The Stratigraphic Framework of the Fort Valley Plateau and the Central Georgia Kaolin District

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26th Annual Field Trip
Georgia Geological Society

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Figure

INTRODUCTION

The lithostratigraphic units that comprise the kaolinitic sand deposits of the inner Coastal Plain of Georgia have not hitherto been adequately subdivided. The objective of this field trip in the Fort Valley Plateau area and the eastern part of the central Georgia kaolin mining district, therefore, is to introduce to the geologic public a lithostratigraphic subdivision of these largely unnamed and undifferentiated deposits (Fig. 1, 2, and 3). The kaolinitic sand deposits, at one time largely included in the Tuscaloosa Formation by Cooke (1943), are here subdivided into two groups: the Oconee Group that is of fluvial origin, and the Fort Valley Group that is of coastal marine (estuarine, bay, sound, lagoon, barrier island?, and shore face) origin. The Oconee Group and Fort Valley Group interfinger and intergrade (Fig. 4).

Of the established lithostratigraphic units that are included here in the Oconee Group, only the Huber Formation is recognized in Georgia. The Middendorf and Cape Fear Formations of the Carolinas are included in the Oconee Group but are not recognized to extend westward into Georgia. The established lithostratigraphic units that are included here in the Fort Valley Group include the Providence Sand and Baker Hill Formation. The Eutaw Formation and Cusseta Sand in their strict lithostratigraphic senses may also be considered as a parts of the Fort Valley Group although they are not known to extend into the Fort Valley area.

New lithostratigraphic units of the Oconee Group that are formally proposed here include from oldest to youngest: the Pio Nono Formation and Gaillard Formation of Late Cretaceous age, the Buffalo Creek Kaolin Member of the Gaillard Formation, and the Marion and Jeffersonville Members of the Huber Formation of Early Paleocene, Midwayan age and late Middle Eocene age, late Claibornian age respectively. New lithostratigraphic units of the Fort Valley Group include from oldest to youngest: the Nakomis Formation of Late Cretaceous Age, the Marshallville Formation of Early Paleocene, Midwayan Age, and the Mossy Creek Sand and Perry Sand of Middle Eocene, late Claibornian Age. Other locally mappable stratigraphic units described here include the Butler-Allon channel deposits in the Fall Line Hills area near the Flint River, Upper Eocene channel deposits east of the Ocmulgee River (channel deposits of LaMoreaux, 1946a, 1946b), and "high terrace" fluvial deposits of both the Flint and Ocmulgee Rivers.

It is not our intent in this guidebook to present a finished lithostratigraphic product. Rather, our purpose is to lay a lithostratigraphic foundation based on the various codes of stratigraphic nomenclature, upon which further geologic studies and stratigraphic refinements may be made.

This effort began in 1975 with the initial measuring and describing of mainly Upper Eocene sections in the kaolin pits of central and eastern Georgia. We recognized that an understanding of the entire fluvial, kaolin-bearing, Cretaceous sediments could not be accomplished within the kaolin mining areas because the principle lithologies for subdividing the lithostratigraphic units, the sand components of the deposits, were not penetrated in the kaolin mines. We therefore sought out lateral equivalents west of the Ocmulgee River. There, in the Fall Line Hills, we were able to define a predominantly sand formation (the Gaillard Formation), containing kaolin lenses of varying sizes and purity. This formation was consistently found to underlie kaolinitic sand deposits that we were able to correlate physically (and in several instances biostratigraphically) southward in the vicinity of the Flint River, and Clinchfield, Georgia, with standard Midwayan and upper Claibornian formations. Therefore, during the middle seventies, the skeletal lithostratigraphic framework as presented in this guidebook was established.

During subsequent scattered field trips and field sessions, we were able to establish the presence of the Gaillard Formation in eastern Georgia and western South Carolina, and also the absence of the Middendorf and Cape Fear Formations in Georgia. Concurrently, we were able to establish the lithostratigraphic basis of the Midwayan and upper Claibornian components of the Huber Formation and their facies relationships with correlative deposits west of the Ocmulgee River. The subsequent recognition of a coastal marine component of the kaolinitic sand series (Fort Valley Group) and fluvial-braided stream series (Oconee Group) greatly increased the capacity for lithostratigraphic resolution of these deposits. Still, all of the lithostratigraphic units described here are closely related paleoenvironmentally and there is locally some substantial lithologic overlap between the lithologies of the

LOCATION MAP

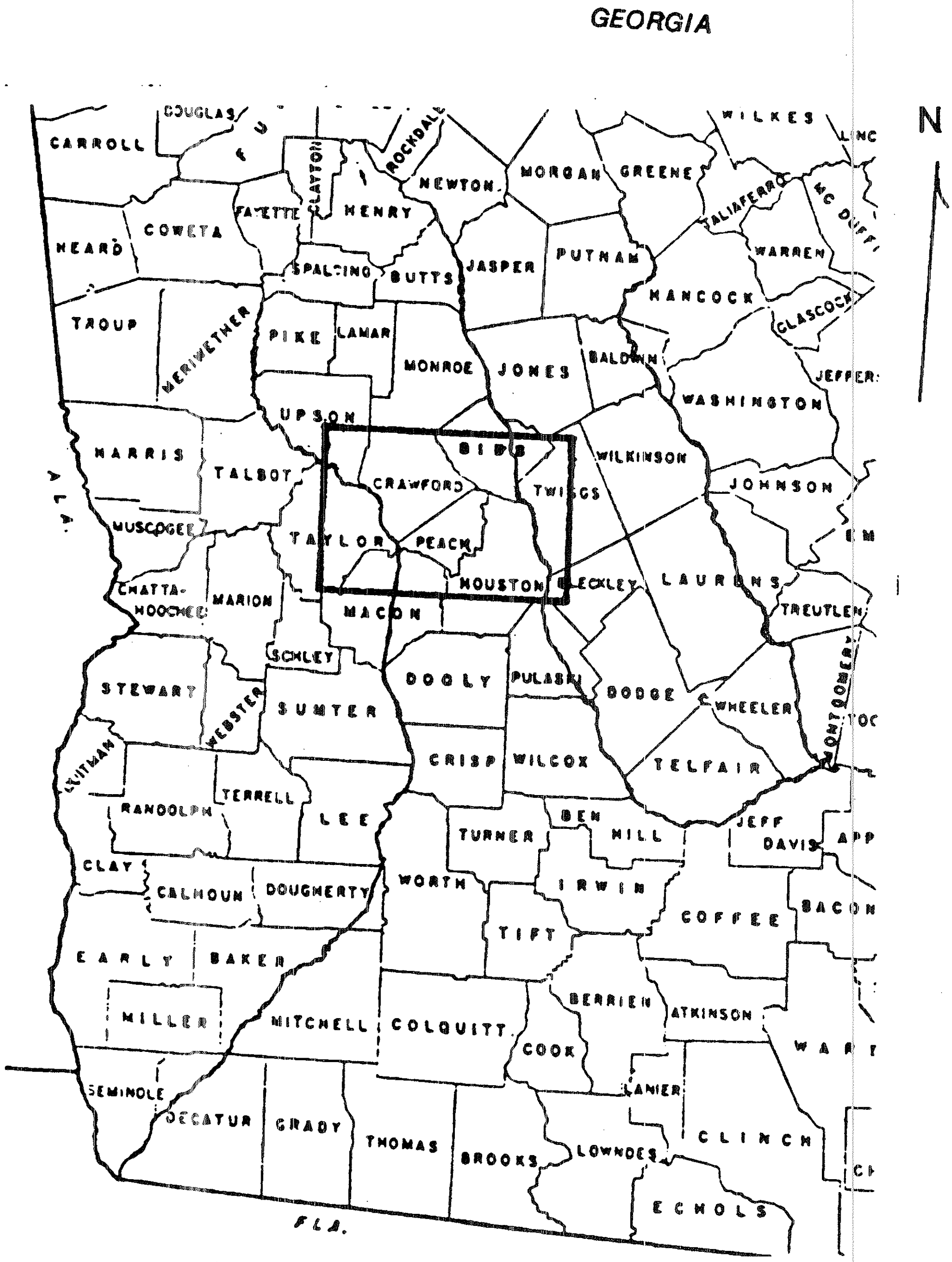


FIGURE 1

FIGURE 2

FIELD TRIP – FIRST DAY

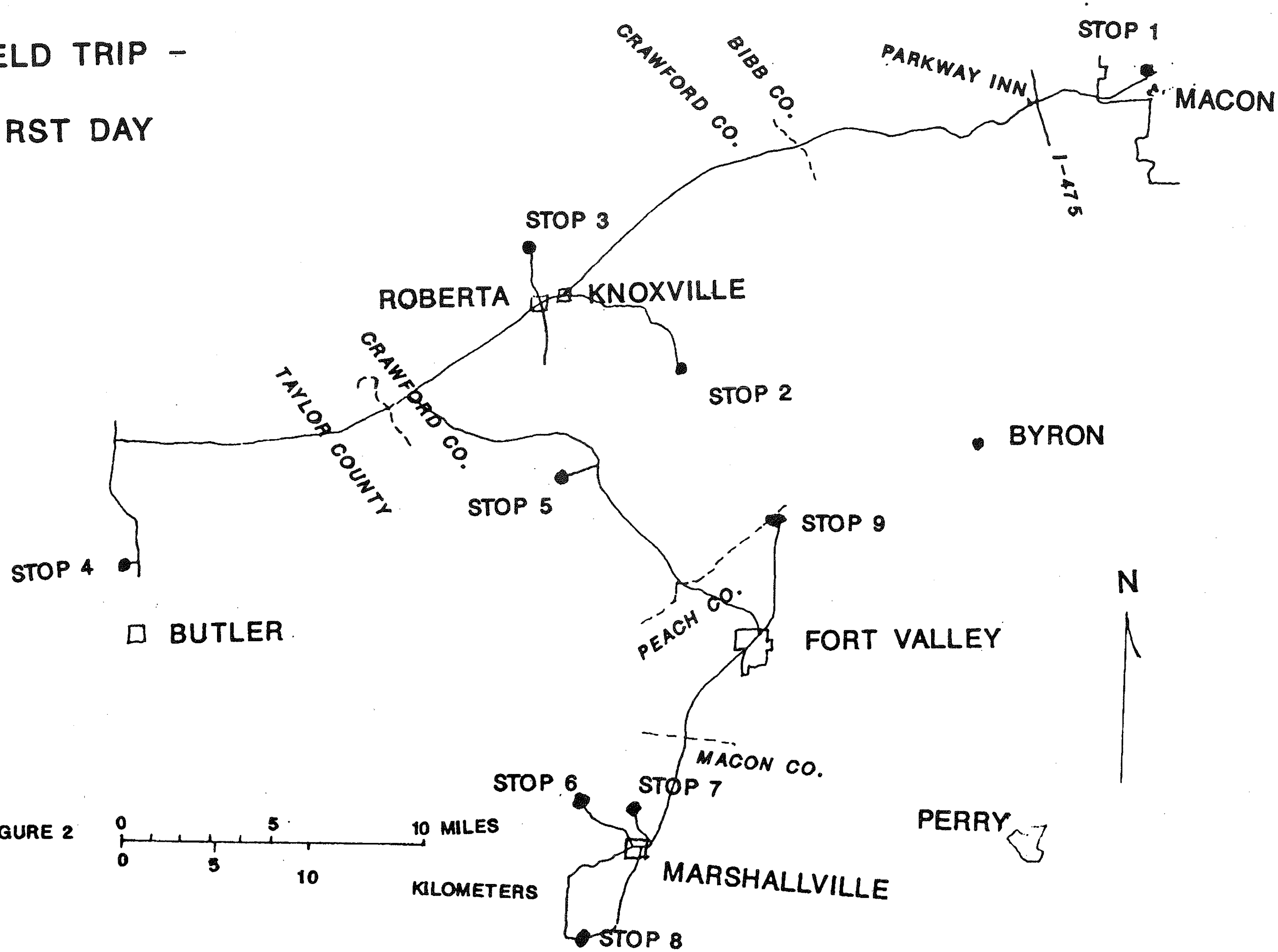
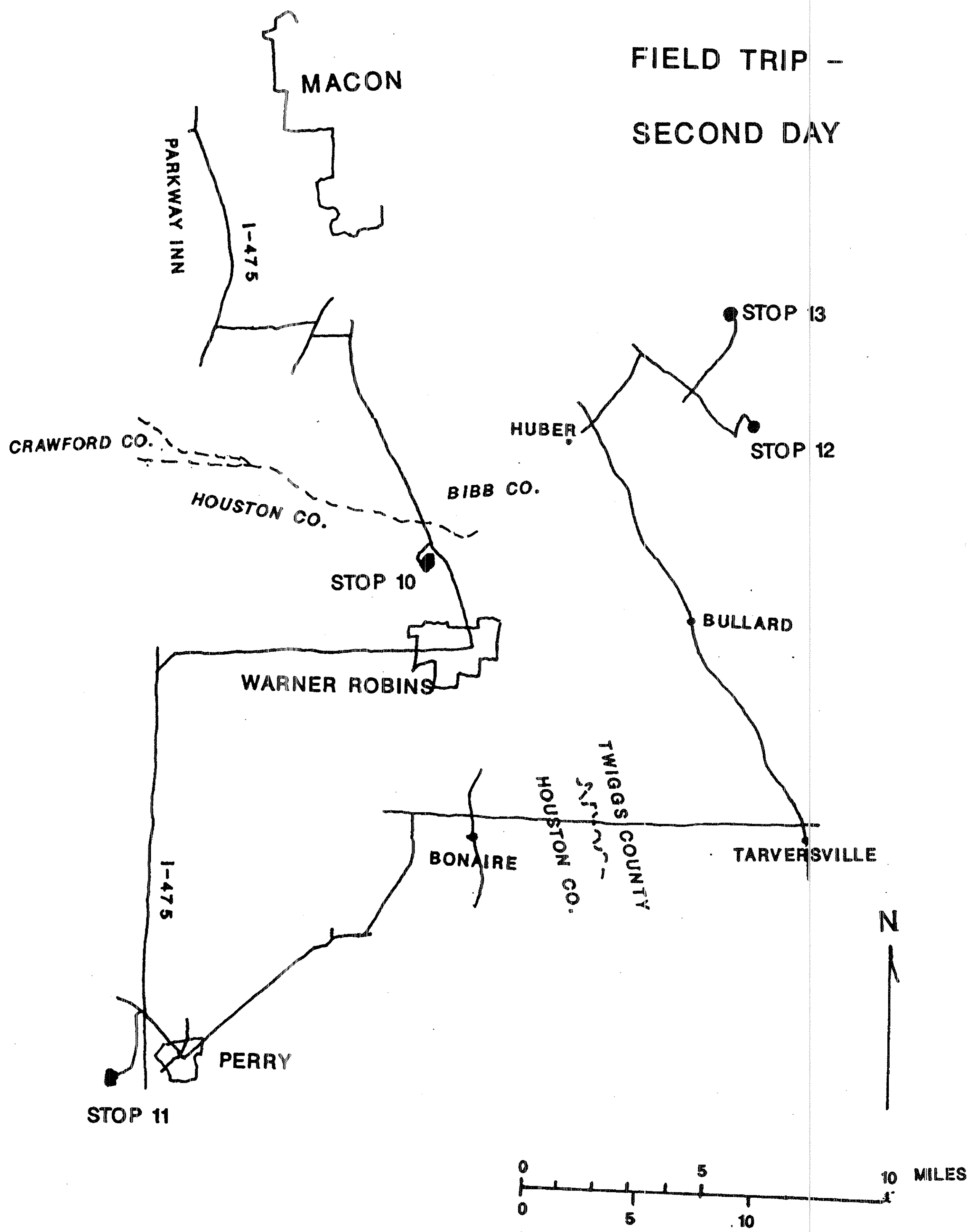


FIGURE 2

FIGURE 3


FIELD TRIP -
SECOND DAY
MACON
PARKWAY INN
I-475
STOP 13
HUBER
STOP 12
CRAWFORD CO.
BIBB CO.
HOUSTON CO.
STOP 10
BULLARD
WARNER ROBINS
TWIGGS COUNTY
HOUSTON CO.
BONAIRE
TARVERSVILLE
I-475
N
PERRY
STOP 11
0
5
10
MILES
0
5
10

CORRELATION CHART

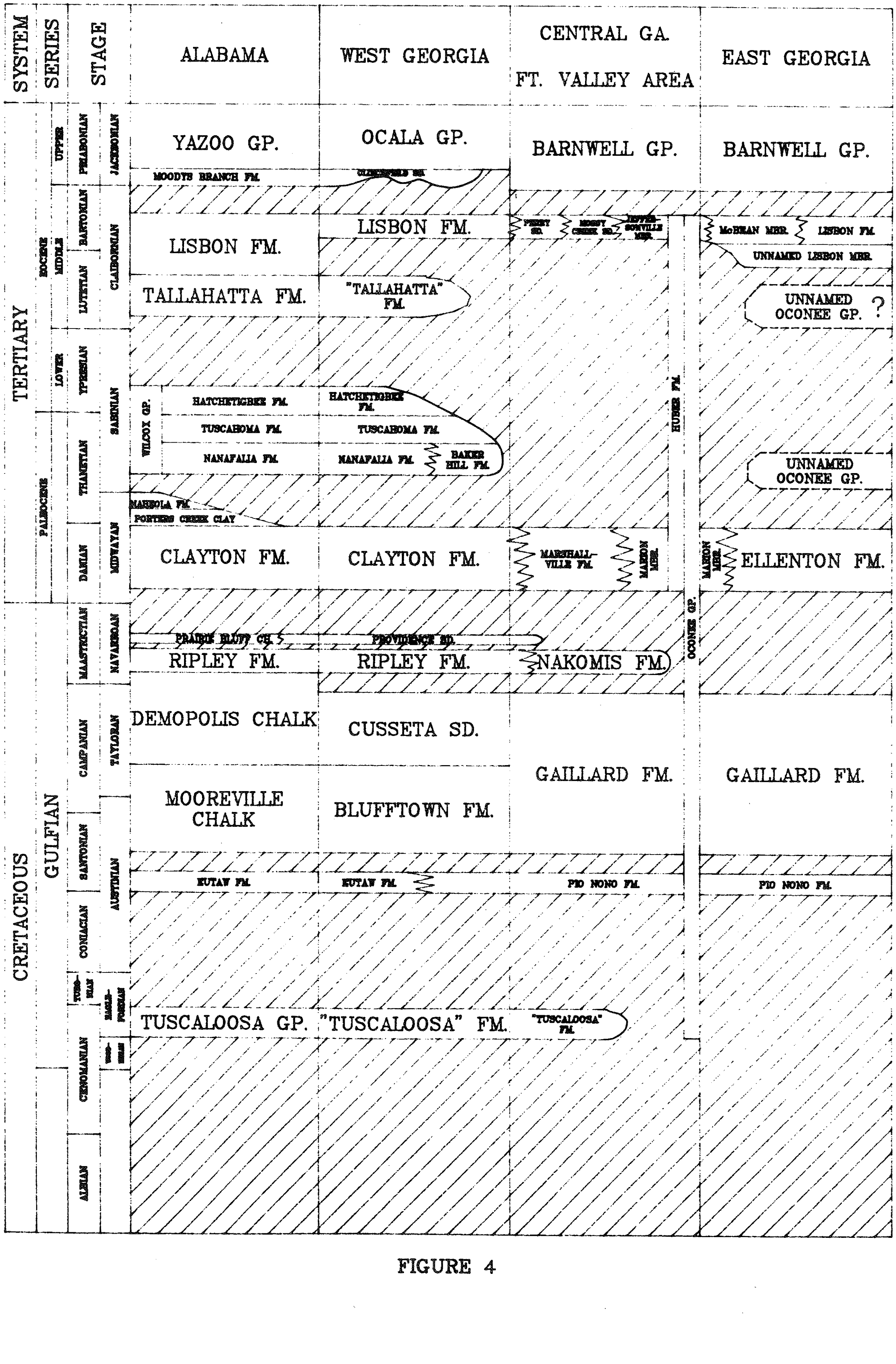


FIGURE 4

various units. However, this is also true for any stack of lithostratigraphic units of similar environmental origin, whether they are deep-sea oozes; far-offshore, microfossiliferous calcarenites; continental shelf, coquinoid-subcoquinoid limestones; nearshore sands; or continental shelf clays. Indeed, the lithostratigraphic subdivision of the Barnwell, Hawthorne, and Alum Bluff Groups have been hampered in the past by these internal lithologic similarities. The problem has been greater for the Upper Cretaceous to Lower Tertiary, kaolinitic sands of the Fall line region of Georgia and the Carolinas due to their unusual nonfossiliferous lithologies that stratigraphers are not accustomed to differentiating, and to their internal lithologic similarities. Within some formations there may be considerable overlap of some of the lithologies, but little overlap in other lithologies. It is in finding the larger exposures with the greatest numbers of beds and stratigraphic units present that one can most easily distinguish these formations from each other. In small exposures, such as small road cuts or sand pits, it may be very difficult to distinguish one formation from one another if the specific lithology exposed is a characteristic lithology of one or more formations but is exceptional for the formation exposed in question.

GEOLOGIC SETTING

The geologic setting of the field trip area is the zone of facies change between the well-known Chattahoochee and Flint Rivers sections of southwestern Georgia and the kaolin mining district of central and eastern Georgia). The Chattahoochee and Flint River sections are characteristic of eastern Gulf Coastal Plain stratigraphic suites of marine, continental shelf origin. The fluvial, kaolinitic stratigraphic suites are unique to the inner Coastal Plain of central Georgia to North Carolina. In outcrop, the zone of facies change, from marine, continental shelf deposits through coastal marine to fluvial deposits, occurs predominantly in the Fort Valley Plateau District of Georgia, between the Flint and Ocmulgee Rivers and the narrow band of Fall line hills immediately north of the plateau Fig. 5). West of the Flint River, the stratigraphic section gradually merges westward into the coastal marine and offshore section of the Chattahoochee River valley. East of the Ocmulgee River, the inner Coastal Plain maintains largely the same stratigraphic section into western South Carolina.

It is within this area between the Flint and Ocmulgee Rivers that large scale facies changes occur in the various chronostratigraphic or depositional units. Eastward from the Flint River the facies change occurs from the offshore, inner continental shelf, Flint River section into the largely fluvial facies exposed in the kaolin mining area of Georgia. It is, therefore, within this small area between the Flint and Ocmulgee Rivers, and to some extent west of the Flint River, that each of the depositional units can be traced in outcrop and cores from offshore, continental shelf deposits through coastal marine deposits, and into fluvial deposits (Fig.6).

PHYSIOGRAPHIC SETTING

The field trip area occurs largely within the Fall Line Hills and Fort Valley Plateau Districts between the Flint and Ocmulgee Rivers. Brief stops will be made both west of the Flint River and east of the Ocmulgee River in order to tie those sections or lithofacies into the principal area of interest between the rivers. Within the main part of the field trip area, the Oconee Group is exposed in outcrop in the Fall Line Hills and only minor and thin exposures of Fort Valley Group are present there. On the other hand, the great volume of deposits exposed in the Fort Valley Plateau District consist of the Fort Valley Group and the Oconee Group occurs at low elevations in the northern part of the district and in the subsurface to the south. The Oconee Group occurs some distance south of the Fort Valley Plateau and in the deeper subsurface where it grades laterally seaward or downdip into coastal marine to continental shelf deposits. On the other hand, the southern limit of much of the Fort Valley Group is near the southern limits of the Fort Valley Plateau, near the Perry Escarpment at Clinchfield and south of Perry.

STRIKE CORRELATION CHART

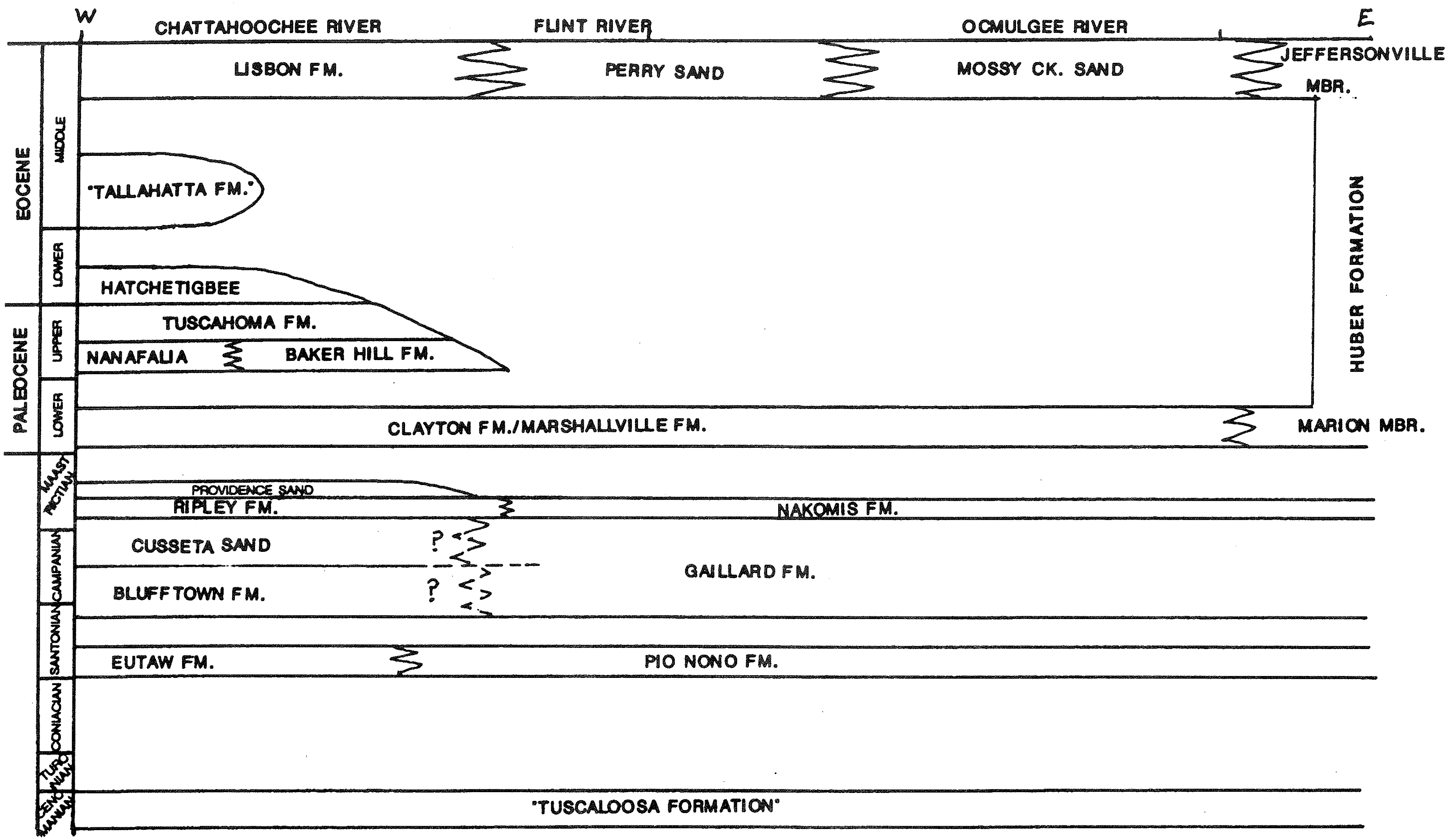


FIGURE 5

FLINT RIVER SECTION

UPDIP-DOWNDIP CORRELATION CHART

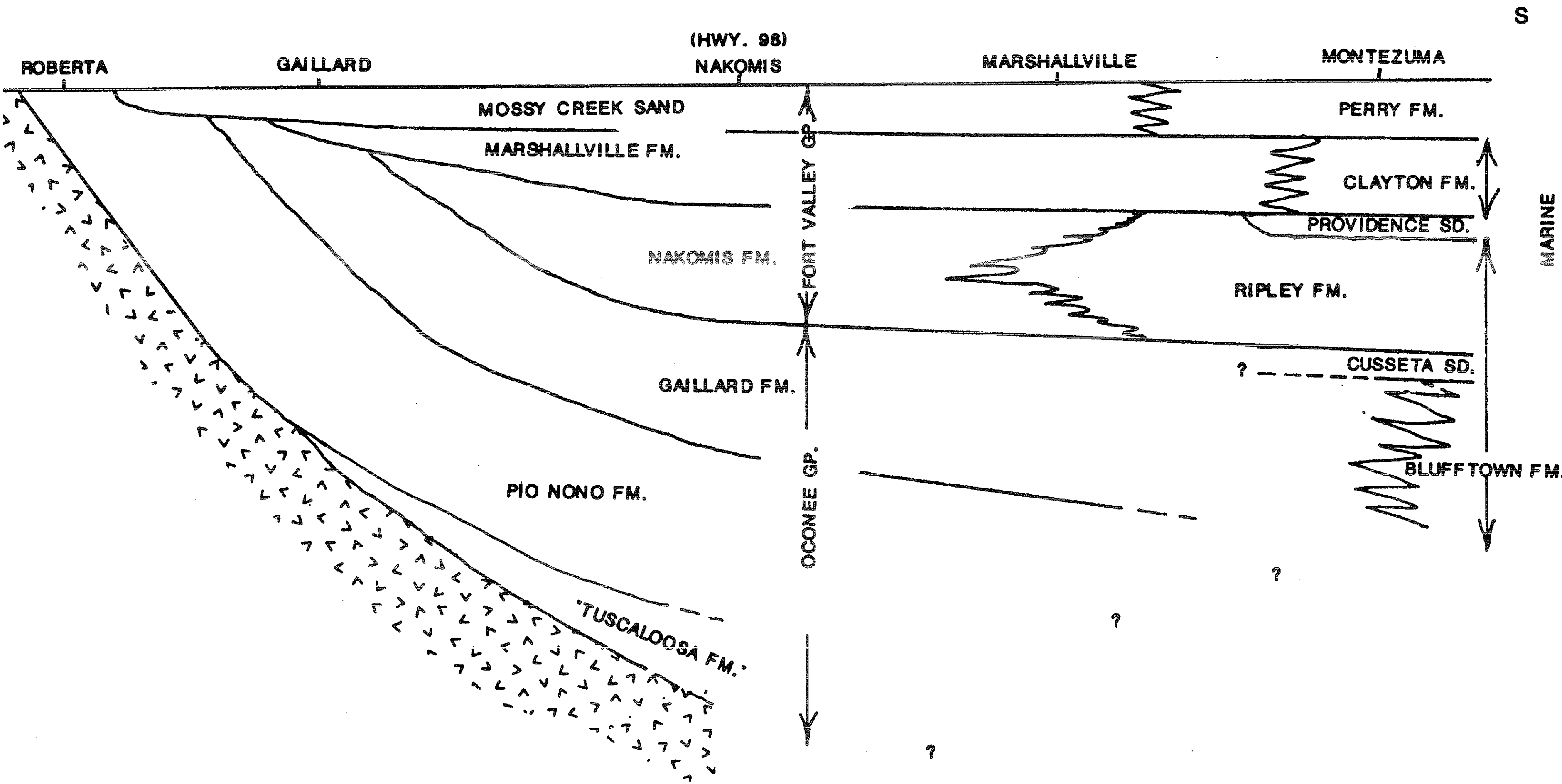


FIGURE 6

LITHOSTRATIGRAPHY

OCONEE GROUP (new name)

DEFINITION

The Oconee Group is a new group that was introduced informally by Huddlestun (1981) and Schroder (1982). The Oconee Group includes all of the pre-Upper Eocene, or pre-Barnwell Group kaolin and kaolinitic sand deposits of fluvial origin in the Fort Valley Plateau and Fall Line Hills districts of the Coastal Plain of Georgia (Cooke, 1925; Fenneman, 1938), and in the Fall Line Hills district of Alabama, South Carolina, and North Carolina. The group includes the following formations in decreasing order of age: "Tuscaloosa formation" of western Georgia, Pio Nono Formation, Cape Fear Formation, Gaillard Formation, Middendorf Formation, and Huber Formation. In contrast, the Fort Valley Group (new name) includes all of the pre-Upper Eocene kaolinitic and kaolinitic sand deposits of coastal marine origin in the Fort Valley Plateau and the Fall Line Hills districts of Georgia, and the Fall Line Hills district of Alabama and South Carolina. Although closely related lithologically, the introduction of these two new groups is considered essential to the field recognition and differentiation of the various kaolinitic sand deposits. For example, as many times as the senior author as examined the Providence Sand in the Providence Canyons in Stewart County, Georgia, the Providence Sand had always appeared to be an ambiguous part of the mass of the kaolinitic sand deposits of Alabama, Georgia and the Carolinas. However, once we had recognized a lithologic distinction between the kaolinitic sand deposits of fluvial origin and that of coastal marine origin, it was immediately apparent on brief inspection that the Providence Sand is of coastal marine origin and belonged in the Fort Valley Group.

There have been no previous attempts to subdivide the kaolinitic sand deposits of the Fall Line Hills district of the southeastern United States into more than one or two large, inclusive lithostratigraphic units. These deposits have been considered to be one formation in central and eastern Georgia and South Carolina (i.e., Lower Cretaceous of Veatch and Stephenson, 1911; Middendorf Formation of Smith, 1929; Tuscaloosa formation of Cooke, 1936, 1943; in part of Siple, 1967). However, neither the Providence Sand nor the Baker Hill Formation were included with the rest of the mass of kaolinitic sands with which they are physically continuous.

The Oconee Group of this report is the lower Cretaceous of Veatch and Stephenson (1911); the Middendorf Formation of Cooke (1926) and Smith (1929); the Tuscaloosa Formation of Cooke (1936, 1943), LeGrand and Furcron (1956), Herrick (1961), LeGrand (1962), Herrick and Vorhis (1963), and in part Siple (1967); Eargle (1955) considered most of the kaolinitic sand deposits in question to be undifferentiated Cretaceous but he also mapped them as Tuscaloosa Formation, Cusseta Sand, Blufftown and Eutaw Formations undifferentiated, Eutaw Formation (in part), Blufftown Formation (in part) and Cusseta Sand (in part). Georgia Geological Survey (1976) mapped the Oconee Group as undifferentiated Tertiary-Cretaceous.

The named formations that constitute the Oconee Group include "Tuscaloosa formation" of western Georgia (the typical Tuscaloosa Group of Alabama does not crop out in Georgia and the type Tuscaloosa is not a component of the Oconee Group), the Cape Fear Formation of North Carolina and South Carolina, the Middendorf Formation of eastern South Carolina (Sloan, 1908), and the Huber Formation of Georgia and South Carolina (Buie, 1978; Nystrom and Willoughby, 1982). New formations of the Oconee Group that are described here include the Pio Nono Formation, Gaillard Formation, and the Marion and Jeffersonville Members of the Huber Formation. An unnamed subsurface formation of the Oconee Group occurs between the Ellenton Formation and the marine Claibornian in the subsurface of Burke County.

The name Oconee Group is proposed in this report because the lithologies of the formations that comprise the group are all closely related and distinctive. The formations of the Oconee Group are characterized by being prominently, even strikingly stratified, with horizontal- and undulatory-bedding, cross-bedding (planar and trough cross bedding), and thin to thick bedding. Sorting is moderate to poor, with rare, well sorted sands. The sediment is fine- to coarse-grained and pebbly or gravelly in the sand fraction, finely to coarsely micaceous, kaolinitic (rarely smectitic or bauxitic), and pale gray to white or brightly pigmented.

The Oconee Group consists predominantly of fluvial sediments. The dominant lithic component is quartz sand but small to large lenticular masses of micaceous, sandy, to relatively pure kaolin, and small to large lenses of variably carbonaceous and lignitic sands and clays also occur locally. Typical Oconee Group deposits consist of a series of fining upward units or sequences with gravelly to pebbly coarse sand occurring at the base of a sequence and fine sand or kaolin lenses at the tops of the sequences. Commonly the fining upward sequences are truncated by subsequent, intraformational disconformities. Channel cut-and-fill structures of small to large scale are commonly well-exposed in kaolin pits.

TYPE LOCALITY

It is with hesitation that we assign a type locality and especially a type section for the Oconee Group. Due to the great susceptibility of the Oconee Group sediments to mechanical erosion and to the great thickness of the group (at least 1000 feet [305 m] thick), there are no useful, naturally occurring, significantly large outcroppings of Oconee deposits that expose more than one formation. The useful and informative exposures occur in kaolin pits and sand pits, all of which are ephemeral and most of which are due to be reclaimed, or filled in, in the near future. Therefore, any type locality and type section that is assigned at the present time (circa 1991) will be lost within a few years. In addition, Oconee Group deposits are characterized by rapid and abrupt lithofacies change within short distances. Because of continuous mining activities, particular sections are exposed and consumed within periods of days, weeks, or months. As a result, any specific section that is exposed during excavation will likely be gone within a year. As a result, it is probably most useful to consider all of the type sections of the various formations of the Oconee Group as a composite type section for the group.

The name Oconee is taken from the Oconee River in Georgia, that flows through the heart of the Georgia kaolin mining district.
This area that extends from the vicinity of the Ocmulgee River in the west, into Washington County, Georgia, in the east, is considered the type area of the group. In outcrop, the formations that constitute the Oconee Group in its type area include the Pio Nono, Gaillard, and Huber Formations.

In the future, workers wishing to understand the concept of the Oconee Group as presented in this report would avail themselves of any useful exposures in the type area, near the Oconee River in Wilkinson and Washington Counties, Georgia, that may be present then.

LITHOLOGY

The Oconee Group is a massive sand apron probably formed by braided streams and rivers disgorging their load of Piedmont chemical and physical erosion debris on an adjacent and narrow, coastal plain between the eroding Piedmont terrain and the continental shelf in the Suwannee Strait. The Oconee Group is characteristically a body of sand with subordinate interstitial clay and clay lenses that consist largely of kaolin with local or trace volumes of smectitic clays and bauxite. In the Gaillard, Middendorf, and Huber Formations, the sand body is characteristically white to light gray in color. The Pio Nono Formation, however, typically is deeply weathered over most of its surface and subsurface extent, indicating that the high pigmentation of the formation is penecontemporaneous with deposition. There are, however, numerous intervals, especially in the upper part of the Pio Nono Formation that have little pigmentation and resemble the Gaillard Formation. The "Tuscaloosa formation" of western Georgia varies from white to dark gray, to highly pigmented.

The sands of the Oconee Group are prominently, and in many places, strikingly stratified, with horizontal- to undulatory- bedding, and planar and trough cross bedding on small to large scales. The sands are laminated to thickly bedded, with sharp to gradation bed boundaries, finely to coarsely micaceous, with common occurrences of dark minerals. The sands are locally feldspathic, kaolinitic (rarely smectitic or bauxitic), well- to poorly sorted, fine- to coarse-grained sand with common occurrences of pebbles, gravel, and clasts and cobbles of kaolin, and small to large lenses and irregular-shaped masses of kaolin.

In kaolin pits and sand pits in the type area in central Georgia, the Oconee Group deposits can be seen to consist commonly of a series of fining-upward sequences. The basal sediments of a fining upward sequence generally are rudely cross-bedded, poorly sorted, pebbly to gravelly, kaolinitic sand with variable quantities of kaolin clasts and kaolin cobbles (rarely bauxite or pseudo-bauxite cobbles). These basal pebbly sands generally become finer grained, better sorted, more thinly cross-bedded to horizontal bedded, and more micaceous upward in the sequence. The upper part of a fining-upward sequence generally consists either of dark mineral-rich, moderately to well-sorted, undulatory to horizontal bedded, fine- to medium-grained sand or of small to large lenses of finely sandy and micaceous to relatively pure kaolin. Commonly the tops of fining-upward sequences have uneven surfaces, indicating some scour and erosion prior to the sedimentation or filling of the overlying fining-upward sequence. These fining-upward sequences generally cannot be traced across large pits and, therefore, are not laterally continuous. They are especially characteristic of the Oconee Group in its type area but are not so obvious, or are absent, outside of the type area.

The Oconee Group is characterized by the presence of small to large lenses of irregular-shaped masses of kaolin. The lenses of kaolin range in thickness from a few feet (less than 1 m) to approximately 50 feet (15 m), and in extent from several hundred square yards (approximately several hundred square meters) to several hundred acres. Kaolinite is generally the only clay mineral in the clay lenses. Smectite and illite also occur with kaolinite in the upper part of the group and near the downdip or seaward limits of the group.

Lenses of carbonaceous to lignitic sand, kaolinitic sand, and kaolin commonly occur scattered throughout some formations of the Oconee Group. The organics occur as finely disseminated carbonaceous material, as lignitic or carbonaceous flecks of uncertain origin, and as discrete carbonized fragments of woody material (lignite) and carbonized impressions of vegetation. Generally the carbonaceous lenses grade in all directions into noncarbonaceous sand, kaolinitic sand, or kaolin. The organic content of the lenses range from minor (based on gray coloration of the sediment due to finely disseminated carbonaceous material in the sand and kaolin, to lenses of almost pure carbonaceous lignite.

One of the most vexing problems in discriminating between the various formations and members of the Oconee Group and Fort Valley Group is the common occurrence of poorly sorted, pebbly, kaolinitic coarse sands and beds or lenses of sedimentary kaolin in most of the units. Whether they occur in the Oconee Group or in the Fort Valley Group, these lithologies are common to both of the groups. Added to this is the lithologic peculiarity of the Oconee and Fort Valley Groups. To our knowledge, sedimentary kaolinitic sand deposits in the Coastal Plain of eastern North America are restricted to the inner Coastal Plain of eastern Alabama to North Carolina. Lithologically the Oconee and Fort Valley Group are unique and, with common peculiarities extending through the groups, it is not surprising that lithostratigraphic subdivision has proved to be so difficult. Stratigraphers and mappers have not been trained to discriminate and differentiate between sedimentary deposits of this nature.

