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STATE DIVISION OF CONSERVATION
DEPARTMENT OF MINES, MINING AND GEOLOGY
GARLAND PEYTON, Director

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GEOLOGY OF THE COASTAL PLAIN OF EAST-CENTRAL GEORGIA

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LETTER OF TRANSMITTAL

DEPARTMENT OF MINES, MINING AND GEOLOGY

ATLANTA, February 15, 1946.

His Excellency, Ellis Arnall, Governor
Commissioner Ex-Officio, State Division of Conservation
Through The Honorable Nelson M. Shipp, Assistant Commissioner

SIR:

I have the honor to submit herewith Georgia Geological Survey Bulletin No. 50, Part 1, "Geology of the Coastal Plain of East-Central Georgia." This is the first in a series of bulletins under this title. Others will be published from time to time until all of the Cretaceous area in the State has been mapped.

The geology of east central Georgia, the area covered in this report, influences in three essential ways the economy of the State:

The Tuscaloosa formation consists of thick beds of sand and gravel that are excellent aquifers. These water-bearing beds will furnish large additional quantities of water of good quality for industrial and municipal uses throughout a belt of 10 to 30 miles in width along the northern margin of the Coastal Plain of Georgia.

Georgia produces approximately 80 per cent of the national output of kaolin. The major portion of this production is from deposits described in this report in Washington, Wilkinson and Twiggs counties. Other commercial minerals mined in this area include bauxite, fuller's earth, limestone, and sand and gravel.

The period 1943-46 has seen progressively stimulated interest in prospecting for oil and gas in the Coastal Plain of Georgia. Activity in this area included the leasing of large tracts of land and the exploratory drilling of a number of wells by oil companies. From the examination and study of samples of drill cuttings, much valuable information about the subsurface geology of southern Georgia has been obtained. Data on the correlation, structure, lithology, and paleontology of the formations exposed at the surface are an aid to their study and interpretation below the surface. Therefore, this investigation of the geology of east-central Georgia should be an aid in the study of these formations in the subsurface.

Respectfully,
GARLAND PEYTON
Director

GEOLOGY OF THE COASTAL PLAIN OF
EAST CENTRAL GEORGIA

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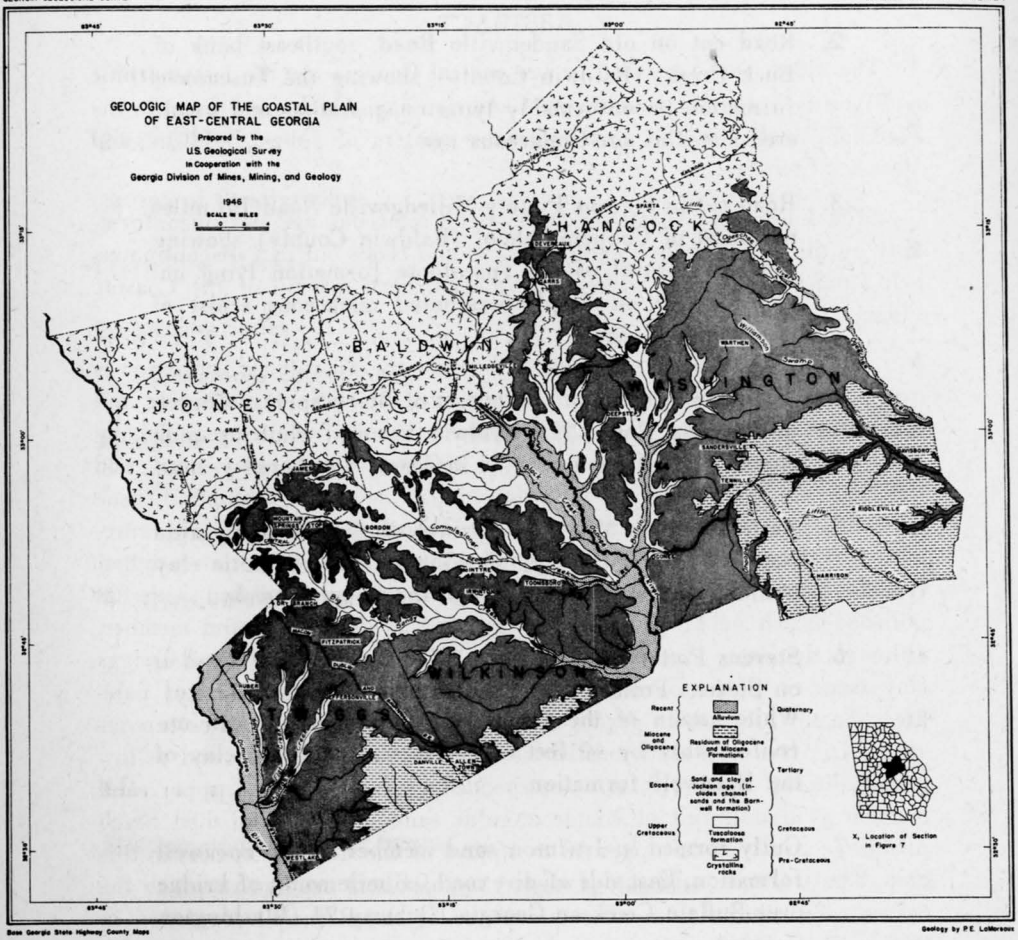

Base Georgia State Highway County Maps

Geology by P.E. LaMoreaux

GEOLOGY OF THE COASTAL PLAIN OF EAST-CENTRAL GEORGIA*

PHILIP E. LaMOREAUX

ABSTRACT

The oldest rocks exposed in east-central Georgia are the metamorphic and igneous rocks of probable pre-Cambrian age, which are present in the Piedmont region in the northern three-quarters of Jones, Baldwin, and Hancock Counties.

The Tuscaloosa formation of Upper Cretaceous age lies unconformably on the peneplaned crystalline rocks and crops out in a discontinuous belt from 2 to 8 miles wide along the northern margin of the Coastal Plain.

Throughout most of east-central Georgia the Tuscaloosa formation is overlapped by deposits of upper Eocene age, for rocks of Paleocene and early and middle Eocene age are not present in much of the area. During late Eocene time, approximately 150 to 200 feet of sand, clay, marl, and limestone were deposited in a shallow marine sea. These upper Eocene deposits which lie uncomformably on the Tuscaloosa formation are represented by the Barnwell formation, which contains the Twiggs clay member, Irwinton sand member, and a possible thin coarse sand bed with flat polished beach pebbles, tentatively included as the upper sand member, although the latter may prove to be of Oligocene age. The basal Twiggs clay member of the Barnwell formation is typically composed of pale-green hackly clay which grades downward into gray marl and calcareous sand. The Irwinton sand member is composed of light gray and yellow unconsolidated sand with thin interbedded clay layers. The upper sand member is a thin bed of coarse angular sand with flat polished beach pebbles, present in the upper 10 to 15 feet of the Eocene deposits in this area. The Irwinton sand and Twiggs clay members are equivalent to the coarse sand and undifferentiated deposits of the Barnwell formation in eastern Georgia. The Irwinton sand is believed to merge laterally with the Twiggs clay into the Ocala limestone in the western half of Georgia.

Undifferentiated deposits of Miocene and Oligocene age lie unconformably on the Eocene deposits in southern Washington, Wilkinson, and Twiggs Counties.

