CAROLINA GEOLOGICAL SOCIETY

and

ATLANTIC COASTAL PLAIN GEOLOGICAL ASSOCIATION

Annual Meetings and Field Trip

FIELD TRIP GUIDEBOOK

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by

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Carolina Geological Society and Atlantic Coastal Plain Geological Association, Field Trip Guidebook (The Geology of the NC Coastal Plain from the Sounds near New Bern to the Piedmont of Wake County)

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INTRODUCTION

The geology of the Coastal Plain from the sounds near New Bern to the Piedmont of Wake County is discussed in the following pages. The major purpose of our work is to help to decipher some of the relationships between the geology and geomorphology of the Coastal Plain and to determine their influence on the genesis and distribution of soils. Therefore, our investigations have been focused on the stratigraphic units that are at the surface in the interstream divide areas (commonly, but imprecisely, called "surficials").

During the last twenty years there has been a large and increasing use of geologic concepts in soils work, not only in the United States but also throughout much of the world (Daniels *et. al.*, 1971c). However, many of the concepts used by pedologists can be of use to stratigraphers. This is especially true in the Upper Coastal Plain where soil information has modified the upper parts of the sedimentary units. Features such as A2 horizons, plinthite, and mottling have been produced by soil-forming processes.

Soil terminology is used in much of this report. The Munsell soil color book was used to describe all colors. The USDA textural triangle in the appendix gives the range of sand, silt, and clay for each textural class. The terms used are standard terminology given in the Soil Survey Manual (Soil Survey Staff, 1962).

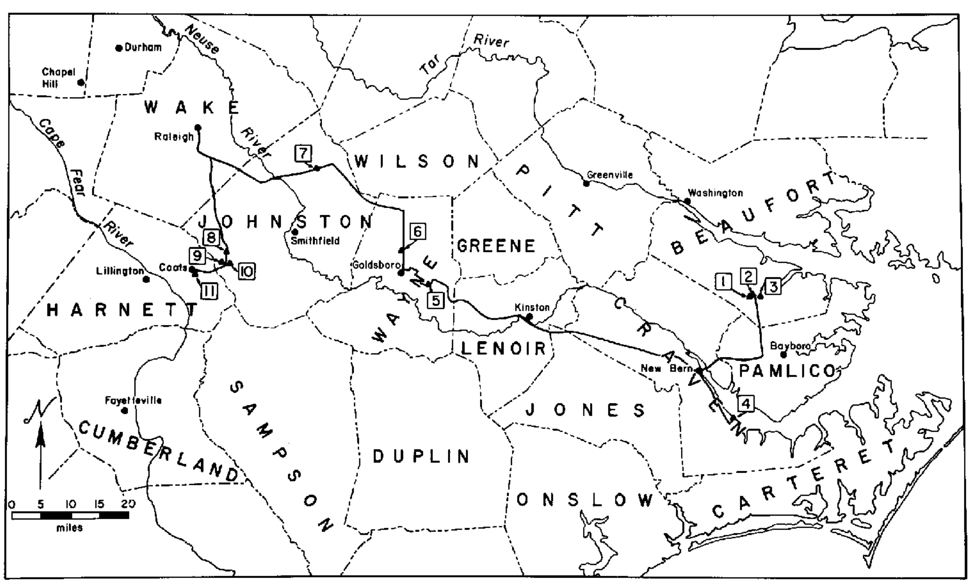

Figure 1.

LOWER COASTAL PLAIN

The field trip in the Lower Coastal Plain (Fig. 1) will be concerned with three sedimentary units, the Small sequence and the Talbot and the Pamlico morphostratigraphic units (Table 1). The term morphostratigraphic unit is applied to surficials deposits in the Coastal Plain because, as Frye and Willman (1960) stated in their original discussion, "…they are identifiable by their form and not their lithology, which in many cases… is not distinguishable form one…to the next, they are not normal rock-stratigraphic units." To quote further for clarification, "A morphostratigraphic unit is defined as comprising a body of rock that is identified primarily from the surface form it displays; it may or may not transgress time through its extent." Frye and Willman (1962), in a later discussion of this idea indicated that the term could be applied to fluvial terraces and other nonmarine stratigraphic and geomorphic elements. We would like to extend the term morphostratigraphic unit (hereafter abbreviated to MSU) to include marine sediments and associated surfaces. The term MSU is preferred to terrace or formation, because a terrace is a surface and a formation is a mappable lithologic unit. Many of the Coastal Plain surficial sediments do not fit the definition of a formation, but the term morphostratigraphic unit can easily be applied to these elements without violating sound stratigraphic principles. The use of MSU does not preclude the application of formational names if they are defined under the rules of formal lithostratigraphic nomenclature.

Many geologists strongly object to giving a geomorphic surface the same name as the underlying formation. This objection can be circumvented by redefining these units as MSU. Most of us can quickly place a MSU within the stratigraphic column and relate it areally to adjacent ones. Thus the surfaces are immediately tied to the sediments responsible for their existence.

Geomorphic elements that will be considered during the field trip are the depositional surfaces at the top of the Talbot and Pamlico MSU, the Talbot and Pamlico geomorphic surfaces and the Minnesott ridge. The Wicomico surface and scarps of the Middle Coastal Plain will be crossed on the return trip to Raleigh. The sediments and scarps of the Upper Coastal Plain will be visited on Sunday.