The problem is basically that the geologist is confronted with an unusual system of braided river deposits and the coastal marine environment where the rivers disgorge their bed and suspended loads. From our experience, the various lithostratigraphic subdivisions can be distinguished in the field, and commonly in cores, where many parameters of the paleoenvironment have influenced the lithology of the deposits. It is where few or even only one parameter of the paleoenvironment dominates the other parameters that lithologic differentiation becomes difficult if not impossible. This is especially the case of sediments deposited under high current energy or diminishing high current energy conditions, e.g., the sand, channel-fill deposits that are characteristically poorly sorted, kaolinitic, pebbly or gravelly, and variably micaceous. This particular lithology appears to be characteristic not only of the fluvial deposits but also of what must be tidal channel deposits in the coastal marine environment. Not only is this particular lithology characteristic of and indistinguishable between units of the Oconee and Fort Valley Groups, but it also recurs in the basal part of the Upper Eocene channel deposits and in the Miocene Altamaha Formation (which is merely a Miocene counterpart of the Oconee Group). Therefore, the geologist must ignore certain lithology types when seeking to identify the various lithostratigraphic subdivisions of the Oconee Group and Fort Valley Group and concentrate on deposits of lower energy origin in which the lithologies are more characteristic.

STRATIGRAPHIC RELATIONSHIPS

The outcrop belt of the Oconee Group extends from eastern Alabama eastward through South Carolina into North Carolina. The updip limit in Georgia is the Fall line. The Oconee Group was probably deposited originally some distance north of the present Fall Line because there are several outliers of the group north of the Fall Line. It is concluded, therefore, that an indefinite amount of Oconee Group deposits have been largely removed by subsequent erosion and the original updip limits of the group are unknown.

Upper Cretaceous and Lower Tertiary formations of the Oconee Group grade seaward into various correlative Upper Cretaceous and Lower Tertiary coastal marine and marine formations. Due to differing high and low stands of the sea during the Late Cretaceous and Early Tertiary, the subdivisions of the Oconee Group grade into coastal marine deposits and marine-equivalent deposits at differing distances from the Fall line. In other words, the position of the strand line relative to the Piedmont Province fluctuated during the deposition of the Oconee Group. The lithofacies change from the Jeffersonville member of the Huber Formation to the Lisbon Formation represents the most updip position of facies change of Oconee deposits to deposits of normal marine, continental shelf origin. This line of facies change extends from Bleckley County eastward through Laurens County, central Jefferson County, and northern Burke County and southernmost Richmond County.

The most seaward extension of the Oconee Group occurs in the lower Upper Cretaceous, probably Tuscaloosa-equivalent in Georgia. Each subsequent depositional episode during the Late Cretaceous resulted in a marine overlap of the older Cretaceous deposits. The Late Cretaceous marine transgressions peaked in the Suwannee Strait region during the early Maastrichtian (deposition of Ripley Formation). The subsequent deposition of the middle Maastrichtian Providence Sand (Fort Valley Group) was offlap of the lower Maastrichtian. The southernmost limit of the Oconee Group in the subsurface extends from southern Quitman County in western Georgia, eastward through northern Randolph, Terrell, Lee, Crisp, northern Montgomery, to Screven County in the east.

The Oconee Group unconformably overlies both Piedmont metamorphic rocks and, locally, triassic red sandstones and shales of the Newark Group in relatively updip positions. In the downdip area of its occurrence, it may overlie the updip feather-edge of the Lower Cretaceous which is not here assigned to the Oconee Group. The Oconee Group is disconformably overlain by the Barnwell Group in outcrop in the Fall Line Hills district and, progressively down the dip and in different areas, by the Mossy Creek Sand, Perry Sand, Lisbon Formation, Marshallville Formation, Nakomis Formation, and Ripley Formation. Near the downdip limits of the Oconee Group, present information is too fragmentary to determine precisely the sequence of facies change and interfingering of the various units of coastal marine and marine origin into the group.

The thickness of the Oconee Group is known only approximately in most places because it is generally thick, and few wells penetrated the group to basement. From the fall line it thickens greatly southward with the top of the pre-Coastal Plain basement dipping between 55 and 100 feet per mile (10 to 19 m per km) southward in western and central Georgia (Eargle, 1953; 1955, p. 8; and from less than 25 feet to 50 feet per mile (4.7 to 9.5 m per km) in eastern Georgia (LeGrand and Furcron, 1956; Gorday, 1984. Because the Jeffersonville member of the Huber Formation grades laterally into the Mossy Creek Sand and Lisbon Formations from 20 to 25 miles (32 to 25 km) south of the Fall line, the Oconee Group can be expected to be at least 1000 feet (305 m) thick before it begins to thin due to facies change and interfingering into deposits of coastal marine to continental shelf origin.

The environment of deposition of the Oconee Group is fluvial and is postulated to be of braided stream origin. This conclusion is based in part on negative evidence. Sedimentary features that can be interpreted as of marine or coastal marine origin (burrows, especially **Ophiomorpha nodosa**; bioturbation and herring-bone cross bedding) and lithic components (limestone, calcite, dolostone, dolomite, glauconite, phosphate, and marine fossils) are absent in the Oconee Group. The common occurrence of undulatory,trough, and planar cross bedding, and the common occurrence of poorly to very poorly sorted, pebbly, clayey (kaolinitic) siliciclastics are evidence for an aqueous origin. The various formations consist of a stack of fining upward sequences. Stacks of fining upward sequences are not found in normal marine, continental shelf depo-environments in the Coastal Plain. In addition, it is also known from core and well cutting information that the various formations of the Oconee Group grade laterally and interfinger seaward (southward) in the shallow subsurface into marine, continental shelf deposits (also compare with Herrick (1961). Therefore we conclude that all evidence concerning the depositional environment of the Oconee Group (excluding the Jeffersonville member of the Huber Formation for lack of evidence) points toward and aqueous, nonmarine environment. Because the formations of the Oconee Group are also blanket deposits, we further interpret them to be that of braided stream origin.

Fossils that are found in the Oconee Group include plant fossils and palynomorphs. Curiously, land vertebrate fossils and associated trace fossils such as foot prints have not been reported from Oconee Group deposits. Similarly, shallow water sedimentary structures such as symmetrical ripple marks or mud cracks also have not been reported from the Oconee Group in Georgia.

AGE

The age of the Oconee Group in Georgia ranges from Late Cretaceous through Middle Eocene. The "Tuscaloosa formation" of western Georgia has conventionally been correlated with the Tuscaloosa Group and that convention is followed here (references beau coup). On that basis, the "Tuscaloosa formation" is considered to be late Cenomanian in age in this report. The Pio Nono Formation interfingers with the Eutaw Formation in western Georgia (in the vicinity of Geneva, Talbot County, Georgia) and is, therefore, considered to be Santonian in age. The Gaillard Formation occurs in the stratigraphic position of the Blufftown Formation and/or Cusseta Sand of western Georgia and contains a Santonian or Campanian palynomorph flora (Christofer, 1991, pers. com.) and is, therefore, considered to be Santonian or Campanian in age and is correlative with the Blufftown Formation and/or Cusseta Sand. In the type area of the group, the Maastrichtian is not known to occur in outcrop unless it occurs as scattered outliers and is only occasionally present in outcrop before being stripped away (also see Tshudy and Patterson, 1975). It is also possible that the a Maastrichtian component of the Oconee Group is present in the subsurface of the Savannah River area. The Marion Member of the Huber Formation is Early Paleocene (Midwayan) in age. The Jeffersonville member (hard kaolin of the kaolin mining district) is physically correlated with the late Claibornian Mossy Creek Formation, Perry Sand, and Lisbon Formation and is, therefore, considered to be late Claibornian in age. A Sabinian (Late Paleocene) or early Claibornian (early Middle Eocene) component of the Oconee Group appears to be present in outcrop in the vicinity of Perry at low elevations, but too little is known of this unit to do more than mention its possible existence. It is known, however, that the early Claibornian, like the Navarroan, is present and thickens greatly in the subsurface to the south of the Oconee Group outcrop belt. Finally, the channel deposits of Lamoreaux (1946a, 1946b) are considered to be the initial nonmarine deposits of the transgressive Upper Eocene. These deposits lithologically cannot be included in the Barnwell Group but the lower parts of the deposits are compatible with Oconee Group lithology. The channel deposits appear to be scattered in occurrence, however, and are restricted to topographic lows on top of the Huber Formation.

PIO NONO FORMATION (new name)

DEFINITION

The Pio Nono Formation is a new named proposed here for a highly pigmented, kaolinitic, variably sorted, locally pebbly to gravelly sand to sandy kaolin that directly overlies Piedmont basement in the type area and disconformably underlies the Gaillard Formation. It has been included variously in other formations or units in the past but heretofore it has not been identified as a separate formation. The Pio Nono Formation of this report was included into Lower Cretaceous of Veatch and Stephenson (1911, in part), the Middendorf Formation (Smith, 1929, in part), the Tuscaloosa Formation (Cooke, 1943, in part; Eargle, 1955, in part; LeGrand, 1962; Herrick, 1961, in part; Herrick and Vorhis, 1963, in part; Georgia Geological Survey, 1976, in part), the Eutaw Formation (Eargle, 1955, in part; Georgia Geological Survey, 1976, in part), the Cusseta, Blufftown, and Eutaw Formations undifferentiated (Eargle, 1955, Pl. 1; Georgia Geological Survey, 1976, in part), undifferentiated Cretaceous rocks (Eargle, 1955, p. 83-86); Blufftown Formation (Georgia Geological Survey, 1976, in part); and Unnamed Formation (Upper Cretaceous) by Hetrick (1990).

TYPE SECTION

The name Pio Nono is taken from Pio Nono Avenue, a major north-south artery (US 41) in the city of Macon, Georgia. The Pio Nono Formation is exposed in small outcroppings at many sites along Pio Nono Avenue and the type locality is the large exposure in the side of a hill formed by the excavation and construction of Brad Henderson Memorial Stadium on Anthony Road, approximately 1.1 airline miles (1.8 km) west-northwest of the intersection of Eisenhower Drive and Pio Nono Avenue (Latitude 32°, 49', 24" N, and Longitude 83°, 40' 40" W). This exposure is here designated the type section or unit-stratotype (holostratotype) of the Pio Nono Formation (Fig. 8). The Pio Nono Formation is exposed in the cut in the hillside on the west side of the stadium. Neither the lower nor upper boundaries are exposed in this section. The holostratotype of the Pio Nono Formation is located near the center of the Macon West, Ga., 1:24,000 Quadrangle map. The Pio Nono Formation is the principal outcropping formation at the Fall line from the vicinity of Jones County in the east to the vicinity of Junction City, Talbot County, in the west.

The section of Pio Nono Formation exposed in a road cut at the intersection of US 341 and a county dirt road, 2.35 miles (3.75 km) north of the intersection of US 341 and US 80 in Roberta, Crawford County, Georgia, is here designated a reference section, parastratotype, and lower boundary stratotype of the Pio Nono Formation (Fig. 10). The Pio Nono Formation unconformably overlies deeply weathered saprolite of strongly foliated and steeply dipping Piedmont rocks at the this locality. This parastratotype is located in the southeastern corner of the Colloden, Ga., 1:24,000 Quadrangle map.

The exposure in a ravine cut into the western valley wall of the Ocmulgee River, approximately 0.2 mile (0.3 km) southeast of the overpass of Mead Road and the Central of Georgia Railroad on the south side of Macon, Bibb County, Georgia, is here designated a reference locality for the top of the formation, parastrato- type, and upper boundary stratotype for the Pio Nono Formation. The disconformity between the Pio Nono Formation and the overlying Gaillard Formation is exposed in this ravine. This exposure is located in the southeastern part of the Macon, Ga., 1:24,000 Quadrangle map.

The series of road cuts in a county dirt road, on the eastern valley wall of Deep Creek, approximately 2.1 airline miles (3.4 km) north of the community of Friendship in southeastern Crawford County, Georgia, is here designated a reference locality and parastratotype of the Pio nono Formation. This exposure is typical of the lithologies present in the Pio Nono Formation in this area and is located in the western part of the Byron, Ga., 1:24,000 Quadrangle map.

The Georgia Geologic Survey core Houston 9 (GGS-3629), taken at Elberta, Houston County, Georgia, is here designated a reference locality and parastratotype of the Pio Nono Formation. The Pio Nono Formation occurs in the interval 390 feet to 643 feet in the core. This core is also designated a lower boundary stratotype for the Pio Nono Formation where it disconformably overlies the "Tuscaloosa formation" at 643 feet. The Gaillard Formation disconformably overlies the Pio Nono Formation in the core Houston 9.

Finally, the Georgia Geologic Survey core Burke 6 (GGS-3758), taken in northern Burke County, Georgia, is here designated a reference locality and parastratotype of the Pio Nono Formation in eastern Georgia. The Pio Nono Formation occurs in the interval 578 feet to metamorphic basement at 852 feet. The Gaillard Formation disconformably overlies the Pio Nono Formation in the core Burke 6.

LITHOLOGY

The Pio Nono Formation is a highly pigmented, thin to thick bedded, variably horizontal-bedded to undulatory-bedded to cross-bedded, moderately to poorly sorted, variably feldspathic and micaceous, sporadically pebbly or gravelly (especially near the Fall line where it resembles Quaternary river terrace deposits), kaolinitic sand, sandy kaolin, sandstone, sandy kaolinitic claystone, and kaolinitic sandstone. Quartz sand is the dominant lithic component of the Pio Nono Formation but kaolin is also significant at some sites. In the area around Macon, Georgia, the formation is especially kaolinitic and fine-grained but it is more sandy in the vicinity of the Flint River and westward. West of the Flint River, from the vicinity of Butler in Taylor County, westward to the vicinity of

Junction City in Talbot County, the Pio Nono Formation is extensively mined for sand. Quartz pebbles range up to approximately 1 inch (2.5 cm) in longest dimension and dark minerals are also present locally.

The quartz component of the formation ranges in grain size from very fine to pebble size. Commonly the sand is poorly sorted and beds of well-sorted sand are rare. Beds of relatively pure sand are not known to occur in the Pio Nono Formation, interstitial kaolin in the sand beds is pervasive. Similarly, beds of relatively pure kaolin are not known to occur in the formation and all of the kaolin beds are sandy.

Bedding style within the Pio Nono Formation is variable but typically consists either of rude, thick, to very massive, horizontal-bedding, undulatory-bedded, or of vague and inconspicuous to very prominent cross bedding on small to moderate (rarely large) scales. Thick beds of massive and structureless sandy kaolins or kaolinitic sands are common. Cross-bedding consists both trough cross bedding and planar cross bedding.

Sandstone and sandy claystone are characteristic of the Pio Nono Formation and some of the indurated phases of the formation are virtually identical lithologically to the indurated phases of the younger, Miocene Altamaha Formation. As a gross comparison, lithologically the Pio Nono Formation resembles the Altamaha Formation more than any other formation in the Coastal Plain of Georgia. The indurated phases of the Pio Nono Formation appear to be less extensively developed than those of the Altamaha Formation. And like the Altamaha Formation, the indurated phases are thick-bedded, massive, and structureless.

STRATIGRAPHIC RELATIONSHIPS

The Pio Nono Formation occurs in outcrop from the vicinity of Jones County, Georgia, in the east, to the vicinity of Geneva, Talbot County, in the west. East of Jones County, the updip feather edge of the Pio Nono Formation is overlapped by the Huber Formation and Barnwell Group and the Pio Nono Formation occurs only in the shallow subsurface. The Pio Nono Formation is known to occur as far east in the subsurface of Georgia as the vicinity of the Savannah River in Burke County. The Pio Nono Formation can be seen to interfinger down dip (seaward) with the Eutaw Formation south of Geneva (Stop 10 of Frazier and Hanley, 1987) and in road cuts along Georgia 137 approximately 5 miles (8 km) southwest of Butler in Taylor County.

The eastern-most known occurrences of the Pio Nono Formation known to date in Georgia are in Georgia Kaolin Company cores from the vicinity of Deepstep, Washington County, Georgia, and in the core Burke 6 (GGS-3758) in northern Burke County, Georgia. Near Deepstep, the Pio Nono Formation is at least at least 86 feet (26 m) thick but is not known to crop out in Washington County at the Fall line 5 miles (8 km) to the north, indicating a thinning of at least 17 feet per mile (3 meters per kilometer) to the north.

In western Georgia, the Pio Nono Formation grades laterally down the depositional dip, seaward, into the Eutaw Formation. East of the Ocmulgee River in Georgia, there is inadequate subsurface information to determine what lithostratigraphic unit of coastal marine, or offshore-continental shelf origin the Pio Nono Formation grades into. However, the Pio Nono Formation appears to grade laterally, along the depositional strike, into the Cape Fear Formation of North Carolina but as yet, there is inadequate subsurface information to determine where this zone of facies change occurs in South Carolina.

In outcrop between the vicinity of Junction City and Jones County, Georgia, the Pio Nono Formation is the basal formation of the Coastal Plain and directly overlies Piedmont basement. In the shallow subsurface from the vicinity south of Junction City to southern Bibb County or northernmost Houston County, the Pio Nono Formation disconformably overlies the "Tuscaloosa formation".

The Pio Nono Formation is disconformably overlain by a number of formations, mostly within the near vicinity of the Fall line. Generally the Pio Nono Formation is disconformably overlain by the Gaillard Formation. In the relatively downdip, Pulaski County core (GGS-3511), however, the Pio Nono Formation appears (due to very poor core recovery in the stratigraphic interval above the Pio Nono Formation) to be overlain by a coastal marine equivalent of the Gaillard Formation. Near the Fall line, the Pio Nono Formation is known to be locally overlain disconformably by the Gaillard, Marshallville, or Mossy Creek Formations, by the Butler-Allon channel deposits, or by river terrace deposits of the Flint and Ocmulgee Rivers.

The Pio Nono Formation is an exceptionally thick Coastal Plain Formation. It thickens rapidly from the edge of the Coastal Plain at the Fall line to at least 209 feet (64 m) in the shallow subsurface in the Crawford 2b (GGS-3598) at Zenith, Crawford County, Georgia, to 252 feet (77 m) in the core Houston 9 (GGS-3629) at Elberta in Houston County, Georgia, to more than 367 feet (112 m) in the Pulaski County core (GGS-3511), and 274 feet (84 m) in the core Burke 6 (GGS-3758) in Burke County.

The Pio Nono Formation is fluvial in origin, probably having been deposited by heavily laden braided streams disgorging their bed loads and suspended loads along a narrow, alluvial coastal plain between an uplifting Piedmont with considerable topographic relief, and a relatively rapidly subsiding continental shelf on the southeastern margin of the continent. There are no indications of coastal marine or upper estuarine environments in the Pio Nono Formation, i.e., there are no known burrows or bioturbation (trace fossils), herringbone cross bedding, marine fossils, or lithic components such as limestone, dolostone, glauconite, or phosphate in the formation.

AGE

The Pio Nono Formation is not known to be fossiliferous in outcrop. Therefore, its age at this time must be conjectured on the basis of facies relationships with other dated formations and by stratigraphic position. The Pio Nono Formation grades laterally southward and southwestward, seaward, into the coastal marine Eutaw Formation. The Eutaw Formation has been dated by various fossil groups as Austinian, lower Santonian). The Tombigbee Member of the Eutaw Formation in southwestern Alabama, i.e., the upper part of the Eutaw Formation to which the Eutaw Formation of the Chattahoochee River area is correlated (Monroe, 1947), contains **Globotruncana concavata** and contains a planktonic foraminiferal suite of the lower part of the **G. concavata** Zone. Therefore, the Eutaw Formation of Georgia, and the Pio Nono Formation, is considered to be Late Cretaceous, middle Austinian, early Santonian in age (also see Huddlestun and others, 1988).

GAILLARD FORMATION (new name)

DEFINITION

The Gaillard Formation is a new formation that was informally introduced by Hetrick (1990). The Gaillard Formation disconformably overlies the Pio Nono Formation and at only one site in eastern Georgia is it thought to directly overly Piedmont rocks. In exposures west of the Ocmulgee River the Gaillard Formation disconformably underlies the Marshallville Formation whereas east of that river it disconformably underlies the Huber Formation in outcrop. In the shallow subsurface of central Georgia, it disconformably underlies the Nakomis Formation (new name) that is a coastal marine (Fort Valley Group) stratigraphic equivalent of the Ripley Formation.

In the past, deposits assigned here to the Gaillard Formation included, in part, the Lower Cretaceous of Veatch and Stephenson (1911), the Middendorf Formation (Smith, 1929, in part), the Tuscaloosa Formation (Cooke, 1936, 1943, in part; LeGrand, 1962; Herrick and Vorhis, 1963, in part), the "Cusseta sand, Blufftown and Eutaw formations undifferentiated" (Eargle, 1955), undifferentiated Cretaceous rocks (Eargle, 1955), and Upper Cretaceous undifferentiated (Georgia Geologic Survey, 1976). In general the Gaillard is the Upper Cretaceous kaolinitic sands and clays of Buie (1978, 1980) and Tshudy and Patterson (1975), and is a part of the Cretaceous component of the Lower Tertiary-Cretaceous undifferentiated of Georgia Geological Survey (1976). Recently, Pickering and Hurst (1989) have given the name Buffalo Creek formation to the commercial Cretaceous kaolin (upper part of the Gaillard Formation of this report) and included all sediments to basement beneath the commercial kaolin within the Buffalo Creek formation. However, the volumetrically greater proportion of the formation is sand and this principal and characteristic component of the formation does not crop out nor is exposed in the type area of the Buffalo Creek. Therefore, the name Buffalo Creek as a formation name is lithostratigraphically invalid because there is no adequate type section to be designated in the type area. We are, therefore, including the Buffalo Creek in this report as an uppermost clay member of the Gaillard Formation, the Buffalo Creek Kaolin Member of the Gaillard Formation. However, it is known to be laterally discontinuous and it has not yet been demonstrated to be everywhere correlative as the uppermost fining upward clay kaolin body of the Gaillard Formation.

TYPE SECTION

The name Gaillard is taken from the community of Gaillard in Crawford County, Georgia, between Knoxville in Crawford County and Fort Valley in Peach County, and adjacent to US highway 341 and along the Southern Railroad. The type locality of the Gaillard Formation is a sand pit of the Atlanta Sand and Supply Company at Gaillard (also see Teas, 1921, p. 181-186). The type section, or unit stratotype (holostratotype), of the Gaillard Formation is exposed in the pit of the Atlanta Sand and Supply Company (Fig. 11). The type section consists of the section of Gaillard Formation from the floor of the pit to the base of the overlying Tertiary formations. The upper boundary stratotype is exposed in the type section where the Marshallville Formation of Early Paleocene, Midwayan age disconformably overlies the Gaillard Formation in the western face of the pit. The disconformity dips to the east and the Marshallville Formation is cut out on the eastern face of the pit where the Butler-Allon channel deposits disconformably overlie the Gaillard.

The railroad cut of the Central of Georgia Railroad in the western valley wall of the Ocmulgee River on the south side of Macon in Bibb County, Georgia, 0.25 miles (0.4 km) northeast of the Mead Road overpass of the railroad, is designated a reference locality and parastratotype of the Gaillard Formation. The lower boundary stratotype is exposed in a ravine in a sand pit 0.2 miles (0.3 km) south of the Mead Road overpass of the Central of Georgia Railroad where the Gaillard Formation can be seen to disconformably overlie the Pio Nono Formation. This is also the upper boundary stratotype of the Pio Nono Formation.

LITHOLOGY

Typical Gaillard lithology may be considered to be a caricature of Oconee Group lithology. The lithology of the Gaillard Formation consists of easily erodible sand and kaolin with volumetrically much more sand than kaolin. However, due to lack of good natural exposures, and most of the exposures occurring in kaolin pits, kaolin in the Gaillard Formation is disproportionately conspicuous in outcrop.

Kaolinite is overwhelmingly the dominant clay mineral component of the Gaillard Formation, with minor smectite and illite in the downdip areas of facies change with the coastal marine and offshore correlative deposits (also see Hetrick, 1982). Other subordinate lithic components of the Gaillard Formation include feldspar, mica, carbonaceous and lignitic material, dark minerals, bauxite, and some pyrite.

The sand component of the Gaillard Formation ranges from fine to very coarse, and quartz of granule- to pebble-size is widespread. Sorting is also variable with some beds of well-sorted sand, but characteristically the sorting within the formation ranges from moderate to very poor. In the poorly sorted sands the size ranges from fine to pebbles in a matrix of kaolin clay. These poorly sorted sands are also typically feldspathic and micaceous. Where the sediment is coarsely micaceous, the size of the mica books (generally muscovite) may be as large as 1 cm. Kaolin rip-up clasts are also present locally and range in size from pebbles to cobbles.

In outcrop, the clay component of the Gaillard Formation is mainly kaolinite, and in most places the clay is represented solely by kaolinite. The kaolin of the Gaillard Formation is characteristically "soft", soapy to the touch, and breaks with strong, smooth, conchoidal fracture. Where silty, the kaolin may fracture along bedding planes. Where the kaolin is uniformly white or very pale pinkish tan and unweathered, the fracture is almost never hackly and irregular as is typical of the Jeffersonville member of the Huber Formations. The conchoidal fracture of kaolins in the Marshallville and Marion Member of the Huber Formations is generally smaller in scale and less regular than that of the Gaillard Formation.

The Buffalo Creek Kaolin (Pickering and Hurst, 1989) at the top of the formation commonly contains faint, pea-size forms which may represent an early stage of pisolite development. There are some occurrences of carbonaceous and lignitic clay and sand lenses within the Gaillard. In outcrop the lignitic lenses are not as common as in the Huber Formation, but they do appear to be more common in the subsurface and especially down the dip, based on limited core data. The clay mineralogy of the lignitic lenses is not known to differ from that of the white, presumably oxidized kaolin lenses.

The Gaillard Formation is prominently and intensely bedded. Cross-bedding is especially characteristic of the formation and the scale of the cross-bedding ranges from small in the finer-grained intervals, to large-scale in the coarser sand, pebbly sand, and gravelly intervals. Channel cut-and-fill structures are also locally conspicuous in the formation but more commonly, the gross bedding is flat to undulatory to expansively lenticular. Bedding is characteristically rude, i.e., transitions from one bed to another are generally gradational over millimeters or centimeters rather than being knife-edge, abrupt, and sharp as in the overlying Marshallville and Huber Formations. As a result, bedding definition is generally somewhat vague, imparting a coarse or rude appearance to the stratification.

The Gaillard Formation, at any given site, consists of a series of fining-upward sequences. Although the specific details of any single sequence may vary from others, the characteristic example of a fining-upward sequence consists of a basal, poorly sorted, pebbly sand that may or may not contain kaolin rip-up clasts. This coarse bed disconformably overlies beds of varying lithologies, including apparently scoured and eroded kaolin beds; sandy, micaceous kaolin beds; and kaolinitic, micaceous, fine sand beds. The overlying sands and pebbly sands are strongly to moderately cross bedded. However, going upward in the section, the average grain-size of the quartz and feldspar diminishes, the scale of the bedding and cross-bedding diminishes, the sorting improves, and the clay and mica content increases. Higher up in the fining upward sequence, the quartz grain-size continues to decrease along with the scale of the bedding, whereas the sorting improves somewhat, and the clay content continues to increase. The top of the fining upward sequence, if preserved, consists of massive, silty, micaceous kaolin or kaolin of fairly high purity and thickness (commercial grade in terms of the Buffalo Creek Kaolin Member at the top of the formation). Not all fining upward sequences are terminated with clay or silty clay beds. This may be due to local truncation of the fining upward sequence or to local, lenticular development of the clay bodies (perhaps in abandoned river channels).

The regional stratigraphic significance of any specific fining upward sequence in the Gaillard Formation (or in the Oconee Group) has not been established, or even addressed at this time. It appears likely, however, that each fining upward sequence in the formation represents a local sedimentary event in a braided stream system, and that no single fining upward sequence is traceable over any extended distance or area.

There are a few broad lithofacies relationships that are known within the Gaillard Formation. In the vicinity of the Ocmulgee River, the Gaillard Formation coarsens eastward and becomes more kaolinitic at the top of the formation. The Buffalo Creek Kaolin Member occurs west of the Ocmulgee River but is thinner, more sporadic in occurrence, is siltier and more micaceous, and is not known to be of commercial value. The Buffalo Creek Kaolin rarely occurs east of Washington County in Georgia but its stratigraphic position is again occupied by a lithologically similar commercial kaolin at the top of the Gaillard Formation in western South Carolina. The precise lithologic distribution of the formation is not known between Washington and Richmond Counties because it occurs in the subsurface in that area and there are no cores from which to document the lithologic distributions of the formation.

STRATIGRAPHIC RELATIONSHIPS

The Gaillard Formation occurs in outcrop across much of the Fall Line Hills in central Georgia. The westernmost known occurrence of the formation is in the vicinity of Butler in Taylor County, Georgia, but it probably occurs as far west as eastern Marion County. It extends eastward in outcrop through Washington County, Georgia, but is overlapped by the overlying Huber Formation and Barnwell Group between Washington County and Richmond County, Georgia, where, due to deep dissection by the Savannah River, the Gaillard Formation again occurs in outcrop. It is traceable across western South Carolina to Lexington County, South Carolina, where it has been referred to the Middendorf Formation.

In the subsurface, the Gaillard Formation is known to occur in Georgia from Macon County in the west, through Houston County and northern Laurens County to Burke County in the Savannah River area. South of this trend, the Gaillard Formations grades seaward into coastal marine deposits of uncertain lithostratigraphic affinities.

In western Georgia, the Gaillard Formation grades laterally westward into the Blufftown Formation and/or Cusseta Sand in eastern Marion County. It grades laterally eastward into the Middendorf Formation in central South Carolina.

The Gaillard Formation disconformably overlies the Pio Nono Formation throughout its area of occurrence in Georgia. The Gaillard in turn is overlain disconformably by the Huber Formation in the outcrop belt east of the Ocmulgee River in Georgia. Generally the Gaillard Formation is overlain disconformably by the Marshallville Formation west of the Ocmulgee River, but locally, in the Fall line area west of the Ocmulgee River, the Marshallville Formation is absent due to post-Midwayan truncation, and the Gaillard Formation is overlain in places disconformably by the Mossy Creek Sand, Butler-Allon channel deposits, or by the Barnwell Group as at Rich Hill in Crawford County, Georgia. Farther down the dip in the shallow subsurface across central Georgia, the Gaillard Formation is overlain disconformably by the Nakomis Formation. It is not yet known how far east the Nakomis Formation occurs in Georgia but it, or a facies equivalent, is known to occur as far east as northern Laurens County. In the Savannah River area, the Gaillard Formation is overlain by the Huber Formation in Richmond County, and by the coastal marine equivalent of the Huber Formation, the Ellenton Formation, seaward in Burke County, Georgia.

The Gaillard Formation is distinguished from the Huber Formation by its typically coarse, rude, and thick bedding; by the general absence of sharp bedding planes; by the sparsity of kaolin intraclast zones relative to that of the Huber; by the pale pinkish tan color of the kaolins compared to the very pale greenish color of the Huber kaolins; and by the much more broadly conchoidal fracture surfaces. In contrast, the bedding in all but the coarsest Huber Formation and Fort Valley Group contains much sharper bedding planes and is typically less thick bedded and rudely bedded. The Huber Formation contains much more intraclastic kaolin, and the conchoidal fracture surfaces are smaller and less even than that of the Gaillard kaolins. In addition, the Gaillard kaolins are uniformly more coarsely crystalline than those of the Huber but specific kaolin beds in the Marion Member of the Huber Formation can be as coarsely crystalline as those of the Gaillard.

The Gaillard Formation is easily distinguished from the Pio Nono Formation in generally being mineralogically mature, and, where freshly exposed, the sands are white to pale gray and the kaolins are white to very pale pinkish tan. Only in scattered beds in some sections due highly pigmented sediments occur in the Gaillard. In addition, Gaillard sediments typically weather to pastels and only where exposed to deep weathering for long periods of time does the Gaillard residuum become highly pigmented. On the other hand, the sands and kaolins of the Pio Nono Formation characteristically are highly pigmented with intense shades of red, brown, purple, and orange even in the deeper subsurface. The Pio Nono Formation also characteristically contains beds of lithified sandstone or claystone that are virtually identical in appearance to similar indurated phases of the Miocene Altamaha Formation (Huddlestun, 1988). Systematic induration is currently not known to exist in the Gaillard Formation.

The sands of the Gaillard Formation are distinguished from those of the Mossy Creek Sand in that the Mossy Creek sands are better sorted, more thinly bedded, and commonly contain trace fossils (burrows and bioturbation)(also see Shroder, 1982). Clays beds or lenses in the Mossy Creek are minor but where they occur, they are generally thinly bedded and grayish in color. On the other hand, Jeffersonville kaolins (Claiborne kaolin of some authors and the Huber Formation of Shroder, 1982) are hackly and of very irregular fracture. Trace fossils such as **Planolites** occur commonly in the upper part of the Jeffersonville member of the Huber Formation but are unknown in the Gaillard Formation.

The Gaillard Formation is distinguished from its eastern stratigraphic equivalent, the Middendorf Formation in being more uniformly rude and thick bedded with larger scale sedimentary structures. In contrast, the Middendorf Formation sands tend to be better sorted and thinly bedded with more bed contacts that are sharply defined. In general, the Middendorf Formation appears to be a lower energy lithofacies of the Gaillard Formation. On the other hand, kaolin beds and lenses are thinner and more sparse than in the Gaillard Formation. As with the Gaillard Formation west of the Ocmulgee River, there are no known deposits of commercial kaolin in the Middendorf Formation.

The Gaillard Formation can be confused with small exposures of coarse-grained beds coastal marine formations of the Fort Valley Group. The Gaillard is distinguished from the updip Marshallville Formation in that the sands of the Marshallville are locally burrowed, much better sorted, generally are finer grained, and bed contacts are commonly sharp. The clays of the Marshallville are commonly thinly bedded, gray, smectitic to kaolinitic clays that in the downdip areas, may contain gray, noncalcareous fossiliferous clays of marine origin. In updip areas, the Marshallville commonly contains argillaceous lenses with abundant leaf and other vegetable fossils. In downdip areas, the Marshallville is not likely to be confused with the Gaillard Formation because the lithology of the Marshallville Formation there resembles more closely that of the Barnwell Group.

The Gaillard Formation is distinguished from the Nakomis Formation in that the Nakomis lithology is more similar to that of the Marshallville Formation. However, the Nakomis Formation contains thick beds of carbonaceous to organic-rich kaolins of irregular and blocky fracture that are rare and atypical of the Marshallville.

The Gaillard Formation is relatively thick and is not known to be exposed in its entirety in any exposure. The thickest known section of the Gaillard Formation is 305 feet (93 m) in the Georgia Geologic Survey core Houston 9 (GGS-3629) in Elberta, Houston County, Georgia. Sixty feet (18 m) of the upper part of the Gaillard Formation are exposed in the type section in the Atlanta Sand and Supply Company pit but the Gaillard is 90 feet (27 m) thick 2 miles (3.2 km) south of the type locality in the Georgia Geologic Survey core Crawford 1b (GGS-3598) taken at Zenith, Georgia. Elsewhere, the Gaillard Formation is 192 feet (59 m) thick in a core taken by the Georgia Kaolin Company from their Rogers mine near Deepstep in Washington County, Georgia. The section tentatively referred to the Gaillard stratigraphic interval in the Georgia Geologic Survey core Pulaski 7 (GGS-3511) taken in northernmost Pulaski County, Georgia, is 339 feet 103 m). The Gaillard Formation is 200 feet (61 m) thick in the core Burke 6 (GGS-3758) from northern Burke County, Georgia. Based on this sparse data, it appears that the Gaillard abruptly thickens from a feather edge near the Fall line and rapidly thickens southward to over 300 feet 91 m) in the subsurface before merging laterally into coastal marine deposits of a different lithostratigraphic unit.

AGE

The internal age constraints on the Gaillard Formation are meager at this time. The best evidence as to the age of the formation is its stratigraphic position overlying the Pio Nono Formation that can be shown to grade laterally westward into the upper Coniacian to lower Santonian (Austinian) Eutaw Formation, and to be disconformably overlain by the lower Maastrichtian (lower Navarroan) Nakomis and Ripley Formations. This stratigraphic position indicates that the Gaillard Formation is broadly correlative with the Mooreville and Demopolis Chalks of the Selma Group of Alabama, and to the Blufftown Formation and Cusseta Sand of the western Georgia. At this time, there is no information available to promote distinction between Blufftown equivalence and/or Cusseta equivalence. Therefore, it is concluded that the age of the Gaillard Formation is broadly upper Santonian to Campanian (upper Austinian to Tayloran).

Ray Christofer, formerly of the U. S. Geological Survey, identified a palynoflora from the Gaillard Formation at its type locality. The biostratigraphically significant pollen types he identified are the following:

Complexiopollis sp. B
Complexiopollis sp. D
Complexiopollis sp. C
Complexiopollis sp. F
Choanopollenites sp. A
?Pseudoplicapollis cuneata (manuscript name)
Pseudoplicapollis sp. A
Pseudoplicapollis sp. E
Pseudoplicapollis longannulata (manuscript name)
Pseudoplicapollis sp. C
Plicapollis sp. C

Plicapollis sp. L
Plicapollis incisa (manuscript name)
Plicapollis sp. F
Plicapollis sp. J
Plicapollis sp. B
Trudopollis sp. B
Osculapollis sp. A
Osculapollis sp. C
Osculapollis sp. D
Osculapollis sp. G
Santalacites minor (manuscript name)
Semioculopollis verrocosa (manuscript name)
Holkopollenities sp. A
Labrapollis sp. A
Sabrapollis sp. C
Momipites sp. A

Christofer (1979; pers. com., 1991) concluded that the above flora is diagnostic of pollen subzone V-C (**?Pseudoplicapollis cuneata-Semioculopollis verrucosa** Assemblage Zone). He concluded that the age of the sample was upper Santonian-lowermost Campanian.

BUFFALO CREEK KAOLIN MEMBER OF THE GAILLARD FORMATION (formalized and redefined)
DEFINITION

The name Buffalo Creek was informally introduced by Pickering and Hurst (1989, p. 39) for all Cretaceous age kaolinitic deposits (Pickering and Hurst, 1989, fig. 1), i.e., kaolinitic deposits of Eaglefordian, Austinian, Tayloran, and Navarroan (Cenomanian, Santonian, Campanian, and Maastrichtian) ages. In terms of the stratigraphic terminology proposed here, the Buffalo Creek formation of Pickering and Hurst (1989) includes all of the Cretaceous formations of the Oconee Group, the "Tuscaloosa formation" of western Georgia, the Pio Nono Formation, and the Gaillard Formation (we have not as yet identified a Navarroan [Maastrichtian] lithostratigraphic component of the Oconee Group in the central Georgia kaolin mining district).

We adopt here the name Buffalo Creek of Pickering and Hurst (1989) but we apply the name in a different stratigraphic sense than they proposed. We are restricting the name Buffalo Creek to the kaolin at the top of the uppermost, fining upward sequence of the Gaillard Formation in local sections and define it as a formal member of the Gaillard Formation. We do not adopt the name Buffalo Creek in the sense of Pickering and Hurst (1989) because the great bulk of the formation predominantly consists of fining upward sequences of sand. This predominantly sand part of the section is not exposed either in the vicinity of Deepstep, Georgia, the type area of the unit, or in most places in the central Georgia kaolin mining district. Therefore, we consider the application of the name Buffalo Creek to be invalid for the entire formation, because the exposed kaolin at the top of the unit is neither lithologically characteristic of the formation as a whole and it is not mappable except on a small scale (1:24,000).

In much of the formation, the upper parts of the fining upward sequences consist of thin beds or lenses of relatively pure, soft kaolin; finely sandy, micaceous kaolin; or micaceous, kaolinitic fine-grained sand. Locally, the kaolin tops of the fining upward sequences appear to have been either truncated prior to the deposition of the succeeding fining upward sequence or to have never been deposited. The kaolin of only the uppermost fining upward sequence is locally widespread and is defined here as the Buffalo Creek Kaolin Member of the Gaillard Formation although other thin beds or lenses of soft kaolin occur lower in the formation. The Buffalo Creek Kaolin as described here includes not only the commercial grade kaolin of the central Georgia and western South Carolina kaolin mining districts, but also includes relatively thin beds of relatively pure kaolin or micaceous, finely sandy kaolin beds or lenses at the top of the Gaillard Formation elsewhere.

The Buffalo Creek Kaolin Member is known to be laterally discontinuous but is locally mappable. This is consistent with Article 25 of the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature, 1983) where

> ... A member, whether formally or informally designated, need not be mappable at the scale required for formations. ...

It is also not known whether the deposition of the various lenses of the Buffalo Creek Kaolin are temporally correlative or equivalent, or whether the deposition of the kaolin represents prevalence for kaolin deposition during the later depositional phase of the Gaillard Formation. Where the Buffalo Creek Kaolin is absent, the upper part of the Gaillard Formation is not known to be distinguishable in any way from the bulk of the underlying formation. Also, we have not encountered thick beds of commercial grade kaolin at the top of a fining upward sequence below the top of the Gaillard Formation or below the Buffalo Creek Kaolin Member. If future studies indicate that the lithology of the sands of the upper part of the Gaillard Formation that include the Buffalo Creek Kaolin is also systematically different from that of the bulk of the underlying sands, it may be useful to redefine the Buffalo Creek to include these sands as well.