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* Prepared under the direction of the United States Geological Survey in cooperation with the Georgia Geological Survey.
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INTRODUCTION

This report is based on a more comprehensive report that is being prepared on the geology and ground-water resources of the Coastal Plain of east-central Georgia. The ground-water investigations are being made in cooperation between the Georgia State Division of Conservation, Department of Mines, Mining, and Geology, and the Geological Survey, United States Department of the Interior.

The field work on which the report is based was done from August 1944 to January 1945. Much time was spent in re-mapping the area, using as a nucleus the "Strategic Minerals Investigations Preliminary Maps" of the bauxite and kaolin deposits in parts of Twiggs, Wilkinson, and Washington Counties. These maps were published by the Geological Survey, U. S. Department of the Interior, in 1943.

The term East-Central Georgia, as used in this report, comprises Washington, Wilkinson, Twiggs, Jones, Baldwin, and Hancock Counties. The location of this area and a generalized geologic map are shown in Plate 1.

Acknowledgment is made of the aid and cooperation of Captain Garland Peyton, Director of the Department of Mines, Mining, and Geology of Georgia. The manuscript has benefited from the suggestions of O. E. Meinzer, V. T. Stringfield, L. C. Conant, C. Wythe Cooke, F. Stearns MacNeil, and S. M. Herrick of the United States Geological Survey. Cooke and MacNeil spent three days in the field with the author, and made valuable suggestions on the stratigraphy of the Eocene beds. Herrick identified and prepared the frequency chart of the foraminifera.

OUTLINE OF STRATIGRAPHY

A correlation chart outlining the stratigraphy of east-central Georgia and showing the relationship to the other parts of the Coastal Plain of Georgia is shown in Figure 1

CRYSTALLINE ROCKS

Complex crystalline rocks, consisting of weathered pre-Cambrian gneiss and schist lie beneath and to the north of the Coastal Plain rocks of east-central Georgia. Injected into the crystalline rocks at some localities are dolerite dikes of Triassic age and granite intrusions of Paleozoic or late Paleozoic age. Following the development of the crystalline rocks, a long period of erosion, which took place prior to the Upper Cretaceous epoch of the Mesozoic era, reduced the surface to a peneplane.

Information from five water wells drilled to the crystalline rocks in Washington County indicates that the surface of these rocks has a southeastward dip of about 55 feet per mile.

<table>
<tr><th></th><th>Western Georgia
(West of Ocmulgee River)</th><th>East Central Georgia</th><th>Eastern Georgia
(East of Ogeechee River)</th></tr>
<tr><td>MIOCENE and OLIGOCENE</td><td colspan="3">Undifferentiated MIOCENE and OLIGOCENE</td></tr>
<tr><td rowspan="4">EOCENE</td><td rowspan="2">OCALA LIMESTONE
TIVOLA TONGUE OF THE OCALA L.S.</td><td>IRWINTON SAND MEMBER</td><td rowspan="2">BARNWELL FORMATION</td><td rowspan="2">BARNWELL FORMATION
(Undifferentiated)</td></tr>
<tr><td>TWIGGS CLAY MEMBER</td></tr>
<tr><td>SANDS OF LOWER JACKSON AGE</td><td colspan="2">SANDS OF LOWER JACKSON AGE</td><td>SANDS OF LOWER JACKSON AGE</td></tr>
<tr><td>Mc BEAN FORMATION</td><td colspan="2">Absent</td><td>Mc BEAN FORMATION</td></tr>
<tr><td>WILCOX FORMATION</td><td colspan="2">Absent</td><td>Absent</td></tr>
<tr><td>PALEOCENE</td><td>CLAYTON FORMATION</td><td colspan="2">Absent</td><td>Absent</td></tr>
<tr><td>UPPER CRETACEOUS</td><td>TUSCALOOSA FORMATION</td><td colspan="2">TUSCALOOSA FORMATION</td><td>TUSCALOOSA FORMATION</td></tr>
<tr><td colspan="4">Undifferentiated CRYSTALLINE ROCKS</td></tr>
</table>

FIGURE 1. Correlation Chart outlining the stratigraphy of east-central Georgia and showing the relationship to the other parts of the Coastal Plain of Georgia.

CRETACEOUS SERIES

TUSCALOOSA FORMATION

In 1887 Smith and Johnson[1] named the Tuscaloosa formation after the town, river, and county of the same name in Alabama. The Tuscaloosa formation in Alabama consists of some 800 feet of light-colored irregularly bedded sands, clays, and gravels, and includes a recently recognized marine zone in its lower half. Earlier workers on the Cretaceous stratigraphy of Georgia who questioned the correlation of the Upper Cretaceous beds of Georgia with the Tuscaloosa formation of Alabama assigned the name Middendorf to them. In 1936, however, that name was discarded in favor of Tuscaloosa[2] for the deposits of Upper Cretaceous age in Georgia. At the present time basal Upper Cretaceous beds from North Carolina to Mississippi, and northward into Tennessee are referred to as the Tuscaloosa formation.

In east-central Georgia the Tuscaloosa formation crops out in a belt from 2 to 8 miles wide along the northern margin of the Coastal Plain. This belt of outcrop is made discontinuous by the progressive overlap of younger beds of upper Eocene age. Typical of the area of outcrop of the Tuscaloosa formation are broad rolling "Sand Hills" with gentle slopes. The formation also crops out in long southeast and southwest belts where streams have stripped away the overlying younger sediments.

In the southern part of the area of this report the Tuscaloosa formation has a maximum thickness of about 800 feet. It thins progressively to the northwest, up dip, to the Fall Line. In a water well drilled for the City of Sandersville at an elevation of 470 feet, the crystalline basement, which was encountered at a depth of 872 feet, is overlain by 605 feet of Tuscaloosa sediments. Well cuttings and outcrops in this area show the Tuscaloosa to be composed of cross-bedded sand, gravel, and lenses of kaolinitic clay ranging from sandy kaolin to the pure white commercial kaolin. The sands are predominantly light-colored, buff, yellow, and gray, micaceous, cross-bedded, and interlensed with light-colored red, purple, gray, and white clay and sandy clay lenses. Some of the clay lenses are as much as 35 or 40 feet thick. Zones of sub-angular to sub-rounded quartz gravel as much as 1½ inches in diameter are common in the massive cross-bedded sand. The basal Tuscaloosa formation at the contact with the crystalline rocks contains large angular and subangular gravel, cobbles, and boulders 6 and 8 inches in diameter. (see figs. 2 and 3) A typical section showing the lithology of the Tuscaloosa formation follows:

[1] Smith, E. A., and Johnson, L. C., Teritary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers: U. S. Geol. Survey Bull. 43, pp. 95-116, 1887.
[2] Cooke, C. W., Geology of the Coastal Plain of South Carolina; U. S. Geol. Survey Bull. 867, p. 17, 1936.