Small Sequence

The basal stratigraphic units in the Lower Coastal Plain and the New Bern-Morehead City vicinity are the Eocene Castle Hayne and the Miocene Yorktown Formations (Fig. 2). The Castle Hayne is found mainly west and south of New Bern, and the Yorktown is found to the northwest and east. Overlying the Castle Hayne and the Yorktown is a complex of stratigraphic units that we call the Small sequence. This name comes from the community of Small in Beaufort County where the sequence was first recognized. The Small

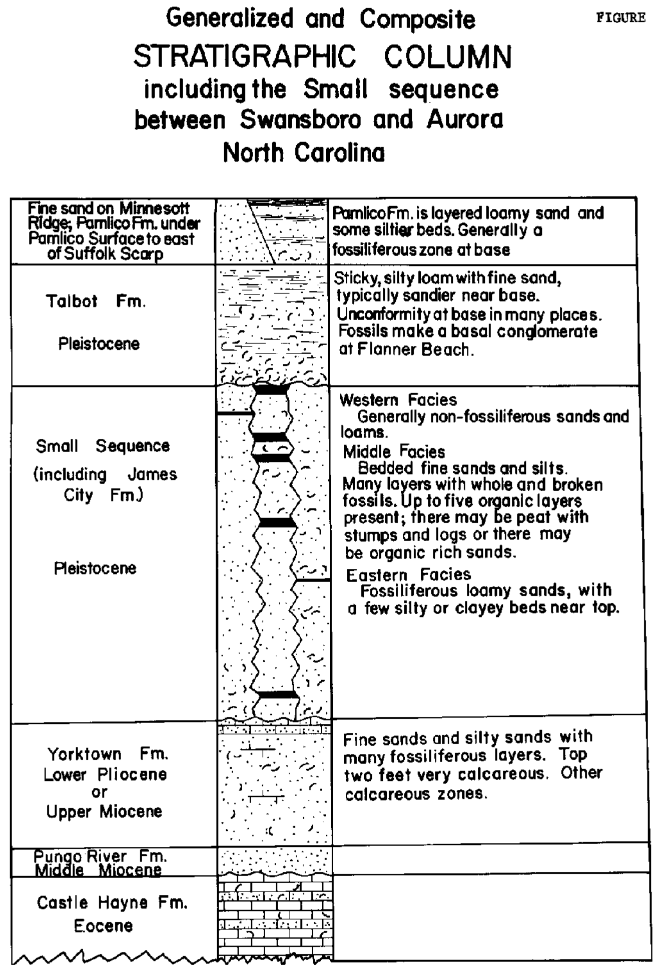

Figure 2.

sequence includes all stratigraphic units between the Castle Hayne or Yorktown and the overlying surficial sediments, our Talbot and Pamlico MSU (Fig. 2). The Small sequence does not include the overlying Flanner Beach of Du Bar and Solliday (1963) or the Neuse Formation of Fallaw and Wheeler (1969). The Small sequence is a complex of interbedded clays to sands with one or more organic horizons. It also includes the fossiliferous James City Formation, a nonfossiliferous unit north of New Bern that occupies the same stratigraphic position as the James City, and a fossiliferous sand and nonfossiliferous sand to clay unit east of the Suffolk Scarp.

A 45-mile traverse across the Talbot and Pamlico surface north of the Neuse River (Fig. 3) shows the division of the Small into three facies. At the west end of the northern traverse, the Small is largely nonfossiliferous sands. These nonfossiliferous sands interfinger toward the east in the vicinity of the Suffolk Scarp with sands to clays that have one or more organic horizons above the Yorktown Formation. Toward the east the multiple organic horizons are replaced by generally fossiliferous sands, although the upper

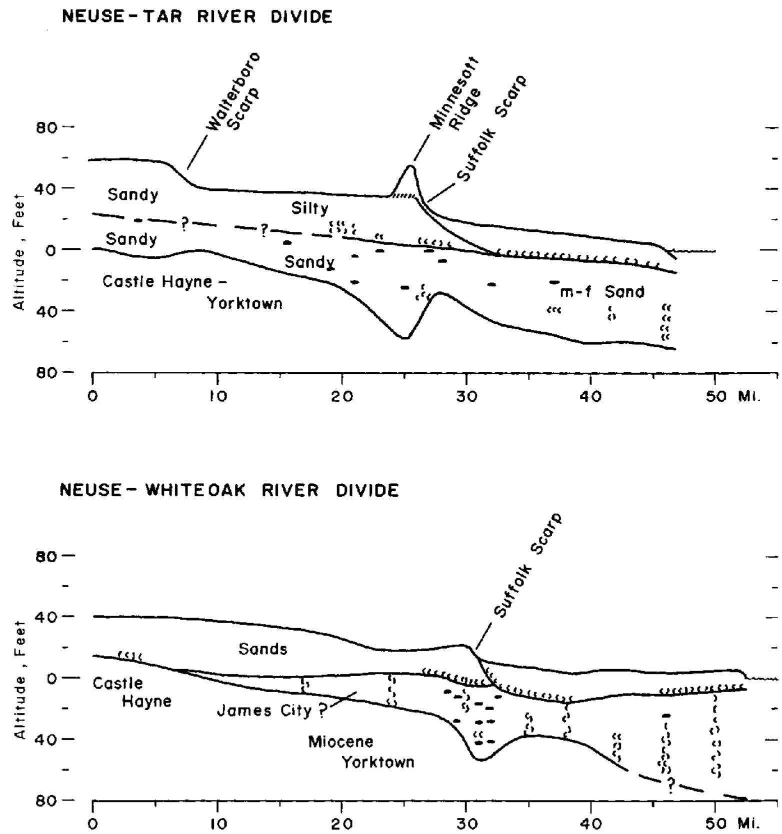

Figure 3.

part of the section may contain silts to clays and occasional thin organic units. The sequence is sharply separated from the underlying Yorktown by the distinct changes in lithology and a distinct disconformity that is traceable over large areas of eastern North Carolina (Welby & Leith, 1969; and Welby, 1971). The contact to the overlying Talbot MSU is questionable in the western part of the traverse, but near the Minnesott Ridge the contact is distinct.