TYPE SECTION

The name Buffalo Creek is taken from Buffalo Creek, a small tributary of the Oconee River in southern Hancock and western Washington Counties, Georgia. The type locality of the Buffalo Creek Kaolin Member of the Gaillard Formation is the Buffalo China Company's Franks and Bland Mines, cut into the eastern valley wall of Buffalo Creek on the south side of highway Ga. 24, approximately 8.5 miles (14 km) west of Sandersville and 4 airline miles (6.4 km) south of Deepstep in Washington County, Georgia. The type section, or unit stratotype (holostratotype) of the Buffalo Creek Kaolin Member of the Gaillard Formation is the section of Cretaceous kaolin exposed in the lower part of the pit. Approximately 50 feet (15 m) of the member is mined here but most of the kaolin occurs below the water table and only the upper 10 to 20 feet (3 to 6 m) subaerially exposed (also see Pickering and Hurst, 1989, fig. 1). The type section also contains the upper boundary stratotype of the member where the Buffalo Creek Kaolin is overlain disconformably by the Marion Member of the Huber Formation.

LITHOLOGY

The Buffalo Creek Kaolin Member of the Gaillard Formation consists of kaolin that ranges in purity from almost pure kaolinite to variably micaceous, and silty to finely sandy kaolin. The relatively pure kaolin of the Buffalo Creek is the soft Cretaceous kaolin of the kaolin industry. It has a very pale tan hue, even when almost white. It is soft and soapy to the touch and breaks with a broad to very broad, even, conchoidal fracture. The kaolin tends to fracture into relatively large blocks, in contrast to the kaolin of the Marion Member or the hard kaolin of the Jeffersonville member of the Huber Formation.

Minor lithic components of the kaolin include smectite, quartz sand, mica, pyrite, and carbonaceous material. Carbonaceous material and pyrite occur in rare scattered lenses within the kaolin body. The carbonaceous lenses grade in all directions into the characteristic white kaolin, suggesting that all of the associated deposits may have been carbonaceous at the time of deposition. Fine mica and quartz sand are common components of the kaolin. West of the Ocmulgee River, all of the Buffalo Creek Kaolin is micaceous and sandy to some extent. This, and the member generally being relatively thin where present, renders the kaolin noncommercial west of the Ocmulgee River.

The description of the Buffalo Creek Kaolin Member in this report is essentially a field description. However, the mineralogy and physical and microscopic characteristics of the Buffalo Creek Kaolin have been described extensively in the literature. The discussions of the Buffalo Creek Kaolin include the following references: Hinckley (1961); Austin (1972); Patterson and Buie (1974); Buie and others (1979); Hetrick (1982); Hetrick and Friddell (1983, 1990); and Pickering and Hurst (1989).

STRATIGRAPHIC RELATIONSHIPS

The Buffalo Creek Kaolin as described here is the kaolin that occurs at the top of the uppermost fining upward sequence of the Gaillard Formation. The member does not appear to be laterally continuous over its range of occurrence. Rather, it appears to consist of numerous lenses of kaolin. The fact that the thickest and most persistent kaolin in the fining upward sequences appears always to occur in the uppermost sequence suggests a general change in the depositional system near the end of the Gaillard depositional period. Although other kaolin lenses or bodies occur at the tops of some of the underlying fining upward sequences, and all of these kaolins are lithologically indistinguishable from the Buffalo Creek, suggests the Buffalo Creek Kaolin probably is unique in the formation and is not simply any of the kaolins from lower in the section that happens now to occur at the top of the formation due to an accident of erosion prior to the deposition of the overlying formations.

AGE

The age of the Buffalo Creek Kaolin Member of the Gaillard Formation is the same age as the rest of the formation. That is, by physical correlation the Gaillard Formation is stratigraphically equivalent to the Blufftown Formation and possibly also with the Cusseta Sand of western Georgia. The Blufftown Formation is considered to be Late Cretaceous, Austinian to Tayloran (Santonian to Campanian) in age. Because the Buffalo Creek Kaolin occurs at the top of the Gaillard Formation, there is more of a possibility that it may be correlative with the Cusseta Sand. This correlation cannot be ruled out at the time because the Blufftown Formation and Cusseta Sand are not known to be disconformable in western Georgia and Alabama, and the correlative Mooreville Chalk, Arkola Limestone, and Demopolis Chalk in Alabama are known to be conformable and gradational.

HUBER FORMATION (amended)

DEFINITION

The Huber Formation was named by Buie (1978, p. 1-7) "...for all of the post-Cretaceous pre-Jacksonian strata in the kaolin mining districts of Georgia, northeast of the Ocmulgee River" (Buie, 1978, p. 1). In this guidebook, the concept of the Huber Formation is retained in much the same way as Buie (1978) originally defined the formation. That is, it is restricted to those Oconee Group deposits that either are exposed or were exposed at the type locality of the Huber Formation (J. M. Huber pit 30) that overlie the Gaillard Formation (Cretaceous kaolin of Buie, 1978) and underlie the Barnwell Group. Currently only the Lower Paleocene component of the formation occurs in the stratigraphic position of the Huber Formation in Pit 30 but according to M. Duncan of the J. M. Huber Corporation (pers. comm., 1991), an upper, Claibornian component of the formation was present in the 1970's, when Buie (1978) first described the formation. This is compatible with the measured section of Pit 30 (Buie, 1978, p. 4) where an unconformity was recognized in the middle of the formation. Because the original definition and description of the Huber Formation was not based on lithostratigraphic content but largely on age and stratigraphic position, there has been continuing ambiguity concerning the identification of the formation in the field.

In the original definition of the Huber Formation, the Huber was considered to have included all Tertiary kaolin-bearing deposits (Buie, 1978) and, therefore, it included Midwayan and Claibornian kaolin-bearing deposits as well as other proposed chronostratigraphic components (see Tshudy and Patterson, 1975). Two members of the Huber Formation are recognized here: a lower Marion Member of Early Paleocene, Midwayan age, and an upper informal Jeffersonville member of late Claibornian age. We have not been able to confirm the existence of lithostratigraphic units of intermediate age within the Huber as suggested by Tshudy and Patterson (1975) for Tertiary age kaolinitic deposits.

The continued recognition of the Huber Formation as defined by Buie (1978) and applied in this guidebook is tentative. The Marion Member of the Huber Formation is clearly a subdivision of the Oconee Group. However, by physical correlation along the depositional and structural strike, it would be anticipated that the Jeffersonville member should be a subdivision of the Fort Valley Group. If this is the case, then the Huber Formation as defined by Buie (1978) at the type locality and in the type area would include two subdivisions that are contained within two different lithostratigraphic groups. According to Article 28 of the North American Stratigraphic Code (North American Commission of Stratigraphic nomenclature (1983, p. 859): "...a formation or its parts may not be assigned to two vertically adjacent groups". Therefore, if the Jeffersonville member is properly a part of the Fort Valley Group, and the names Marion and Jeffersonville are adopted, then the name Huber Formation will have to be abandoned.

Reconnaissance fieldwork in Twiggs, Wilkinson, and Washington Counties supports this conclusion. However, based on cores and exposures in kaolin pits, it appears that much or most of the Jeffersonville member that we have been able to identify consists of the "hard", Claibornian kaolin. It also appears that the Jeffersonville member is discontinuous in updip areas, and that the sand lithofacies of the member is volumetrically minor. On the other hand, Mossy Creek Sand is present in topographic lows overlying the Marion Member in Huber Pit 36 area, the type locality of the Marion Member and thin, discontinuous Mossy Creek-type sand is present at the top of the "Huber" section in kaolin pits in the vicinity of McIntyre, Wilkinson County. Because it is the sand lithology that determines whether a formation is a part of the Oconee Group or Fort Valley Group, little can be said about the higher lithostratigraphic status of the Jeffersonville member at this time. Certainly we have found no exposures where relatively thick, continuous Mossy Creek-type sand, or any other sand stratigraphically associated with the Jeffersonville kaolin, occurs disconformably above the Marion Member and below the Barnwell Group. As a consequence until what time the lithostratigraphic status of the Jeffersonville can be unambiguously demonstrated in the field based on sand lithology, and a clear type section be designated for the unit, we consider it prudent to leave the Jeffersonville an informal member in the Huber Formation of the Oconee Group.

In earlier years, the deposits now known as the Huber Formation were believed to be Cretaceous in age and had been included in the Lower Cretaceous (Veatch and Stephenson, 1911), Middendorf Formation (Smith, 1929), Tuscaloosa Formation (Cooke, 1943), and Tuscaloosa Formation in part (Herrick, 1961; Herrick and Vorhis, 1963). Buie and Fountain (1967) and Tshudy and Patterson (1975) first treated these deposits as part of the lower Tertiary and the Huber Formation was included in the Lower Tertiary-Cretaceous undifferentiated on the geologic map of Georgia (Georgia Geological Survey, 1976).

Usage of the name Huber Formation in South Carolina was initiated in South Carolina by Nystrom et al. (1982, 1987). However, the Huber Formation as identified in South Carolina is considered to be largely early Claibornian in age (Congaree-equivalent) and the correlation and lithologic identity of the South Carolina Huber Formation, therefore, with the type Huber in Georgia is uncertain at this time.

TYPE SECTION

The name Huber was taken from the "Post Office of Huber, Georgia, located on the Southern Railway in the northwestern part of Twiggs County" (Buie, 1978). The formation was first studied in detail and its age postulated from fossil collections near the top of the formation in J. M. Huber mine 30, 4 to 6 miles (6.4 to 9.6 km) northeast of the post office and railroad crossing at Huber. The Huber Formation has become extensively exposed wherever mines have been opened, from the vicinity of Dry Branch and Stone Creek Church in the northwest to Flat Creek in the southeast, a distance of about 5 miles (8 km). This may be considered the type area of the Huber Formation.

Mine 30 is considered to the type locality of the formation although no specific site was expressly designated by Buie (1978). Buie (1978, p. 1) laid particular emphasis on the J. M. Huber Mine 30 as the first location where the Huber Formation was studied, and he presented a lithologic description of the Huber Formation from this mine (Buie, 1978, p. 4). As a consequence, J. M. Huber Mine 30 is formally designated in this report the type locality of the Huber Formation. The section of the Huber Formation exposed in mine 30 is the unit-stratotype (holostratotype) of the Huber Formation (Fig. 13). According to Buie (1978, p. 4), 33.4 feet (10.2 m) of Huber Formation was exposed at the type section when he measured and described the formation there. Currently at mine 30, the Huber Formation disconformably overlies the Buffalo Creek Kaolin Member of the Gaillard Formation and is disconformably overlain by the Riggins Mill Member of the Clinchfield Formation of the Barnwell

Group. Only the Marion Member of the Huber Formation is currently exposed at the type locality. Mine 30 is also designated here the lower and upper boundary stratotypes of the formation.

The J. M. Huber mine 30 is located in Twiggs County, Georgia, 5.8 miles (9.3 km) northeast of the railroad crossing at Huber post office and approximately 4 miles (6.4 km) south-southeast of the community of Dry Branch. It is approximately 1.5 to 2.0 miles (2.4 to 3.2 km) south of the type locality of the Dry Branch Formation, and is less than 1 mile (1.6 km) south of the type locality of the Twiggs Clay Member of the Dry Branch Formation. The J. M. Huber mine 30 is located in the Marion, Ga., 1:24,000 Quadrangle map.

LITHOLOGY

As with the other formations of the Oconee Group, the Huber Formation is characteristically a predominantly horizontal, undulatory, to cross-bedded sand with scattered occurrences of quartz pebbles and gravel, lenses of kaolin, and lenses of carbonaceous or lignitic sediments. The lithology of the Huber Formation is dominated by quartz sand, but lenses of kaolin are locally prominent. Other subordinate lithic components include quartz pebbles and gravel, mica, carbonaceous material and lignite, pyrite (and marcasite?), bauxite, goethite, hematite, and dark minerals. The clay minerals and associated minerals reported from the Huber Formation include kaolinite, montmorillonite, illite, gibbsite, and bauxite. Kaolinite and carbonaceous material are dominant or sole lithic components in some beds or lenses.

Typical Huber Formation consists of predominantly small- to large-scale cross-bedded, well-sorted to poorly sorted, fine- to coarse-grained, pebbly to gravelly, variably micaceous sands with typically common to abundant, angular to rounded kaolin clasts that range in size from coarse sand-size to boulders (several feet [up to 1 m] in diameter. Generally the clay clasts consist of kaolin be cobbles and boulders in the upper part of the formation locally consist of bauxite and pseudobauxite. The abundance and conspicuousness of the kaolin clasts is characteristic of the Huber Formation. The abundance of the kaolin clasts is attributed to the abundance of kaolin lenses, both large and small, within the Huber Formation, and their frequent destruction through erosion by shifting stream channels during deposition of the Huber Formation. Channel cut-and-fill structures are locally conspicuous, and channel-fill deposits include pebbly sand, sand, and kaolin. Cross-bedding occurs on scales ranging from less than 1 inch (approximately 1 cm) to several feet (more than 1 m) and consists of both planar and trough types. Herring bone cross bedding is unknown in the Huber Formation.

Carbonaceous and lignitic beds are more commonly found in exposures of the Huber Formation than the underlying Gaillard Formation. However, these beds and lenses are characteristic of the Huber Formation in the subsurface in the type area. The organic material consists of finely disseminated carbonaceous particles invisible to the unaided eye, lignitic material that ranges from flecks to carbonized logs, and impressions or carbonaceous prints of stem and leaves. However, in places the plant impressions in kaolin are devoid of carbonaceous material. The organic content of the carbonaceous sediments ranges from a trace (producing a gray to dark gray coloration) to being the dominant component of the bed (lignite) that is black or brown in color. The carbonaceous layers range in thickness from less than 1 mm to more than 10 feet (3 m).

There is greater lithologic variability in the Huber Formation than in other formations of the Oconee Group. The sands of the Huber range from very poorly sorted clayey, coarsely micaceous and pebbly (first occurrence of smokey quartz pebbles) on one extreme (lithofacies more characteristic of the Gaillard Formation) to fine- or medium-grained and very well sorted on the other extreme. Similarly, bedding definition ranges from rude and vague on the one hand (like the Gaillard Formation), to very well defined and sharp on the other hand. Bedding structures range in size from large to small scale with horizontal bedding units varying from laminae less than 1 mm thick to thick beds more than 3 feet (1 m) thick. The amplitude to cross-bed sets range from a few inches (greater than 5 cm) to more than 4 feet (1.2 m). Mica content is variable and ranges from absent to abundant, and very fine grained to coarse.

Kaolin in the Marion Member of the Huber Formation is more reminiscent of the kaolin of the underlying Gaillard Formation in that it is predominantly soft and fractures conchoidally. However, the Marion kaolin appears to be somewhat more irregular in fracture than that of the underlying Gaillard and its conchoidal fracture is smaller in radius and the surface of the fractures are less soapy to the touch. The kaolin in the Jeffersonville member, on the other hand is relatively hard and breaks with blocky, irregular fractures.

One distinctive lithological difference between the Huber and the Gaillard, but which is not macroscopically evident, is the composition of the dark mineral suite of each. The dark mineral composition of the Gaillard is dominated by zircon, while Huber sediments contain a suite rich in tourmaline, epidote, and staurolite (Hetrick and Friddell, 1983). This difference can be explained by either a different source rock (granite vs. metamorphic) or by the degree of weathering of each source material (before or after deposition). However, what is clear is that two entirely different sets of sediment are involved and not just later reworking and deposition of Gaillard sediment during the Tertiary.

At many places in the type area of the Huber, burrows and traces fossils occur at the top of the Huber Formation that are derived from the overlying Riggins Mill Member of the Clinchfield Formation. These trace fossils are developed in the upper part of the Huber Formation due to occupation of the Huber sediments by marine organisms during the early, coastal phase of the Late Eocene (Barnwell) marine transgression.

The Huber Formation in its type area is characteristically constructed of a series of fining-upward sequences. Any particular fining-upward sequence may be complete or parts of the sequence may be missing. The basal sediments of a fining-upward sequence consists typically of rudely cross-bedded, poorly sorted, pebbly, kaolinitic sand with varying quantities of kaolin clasts and kaolin cobbles derived from the underlying kaolin body. The coarseness of the basal sediments is variable, however, and some beds consist only of kaolinitic, poorly sorted, medium- to coarse-grained sand within abundance of small(less than 1 inch [2.5 cm] in diameter) kaolin clasts. In some channels scoured into the top of the Buffalo Creek Kaolin, the basal Huber consists of brown to black, sandy, carbonaceous or lignitic kaolin or brown to black, sandy, kaolinitic, lignite. The basal coarse sands generally become finer grained, better sorted, more variably horizontal and cross-bedded, and more micaceous upward in the sequence. The upper part of a fining upward sequence generally consists either of variably dark mineral-bearing, moderately to well-sorted, undulatory to horizontal bedded, fine- to medium-grained sand, or of small to large lenses of sand and micaceous to relatively pure kaolin. Commonly the tops of the fining upward sequences have uneven upper surfaces, indicating some scour and erosion prior to deposition of the overlying fining upward sequence. The scale of the fining upward sequences is variable, ranging from roughly 20 feet (6.1 m), to greater than 50 feet (15 m) in thickness. Fining upward sequences can generally be traced around even the largest kaolin pits. However, it is not clear at this time whether particular fining upward sequences can be traced between kaolin pits, but the sequences are considered to represent local sedimentary events in an alluvial, braided stream, to upper estuarine environment.

The Marion Member of the Huber Formation is lithologically similar to the underlying Gaillard Formation. Because of the stress on lithology of only the upper part of the Huber Formation in its original definition (Buie, 1978)(i.e., the Jeffersonville member of this report), there has been a lingering ambiguity on the lithologic characteristics of the Huber Formation and the underlying Gaillard Formation. The lithologic differences between the Marion Member of the Huber and the Gaillard are primarily of degree rather than of kind. The lithologic features characteristic of the Marion Member are found less commonly, or rarely, in the Gaillard Formation and conversely, those lithologic features most characteristic of the Gaillard Formation are also found in the Marion Member but are less commonly encountered. There are enough differences of degree between the two formations, however, that the field geologist can differentiate between the Huber and Gaillard in moderate to large exposures. The following is a list of lithologic distinctions between the Marion Member of the Huber Formation and the Gaillard Formation: (1) Bedding planes tend to be sharper and more clearly defined in the Huber Formation. Bedding in the Gaillard is more commonly gradational and rude in appearance. This may be due to more discontinuous sedimentation during deposition of the Huber Formation and the consequence of bedding planes tending more to represent diastems, even within fining upward sequences. In contrast, sedimentation is postulated as having been more continuous during deposition of the Gaillard Formation with relatively few diastems occurring mainly at the tops of fining upward sequences. (2) Sand in the Huber Formation is generally better sorted and finer grained than in the Gaillard. Locally, or in discrete beds however, the Huber sands can be as poorly sorted and coarse as those of the Gaillard Formation. (3) An abundance and widespread occurrence of rounded kaolin intraclasts of a wide range of sizes is especially characteristic of the Huber Formation. Kaolin intraclasts are locally abundant in the Gaillard Formation but not widespread as in the Huber. (4) The size scale of sedimentary structures is on the average smaller in the Huber Formation than in the Gaillard. This includes thickness of bedding units, amplitudes of cross-bed sets, and scale of cut and fill structures. (5) In relatively pure or commercial grade kaolin, very pale pinkish tan, soft kaolin with broadly conchoidal fracture is characteristic of the Gaillard Formation. Kaolin of the soft variety is present in the Marion Member but the color is more greenish and the fracture varies from conchoidal on a smaller scale, to subconchoidal with some degree of uneven fracture. (6) Finally, commercial grade (purity and thickness) is not common in the Marion Member and the greatest volume of commercial kaolin are contained in the Gaillard Formation (Buffalo Creek Kaolin Member) and the Jeffersonville member of the Huber Formation. The known lithologies of the Jeffersonville member are distinctly different from that of the Gaillard Formation and the Marion Member and once the field geologist becomes acquainted with these lithologies, there should be little confusion between the Jeffersonville and the underlying kaolinitic units.

STRATIGRAPHIC RELATIONSHIPS

The Huber Formation is restricted, in outcrop and subcrop, to the Fall Line Hills district of central and eastern Georgia, the northern part of the Louisville Plateau District of eastern Georgia, and its name has been applied as far east as Lexington County, South Carolina (Paul Nystrom, pers. com., 1990), although the precise correlation of the type Huber with the South Carolina Huber is uncertain at this time. The formation extends in the west from the vicinity of the Ocmulgee River at least as far east as the Savannah River. Its updip limit is the Fall line where it either pinches out locally or terminates by erosional truncation. Its downdip limit extends in a southwest-northeast trending zone of facies change from southern Twiggs County in the west, eastward through southern Wilkinson County, and northeastward through southern Richmond County, Georgia.

In the vicinity of the Ocmulgee River, the Marion Member of the Huber Formation grades down the dip or seaward into the coastal marine Marshallville Formation. The eastern extent of the Marshallville Formation is unknown at this time due to insufficient core data. However, in the Savannah River area, the Marion Member grades down dip into the coastal marine Ellenton Formation and the Jeffersonville member grades downdip into the McBean Member of the Lisbon Formation of offshore, continental shelf origin.

The Huber Formation does not occur west of the Ocmulgee River. The Marion Member grades laterally southwestward in the vicinity of the Ocmulgee River into the coastal marine Marshallville Formation of the Fort Valley Group and the Jeffersonville member grades laterally southwestward into the Mossy Creek and Perry Sands of the Fort Valley Group. It is possible that the Huber Formation may once have occurred west of the Ocmulgee River but was subsequently stripped off by erosion in the Fall Line Hills area.

The Huber Formation disconformably overlies the Gaillard Formation in most places in Georgia. Locally along the Fall line, the Huber Formation may unconformably overlie Piedmont basement rocks or disconformably overlie the Pio Nono Formation. The Huber Formation is not known to overlie any other formations in Georgia. Over most of its area, the Huber Formation is disconformably overlain by the Barnwell Group or by Upper Eocene channel deposits.

AGE

The age of the Huber Formation is considered to be Early Paleocene, Midwayan at its type locality although Middle Eocene, upper Claibornian deposits were one time exposed there. By physical correlation from the Flint River area through the Marshallville Formation to the kaolin mining district east of the Ocmulgee River, it can be demonstrated that the Clayton Formation grades landward into the coastal marine Marshallville Formation, and the Marshallville Formation grades laterally northeastward in the vicinity of the Ocmulgee River into the Marion Member of the Huber Formation. Similarly, by physical correlation it would appear that the Jeffersonville member grades laterally westward, in the vicinity of the Ocmulgee River into the Mossy Creek Sand. This correlation, however, has not yet been fully established.

Tshudy and Patterson (1975) reported ages for the Tertiary kaolinitic deposits as Midwayan, Sabinian, and lower and upper Claibornian. Most of the samples identified were of early Claibornian age (Tallahatta equivalents) whereas some were of Midwayan age. However, they presented no elevations, lithologies or stratigraphic positions for their samples and, therefore, their results are not duplicatable. Deposits of early Claibornian age are not present in outcrop on the Flint River nor are they present in the Fort Valley Plateau District between the Flint and Ocmulgee Rivers. Only one exposure in a steep head near the type locality of the Perry Sand could be an updip feather edge of the lower Claibornian. At that site, the deposits underlying the Perry Sand are of Oconee Group lithology but occur disconformably below the upper Claibornian Perry Sand and disconformably above deposits lithologically transitional from the coastal marine Marshallville Formation to the offshore, continental shelf Clayton Formation.

It is possible that there are outliers of Sabinian and early Claibornian age present in topographic lows on the top of the Marion Member of the Huber Formation. However, these hypothetical deposits have not been lithologically differentiated from the rest of the Huber Formation and their occurrence is uncertain at this time.

MARION MEMBER OF THE HUBER FORMATION (new name)

DEFINITION

The Marion Member of the Huber Formation is a new name introduced here for a kaolinitic sand deposit that heretofore has been considered as the lower part of the Huber Formation. As understood here, the Marion Member is the Lower Paleocene, Midwayan component of the Huber Formation. It is the thickest and most widespread component of the Huber Formation in central Georgia and it is the only component of the Huber Formation now exposed at the type locality of the formation in Huber Pit 30. The Marion Member is locally absent only in the most updip areas near the Fall line. Elsewhere, in Twiggs, Wilkinson, and Washington Counties, the Marion Member is consistently present overlying the Gaillard Formation.

As with the rest of the Huber Formation, in earlier years the Marion Member was believed to be Cretaceous in age and had been included in the Lower Cretaceous (Veatch and Stephenson, 1911), Middendorf Formation (Smith, 1929), Tuscaloosa Formation (Cooke, 1943), and Tuscaloosa Formation in part (Herrick, 1961; Herrick and Vorhis, 1963). Buie and Fountain (1967) and Tshudy and Patterson (1975) first treated these deposits as part of the lower Tertiary and the Marion Member of the Huber Formation was included in the Lower Tertiary-Cretaceous undifferentiated on the geologic map of Georgia (Georgia Geological Survey, 1976).

TYPE SECTION

The name Marion is taken from the community of Marion in Twiggs County, approximately 4 miles (1.2 km) southeast of the type locality. The type locality of the Marion Member is Huber Pit 36 (Fig. 19). The type section, or unit stratotype (holostratotype) of the Marion Member is that section of the Huber Formation disconformably overlying the Buffalo Creek Kaolin and disconformably underlying either the Mossy Creek Sand or residuum of the Barnwell Group (Fig. 19). Both the lower and upper boundary stratotypes are exposed in Pit 36.

LITHOLOGY

Because the great bulk of the Huber Formation in central Georgia consists of the Marion Member, much of the lithologic description of the formation is also that of the member. As with the other formations of the Oconee Group, the Marion Member of the Huber Formation is characteristically a predominantly horizontal, undulatory, to cross-bedded sand with scattered occurrences of quartz pebbles and gravel, lenses of kaolin, and lenses of carbonaceous or lignitic sediments. The lithology of the Huber Formation is dominated by quartz sand, but lenses of kaolin are locally prominent. Other subordinate lithic components include quartz pebbles and gravel, mica, carbonaceous material and lignite, pyrite (and marcasite?), bauxite, goethite, hematite, and dark minerals. The clay minerals and associated minerals reported from the Huber Formation include kaolinite, montmorillonite, illite, gibbsite, and bauxite. Kaolinite and carbonaceous material are dominant or sole lithic components in some beds or lenses.

Typical Marion Member consists of predominantly small- to large-scale cross-bedded, well-sorted to poorly sorted, fine- to coarse-grained, pebbly to gravelly, variably micaceous sands with typically common to abundant, angular to rounded kaolin clasts that range in size from coarse sand-size to boulders (several feet [up to 1 m] in diameter. Generally the clay clasts consist of kaolin but there are rare occurrences of cobbles and pebbles in the upper part of the formation that consist of bauxite and pseudobauxite. The abundance and conspicuousness of the kaolin clasts is characteristic of the Marion Member. The abundance of the kaolin clasts is attributed to the abundance of kaolin lenses, both large and small, within the Huber Formation, and their frequent destruction through erosion by shifting stream channels during deposition of the member. Channel cut-and-fill structures are locally conspicuous, and channel-fill deposits include pebbly sand, sand, and kaolin. Cross-bedding occurs on scales ranging from less than 1 inch (approximately 1 cm) to several feet (more than 1 m) and consists of both planar and trough types. Herring bone cross bedding is unknown in the Marion Member.

Carbonaceous and lignitic beds are more commonly found in exposures of the Marion Member of the Huber Formation than in the underlying Gaillard Formation. These beds and lenses are also characteristic of the Huber Formation in the subsurface in the type area. The organic material consists of finely disseminated carbonaceous particles invisible to the unaided eye, lignitic material that ranges from flecks to carbonized logs, and impressions or carbonaceous prints of stem and leaves. In places the plant impressions in kaolin are devoid of carbonaceous material. The organic content of the carbonaceous sediments ranges from a trace (producing a gray to dark gray coloration) to being the dominant component of the bed (lignite) that is black or brown in color. The carbonaceous layers range in thickness from less than 1 mm to more than 10 feet (3 m).

There is greater lithologic variability in the Marion Member of the Huber Formation than in other formations of the Oconee Group. The sands of the Huber range from the very poorly sorted clayey, coarsely micaceous and pebbly lithofacies more characteristic of the Gaillard Formation on one extreme to fine- or medium-grained and very well sorted sand on the other extreme. Similarly, bedding definition ranges from rude and vague on the one hand (like the Gaillard Formation), to very well defined and sharp on the other hand. Bedding structures range in size from large to small scale with horizontal bedding units varying from laminae less than 1 mm thick to thick beds more than 3 feet (1 m) thick. The amplitude to cross-bed sets range from a few inches (greater than 5 cm) to more than 4 feet (1.2 m). Mica content is variable and ranges from absent to abundant, and very fine grained to coarse.

Kaolin in the Marion Member of the Huber Formation is more reminiscent of the kaolin of the underlying Gaillard Formation in that it is predominantly soft and fractures conchoidally. However, the Marion kaolin appears to be somewhat more irregular in fracture than that of the underlying Gaillard and its conchoidal fracture is smaller in radius and the surface of the fractures are less soapy to the touch.

The Marion Member, like other lithostratigraphic subdivisions of the Oconee Group, is characteristically constructed of a series of fining-upward sequences. Any particular fining-upward sequence may be complete or parts of the sequence may be missing. The basal sediments of a fining-upward sequence consists typically of rudely cross-bedded, poorly sorted, pebbly, kaolinitic sand with varying quantities of kaolin clasts and kaolin cobbles derived from the underlying kaolin body. The coarseness of the basal sediments is variable, however, and some beds consist only of kaolinitic, poorly sorted, medium- to coarse-grained sand within abundance of small(less than 1 inch [2.5 cm] in diameter) kaolin clasts. In some channels scoured into the top of the Buffalo Creek Kaolin, the basal Marion Member consists of brown to black, sandy, carbonaceous or lignitic kaolin or brown to black, sandy, kaolinitic, lignite. The basal coarse sands generally become finer grained, better sorted, more variably horizontal and cross-bedded, and more micaceous upward in the sequence. The upper part of a fining upward sequence generally consists either of variably dark mineral-bearing, moderately to well-sorted, undulatory to horizontal bedded, fine- to medium-grained sand, or of small to large lenses of sand and micaceous to relatively pure kaolin. Commonly the tops of the fining upward sequences have uneven upper surfaces, indicating some scour and erosion prior to deposition of the overlying fining upward sequence. The scale of the fining upward sequences is variable, ranging from roughly 20 feet (6.1 m), to greater than 50 feet (15 m) in thickness. Fining upward sequences can generally be traced around even the largest kaolin pits. However, it is not clear at this time whether particular fining upward sequences can be traced between kaolin pits, but the sequences are considered to represent local sedimentary events in an alluvial, lower delta flood plain to upper estuarine environment.

The Marion Member of the Huber Formation is lithologically similar to the underlying Gaillard Formation. Because of the stress on lithology of the upper part of the Huber Formation in its original definition (Buie, 1978)(i.e., the Jeffersonville member of this report), there has been a lingering ambiguity on the lithologic characteristics of the Huber Formation and its subdivisions, and of the underlying Gaillard Formation. The lithologic differences between the Marion Member of the Huber and the Gaillard are primarily of degree rather than of kind. The lithologic features characteristic of the Marion Member are found less commonly, or rarely, in the Gaillard Formation and conversely, those lithologic features most characteristic of the Gaillard Formation are also found in the Marion Member but are less commonly encountered. There are enough differences of degree between the two units, however, that the field geologist can differentiate between the Marion Member and Gaillard in moderate to large exposures. The following is a list of lithologic distinctions between the Marion Member of the Huber Formation and the Gaillard Formation: (1) Bedding planes tend to be sharper and more clearly defined in the Huber Formation. Bedding in the Gaillard is more commonly gradational and rude in appearance. This may be due to more discontinuous sedimentation during deposition of the Huber Formation and the consequence of bedding planes tending more to represent diastems, even within fining upward sequences. In contrast, sedimentation is postulated as having been more continuous during deposition of the Gaillard Formation with relatively few diastems occurring mainly at the tops of fining upward sequences. (2) Sand in the Huber Formation is generally better sorted and finer grained than in the Gaillard. Locally, or in discrete beds however, the Huber sands can be as poorly sorted and coarse as those of the Gaillard Formation. (3) Very thinly bedded, well-sorted sands with concentrations of dark minerals are common in the Marion Member of the Huber Formation. (4) An abundance and widespread occurrence of rounded kaolin intraclasts of a wide range of sizes is especially characteristic of the Huber Formation. Kaolin intraclasts are locally abundant in the Gaillard Formation but not widespread as in the Huber. (5) The size scale of sedimentary structures is on the average smaller in the Huber Formation than in the Gaillard. This includes thickness of bedding units, amplitudes of cross-bed sets, and scale of cut and fill structures. (6) In relatively pure or commercial grade kaolin, very pale pinkish tan, soft kaolin with broadly conchoidal fracture is characteristic of the Gaillard Formation. Kaolin of the soft variety is present in the Marion Member but the color is more greenish and the fracture varies from conchoidal on a smaller scale, to subconchoidal with some degree of uneven fracture. (7) Finally, commercial grade (purity and thickness) is not common in the Marion Member and the greatest volume of commercial kaolin are contained in the Gaillard Formation (Buffalo Creek Kaolin Member) and the Jeffersonville member of the Huber Formatio1986X

STRATIGRAPHIC RELATIONSHIPS

The Marion Member of the Huber Formation is restricted to the Fall Line Hills District of central and perhaps eastern Georgia. The formation extends in the west from the vicinity of the Ocmulgee River at least as far east as central Washington County, Georgia. Its updip limit is the Fall line where it either pinches out locally or terminates by erosional truncation. Its downdip limit extends in a southwest-northeast trending zone of facies change from southern Twiggs County in the west, eastward through southern Wilkinson County.

In the vicinity of the Ocmulgee River, the Marion Member of the Huber Formation grades down the dip or seaward into the coastal marine Marshallville Formation. The eastern extent of the Marshallville Formation is unknown at this time due to insufficient core data. However, in the Savannah River area, the Marion Member grades down dip into the coastal marine Ellenton Formation and the Jeffersonville member grades downdip into the McBean Member of the Lisbon Formation of offshore, continental shelf origin.

The Marion Member does not occur west of the Ocmulgee River. The member grades laterally southwestward in the vicinity of the Ocmulgee River into the coastal marine Marshallville Formation of the Fort Valley Group. It is possible that the Marion Member may once have occurred west of the Ocmulgee River but was subsequently stripped off by erosion in the Fall Line Hills area.

The Marion Member of the Huber Formation disconformably overlies the Gaillard Formation in most places in Georgia. Locally along the Fall line, the member may unconformably overlie Piedmont basement rocks or disconformably overlie the Pio Nono Formation. The Marion Member is not known to overlie any other formations in Georgia. Over most of its area, the Marion Member is disconformably overlain by the Barnwell Group or locally by the Jeffersonville member or Upper Eocene channel deposits.

AGE

The age of the Marion Member of the Huber Formation is considered to be Early Paleocene, Midwayan at its type locality. By physical correlation from the Flint River area through the For Valley Plateau to the kaolin mining district east of the Ocmulgee River, it can be demonstrated that the Clayton Formation grades landward into the coastal marine Marshallville Formation, and the Marshallville Formation grades laterally northeastward in the vicinity of the Ocmulgee River into the Marion Member of the Huber Formation.

JEFFERSONVILLE MEMBER OF THE HUBER FORMATION (new informal name)

DEFINITION

The Jeffersonville member of the Huber Formation is a new name informally introduced here for kaolin deposits that have previously been referred to the upper part of the Huber Formation and have been called Tertiary hard kaolin or Claiborne kaolin. The Jeffersonville member is distinguished in this guidebook from the underlying Marion Member of the Huber in that it overlies the Marion Member disconformably, it is known to consist mainly of kaolin, the kaolin is lithologically distinctive, and what little is known of the sand lithofacies suggests that it too is lithologically distinctive. In its type area in the vicinity of Jeffersonville, Twiggs County, Georgia, the Jeffersonville member comprises the entire Middle Eocene section and contains no appreciable sand. The kaolin component of the Jeffersonville member is distinguished from kaolin component of the Marion Member in consisting only of pale greenish, hard, brittle kaolin with a hackly fracture. The trace fossil **Planolithes** commonly occurs in the upper part or top of the kaolin in the central Georgia kaolin mining area (Schroder, 1982). The kaolin component of the Marion Member, seldom commercial in grade or volume, is a softer kaolin with a conchoidal to subconchoidal fracture. It resembles more the Gaillard kaolin than the Jeffersonville kaolin.

Except for the occurrences of Mossy Creek Sand in topographic lows on the top of the Marion Member in the Huber Pit 36 area in western Twiggs County and scattered occurrences of Mossy Creek-type sand in the vicinity of McIntyre in Wilkinson County, a sand component of the Jeffersonville member is largely unknown at this time. However, it is difficult to conceive of an estuarine-coastal marine depositional system where sand bypasses the entire system and clay (kaolin) is systematically deposited. On the other hand, the coastal marine stratigraphic equivalents of the Jeffersonville member west of the Ocmulgee River (Mossy Creek and Perry Sands), consist principally of quartz sand.

Between the Ocmulgee and Oconee Rivers, little sand appears to have been supplied to the offshore, continental shelf at this time as can be seen in the quartz sand deficient Blue Bluff Member of the Lisbon Formation. In that area, quartz sand consistently dominates the lithology of this late Clabornian depositional interval only in the transitional zone of the innermost, offshore Lisbon Formation, a narrow band of dominantly, macrofossiliferous, calcareous, sandy deposits between the shoreface and the offshore.

TYPE AREA

The name Jeffersonville is taken from the town of Jeffersonville, the county seat of Twiggs County, Georgia. The type area of the Jeffersonville member of the Huber formation is the kaolin mining area around Porters Creek, east of Jeffersonville, Twiggs County, Georgia. In that area, the entire Middle Eocene section consists of "hard" kaolin.

LITHOLOGY

The Jeffersonville member of the Huber Formation consists of relatively pure to slightly sandy kaolin that is characteristically pale greenish, hard, brittle, and has a hackly fracture. It is characteristically massive and structureless, and devoid of any sedimentary structures except in the upper part of the formation where the trace fossil **Planolithes** locally occurs in abundance, and various kinds of burrows and other stratification disruptions (bioturbation) from the overlying Clinchfield Formation occur in abundance (Schroder, 1982). Locally, the kaolin is pyritic, carbonaceous, or lignitic, and the organic-rich kaolins occur in lenses, grading in all directions into relatively pure, pale greenish kaolin.

It is suggested that a sand lithofacies must also occur in association with the "hard" kaolin but we have seen few exposures of lithologically distinctive sand in the proposed stratigraphic position of the Jeffersonville member. In the two places that we have seen beds of quartz sand in the proper stratigraphic position, the sand lithology is typical of that of the Mossy Creek Sand west of the Ocmulgee River.

STRATIGRAPHIC RELATIONSHIPS

The Jeffersonville member of the Huber Formation occurs from the vicinity the Ocmulgee River in the west at least as far as Richmond County Georgia, in the east. Eocene hard kaolin of Aiken County, South Carolina has been included in the Huber Formation (Nystrom and Willoughby, 1982; Nystrom and others, 1987) that lithologically is identical or similar to the Jeffersonville kaolins.

The Jeffersonville member occurs from the vicinity of the Fall line in Georgia, and even occurs well onto the Piedmont in the Devereaux prong in Hancock County, Georgia, and in outliers on the Piedmont to the east of the prong in Hancock County. Its downdip limits occur in the shallow subsurface from southern Twiggs County, northeastward through southernmost Washington County, to southern Richmond County. It grades downdip (seaward) into the McBean Member of the Lisbon Formation in the vicinity of the Richmond/Burke Counties line immediately north of McBean Creek in the Savannah River area.

The Jeffersonville member is known to disconformably overlie the Marion Member of the Huber Formation at 254 feet in the core Twiggs 2 (GGS-3174) taken at Jeffersonville in Twiggs County, and at 233 feet in the core Wilkinson 2 (GGS-3175) taken near McIntyre in Wilkinson County. Locally the Jeffersonville member may disconformably overlie the Gaillard Formation but this has not yet been established in the field.

The Jeffersonville member is overlain disconformably by the Barnwell Group or by Upper Eocene channel deposits in its known area of extent. The specific formations of the Barnwell Group include either the Riggins Mill Member of the Clinchfield Sand or, where that is locally absent, by the Twiggs Clay Member of the Dry Branch Formation, or by undifferentiated Dry Branch Formation.

The kaolin lithofacies of the Jeffersonville member can be distinguished from the kaolins of other formations of the Oconee Group in that it is characteristically, and uniformly, hard, brittle, and of hackly fracture. The only other formation studied in this report that contains Jeffersonville-type kaolins are those kaolins that occur in lenses within the Perry Sand immediately west of the Ocmulgee River in eastern Houston County. However, these Perry kaolins are considered to have been deposited contemporaneously with those of the Jeffersonville member and are thought to be of similar environmental origin. In fact, the Perry kaolins are considered here to be lenses of the westernmost occurrence of Jeffersonville-type kaolins. The Jeffersonville kaolins are not as slick and soapy to the touch as the kaolins of the Gaillard and Marion Member of the Huber, and they are not known anywhere to break with a conchoidal fracture. Also, Jeffersonville kaolin is low in mica content compared with the kaolins of the Marion Member and Gaillard. The kaolins of the Nakomis Formation resemble the Jeffersonville kaolins more than those of any other formation examined in this report. However, the Nakomis Formation is not known to occur in association with the Jeffersonville member and the Nakomis kaolins are known only from the shallow subsurface.

The environment of deposition of Jeffersonville member of the Huber Formation is problematic. Because Jeffersonville-type kaolins occur within the Perry Sand, considered here to be of shoreface or barrier island-related origin, the Jeffersonville member would then be thought to have been deposited in a similar environment. However, by extrapolating the lithofacies of the Mossy Creek Sand and the Perry Sand eastward across the Ocmulgee River, it would appear that the outcropping Jeffersonville member may be correlative with the Mossy Creek Sand but also possibly with the Perry Sand. According to that interpretation, the Jeffersonville member should be of coastal marine, sound/lagoon origin. Any sandy lithofacies of the formation therefore should contain well sorted, fine-grained sand that is locally burrowed and bioturbated. We have observed deposits of this nature in the field in the appropriate stratigraphic position, but the exposures examined are too rare and isolated for one to form an impression of any systematic lithologic variation.