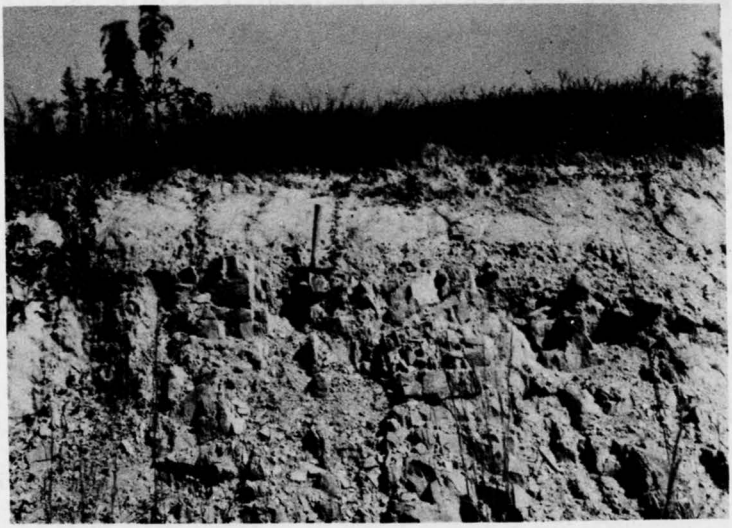

FIGURE 2. Road cut on old Sandersville Road, southeast bank of Buck Creek (Baldwin County), showing the Tuscaloosa formation unconformably lying on quartzites and weathered slates of pre-Cretaceous age.

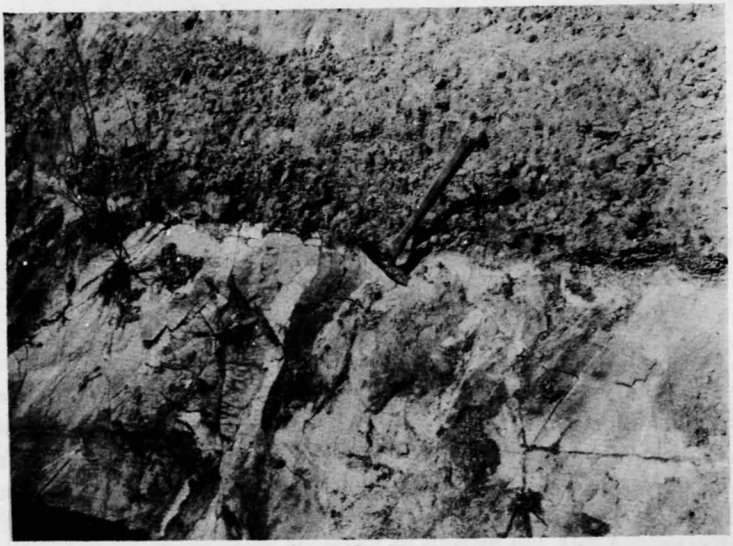

FIGURE 3. Road cut in Stevens Pottery—Miiledgeville Road 1.8 miles northeast of Coopers School (Baldwin County), showing sand and gravel of the Tuscaloosa formation lying unconformably on deeply weathered micaceous schist of pre-Cambrian age.

SECTION IN A ROAD CUT ON THE SOUTHEAST BANK OF BUCK CREEK, 5.1 MILES (AIR LINE) SOUTHEAST OF MILLEDGEVILLE, BALDWIN COUNTY, GEORGIA, ON THE OLD SANDERSVILLE ROAD

Feet

Upper Eocene
Beds of Jackson age

5. Pinkish-red, fine to medium-grained, cross-bedded sand with thin white layers of clay and rounded clay balls as much as 1 inch in diameter. Scattered gravel at base 24

Unconformity (poorly exposed contact)
Cretaceous

Tuscaloosa formation (Upper Cretaceous)

4. Mottled red, gray, and yellow sandy clay with scattered sub-angular to sub-rounded quartz gravel ⅛ to ½ inch in diameter 10

3. Light-gray and pinkish white, medium to coarse-grained, cross-bedded micaceous, quartz sand with many stringers of quartz gravel up to 1 inch in diameter. Interbedded lenses of purple, red, and light-gray, finely sandy micaceous clay. At sand-clay contact a 1- to 2-inch purple ironstone contains quartz gravel. 79

2. Light-gray, cross-bedded, micaceous sandy clay grades downward into basal bed of angular to sub-angular quartz gravel, as much as 2 inches in diameter. Contact irregular 2

Unconformity
Pre-Cretaceous rocks

1. Gray, tan, and yellow alternating hard quartzites and soft, highly weathered slates 33

The sand, sandy clay, and clay of the Tuscaloosa formation in this area apparently is of continental origin. These deposits are composed of erosional products of the ancient crystalline rocks of the Piedmont, which accumulated in fresh water bodies or possibly near the shore of a shallow marine Cretaceous sea. The scarcity of fossil plants or animal remains in the Tuscaloosa formation makes it difficult to determine its exact age. At one locality in east-central Georgia a few poorly preserved plant remains were collected by Stephenson and Thompson[3] from a lens of sandy carbonaceous clay overlain by 19 feet of kaolinitic clay at one of Martin's abandoned clay mines, 1 mile south of Gordon, Wilkinson

[3] Stephenson, L. W., and Thompson, R. M., Notes on Cretaceous and adjacent Eocene formations in central and west-central Georgia, pp. 29-30. Uupublished.

County. From this collection R. W. Brown recognized a species resembling *Phyllites asplenoides* Berry, fragments of dicotyledonous leaves, and unidentified fruits or seeds. On the basis of a probable specimen of *P. asplenoides* which Berry described from the Coffee sand of the Eutaw formation, Brown believes this to be a collection of Upper Cretaceous plants.

The Tuscaloosa formation in this area strikes northeast-southwest and dips southeast about 15 feet per mile. It is overlain unconformably by the younger Eocene beds which locally, in Jones, Baldwin, and Hancock Counties, entirely overlap the Cretaceous deposits and rest directly on the crystalline rocks.

In 1943 about 78 percent of the kaolin produced in the United States was mined in Georgia. Most of this came from western Washington, central and western Wilkinson, and northern Twiggs Counties, and a lesser amount from Hancock County near Carr's Station. The entire production from this area is from kaolin lenses in the Tuscaloosa formation. Bauxite has also been mined in this area, and Warren[4] states that bauxite bodies ranging from a few inches to 10 feet in thickness and from a few square feet to 5 acres in extent are present in small and medium-sized kaolin lenses lying in the upper 20 feet of the Tuscaloosa formation.

The thick sand and gravel beds of the Tuscaloosa formation are the best source of ground water in east-central Georgia. Many shallow dug wells along the northern margin of the Fall Line furnish ground water for domestic and stock supplies from this aquifer. Farther south wells drilled to water sands in the Tuscaloosa formation furnish as much as 800 gallons a minute for domestic, municipal, and industrial use at Sandersville, Deepstep, Oconee, McIntyre, Huber, Jeffersonville, and other nearby localities.

EOCENE SERIES

UPPER EOCENE

CHANNEL SANDS

At many localities along the Fall Line in east-central Georgia where the Eocene strata overlap the Tuscaloosa formation and lie on the crystalline rocks, the Coastal Plain sediments are represented by a pink and white kaolinitic quartz sand that fills channels in the crystalline rocks of the Piedmont (see fig. 4). In northern Twiggs, Wilkinson, Washington, and at many places in southern Jones, Baldwin, and Hancock Counties, similar channel sands were observed to overlie the Tuscaloosa formation unconformably.

[4] Warren, Walter C., Bauxite and kaolin deposits of Wilkinson County, Georgia, U. S. Geol. Survey, Strategic Minerals Investigations Preliminary Maps, 1943.