South of the Neuse River the 3 facies of the Small sequence are similar to those found in the northern traverse. The fossiliferous facies occurring west of the multiple organics is the James City Formation. In the north traverse the multiple organics occupy an area a few miles wide but they apparently are limited to a very narrow band south of the Neuse River. In both cross sections the organics occur in the immediate vicinity of the Suffolk Scarp, but this probably is a coincidence because organics occur over an area about 20 to 25 miles wide between the Neuse and Pamlico estuaries (Fig. 4). In both traverses the Small sequence thickens considerably toward the east.

A section through the Talbot and the Small sequence in the western part of our investigations is given.

Location: About 1/8 mile east of 77° 05’ west longitude on the Beaufort-Craven County line. Altitude 42 feet.

Depth in Feet	Description
0 to 2½	Road fill
2½ to 4	Organic layer; very dark brown (7.5YR 2/2) very fluffy organic material; abrupt to
4 to 9	Light gray and dark gray (10YR 6/1 and 4/1) very fine micaceous sandy clay; Talbot MSU; gradual to
9 to 19½	Light gray (5Y 6/1) fluid loam grading at 13½ feet to greenish gray (5GY 5/1) sticky loam; gradual to
19½ to 28½	Dark greenish gray (5GY 4/1) fine sandy loam grading downward to medium-fine sand loam at base; base of
28½ to 30	Olive gray (5Y 5/2) organic-rich clay; common pieces of wood in upper 6 inches; grading to dark greenish gray (5GY 4/1) at base; abrupt to
30 to 43	Dark greenish gray (5GY 4/1) medium-course loamy sand; base of Small sequence, abrupt to
43 to 48	Olive gray (5Y 4/2) loam; Yorktown Formation, abrupt to
48 to 58½	Greenish gray (5GY 6/1) hard drilling lumpy marl; base of hole 58½ feet.

A section with multiple organics in the Small sequence is located on Beaufort County Road 1931, 0.5 mi west of junction with County Road 1927. This is stop 1 of the field tour. Altitude 34.2.

Depth in Feet	Description
0 to ½	Road fill
½ to 5	Sandy loam to loamy sand soil profile in the Talbot MSU
5 to 7	Pale yellow (54 7/3) to light gray (2.5Y 7/2) fine sand; abrupt to
7 to 11½	Greenish gray (5GY 5/1) sticky silt loam grading downward to dark greenish gray (5GY 4/1) loamy fine sand at 8½ feet; clear to
11½ to 13½	Yellow (10YR 7/6) medium fine to fine sand; gradual to
13½ to 21½	Greenish gray (5GY 6/1 to 5/1) medium fine to fine sand to loamy sand; lower two feet are sticky loam; base of Talbot; abrupt to Small sequence.
21½ to 24	Darker than very dark brown (10YR 2/2) organic clay loam; contains wood fragments up to 2 inches long; gradual to
24 to 26	Darker than very dark brown (10YR 2/2) fine loamy sand to sandy loam; gradual to
26 to 31½	Gray (5Y 5/1) medium fine loamy sand with bodies of very dark grayish brown (10YR 5/3); abrupt to
31½ to 38½	Greenish gray (5GY 5/1) medium fine loamy sand becoming greener than dark greenish gray (5GY 4/1) at 36 feet; abrupt to
38½ to 49	Greenish gray (5GY 5/1) medium fine sand grading to medium coarse sand at 49 feet; abrupt to
49 to 58	Dark greenish gray (5GY 4/1) stiff sticky silty clay to fine clay loam; clear to
58 to 63½	Dark gray (10YR 4/1) medium sandy loam; common to many wood fragments ½ inch in diameter or less; clear to
63½ to 66½	Dark gray (10YR 4/1) sticky silty clay with few to common wood fragments, abrupt to
66½ to 74	Black (5YR 2/1) peaty sticky silty clay loam, common small (less than ½ inch) wood fragments, abrupt to
74 to 78½	Dark gray (10YR 4/1) sticky silty clay loam to silty clay; gradual to
78½ to 89	Dark greenish gray (5GY 4/1) silty clay loam grading to medium fine sandy clay loam at 81 feet; sands become fine to very fine at 86.6 feet; clear to abrupt to
89 to 91	Dark gray (5Y 4/1) fine sandy clay loam with few to common darker bodies of disseminated organic matter; base of Small sequence; abrupt to
91 to 98½	Dark greenish gray (10GY 4/1) medium coarse sandy clay loam grading to light olive gray (5Y 6/2) "marl" with some material partially cemented by carbonate; Yorktown Formation base of hole at 98½.

A section through the Pamlico and the Small sequence that shows some of the variation of the Small in its eastern distribution is given below.
Location: East of Hobucken on Pamlico County road 1228, 1.75 miles from end of pavement and 0.1 mile from end of road. Altitude 3 feet.

Depth in Feet	Description
0 to 1	Road fill
1 to 5½	Sandy clay loams soil profile in Pamlico MSU; gradual to
5½ to 10	Pale olive to olive (5Y 6/3 to 5/3) medium sand interbedded with minor strata of fine sand; grades to gray (5Y 5/1) medium sand with minor strata of fine sand to loamy at 8½ feet; clear to
10 to 18	Olive gray (5Y 4/2) fine sandy clay loam interbedded with fine sandy loam and medium sand; base of Pamlico; abrupt to
18 to 27	Greenish gray (5GY 5/1) sandy clay loam interbedded with medium loamy sand to sand; abrupt to
27 to 28	Dark olive gray (5Y 3/2) micaceous organic-rich silty clay that darkens on exposure; clear to
28 to 31½	Greenish gray (5GY 5/1) loamy medium sand interbedded with thin strata of more clayey material; abrupt to
31½ to 57	Bluish gray (5B 6/1) "marl"; coarse and medium sand with abundant shells; highly calcareous; grades to greenish gray (5GY 6/1) at 40 feet; clear to
57 to 66	Greenish gray (5GY 5/1) sticky silty clay loam; calcareous; base of Small sequence; abrupt to
66 to 68½	Bluish gray (5B 6/1) slightly sticky hard drilling clay loam marl; probably Yorktown Formation; base of hole 68½ feet.