AGE

By physical correlation and stratigraphic position, the Jeffersonville member of the Huber Formation is correlated with the Mossy Creek Sand and the Perry Sand west of the Ocmulgee River. These formations are correlated with, on the same basis, with the Lisbon Formation that occurs in the shallow subsurface south of the Perry Sand/Mossy Creek-Jeffersonville outcrop belt. As a result, the Jeffersonville member is correlated with the Lisbon Formation in this report and is considered to be of late Middle Eocene, Late Claibornian, Bartonian age. It would be included in planktonic foraminiferal Zone P 13 of Berggren (1973) and in the **Orbulinoides beckmanni** Zone of Bolli (1957) and Stainforth and others (1975).

DEPOSITS ASSOCIATED WITH AND RELATED TO THE OCONEE GROUP.

BUTLER-ALLON CHANNEL DEPOSITS

DEFINITION

The Butler-Allon channel deposits are lithologically distinctive siliciclastic sediments of apparent fluvial or alluvial origin that fill in topographic lows on top of the Gaillard and Marshallville Formations in the vicinity of the Flint River near Butler in Taylor County and Gaillard in Crawford County, Georgia. At this time they are known to occur only in the pits of the Butler Sand and Gravel Company in Taylor County and in the pits of the Atlanta Sand and Supply Company in Crawford County and are part of the deposits being mined for sand. Because rounded to angular plinthite pebbles and subangular ironstone clasts are a characteristic component of these deposits, we at first considered them to be modern in origin, perhaps related to earlier sand mining activities. However, in all instances, the Butler-Allon channel deposits are overlain abruptly but without apparent disconformity by the Mossy Creek Sand of late Claibornian age. And, at the Butler sand pit, the lithology of the Butler-Allon channel deposits resembles the lithology of the overlying Mossy Creek Sand. As a result, we interpret the age of the Butler-Allon channel deposits to be pre-Mossy Creek and post Gaillard. We have not yet seen the channel deposits overlying the Marshallville Formation so we are not now certain what the stratigraphic relationships are with the Marshallville. However, in the Atlanta Sand and Supply Company pits, where the Marshallville Formation occurs high in the section and is directly overlain by the Mossy Creek Sand, the Butler-Allon channel deposits are absent, suggesting that the channel deposits are post Marshallville.

We tentatively interpret the Butler-Allon channel deposits to have been deposited during a period of rising geomorphic base level, either immediately preceding the deposition of the coastal-marine Mossy Creek Sand or, possibly, during one of the preceding and lower Claibornian high stands of the sea. In this way we consider the Butler-Allon channel deposits to be analogous to the Upper Eocene channel sands of central Georgia, but of earlier age and deposited in a different area.

TYPE AREA

The Butler-Allon channel deposits are known to occur only in the pits of the Butler Sand and Gravel Company north of Butler in Taylor County, and in the pits of the Atlanta Sand and Supply Company in Crawford County, Georgia. The informal term Butler-Allon is taken from the town of Butler in Taylor County and from the community of Allon near the pits of the Atlanta Sand and Supply Company in Crawford County.

Although we assume that the channel deposits are more widespread in occurrence than just within these pits, we have not yet recognized them in outcrop in nearby pits and road cuts (perhaps because of their resemblance to residuum, colluvium or fill). Because the channel deposits are extremely variable in thickness, ranging from 0 feet to over 60 feet (19 m) within short distances, we consider them to have been deposited in topographic lows in the near vicinity of the paleo-Flint River during a period of rising geomorphic base level. We have seen no other deposits of this lithology and in this stratigraphic position outside of the two sand mining areas in question. As a result, we are describing the type area of these deposits as eastern Taylor County and southwestern Crawford County, Georgia.

LITHOLOGY

The Butler-Allon channel deposits consist of sand with clay in varying proportions. In general the quartz sand size is fine- to fine/medium-grained but beds or lenses of coarse to very coarse and pebbly sand also occurs. The sand is well sorted where fine-grained but the sorting deteriorates as the sand size increases. The coarser beds of sand and pebbly sand are poorly to very poorly sorted. In general, the finer sand sizes predominate and the sand that is coarser than fine/medium is volumetrically minor. The coarser sands occur in thin beds and lenses, and especially near the base of the deposits.

Clay appears to vary irregularly but is a consistent and characteristic component of the Butler-Allon channel deposits. Virtually all beds within the unit we have examined are argillaceous to some degree. However, the Butler-Allon deposits at Gaillard are considerably more argillaceous than they are at Butler, where the channel deposits more closely resemble the overlying Mossy Creek Sand.

Other lithic components of the Butler-Allon channel deposits include minor pea gravel, plinthite pebbles, and subrounded to angular fragments of iron stone and iron-cemented sandstone. The coarser components of the lithology generally are concentrated toward the base of the unit and in the deeper channels. This is certainly true for plinthite pebbles and especially angular fragments of iron stone and iron-cemented sandstone. However, these coarser components can also occur in thin beds, stringers, or lenses well above the base of the deposits.

The Butler-Allon deposits are prominently stratified. The stratification is generally horizontal to undulatory with thin to medium bedding. Cross-bedding is minor and is found mainly near the base of the unit. Small-scale planar cross bedding occurs throughout most of the lower part of the section and especially in the lower part. Small-to moderate scale trough cross bedding occurs mainly in the lowest parts of the channels and is associated with the coarser grained sediments.

The Butler-Allon channel deposits are very firm and coherent relative to the overlying Mossy Creek Sand or the underlying Gaillard Formation. In terms of resistance to physical erosion, the channel deposits are comparable to that of the underlying Pio Nono Formation

The Butler-Allon deposits are variably pigmented. We have seen no exposures where these deposits are not pigmented to some degree. Most typically, they are strongly pigmented with varying shades of yellowish gray to dusky yellow (5 Y 7/2 - 5 Y 6/4) and red (5 R 5/6). The pigmentation is considered to have been penecontemporaneous, as with much of the underlying Pio Nono, and is thought to be the consequence of immature iron-bearing minerals deposited during the initial phases of fluvial or alluvial sedimentation of a rising sea level.

STRATIGRAPHIC RELATIONSHIPS

The Butler-Allon channel deposits are known to occur only in southwestern Crawford County and easter Taylor County, Georgia. They occur in the near vicinity of the Flint River and are thought to be restricted to that area. We think that there had been considerable topographic relief in the vicinity of the paleo-Flint River near the Fall line during the low stands of the sea of the Paleocene through Middle Eocene. During one of the periods of rising sea level in the Middle Eocene, perhaps during the latest phase of the Middle Eocene that resulted in the deposition of the coastal marine Mossy Creek Sand, Perry Sand, and the offshore Lisbon Formation (Cooke Mountain-equivalent), local base level within the stream valleys continued to rise along with the rising sea level. This resulted in the sediment filling of the valleys which outpaced the rise in sea level. Eventually the topographic relief was eliminated with the complete filling of the valleys and the rise of sea level to the present vicinity of the fall line. The youngest deposits of the Butler-Allon channel deposits are uniformly fine-grained and indicative of low energy conditions.

The Butler-Allon channel deposits disconformably overlie the Pio Nono Formation in Taylor County and the Gaillard Formation and probably the Marshallville Formation in Crawford County. In both areas, there is considerable relief on top of the pre-Butler-Allon. In one of the Butler Sand and Gravel Company pits, there is more than 50 feet (15 m) of relief on top of the Pio Nono. Where the Marshallville Formation is present in the Atlanta Sand and Supply pits in Crawford County, it occurs at high elevations within the pits and is disconformably overlain by the Mossy Creek Sand.

The Butler-Allon deposits, everywhere we have seen, are directly overlain by the Mossy Creek Sand. The contact relationships are uncertain but they appear as abrupt bed changes. In all exposures we have examined, the contact is sharp and does not appear to be disconformable. On the other hand, in the active pit of the Butler Sand and Gravel Company, there appears to be some minor relief on the contact across the pit although the contact relationships remain the same.

Being channel deposits, the Butler-Allon is confined to topographic lows occurring within older formations. As a result, we have not seen these deposits grading laterally into any other formations.

AGE

The age of the Butler-Allon channel deposits must be interpreted on the basis of their physical relationships because they are not known to fossiliferous. The deposits disconformably overlie the Gaillard Formation of Late Cretaceous, probably Tayloran age and are, therefore, younger than Tayloran. They also appear to be younger than the Marshallville Formation of Early Paleocene, Midwayan age. Therefore, it is concluded that the Butler-Allon channel deposits are probably younger than Midwayan.

Everywhere we have seen the channel deposits, they are overlain either conformably or paraconformably by the Mossy Creek Sand of late Claibornian, Middle Eocene age. Therefore we infer the channel deposits to be approximately late Claibornian in age (related to the deposition of the Mossy Creek Sand) or are somewhat older (Fig. 3).

UPPER EOCENE CHANNEL SANDS

DEFINITION

The Upper Eocene channels sands were first recognized by LaMoreaux (1946a, 1946b). Huddlestun and Hetrick (1979, 1986) were not able to identify with certainty these discrete deposits in the field and, therefore, did not include them in their discussion of Upper Eocene deposits or related deposits. However, during subsequent fieldwork we have been able to identify with reasonable certainty what LaMoreaux (1946a, p. 48-51; 1946b) had called "(Upper (?) Eocene) Channel Sands". These channel fill sediments occur only locally and appear to have been deposited in topographic lows on the top of the Jeffersonville member or Marion Member of the Huber Formation during the initial stages of the Late Eocene transgression. The lower parts of the channel fill deposits are lithologically more akin to the Oconee Group than to the Barnwell Group. However, the upper parts of the channel fill deposits are lithologically related to the Oconee Group lithologies whereas the upper parts of the channel fill deposits are more closely related to Fort Valley Group. The upper middle or upper parts of channel deposits commonly contain **Ophiomorpha nodosa** which are of coastal marine origin. The sediments in the upper parts of the channels are compatible with Barnwell Group lithology but lithologically unlike any other subdivision of the Barnwell Group.

The environment of deposition of the sediments in the lower parts of the channels are apparently nonmarine in origin because all of the samples from this interval examined by L. Edwards of the U. S. Geological Survey were barren of dinoflagellates, chitinous microfossils that live only in marine environments (Edwards, pers. com., 1988). Finally, it is observed that the channel sands grade upward into, or appear to grade upward into, over several inches (at least 5 cm),. into the Clinchfield Formation of the Barnwell Group. Over all, in a well-developed vertical channel sequence, the vertical stacking of sediments indicated the lowest parts of the channel deposits are genetically related to the Oconee Group. The Oconee Group type sediments grade upward into Fort Valley type sediments, and the Fort Valley type sediments grade upward into Clinchfield Formation. Where the Clinchfield

Formation has been locally truncated, the overlying Dry Branch Formation of the Barnwell Group should have the appearance of disconformably overlying the channel deposits. As an example of the difficulties in first recognizing less well developed Upper Eocene channels, we point out that we now assign beds 2 and 3 of Georgia Kaolin Pit 50 (Huddlestun and Hetrick, 1979, 1986, p. 65, fig.16) to the Upper Eocene channel sands and not to the Huber Formation.

The channel sands are not a blanket deposit and are found only locally. At this time there is insufficient information to determine whether there occurrence is systematic or apparently random. Therefore, because of their lithologic distinctiveness and the lack of predictability in the occurrence of the channel sands, we choose not to include them in any particular lithostratigraphic unit at this time, only pointing out their stratigraphic association.

REFERENCE SECTIONS

There are only two extent kaolin pits at this time that may temporarily serve as reference localities. These include the channel sands exposed in the kaolin pit of the Anglo-American mine at Oconee, and in the Shepard Mine of Georgia Kaolin Company near Deepstep, both in Washington County, Georgia. During our last visit to the Anglo-American mine at Oconee, there were several incised channels with channel sands exposed within the channels. However, there is one large channel present that is approximately 15 feet (4.6) deep. In this mine, the channel sands disconformably overlie the Jeffersonville member of the Huber Formation, which is being mined for kaolin, and conformably and gradationally underlie the Riggins Mill Member of the Clinchfield Formation.

The Shepard Mine of Georgia Kaolin Company near Deepstep contains one large asymmetrical channel with a lens of lignitic sediments against the vertical to undercut face of the channel (see Pickering and Hurst, 1989, fig. 20). In this mine, the channel sands disconformably overlie the Huber Formation (Marion Member?) but are conformably and gradationally overlain by the Riggins Mill Member of the Clinchfield Formation.

Georgia Kaolin Mine 50, the type locality of the Riggins Mill Member of the Clinchfield Formation is interpreted here to contain channel sand deposits (see Huddlestun and Hetrick, 1979, 1986). Beds 2 and 3 of Huddlestun and Hetrick (1979, 1986) are correlated here with the channel sands but were previously included in the Huber Formation. Subsequent to our recognizing the channel sands in Washington County, we now interpret the pre-Barnwell section in Pit 50 to consist of the Marion Member of the Huber Formation at the base (the mined kaolin, bed 1), channel sands (beds 2 and 3), and the Barnwell and Ocala Groups (beds 4 through 11). The channel sands are interpreted to disconformably overlie the Huber Formation, and are conformably or paraconformably overlain by the Riggins Mill Member of the Clinchfield Formation. At Mine 50, except where the **Ophiomorpha**-bearing sands were present, there appears to have been a pause in sedimentation prior to deposition of the Clinchfield. The upper surfaces of a gray, silty kaolin lens that occurred in two faces of the mine hand been burrowed into and filled with sediments of the overlying Clinchfield Formation. The **Ophiomorpha**-bearing sands that occurred in a part of the mine appeared to be conformable and gradational with the overlying Clinchfield Formation. Unfortunately, this kaolin mine has been completely reclaimed and there are no longer exposures at the site.

LITHOLOGY

The lithology of the channel sands varies from bottom to top of the channel section, and the proportion of each type of sediment within the channel may vary from channel to channel. The lower part of the channel deposits consists of typical Oconee Group coarsely planar and trough cross-bedded sands with a kaolinitic matrix. Some thin kaolin stringers may be present locally but kaolin is a minor component of this lithofacies. Commonly the cross-bedded sands are moderately poorly sorted but in some beds they may be well sorted or very poorly sorted, kaolinitic, and pebbly. This Oconee Group lithofacies of the channels is devoid of trace fossils or sedimentary structures of biogenic origin. However, locally there are lenses of carbonaceous debris with preserved leaves, stems, and undifferentiable organic material. So far, these carbonaceous lenses near the base of the channel sands have proven to be devoid of dinoflagellates but not palynomorphs, indicating that the accumulations are of nonmarine origin or influence.

The middle or upper parts of the sections within the channel sands commonly, but not invariably, contain moderately well sorted, medium- to coarser-grained sand with varying abundances of **Ophiomorpha nodosa.** In some pits, in parts of the faces of the pits, the sands contain a profusion of **Ophiomorpha nodosa**. At one site in the kaolin mine at Oconee in Washington County, Georgia, this interval contains abundant pyrite and the tubes of **Ophiomorpha nodosa** are pyritized. At some sites, finer grained, argillaceous well-sorted sands underlying the coarse-grained, **Ophiomorpha**-bearing sands contain scattered concentrations of smaller, nondescript burrows and bedding surfaces with floral impressions.

The upper part of the channel sands, that part of the sections above the **Ophiomorpha**-bearing sand, appears to be lithologically more variable than that of the underlying channel deposits and is more likely to be absent at any particular site. At the Anglo-American Kaolin Mine at Oconee, Georgia, this section becomes more argillaceous and grades upward over several feet approximately 1 m) into the overlying Riggins Mill Member of the Clinchfield Formation, with scattered Riggins Mill macrofossil molds occurring deep within the transitional interval. Elsewhere, such as in the vicinity of Deepstep, this upper argillaceous zone is apparently absent with coarser sands bearing scattered **Ophiomorpha nodosa** grading upward into Riggins Mill lithology. On the other hand, at the former site of Georgia Kaolin pit 50 (Huddlestun and Hetrick, 1979, 1986, p. 65, fig. 16), lenses of gray, hackly, finely micaceous, smectitic kaolin occur between the **Ophiomorpha**-bearing sand and the overlying Riggins Mill. The tops of these gray, smectitic kaolin lenses were burrowed in pit 50. We made several excursions to pit 50 in trying to ascertain the nature of the contact between the Barnwell Group and the underlying deposits prior to and subsequent to measuring and describing the section exposed there. At no time could we be reasonably certain that the contact between the Riggins Mill and the underlying deposits was conformable. Therefore we opted for a vague paraconformity. The channel present at Pit 50 was broader than what we have subsequently seen in the field and the channel there encompassed the entire pit. Therefore its channel nature was not evident in outcrop.

It is clear to us that the channel sands are the basal transgressive deposits of the Late Eocene marine transgression. During the initial sedimentary phase of this transgression, nonmarine-influenced sediments were deposited in channeled topographic lows on the pre-Barnwell surface. These initial sediments are Oconee Group in lithology and appearance. However, they broadly grade upward into coastal marine sediments that are commonly burrowed, especially with local abundant occurrences of **Ophiomorpha nodosa** in the coarser sand lithofacies. The transition from coastal marine to open marine, offshore shelf, continental shelf occurs between the upper part of the channel deposits or, where missing, between the **Ophiomorpha nodosa**-bearing sands and the Riggins Mill. This interval probably represents the basal, shore face environment of the Jacksonian transgression and, where present, is intermediate between the coastal marine lithofacies and the open marine lithofacies of the transgressive Barnwell Group.

STRATIGRAPHIC RELATIONSHIPS

The channel sands have been identified to date only in the central Georgia kaolin mining district, from Twiggs County eastward through eastern Washington County. Their occurrence is sporadic and there has been no effort either to recognize them in the field or to plot their occurrences and distributions. They may be relatively large structures, however, certainly encompassing the aerial extent of small kaolin pits and possibly encompassing that of large kaolin pits as well. The channel sands always disconformably overlie the Jeffersonville Member of Marion Member of the Huber Formation but they are not known, yet, to directly overlie the Gaillard Formation.

Wherever we have observed the channel sands, they conformably and gradationally underlie the Riggins Mill Member of the Clinchfield Formation, indicating that they are intimately related to Upper Eocene deposition patterns and not to that of older deposits. As described above, the channel sands represent initial nonmarine sedimentation within the topographic lows of pre-existing drainage. Where that drainage was established on clay surfaces, the channel grid appears to be closely spaced and not deeply entrenched, probably not exceeding 30 feet (9.1 m). Where the pre-existing drainage was established on sand surfaces, however, it is likely that the channels would be much broader, deeper, are more widely spaced.

AGE

The age of the channel sands is approximately the same age as that of the Clinchfield Formation. Because the transgression progressed normal to the depositional strike, the ensuing deposits almost certainly cross time lines. At any given site, the channel sands may be contemporaneous with, or slightly younger and older than any other specific occurrence of Clinchfield Formation. The specific age of the channel deposits is contingent upon the age of the Clinchfield Sand. As described previously (Huddlestun and Hetrick, 1986, p. 26), there is some controversy as to the age of the Clinchfield Formation. On the basis of some elements of the molluscan fauna, it could be argued that the age of the Clinchfield is upper Claibornian, possibly Gosport Sand-equivalent. It is our contention here, however, that the physical stratigraphic relationships between the Clinchfield Formation and the underlying and overlying deposits require including the Clinchfield with the Barnwell Group and with Barnwell deposition. The Clinchfield Formation is characteristically conformable with the overlying Tivola Limestone or Dry Branch Formation and the boundary of conformity is horizontal, no matter how thin the Clinchfield Formation is (less than 2 feet [0.6 m]) at any one site. In contrast, the Clinchfield is always disconformable over the underlying Jeffersonville member or Marion Member of the Huber Formation. Therefore, we conclude in this report that there is no physical evidence to exclude the Clinchfield Formation from the Upper Eocene. Similarly, there would be no reason to exclude the channel sands, that gradationally and conformably underlie the Clinchfield Formation, from the Upper Eocene. The channel sands, therefore, are considered to by Late Eocene, earliest Jacksonian, upper Priabonian in age. They would be included within the **Globigerinatheka semiinvoluta-Cribrohantkenina inflata** concurrent range zone, which is a very narrow range and occurs in the type Moodys Branch Formation at Riverside Park in Jackson, Mississippi. Others would include this time interval near the base of P16 of Blow (1969) or near the top of the **Globigerina semiinvoluta** Zone (Stainforth and others, 1975).

FORT VALLEY GROUP (new name)

DEFINITION

The Fort Valley Group is a new name introduced here for a group of kaolinitic, sandy formations of coastal marine origin that are concentrated in but not confined to the Fort Valley Plateau region of the updip central Coastal Plain of Georgia. The formations here included in the Fort Valley Group are in order of decreasing age, the Nakomis Formation, Providence Sand, Marshallville Formation, Mossy Creek Sand, and Perry Sand. Previously, deposits of this group have not been identified in terms of one encompassing lithostratigraphic unit. And the formations of this group had in the past been included in various other formations by way of physical correlation with formations outside of the area (see synonomies under the various formations below).

The Fort Valley Group is essentially the coastal marine facies of the landward, fluvial Oconee Group. Offshore, continental shelf correlatives of the Fort Valley Group of this report include the Ripley Formation, Clayton Formation, and Lisbon Formation. Lithologically, the formations of the Fort Valley Group resemble other sandy formations of coastal marine origin in the Georgia region. These include the Eutaw Formation of Late Cretaceous, Austinian (Santonian) age, the Cusseta Sand of Late Cretaceous, Tayloran (Campanian) age, the Baker Hill Formation of Late Paleocene, Sabinian (Thanetian) age, the Irwinton Sand Member of the Dry Branch Formation and Tobacco Road Sand (Barnwell Group) of Late Eocene age, the Cypresshead, Miccosukee, and Citronelle Formations of Late Pliocene age, and the Satilla Formation of Late Pleistocene and Holocene age. If all of these other formations occurred in physical association with each other in the Fort Valley area, they would all be included within the Fort Valley Group.

TYPE AREA

The name Fort Valley is taken from the town of Fort Valley in Peach County, Georgia and, specifically, from the Fort Valley Plateau in Peach, Macon, Crawford, and Houston Counties, Georgia, where the group is typically developed. The exposure at a large, unnamed bluff in the eastern valley wall of the Flint River on an unimproved county road, approximately 3.2 airline miles (5.1 km) west-northwest of the town of Marshallville, is here designated the type locality of the group. The section exposed in the bluff is the unit-stratotype (holostratotype), of the group. The Marshallville Formation and Mossy Creek Sand are exposed in the bluff and the Nakomis Formation is exposed in roadcuts in the northern valley wall of Bryants Swamp Creek approximately 0.9 mile (1.4 km) southeast of the type locality. This type locality is also the type locality of the Marshallville Formation. Additionally, there are numerous small exposures of the Marshallville Formation, Mossy Creek Sand, and Perry Sand, in roadcuts, sand pits, and barrow pits in or near the valley walls of Mossy Creek, from the vicinity of Fort Valley southeastward to the vicinity of Mossy Lake east of Perry.

LITHOLOGY

The Fort Valley Group is a coastal marine facies of parts of the Oconee Group and, therefore, consist mainly of sand and subordinate kaolin. The ratio of sand and kaolin varies between the formations and especially within the formations at different sites. However, in general it appears that the Nakomis Formation consists of roughly subequal amounts of sand and kaolin, the Marshallville Formation consists largely of sand but with a significant kaolin component, and the Mossy Creek and Perry Sands consist predominantly of sand with only minor kaolin (either interstitially or in discrete beds. However, the Perry Sand does contain significant lenses of minable kaolin in the vicinity of Kathleen and Bonaire in eastern Houston County.

The sand component of the Fort Valley Group ranges in size from coarse and pebbly through fine to very fine. Sorting of the quartz sand ranges from very poorly sorted (pebbly and clayey) to extremely well sorted. The Nakomis Formation, Marshallville Formation, and Mossy Creek Sand contain a significant component of poorly sorted, very coarse sand that is generally micaceous and kaolinitic to some degree. Kaolin intraclasts are common in the coarser phases of these formations but especially in the Marshallville Formation and Mossy Creek Sand. Portions of the sand lithofacies are also well-sorted, and very fine through coarse-grained and well sorted sands are common and characteristic of the group. Well-sorted, fine- to very fine grained sand is very low in mica and dark minerals and is especially characteristic of the Perry Sand.

The sand lithofacies of the Fort Valley Group is also prominently and intricately stratified. Stratification includes horizontal bedding, undulatory bedding, and trough, planar, and herringbone cross bedding. Bedding styles range from rudely bedded where coarse and poorly sorted, to very sharp bedding planes where the sands are well sorted. Also, bedding thicknesses range from very thick, especially in the Nakomis, to very thin. The predominant clay mineral component of the Fort Valley Group is kaolinite. Smectitic clays are minor, except near the downdip (seaward) limits of the various formations. The kaolin is generally silty or finely sandy and variably micaceous. However, relatively pure, soft, conchoidally fracturing kaolin is known to occur in the updip areas of the Marshallville Formation. The thicker beds of kaolin, especially in the Nakomis Formation, may be carbonaceous and lignitic to some degree. Bedding thickness in the clay lithofacies of the group ranges from very thick, especially in the Nakomis Formation, to thinly bedded or laminated. The thinly bedded and laminated clays are most characteristic of the Nakomis and Marshallville Formations, but also occur rarely in the Mossy Creek Sand. At the present, thinly bedded clays are not known to occur in the Perry Sand and the clay content of this formation is generally restricted to argillaceous laminae distributed in clean, well-sorted, very fine sand.

Bioturbation structures and burrows are characteristic of the Fort Valley Group. They are especially prevalent locally in the Marshallville Formation and Mossy Creek Sand, but they may be absent at some sites or in some beds. For example, trace fossils are rare in the type section of the Marshallville Formation and their occurrence there is restricted to the lower and upper parts of the exposure. Trace fossils are least common in the Nakomis Formation. Bioturbation structures are not known to occur in the Perry Sand but burrows are common locally or in some scattered intervals. **Ophiomorpha nodosa** and related forms are known to occur in the Marshallville Formation and the Mossy Creek Sand. **Ophiomorpha nodosa** is not yet known to occur in either the Nakomis Formation or the Perry Sand.

STRATIGRAPHIC RELATIONSHIPS

Except for the Perry Sand, the Fort Valley Group of this report is known to extend from eastern Taylor County in the west at least as far east as the Ocmulgee River. The western limit of the Perry Sand is Terrell and Randolph Counties in southwestern Georgia. West of this, in the Chattahoochee River area and in Alabama, the Nakomis Formation, Marshallville Formation, and Perry Sand appears to have been stripped off by erosion prior to deposition of the suite of Chattahoochee River, Pleistocene terrace deposits. To the east, it appears that most subdivisions of the Fort Valley Group change facies in the vicinity of the Ocmulgee River. The Nakomis and the Marshallville both become more sandy and less clayey whereas the Perry and Mossy Creek Sands grade into a dominantly kaolin unit (Jeffersonville member of the Huber Formation. However, the eastward facies change in the Nakomis and Marshallville Formations occurs in the subsurface and there is currently too little core information on which to base an evaluation of the proper lithostratigraphic terminology of these deposits.

The updip limit of the group varies from formation to formation. However, the Fall line area in the vicinity of the Flint River appears to be the updip limit of the Mossy Creek Sand but in the vicinity of the Ocmulgee River, Tobesofkee Creek, south of Macon, is the updip limit of the group (Marshallville Formation and Mossy Creek Sand). Presumably these formations have been stripped from the region north of Tobesofkee Creek prior to deposition of the suite of Ocmulgee River, Pleistocene terrace deposits.

In the type area of the group, the downdip limit of the Fort Valley Group, excluding the Perry Sand, appears to be the southern boundary of the Fort Valley Plateau. That is, the southern boundary occurs along the east-west trend of Big Indian Creek and the Perry Escarpment in central Houston County and northeastern Macon County. Between the vicinity of Perry and the escarpment, the subsurface Nakomis Formation and Marshallville Formation grade downdip (seaward) into the Ripley Formation and Clayton Formation respectively.

The depositional strike of the upper Claibornian is rotated a few degrees counterclockwise to a more northeast-southwest direction relative to that of the underlying units. To the west the line (depositional strike) separating the Perry from the Lisbon extends through southeastern Macon County, northwestern Dooly County, Sumter County, northern Terrell County, and northern Randolph County.

The Fort Valley Group disconformably overlies the Pio Nono Formation in the vicinity of the Fall line but farther south, overlies the Gaillard Formation, both of the Oconee Group. In the vicinity of Huber in Twiggs County, the Mossy Creek Sand disconformably overlies the Marion Member of the Huber Formation. Farther west in Georgia, the Perry Sand progressively in a southwestward direction, disconformably overlies the Tuscahoma Formation, and the Baker Hill Formation. Throughout most of its range, the Fort Valley Group occurs at the top of the local stratigraphic section. However, in the type area, the group is locally overlain by outliers of the Barnwell Group or by Pleistocene river terrace deposits associated with the Flint and Ocmulgee Rivers.

Formations of the Fort Valley Group can be distinguished from formations of the Oconee Group in containing (1) a much higher proportion of beds of well-sorted, fine- to medium-grained quartz sand, (2) more beds of thinly layered, gray clay, (3) scattered and local abundance of dinoflagellates, bioturbated sands, and trace fossils throughout the formations (in contrast to the local abundance of trace fossils, mostly of Upper Eocene origin, in the top of the Huber Formation), and in (4) containing scattered occurrences of sand beds with herringbone cross bedding. Formations of the Oconee Group characteristically contain (1) moderately to very poorly sorted sands, (2) consist of fining upward sequences, (3) contain extremely rare occurrences of trace fossils, (4) no occurrences of bioturbated sands, (5) no dinoflagellates and, (6) is not known to contain sand beds with herringbone cross bedding. Trace fossils such as **Ophiomorpha nodosa** are not found in Oconee Group. Similarly, in more fluvial dominated phases within the Fort Valley Group, fining upward sequences are known to exist, such as in the type section of the Marshallville Formation.

The environment of deposition of the Fort Valley Group is interpreted to be of coastal marine origin. It contains locally abundant trace fossils, dinoflagellates that are only of marine origin, bioturbation structures, and herringbone cross bedding. The channels and channel fill deposits in the Fort Valley Group are interpreted to be of tidal origin although locally, and especially in updip areas, some channels and channel fill deposits could have a fluvial origin.

There is at present some evidence for barrier island systems separating the Fort Valley Group deposits from marine, offshore, continental shelf deposits. This evidence consists of a band of very coarse, channel deposits near the downdip extremities of the Marshallville Formation and Mossy Creek Sand. These coarse, channel deposits can be interpreted as the filled-in tidal channels between laterally migrating barrier islands. The barrier island deposits have long since been eroded, but the deeper parts of the tidal channels separating the islands may have survived in the geologic record.

AGE

The age of the Fort Valley Group is interpreted mainly from stratigraphic position and physical correlation. The Nakomis Formation grades downdip (seaward) into the Ripley Formation and, therefore, is considered to be Late Cretaceous, Early Navarroan (Early Maastrichtian) in age. The Marshallville Formation grades downdip (seaward) into the Clayton Formation and, therefore, is considered to be Early Paleocene, Early Midwayan (Early Danian) in age. This is supported by paleontological evidence in the Marshallville, Georgia, area. Similarly, the Mossy Creek Sand grades laterally into the Perry Sand which grades laterally into the Lisbon Formation of late Middle Eocene, Late Claibornian, Bartonian age.

NAKOMIS FORMATION (new name)

DEFINITION

The Nakomis Formation is a new formation proposed here for variably bedded sands with gray, thinly bedded clay and massive, white to carbonaceous kaolin deposits that are of coastal marine origin and early Navarroan age. The Nakomis grades laterally down the dip, or seaward, into the Ripley Formation. The Nakomis is largely a subsurface formation but it crops out in a small area along and near the Flint River in the vicinity of Nakomis in Crawford County, and west of Reynolds in Taylor County, Georgia. The Nakomis Formation of this report was included in the Cusseta Sand Member of the Ripley Formation by Veatch and Stephenson (1911), the Tuscaloosa Formation by Cooke (1943, 1944), it appears to have been mapped as alluvium by LeGrand (1962), and was apparently mapped by Georgia Geological Survey (1976) both as Ripley and Cusseta, Blufftown, and Eutaw Formations undifferentiated on the east side of the Flint River, and as Blufftown Formation on the west side of the Flint River near Reynolds.

TYPE LOCALITY

The name Nakomis is taken from the community of Nakomis in western Crawford County, Georgia. Nakomis is a crossroads on Georgia Highway 96, 0.8 mile (1.3 km) east of the Flint River. The type locality of the Nakomis Formation is the line of bluffs along the east bank (left bank) of the Flint River from 0.5 to 1 mile (0.8 to 1.6 km) south of Nakomis. The type section, or unit stratotype (holostratotype), of the Nakomis Formation is the section of Nakomis Formation exposed in the bluffs. Neither the lower nor upper boundaries of the formation are present in the type section.

The Georgia Geologic Survey cores Crawford 2a and 2b (GGS-3600) are here designated a reference locality, parastratotypes, and the upper boundary stratotype for the Nakomis Formation. These cores were taken along the north shoulder of Georgia Highway 96, 1.9 miles (3.0 km) east of the community of Nakomis and immediately within Crawford County where highway 96 crosses the Crawford/Peach Counties line. The Nakomis Formation occurs in the interval 105 feet to 231 feet. The Marshallville Formation disconformably overlies the Nakomis Formation at 105 feet. Ten feet of sediments of uncertain stratigraphic affinity underlie the Nakomis at 231 feet. The core Crawford 2a is that part of GGS-3600 from 0 feet to 146 feet and includes the top of the Nakomis Formation. Crawford 2b was later taken at the same site and includes the cored interval from 140 feet to 241 feet.

The Georgia Geologic Survey core Crawford 1b (GGS-3598) is here designated a reference locality, parastratotype, and lower boundary stratotype of the Nakomis Formation. This core was taken along the shoulder of a county highway at Zenith, Crawford County, Georgia. The Nakomis Formations occurs in the interval 127 feet to 231 feet in the core. The lower boundary stratotype occurs at 231 feet where the Nakomis Formation disconformably overlies the Gaillard Formation.

LITHOLOGY

The Nakomis Formation is a siliciclastic formation of coastal marine origin that is characterized by thin to very thick beds of sand, and thin to very thick beds of massive kaolin, and thinly layered (smectitic?) clay. In the type area, based on sparse core and outcrop data, it appears that the Nakomis Formation consists of subequal volumes of sand and clay. Subordinate lithic components of the Nakomis Formation include mica (fine- to coarse-grained), fine carbonaceous material, fine to coarse lignitic material and leaf impressions, limonite, dark minerals, and finely disseminated pyrite. The silty clay and kaolin components of the Nakomis lithology appear to be characteristic of the formation. Individual clay beds range in thickness from less than 1 foot (less than 30 cm) up to 34 feet (10 m). The thickest clay beds consist of kaolin that resemble the hard kaolin of the Jeffersonville member of the Huber Formation. The lithology of this kaolin is generally massive and structureless but in some intervals can be seen to be prominently thin bedded or laminated to vaguely layered. It is tough, waxy, and feels soapy. The fracture of this kaolin is generally irregular with slickensides commonly developed in the cores. In some intervals, the clay is very brittle and breaks readily into many small (roughly 1 cm), irregular, angular fragments or clasts. The kaolin rarely is pure but characteristically contains such impurities or other minor lithic components as mica, carbonaceous material, lignitic debris, woody material, leaf impressions and finely disseminated pyrite. The color of the massive kaolin ranges from very pale orange to mottled maroon and gray (5 R 8/1-7/2-5 YR7/2-10 YR7/2) where weathered, to light gray where unweathered, and gray to dark gray and black where unweathered and organic-rich. Some of the kaolin contains interbedded silt to very fine sand and fine- to coarse-grained mica along the bedding planes. In this particular phase of the lithology, the clay is commonly very dark gray to black and the silt to very fine sand along the bedding planes is generally fairly clean so the sediment as a whole has a strongly contrasting white/black layering. Bedding in this phase of the clay lithology is horizontal to undulatory with some very fine scale cross bedding. Some disrupted bedding also is present in some thin intervals suggesting possible disruption of the sediment by burrowing organisms.

Thinly bedded (smectitic?) clay is also present in some beds. Silt to very fine, variably micaceous sand occurs along bedding planes. This lithology resembles the above described black/white, thinly bedded kaolin but it is not known to be organic-rich. This clay also is lithologically very similar to or identical with the gray, thinly bedded clay facies of the overlying Marshallville Formation. However, the thinly bedded clays of the Nakomis tend to be substantially thicker than those of the Marshallville.

The quartz sand component of the Nakomis Formation ranges in sand-size from very fine grained to very coarse grained and granully or pebbly. The sand lithologies are variable, with variably micaceous, thinly layered, very fine-grained, well-sorted, kaolinitic sand; thinly bedded with some thin clay laminae or layers, well-sorted, very fine- to medium-grained sand; rudely bedded, micaceous, moderately well sorted, medium-grained sand; micaceous, moderately sorted, medium- to coarse-grained sand; poorly sorted, coarse-grained sand with pea-gravel; coarsely micaceous, kaolinitic, moderately sorted, medium- to coarse-grained sand; kaolinitic, poorly sorted, granully sand; and rare thin beds of limonitic sandstone or sand.

The thickness of the sand beds range from laminae in clay beds to as much as 30 feet (9.1 m) thick. Stratification in the sand ranges from horizontal-bedded through undulatory-bedded to cross-bedded. All cross bedding observed to date are small in scale and generally consists of planar cross bedding.

East of the Ocmulgee River, the stratigraphic interval assigned to the Lower Navarroan (Lower Maastrichtian), in the Pulaski County core (GGS-3511) occurs between 506 feet and 861 feet). This stratigraphic interval includes the intertonguing of the Ripley Formation into the Nakomis Formation. In a strict sense, the Nakomis lithology occurs in the intervals 506 feet to 679 feet and 796 feet to 861 feet. Ripley Formation lithology occurs in the stratigraphic interval 679 feet to 797 feet. The Nakomis Formation in this core is generally typical of the Nakomis in that it is apparently of coastal-marine origin and consists of very thick beds of kaolin and sand. The kaolin beds range in thickness from a few feet (less than 1 m) upward to 26 feet (7.9 m). The sand beds, however, range from a few feet (less than 1 m) to 95 feet (29 m) thick. The thick kaolin beds in the Pulaski County core are mostly weathered and oxidized, evidently in place (penecontemporaneously), but thin intervals of dark gray to black, carbonaceous to lignitic kaolin is also present. Much of the sand in the thick sand beds consists of almost incoherent, massive, variably micaceous, well-sorted, fine- to medium- to medium-grained sand that contains little clay.

In the Laurens County core (GGS-3523) in northern Laurens County, the Nakomis Formation, or a stratigraphic equivalent thereof, occurs in the interval 562 feet to 767 feet at the total depth of the core. This section is similar to that of the Pulaski County core in that sand predominates over kaolin. But in the Laurens County core, it appears that the sand constitutes much the greater part of the lithology and the beds of thick kaolin have diminished in thickness to a few feet (less than 1 m) to 13 feet (4.0 m). In other words, it appears that the typical, coastal marine, sand and kaolin Nakomis Formation west of the Ocmulgee River appears to increase greatly in sand content and diminish in clay content east of the Ocmulgee River. There is at present insufficient core control to determine the extent and lithologic content of the shallow subsurface, coastal marine, lower Navarroan (lower Maastrichtian) east of the Ocmulgee River in Georgia.

The Nakomis grades down the dip (seaward into the Ripley Formation. The Ripley lithology (offshore, continental shelf facies) appears to reach its greatest updip (landward) penetration near the middle of the stratigraphic interval. Where the two formations intertongue, the lithology change appears abrupt and between beds. Nakomis lithology in this area occurs both above and below the Ripley lithology.

STRATIGRAPHIC RELATIONSHIPS

Typical Nakomis Formation is known to occur in a narrow band in the shallow subsurface from eastern Taylor County in the west to the Ocmulgee River area in the east. The Nakomis Formation has not yet been traced west of eastern Taylor County although it may occur commonly in outcrop southwest of Reynolds. The formation appears to undergo lithofacies change in the Ocmulgee River area, east of which the stratigraphic interval becomes pervasively sandy. The Nakomis Formation is largely a shallow subsurface formation but it crops out in a small area in the vicinity of Nakomis near Reynolds, Georgia, where the Flint River is deeply incised. In the Fort Valley Plateau area, the belt of Nakomis Formation appears to be not much more than approximately 7 miles (11 km) across. It pinches out northward very abruptly near the northern edge of the Fort Valley Plateau escarpment in the Flint River area and greatly thickens to the south. The Nakomis Formation is not present in the pits of the Atlanta Sand and Supply Company at Gaillard, but it occurs in the interval 127 feet to 231 feet (103 feet [32 m] thick) in the Georgia Geologic Survey core Crawford 1b (GGS-3598) taken at Zenith, less than 2 miles (3.2 km) south of the sand pits at Gaillard. The Nakomis Formation continues to thicken south of Zenith to 126 feet (38 m) in the interval 105 feet to 231 feet in the core Crawford 2a and 2b (GGS-3600) 4 miles (6 km) south of Zenith. Only Ripley Formation is known to occur near Marshallville in the Georgia Geologic Survey core Macon 1a (GGS-3597) but the core bottoms in the Ripley Formation at 126 feet. Farther south on the Flint River, the Ripley Formation crops out at low water at the site of the old car ferry approximately 5 miles (8 km) west-southwest of Marshallville.