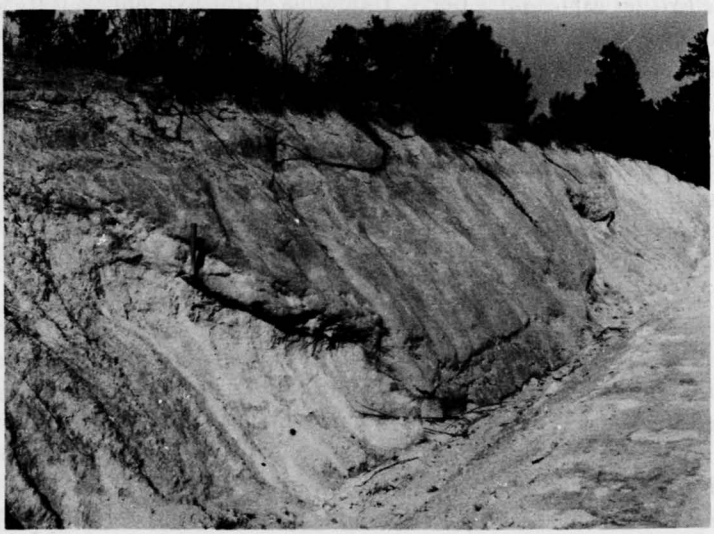

FIGURE 4. Exposure in road cut 1 mile east of Black Springs Church on Georgia Route 22 (Baldwin County) showing pink coarse sand filling a channel in deeply weathered granite.

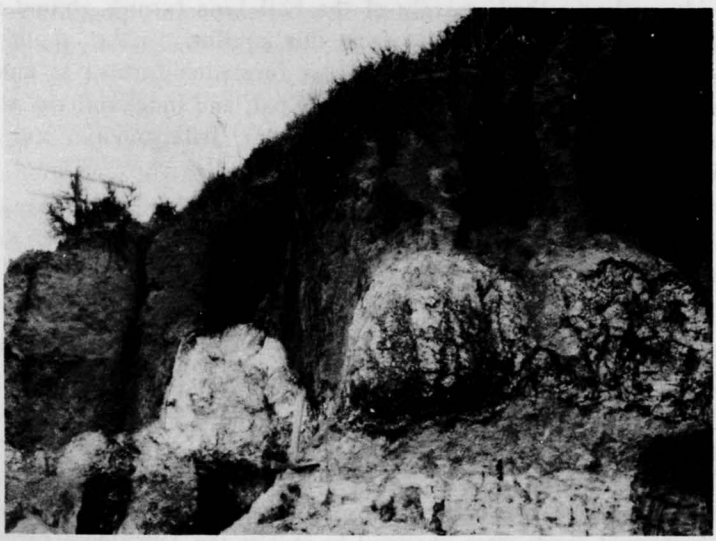

FIGURE 5. Railroad cut at Mountain Springs on Central of Georgia Railway (Jones County) showing rounded bauxitic clay boulders scattered along base of the channel sands.

The channel sands range from a few inches up to 25 feet in thickness, and consist of light-pink, gray, and white fine to coarse and gravelly cross-bedded sand with many white rounded kaolin balls scattered throughout. In southern Jones County at a railroad cut at Mountain Springs, and at other localities in Wilkinson and Twiggs Counties, rounded pisolitic bauxitic clay and kaolin boulders as much as 3 feet in diameter are scattered along the base of the channel sands at the contact with the Tuscaloosa formation (see fig. 5).

The channel sands consist of coarse sand, gravel, and kaolin fragments eroded from the older crystalline rocks and the Tuscaloosa formation. This material was carried in suspension or rolled along stream beds and deposited near shore in a marine sea during Eocene time.

On the north side of Georgia Highway 57, about 0.7 mile west of the Irwinton courthouse, a borrow pit and drainage ditch expose 15 feet of coarse pinkish-gray channel sand overlying unconformably the gray sandy kaolin of the Tuscaloosa formation. At this locality and others in this area, the channel sand contains borings of *Halymenites*, indicating a shallow marine origin. In some sections the channel sand appears to grade upward into the overlying sands of upper Eocene age, while at other places it is overlain by a bed of coarse pebbly sand suggesting an unconformable relationship with the overlying beds.

L. W. Stephenson and R. M. Thompson[5] suggest that the channel sands may be remnants of an older Eocene formation, possibly even of pre-Jackson age, such remnants having escaped destruction by the advancing Jackson sea, because of their position in channel-like depressions below the level of cutting. As the channel sands locally contain reworked boulders of bauxite, it appears they were deposited subsequent to the bauxite-forming period, though conceivably bauxitization might have altered the kaolin cobbles and boulders after they were incorporated in the sands. The channel sands, where present, were mapped with the upper Eocene deposits because of their small extent and because of the possibility of their being upper Eocene in age. The progressive overlap exhibited by these and other units of upper Eocene age suggested their close relationship. They may be equivalent to the Gosport sand of Alabama.

BARNWELL FORMATION

The term Barnwell "buhr sands" or Barnwell "phase" was first used by Sloan[6] in 1907 for material consisting of silicified shells and red

[5] Stephenson, L. W., and Thompson, R. M., Notes on Cretaceous and adjacent Eocene formations in central and west-central Georgia, pp. 26-28. Unpublished. (Manuscript on file, U. S. Geological Survey, Washington, D. C.)

[6] Sloan, Earle, Geology and mineral resources: S. C. State Department Agriculture, Handbook of South Carolina, Chapter 5, p. 90, 1907.

ferruginous sands that were typically exposed in Barnwell County, South Carolina. Sloan classified these sands as middle Eocene. In 1911 Veatch and Stephenson[7] used the term "Barnwell sand" for the same deposits in Georgia and included the Barnwell with the McBean in the Claiborne group.

Cooke and Shearer[8] later found that most of the fauna upon which the Claiborne age of the Barnwell was based also occurred in deposits of Jackson age so reclassified the Barnwell as of Jackson age.

The Barnwell formation of east-central Georgia has a diverse lithology, and, for convenience of discussion of the geology and ground water, it has been divided into three members: the basal or Twiggs clay member, the Irwinton sand member, and a possible, and unnamed thin upper member of coarse red sand with flat rounded beach pebbles.

A section exposed in a tramway and road cut 1.8 miles southwest of Gordon 0.1 mile east of the intersection of Georgia Highways 18 and 57 exhibits well the lithology and stratigraphic relationship of the members of the Barnwell formation. (See also Gordon—section X2, figure 8)

SECTION X2 EXPOSED IN GORDON CLAYS TRAM LINE CUT AT OVERPASS ON GEORGIA HIGHWAY 57, 1.8 MILES SOUTHWEST OF GORDON, CONTINUED IN A ROAD CUT ON GEORGIA HIGHWAY 18, 1.6 MILES SOUTH OF GORDON.

	Feet
Colluvium (Exposed in tramway cut)	
8. Reddish-brown coarse sub-angular sandy clay with scattered brown iron pellets.	4
Upper Eocene	
Barnwell formation	
Upper sand member	
7. Pink cross-bedded coarse and granular sub-angular to sub-rounded quartz sand with thin gray clay stringers. At base many flat rounded highly polished quartz pebbles as much as 2 inches in diameter and stringers of fine gravel	12½
Irwinton sand member	
6. Thin beds of buff-yellow fine-grained quartz sand and alternating beds of gray micaceous clay. Clay weathers into purple flakes. The sand beds thicken and grade downward into bed below.	5
(Off-set 0.1 mile east to road-cut on Georgia Highway 18.)	

[7] Veatch, Otto, and Stephenson, L. W., Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geological Survey Bull. 26, pp. 285-296, 1911.
[8] Cooke, C. W., and Shearer, H. K., Deposits of Claiborne and Jackson age in Georgia; U. S. Geol. Survey Prof. Paper 120, pp. 41-81, 1918.

