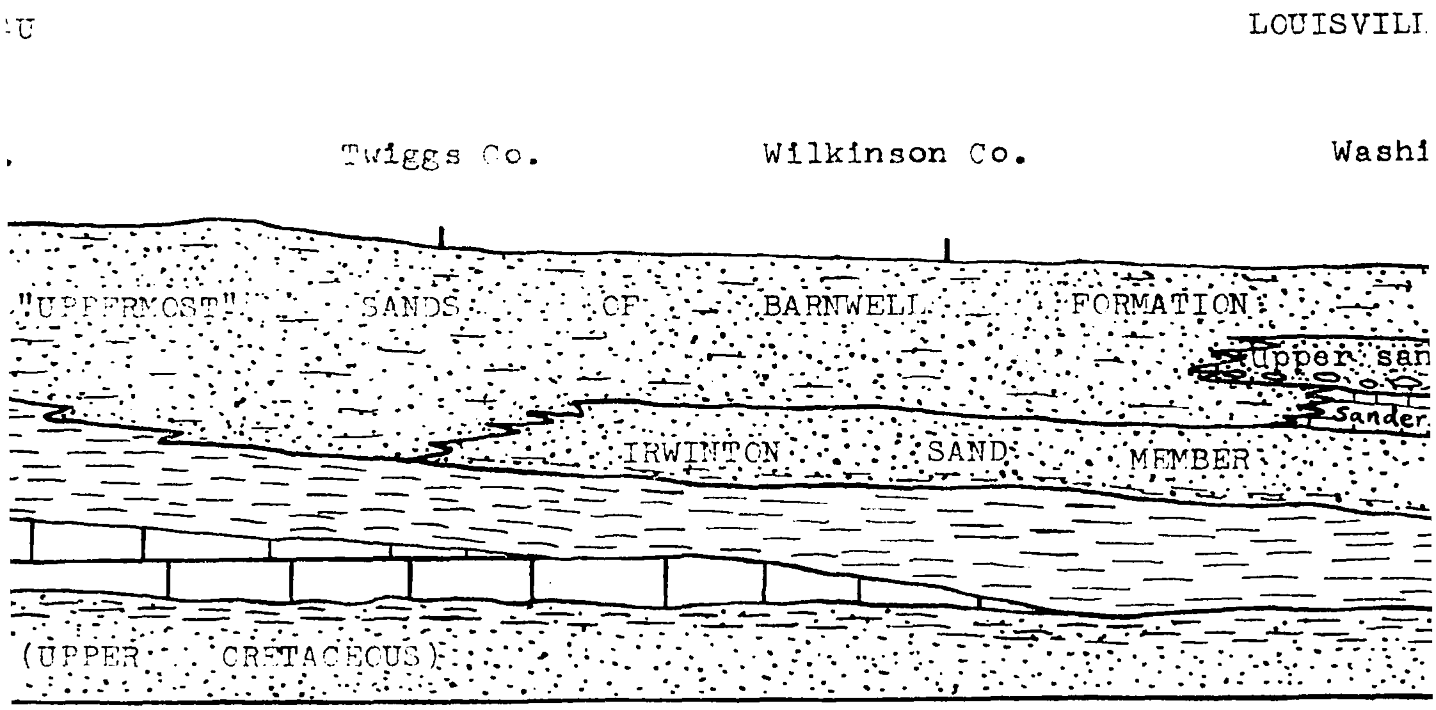


NORTHEAST-
SHOWING TH



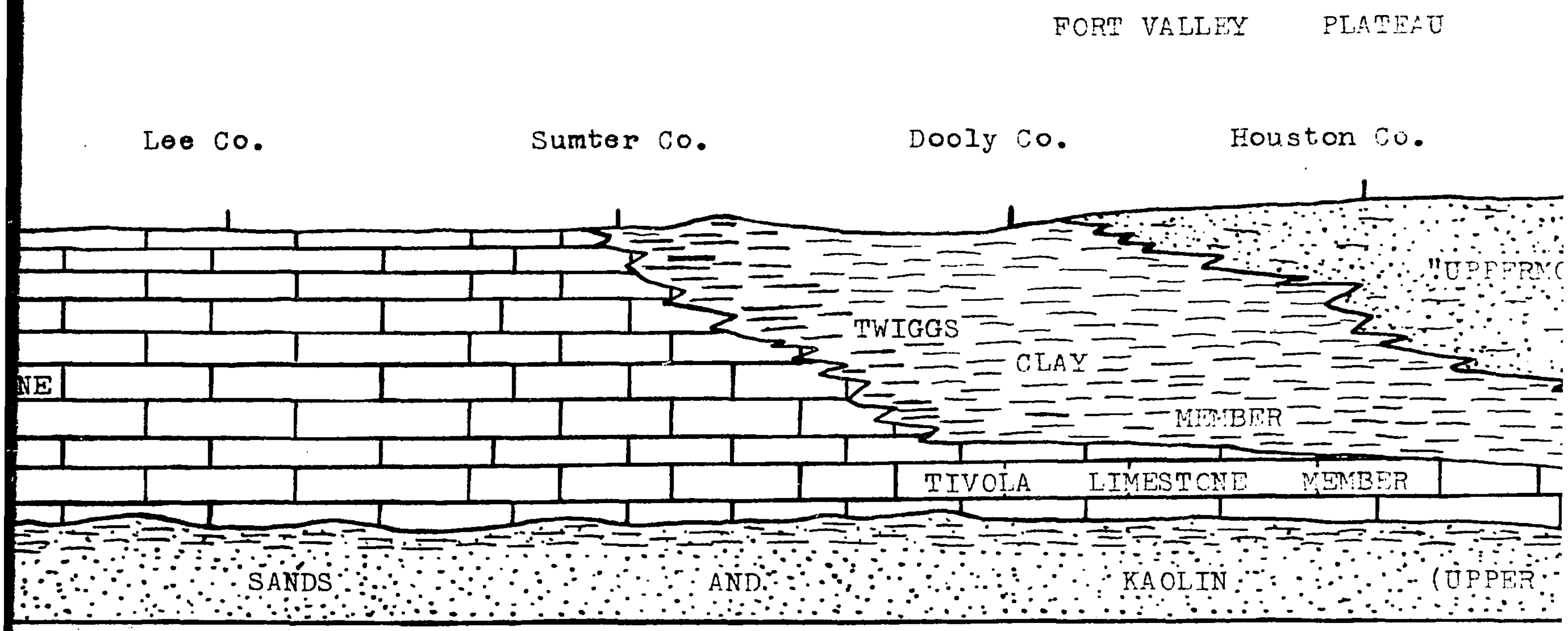
NORTHEAST-SOUTHWEST CROSS SECTION THROUGH THE JACKSON GROUP OF GEORGIA SHOWING THE RELATIONSHIPS BETWEEN THE VARIOUS FACIES OF THE OCALA AND BARNWELL FORMATIONS.

Scale: $1\frac{1}{2}$" = approx. 15.5 miles



H THE JACKSON GROUP OF GEORGIA
RICUS FACIES OF THE OCALA AND
IONS.