A series of 12 drill holes in a 4-mile traverse across the Suffolk Scarp clearly shows the discontinuous nature of the organic horizons and the associated beds (Fig. 5). The marl or soft limestone at the top of the Yorktown is removed in places and the relief of the erosion surface is about 30 feet. The base of the Small sequence in the western part of the traverse is fossiliferous sands (James City?) grading upward into fossiliferous and nonfossiliferous silty beds. Near the Suffolk Scarp is a complex sequence of fossiliferous and non-fossiliferous silty beds with intercalated but horizontally discontinuous organic-rich beds that contain bald cypress wood (A.C. Barefoot, personal communication). Many of these organic horizons with cypress wood are at –20 to –50 feet. Fossiliferous marine sands and nonfossiliferous sands

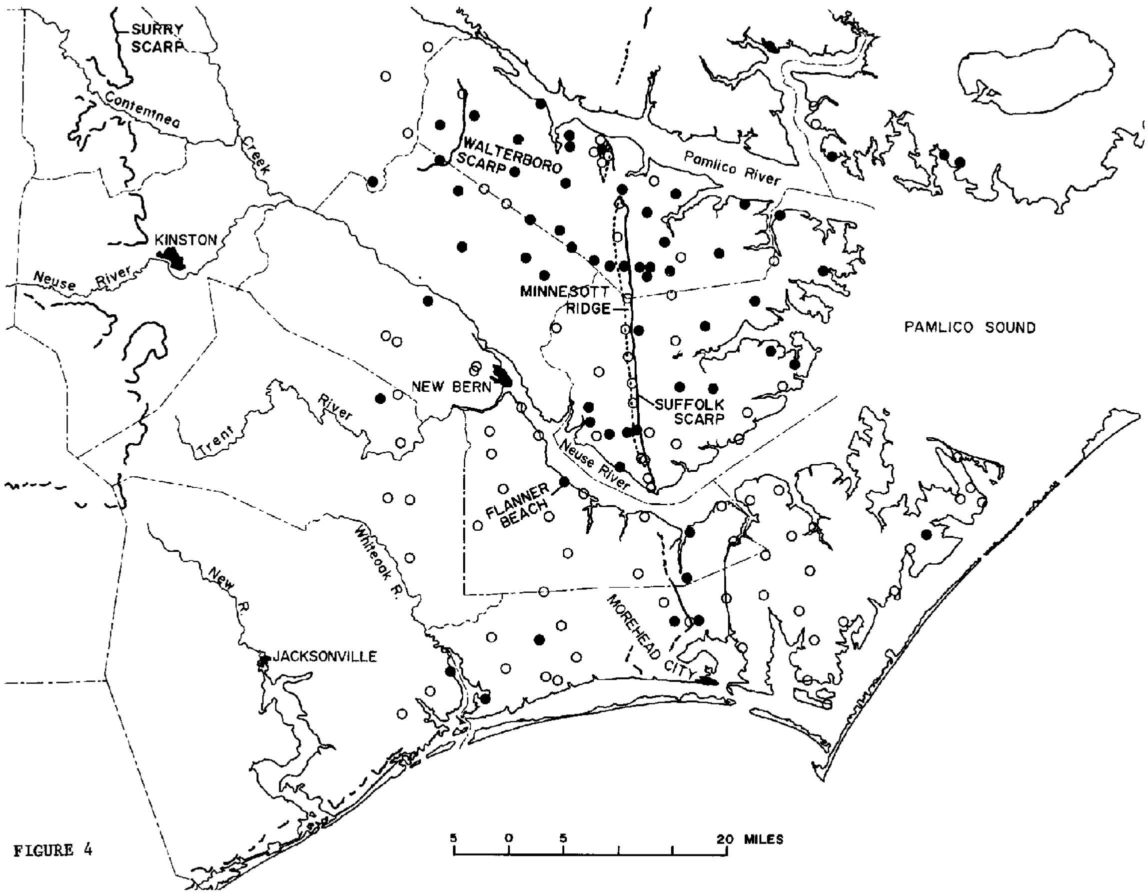

Figure 4.

of probably marine origin also are found interbedded with the silts to silty clays. The organic horizons and associated silty beds pinch out to the east and interfinger with fine to medium sands.

A detailed section shows the complex vertical changes in sediments (Fig. 6). Some of the silty beds are extremely soft and semi-fluid are very similar to the sediments in the modern salt marshes at the mouth of the Cape Fear River. This suggests that these soft, semi-fluid beds have never been dried. Yet within the same section there can be extremely tough dense clays separated by organic horizons. The tough clays, if deposited in a saltwater environment, must have been dried or dewatered sometime during their history. The organic zones and the cypress wood indicate at least short periods where vegetation was growing in a swamp or brackish water marsh.

The relation between the buried organic horizons and the surficial Talbot MSU is well illustrated at Flanner Beach on the south side of the Neuse Estuary. The base of the section is a gray to olive brown clay exposed about 2 feet above the estuary. The weakly to strongly developed organic horizon, a buried Al, at the top of the clay (Fig. 7) is truncated by the *Dinocardium* layer. The clay is without marine fossils in the exposed section but fossils do occur in four nearby drill holes. There apparently was some weathering of the clay, as shown by the organic carbon and oxidation of iron, before the overlying Talbot MSU was deposited.

Depositional Environment

Our studies of fossils contained within the Small sequence are far from complete, but some speculation about depositional environments can be made. There seems to be a distinct possibility that the relatively clean fossiliferous sands in the eastern part of the Small sequence represent fully marine conditions. There are no or few muds and organics within the sands that can be interpreted as estuarine or lagoon facies. An upper clayey part occurs in about ½ of the boreholes, and these may represent localized lagoon conditions.