5. Red coarse quartz sand. Grades downward into 31 feet of yellow cross-bedded fine-grained quartz sand with thin gray clay partings which become thicker near base of bed..... 46

Twiggs clay member

4. Pale green hackly, blocky clay, fuller's earth type, with thin fine sand streaks. (Offset down gully 20 yards west to tramway cut) Clay contains more fine and medium-grained sand in basal 20 feet. Tan gray-green and fossiliferous at base..... 42

3. Mottled red, brown, and gray, coarse clayey sand with scattered granules and sub-angular gravel up to ¾ inch in diameter. 10

Channel sand

2. Pink and white cross-bedded fine to coarse sand with clay balls up to 2 inches in diameter..... 6-12

Unconformity

Cretaceous

Tuscaloosa formation

1. Gray sandy kaolin overlying gray-white, coarse, cross-bedded, micaceous sand..... 25±

Twiggs clay member.—The type locality of the Twiggs clay member of the Barnwell formation is at Pikes Peak station on the Macon, Dublin, and Savannah Railroad in Twiggs County.

The Twiggs clay was formerly considered to be of Claiborne age, and called the Congaree clay member of the McBean formation by Veatch and Stephenson[9]. Cooke and Shearer[10] later found fossil evidence indicating the Jackson age of the Congaree clay, which they renamed "Twiggs clay" and made a member of the Barnwell formation. Cooke[11] adopted the same usage, except that he restored part of the so-called Congaree clay to the McBean formation, and stated that this restored part may be an upper Eocene deposit, intermediate between the Barnwell and McBean.

It was found during this investigation that no part of the so-called Congaree clay or Twiggs clay in east-central Georgia was of Claiborne age, and that the base of the Barnwell in this area is the base of the Twiggs clay member, which rests unconformably on the Tuscaloosa formation except where the channel sands are present.

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[9] Veatch, Otto, and Stephenson, L. W., Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geological Survey, Bull. 26, p. 267, 1911.

[10] Cooke, C. W., and Shearer, H. K., Deposits of Claiborne and Jackson age in Georgia: U. S. Geol. Survey Prof. Paper 120, pp. 41-81, 1918.

[11] Cooke, C. Wythe, Geology of the Coastal Plain of Georgia: U. S. Geol. Survey Bull. 941, pp. 61-62, 1942.

In northern Washington and southern Jones, Baldwin, and Hancock Counties, the Twiggs clay member of the Barnwell consists of about 25 feet of pale-green hackly fuller's earth clay, but to the south and southwest in western Washington and Wilkinson Counties it thickens gradually, and locally includes 20 to 40 feet of green hackly clay which grades down into 10 feet of gray marl, which in turn grades at some localities into 15 feet of calcareous sand at the base of the member. Near the type locality at Pikes Peak station in Twiggs County, the Twiggs clay member attains its maximum thickness of nearly 80 feet, and in the western and northern part of the county it interfingers with the Ocala limestone (Tivola tongue).

All of these lithologic types were probably deposited in a shallow sea, and as is to be expected, a slightly different fauna is present in each of the facies.

A typical example of the lithology of the Twiggs clay is shown in the following section exposed at the Stevens Pottery Pit, 5.7 miles (air line) northeast of Gordon near the Baldwin-Wilkinson County line, 200 yards east of the Stevens Pottery-Gordon road (See fig. 6).

SECTION AT STEVENS POTTERY KAOLIN PIT

Feet

Upper Eocene
  Barnwell formation
    Twiggs clay member
      5. Pale-green hackly, blocky clay. Thin brown sandy fossiliferous beds near base. Grades downward into bed 4 25
      4. Gray blocky fossiliferous marl (blue-gray when wet). Grades downward into bed 3 10
      3. Yellow argillaceous, calcareous, fossiliferous sand with lime nodules. *Pecten* sp., Bryozoa, coral, pelecypod and gastropod casts. 12
    Channel sand
      2. Green glauconitic coarse quartz sand. Contains scattered rounded kaolinitic particles 2-18

Unconformity
Cretaceous
  Tuscaloosa formation
      1. White massive, blocky kaolin 25

The pale-green hackly clay of the Twiggs contains a very few poorly preserved pelecypod and gastropod molds. The gray and brownish gray marl zone of the Twiggs, however, is rich in both macro-fossils and foraminifera. A sample collected by F. S. MacNeil and the author from the

marl zone of the Twiggs clay at an exposure in a gully at the head of a branch of Lamars Creek, 4.5 miles southwest of Sandersville, on the old Oconee road, Washington County, was sent to Joseph A. Cushman, who has published a complete list of the foraminifera.[12] In this report Cushman states:

> "The fauna of this Twiggs clay material, while evidently of Jackson age, does not contain many of the typical Jackson foraminifera that one would expect to find. On the other hand some of the species are very unusual, as the genera have not previously been recorded earlier than the Miocene. The entire fauna is composed of very small foraminifera, many of them of only about one-half normal size for the species and evidently representing peculiar ecologic conditions. The almost entire absence of the Lagenidae, but fairly numerous Polymorphinidae, is difficult to explain. At first it almost seemed as though this were a brackish water fauna, but the occurrence of some Globigerinidae rather does away with this possibility."

A still better section of the gray marl zone of the Twiggs clay member is exposed in a small creek gully 0.8 mile south on a dirt road from the bridge over Buffalo Creek on Georgia Highway 24, Washington County. The gully runs nearly parallel to and is about 150 yards east of the dirt road. (see also Buffalo Creek section X4, Figure 8). A picture of this gully illustrates the unconsolidated nature of the Irwinton sand member at this locality, (see fig. 7)

SECTION X4, IN CREEK GULLY JUST EAST OF BUFFALO CREEK. WEST OF SANDERSVILLE (AIR LINE) 8 MILES.

	Feet
Colluvium	
10. Medium and coarse red sandy clay	20
Upper Eocene	
Barnwell formation	
Irwinton sand member	
9. Gray waxy clay, mottled red	4
8. Light colored yellow, white and gray loose fine to coarse sub-angular quartz sand having thin beds of tough yellow plastic clay.	34

[12] Cushman, Joseph A., A Foraminiferal Fauna from the Twiggs Clay of Georgia, Contributions from the Cushman Laboratory for Foraminiferal Research, Vol. 21, Part 1, March 1945.

FIGURE 6. Stevens Pottery kaolin mine, 5.7 miles north of Gordon on Stevens Pottery-Gordon road (Wilkinson County). White kaolin of the Tuscaloosa formation overlain unconformably by 40 feet of calcareous sand and clay of the Barnwell formation.

FIGURE 7. Gully formed in Irwinton sand member of the Barnwell formation. East side of dirt road 0.8 mile south of bridge over Buffalo Creek on Georgia Highway 24 (Washington County).

Twiggs clay member

7. Pale-green hackly, blocky clay with thin beds of white fine angular quartz sand 22
6. Tan fine sandy marl 5
5. Gray blocky fossiliferous marl 10
4. Buff blocky fossiliferous marl 4
3. Brownish gray fossiliferous sandy clay, grades upward into green sandy clay 5
2. Dark greenish gray hackly fine sandy clay 11

Unconformity

Cretaceous

Tuscaloosa formation

1. White, massive, blocky, sandy kaolin ..... 15+

A list and frequency chart of the foraminifera in beds 2, 4 and 5 of the Twiggs clay member (Barnwell formation) of the above section follows. R = Rare, C = Common, A = Abundant.