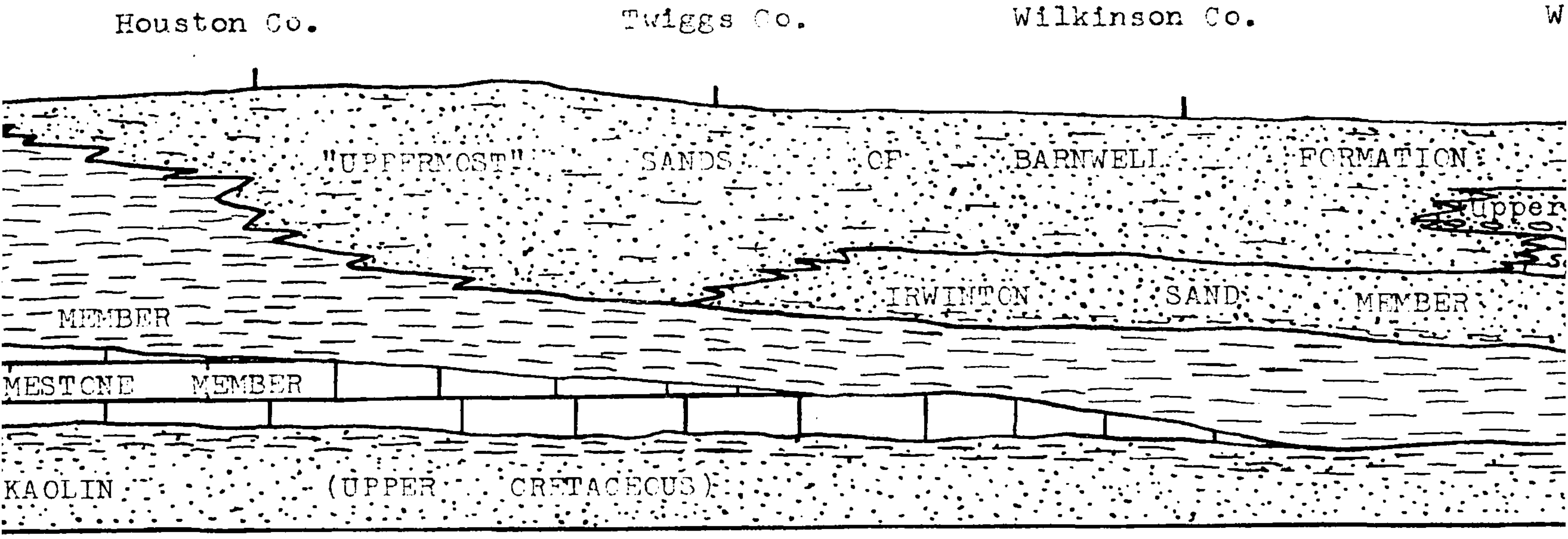
15.5 miles



NORTHEAST-SOUTHWEST CROSS SECTION THROUGH THE JA
SHOWING THE RELATIONSHIPS BETWEEN THE VARIOUS FA
BARNWELL FORMATIONS.