The organic horizons of the Small indicate that the sediments had to be exposed to subaerial conditions for a few hundred years to develop the relatively thick peat layers and allow cypress stumps 6 feet or more in diameter (Flanner Beach section, Fig. 7) to develop. Marine shells intercalated with organic debris in other sections suggest that these organics formed very close to sea level. The relatively restricted horizontal area occupied by multiple organic layers suggest that the fluctuating marine, that these organics

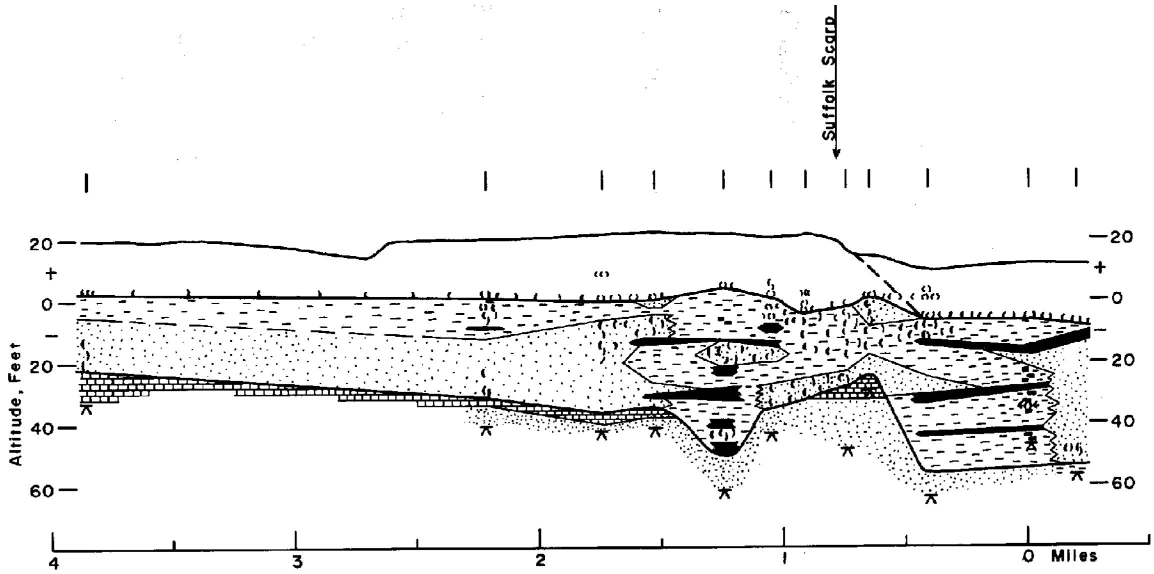

Figure 5.

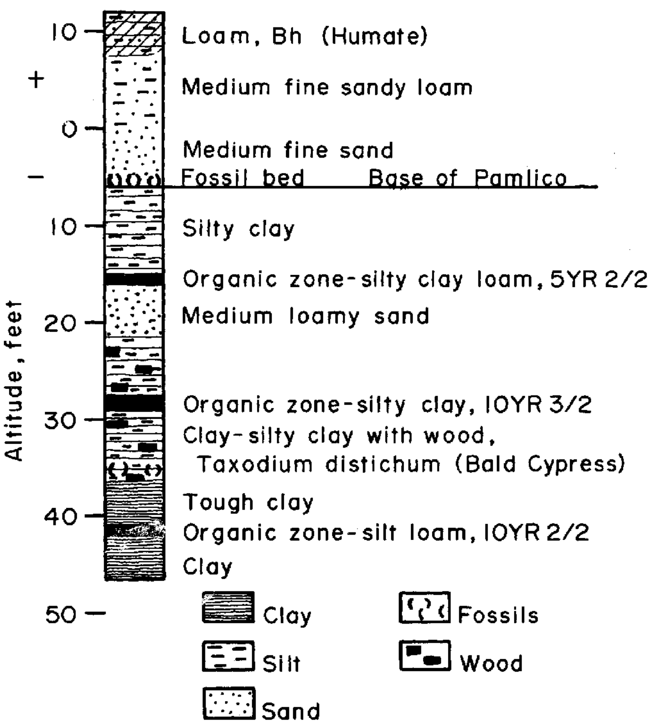

Figure 6.

formed very close to sea level. The relatively restricted horizontal area occupied by multiple organic layers suggests that the fluctuating marine, lagoonal and subaerial conditions remained in about the same geographic location throughout the deposition of 20 to 40 feet of sediment. There appears to be little evidence that these conditions shifted westward as sea level rose.

The origin of the nonfossiliferous sands west of the multiple organics is open to considerable question. We are not sure whether or not these sands interfinger with the James City farther to the south, or whether they represent a leached James city, or a third possibility, they are lagoonal to fluvial sands that may or may not be related to the James City.

There is a problem in determining the behavior of sea level during the deposition of the Small sequence. If each organic horizon represents a separate transgression and regression, then in some areas there have been at least 5 of these. However, it can also be suggested that sea level may have risen in small increments during deposition of the Small, and sediment accumulation may more or less have kept pace with this rise in the manner shown to be taking place in North Carolina lagoons today (Ingram, 1968). The first hypothesis requires repeated rise and fall of sea level with transgression and regression, but the second one requires only that the shoreline remain somewhere within a limited geographic area as sea level rose.

Relation of Small Sequence to Surficial Sediments

The relations between the Talbot and Pamlico MSU and the Small sequence will be important in dating and developing a history of the Upper Coastal Plain. Locally, such as at the Flanner Beach section, there is a distinct lithologic disconformity separating the Talbot and the Small sequence. Yet if one considers the multiple organic layers of the Small and their relation to one another, there are disconformities within the Small that are just as distinct and may represent as much change in depositional environment. Are we, then, justified in placing formational breaks at the base of the *Dinocardium* layer in the Flanner Beach section?