[Identified by S. M. Herrick]

	Bed 2	*Bed 4*	*Bed 5*
Textularia sp.			R
Robulus cf. propinquus Hantken			R
Robulus limbosus (Reuss), var.		R	R
Lenticulina cf. fragaria (Gumbel), var.			R
Planularia sp.		R	
Marginulina cocoensis Cushman		R	R
Dentalina jacksonensis (Cushman and Applin)		R	R
Nodosaria longiscata D'Orbigny			R
Guttulina irregularis (D'Orbigny)		C	C
Guttulina problema D'Orbigny		R	C
Guttulina spicaeformis (Roemer)		R	R
Guttulina caudata D'Orbigny		R	R
Globulina gibba D'Orbigny, var. globosa (Von Munster)		R	R
Globulina munsteri (Reuss)		R	R
Psuedopolymorphina decora (Reuss)		R	C
Pseudopolymorphina dumblei (Cushman and Applin)		R	C
Sigmomorphina jacksonensis (Cushman)		C	C
Pullenia cf. quinqueloba (Reuss)			R

	Bed 2	*Bed 4*	*Bed 5*
Nonion advenum (Cushman)	A	A	A
Nonion inexcavatum (Cushman and Applin)	A	C	A
Nonion planatum Cushman and Thomas		A	A
Nonion micrum Cole			R
Nonionella jacksonensis Cushman			R
Nonionella cf. hantkeni (Cushman and Applin)		R	C
Elphidium twiggsanum Cushman			R
Elphidoides americanus Cushman			R
Buliminella elegantissima (D'Orbigny)	A	C	A
Virgulina dibollensis Cushman and Applin			R
Virgulina minutissima Cushman		R	R
Bolivina jacksonensis Cushman and Applin	C	C	C
Bolivina jacksonensis Cushman and Applin, var. striatella Cushman and Applin	R		R
Angulogerina ocalana Cushman	R	C	A
Discorbis assulata Cushman	R		R
Discorbis globulo-spinosa Cushman			R
Valvulineria jacksonensis Cushman var. dentata Cushman	C	A	A
Eponides minimus Cushman		R	R
Siphonina jacksonensis Cushman and Applin		R	
Pulvinulinella danvillensis Howe and Wallace			C
Cassidulina twiggsana Cushman		C	R
Globigerina bulloides O'Orbigny		R	R
Globigerina sp.		R	C
Anomalina bilateralis Cushman			R
Cibicides preconcentricus Cushman	R	C	C
Cibicides lobatulus (Walker and Jacob)	R	A	A
Cibicides mississippiensis (Cushman)			R
Cibicides pseudoungerianus (Cushman)			A

The Twiggs clay member is conformably overlain by the Irwinton sand member, and in east-central Georgia dips southeast about 15 feet per mile. West of the Ocmulgee River it becomes more calcareous and merges laterally into the Ocala limestone; east of the Ogeechee River it tongues into the lower part of the Barnwell formation of eastern Georgia, and may be equivalent to the Santee limestone of South Carolina.

Fuller's earth is mined from the Twiggs clay near Pikes Peak in Twiggs County and near Irwinton in Wilkinson County. Analysis of a sample from the Tivola tongue of the Ocala limestone in western Twiggs shows enough calcium carbonate equivalent to allow its use as an agricultural lime.

Irwinton sand member.—During this investigation it was noted that many dug wells throughout the "Red Hills" area obtained their water from a persistent bed of fine to coarse loose sand lying conformably on the Twiggs clay. It was also noted that the sand capped many of the uplands in the northern half of the area of outcrop of the upper Eocene deposits (see Plate 1). This sand bed, which is here named the Irwinton sand member of the Barnwell formation ranges in thickness from about 15 feet, along the northern margin of the outcrop area of the Barnwell formation, to a maximum of 52 feet in the vicinity of Irwinton.

Several good exposures of the Irwinton sand are present at the type locality in gullies on the Hatfield property 150 yards west of a cemetery which is 0.3 mile south of the courthouse at Irwinton along Georgia Highway 29.

SECTION EXPOSED IN GULLIES ON OLD HATFIELD PLACE, IRWINTON, GEORGIA.

	Feet
Colluvium	
4. Red coarse sandy clay	12±
Upper Eocene	
Barnwell formation	
Irwinton sand member	
3. Gray waxy clay, mottled red	3
2. Yellow and gray loose fine to medium quartz sand having many thin tough yellow clay layers	41
Twiggs clay member	
1. Pale-green, hackly clay with thin beds of fine angular quartz sand.	20+

In southern Washington, Wilkinson, and Twiggs Counties in the area where the coarse red sandy clay residuum of undifferentiated Miocene and Oligocene age caps the hills, thick sections of yellow and light-gray

fine to medium cross-bedded Irwinton sand can be seen in road cuts and gullies. As in the gully exposures at the type locality, the Irwinton sand in Washington, Wilkinson, and Twiggs Counties consists of 30 to 50 feet of light-colored yellow, gray and white fine to medium-grained micaceous quartz sand interbedded with thin gray and yellow clay layers, and an occasional bed of coarse white sand with carbonaceous zones. The Irwinton sand thins up dip to about 15 to 20 feet, at some localities becomes coarse-grained, and has an increasing number of clay beds, so that in southern Jones, Baldwin, Hancock and northern Washington Counties it contains about equally thick, 1- to 6-inch, alternating beds of fine, medium or coarse sand and yellow and gray clay layers. In east-central and southern Washington County the Irwinton sand contains thin siliceous limestone layers. A soft white limestone called the Sandersville limestone member[13] of the Barnwell is exposed in a quarry and several sink holes three-fourths of a mile southwest of the courthouse at Sandersville, Georgia, and contains an abundance of *Periarchus quinquefarius* (Say), *a Pecten* sp., and many pelecypod and gastropod molds. The Sandersville limestone member is believed to be equivalent in part to the Irwinton sand member, but may represent in part a still younger bed of Jackson age.

A section showing the stratigraphic relationship and lithology of the Irwinton sand member is seen in the Georgia Kaolin Company's pit No. 1 (See also Dry Branch Section X1, Figure 8).

SECTION X1 IN A KAOLIN PIT 3 MILES EAST OF DRY BRANCH, TWIGGS COUNTY

	Feet
Upper Eocene	
Barnwell formation	
14. Firm, massive coarse sand; mottled gray and pebbly in lower half.	6
Irwinton sand member	
13. Gray waxy clay, mottled red	3
12. Loose, white and yellow, fine-grained micaceous sand having thin layers of purple clay	20
11. Light gray bentonitic clay	8
10. Pink, buff, and gray very clayey sand	6
Twiggs clay member	
9. Gray fossiliferous marl	6
8. Greenish-gray nodular lime ledge	½
7. Buff and gray medium-hard sandy fossiliferous marl	4

[13] Cooke, C. Wythe, Geology of the Coastal Plain of Georgia: U. S. Geol. Survey, Bull. 941, p. 62, 1942.