Similarly in the Ocmulgee River area, the Nakomis is identified as an updip, feather edge in the Georgia Geologic Survey core Houston 9 (GGS-3629) in the interval 63 feet to 85 feet, at Elberta, Georgia. Seventeen miles (27 km) southwest of Elberta at Perry, Georgia, the Nakomis occurs as a relatively thin interval 65 feet (20 m) thick (from 166 feet to 231 feet), gradationally overlying the Ripley Formation. The Ripley Formation occurs in the interval 231 feet to 306 feet and total depth in that core.

It would appear that the breadth of the formation subcrop increases in the Ocmulgee River area and east of the river, it appears to be more than 20 miles (32 km) across, based on the occurrence of Nakomis Formation at Elberta and in the Pulaski County core in northernmost Pulaski County.

The Nakomis Formation disconformably overlies the Gaillard Formation. However, where it intertongues with the Ripley Formation, the upper tongue of the Nakomis gradationally overlies the Ripley Formation by bed change. There is insufficient subsurface information at this time to determine whether the lower tongue of the Nakomis disconformably overlies the Gaillard Formation or the updip feather edge of the Cusseta Sand.

The Nakomis Formation is disconformably overlain by the Marshallville Formation at all known sites west of the Ocmulgee River. However, it is overlain disconformably by well-sorted, fine-grained, coastal marine sands that are correlative with typical Marshallville Formation east of the Ocmulgee River, and fluvial Marion Member of the Huber Formation to the north.

Tshudy and Patterson (1975) reported the occurrence of Maastrichtian palynomorphs from the kaolin mining area east of the Ocmulgee River. We know of no Nakomis lithologies from our visits to the mines and, in addition, the Nakomis Formation is projected to pinch out south of the mining area of the Cretaceous kaolins, i.e., south of the vicinity of Jeffersonville in Twiggs County. It is possible that outliers of Nakomis Formation may exist in the Cretaceous kaolin mining area but their exposure and sampling would be fortuitous. On the other hand, our observations on Nakomis lithology indicates that it should be more carbonaceous and lignitic than either the underlying Gaillard Formation or the overlying Marion Member of the Huber Formation and, if it is exposed briefly in mining operations, it would probably attract the attentions of any attentive palynologist.

The Nakomis Formation can be distinguished from the underlying or older Gaillard Formation in (1) consisting of thick beds of carbonaceous to noncarbonaceous kaolin that commonly has a "hard" kaolin appearance, (2) in containing beds of thinly layered, gray clay (smectitic?) and, (3) in containing common beds, thin or very thick, of well-sorted, fine- medium- and coarse-grained sand. In appearance, the Nakomis Formation resembles the younger Marshallville Formation more than that of other Oconee Group formations.

The Nakomis Formation can be distinguished from the Marshallville Formation in (1) containing much thicker beds of kaolin and thinly bedded, gray clay, (2) in containing much more carbonaceous material than the Marshallville, (3) in containing fewer trace fossils and, (4) in containing much thicker beds of fine-, medium-, and coarse-grained sand. The Nakomis Formation can also be distinguished from the Marion Member of the Huber Formation by the above characteristics (1), (2), and (4), but the Nakomis Formation does contain trace fossils whereas the Huber Formation is devoid of trace fossils.

The Nakomis Formation is considered to be of coastal marine origin. The bases for this conclusion is the prevalence of well-sorted sand of varying size grades, more importantly, the scattered occurrence of trace fossils, especially in the cores, and its intertonguing relationship with the offshore, inner neritic, Ripley Formation. It does not appear that barrier islands separated the site of deposition of the Nakomis Formation from the open marine Ripley Formation because the kaolins of the Nakomis Formation thicken, become more carbonaceous in a seaward direction, and become extensively burrowed and bioturbated where is grades into Ripley lithology.

AGE

The age of the Nakomis Formation is projected to be Late Cretaceous, early Navarroan, early Maastrichtian. This is based on the physical correlation, both in terms of intergradation and stratigraphic position, with the Ripley Formation to the south in the subsurface and in outcrop along the Flint River. The Ripley Formation occurs in the **Globotruncana scutilla** Zone (UC 13) of Van Hinte (1976), in the **Globotruncana stuartiformis** Zone of Postuma (1971), and in the **Globotruncana lapparenti tricarinata** Zone of Bolli (1957).

MARSHALLVILLE FORMATION (new name)

DEFINITION

The Marshallville Formation is a new formation, named here for coastal marine, prominently bedded sand to pebbly sand with scattered beds of gray, thinly bedded clay or massive kaolins, of early Midwayan age. Heretofore, deposits that are included in the Marshallville Formation of this report, were not included in any single formation. In the past, various parts of the Marshallville Formation were included in the Cusseta Sand member of the Ripley Formation (Veatch and Stephenson, 1911), and Cusseta Sand and Providence Sand (Cooke, 1943). It was largely included in the Cretaceous by MacNeil, 1947 (by exclusion from the Tertiary) but the downdip phases of the formation were also included by MacNeil (1947) in the "Nanafalia and Clayton formations". Eargle (1955) and Georgia Geological Survey (1976) included the Marshallville Formation of this report in both the Ripley and Providence Formations whereas LeGrand (1962) included the bulk of the Marshallville in the Providence Sand but also evidently included parts of the Marshallville in the Tuscaloosa Formation and the Gosport Sand.

TYPE SECTION

The name Marshallville is taken from the town of Marshallville in Macon County, Georgia. A large, unnamed bluff overlooking the Flint River Valley on the eastern side of the Flint River is here designated the type locality of the Marshallville Formation. The type locality is approximately 3.2 airline miles (5.1 km) west-northwest of Marshallville, and 0.9 mile (1.4 km) northwest of Bryants Swamp Creek. The section of Marshallville Formation that is exposed in the bluff is the type section, or unit-stratotype (holostratotype), of the formation. This section also includes the upper boundary stratotype, where the Marshallville Formation is disconformably overlain by the Mossy Creek Sand. The lower boundary of the Marshallville Formation is not exposed at the type locality.

A composite reference locality and parastratotype is here designated a series of roadcuts on an unimproved county road in the northern valley wall of Nakomis Creek, 2.3 miles (3.7 km) northeast of Nakomis. This exposure is considered to be significant in that it exhibits a lithofacies of the formation intermediate to the high energy lithofacies and the low energy lithofacies. The lower part of the road cut exposes a burrowed, highly cross bedded, well-sorted sand lithofacies. The upper part of the roadcut exposes a massive, bioturbated and burrowed sand lithofacies. Another composite reference locality and composite parastratotype is here designated a series of roadcuts and a sand pit along a paved county road that extends from Powersville, Peach County, Georgia, northeastward 2.6 miles (4.2 km) to the junction of the county road with Georgia Highway 49, 1.4 miles (2.2 km) southwest of Byron, Peach County, Georgia. The paved county highway parallels on the east the Central of Georgia Railroad. This series of exposures is considered significant in that it exposes the burrowed, very coarse, pebbly Marshallville, the highly cross bedded, well-sorted, medium sand lithofacies with a kaolin lens, and the characteristic, thinly bedded, gray clay lithofacies of the formation.

The Georgia Geologic Survey core Crawford 2a (GGS-3600) is here designated a reference locality, parastratotype, and lower boundary stratotype of the Marshallville Formation. The site of the core is on the north shoulder of Georgia Highway 96, approximately 1.9 miles (3.0 km) west of the community of Nakomis and 5 miles (8 km) west of Fort Valley, almost on the Crawford-Peach Counties line where Georgia 96 crosses the county line. In the core, the Marshallville Formation occurs in the interval 0 feet to 105 feet, where it disconformably overlies the Nakomis Formation.

In updip areas, the Marshallville Formation disconformably overlies the Gaillard Formation. Therefore, a lower boundary stratotype where the Marshallville Formation disconformably overlies the Buffalo Creek Kaolin Member of the Gaillard Formation is designated here as the ravine on the north side of Georgia Highway 49, approximately 2.1 miles (3.4 km) northeast of the I-75 and Georgia 49 junction and 0.4 mile (0.6 km) west of the US 41 and Georgia 49 intersection near the Peach-Houston Counties line. This site is significant because the characteristic thinly bedded, gray clay of the Marshallville Formation overlies a surface of relatively high relief (at least 18 feet [5.5 m]) on the top of the Buffalo Creek Kaolin.

LITHOLOGY

The Marshallville Formation is a siliciclastic formation that consists predominantly of quartz sand but also contains considerable clay, both interstitially and in discrete beds. The lithologies within the Marshallville Formation range from very coarse and pebbly with interstitial clay, to beds or lenses of kaolin or gray, thinly layered, silty clay that range up to 10 feet (3 m) in thickness. The lithology of the Marshallville Formation can best be exemplified by the finer grained lithofacies. Here, the quartz sand component of the formation is typically fine- to medium-grained and well- to moderately sorted. The clay component of the formation can occur interstitially, as lenses of massive kaolin or sandy kaolin, or as beds or lenses of varying thickness and extent of gray, thinly bedded, finely sandy (smectitic?) clay to clayey, well-sorted, fine sand. Other minor components of the lithology include dark minerals, limonite cemented sandstone, borrows, and one known occurrence of silicified shells.

Bedding scale ranges from thinly bedded or laminated, especially in the gray, (smectitic?) clay lithofacies, to medium and thick bedded. Bedding style ranges from horizontal-bedded to undulatory-bedded to cross-bedded. The finer the grain-size, the smaller the scale of the bedding. The cross-bedding ranges from trough to planar to herringbone. The planar and herringbone cross bedding is restricted to the sandier parts of the fine-grained lithofacies of the formation.

The coarse, poorly sorted sand lithofacies appears to be more limited in occurrence than the fine-grained lithofacies of the formation. The coarse lithofacies can be conspicuously pebbly, even gravelly, in general is poorly sorted, and commonly but not invariably contains burrows of **Ophiomorpha nodosa**. Bedding ranges from medium to very thick, and at many sites where the formation is conspicuously bioturbated and burrowed, the bedding is massive. This lithofacies is difficult to distinguish purely on physical evidence from the coarser lithofacies of the overlying and younger Mossy Creek Sand. The reason is postulated to be that both of these formations were deposited under similar coastal marine conditions. In this particular lithofacies, which may be of tidal channel origin, the high energy of the environment is the single most critical parameter determining the lithology of the sediment. Therefore, these lithofacies closely resemble each other lithologically. Differentiating the coarser lithofacies of the Marshallville Formation and Mossy Creek Sand can best be done on considering the stratigraphic positions, elevations of exposures, and lithofacies relationships over broader areas than single outcrops or pits.

STRATIGRAPHIC RELATIONSHIPS

The Marshallville Formation is known to occur in a band from eastern Taylor County in the west to the vicinity of the Ocmulgee River in the east. The Marshallville Formation grades laterally eastward into the Marion Member of the Huber Formation east of the Ocmulgee River and it grades downdip, or seaward, into the Clayton Formation. This zone of facies change from Marshallville into Clayton occurs along a broad, almost east-west trending band from the vicinity immediately south of Marshallville in the west, eastward through northern Bleckley County in the east. In this zone of facies change from a coastal marine environment (Marshallville Formation) to an offshore, inner continental shelf environment (Clayton Formation), the lithology becomes prevailingly more argillaceous until the formation can be best described as a massive, finely sandy clay to clayey fine sand, as in the roadcut on Georgia Highway 96 in the western valley wall of Mossy Creek, near Miami Valley in Peach County. The Marshallville Formation appears to be truncated west of eastern Taylor County because no occurrences of the formation are known west of the longitude of Butler in Taylor County. However, farther south in western Macon and Schley Counties, the Marshallville stratigraphic position is occupied by the Clayton Formation.

In outcrop east of the Flint River, the Marshallville Formation is known to disconformably overlie only the Gaillard Formation. However, in the vicinity of Nakomis near the Flint River, the Marshallville Formation must disconformably overlie the Nakomis Formation, but this contact has not yet been identified in outcrop. In the shallow subsurface, south of an east-west line from the vicinity of Zenith in the west to the vicinity of Elberta on the Ocmulgee River in the east, the Marshallville Formation disconformably overlies the Nakomis Formation. Farther east, there is insufficient subsurface data to define the lithostratigraphy of the downdip coastal marine Midwayan from the Marion Member of the Huber Formation. However, predominantly sandy, coastal marine deposits of Midwayan (Marshallville-equivalent) age are known to be present in the Pulaski County core (GGS-3511) and in the Laurens County core (GGS-3523). The Midwayan lithologies in these two cores are unlike that of the Marshallville Formation in that well-sorted, fine- to coarse-grained quartz sand greatly dominates the lithology and clay beds are minor and thin. However, poor core recovery due to the relative cleanness of the sand precludes adequate lithologic distinctions to be made with the Marshallville Formation west of the Ocmulgee River.

The Marshallville Formation is disconformably overlain by the Mossy Creek Sand in up dip areas where it had not been truncated prior to deposition of the Mossy Creek Sand. In some areas, the Marshallville Formation is overlain disconformably by the Butler-allon channel deposits. Farther down dip, the Marshallville Formation is disconformably overlain by the Perry Sand. Locally, near the Ocmulgee River in the vicinity of Elberta, the Marshallville Formation is known to be overlain by river terrace deposits of the Ocmulgee River.

The Marshallville Formation ranges in thickness from 0 feet at pinch-out in the Fall line area, to over 100 feet (30 m). It is approximately 60 feet (18 m) thick at the type locality but the bottom of the formation is not exposed there. The formation is at least 100 feet (30 m) thick at the reference locality 2.3 miles (3.7 km) northeast of Nakomis; 126 feet (38.4 m) thick in the Georgia Geologic Survey cores Crawford 1a (GGS-3598)at Zenith, 105 feet (32 m) thick in the Crawford 2a (GGS-3600) 5 miles (8 km) west of Fort Valley, 105 feet (32 m) thick in the Macon 1a and 1b (GGS-3597) 1.4 miles (2.2 km) north-northwest of Marshallville, 65 feet (20 m) thick in the Peach 1a and 1b (GGS-3595) 5.3 miles (8.5 km) northwest of Perry, 53 feet (16 m) thick in the Houston 7 (GGS-3605) 2.6 miles (4.2 km) west of Perry, and 62 feet (19 m) thick in the Houston 9 (GGS-3629) at Elberta, Georgia. In general, then, the Marshallville Formation ranges in thickness from roughly 50 feet (15 m) to 125 feet (38 m). The only apparent trend in its thickness distribution is that it appears to thin down the dip or in a seaward direction, which is consistent with the increasing clay content and decreasing sand content in a downdip, seaward direction. In contrast, the sandy, coastal marine Midwayan is 80 feet (24 m) thick in the Pulaski County core (GGS-3511) and is 106 feet (32 m) thick in the Laurens County core (GGS-3523), indicating no seaward thinning east of the Ocmulgee River.

The environment of deposition of the Marshallville Formation is interpreted to be coastal marine. There is some evidence that barrier islands separated the coastal marine environment (Marshallville Formation) from the offshore, continental shelf environment (Clayton Formation). The coastal marine origin of the Marshallville Formation is based on the scattered but common occurrence of bioturbation and burrows (especially **Ophiomorpha nodosa**), the occurrence of **Ostrea crenulimarginata** in the formation 0.5 mile (0.8 km) north of the type locality, the presence of dinoflagellates in the formation near Marshallville (L. Edwards, pers. com., 1988), and the presence of herringbone cross bedding in the coarser facies of the formation.

AGE

The age of the Marshallville Formation is based on the occurrence of silicified **Ostrea crenulimarginata** in residuum of the formation in a road cut of the unimproved county road 0.5 mile (0.8 km) north of the type locality. L. Edwards (pers. com., 1988) identified the following flora of dinoflagellates from an intermediate lithofacies between Marshallville Formation and "Clayton" Formation in a ravine draining a sand pit (Stop 7) in the southern valley wall of Bryants Swamp Creek approximately 1.3 miles (2.1 km) northwest of Marshallville:

Adnatosphaeridium sp.
Andalusiella polymorpha
Areoligera sp.
Catillopsis sp.
cf. **Danea californica**
Defl. cf. **D. pentaradiata** sense Benson
Defl. cf. **D. diebelii** sensu Drugg
Hafniasphaera septata
Hystrichosphaeridium sp.
Oligosphaeridium complex
Palaeocystodinium colzowense
Peridiniacean cyst A of Edwards
Spinidium pulchrum
Spiniferites cornutus

Edwards (pers. com., 1991) correlated the above flora with "the Clayton or Porters Creek as I have seen them."

The occurrence of **O. crenulimarginata** and the dinoflagellate flora identified by L. Edwards is consistent with the stratigraphic position of the Marshallville Formation, and with the physical correlation of the Marshallville Formation with the Clayton Formation that crops out on the Flint River at Montezuma, Macon County, Georgia, and in the eastern valley wall of the Flint River approximately 2.5 miles (4.0 km) north of Montezuma (Huddlestun and others, 1974, p. 2-1, 2-2, fig. 16). The age of the Marshallville Formation, therefore, is considered to be Early Paleocene, early Midwayan (early Danian), and is included in planktonic foraminiferal zone P1 of Berggren (1971) or **Globorotalia trinidadensis** Zone of Bolli (1966) and Stainforth and others (1975).

MOSSY CREEK SAND (new name)

DEFINITION

The Mossy Creek Sand is a new formation proposed here for a dominantly sand formation of coastal marine, sound/lagoon origin of late Claibornian age that grades laterally down the dip, or seaward, into the Perry Sand, and laterally along the depositional strike and up the dip, or landward, into the Jeffersonville member of the Huber Formation. As with the other formations of the Oconee Group and Fort Valley Group in the Fort Valley Plateau district, the Mossy Creek Sand has been included with various other units in the past, in some instances as a consistent formation but in other instances with various formations. Veatch and Stephenson (1911) mapped the Mossy Creek Sand with the Claiborne Group, Cooke (1943, 1944) mapped it and the Marshallville with the Clayton Formation. MacNeil (1947) included the Mossy Creek Sand with both residuum and the Claiborne Group (Gosport sand and McBean, Lisbon, and Tallahatta Formations). LeGrand (1962) did not differentiate between the Perry and Mossy Creek Sands and included them both in the Gosport Sand. Georgia Geological Survey (1976) mapped the Mossy Creek Sand as "Eocene undifferentiated".

TYPE SECTION

The name Mossy Creek is taken from Mossy Creek that flows southeastward across the Fort Valley Plateau near the type locality. The type locality is a sandpit on the northern valley wall of Mossy Creek, on the west side of Taylors Mill Road, opposite Fairview Church, approximately 2.9 miles (4.6 km) north of the junction of Taylors Mill road and Georgia 49. The type locality is approximately 3.8 airline miles (6.1 km) north-northeast of the town of Fort Valley. The section exposed in the sand pit is here designated the type section, unit-stratotype (holostratotype), of the Mossy Creek Sand. The lower boundary stratotype is not exposed in the sand pit, but the Mossy Creek Sand is disconformably overlain at this site by high river terrace deposits, probably those of the Ocmulgee River. Therefore, the type section is also considered to be a local upper boundary stratotype. There are no known occurrences of a general upper boundary stratotype where the Mossy Creek Sand can be seen to physically underlie the Barnwell Group. At Rich Hill in Crawford County, The Clinchfield Sand disconformably overlies the Gaillard Formation although the Mossy Creek Sand occurs nearby in outcrop.

The lower boundary stratotype is here designated as the roadcut in a hardtop county road, 0.8 airline miles (1.3 km northwest of the type locality. At this site, a bioturbated and burrowed, coarse, poorly sorted sand of the basal Mossy Creek Sand disconformably overlies a kaolinitic clay and thinly bedded gray clay of the Marshallville Formation. The lower part of the Marshallville Formation in this cut consists of coarsely cross-bedded, well-sorted, medium sand. This roadcut occurs on the eastern valley wall of Mossy Creek, approximately 0.2 miles east of the county highway bridge over Mossy Creek, and approximately 0.7 mile (1.1 km) west-southwest of the intersection on the county highway with Taylors Mill Road. The lower boundary stratotype occurs in Crawford County, approximately 0.3 mile (0.5 km) from the Peach County line. The sand pit 0.6 mile (1 km) south of the Mossy Creek type locality, located on the southern valley wall of Mossy Creek, on the east side of Taylors Mill Road in Peach County, is here designated a reference locality, reference section, and parastratotype of the Fort Valley Sand. This section, although poorly exposed at the time of this writing, is significant in that it occurs near the same elevation but slightly higher in the section and is finer grained and lithologically intermediate from the Mossy Creek Sand to the Perry Sand. The sand exposed in this parastratotype is considered to be typical of the finer grained sand lithofacies of the Mossy Creek and is found in scattered occurrences throughout the outcrop belt of the formation all the way to the Fall line.

A last parastratotype of the Mossy Creek Sand is designated as the road cut along a paved county road 1.3 airline miles (2.1 km) north of the center of Byron, Peach County, Georgia. This lithofacies represents the cross-bedded, channeled, coarse, bioturbated and burrowed lithofacies of the formation. **Ophiomorpha nodosa** is common at this site and its occurrences is considered to be typical for the coarse lithofacies of the formation where sedimentary structures are still preserved in the typically weathered sand of the upper part of the formation. The contact between this lithofacies of the Mossy Creek Sand and the underlying, finer grained, Marshallville Formation is exposed in the roadcut of the paved, county highway approximately 1.75 airline miles (1 km) north of the center of the town of Byron, and approximately 0.4 airline miles (0.6 km) north-northwest of the aforementioned parastratotype, where the road dips over the edge of the Fort Valley Plateau escarpment and into the valley system of Echeconnee Creek.

LITHOLOGY

The Mossy Creek Sand is predominantly a sand with minor thin beds or lenses of clay (smectite or kaolin). There are two predominant sand lithofacies within the Mossy Creek Sand: a coarse, poorly sorted, sporadically pebbly lithofacies that is prominently cross-bedded to undulatory bedded, sporadically bioturbated and burrowed with (**Ophiomorpha nodosa**), and contains clay rip-up-clasts in the vicinity of clay lenses; and a well- to moderately sorted, prominently but thinly stratified, fine to medium sand. This later lithofacies is reminiscent of the Perry Sand whereas the former lithofacies is more reminiscent of the Tobacco Road Sand of the Barnwell Group. Generally, the coarser sand lithofacies is deeply weathered in outcrop, appears to be a massive, structureless, resistant residuum that resembles the residuum of the Tobacco Road Sand.

Quartz sand is overwhelmingly the predominant lithic component of the Mossy Creek Sand; all other lithic components are minor. These include scattered beds or clasts of clay (smectite or kaolin), mica, and limonite cemented sandstone. There are rare occurrences of the thinly bedded, gray clay that is characteristic of the underlying Marshallville Formation, but this clay-type is minor in the Mossy Creek.

The distributions of the coarse sand lithofacies and the fine sand lithofacies suggests that the coarse lithofacies is associated with relatively high energy coastal marine areas (perhaps broad tidal channels) whereas the fine sand lithofacies is associated with lower energy areas (perhaps interchannel areas in a broad sound or lagoon). There appears to be no spatial relationship between the coarser lithofacies and the locations of the modern major rivers of the area (Flint and Ocmulgee Rivers). No molds or cast of macrofossils or silicified shells have been observed yet in the Mossy Creek Sand, nor siliceous beds of silica-cemented sandstone as can be found locally in the Barnwell Group. The Mossy Creek depositional environment appears to have been devoid of a shelley fauna, the only fauna that has left any indication of its former presence is the bioturbation forming infauna and borrows of various kinds, including **Ophiomorpha nodosa**.

The Mossy Creek Sand appears to be most consistently coarse and poorly sorted in the southern or offshore range of its distribution, immediately north (landward) of the Perry Sand. This distribution suggests to us the presence of a former system of laterally migrating barrier islands in the seaward extremity of the formation. The barrier island lithofacies would have been truncated by erosion prior to the deposition of the Barnwell Group, and only the sediments in the deeper parts of the tidal channels would have been subsequently preserved. This aspect of the Mossy Creek may be what we see at the type locality and in the vicinity of Byron, Georgia.

STRATIGRAPHIC RELATIONSHIPS

The Mossy Creek Sand occurs as a westward broadening band and uppermost and youngest mappable formation of the inner part of the Fort Valley Plateau in Georgia. It is known to occur only in one area east of the Ocmulgee River, in Huber Pit 36 in Twiggs County, where it disconformably overlies the Huber Formation. Scattered occurrences of Mossy Creek-type sand in the Mossy Creek stratigraphic position is also present in the vicinity of McIntyre in Wilkinson County, Georgia. The Mossy Creek apparently grades laterally eastward into the Jeffersonville member of the Huber Formation east of the vicinity of Huber, Georgia.

The Mossy Creek Sand is also known to occur west of the Flint River only in the vicinity of Butler in Taylor County, Georgia. The Mossy Creek Sand was apparently either not deposited in the area west of Butler or was subsequently truncated by erosion. Because the strike of the belt of its seaward equivalent, the Perry Sand, occurs in a southwest-northeast band across southwestern Georgia, it appears likely because of depositional facies relationships that the original belt of Mossy Creek Sand trended in the same direction as the Perry Sand. However, the Mossy Creek Sand or a stratigraphic equivalent thereof is not known to occur west of the vicinity of Butler in Taylor County. The Mossy Creek Sand grades laterally down the dip (seaward) rather abruptly into the Perry Sand.

The Mossy Creek Sand generally occurs at the top of the geologic section where it is present in the northern part of the Fort Valley Plateau. It produces a resistant and tough residuum that underlies most of the northern part of the Fort Valley upland surface. However, it is locally overlain disconformably by high elevation, river terrace deposits that are evidently related to the Ocmulgee River because they occur discontinuously from the vicinity of Fort Valley in Peach County, eastward to the Ocmulgee River. No high elevation, river terrace deposits are known to occur between the vicinity of Fort Valley and the Flint River. All of the known Flint River terrace deposits occur west of the Flint River in the Fort Valley Plateau area and lithologically are much coarser than those of the Ocmulgee River. It is possible that outliers of the Barnwell Group locally overlie the Mossy Creek Sand but this relationship has not been observed yet in the field.

The Mossy Creek Sand disconformably overlies various formations. It generally overlies the Marshallville Formation, but where that formation was locally removed prior to deposition of the Mossy Creek Sand in the vicinity of the Fall line, the Mossy Creek
Sand disconformably overlies the Gaillard Formation or the Butler-Allon channel deposits. Immediately east of the Ocmulgee River, the Mossy Creek Sand disconformably overlies the Marion Member of the Huber Formation. West of the Flint River and north of the vicinity of Butler, Georgia, the Mossy Creek locally overlies the Pio Nono Formation disconformably.

The Mossy Creek Sand is distinguished from its seaward equivalent Perry Sand, in being consistently coarser. Quartz grain size in the Mossy Creek Sand typically ranges from pebble to medium-grained and moderately well to poorly sorted. The Perry Sand is typically fine- to very fine grained and well sorted to very well sorted. In addition, bedding in the Mossy Creek Sand is consistently larger in scale than that of the Perry Sand, including horizontal-bedding, undulatory-bedding, and cross-bedding. Locally, in the vicinity of Kathleen and Bonaire in Houston County, the Perry Sand contains minable lenses of hard kaolin but such large lenses of clay are not known to occur in the Mossy Creek Sand.

The finer grained sand lithofacies of the Mossy Creek Sand is distinguished from that of the underlying, older Marshallville Formation in being cleaner, better sorted, and more consistently thinner bedded. The Mossy Creek contains only minor, small, and locally occurring lenses of clay. The finer grained sand lithofacies of the Marshallville Formation, on the other hand, is more argillaceous with thick and aerially more extensive clay beds. It is the greater prevalence of clay in the Marshallville Formation, both interstitially and in discrete beds, that distinguishes the Marshallville Formation from the Mossy Creek Sand.

As described above, the coarse, poorly sorted sand lithofacies of the Mossy Creek Sand and Marshallville Formation are difficult to distinguish in the field based only on physical characteristics of the sediments. Both lithofacies are dominated by high energy, probably, tidal channel environments and, therefore, are lithologically very similar. In individual road cuts or even in small pits, the coarser lithofacies of the two formations may be practically indistinguishable. However, when considering stratigraphic position and larger areas of occurrence than single exposures, the variably burrowed, coarse, poorly sorted sand lithofacies of either formation can be seen to grade laterally or vertically into more typical Mossy Creek or Marshallville lithologies.

Various lithologies of the Barnwell Group (Irwinton Sand of the Dry Branch Formation and Tobacco Road Sand) of central and especially eastern Georgia can be confused with some of the lithologies of the Mossy Creek Sand. However, the Upper Eocene of the Fort Valley Plateau region is of farther offshore, continental shelf origin so that no confusion is likely where the two units may occur together, as in the vicinity of Rich Hill in Crawford County. Where the Mossy Creek Sand occurs in association with Oconee Group formations, the Oconee Group formations do not have coastal marine sedimentary or biogenic structures and contain considerably more clay, either interstitially or in discrete beds. Therefore, formations of the Oconee Group are not likely to be confused with the Mossy Creek Sand.

The thickness of the Mossy Creek Sand is not known to exceed 83 feet (25 m). Only 15 feet (4.6 m) of the formation is exposed at the type locality but and maximum of 83 feet (25 m), including residuum, is exposed at the lower boundary stratotype 0.8 airline miles (1.3 km) northwest of the type locality. Its greatest thickness in the pits of the Atlanta Sand and Supply Company near Gaillard, Georgia, is 35 feet (11 m).

The environment of deposition of the Mossy Creek Sand is considered to be coastal marine, probably sound/lagoon in origin. This assessment is based on the common local occurrence of bioturbation and burrows (especially that of **Ophiomorpha nodosa**), scattered occurrences of herringbone cross bedding, and the broad, blanket-type of distribution of the formation.

AGE

Except for the local presence of trace fossils, the Mossy Creek Sand is nonfossiliferous. Therefore an assessment of its age must be based on physical relationships such as stratigraphic position and facies relationships. The type locality of the Mossy Creek Sand was placed where it was because of the close proximity to exposures in a sand pit, on the opposite valley wall of Mossy Creek, that are lithologically intermediate with the Perry Sand and resembles the Perry Sand except for its coarser sand size. The physical resemblance of the finer sand lithofacies of the Mossy Creek Sand to that of the Perry Sand, and the same stratigraphic position and elevations where the two formations closely exposed, indicate that the Mossy Creek Sand is an updip, shoreward, lateral equivalent of the Perry Sand. Similarly, the Perry Sand occurs in the same stratigraphic position and elevations where it and the Lisbon Formation occur in close proximity. Therefore the Mossy Creek Sand is considered to be a facies equivalent of the Perry Sand and the Perry Sand is considered to be a facies equivalent of the Lisbon Formation. The Lisbon Formation, in the updip area of Georgia, (and, therefore, the Mossy Creek Sand) is late Middle Eocene, Bartonian, Claibornian in age and is considered to be in planktonic foraminiferal zone P13 of Blow (1969) and Berggren (1973), or the **Orbulinoides beckmanni** Zone of Bolli (1957) Stainforth and others (1975).

PERRY SAND

DEFINITION

The Perry Sand was named by Hetrick (1990) for prominently but thinly and delicately bedded, noncalcareous, nonfossiliferous, typically clean, well-sorted, incoherent, fine sands in the western half of Georgia. Where moderately to deeply weathered, the residuum of the Perry Sand resembles loess. In the past, only LeGrand (1962, p. 28-29) and Zapp (1965, p. 7-8) have made clear references to the Perry Sand of this report. LeGrand (1962) included this formation in the Gosport Sand (or Gosport dry sand), and Zapp (1965) referred to it as the "sand unit of the Claiborne Group". The Gosport Sand of MacNeil (1947a, 1947b) of western and central Georgia probably included the Perry Sand, but the lithostratigraphic definition of his "Gosport" is ambiguous and cannot be applied in the field. Similarly, the Gosport Sand of Herrick (1961, p. 3) and Herrick and Vorhis (1963, p. 25) appears to include the Perry Sand of this report. However, the sand unit to which Herrick (1961, p. 28, 144, 147) specifically applied the name Gosport is probably the Clinchfield Sand named subsequently by Pickering (1970). Finally, the Tallahatta Formation of northern Sumter County of Vorhis (1972) is almost certainly Perry Sand. Veatch and Stephenson (1911) mapped the Perry Sand with both the "Claiborne Group" and "Midway formation". Cooke (1943, 1944) mapped the Perry Sand as the Clayton Formation but MacNeil (1947) appears to have mapped the Perry with the Claiborne Group ("Gosport sand and McBean, Lisbon, and Tallahatta formations"). Georgia Geological Survey (1976) mapped the Perry Sand with the Mossy Creek Sand as "Eocene undifferentiated".

TYPE SECTION

The name Perry is taken from the town of Perry, Houston County, Georgia. The Perry Sand is the surficial formation exposed in and around Perry. The road cut and an abandoned sand pit on Valley Drive, where Valley Drive ascends the southern valley wall of Bay Creek, approximately 1.5 miles (2.4 km) west of the I-75/US 341 interchange at Perry, is here designated the type locality of the Perry Sand. The type locality of the Perry Sand is located in the Perry West, 1:24,000 quadrangle map. The section of Perry sand exposed at this roadcut is the type section, or unit-stratotype (holostratotype), of the formation. Twenty-five feet (7.6 m) of Perry Sand is exposed in the type section. The type section also contains the lower boundary stratotype where the Perry Sand disconformably overlies a lens of kaolin of uncertain stratigraphic affinity (either Oconee Group or Fort Valley Group). Current outcrop subsurface core information from the region suggests that the underlying Oconee Group deposits may be the updip feather edge of the Sabinian and, therefore, correlative with the Baker Hill Formation (but lithologically it is not Baker Hill Formation).

LITHOLOGY

The Perry Sand typically consists of thinly and delicately horizontal, undulatory to finely cross-bedded, noncalcareous, nonfossiliferous, well to very well-sorted, soft, incoherent, fine-grained sand. Much of the sand is clean, like sugar sand, and lacks any discernible impurities where freshly exposed. Medium-grained sand occurs locally and appears to be associated with channel features. Medium-grained sand is also more prevalent in updip areas where the Perry Sand merges into the Fort Valley Formation. Clay is a minor component of the lithology and dark minerals either are absent or occur in trace amounts. Through most of the formation, clay occurs interstitially in thin layers of fine sand that results in the thin argillaceous beds standing out prominently in weathering faces. In the eastern-most exposures of the Perry Sand near the Ocmulgee River, commercially thick and sufficiently pure kaolin occurs in large lenses. These kaolin bodies in the Perry Sand are of the hard, hackly type of kaolin that is characteristic of the kaolin of the Jeffersonville member of the Huber Formation. Burrows and other trace fossils, are locally common in the Perry Sand but their occurrences are scattered.

Prominent, delicate, fine-scale, thin bedding is characteristic of the Perry Sand. The bedding planes are typically defined by very thin layers that have slight concentrations of clay in a matrix of sand. During exposure, the well-sorted, clean, incoherent sand is selectively and gently eroded by gravity, wind, or rain, leaving reentrants between the more durable, thin, argillaceous sand layers. This gentle mass wasting of the incoherent sand produces highly etched appearances to the surfaces of many exposures in an intermediate state of weathering and imparts a woodgrain-like surface to the exposure. Where burrows are locally common and conspicuous in the Perry Sand, the burrow tubes stand out in relief or are left isolated by the mass wasting of the incoherent sand as small columns between the thin argillaceous sand layers.

Bedding type in the Perry Sand ranges from horizontal or broadly undulatory to cross-bedded or various kinds, including herringbone cross bedding. The bedding scale is always small with beds generally ranging in thickness from a few millimeters to 10 cm. Thicker bedding is not uncommon and occurs mainly in the medium-grained sand, channel lithofacies.

STRATIGRAPHIC RELATIONSHIPS

The Perry Sand occurs in a relatively narrow, northeast-southwest trending band, approximately 11 miles (17.7 km) across, from the Ocmulgee River in Houston County in the east, westward through Randolph County. It is not known to occur in the vicinity of the Chattahoochee River and may have been removed by erosional truncation west of Randolph County, Georgia, and in Alabama. The Perry Sand is not known to occur east of the Ocmulgee River where its stratigraphic position is occupied by the Jeffersonville member of the Huber Formation in outcrop. The Perry Sand may grade eastward into the downdip Jeffersonville member through decrease in the sand content of the formation and through increase and coalescence of the kaolin lenses and bodies. In the vicinity of Jeffersonville, Twiggs County, the kaolin component of the Jeffersonville member constitutes the entire thickness of the unit.

The Perry Sand grades laterally updip or landward into the Mossy Creek Sand, a much coarser siliciclastic formation than the Perry Sand; and the Perry Sand grades laterally downdip or seaward into the upper part of the Lisbon Formation (**Cubitostrea sellaeformis** Zone.

The Perry Sand disconformably overlies an Oconee or Fort Valley Group unit of uncertain age at the type locality that is considered most likely to be lower Sabinian. Elsewhere, the Perry Sand disconformably overlies the Marshallville Formation or a lithofacies intermediate from Marshallville to Clayton. In the northern part of the Andersonville area of northern Sumter and southern Schley Counties, the Perry Sand disconformably overlies the Baker Hill Formation. In the southern part of the Andersonville area, the Perry Sand disconformably overlies the Tuscahoma Formation (also see Zapp, 1965). In Randolph County, Georgia, the Perry Sand directly overlies a coastal marine lithofacies (Fort Valley Group lithology) of the lower Claibornian "Tallahatta Formation".

The Perry Sand directly underlies the upland surface of the southern part of the Fort Valley Plateau. It is locally overlain disconformably by outliers of the Barnwell group in the southern part of the Fort Valley Plateau, and west of the Flint River it is overlain by Oligocene or Upper Eocene residuum.

The Perry Sand is distinguished from all other formations of the Fort Valley Group in characteristically being a fairly pure, well-sorted, fine- to very fine grained quartz sand that is locally burrowed and is thinly and delicately stratified on a small scale. Coarse channel facies of the Perry Sand consist of well-sorted, fine- to medium-grained, more thickly stratified sands. In the vicinity of Kathleen and Bonaire in eastern Houston County, the Perry Sand also contains relatively thick and extensive lenses of hard kaolin. Only the finer grained lithofacies of the correlative Mossy Creek Sand lithologically resembles the Perry Sand, but this lithofacies consists of coarser, fine- to medium-grained sand and is more thickly stratified.

The Perry Sand is considered to be a shoreface deposit in this report. It occurs landward from the continental shelf, offshore Lisbon Formation, and occurs seaward from the more coarsely siliciclastic Mossy Creek Sand that is interpreted in this report to be of coastal marine, sound/lagoon origin.

AGE

Except for burrows, the Perry Sand is nonfossiliferous in terms of calcite-based fossils. Therefore, the estimation of the age of the formation is based on physical correlation and stratigraphic position. The best evidence, based on both cores and outcrops, indicates that the Perry Sand grades laterally down the dip, or seaward, in Sumter and Houston Counties, into the Lisbon Formation. In Sumter County on the Flint river, the zone of facies change occurs between the vicinity of Copperas Bluff and Danville Bluff, a distance of approximately 6 miles (10 km). In the vicinity of Copperas Bluff, the Perry Sand is underlain by the Tuscahoma Formation and is overlain by Upper Eocene residuum. At Danville Bluff, in the Georgia Geologic Survey core Sumter 9 (GGS-3366), the Upper Eocene residuum is underlain by approximately 90 feet (27 m) of Lisbon Formation, which in turn is underlain by approximately 68 feet (21 m) of lower Claibornian "Tallahatta Formation", all of which overlies the Tuscahoma Formation. Similarly, in Houston County the Perry Sand is known to occur in a northeast-southwest band through Perry to the south side of Warner Robins, approximately miles (km) northeast of Perry. At the site of the Georgia Geologic Survey core Houston 8 (GGS-3599) near the brewery 6.2 miles (9.9 km) east of Perry and 2.5 miles (4 km) north of Clinchfield in southeastern Houston County, Georgia, the Perry Sand occurs from the surface of the Fort Valley Plateau to a depth of 86 feet. It occurs in the same stratigraphic position as the Lisbon Formation 3 miles south at the Clinchfield quarry. At the quarry, the Lisbon is sporadically found in sump pits in the floor of the pit. The Lisbon Formation in the Georgia Geologic Survey core Houston 4 (GGS-3058) at the lime pit near Clinchfield disconformably underlies the Clinchfield Sand of the Barnwell Group (also see Huddlestun and others, 1974, p. 2-27, and disconformably overlies Oconee Group-type deposits that overlie Sabinian age (pers. com., L. Edwards, 1991) marine clays. The Lisbon Formation also occurs in this stratigraphic position in the Georgia Geologic Survey core Houston 3 (GGS-3097) on the Perry-Elko Road 3.5 miles (5.6 km) south of Perry and 2 miles (3.2 km) south of the Perry Sand exposures in sanitary land fill sites on the south side of Perry. In addition, the Lisbon Formation is not known to occur in association with the Perry Sand at any site or in any core and is not known to occur updip from known occurrences of the Perry Sand.

The line of lithofacies change from the Perry Sand seaward into the Lisbon Formation appears to be very abrupt, occurring within a distance of 2 miles (3.2 km) south of Perry, 3 miles (4.8 km) in the vicinity of Clinchfield, and within a distance of 6 miles (10 km) along the Flint River. The Lisbon Formation is known to occur only down the dip from the Perry outcrop belt and in the same stratigraphic position. Therefore, the stratigraphic evidences indicates that the Perry Sand is a nearshore, shoreface facies of the Lisbon Formation. If so, the Perry Sand is Middle Eocene, Bartonian, late Claibornian in age and is correlative with the Blue Bluff Member of the Lisbon Formation, the Cook Mountain Formation of Louisiana, and the upper part of the **Cubitostrea sellaeformis** Zone of Alabama and Mississippi.