The traceable change in lithology at the base of the Talbot overlies organics, clays, and sands of the Small sequence over a wide area. This would seem to indicate a regional disconformity at the base of the Talbot. Supporting evidence can be found in the truncation of the organic zones, and in

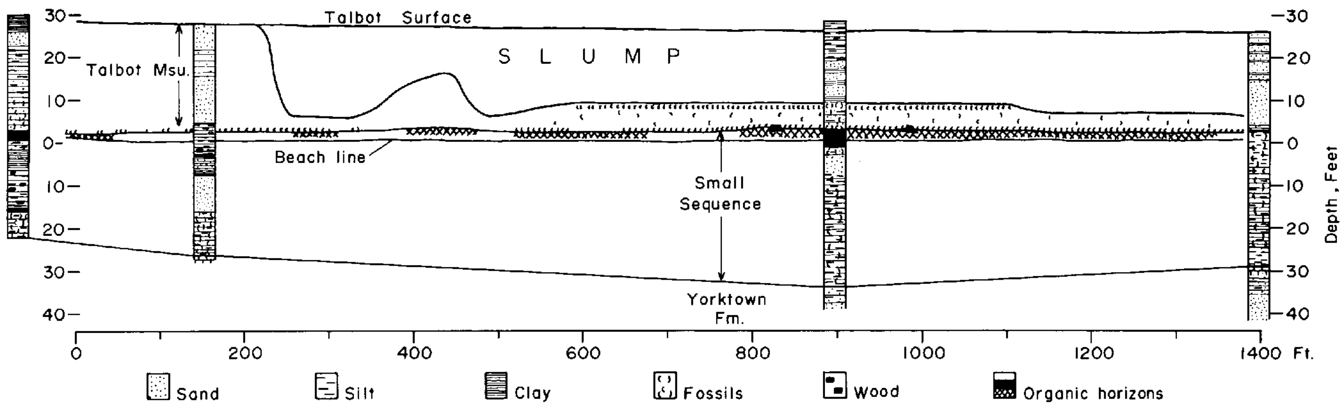

Figure 7.

the apparent truncation of the Small sequence by the overlying Talbot where the latter passes onto the Castle Hayne Formation (Fig. 3). The evidence for a separation of the Small and Talbot in their western distribution north of the Neuse River may not be overly strong, however. North of the Neuse there are large areas where there is so little vertical lithologic change in the sediments above the Yorktown that formational boundaries are little more than educated guesses. If we assume there is a contact between the Talbot and the Small, then the Talbot and the Wicomico, and Talbot are part of the same sedimentary unit. If true, this suggests the possibility of a rise in sea level from near –30 to –50 feet to somewhere near +95 feet, the toe of the Surry Scarp (Daniels, *et. al.*, 1966a), followed by a regression to at least the Suffolk Scarp.

The relation between the Pamlico MSU and the underlying Small seems to be much more distinct than between the Small and the Talbot. The Pamlico nearly everywhere is sharply separated from the Small by a basal "fossil has" layer that carries for miles at about the same plane. About 8 out of 10 holes have this hash layer and seldom does it vary more than 3 to 5 feet to altitude, usually less within an area.

Talbot and Pamlico Morphostratigraphic Units

The major MSU in the area are the Talbot and Pamlico of Stephenson (1912) and other authors, These surface units are difficult to describe lithologically so that they may be separated from adjacent or even underlying formations, largely because they are similar in composition. The concept of distinct lithologic units does not apply well here, although if highly detailed work were done in a small area it would be possible to sort out several units. We believe that the term, morphostratigraphic units, used by Frye and Willman (1960, 1962) is very useful in this area. It is in this sense that we are using the names Talbot and Pamlico, because this seems to be, in effect, the way Stephenson used them.

Talbot Morphostratigraphic Unit

By our definition, the Talbot MSU is the Surface unit that occurs between the toe of the Walterboro Scarp, altitude 45 feet, and the top of the Suffolk Scarp. The Minnesott ridge sand at the top of the Suffolk Scarp in Beaufort County and Pamlico County is excluded from the Talbot. We have not mapped the exact area distribution of the Talbot throughout the Neuse Basin, although its eastern limit, the Suffolk Scarp, has been mapped (Fig. 4).

The Talbot MSU has almost any texture from sand to silt to clay. It is somewhat similar to Middle and Upper Coastal Plain surface units by being coarsest at the base and becoming finer toward the top in about 50 percent of our drill holes. However, as at the Flanner Beach section (Fig. 7), there are vertical and horizontal changes in texture over short distances that can range from sands to clays with any one lithology occurring at any level within a vertical section.

Fossils occur near the base of the Talbot only in its eastern distribution (Figs. 3, 5), and then usually in a somewhat clayey matrix. Fossils occur less frequently in sand or loamy sand. The clayey matrix may protect the fossils from leaching. Only 20 of 59 boreholes in the Talbot have marine fossils somewhere within the section, and the largest number of holes with fossils are south of the Neuse River. The fossils may form a very concentrated layer or layers such as the basal *Dinocardium* zone at Flanner Beach (Fig. 7), or they may be sparsely scattered throughout a silty or clayey matrix.

The fossils at Flanner Beach (Du Bar & Soliday, 1963) and at sections near Bear Creek (Fallaw & Wheeler, 1969) place the Talbot definitely within the Pleistocene.

Some mineralogical work has been done on Talbot sediments. Two theses (Smith, 1970; Granger, 1970) on the mineral content of soil B horizons suggest that soils on the Talbot have either had most of the feldspar removed by weathering or the sediments had very little in the beginning. Additional data are given in tables 2 and 3 in the appendix.