6. Greenish-gray nodular lime ledge..... ½
5. Bluish-gray massive, blocky, fossiliferous marl..... 25
4. Pale-green hackly blocky clay..... 4

Ocala limestone (Tivola tongue)

3. Very fossiliferous cream-colored limestone, sandy in lower part. Contains *Periarchus pileus-sinensis* (Ravenel), abundant in lower part; bryozoa abundant in upper part. *Pecten spillmani* and *Ostrea sp*..... 18
2. Buff, medium-grained sand..... 12

Unconformity

Cretaceous

Tuscaloosa formation

1. White massive blocky kaolin..... 14+

The Irwinton sand lies conformably on the Twiggs clay, and is in turn overlain, with possible unconformity, by a coarse red sand containing scattered rounded, flat, polished beach pebbles. East of the Oconee River the Irwinton sand becomes an upper part of the undifferentiated Barnwell formation of eastern Georgia. West of the Ocmulgee River in the vicinity of Clinchfield, Houston County, the Irwinton sand member appears to be represented at least in part by the Cooper marl, which lies above the Twiggs clay. The Cooper marl of Houston County, together with the Twiggs clay, probably grades laterally into the Ocala limestone in western Georgia.

A study by S. M. Herrick[14] of the foraminifera from an exposure of Cooper marl in a road cut about 4 miles south of Clinchfield on U. S. Highway 341 revealed that the Cooper marl of this locality contains most of the foraminifera present in the Cooper marl of South Carolina, and a fauna definitely related to Cushman's Cocoa sand fauna of Alabama. Cushman's horizon is uppermost Jackson and higher stratigraphically than the Cocoa sand of Cooke.

List of foraminifera occurring in Cooper marl exposed in a ditch at top of a hill 4.3 miles south of overhead railroad bridge on U. S. Highway 341 near entrance to Penn-Dixie Cement Quarry at Clinchfield, Georgia.

[Identified by S. M. Herrick]

Textularia cuyleri Davis
Textularia recta Cushman
Textularia dibollensis Cushman and Applin
Textularia plummerae Lalicker

[14] Letter dated July 9, 1945.

Gaudryina cf. jacksonensis Cushman
Spiroloculina sp.
Robulus alato-limbatus (Gumbel)
Robulus limbosus (Reuss), var.
Robulus arcuato-striatus (Hantken), var.
Planularia sp.
Marginulina cocoaensis Cushman
Dentalina cooperensis Cushman
Dentalina cocoaensis (Cushman)
Dentalina jacksonensis (Cushman and Applin)
Dentalina hantkeni Cushman
Nodosaria latejugata Gumbel, var. carolinensis Cushman
Nodosaria longiscata D'Orbigny
Textularia mississippiensis Cushman, var.
Saracenaria cf. moresiana Howe and Wallace
Guttulina irregularis (D'Orbigny)
Guttulina problema D'Orbigny
Guttulina spicaeformis (Roemer)
Globulina gibba D'Orbigny, var. globosa (Von Munster)
Globulina gibba D'Orbigny, var. tuberculata D'Orbigny
Sigomorphina cf. jacksonensis (Cushman)
Nonion advenum (Cushman)
Nonion inexcavatum (Cushman and Applin)
Nonionella hantkeni (Cushman and Applin)
Plectofrondicularia sp.
Bulimina jacksonensis Cushman
Virgulina dibollensis Cushman and Applin
Bolivina jacksonensis Cushman and Applin
Boliv. jacksonensis Cushman and Applin, var. striatella Cushman and Applin
Robulus cf. gutticostata (Gumbel)
Uvigerina jacksonensis Cushman
Uvigerina glabrans Cushman
Uvigerina cf. yazooensis Cushman
Uvigerina cookei Cushman
Angulogerina ocalana Cushman
Discorbis assulata Cushman
Discorbis bulla Cushman
Valvulineria texana Cushman and Ellisor
Valvulineria jacksonensis Cushman
Gyroidina soldanii D'Orbigny, var. octocamerata Cushman and G. D. Hanna

Eponides jacksonensis (Cushman and Applin)
Spirillina vivipara Ehrenberg
Hantkenina alabamensis Cushman
Globorotalia cocoaensis Cushman
Siphonina jacksonensis Cushman and Applin
Planulina cocoaensis Cushman, var. cooperensis Cushman
Cibicides lobatulus (Walker and Jacob)
Cibicides preconcentricus Cushman
Cibicides pseudoungerianus (Cushman)

The Irwinton sand is a valuable aquifer for ground water in east-central Georgia. It is not a large producer, but yields an adequate supply of water to many shallow wells for domestic and stock use.

Upper sand member.—In the southern half of the area of outcrop of upper Eocene deposits a coarse red sand overlies the thin clay bed at the top of the Irwinton sand member. Characteristic of this bed in the area of this report are the flat polished beach pebbles scattered along the base of the bed. These pebbles are believed to be derived from flat fragments of the many resistant quartz veins in the weathered schist and gneiss of the Piedmont north of the Coastal Plain in eastern Georgia. The pebbles range from ¼ inch to 2 inches in diameter, and were probably rounded by wave action along a beach.

The upper sand member appears to lie unconformably on the Irwinton sand member and in this area it seldom exceeds 20 feet in thickness. It may represent a thin upper member of the Barnwell or possibly a thin residual bed of Oligocene or Miocene age. In the report it is considered the upper member of the Barnwell formation and was mapped as such.

A section showing the relationship of the upper sand member to the rest of the Barnwell formation is exposed in a road cut 1.1 miles southeast of Toomsboro along Georgia Highway 57 in the southeast bank of Camp Creek. A description of this section follows:

SECTION EXPOSED IN ROAD CUT 1.1 MILES SOUTHEAST OF TOOMSBORO ON GEORCIA HIGHWAY 57

	Feet
Upper Eocene	
Barnwell formation	
Upper sand member	
11. Red coarse-grained clayey sand with scattered flat rounded pebbles at the base	4
Irwinton sand member	
10. Pale greenish-gray waxy semi-blocky clay with many red ironstain blotches	4

9. Massive yellowish-tan fine-to medium-grained subangular quartz sand with many fine dark angular particles scattered throughout and many thin gray clay partings. Near base of bed and in upper part clay partings increase in thickness to 6 or 8 inches 50

Twiggs clay member

8. Pale greenish-gray hackly, blocky clay with thin fine sand streaks. In basal 15 feet the clay is more sandy and contains a few pelecypod molds 42
7. Brown and gray mottled clayey fine to medium sand. Partings of green waxy clay. Grades into the clay above 8
6. Tan, gray indurated nodular lime ledge ..... ½
5. Buff-yellow medium-grained clayey calcareous, fossiliferous sand 8
4. Pale greenish-gray indurated fossiliferous nodular lime ledge ..... ½
3. Pale-greenish gray hackly, blocky fossiliferous fuller's earth clay with lime nodules 3
2. Greenish-gray indurated nodular lime ledge ..... ½
1. Buff-tan very fossiliferous, argillaceous, calcareous, glauconitic sand 6

Unconformity (Elevation of Tertiary-Cretaceous contact approximately 230 feet. Cretaceous beds not exposed in section).

Fossils from yellow calcareous sand in beds 1 and 5 of above section.

(Identified by C. Wythe Cooke)

Periarchus lyelli (Conrad)
Bryozoans, undetermined
Pecten membranosus (Morton)
Ostrea sp.
Pelecypod, undeterminable
Gastropod, undeterminable

MIOCENE AND OLIGOCENE SERIES

UNDIFFERENTIATED MIOCENE AND OLIGOCENE DEPOSITS

A residuum of undifferentiated deposits of Miocene and Oligocene age overlies rocks of Eocene age in the southeastern quarter of Washington County, in Wilkinson County near Allentown, and along the southern line of Twiggs County. These deposits in Twiggs, Wilkinson, and east-central Washington Counties consist of mottled pink and gray coarse sandy clay, the weathering of which has produced a gray to yellowish gray sandy soil with many red ferruginous pellets scattered along the land surface. In southern Washington County in the vicinity of Harrison many road cuts expose beds of pale green clay containing

many scattered fine to very coarse angular quartz sand and some fine gravel. The sand and fine gravel content increases at some localities to form beds of clayey sand and gravel. The undifferentiated Miocene and Oligocene deposits in this area weather into light-colored sandy soils with many white quartz granules and fine gravel scattered along the land surface.