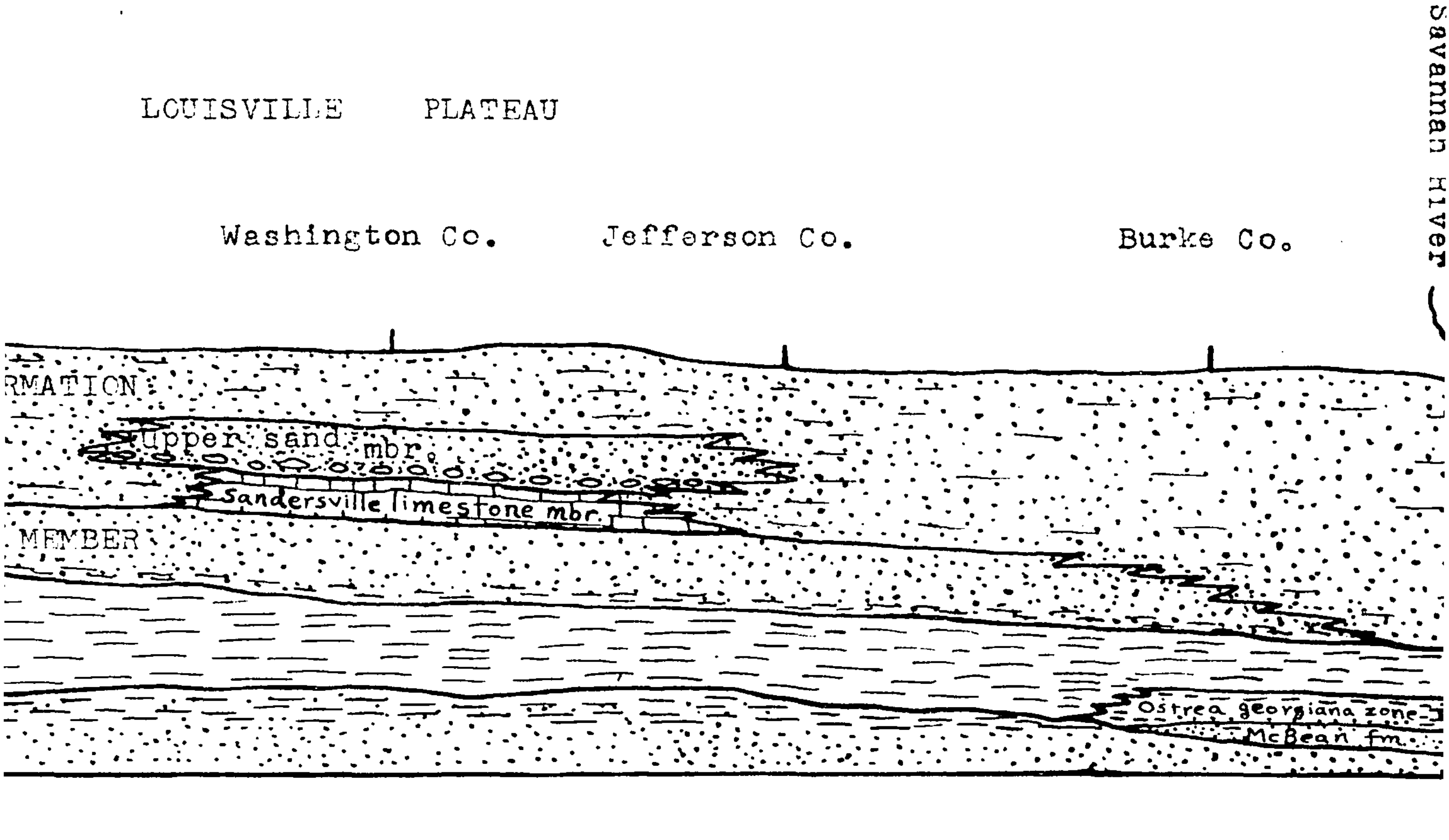
Scale: $1\frac{1}{2}$"= approx. 15.5 mi

VALLEY PLATEAU LOUIS

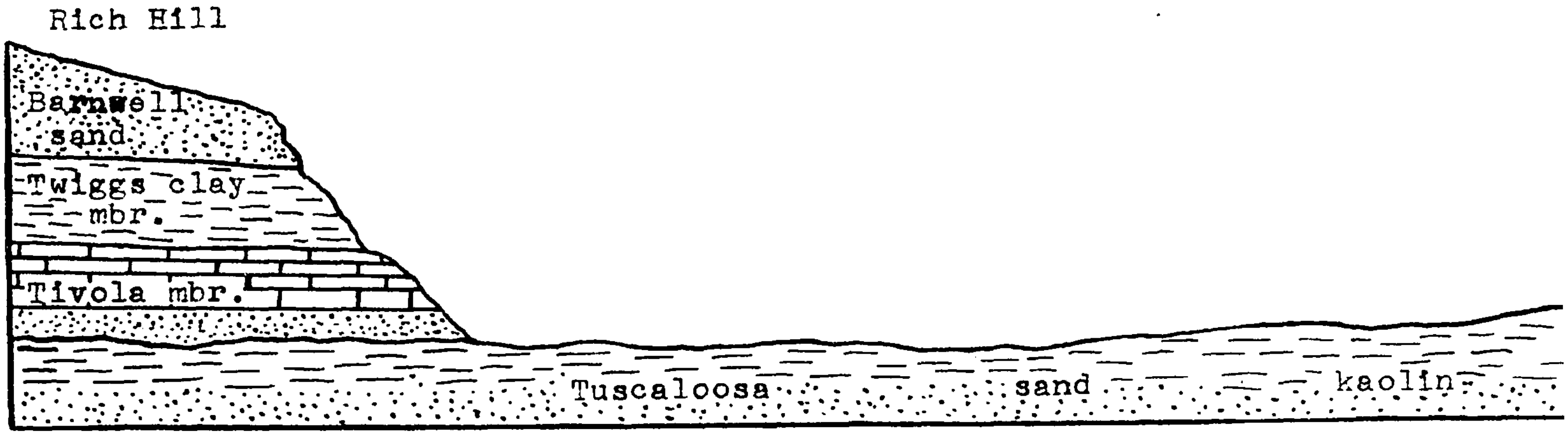


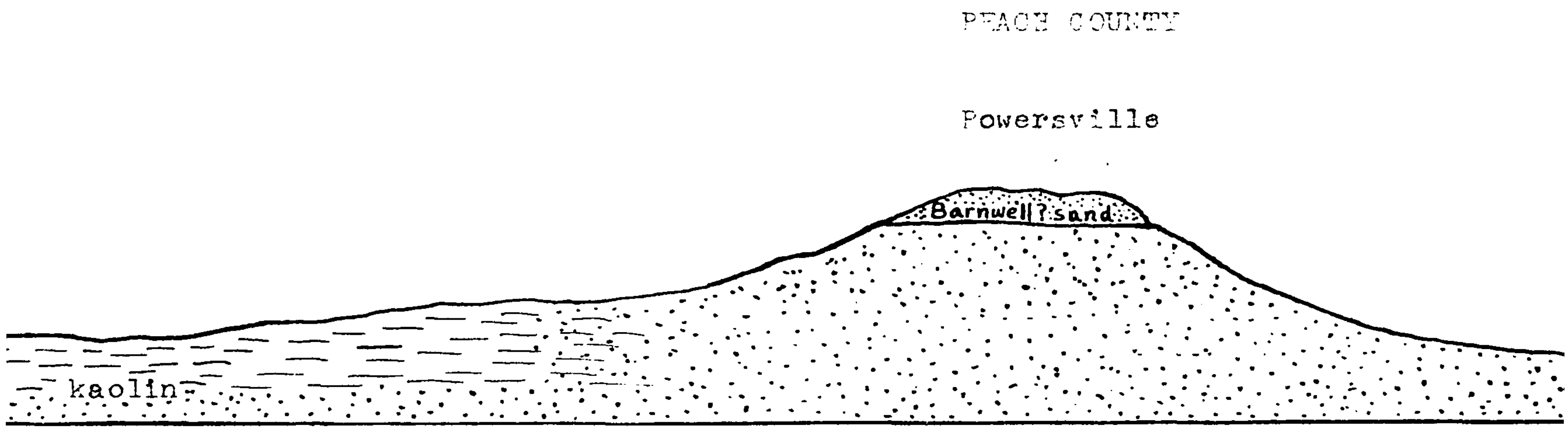
SS SECTION THROUGH THE JACKSON GROUP OF GEORGIA
PS BETWEEN THE VARIOUS FACIES OF THE OCALA AND
BARNWELL FORMATIONS.

le: 1½"= approx. 15.5 miles


LOUISVILLE PLATEAU
Washington Co.
Jefferson Co.
Burke Co.
Savannah River
RMATION
upper sand mbr.
Sandersville limestone mbr.
MEMBER
Ostrea georgiana zone
McBean fm.