Pamlico MSU and Minnesott Ridge Sand

Minnesott Ridge Sand. The Pamlico MSU includes all sur-

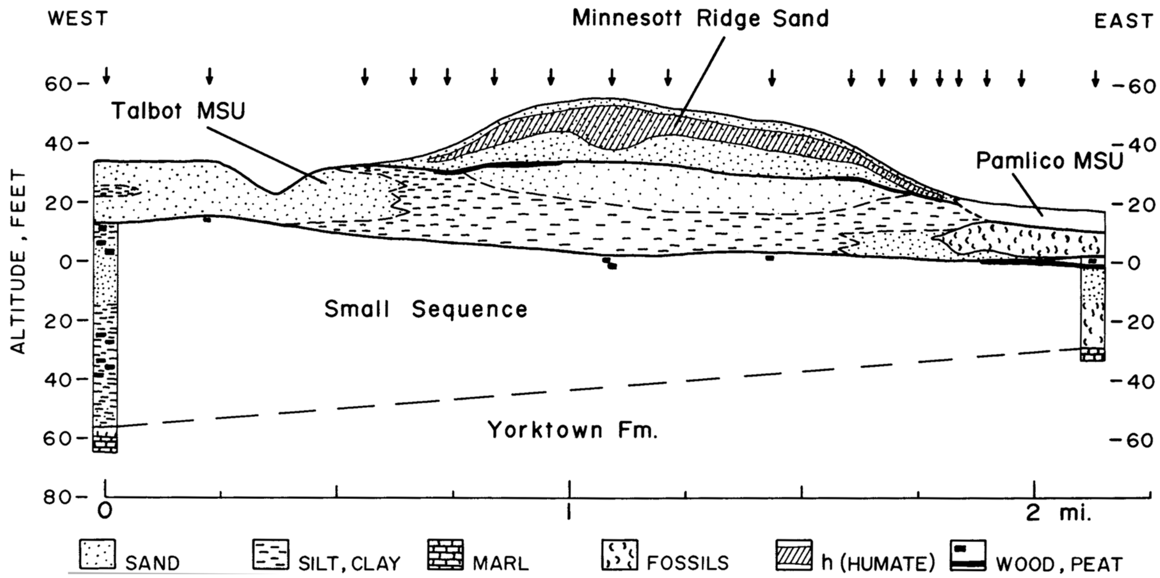

Figure 8.

face sediments on the mainland east of the Suffolk Scarp with the exclusion of recent eolian sands and swamp or marsh deposits in river valleys and lagoons. The Minnesott Ridge is a ridge of sand 1 mile or less wide, whose seaward face forms part of the Suffolk Scarp between the Pamlico and Neuse Estuaries. The ridge has an altitude of up to 65 feet. It rises 25 to 30 feet above the Talbot surface to the west and 50 feet above the Pamlico surface to the east. The topography of the ridge crest is extremely variable. It may be flat or dune-like with small irregular-shaped depressions. Texturally the ridge is sand to loamy sand. We have not found clay or silt lenses in the more than 20 holes we have drilled. The ridge sand, along its west edge buries organic layers at the top of the Talbot (Fig. 8).

Near the center and eastern part of the ridge, the organic layers are missing ad the ridge sands overlie sands and other lithologies of the Talbot MSU. The east side of the ridge is the Suffolk Scarp and the ridge sands merge laterally to the east with the clayey and sandy Pamlico that everywhere lies below 20 feet.

The sand texture of the ridge plus the perched water levels above the less permeable Talbot have resulted in the accumulation of thick Bh horizons, the humates of geologists (Swanson & Palacas, 1965) in the wetter parts of the ridge. These h horizons are the result of organic carbon becoming water soluble and moving downward into the sand from the surface litter (Daniels *et. al.*, in preparation). These thick, and extremely variable (horizontally and vertically) humates have little or no pollen, no wood (excluding roots), and should not be confused with buried Al horizons. A section illustrating the morphology of the h horizon, the ridge sand, and the contact to the buried organic layer at the top of the Talbot is given below.

This section is stop 2 of the field tour.

Location: 0.32 miles west of the junction of North Carolina Highway 306 and Beaufort County Road 1927.

Depth in Feet			Description
0	to	½	Road fill
½	to	1½	Al soil horizon; Black (10YR) fine loamy sand; abrupt to
1½	to	2	A2 soil horizon; dark gray (10YR 4/1) fine loamy sand to sand; abrupt to
2	to	3½	Bhl very dark gray (5YR 3/1) fine loamy sand; organic material covers sand grains; common to many roots, grades downward to
3½	to	8	Bh2 dark reddish brown (5YR 2/2) fine loamy sand grading downward to very dark grayish brown (10YR 3/2) fine sand; base of Minnesott Ridge sand; abrupt to buried Talbot surface.
8	to	9½	Dark reddish brown (5YR 2/2) peat; some fine mineral matter intermixed in base; clear to
9½	to	14	Dark greenish gray (GB 4/1) very sticky silty clay loam to silty clay; base of hole at 14 feet.

Note how the vegetation is extremely thick in this area. The same phenomena occurs on the east side of the ridge near the toe. Hartshorn (1968) has described the vegetation and its relation to seepage area in the ridge sand.

The Minnesott ridge is a distinct topographic feature between the Pamlico and Neuse Rivers, but there is little evidence of the ridge sand occurring elsewhere along the Suffolk Scarp. The ridge appears to be a combination storm and dune ridge. Its position must have somehow been unique because there is no other area along the Suffolk Scarp in North Carolina that is similar. The ridge is most certainly associated with the forces that resulted in deposition of the Pamlico MSU (Fig. 8) because it merges with the Pamlico on the east and buries peat and other soils or evidence of subaerial weathering at the top of the Talbot to the west. We suggest the possibility of this area to the east being open ocean.