Most noticeable in the vicinity of the contact of the Eocene beds and the overlying undifferentiated Miocene and Oligocene residuum are the differences between the topography and soil of the two deposits. The area of outcrop of the Eocene beds is characterized by a series of hills capped by red sand and sandy loam. The relief of this area ranges from 100 to 250 feet and gullies of 50 to 100 feet in depth can be seen at some localities. In contrast to this, the topography of the area of outcrop of the undifferentiated Miocene and Oligocene deposits is characterized by gently rolling hills with broad rounded summits and the soils are light gray and yellowish gray sandy loams. The relief of the area rarely exceeds 50 feet. There is little dissection by streams, and only near the larger rivers do the slopes become steeper.

The exact location of the contact between these undifferentiated deposits, formerly mapped as Hawthorn and Flint River formations,[15] is difficult to ascertain because of the residual nature of most of the beds. Up dip, in this area, these deposits form a thin layer covering the upper part of the Eocene beds and fill sink-holes in these beds.

Because of the confused character of these deposits, mapping of the contact between the undifferentiated Miocene and Oligocene residuum and the Eocene deposits is necessarily inexact and has been done by observing changes in the soil and topography of the area in which the younger beds overlie the coarse Upper sand member of the Barnwell formation.

The undifferentiated Miocene and Oligocene residuum ranges in thickness from a few feet along the northern margin of its outcrop to 60 or 80 feet in southern Washington County.

The new Sandersville public water well drilled by Layne-Atlantic Company in June and July, 1944, at the City reservoir 1.6 miles south of Sandersville penetrated 60 feet of undifferentiated Miocene and Oligocene sediments overlying the Barnwell formation. A summary of the log of this well fellows:

[15] Cooke, C. W., Geology of the Coastal Plain of Georgia, U. S. Geol. Sur. Bull. 941, pp. 77, 84-89, 98, 1943.

CONDENSED LOG OF CITY OF SANDERSVILLE WELL
(Top of well 465 feet above sea level)

	Thickness (feet)	*Depth (feet)*
Tertiary		
Undifferentiated Miocene and Oligocene deposits	60	60
Eocene		
Barnwell formation (Includes basal Twiggs clay member, Irwinton sand member, and the Upper sand member. Approximately 40 feet of Sandersville limestone was present and appeared to represent a part of the Irwinton sand	190	250
Channel sand ? (coarse gravelly sand)	16	266
Cretaceous		
Upper Cretaceous		
Tuscaloosa formation	605	871
Pre-Cambrian		
Crystalline basement rock	1.5	872.5

GEOLOGIC SECTIONS IN EAST-CENTRAL GEORGIA

Figure 8 shows four sections in the outcrop area of the Barnwell formation. A detailed description of the sections in figure 8 have been given previously in this paper.

In each case the elevation is given for the top of the Tuscaloosa formation and the beds of the sections are scaled, in feet above sea level, from that point. The irregular base in figure 2 indicates down the dip variations in elevation above sea level of the top of the Tuscaloosa formation instead of structure.

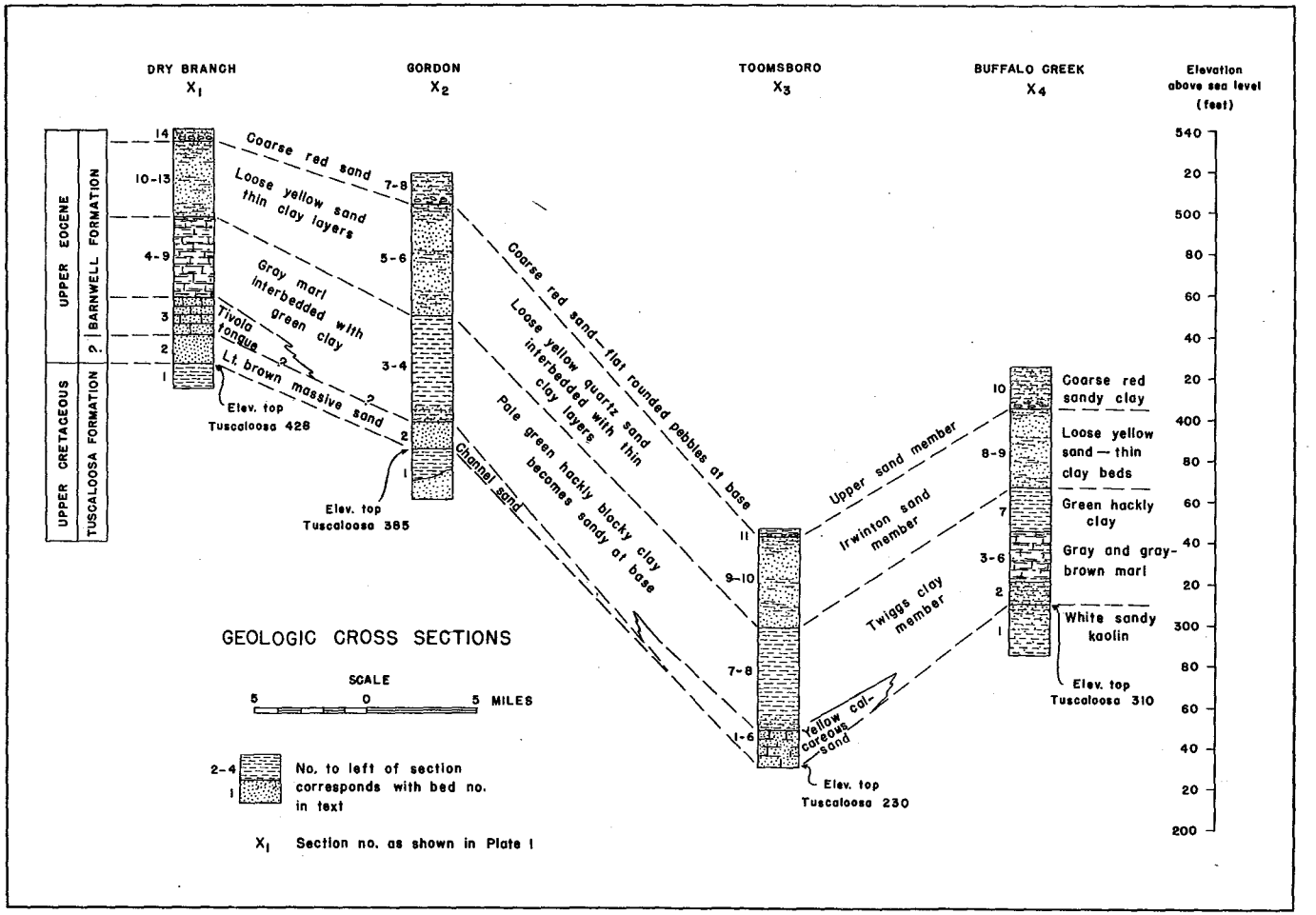

Figure 8. Four geologic cross sections exposed at locations marked X in figure 1

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