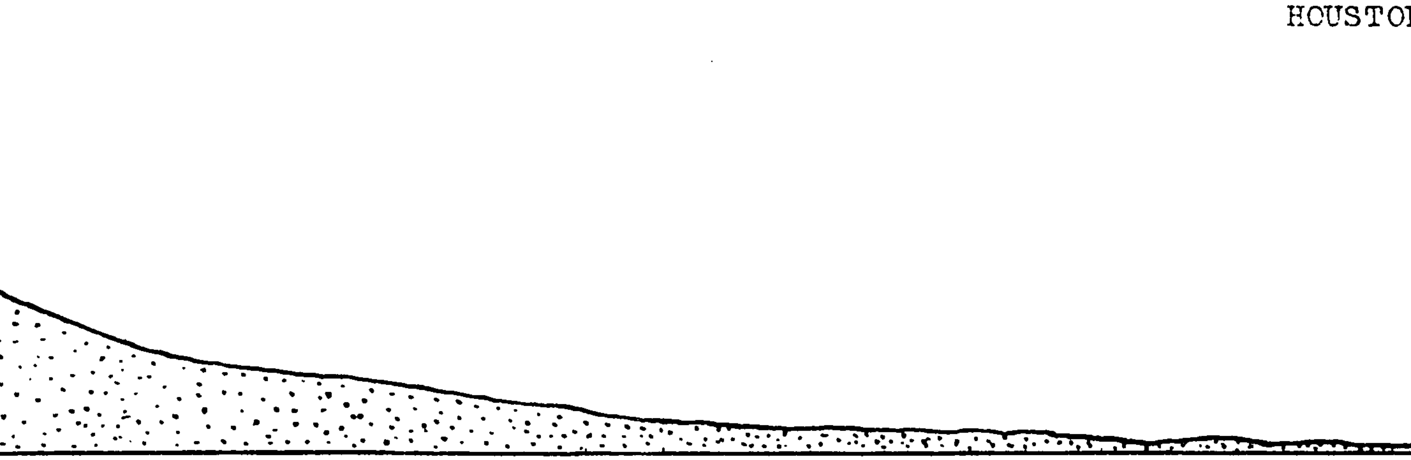
CRAWFORD COUNTY





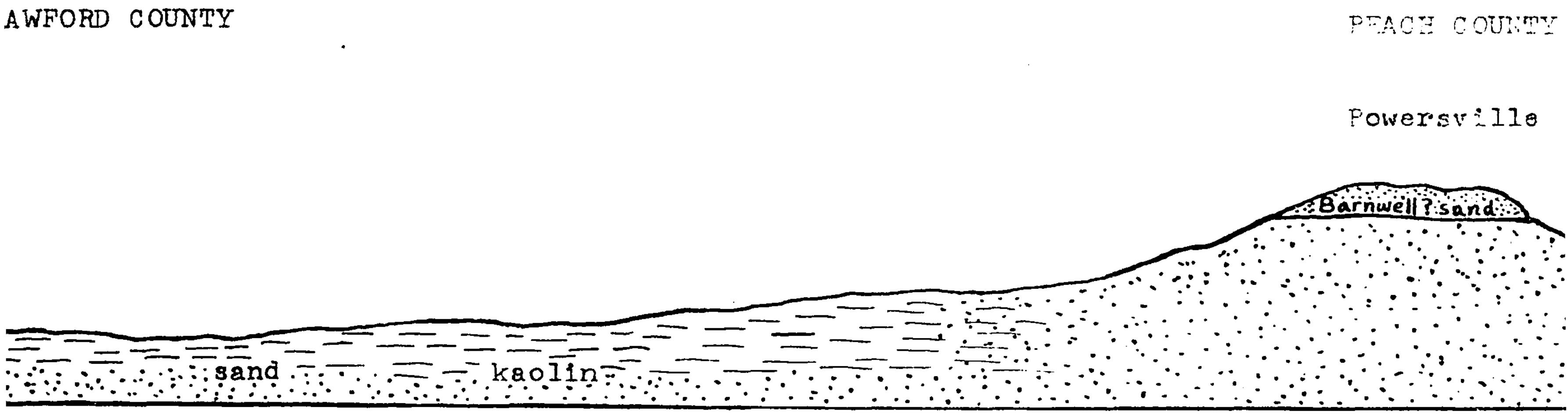
NORTHWEST-SOUTHEAST CROSS SECTION FROM CENTRAL CRAWFORD COUNTY TO CI
HOUSTON COUNTY, GEORGIA, SHOWING THE RELATIONSHIPS BETWEEN THE OUTLIE
JACKSON GROUP AT RICH HILL, AND THE NEAREST TYPICAL EXPOSURE AT CLINC
QUARRY.

Scale: 3/4" = approx. 10 miles



WFORD COUNTY TO CLINCHFIELD,
BETWEEN THE OUTLIER OF THE
EXPOSURE AT CLINCHFIELD

miles

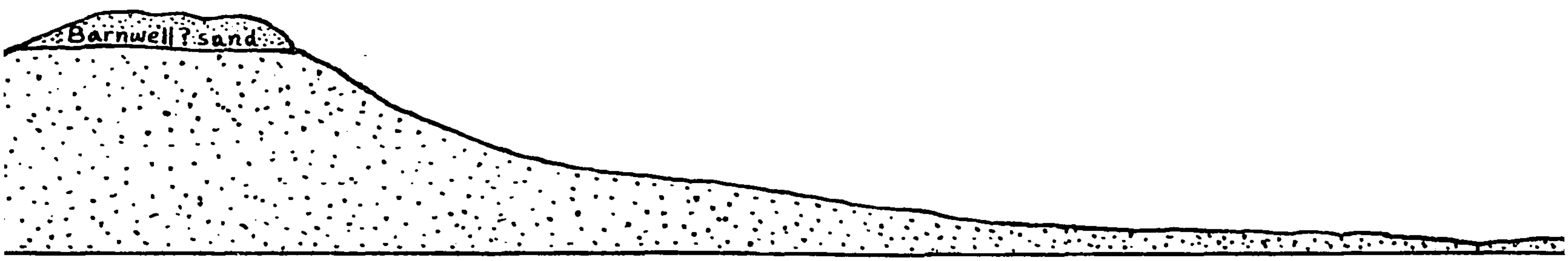


NORTHWEST-SOUTHEAST CROSS SECTION FROM CENTRAL C
HOUSTON COUNTY, GEORGIA, SHOWING THE RELATIONSHI
JACKSON GROUP AT RICH HILL, AND THE NEAREST TYPIC
QUARRY.

Scale: 3/4" = approx.

PEACH COUNTY

Powersville



ION FROM CENTRAL CRAWFORD COUNTY TO CLINCHFIELD,
D THE RELATIONSHIPS BETWEEN THE OUTLIER OF THE
THE NEAREST TYPICAL EXPOSURE AT CLINCHFIELD
QUARRY.

le: 3/4" = approx. 10 miles

HOUSTON COUNTY