OTHER STRATIGRAPHIC UNITS

FLUVIAL DEPOSITS OF THE OCMULGEE RIVER TERRACES

DEFINITION

River terrace deposits consists of sand, gravel, and local and minor clay lenses. These fluvial deposits are coarsest and more uniform in distribution near the Ocmulgee river. Farther west from the Ocmulgee River, the terrace deposits become more scattered in distribution and occur at progressively higher elevations relative to the modern Ocmulgee River. The westernmost occurrence of the high river terraces is at the type locality of the Mossy Creek Sand (Stop 9), immediately northeast of Fort Valley, where high fluvial terrace deposits occur as high as 250 feet (76 m) above the modern Ocmulgee River, 19 miles (30 km) to the east. These high river terrace deposits are not considered to have been deposited by the Flint River system because there are no known occurrences of high elevation river terrace deposits between the longitude of Fort Valley and the Flint River. However, there is a series of ascending terraces west of the Flint River, and those river deposits are considerably coarser grained than those of the Ocmulgee River.

The high river terraces in the eastern part of the Fort Valley Plateau may have been deposited on high terraces by the ancient nearby streams, Mossy Creek and Echeconnee Creek. No pebbly high river terrace deposits are known to occur in exposures or cores from the interfluve uplands on the Fort Valley Plateau. All occurrences of high terrace deposits in the western part of the Ocmulgee high terrace deposits in the eastern Fort Valley Plateau are located along the upper valley walls of Mossy Creek and Echeconnee Creek. Modern Mossy Creek heads in the Coastal Plain in the Gaillard outcrop belt and if the pebble-size quartz in the terrace deposits were reworked from the Gaillard, Marshallville, and Mossy Creek Formations, then the concentration effect of Pleistocene erosion of these formations must have been very efficient to account for the abundance of gravel in the nearby high terraces. Fluvial terrace deposits are not known to occur at lower elevations along the southern valley wall of Echeconnee Creek or along either valley wall of Mossy Creek. Whether the source of these high terrace deposits is local and reworked Coastal Plain or nearby Piedmont is difficult to say at this time. However, similar high terrace deposits are not known to occur on the valley walls of tributaries of the larger rivers (Flint, Ocmulgee and Oconee)far from those rivers. Therefore it is surmised here the source of the pebbles and gravel associated with the high terrace deposits in the field trip area east of the Flint River is the Ocmulgee River.

The high river terrace deposits are considerably weathered and, in some areas, the nature of the original deposit can be recognized only by the presence of coarse gravel stringers in a moderate reddish brown (5 R 4/6) massive, structureless, sandy residuum that resembles the massive residuum of the Mossy Creek Sand, Perry Sand, or the Tobacco Road Sand. If gravel stringers are not present in this residuum of the terrace deposits, differentiation between the terrace deposits and residuum of Fort Valley Group deposits is impossible.

Between Echeconnee Creek on the south and Tobesofkee Creek on the north, there is a gently southward sloping, terraced surface that gradually descends to the Echeconnee Creek floodplain to the south. The southern valley wall of Echeconnee Creek is steep and abrupt, indicating that Echeconnee Creek has migrated southward during the Pleistocene. The western part of this area also includes the outcrop belt of the Pio Nono Formation and we have found it very difficult in places to lithologically distinguish between high river terrace deposits and Pio Nono Formation and similar lithologies of the Pio Nono Formation . Across this southward terraced sloped north of Echeconnee Creek, the deposits exposed in road cuts generally have the appearance of Pio Nono Formation. However, this area should include mostly the outcrop belt of the Gaillard Formation and we are, therefore, including these Pio Nono-type deposits in terrace deposits of Echeconnee Creek.

In contrast, deposits exposed in road cuts in the vicinity of Roberta and Knoxville, and in scattered road cuts from the vicinity of Knoxville in Crawford County, to Lizella in Bibb County, lithologically resemble high terrace deposits of the Ocmulgee River. However, these particular weathered, pebbly to gravelly, cross-stratified deposits occur only within the outcrop belt of the Pio Nono Formation and are not known to overlie the Gaillard Formation in its outcrop belt to the south. Therefore, we conclude that the deposits that resemble high river terrace deposits of the Ocmulgee River and that occur as far west as the vicinity of Roberta near the Flint River, are a part of the Pio Nono Formation and that parts of the Pio Nono Formation greatly resemble the Pleistocene high river terrace deposits in Georgia.

We also believe that these high terrace deposits were once more extensive across the eastern Fort Valley plateau than their current distribution. We think the high river terrace deposits exposed along Ga 247 at the top of the southern valley wall above Big Indian Creek, 3.5 miles (5.6 km) east of Haynesville in eastern Houston County, is correlative and contemporaneous with the other high elevation river terrace deposits to the northwest on the Fort Valley Plateau. The only difference between the river terrace deposits above Big Indian Creek and those farther to the northwest is that the Big Indian Creek terrace deposits are widely separated from the rest of the exposures of the Fort Valley Plateau high terrace deposits.

LITHOLOGY

The lithology of the high elevation, river terrace deposits is largely sand of all size grades, granules, pebbles, and rarely small cobbles. Clay lenses of varying size occur locally but are not common in outcrop. Generally the terrace deposits are deeply weathered. At some sites the weathering and leaching has been so intensive as to completely mask the nature of the original sediments. Only the fortuitous presence of stringers of deeply leached, coarse quartz gravel or, rarely, of silicified pebbles of Tivola Limestone, allows the sediments overlying these gravel stringers to be identified as residuum of high river terrace deposits. Rarely, and in all cases nearer the Ocmulgee River, these terrace deposits are only moderately to slightly weathered.

Due to the deep weathering of the fluvial deposits, little remains of the accessory lithic components. In some places limonite-cemented sandstone is encountered, and I know of a frosted, slightly rounded, six-sided quartz crystal to have been retrieved from one sand pit in the terrace deposits. The relatively unweathered clay lenses commonly are finely micaceous.

Generally the high river terrace deposits are extensively cross-bedded with both planar and trough types present on varying scales. At many sites, however, the bedding appears to be thick and massive with either horizontal or undulatory bedding. This type of stratification, and the occurrence of clay lenses, indicates overbank deposition with the clay lenses having been deposited in restricted ponds of standing water. The more coarsely cross bedded deposits are considered to be high energy, channel-fill deposits.

STRATIGRAPHIC RELATIONSHIPS

The high elevation, river terrace deposits occur scattered across much of the eastern half of the Fort Valley Plateau and in the Fall Line Hills east of the longitude of Fort Valley. The occurrence, or recognizable occurrence, of the terrace deposits, their thickness, and preservation all improves or increases in the direction of the Ocmulgee River. The river terrace deposits are most extensively developed along the western side of the Ocmulgee River. In contrast, the high elevation, river terraces deposits are only poorly developed on the eastern side of the river, and their occurrence is restricted to the vicinity of the eastern valley wall to the east of the Ocmulgee River.

The breadth of the river terrace sequence in the study area indicates the Ocmulgee River either migrated eastward since the deposition of the highest terrace at approximately 250 feet (76 m) above present river level or that the flood plain system at the Fall line was at one time vastly broader than it is today. That high Ocmulgee River terrace deposits occur at least 130 feet (40 m) above the present river on the eastern valley wall of the Ocmulgee River in northwestern Bleckley County indicates the Ocmulgee River has occupied its present channel position for a considerable period of time during the later Pleistocene. That would suggest the flood plain of the Ocmulgee River was much broader during the earlier Pleistocene than it now is and could have been as much as 22 miles (35 km) across. If so, the Early Pleistocene landscape of the Georgia Fall line area was tremendously different than it now is, with large, braided, Platte-like rivers disgorging their sediment load from the Piedmont unto the inner Coastal Plain.

The river terrace deposits of the Ocmulgee River occur at the top of the local stratigraphic sections, i.e., no other deposits other than nondescript residuum or soil overlies the terrace deposits. On the other hand, the terrace deposits all disconformably overlie deposits of the Oconee Group, Fort Valley Group, outliers of Barnwell Group, or Oligocene residuum. No attempt has been made here do systematically map the terrace surfaces and to correlate specific terrace sequences.

The Thickness distribution of the river terrace deposits vary greatly, from what would otherwise appear to be locally absent to thicknesses greater than 50 feet (15 m). The thickest sections of terrace deposits occur within a few miles (several kilometers of the Ocmulgee River in Macon and the vicinity of Warner Robins in Houston County.

AGE

Based on reconnaissance mapping of the river terraces by the senior author along the Chattahoochee, Flint, and Ocmulgee Rivers, he concludes that none of the terraces developed along these rivers, and especially the Flint River, have been more uplifted near the Piedmont than to the south in the Coastal Plain. This accords with his observation (Huddlestun, 1988) that none of the marine terraces in Georgia, including the highest, Hazlehurst terrace at 275 feet (84 m), has been differentially tilted or warped, in contrast to Upper Pliocene deposits that have been tilted. Therefore, it is our tentative conclusion that the age of all of the river terraces in the Fall Line Hill District and the Fort Valley Plateau District between the Flint and Ocmulgee Rivers are Pleistocene in age. Presumably, the highest terrace deposits that occur farthest from the Ocmulgee River are the oldest terraces and may be early to middle Pleistocene in age. Other than the tentative identification of a Pliocene fossil horse tooth from terrace deposits of moderate elevation above the Flint River south of Reynolds in Taylor County (Voorhies, 1974), there is no indication the high elevation, river terrace deposits are any older than the Pleistocene.

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APPENDIX

ROAD LOG

FIRST DAY

Mileage		
Interval	**Cumulative**	
0.0	0.0	Exposures near the Parkway Inn are all Pio Nono Formation. Leave Parkway Inn in Macon. Turn left (east) on U.S. 80 (Eisenhower Parkway).
0.3	0.3	I-75
0.4	0.7	Crakerbarrel Restaurant on left. Foliated Piedmont saprolite is exposed in the ditch in front of the restaurant.
1.05	1.75	Pio Nono Formation exposed in cut behind Comfort Inn Motel on the right.
0.85	2.6	Rocky Creek.
0.7	3.3	Key Street, turn left.
0.4	3.7	Anthony Street, turn left.
0.3	4.0	**Stop 1.** Pio Nono type locality, Brad Henderson Stadium; The exposure of the Pio Nono Formation is the cut into the eastern hill side west and north of the stadium. This is an easily accessible, relatively thick exposure displaying most of the characteristic and distinctive lithologies of the Pio Nono Formation. Neither the base nor the top of the thick formation is exposed at this locality. Return to Anthony Street, turn left.
0.4	4.4	Key Street, turn right.
0.3	4.7	US 80 (Eisenhower Blvd), turn right.
3.0	7.7	I-75.
2.0	9.7	Tobesofkee Creek.
3.7	13.4	Lizella, Georgia.

2.7	16.1	Echeconnee Creek
5.1	21.2	Pio Nono Formation on the right.
0.5	21.7	Pio Nono Formation on the left.
1.9	23.5	Pio Nono Formation on left and right.
2.1	25.6	Knoxville, jct. US 80 and Ga. 42, turn left on Ga. 42.
0.8	26.4	Pio Nono Formation of right.
0.4	26.8	Pio Nono Formation of left.
1.2	28.0	Gaillard Formation.
0.3	28.5	Mossy Creek Sand on left.
1.6	30.1	**Stop 2.** Rich Hill is down the hill to the right: the lower part of the Barnwell Group including Clinchfield Formation, the Tivola Limestone of the Ocala Group, and the Twiggs Clay and basal part of the Irwinton Sand Members of the Dry Branch Formation are exposed here. The Barnwell Group disconformably overlies the Upper Cretaceous Gaillard Formation at this site. Turn around and return to Knoxville.
4.7	34.8	Knoxville, Jct. Ga. 42 and US 80. Turn left onto US 80
0.9	35.7	Jct. US 341 and US 80 in Roberta. Turn right (north) on US 341.
2.3	38.0	**Stop 3.** Jct US 341 and unimproved dirt road. Parastratotype of the Pio Nono Formation. The basal part of the Pio Nono Formation and its unconformable contact on metamorphic basement (schist or phyllite) is exposed at this site. The Pio Nono Formation in this area appears to be generally more sandy or less kaolinitic than in the Macon area. Much of the formation is typical at this site. Turn around and proceed south on US 341.
2.4	40.4	Jct. US 341 and US 80 in Roberta. Continue south on US 341.

0.2	40.6	Jct US 341 and Ga. 128. Turn right (west) on Ga. 128.
6.1	46.7	Flint River.
0.4	47.1	Jct. Ga. 128 and Ga. 137. Turn right on Ga. 137.
0.3	47.4	Exposures of high level, Flint River terrace deposits on left.
4.1	51.5	Fickling Mill, Patsiliga Creek.
0.1	51.6	Jct. Ga. 137 and Ga. 208. Turn right on Ga. 208.
1.1	52.7	High Flint river terrace deposit over Pio Nono Formation.
0.7	53.4	Patsiliga Creek.
2.6	56.0	Jct. Ga. 208 and US. 19. Turn left (south) on US 19.
1.5	57.5	Tuscaloosa Formation marker on the right.
0.9	58.4	Patsiliga Creek.
2.1	60.5	Jct. US 19 and unimproved dirt road to Butler Sand Co. Turn right onto dirt road.
0.6	61.1	**Stop 4.** Sand pit of the Butler Sand Company. The Middle Eocene Mossy Creek Sand, the Butler-Allon channel beds, and the Pio Nono Formation are exposed in these sand pits. In this updip area, the Gaillard Formation has been eroded out, leaving Tertiary channel deposits and coastal marine deposits disconformably overlying the topographically irregular surface of the Pio Nono Formation.
		Return to US 19.
0.7	61.8	Jct. unimproved dirt road and US 19. Turn left (north) on US 19.
4.5	66.3	Jct., US 19 and Ga. 208. Turn right (east) on Ga. 208.
4.5	70.8	Jct., Ga. 208 and Ga. 137. Left on Ga. 137.

4.4	75.2	Jct., Ga. 137 and Ga. 128. Left on Ga. 128.
0.4	75.6	Flint River
1.0	76.6	Jct. Ga. 128 and paved county road. Turn right on paved county road.
3.7	80.3	Avery Creek
0.2	80.3	Pio Nono Formation on left.
0.7	81.0	Railroad crossing. Hammet, Georgia.
0.5	81.5	Pio Nono Formation exposed along both side of the highway.
0.1	81.6	Jct., paved county road, continue ahead.
0.4	82.0	Pio Nono Formation on right.
0.6	82.6	Jct., paved county road and US 341. Turn right (south) on US 341.
0.2	82.8	Pio Nono Formation exposed in road cut on both sides of the highway.
1.0	83.8	Jct., US 341 and unimproved dirt road. Turn right (west) on dirt road into Atlanta Sand and Gravel Company.
0.7	84.5	**Stop 5.** Atlanta Sand and Supply Co. pit; type locality of the Gaillard Formation. the Gaillard Formation, Marshallville Formation, Butler-Allon channel deposits, and Mossy Creek Sand are exposed in the pits. The Gaillard Formation and Mossy Creek Sand are consistently present in the various sand pits but the Marshallville Formation and Butler-Allon channel deposits are locally absent. Return to US 341.
0.7	85.2	Jct., dirt road and US 341. Turn right (south) on US 341.
1.5	86.7	Mossy Creek Sand exposed in roadcut on the left.
0.6	87.3	We are leaving the Fall line hills and are approaching the upland surface of the Fort Valley Plateau. The upland surface dips to the southeast and approximates the top of the Claibornian. However, there are a few, small Jacksonian outliers on and local and scattered outliers of high

		elevation, Ocmulgee River terrace deposits as far west as the vicinity of Fort Valley on the plateau.
2.8	90.1	Enter Peach County.
2.3	92.4	Fort Valley city limits.
1.3	93.7	Fort Valley, Georgia. Jct., US 341 and Ga. 49. Turn right on Ga. 49.
4.2	97.9	Enter Macon County.
3.0	100.9	Marshallville city limits.
0.9	101.8	Turn right on Ga. 49 in Marshallville.
0.6	102.4	Jct. 49 and paved county road. Turn right on county road.
1.8	104.2	Weathered Nakomis Formation on right.
0.3	104.5	Weathered Nakomis Formation on right.
0.4	104.9	T jct., turn left on dirt road. Exposures of marine Marshallville, bluish-gray, thinly bedded fine sand in ditch on the left.
0.3	105.2	**Stop 6.** Bluffs overlooking the Flint River valley to the west. This is the type locality of the Marshallville Formation. Both the Marshallville Formation and the Mossy Creek Sand are exposed in the bluffs. The Marshallville Formation in this area appears to represent an interfingering of coastal marine and probably fluvial deposits. The upper part of the Marshallville Formation at this site appears to be largely nonmarine in origin whereas the lower part of the formation is marginal marine. Elsewhere nearby, the beds or lenses of dark bluish gray, thinly bedded argillaceous fine sand contain a diverse, lower Midwayan dinoflagellate flora, indicating open-marine influence.
		Return to Marshallville.
		Stop 7 (optional)
0.3	105.5	Jct., turn right on paved county road.

2.4	107.9	Jct., paved county road and Ga. 49. Turn right on Ga. 49 in Marshallville.
2.5	110.4	Jct. Ga. 49 and unimproved dirt road. Turn left on dirt road.
2.0	112.4	T jct., Turn left (east) on unimproved, dirt road.
0.6	113.0	**Stop 8.** Old abandoned sand pit. This is the best preserved exposure of Upper Claibornian Perry Sand we have found in field trip area. Although the exposure is not thick here and neither lower nor upper contact is exposed, the formation is lithologically typical and characteristic. Southeast of a line trending northeast-southwest through the vicinity of Marshallville and Warner Robins, the Perry Sand generally underlies the upland surface of the Fort Valley Plateau. Continue east on dirt road.
0.3	113.3	Perry residuum on left.
0.7	114	Y jct., bear left (north).
3.0	117	Marshallville, Georgia. Jct., county road and Ga. 49. Turn right onto Ga. 49.
0.4	117.4	Turn left on Ga. 49 in Marshallville.
6.5	123.9	Fort Valley city limits.
1.2	125.1	Fort Valley commercial district.
0.4	125.5	Jct., Ga. 49 and US 341. Continue on Ga. 49.
0.9	126.4	Jct., Ga. 49 and Taylors Mill Road. Turn left on Taylors Mill Road.
1.9	128.3	Residuum of Mossy Creek Sand.
0.3	128.6	Abandoned sand pit on right (east) side of road. The Mossy Creek Sand is exposed here (poorly now) and is largely intermediate in lithology between typical Mossy Creek Sand and its seaward facies, the Perry Sand. We have observed four different kinds of burrows in this sand pit.

0.3	128.9	Mossy Creek, a major drainage shed of the Fort Valley Plateau.
0.5	129.4	**Stop 9.** Sand pit on the west side of road, across from Fairview Church. This is the type locality of Mossy Creek Sand. The section exposed here is not thick but is lithologically typical of sections where the formation is not too deeply weathered. In addition, the Mossy Creek Sand is overlain by the highest and most westerly known exposure of Ocmulgee River terrace deposits. Northwest of a line trending southwest-northeast through the vicinities of Marshallville and Warner Robins, the Mossy Creek Sand generally underlies the upland surface of the Fort Valley Plateau. This is the last stop of the first day. The field trip party will return to the Parkway Inn in Macon via Ga. 49 and I-75.
24.5	153.9	Parkway Inn in Macon.

SECOND DAY

0.0	0.0	Parkway Inn, Macon. Turn left on US 80.
0.1	0.1	Jct. US 80. Turn left (east) on US 80.
0.15	0.25	Jct. US 80 and I-75. Turn right (south) onto I-75.
3.15	3.4	Tobesofkee Creek.
0.8	4.2	Jct., I-475 and I-75. Continue south on I-75.
0.7	4.9	Jct. I-75 and Hartley Bridge Road (Ga. 361). Exit I-75 and turn left (east) onto Hartley Bridge Road.
2.8	7.7	T jct., Hartley Bridge Road and Ga. 49 (Houston Road). Turn right (south) onto Ga. 49.
0.5	8.2	Jct. Ga. 49 and Allen Road. Turn left (east) Allen Road (Ga. 361).

1.1	9.3	Jct., Allen road and US 129. Turn right (south) onto US 129.
0.8	10.1	Jct. US 41. Continue south on US 129.
5.0	15.1	Echeconnee Creek.
0.3	15.4	Jct. US 129 and Elberta Road. Turn left onto Elberta Road.
0.1	15.5	Turn left into parking area. **Stop 10.** Abandoned sand pit in Elberta, Georgia. This site is on the eastern valley wall of the Ocmulgee River near the confluence of Echeconnee Creek with the Ocmulgee River. The deposits exposed in the sand pit include the Marshallville Formation in the lower part and terrace deposits of the Ocmulgee River in the upper part. The Marshallville Formation is significant here because it is lithologically intermediate with its updip equivalent, the fluvial Marion Member of the Huber Formation. Huber post office is only 5 miles northeast of Elberta on a lower terrace of the Ocmulgee River.
0.1	15.6	Return to US 129. Turn right (south) onto US 129.
2.9	18.5	Jct. US 129 and Watson Blvd (Ga. 247C) in Warner Robins. Turn right (south) onto Watson Blvd. The many exposures deeply weathered sand and residuum exposed intermittently along Watson Blvd. are exposures of Mossy Creek Sand.
8.4	26.9	Jct. Ga 247C and I-75. Turn left (south) onto I-75.
9.6	36.5	Jct., I-75 and US 341 in Perry. Turn right (west) onto US 341. Almost immediately after turning onto US 341, turn left (south) onto connector road, Valley Drive, that parallels I-75. Continue south on Valley Drive.
1.1	37.6	Residuum of Perry Sand on right.
0.3	37.9	Bay Creek
0.1	38.0	**Stop 11.** Road cut in southern valley wall of Bay Creek. This is the type locality

of Perry Sand. The full local thickness of the Perry Sand is exposed at this site. The Perry Sand here is disconformably underlain by a finely sandy kaolin at the top of a fining upward sequence of an unnamed and unidentified component of the Oconee or Fort Valley Groups. The Perry Sand is in turn disconformably overlain by high river terrace deposits related either to the Ocmulgee River or Bay Creek. A core, the Georgia Geologic Survey Houston 7 (GGS-3605), was taken 0.9 miles west of the type locality on the upland surface.

1.6	39.6	Return the jct. US 341 and I-75. Continue on US 341 into Perry, Georgia.
0.6	40.2	Residuum of Perry Sand on left.
0.4	40.6	Jct. US 341 and Ga. 127 in Perry. Turn left onto Ga. 127 and continue through Perry on 127.
4.3	44.9	Residuum of Perry Sand.
0.9	45.5	Mossy Creek.
1.1	46.6	Jct. Ga. 127 and Moody Road. Turn left on Moody Road.
1.2	47.8	Kaolinitic Perry Sand in road cut.
1.8	49.6	Twiggs Clay of the Barnwell Group on right. Here we are crossing an outlier of the Upper Eocene near the eastern edge of the Fort Valley Plateau.
0.5	50.1	Cobbles of Tivola Limestone on the left.
0.3	50.4	Jct. Moody Road and Ga. 96. Turn right onto Ga. 96.
1.7	52.1	Jct. Ga. 96 and US 129/Ga. 247 in Bonaire, Georgia. Continue east on Ga. 96.
2.3	54.4	"Perry" kaolin on the left.
1.3	55.7	Ocmulgee River.
1.4	57.1	Railroad crossing.
4.1	61.2	Tarversville, Georgia. Jct. Ga. 96 and US 23. Turn left (north) onto US 23.
1.4	62.6	Richland Creek.

2.5	65.1	Savage Creek.
3.0	68.1	Bullard, Georgia.
6.1	74.2	Jct., US 23 and paved county road (Sgoda Road), turn right (east).
1.0	75.2	Jct., Sgoda Road and I-16, continue on Sgoda Road.
0.3	75.5	Jct., Sgoda Road and Marion Road, turn right (south) on Marion Road.
1.1	76.6	Jct., Marion Road and kaolin haul roads, continue south on Marion Road.
0.2	76.8	Jct. Marion Road and county road, J. M. Huber maintenance building on left. Continue on Marion Road.
0.05	76.8	Y jct., Floyds Mine Store on left, continue on Marion Road on right.
0.7	77.5	White Springs Church on right, continue on Marion Road.
0.6	78.1	Jct. Marion Road and kaolin haul road, turn left (east) onto kaolin haul road.
0.5	78.6	**Stop 12** Huber Pit 36 area. The section exposed in Huber Pit 36 is the Buffalo Creek Kaolin Member of the Gaillard Formation exposed at the base of the section (the mined kaolin in this pit). The Marion Member of the Huber Formation disconformably overlies the Buffalo Creek Kaolin Member and the Marion Member is disconformably overlain, in topographic lows on its upper surface by the Mossy Creek Sand. Barnwell Group residuum occurs at the top of the section here and disconformably overlies either the Mossy Creek Sand or the Marion Member. This site is significant because it can be seen that the Mossy Creek Sand disconformably overlies the Lower Paleocene, Marion Member of the Huber Formation.
0.5	79.1	Return to Marion Road. Jct., Marion Road and kaolin haul road, turn right (north) on Marion Road.
1.4	80.5	Jct., Marion Road and paved county road (J. M. Huber maintenance building on

		right) turn right (east) onto paved road.
1.0	81.5	Buck Branch
0.3	81.8	Jct., Stop sign, county paved road and dirt road, end of paved road. Continue east on dirt road.
1.3	83.1	**Stop 13.** Huber Pit 30 area; type locality of Huber Formation. When B. F. Buie originally measured and described Pit 30, the Tertiary section consisted of both an upper section (Jeffersonville member of this guidebook), and a lower section (Marion Member of this guidebook), separated by a disconformity. At the current time, the upper, Jeffersonville member is not present in the pit area, and the Marion Member of the Huber Formation is disconformably overlain by the Barnwell Group.

This is the end of the field trip. The field trip party will return to the Parkway Inn in Macon.

LITHOLOGY EXPLANATION

SAND

BEDDED SAND

GRAVEL

CARBONATE

IMPURE CARBONATE

CLAY

LIMEY CLAY

CLAY INCLUSIONS

MICA

SILT

SHELLY FOSSILS

BIOTURBATION

BURROWS

FIGURE 7

STOP 1

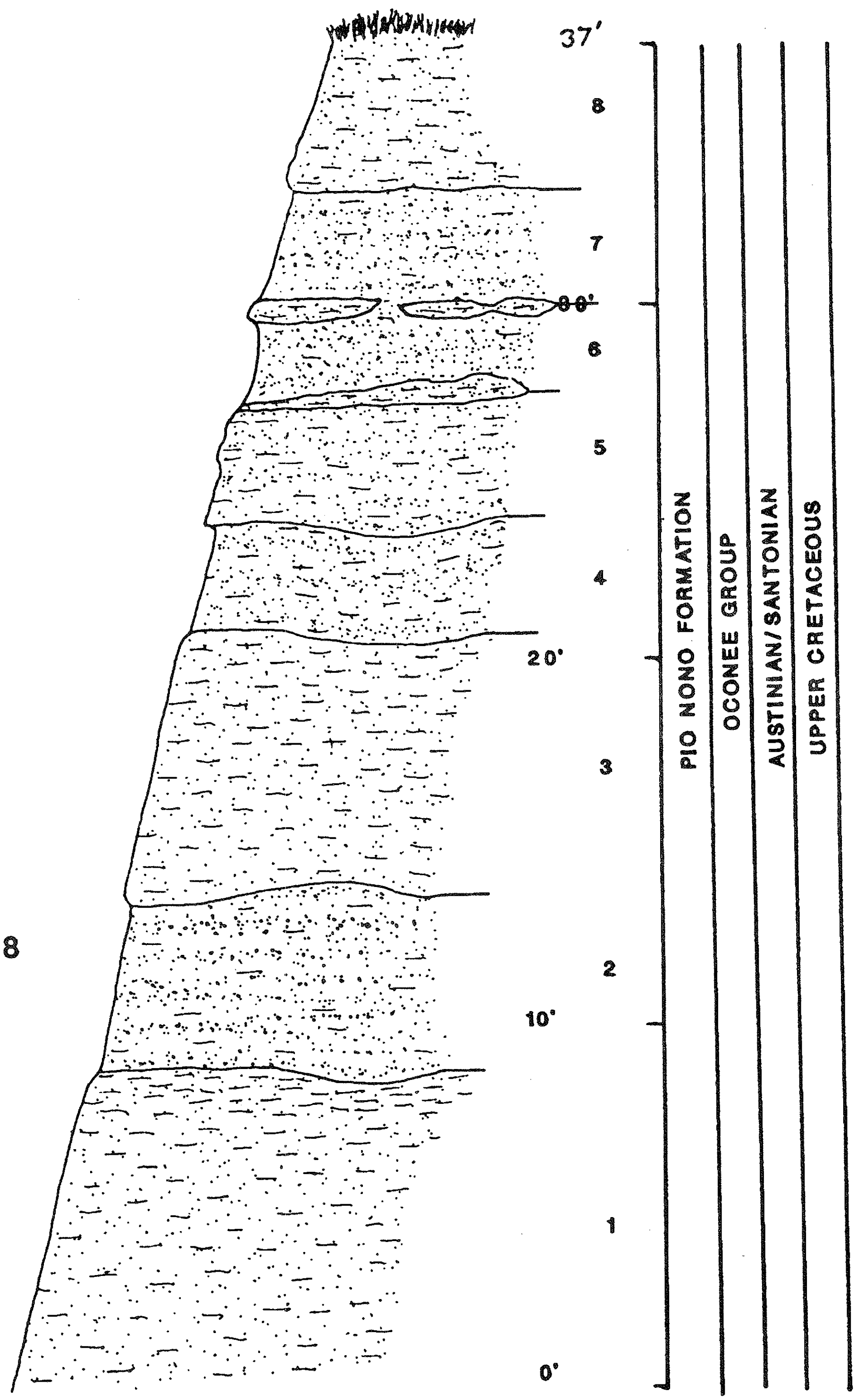

FIGURE 8

STOP 1

LITHOLOGIC DESCRIPTION OF THE PIO NONO FORMATION AT THE TYPE SECTION AT BRAD HENDERSON STADIUM IN MACON, BIBB COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
PIO NONO FORMATION		
Bed 8	Residuum: deeply weathered clayey sand; abruptly overlies:	4 feet (1.3 m)
Bed 7	Sand: kaolinitic; poorly sorted, generally massive-bedded but very vaguely stratified; gradationally overlies:	3 feet 0.9 m)
Bed 6	Sand and sandstone: kaolinitic, poorly sorted sand with lenticular beds of soft, crumbly, kaolinitic sandstone, rudely bedded but massive; grades downward into:	3 feet (0.9 m)
Bed 5	Sandstone: kaolinitic with some more kaolinitic intervals; sand poorly sorted, friable and crumbly; rudely and vaguely stratified; grades downward into:	3 feet (0.9 m)
Bed 4	Sand: somewhat kaolinitic; sand poorly to moderately sorted; rudely stratified; grades abruptly downward into:	3 feet (0.9 m)
Bed 3	Sandstone: clayey, contains some dark minerals; tough and slightly consolidated to lightly indurated; sand is poorly sorted and fine- to medium grained; bedding is massive and structureless with vague stratification, irregular blocky fracture yields blocks of sediment roughly 6-8 inches (15-20 cm), irregularly mottled color patterns: ocher, yellow, white (N 8), and dusky red: grades abruptly down into:	7.7 feet (2.3 m)
Bed 2	Sand: slightly kaolinitic; poorly sorted, granully, coarse-grained sand; massive-bedded but with rude stratification that can best be seem from a distance; irregular mottled color patterns which	5.0 feet (1.5 m)

include light brown, grayish orange, and dark yellowish orange; grades abruptly down into:

Bed 1	Sandy kaolin to kaolinitic sand: common dark minerals; quartz sand moderately sorted, fine- to medium-grained; bedding is massive and structureless with no evidence of stratification, fairly uniform across the exposure; color is dominantly light bluish gray with irregular shaped patches and mottling of dusky red to pale red to grayish red: the base of the bed is not exposed.	8.0 feet (2.4 m)
		37 feet (11 m)

STOP 2

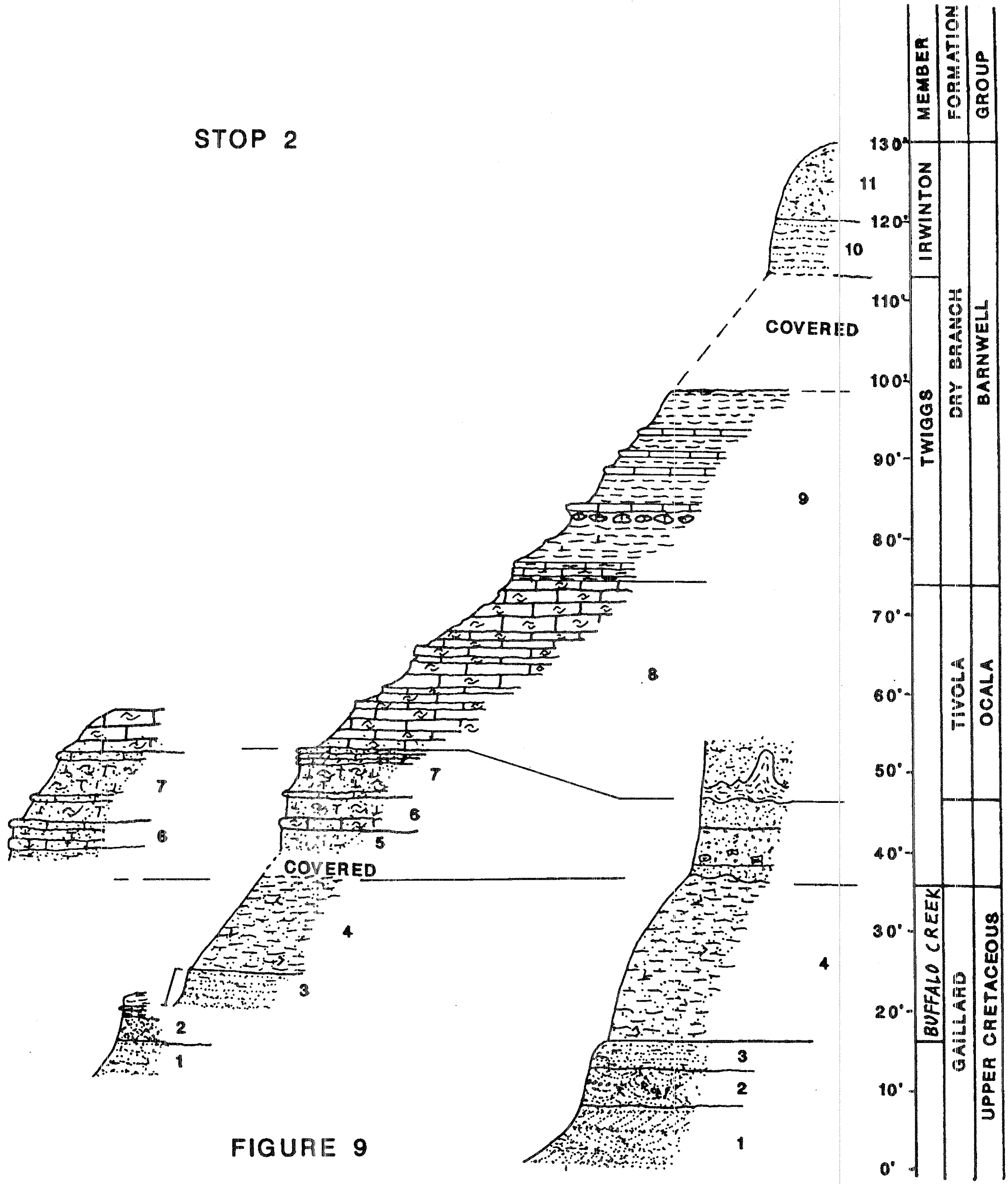

FIGURE 9

STOP 2

DESCRIPTION OF THE SECTION EXPOSED AT RICH HILL, CRAWFORD COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
BARNWELL GROUP DRY BRANCH FM IRWINTON SAND MEMBER		
Bed 11	Sand, residuum: argillaceous, fine- to medium-grained, well sorted; massive, structureless, devoid of sedimentary structures; moderate reddish brown (10 r 4/6); gradationally overlies:	10 feet (3 m)
Bed 10	Sand and clay: thinly interbedded, fine-grained, well sorted sand with thin interlayers or laminae of Twiggs-like clay, beds essentially horizontal to subhorizontal; deeply weathered:	7 feet (2 m)
Covered Interval		15 feet (4.6 m)
TWIGGS CLAY MEMBER		
Bed 9	Clay: calcareous toward base, with thin beds or lenses of fine-grained limestone scattered throughout, some calcareous concretions in the lower part; clay is sticky and plastic when wet; well bedded to laminated, with blocky to conchoidal fracture; yellowish gray (5 Y 8/1); grades downward through a thin interval (about 1 foot) of thinly bedded, argillaceous limestone into:	23 feet (7.0 m)
OCALA GROUP TIVOLA LIMESTONE		
Bed 8	Limestone: abundantly fossiliferous; medium to coarse textured, uneven-grained due to the abundance of clastic bryozoan debris; very tough and brittle with irregular, bioclastic fracture; some minor quartz sand in the basal 1 foot; rudely bedded with scattered thin beds or	21 feet (6.4 m)

ledges of more indurated limestone, otherwise massive and structureless in appearance; **Aequipecten spillmani** common, rare **Periarchus pileussinensis** and molds of mollusks; very pale orange (10 YR 8/2) to pale yellowish orange (10 YR 8/6); grades abruptly downward into:

BARNWELL GROUP
CLINCHFIELD FM

Bed 7	Sand: very calcareous, some calcitic shell debris with scattered fragments of **Periarchus**, less calcareous near base of bed; sand fine- medium-grained and well-sorted; massive and devoid of sedimentary or biogenic structures except at top of bed, the upper 1 foot of Bed 7 consists of a ledge of shaley, granular calcarenite or calcarenitic sand suggesting a discontinuity in deposition; separated from underlying bed by a thin (6 inch) calcareous sandstone ledge:	5 feet (1.5 m)
Bed 6	Sand: calcareous with a discontinuous ledge or series of calcareous concretions in the middle and basal part of bed, some calcitic shell fragments, especially in the upper part of the bed; sand fine-to medium-grained and well sorted; separated from underlying bed by a calcareous sandstone ledge:	4-5 feet (1.2-1.5 m)
Bed 5	Sand: noncalcareous, slightly argillaceous; unconsolidated; medium-grained and moderately well sorted; massive and devoid of sedimentary structures. On the east side of the ravine, the sand that occurs in this stratigraphic position is that of typical weathered, poorly sorted sand of the Riggins Mill Member.	2 feet (0.6 m)

Covered interval on west side of ravine; on the east side of the ravine the Clinchfield Sand disconformably overlies:

OCONEE GROUP
GAILLARD FORMATION

Bed 4	Kaolin: silty to finely sandy, micaceous, some dark minerals; massive and structureless, blocky fracture; grades downward into:	21 feet (6.4 m)

Bed 3	Sand: slightly kaolinitic and micaceous; rudely and horizontally stratified; poorly sorted; abruptly overlies	2 feet (0.6 m)
Bed 2	Sand: kaolinitic, pebbly; very poorly sorted; generally trough cross bedded; abruptly overlies:	4 feet (1.2 m)
Bed 1	Sand: kaolinitic, somewhat micaceous, some scattered, thin kaolin lenses; sand medium- to medium/coarse grained; moderately to moderately poorly sorted; horizontal to lenticular to planar cross bedded on a small scale.	8+ feet (2.4+ m)
	Bottom of section.	
		123 feet (37.5 m)

STOP 3

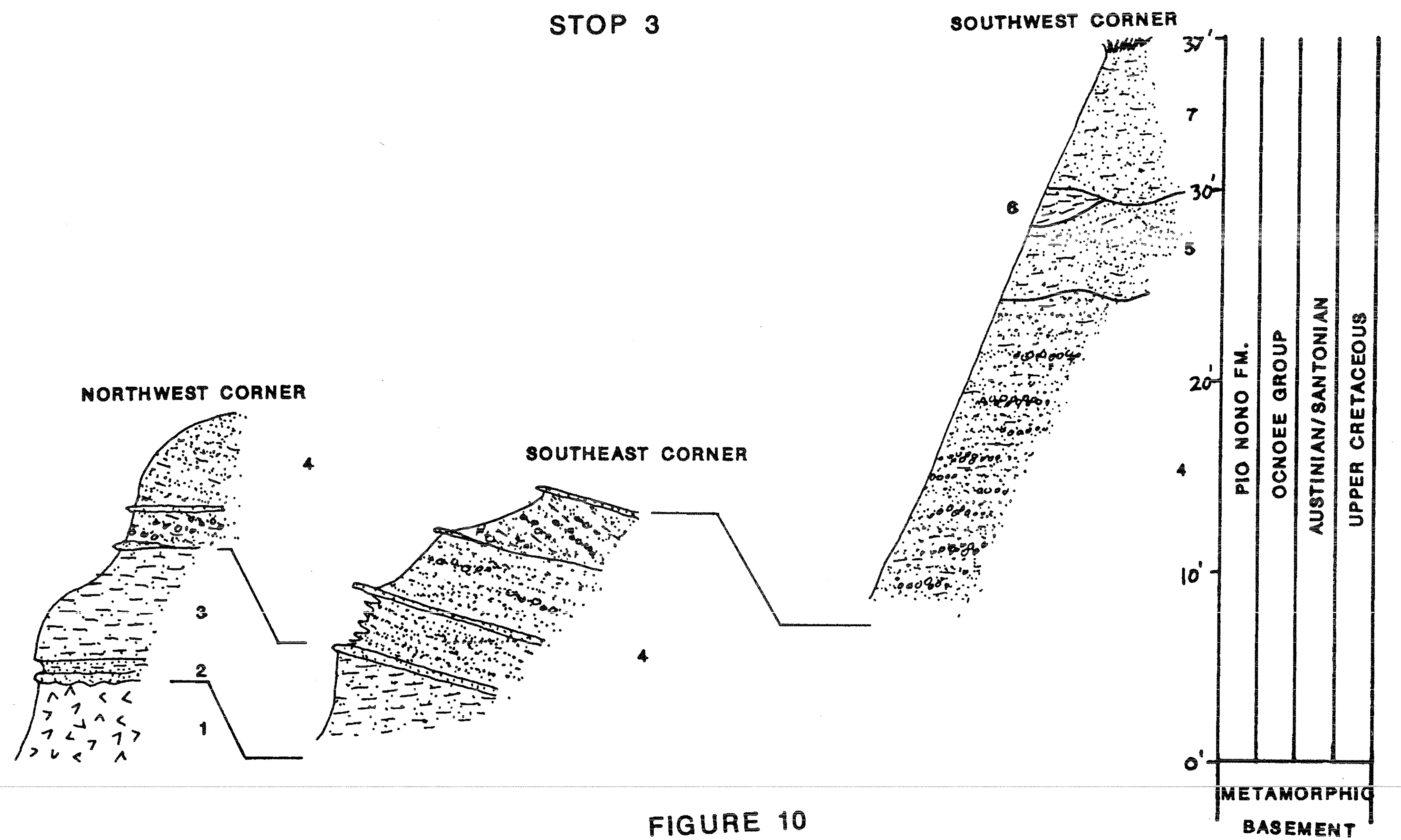

FIGURE 10

STOP 3

DESCRIPTION OF THE SECTION OF PIO NONO FORMATION EXPOSED ALONG US 341, 2.35 MILES (3.8 KM) NORTH OF THE JUNCTION OF US 80 AND US 341 IN ROBERTA, CRAWFORD COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
OCONEE GROUP **PIO NONO FORMATION**		
Bed 7	Residuum: sand, argillaceous; massive, structureless, no internal bedding structure evident; moderate reddish brown (10 R 4/6); grades downward into bed 6 or bed 5.	8.0 feet (2.4 m)
Bed 6	Kaolinitic sand lens: sandy; massive bedded and structureless; appears to consist of clay channel-fill; kaolin clasts at base and strung out from lens above bed 5; appears to overlie bed 5 abruptly; the lens is discontinuous along the length of the exposure.	0-2 feet (0-0.6 m)
Bed 5	Sand: somewhat kaolinitic, no apparent gravel stringers or pebbles: prominently trough cross bedded and undulatory bedded; poorly sorted, kaolinitic in proximity to overlying kaolin lens; appears to overlie bed 4 abruptly.	4 feet (1.2 m)
Bed 4	Sand: thin iron-cemented sandstone layers, some thin white clay stingers or partings, quartz gravel stringers; prominently and rudely stratified, stratification gently inclined to gently wavy to horizontal; thin to medium to irregularly bedded with stratification defined by concentrations of coarse, poorly sorted sand between layers of finer, less poorly sorted sand; sand very poorly sorted, coarse and granully to moderately poorly sorted and medium- to coarse-grained; quartz pebbles rounded to subangular; inclined thin ironstone bed occurs approximately 2 feet above base of bed, above the thin layer of ironstone the sand is consistently very coarse, pebbly and poorly sorted; very pale orange to very pale yellowish orange to dark yellowish	28 feet (8.5 m)

orange to moderate reddish orange (10 YR 8/2 - 8/6 - 6/6 - 10 R 6/6).

On the southeastern corner of the intersection bed 4 is more prominently cross-bedded with both trough and planar, cross bedding, discrete gravel beds are up to 3 inches (8 cm) thick, there are more ironstone beds up to 1.5 inches (4 cm) thick, and the stratification is more undulatory; Bed 4 abruptly overlies bed 3 and commonly contains a thin layer of iron-cemented sandstone at the base of the bed.

Along the face of the southwestern corner: Sand: granully and gravelly, gravel is rounded to angular, most is subangular to subrounded, up to 1.5 inches (4 cm) along major axis, mainly smokey quartz, probably minor interstitial kaolin is present; very poorly sorted; well stratified, thin- to medium-bedded generally discrete beds consist of laminae to thin beds, aggregates of laminae and thin beds produce inclined medium beds, lenses, and cross bed sets; cross bedding is lenticular, trough, and planar, some planar cross bed sets are confined to lenses; stratification defined by change in quartz particle size. The base of bed 4 is not exposed in the southwestern corner of the road cut.

Bed 3	On the northeast corner of the intersection: Sandstone, grading upward into sandy kaolin: contains angular pebbles of red quartz eroded from veins in the underlying Piedmont; indurated in lower part, massive in appearance except for lines of pebbles and vague stratification, prominently jointed in places; the kaolin in the upper part of the bed is finely sandy, massive, tough, and with irregular fracture, less weathered on the southeastern corner; yellowish gray (5 Y 8/1); grades abruptly into:	6 feet (1.8 m)
Bed 2	Sand; clayey, micaceous, upper part is more clayey, lower more sandy; sand is partially indurated; moderately poorly sorted; lower six inches is ledge forming, upper six inches is a reentrant; horizontal stratification, rudely bedded; weathered, pale yellowish orange to dark yellowish orange to grayish orange (10 YR 8/6 - 7/4 - 6/6); overlies with angular unconformity:	1 foot (0.3 m)

PIEDMONT,
RESIDUUM OF
BIOTITE GNEISS

Bed 1	Crystalline Piedmont metamorphic rocks: deeply weathered saprolite; beds close spaced, steeply inclined, strongly foliated; color grayish red purple (5 RP 6/2) to moderate reddish orange (10 R 6/6) to moderate reddish brown (10 R 4/6); base of bed is not exposed.	4.0 feet (1.2 m)
		51feet (16 m)

STOP 4

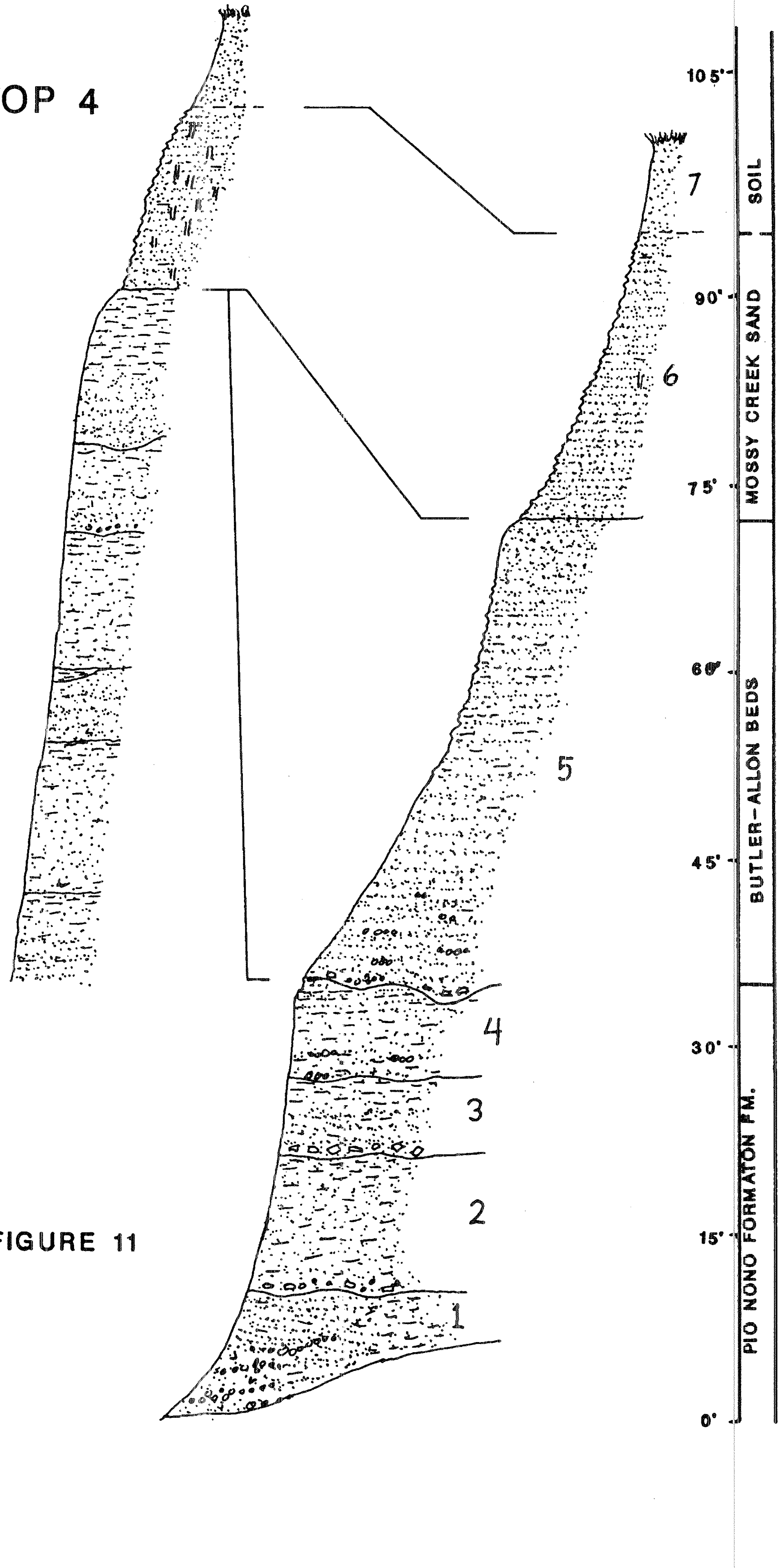

FIGURE 11

STOP 4

SECTION EXPOSED IN THE PIT OF THE BUTLER SAND COMPANY, ON THE WEST SIDE OF US 19, 2.4 AIRLINE MILES (3.9 KM) NORTH OF BUTLER, TAYLOR COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
FORT VALLEY GROUP MOSSY CREEK SAND		
Bed 7	Residual sand: moderately sorted, fine- to medium-grained; massive and structureless; loose and incoherent; yellowish gray (5 Y 8/1); probably partly of eolian origin: grades downward into:	5.0 feet (1.5 m)
Bed 6	Sand, slightly argillaceous; sand is fine- to medium-grained, moderately sorted and relatively clean, very soft and almost incoherent; stratified with slight interstitial clay concentrations along bedding planes that produce a characteristic "ledge" and reentrant alternation within the sand, stratification undulatory on small to moderate scales; burrows occur locally in profusion, some with compaction bands within burrows; yellowish gray (5 Y 8/1); disconformably overlies Pio Nono Formation in north face of pit and appears to conformably overlie the Butler-Allon channel deposits in south face of pit.	15 feet (4.6 m)
BUTLER-ALLON CHANNEL DEPOSITS		
BED 5	Sand: slightly argillaceous, with rounded to subangular plinthite or ironstone pebbles scattered in layers or in stringers (especially in lower part), some kaolin clasts in basal bed; sand is coarse-grained and poorly sorted in the lower part, fining upward irregularly into fine-grained, well sorted sand in upper part in south face of the pit; stratified, lower part with mainly trough cross bedding on moderate scales, undulatory bedding in middle to upper part, and "disrupted, chaotic" bedding near top of bed, minor interstitial clay with slight concentrations along some bedding planes producing more resistant layers up to a few cm thick (similar to the overlying Mossy Creek	0-37 feet (0-11 m)

Formation); sand is soft in lower part and more compact in upper part, almost incoherent in lower 6 feet (1.8 m); similar to Butler-Allon deposits at Gaillard but less argillaceous and less pigmented; abruptly and disconformably overlies:

OCONEE GROUP
PIO NONO FORMATION

Topographic relief on the top of the Pio Nono Formation is at least 50 feet (15 m) in the Butler sand pit. The upper part of the Pio Nono Formation is exposed only in the northern face of the sand pit. There it consists of a variable series of kaolinitic sand, fining upward sequences

Bed 4	Exposed in the south face of the sand pit.	
	Kaolin: sandy to silty, no pure kaolin, some thin beds of kaolinitic silt to silty fine sand, some thin stringers of kaolinitic pebbly sand in lower part; very indistinctly and rudely stratified, bedding mostly defined on change in sand-size and content; color of clay is bluish; base of bed not exposed.	8 feet (2.4 m)
Bed 3	Sand and clayey sand: fining upward sequence; sand is poorly sorted to moderately poorly sorted, medium- to coarse-grained, some gravel stringers in trough cross bed sets; rudely but prominently to indistinctly stratified, trough cross bedding of small to moderate scale amplitudes, some truncated planar cross bedding and undulatory bedding, a stringer of kaolin clasts at base of bed; highly pigmented with common liesegang banding; abruptly and with sharp contact overlies:	6 feet (1.8 m)
Bed 2	Sand and clayey sand: fining upward sequence; sand is poorly sorted, fine- to coarse-grained; more coarsely sandy in lower part with stringer of kaolin clasts along base of bed, more clayey or kaolinitic in upper part of bed; little stratification, mainly tough, massive and structureless; highly pigmented; abruptly and with sharp	11 feet (3.4 m)

	contact overlies:	
Bed 1	Clayey sand: top of fining upward sequence; clayey, moderately well sorted, fine- to medium-grained sand, slightly micaceous; massive and structureless; highly pigmented; base of bed not exposed;	>4.0 feet (>1.2 m)
	Grades laterally into channel deposit; Sand: kaolinitic, micaceous, with scattered small kaolin clasts; sand is poorly to very poorly sorted, coarse and pebbly with stringers of quartz pebbles; prominently trough cross bedded to undulatory bedded; bedding is defined primarily on variation in sand-size and amount of interstitial kaolin; not highly pigmented, yellowish gray (5 Y 8/1); strongly resembles lithology of higher energy facies of Gaillard Formation and Marion Member of the Huber Formation; base of bed not exposed.	>10 feet (>3 m)
		>92feet (>28 m)

STOP 5

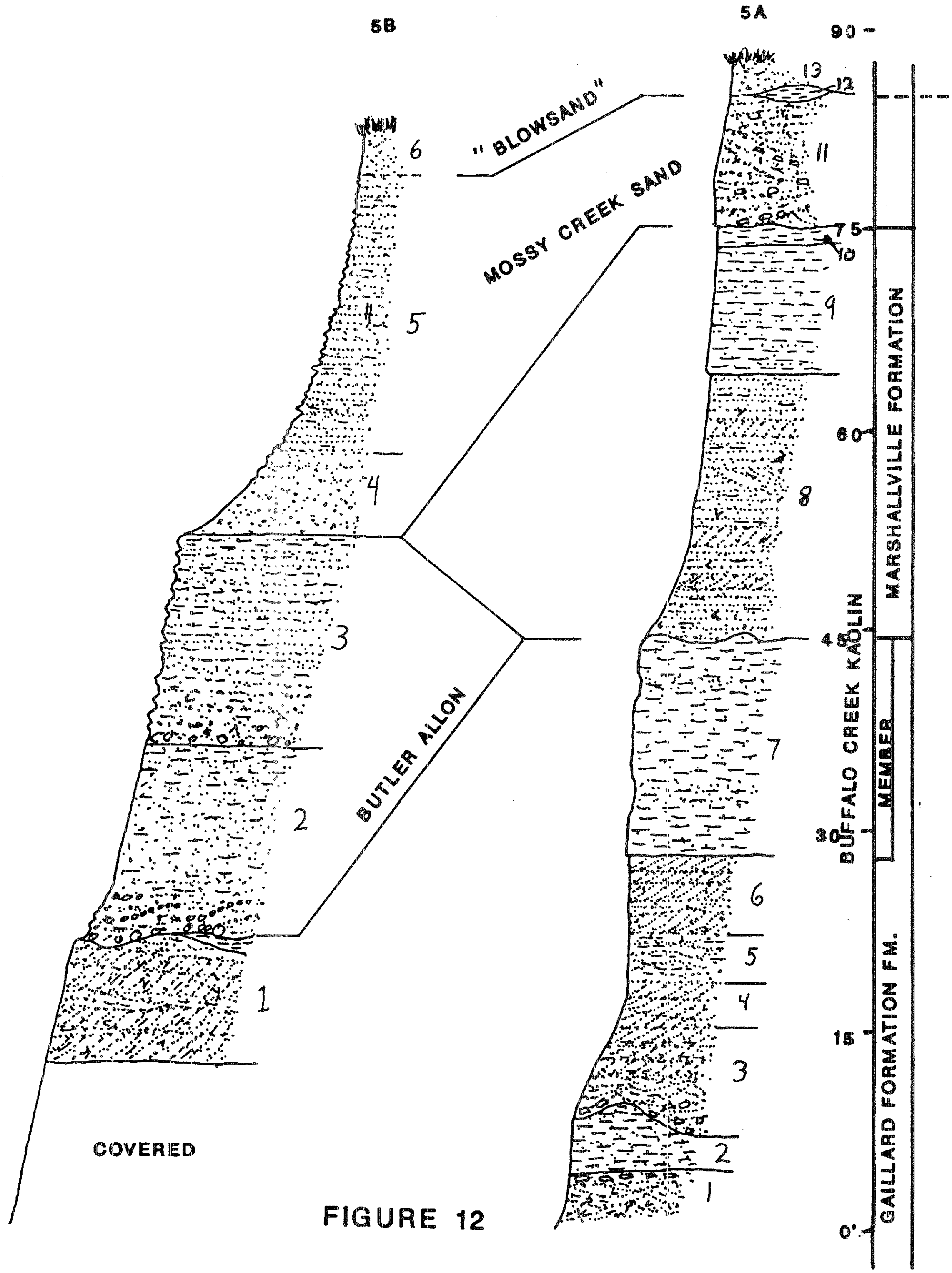

FIGURE 12

STOP 5a

SECTION EXPOSED IN THE WEST FACE OF THE SOUTH PIT OF THE ATLANTA SAND AND SUPPLY COMPANY AT GAILLARD, CRAWFORD COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
FORT VALLEY GROUP		
MOSSY CREEK SAND		
Bed 13	Sand residuum: coarse-grained, moderately poorly sorted; massive and structureless; deeply weathered, moderate reddish brown to dark reddish brown (10 R 4/6 - 3/4); abruptly but gradationally overlies both Beds 12 and 11.	2 feet (0.6 m)
Bed 12	Kaolin lens: sandy; massive and structureless; irregular fracture; deeply weathered, white (N 9); pinches out laterally within the outcrop; abruptly overlies:	0-2 feet (0-0.6 m)
Bed 11	Sand: kaolinitic with kaolin clasts and thin discontinuous layers and laminae; sand is variably moderate to very poorly sorted, coarse to very coarse grained; rudely and prominently stratified, steeply trough cross bedded, planar cross bedding within trough cross bed sets, small to large scale (>3 feet [1 m]) in amplitude, stratification generally defined by quartz sand size and sorting changes but also defined by stringers of kaolin clasts and thin kaolin layers or laminae; deeply weathered, sand is moderate reddish brown (10 R 4/6) and kaolin is grayish pink (5 R 8/2) to white (N 9); Bed 11 appears to be a tidal channel within the Mossy Creek Sand; disconformably overlies;	10 feet (3.0 m)
MARSHALLVILLE FORMATION		
Bed 10	Kaolin: Beds 5-7 constitute one fining upward sequence; finely micaceous, little apparent silt or sand, slightly carbonaceous?; massive and structureless; some horizontal pigmentation; waxy to	2.0 feet (0.6 m)

the touch; fracture is mainly irregular but in places is blocky to slightly conchoidal; top of Bed 10 has several inches (<15 cm) of relief; varying shades of gray; gradationally overlies:

Bed 9	Kaolin: silty and slightly micaceous along partings, scattered plant remains or prints along partings; stratified, laminated; blocky fracture; gray; abruptly but gradationally overlies:	6.0 feet (1.8 m)
Bed 8	Sand: little interstitial clay but most clay occurs as discontinuous kaolin laminae or partings, micaceous, some dark minerals; lower 3-4 feet (roughly 1 m) consists of very rudely and horizontally bedded, moderately to moderately poorly sorted, medium-grained sand with some quartz granules and scattered kaolin laminae. Above this the bed consists of micaceous, well sorted, fine- to medium-grained sand that is thinly and undulatory to parallel bedded with some fine scale trough and planar cross bedding; there is little interstitial clay but more kaolin laminae scattered throughout. The upper part of the Bed 8 consists of horizontally bedded, slightly kaolinitic, well sorted, fine- to very fine grained sand with dark minerals. Bed 8 is very light gray (N 8); disconformably overlies:	24 feet (7.3 m)

OCONEE GROUP
GAILLARD FORMATION
BUFFALO CREEK MEMBER

Bed 7	Kaolin: silty, some dark minerals, some scattered occurrences of thinly bedded fine-grained sand beds or lenses in the basal part, some scattered lenses or beds of more sandy kaolin, a carbonaceous lens with plant fragments along bedding planes occurs in the south face of the pit; generally massive and structureless except in carbonaceous lens where it is thinly bedded to laminated; fracture is blocky to subconchoidal to conchoidal, where the fracture is conchoidal, the conchoidal partings have a large radius; yellowish	16 feet (4.9 m)

gray (5 Y 8/1); abruptly and without apparent gradation overlies:

GAILLARD FORMATION UNDIFFERENTIATED

Bed 6	Sand: appears to constitute another fining upward sequence; slightly kaolinitic and micaceous; lower few feet consists of very poorly sorted, granully, coarse-grained sand with some rounded kaolin clasts and pea-size pebbles; fines upward into irregularly planar cross bedded, fine- to medium-grained sand; abruptly and with apparent discontinuity overlies:	6.0 feet (1.8 m)
Bed 5	Sand: continuous within underlying fining upward sequence; very little kaolin and mica; sand is moderately poorly sorted fine- to coarse-grained, generally finer than underlying bed, a few granules but no pebbles; one continuous set of steeply dipping, truncated, planar cross-beds; abruptly overlies:	4.0 feet (1.2 m)
Bed 4	Sand: continuous with underlying fining upward sequence; micaceous, variably kaolinitic; sand is very poorly to moderately sorted, coarse- to medium-grained; scale of stratification smaller than underlying Bed 3, predominantly trough to planar cross bedded, stratification defined on variation in clay content and sand size; grades downward rather abruptly into:	3.5 feet (1.1 m)
Bed 3	Sand: fining upward sequence; micaceous, variably kaolinitic, a few rare kaolin clasts, some fairly clean sand, a few rare kaolin kaolin clasts with scattered stringers of kaolin clasts on basal discontinuity; sand coarse, granully and pebbly, poorly to moderately poorly sorted; rudely lenticular bedded and trough and planar cross-bedded on varying scales, mostly on moderate scales; abruptly and with erosional discontinuity overlies:	7.5 feet (2.3 m)
Bed 2	Kaolin: silty with dark minerals present; massive and structureless; subconchoidal to blocky fracture; soapy to the touch; yellowish gray (5 Y 8/1); top of kaolin bed uneven with several feet (up to 1 m) relief on the upper surface;	3-5 feet (0.9-1.5 m)

	abruptly and with sharp contact overlies:	
Bed 1	Sand: fining upward; variably kaolinitic, micaceous, dark minerals present; sand coarse-grained, granully, and very poorly sorted in lower part to medium-grained and moderately poorly sorted in upper part; thin stringers of small kaolin clasts occur locally at the top of the bed; rudely stratified, trough cross bedded to lenticular-bedded; base of bed not exposed.	4.0 feet (1.2 m)
		89 feet (27 m)

STOP 5b

SECTION EXPOSED IN THE EAST FACE OF THE SOUTH PIT OF THE ATLANTA SAND AND SUPPLY COMPANY AT GAILLARD, CRAWFORD COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
FORT VALLEY GROUP MOSSY CREEK SAND		
Bed 7	Residual sand: soil, incoherent, massive and structureless, probably in part of eolian origin: pinkish gray (5 R 8/1); grades downward into:	3 feet (0.9 m)
Bed 6	Sand: slightly argillaceous in thin discontinuous laminae, some dark minerals; sand is very well sorted, medium-grained; undulatory to roughly horizontal bedded on a small scale, stratification is prominent and is defined by laminae of slightly argillaceous sand that stand out on a weathering surface as small resistent layers, the sand between the argillaceous laminae weather out like sugar sand, leaving an etched surface of the deposit, bedding is generally thin, from <1 cm to 2 cm, small scale lenses over a few feet (<1 m); burrows scattered throughout, some contain compaction structures within the burrows, burrows most abundant in lower part; off-white (N 8.5) where freshly exposed,	22 feet (6.7 m)

moderate reddish orange where weathered (10 R 6/6); grades downward into:

Bed 5	Sand: poorly exposed, essentially pure sand with no apparent secondary components of the lithology, slope former; well-sorted, medium- to medium/coarse-grained; stratification appears to be rudely and vaguely horizontal to broadly undulatory; very light gray (N 8); abruptly but with apparent conformity overlies:	5.0 feet (1.5 m)

BUTLER-ALLON CHANNEL DEPOSITS

Bed 4	Sand: clayey, variably micaceous, with scattered stringers of pebbles, pebbles consist mostly of rounded to subangular plinthite or ironstone, few quartz pebbles or granules; quartz sand is fine to coarse-grained, variably poorly sorted, all sand layers contain interstitial clay; sediment is generally tough and resistant; stratified, stratification ranges from horizontal to undulatory with some trough cross bedding and some small scale planar cross bedding, strata are medium- to thin-bedded, from a few feet thick to a few inches thick; Bed 4 is generally coarser in lower part but does not appear to be a fining upward unit; in contrast to the underlying Gaillard Formation and overlying Mossy Creek Sand, Bed 4 is moderately pigmented, mottled pale greenish gray and pale maroon; Bed 4 has the appearance of colluvium; abruptly but conformably overlies:	16 feet (4.9 m)
Bed 3	Sand: clayey, variably micaceous, with stringers of rounded to subangular plinthite and ironstone pebbles and clasts in lower part; Bed 3 appears to be a fining upward sequence, quartz sand in lower part is coarse-grained and poorly sorted whereas sand in upper part is fine and moderately sorted, top of bed is a sandy kaolin; prominently stratified, lower part is trough cross bedded with some planar cross bedding, upper part is medium-to thick-bedded and very rudely bedded; Bed 3 is less pigmented than Bed 4 but still is characteristically pale greenish and pale maroonish; disconformably overlies:	9-17 feet (3-5 m)

OCONEE GROUP
GAILLARD FORMATION

There is at least 8 feet (2 m) of relief on the top of the Gaillard Formation at this site.

Bed 2	Sand: micaceous, variably kaolinitic, some fairly clean sand; sand is very poorly sorted to moderately sorted, coarse- to medium-grained, some scattered granules and pebbles; prominently stratified, most stratification consisting of truncated planar cross bedding, most planar cross bed sets are medium but some thin cross bed sets also occur, stratification defined on variation in clay content and sand size; yellowish gray (5 Y 8/1); the lower part of the section is covered by:	11 feet (3.4 m)

SAND PIT COLLUVIUM

Bed 1	Sand pit colluvium:	12 feet (3.7 m)
		93 feet (28 m)

STOP 6

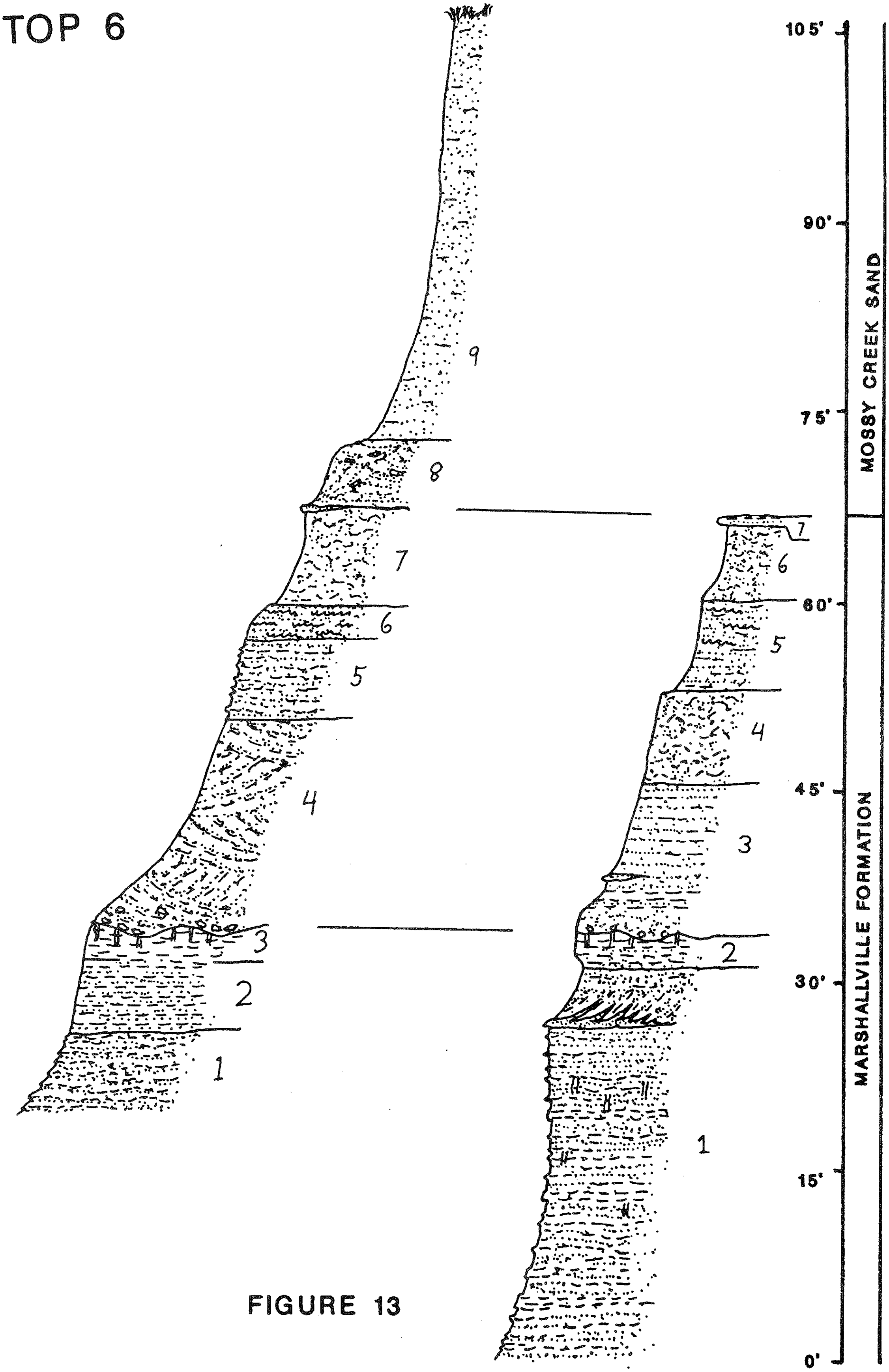

FIGURE 13

STOP 6a

LITHOLOGIC DESCRIPTIONS OF THE MARSHALLVILLE FORMATION AND MOSSY CREEK SAND EXPOSED IN THE BLUFF OVERLOOKING THE FLINT RIVER VALLEY, APPROXIMATELY 3.2 AIRLINE MILES (5.1 KM) WEST-NORTHWEST OF MARSHALLVILLE, MACON COUNTY, GEORGIA

(Section 1, bluff beneath roadcut)

Lithostratigraphic unit and bed number	Description	Thickness
FORT VALLEY GROUP: MOSSY CREEK SAND		
BED 9	Residuum: argillaceous, medium- to coarse-grained; poorly sorted sand; tough, resistant to erosion; massive, structureless; color moderate reddish brown (10 R 4/6), grades downward into:	32 feet (9.8 m)
BED 8	Sand: deeply weathered, discontinuous streaks or laminae of white clay and bean-sized white kaolin clasts; trough cross-bedded and rudely bedded; poorly sorted, pebbly and very coarse-grained, the basal few inches (5-6 cm) of Bed 7 is commonly cemented with iron oxide; moderate reddish brown (10 R 4/6); disconformably overlies:	6 feet (1.8 m)
MARSHALLVILLE FORMATION		
BED 7	Sand: argillaceous, fine-grained, well sorted; contains numerous, discontinuous, irregular, disrupted and, in some instances, bioturbated clay laminae; a few small burrows were noted, most of which are horizontal; compaction was found in several of the vertical burrows; at the top of this bed is several inches (several cm) of gray to reddish brown, clayey fine sand that was probably concentrated there by soil processes; grades downward into:	8.0 feet (2.4 m)
Bed 6	Silt: argillaceous, thinly bedded; grades downward into:	3.0 feet (0.9 m)
Bed 5	Sand with clay layers: thinly layered, wavy and undulatory bedded but apparently continuous; sand is fine-grained and well-sorted, white to pale yellow to dusky red;	8.0 feet (2.7 m)

	clay layers range from laminae a few millimeters to thin beds up to several inches (several cm) thick: grades downward into:	
Bed 4	Sand: feldspathic, discontinuous clay laminae, more clay laminae and thin layers (up to 2 mm) in upper half of bed, at the top of the bed is a continuous 1 inch (2.5 cm) thick layer of interlaminated very fine sand and clay; The quartz sand component is coarse-grained, extremely poorly sorted, and is low in mica and dark minerals; The bedding in the lower part is characterized by large-scale trough cross bedding but elsewhere thick and massive to thinly bedded and bedding can differentiated only by change in grain-size or by the presence of the discontinuous clay laminae; The color of the basal three to feet of the bed is pale yellow to dusky red. These colors grade upward to an N8 (pale gray) for both sand and clay; overlies with erosional discontinuity:	11 feet (3.4 m)
Bed 3	Clay: massive and structureless, finely sandy kaolin that is speckled dusky red; The top of the clay bed is irregular with a relief of up to 2 feet; grades downward into:	2 feet (0.6 m)
Bed 2	Clay: finely sandy to silty clay to clayey silt: silt and fine grained sand is concentrated in laminae to very thin layers; grades downward into:	5.0 feet (1.5 m)
Bed 1	Sand and clay: fine-grained and well sorted, stratified, with scattered discontinuous laminae of clay; contains abundant small flecks or spots of iron and manganese oxide; unweathered sand is very pale greenish gray.	6.0 feet (1.8 m)
		81 feet (25 m)

STOP 6b

(Section 2, in ravine at south end of bluff)

MARSHALLVILLE FORMATION

Bed 7	Sandstone: poorly sorted, argillaceous, thinly layered; deeply weathered; abruptly overlies:	1.0 foot (0.3 m)
Bed 6	Sand: argillaceous, bioturbated, poorly sorted, fine- to coarse-grained, weathered; abruptly overlies:	6.5 feet (2.0 m)
Bed 5	Clayey, silty fine sand to silty clay: fining upward from fine- to medium-grained sand. upper part prominently laminated and lenticular bedded, lower part more obscurely bedded; gradationally overlies:	7.0 feet (2.1 m)
Bed 4	Sand with thin clay beds: sand is massive, bioturbated, and very poorly sorted; the basal 1/2 inches an interlaminated clay and sand; Clay layers within Bed 4 are as much as 1 inch thick, the clay beds are laminated and contain thin lenses and partings of fine- to very fined grained sand producing gently undulating patterns within the clay inter-layers; overlies with a sharp contact:	8.0 feet (2.4 m)
Bed 3	Sand with thin clay beds: basal 1 foot of bed consists of massive and structureless, poorly sorted, coarse-grained sand with small pebbles up to 3 mm in diameter; the basal sand grades abruptly upward into very thinly layered (up to 1 inch [2.5 cm] thick), undulating, moderately sorted, medium-grained sand containing white clay partings and flasers. These thin beds are generally continuous across the 6 feet (1.8 m) of local exposure; The thin sand layers grade upward into a more massive, prominently stratified and cross-bedded sand. The upper part of Bed 3 is thinly bedded. A six inch (15 cm) thick layer of clay occurs several inches (>5 cm) from the top of Bed 3; abruptly and with discontinuity overlies:	11 feet (3.4 m)
Bed 2	Clay: dense and somewhat fissile with silt and fine-grained sand along the partings, in places the layers within the clay consist of welded, rounded clay clasts; the upper	3.0 feet (0.9 m)

surface of the clay bed is irregular and there is some relief on it, the top of the Bed 2 is burrowed and contains clay clasts in places, the burrows are filled with sand from the overlying Bed 3; color of clay is light gray to yellow, to dusky red; grades downward into:

Bed 1	Sand: predominantly a well-sorted, medium-grained sand with thin lenses (up to a few inches [>5 cm] thick) of coarser and more poorly sorted sand; the bedding in the sand is horizontal to undulatory to gently sweeping cross bedding, some of the cross-beds resemble large-scale, herring-bone cross bedding; one prominent zone of cross-bedded sand is cemented with iron oxide producing a dusky red to black colored cross-bedded sandstone ledge, this cross-bedded sandstone appears to be an extension to zones or layers of dusky red, thin-bedded, well sorted, fine-grained sand, in places the sand overlying the cross-bedded sandstone consists of prominently truncated, planar cross bedded sand with amplitudes of 6 to 12 inches (15-30 mm); the upper 11 feet (3.4 m) of the bed contains scattered burrows that range in diameter from 2 to 6 mm, no bioturbation was observed; Clay is present as intraclasts and as laminae and thin layers that range up to 6 inches (15 cm) in thickness; the clay layers are present as short stringers, the lengths of which appear to be directly proportional to the thickness of the clay layer; The color of the unweathered sediment is pale yellow to very light gray to white.	>31 feet (>9.5 m)
		67.5 feet (20.6m)

STOP 7 (AUXILLIARY STOP)

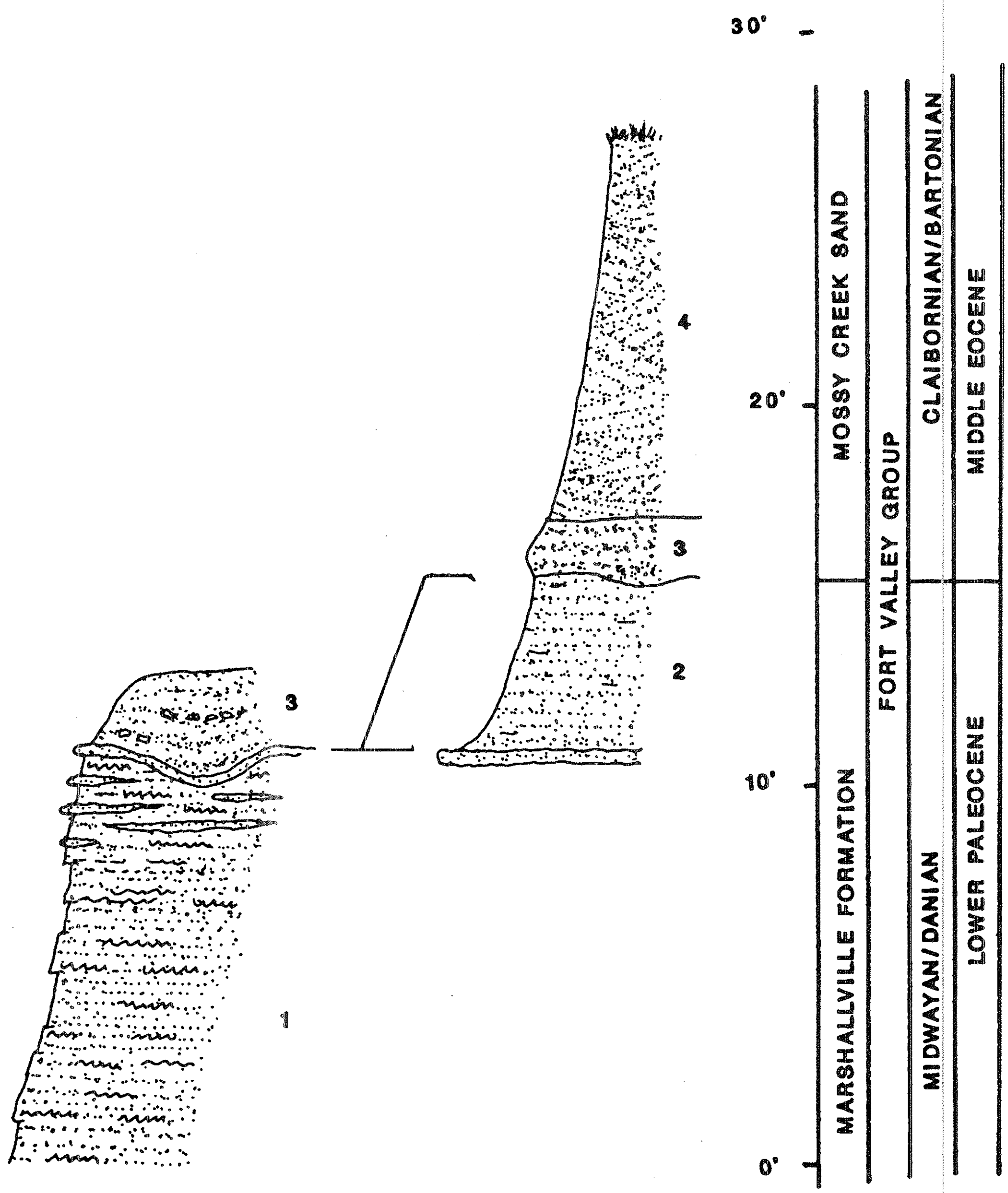

FIGURE 14

STOP 7 (Optional)

LITHOLOGIC DESCRIPTION OF THE EXPOSURE IN THE SAND PIT IN THE SOUTHERN VALLEY WALL OF BRYANTS SWAMP CREEK, ADJACENT TO A PAVED COUNTY ROAD, APPROXIMATELY 2.5 AIRLINE MILES (4 KM) NORTH OF MARSHALLVILLE, MACON COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
FORT VALLEY GROUP MOSSY CREEK SAND		
Bed 4	Sand: well-sorted, medium-grained sand; soft and unconsolidated with well-defined, small-scale trough cross bedded sand; pale yellow; gradationally overlies:	10 feet (3 m)
Bed 3	Sand: poorly sorted, predominantly medium-grained sand with pea gravel; vaguely and rudely stratified; in the eastern wall of the pit; Beds 3 and 4 dip conspicuously to the north; abruptly and, apparently, disconformably overlies:	1.5 feet (0.5 m)
MARSHALLVILLE FORMATION		
Bed 2	Sand: soft, well-sorted, fine-grained; thinly and variably cross-bedded to undulatory bedded, clay laminae and partings define bedding planes; clay laminae are light blue to pale yellow, sand is pale yellow; in the eastern wall of the pit, abruptly overlies Bed 1.	5.0 feet (1.5 m)
		16.5 feet (5.0 m)

Exposed in ravine draining the northwestern part of the sand pit, Bed 2 not present

MOSSY CREEK SAND		
Bed 3	Sand: pebbly with small kaolin clasts; poorly sorted, coarse-grained; rudely stratified; tough and case-hardened; abruptly and disconformably overlies Bed	3.0 feet (0.9 m)

1 on which there is topographic relief of up to 1.5 feet (0.5 m):

MARSHALLVILLE FORMATION

Bed 1	Silty clay to argillaceous silt: thin layers or lenses (up to inch [2.5 cm] in thickness) of ironstone-cemented siltstone or very fine grained sandstone in the upper 3 feet (0.9 m), these thin layers range from a few inches (>5 cm) in length to 10 feet (3.0 m) in length; sediments thinly layered to laminated, fissile, and horizontal-bedded with very finely micaceous silt along partings; in fresh exposures it appears massive; the upper 1.5 feet (0.5 m) of Bed 1 is less argillaceous than the underlying sediments and consists of argillaceous, fine-grained sand; color when fresh is dark olive gray where more clayey and moderate olive gray in silty laminae, the weathered sediment is light gray to yellowish gray with scattered brown to reddish brown iron oxide markings parallel to the stratification in the upper part and with considerable dusky red staining or mottling in the lower part; the base of the bed is not exposed.	13 feet (4.0 m)
		16 feet (4.9 m)

STOP 8

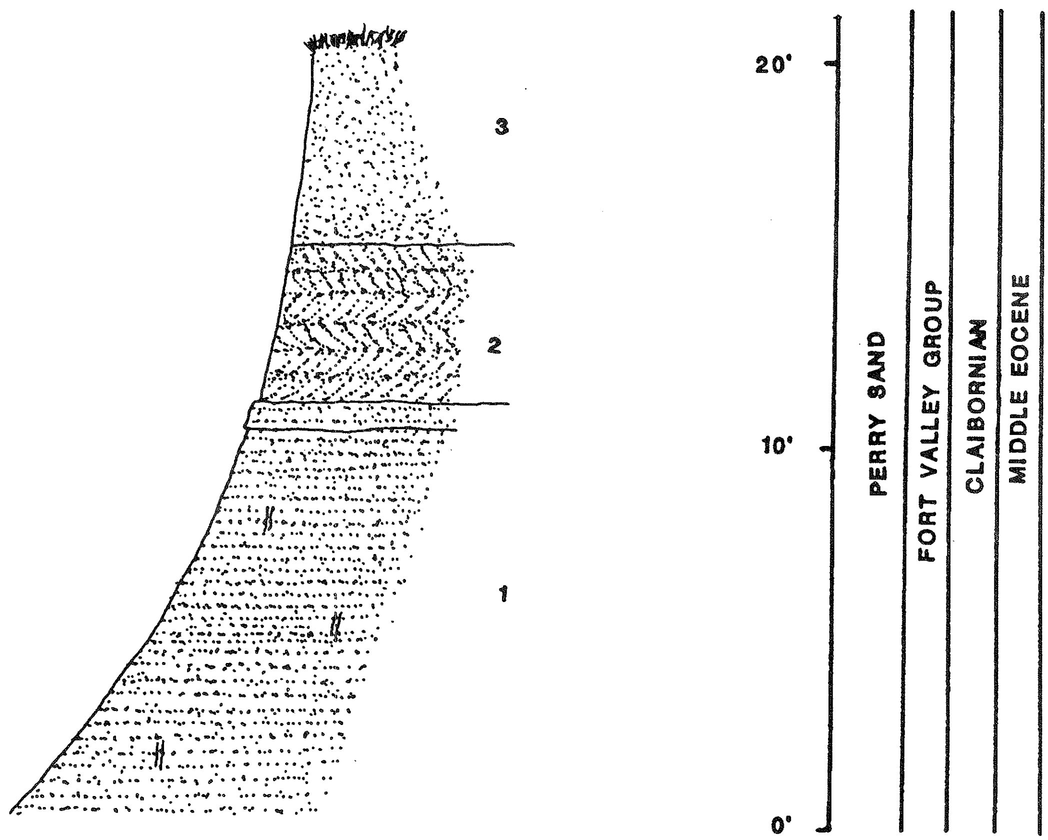

FIGURE 15

STOP 8

SECTION OF PERRY SAND EXPOSED IN A SAND PIT, 4.0 AIRLINE MILES (6 KM) SOUTHWEST OF MARSHALLVILLE, MACON COUNTY, GEORGIA

lithostratigraphic unit and bed number	Description	Thickness
FORT VALLEY GROUP		
PERRY SAND		
Bed 3	Sand residuum: appears slightly argillaceous; sand is well-sorted, fine to fine-medium grained soft, slightly coherent; massive and structureless; moderate reddish brown (10 R 4/6); grades downward over several feet (<1 m) into Bed 2 through becoming less weathered.	5.0 feet (1.5 m)
Bed 2	Sand: soft, incoherent, moderately well sorted, medium-grained; cross-bedded, some herring-bone, some planar, truncated and some small scale trough cross bedding; beds generally thin to laminar, producing thin to medium bedding sets; scattered burrows; more color stain with ocherous colors; grades abruptly into:	3.0 feet (0.9 m)
Bed 1	Sand: almost pure quartz,a trace of dark minerals, perhaps a trace of clay that defines bedding planes; sand is very well sorted, very fine grained; soft, incoherent, erodes readily but is also readily case-hardened; very thinly bedded to laminar, stratification is extremely horizontal but laminae and thin layers are discontinuous; scattered medium-sized burrows; in general the sediment is so fine-grained and well sorted that it resembles loess; A more argillaceous, stratified bed about 4-5 inches (10-13 cm) thick occurs at top of bed, each layer is about 1-2 inches (2.5-5 cm) thick, the sand in this bed is more variable, medium-grained to fine-grained, and moderately to well-sorted; bottom of the bed is not exposed; relatively unweathered sand is grayish pink (5 R 8/2), weathered sand is moderate reddish brown (10 R 4/6).	>11 feet (>3.4 m)
		>19 feet (>5.8 m)

STOP 9

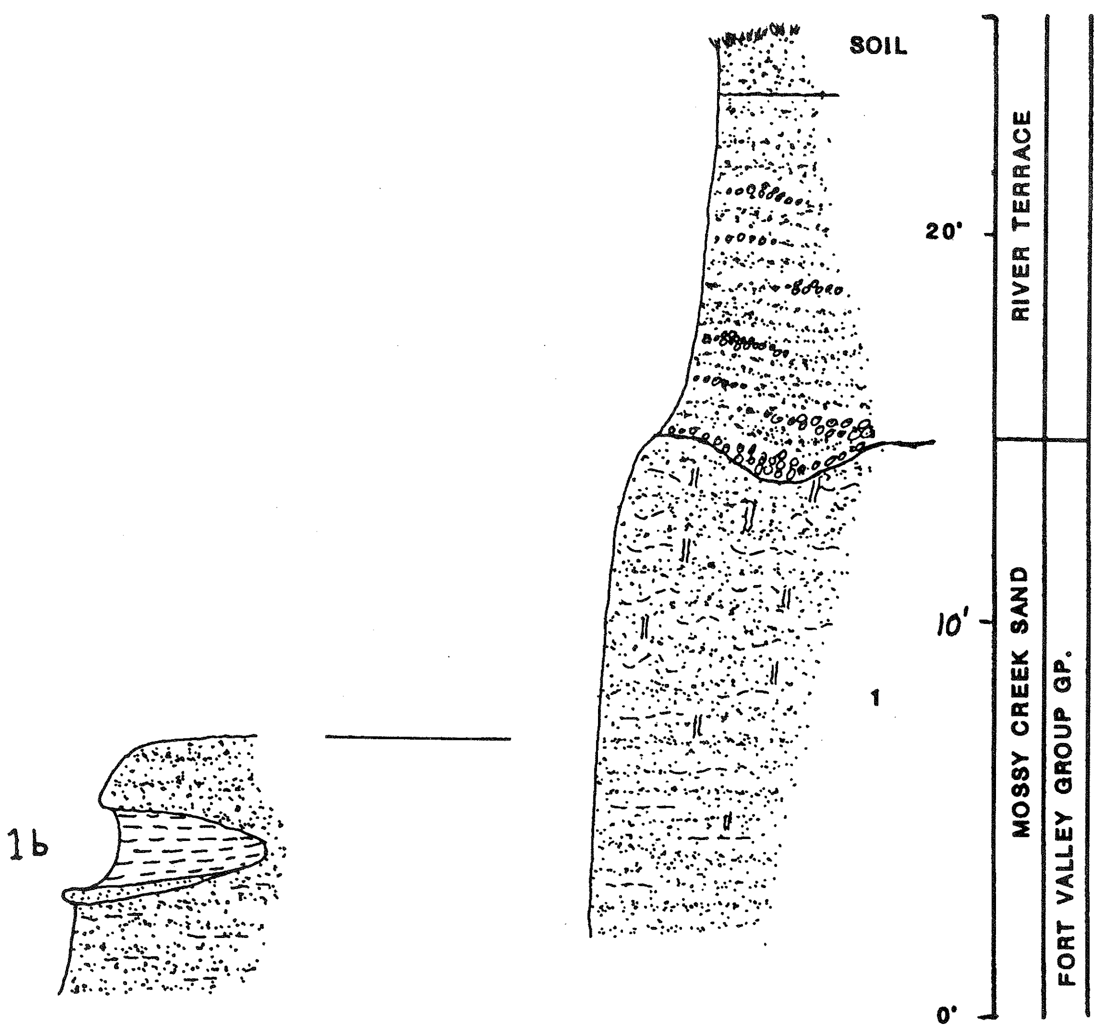

FIGURE 16

STOP 9

LITHOLOGIC DESCRIPTION OF THE MOSSY CREEK SAND AT THE TYPE SECTION ON TAYLORS MILL ROAD, 3.8 MILES (6.1 KM) NORTH-NORTHEAST OF FORT VALLEY, PEACH COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
PLEISTOCENE FLUVIAL DEPOSITS		
Bed 3	Sand: gravelly, probably slightly argillaceous, very poorly sorted, granully, coarse-grained sand with gravel stringers, the bulk of the sediment is pea gravel and coarse-grained sand; pebbles in the gravel up to 3 inches (8 cm) in longest dimension, gravel angular to rounded, some of the gravel stringers are up to 1 foot (0.3 m) in thickness; the upper part of the bed is very deeply weathered but rude stratification is evident to the top of the section; color moderate reddish brown (10 R 4/6); the basal contact is sharp and irregular with a relief of at least 1 foot (0.3 m) observed in the exposure,a gravel bed of variable thickness occurs at the base of the bed across the outcrop; disconformably overlies:	10 feet (3.0 m)
MOSSY CREEK SAND		
Bed 2	Sand: minor clay and mica, highly borrowed; the quartz sand component is moderately sorted and medium- to fine grained; the bed is resistent and tough; bedding tends to be thin but the burrows have disrupted much of the original stratification; the burrows are of mixed diameters with the largest having diameters of roughly 0.75 inch (2 cm) and the smallest being roughly 2 mm, the configuration of most of the burrows range from vertical (90°) to 45°, the borrows are high-lighted by concentrations of kaolin in and near the borrow walls; color of sand is moderate reddish brown (10 R 4/6), color of burrows is light gray (N 8); grades broadly downward into:	6.0 feet (1.8 m)
Bed 1	Sand: scattered clay clasts and scattered burrows; quartz sand moderately sorted, medium- to fine-grained; fewer burrows and	7 feet (2 m)

better stratification than overlying Bed 2, scattered concentrations of small, vertically oriented burrows (approximately 2 mm in diameter); horizontal to undulatory bedded, thinly and rudely stratified, bedding is marked by abundances of clay clasts and by differences in quartz grain size, scattered and indistinct cross bedding is also present; beneath the case-hardened surface, the sand is soft and only slightly coherent; the base of the bed is not exposed.

In the opposite side of the sand pit, approximately 150 feet (46 m) southwest of the above section exposed in the northeastern wall of the pit, there is an additional shallow exposure that occurs at approximately the same elevation as the base of the section in the northeastern wall. In this exposure there is a thinly layered, sandy clay lens that is badly weathered. A crust of limonite cemented sand approximately 0.5 inch (1.2 cm) thick occurs at the base of the clay. In places, 1.5 feet (0.5 m) of incoherent, moderately well sorted, medium- to coarse-grained sand underlies the clay lens. The clay lens is overlain by deeply weathered, vaguely stratified, case-hardened, poorly sorted, coarse-grained sand that appears to be Bed 1 that is exposed in the northeastern wall of the pit.

23 feet
(7.0 m)

STOP 10

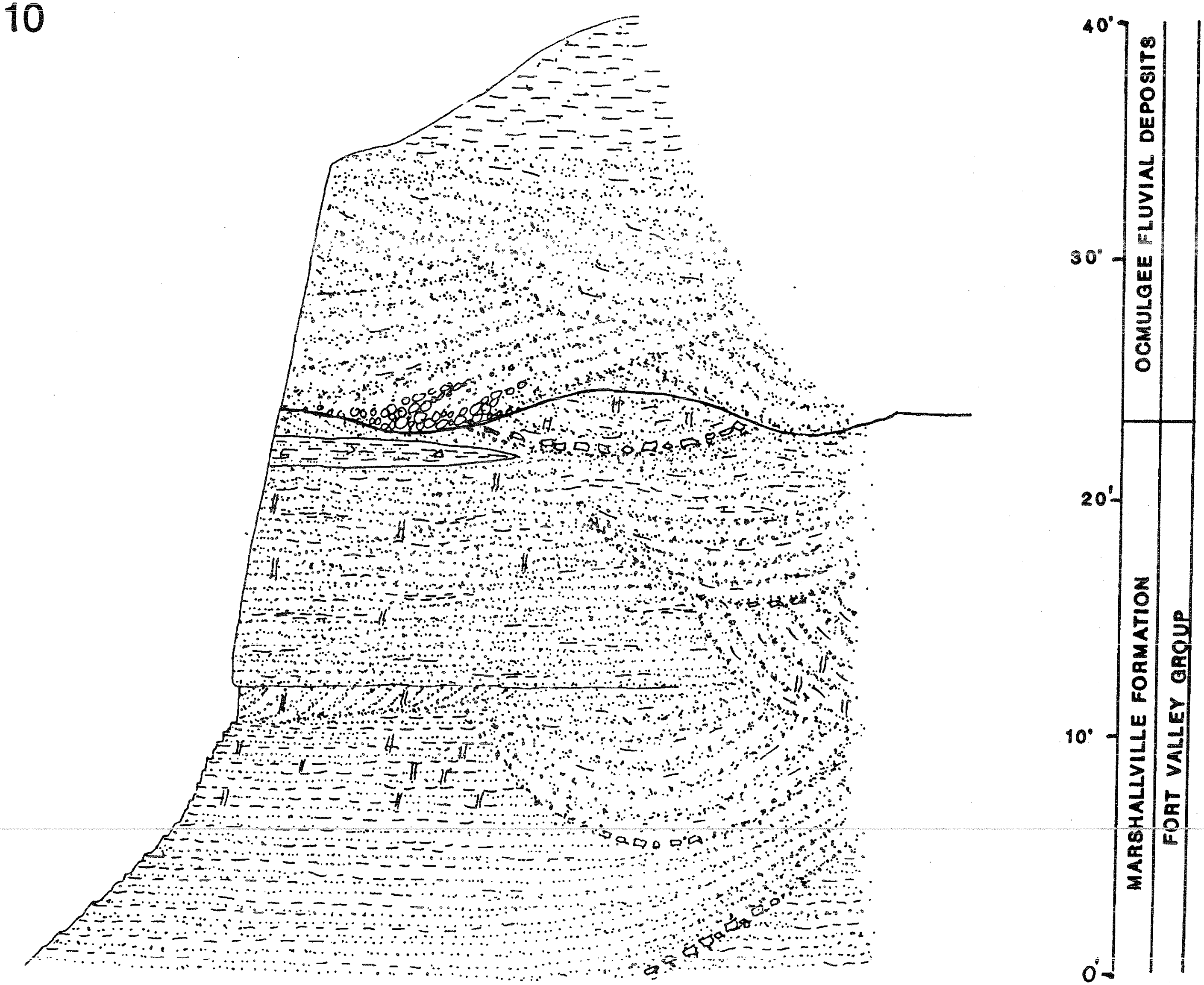

FIGURE 17

STOP 10

SECTION EXPOSED IN AN ABANDONED SAND PIT 0.2 MILE (0.3 KM) SOUTH OF THE JUNCTION OF DUNBAR ROAD AND US 129 IN ELBERTA, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
PLEISTOCENE FLUVIAL DEPOSITS OF THE OCMULGEE RIVER		
Bed 6	Clay residuum: sandy; massive and structureless; deeply weathered, mottled gray, dusky red, and moderate reddish brown (10 R 4/6); grades downward abruptly into:	5.0 feet (1.5 m)
Bed 5	Sand: pebbly and gravelly with some clasts of underlying clay above base of bed; sand is very poorly sorted, coarse-grained, granully and pebbly in lower part; gravel stringers occur in lower several feet and are up to 1.5 feet (0.5 m) thick; pebbles consist of vein quartz and range up to 3.5 inches (8.9 cm) along greatest dimension, pebbles are subrounded to angular; prominently stratified, bedding consists of large scale trough cross bedding in lower part and undulatory bedding in upper part; weathered, moderate reddish brown (10 R 4/6); disconformably overlies:	12 feet 3.7 m)
FORT VALLEY GROUP MARSHALLVILLE FORMATION		
Bed 4	Sand: slightly argillaceous; sand is coarse-grained and poorly sorted, a stringer of clay clasts occurs at the base of the bed in places; prominently stratified and broadly trough cross bedded; **Ophiomorpha nodosa** present in scattered concentrations; the top of the bed has relief of roughly 3 feet (1 m), the base of the bed is also irregular but the relief on the base of the bed appears to be no more than 1 or 2 feet (0.3-0.6 m); Bed 4 appears to be discontinuous in outcrop because of the topographic relief on the top of the formation; moderate reddish brown	0-3 feet (0-1 m)

(10 R 4/6); abruptly overlies:

Bed 3	Sand: argillaceous, micaceous, thin discontinuous clay stringers and laminae, contains at least one discontinuous bed of finely sandy, thinly bedded to laminated gray kaolin; sand is well-sorted, very fine grained to silt size; thinly bedded to laminated, bedding horizontal and parallel; unconsolidated but firm; scattered **Ophiomorpha nodosa** burrows; yellowish gray (5 Y 8/1) to very light gray (N 8); abruptly overlies both beds 1 and 2 and is cut out locally by Bed 2 channel deposits at northern end of cut:	10 feet (3 m)
Bed 2	Bed cut consists of an overlapping series of small channel cut-and-fill sand deposits: sand coarse, poorly sorted, variable in grain-size, common clay clasts up to several inches (8 cm) in major diameter; stratification very prominent and consists of trough cross bedding on varying scales, kaolin clasts strung out along bedding planes, especially at bases of channels; channel sets strongly discordant; some scattered small burrows (<2 mm) in upper channels; channels occur to base of section and appear to cut out Bed 3 and most of Bed 1:	(20 feet) (6.1 m)
Bed 1	Sand: bed tends to fine upward somewhat; some discontinuous clay beds less than 1.0 inch (2.5 cm) thick to clay laminae, some micaceous; sand poorly sorted, medium- to coarse-grained with some coarse granules and pea gravel; most stratification horizontal to gently undulatory bedded, Some low angle, thin bedded trough cross bedding and planar cross bedding, most bedding differentiated on grain-size changes, more clay laminae and streaks in upper part, a few coarse, granully layers or lenses; **Ophiomorpha nodosa** and other burrows scattered or in minor concentrations throughout the bed; yellowish gray (5 Y 8/1) to light gray (N 8) where unweathered: Bed 1 occurs at the base of the section.	12 feet (3.5 m)
		40 feet (12 m)

STOP 11

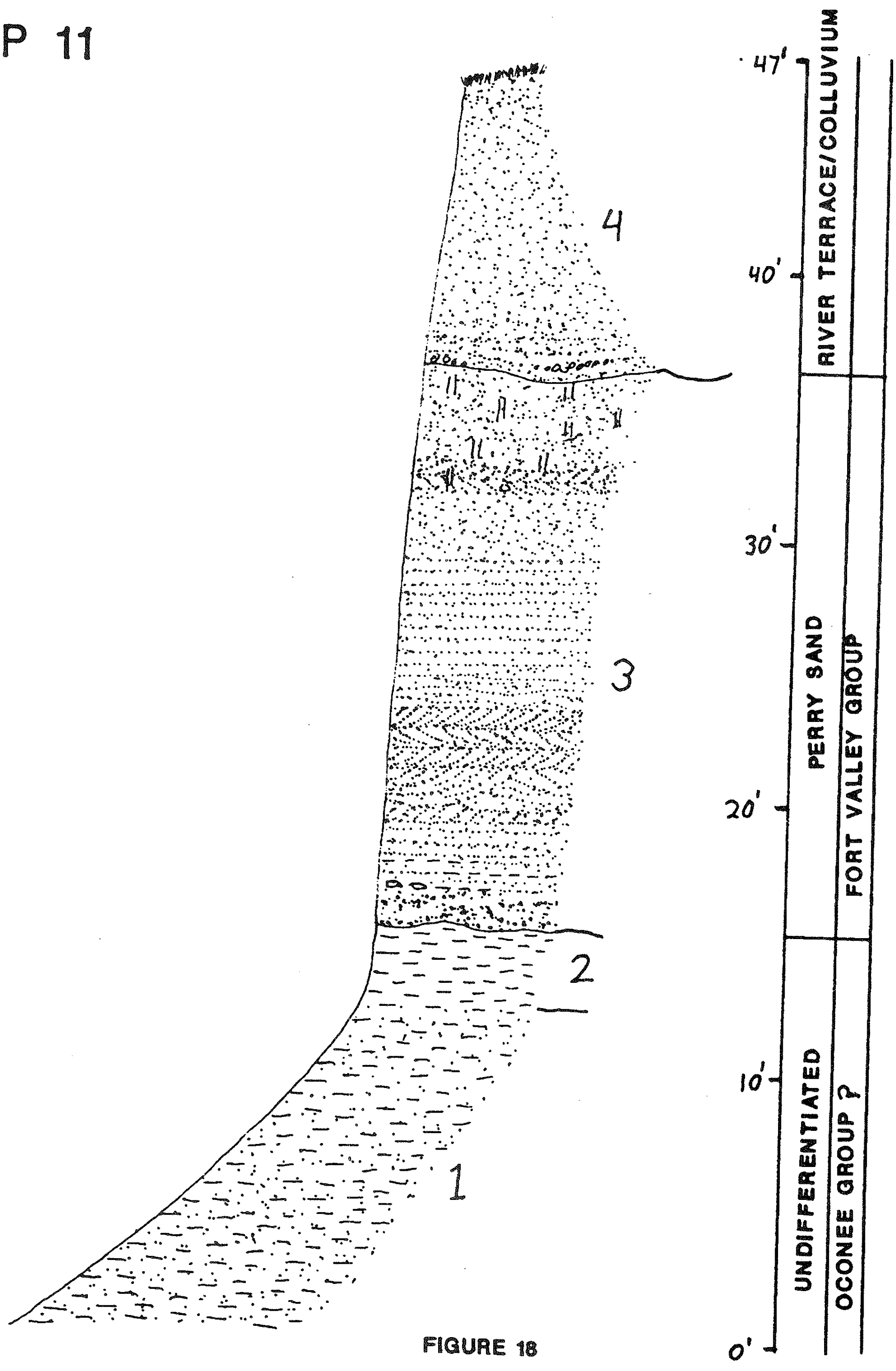

FIGURE 18

STOP 11

DESCRIPTION OF THE TYPE LOCALITY OF THE PERRY SAND ON VALLEY DRIVE, I.5 MILES (2.4 KM) SOUTHWEST OF THE INTERCHANGE OF I-75 AND US 341 AT PERRY

Lithostratigraphic unit and bed number	Description	Thickness
PLEISTOCENE FLUVIAL DEPOSITS		
Bed 3	Sand: gravel stringers at base; quartz sand is very poorly sorted in lower part but moderately to well-sorted in upper part, sand coarse-grained in lower part but moderately to well-sorted in upper part, pebbles up to roughly 1 inch (2.5 cm) in diameter, both rounded to angular and more commonly pea gravel in size; massive-bedded and structureless above the basal few feet (<1 m); color moderate reddish brown (10 R 4/6); disconformably overlies:	8.0 feet (2.4 m)
PERRY SAND		
Bed 2	Sand: minor interstitial clay and thin beds or lenses of white clay (<1 inch [2.5 cm]) in lower part, scattered burrows. The upper 3-4 feet (0.9-1.2 m) of the bed consists of clean, well-sorted, fine-grained sand; massive bedded and heavily burrowed, compaction structures are present in some of the burrows. The underlying sediment consists of well-sorted, medium-grained sand with some small white clay clasts and/or burrows; bedding is sharply defined and finely trough cross-bedded in various directions. Within the upper half of the bed a lens of well-sorted, coarse-grained sand 3.5 - 4.0 feet thick is present that appears to pinch out laterally at either end of the exposure. Eight feet below the top of Bed 2 the Perry Sand consists of well-sorted, very fine grained sand; mainly horizontal- to	11 feet (3.4 m)

undulatory-bedded and cross-bedding is less apparent; this sand is somewhat massive and has a sharp but gradational contact with the overlying strongly cross-bedded sand; the sand contains a few burrows and small amounts of clay is present as clasts and thin, discontinuous laminae or partings.

At places between the above very fine grained sand and the base of the Perry Sand there are thin beds or zones of well-sorted,medium-grained sand; in the lower half of the Perry Sand section there is one 2 feet thick zone of herringbone, cross-bedded sand.

The basal 4-5 feet (1.2-1.5 m) of the Perry Sand consists of broadly trough cross bedded, well-sorted, fine- to medium-grained sand with a small proportion of truncated, planar cross-bedded sand; two feet above the base of the Perry Sand there are thin beds (<1 inch [2.5 cm]) of what clay present, some of which have been partially eroded penecontemporaneously to leave tabular clasts spread out on bedding planes; no burrows were observed in this basal part of the Perry Sand; the color of this interval is bright orange with some black manganese oxide staining of the quartz grains; overlies with an abrupt, uneven, (with 3-4 inches [8-10 cm] of relief), disconformably overlies:

undifferentiated
Oconee Group

Bed 1	Kaolin to kaolinitic sand: the top of the kaolin immediately under the Perry Sand is fairly pure with a blocky fracture, soapy feel, and some ocher staining; the kaolin becomes progressively more sandy down the section and the lower part of the bed gradually merges into a kaolinitic, poorly sorted sand; Bed 1 is massive bedded, structureless, and jointed, the kaolin and kaolinitic sand weathers by spalling in exfoliation sheets parallel to the outcrop surface; color is pale gray with scattered irregular patches of dusky red; the base of Bed 1 is not exposed.	25 feet (7.6 m)
		44 feet (13 m)

STOP 12

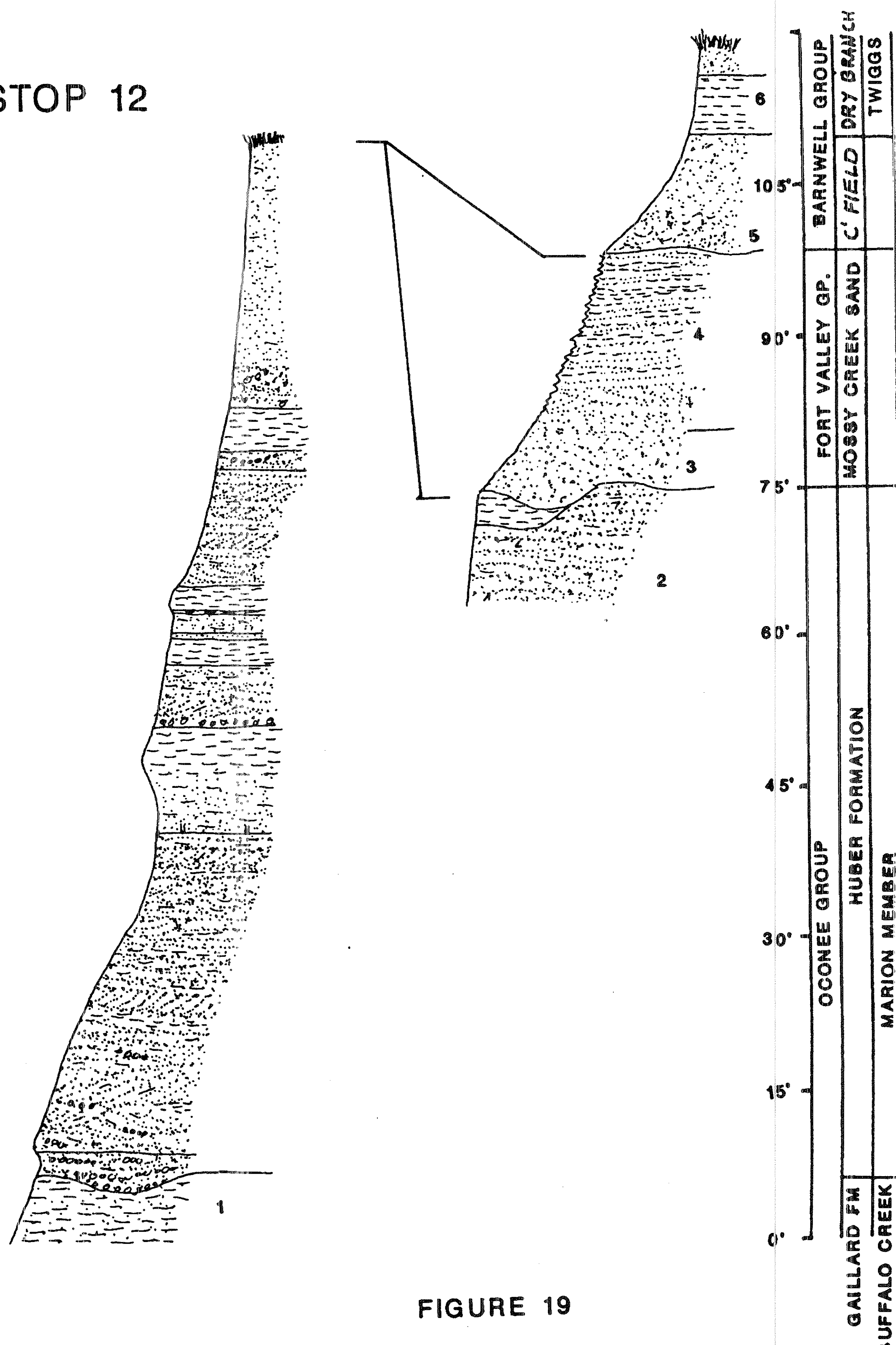

FIGURE 19

STOP 12

SECTION EXPOSED IN J. M. HUBER PIT 36, TWIGGS COUNTY, GEORGIA

Lithostratigraphic unit and bed number	Description	Thickness
RESIDUUM		
Bed 7	Sand residuum: argillaceous; massive, structureless; moderate reddish brown (10 R 4/6); grades downward into:	5.0 feet (1.5 m)
BARNWELL GROUP **DRY BRANCH FORMATION** **TWIGGS CLAY MEMBER**		
Bed 6	Clay: deeply weathered; thinly layered; breaks with irregular, blocky fracture; abruptly overlies:	6.0 feet (1.8 m)
CLINCHFIELD FORMATION		
Bed 5	Sand: very slightly argillaceous. irregular patches of clay in lower part; sand fine-to medium-grained; moderately to moderately well sorted; appears massive and structureless in upper part, burrowed and bioturbated in lower part; deeply weathered in upper part and moderately weathered in lower part, moderate reddish brown (10 R 4/6)(except grayish clayey streaks and concentrations in lower part) Riggins Mill lithology is absent in Pit 36 area; disconformably overlies:	12 feet (3.7 m)
FORT VALLEY GROUP **MOSSY CREEK SAND**		
Bed 4	Sand and clay: sand is fine- to medium-grained, moderately to well-sorted, sand layers are relatively clean with no apparent interstitial clay; sand is variably undulatory, trough, and planar cross-bedded on small to moderate scales; gray clay layers are laminated to thin bedded, increasing in thickness and proportion to sand layers in upper part of bed, clay beds contain little quartz sand; rare burrows scattered in concentrations, most intervals devoid of burrows, **Ophiomorpha nodosa** occurs in trace frequencies; gradationally overlies:	24 feet (7.3 m)

Bed 3	Sand: fine- to coarse-grained; poorly sorted; soft, almost incoherent; massive and structureless; disconformably overlies:	6.0 feet (1.8 m)
Bed 2	As below:	2.0 feet (0.6 m)
		53 feet (17 m)

This section measured in 1976 in original Pit 36

OCONEE GROUP
HUBER FORMATION
MARION MEMBER

Bed 2 — Sand: kaolinitic and with scattered lenses of kaolin, variably micaceous, scattered but common intervals with kaolin intraclasts, scattered concentrations of dark minerals, and scattered occurrences and periodic exposures (during mining excavation) of carbonaceous or lignitic lenses of sand or kaolin; — 76 feet (23 m)

Bed 2 consists of a variable stack of fining upward sequences, some truncated, some kaolin-filled channels (lenses), bases of fining upward sequences coarse-grained, some basal beds are pebbly and the sand is poorly sorted with kaolin clasts, upper parts of fining upward sequences variably kaolin or finely micaceous, kaolinitic, fine-grained sand; bedding is variable on large and small scales with undulatory bedding, trough cross bedding, and planar cross bedding, some broad, cross-cutting channel features, finer grained sand beds commonly with sharply defined bedding planes;

Sand sorting ranges from very poor to moderately well sorted with interstitial kaolin, the sand is not well-sorted and largely devoid of interstitial clay as is the overlying Mossy Creek Sand or Clinchfield Formation;

Kaolin in clay lenses is generally soft and soapy to the touch, with rough conchoidal to irregular fracture; disconformably overlies:

GAILLARD FORMATION
BUFFALO CREEK KAOLIN MEMBER

Bed 1	Kaolin: soft, soapy to the touch; massive and structureless; large, smooth, conchoidal fracture surfaces; very pale pinkish color; bottom of bed is not exposed.	7 feet (2 m)
		83 feet (25 m)

STOP 13 (OPTIONAL)

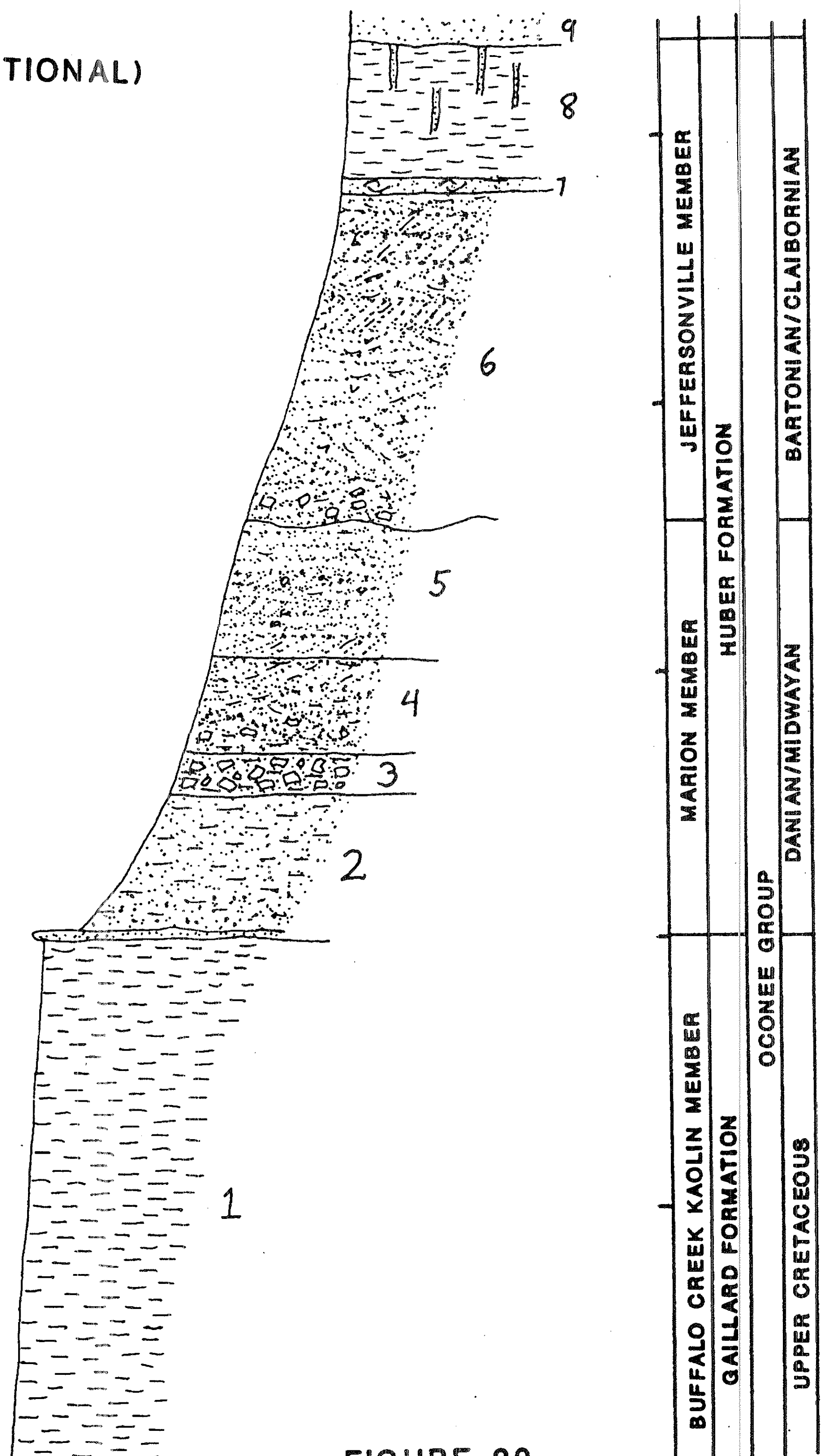

FIGURE 20

STOP 13

SECTION EXPOSED IN J. M. HUBER PIT 30, THE TYPE SECTION OF THE HUBER FORMATION, TWIGGS COUNTY, GEORGIA
Adapted from Buie (1978)

Lithostratigraphic unit and bed number	Description	Thickness
BARNWELL GROUP		
Bed 9	Fossiliferous sands and clays: disconformably overlies:	
OCONEE GROUP		
HUBER FORMATION		
JEFFERSONVILLE MEMBER		
Bed 8	Kaolin: with numerous kaolin-filled tubular forms about 0.1 inch (2.5 cm) diameter; also, cracks filled with sand and fossil fragments from the overlying unit.	5.0 feet (1.5 m)
Bed 7	Quartz sand with imprints and molds of small mollusks.	0.5 feet (0.2 m)
Bed 6	Sand: medium to coarse grained white, kaolinitic, cross-bedded quartz sand with flakes of mica; heavy minerals along cross-bedding. A few kaolin balls, 0.5 inch (1.3 m) diameter, in basal 2 ft. (0.5 m) of coarse sand: disconformably overlies:	12.5 feet (3.8 m)
HUBER FORMATION		
MARION MEMBER		
Bed 5	Sand: medium grained white micaceous quartz sand with laminae of dark minerals; a few kaolin balls to 0.5 inch (1.3 cm) diameter; some cross-bedded lenses of small pebbles of quartz; gradational with underlying bed.	4.8 feet (1.5 m)
Bed 4	Sand: Kaolinitic very coarse quartz sand and granules; cross-bedded; discoidal balls of kaolin having maximum dimensions of 1 inch (2.5 cm) by 2 inches (5 cm), in lower half.	3.6 feet (1.1 m)
Bed 3	Sand and clay balls: Discontinuous	1.7 feet

	layer of clay balls, 0.2 to 2 inches (0.5 to 5 cm), and quartz pebbles having smaller maximum diameter; dark minerals conspicuous, possibly 5% of total. Much of the quartz, especially that of the milky quartz pebbles, is friable.	(0.5 m)
Bed 2	Sand: coarse grained kaolinitic quartz sand, with abundant dark mineral grains. Basal 1 ft. (30 cm) very coarse. Includes 1 to 2 inches (2.5 to 5 cm) of limonite and limonite-cemented sand at basal contact. Disconformably overlies:	5.3 feet (1.6 m)

GAILLARD FORMATION
BUFFALO CREEK MEMBER

Bed 1	Kaolin: white, except for 2 inches (5.0 cm) limonite stain at top. Bottom not exposed.	20 feet (6.1 m)
		53.4 feet (16.3m)

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