Pamlico MSU

The Pamlico sediments commonly are fine textured in the upper 3 to 5 feet and range from sands to silty clay loams from 5 feet to the base. Marine fossils are abundant both as basal hash layer and as few to common shells dispersed throughout a sandy matrix. Out of 45 boreholes through the Pamlico, 32 had fossils. This ¾ ratio is larger than the ratio of the holes in the Talbot. There also seems to be little areal differentiation because the fossils are equally abundant north or south of the Neuse Estuary. The Pamlico MSU has an altitude range of +20 to –20 feet. Marine fossils may occur in the Pamlico at altitudes of about +5 to the base. The altitude of the fossils at Flanner Beach (Fig. 7) is within the altitude range of the Pamlico MSU, but the Flanner Beach section is Talbot MSU because it occurs west of the Suffolk Scarp and the sediments associated with the fossils rise to nearly +30.

Relation Between Morphostratigraphic Units

During the initial work on the Atlantic Coastal Plain, Stephenson (1912) and others separated the Talbot and Pamlico MSU largely on the basis that a scarp meant a new cycle of transgression and regression. The earlier workers mapped a different formation between each scarp, although they had little direct evidence of formational changes. The scarps and surfaces that Stephenson mapped in North Carolina generally hold. He did an excellent job in a short time with very poor topographic coverage. Whether or not a new formation starts at the toe of each scarp, however, may be debated for years because even intensive work with drill rigs and modern laboratory techniques frequently leaves us only with numbers and a few facts, but not unequivocal proof.

Wicomico-Talbot. We have not drilled across the Walterboro Scarp in great detail so whether or not there is a formational change at this scarp is debatable. But the initial evidence suggests that the sediments of the Wicomico continue eastward under the Talbot surface (Fig. 3). There is not change in the general character of the sediment across the scarp, nor is there any change in the general character of the sediment across the scarp, nor is there any change in the slope at the base of the MSU. For these reasons we suggest the possibility of one stratigraphic unit from the Surry to the Suffolk Scarp.

Talbot-Pamlico. We have three detailed traverses across the Suffolk Scarp that will allow us to speculate somewhat on the possible stratigraphic changes across the scarp (Figs. 5,8,9). South of the Neuse Estuary the Suffolk Scarp is a somewhat indistinct feature with a tow altitude between +15 to +20 feet. Several drill holes across the scarp suggest that the Pamlico the east of the scarp is inset into and slightly below the Talbot that lies to the west (Fig. 5). This relation is based upon a fossil hash assumed to be at the base of the Pamlico that occurs at a reasonably uniform level over wide areas east of the scarp. The traverse across the Suffolk Scarp in Beaufort County, stops 1 to 3 of the field trip, can be interpreted in at least two ways. We presently argue that the Minnesott Ridge sands grade into the silty and clayey upper part of the Pamlico at the toe of the scarp. The fossiliferous bed near the base of the Talbot east of the scarp is truncated by the over-lying Pamlico farther east. The change in lithology across this contact between the Pamlico and Talbot east of the scarp may be minor.

A second alternative is that the Pamlico and Talbot is one sedimentary unit. This would make the Minnesott Ridge a post-depositional feature probably associated with a high stand of sea level at about +20 feet, and it would make the Pamlico surface an erosion surface.

A third traverse across the Suffolk Scarp (Fig. 9) leaves us with about the same questions as the other two. This cross section does suggest that the basal fossil zone of the Talbot extends out under the Pamlico surface.

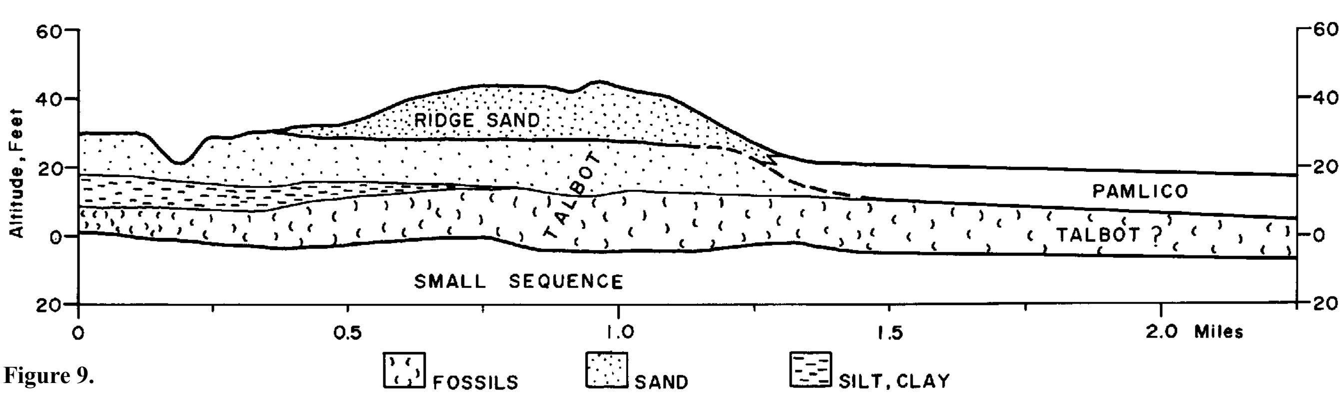

Figure 9.

Geomorphology

We have done very little geomorphic work in the Lower Coastal Plain. The Talbot and Pamlico surfaces are rather monotonous features north of the Neuse River, and there seems to be no break or suggestion of a scarp between the Walterboro and the Suffolk scarps. Between the Suffolk Scarp and sea level there are a few minor slopes at altitudes somewhere between +5 and +10 feet, but at present they do not appear to be traceable features, and there is little if any change in sediments across these slopes.

Between the Neuse Estuary and Albermarle Sound, the gently sloping plane between the Suffolk Scarp and current sea level may be a complex of surfaces. Thick organics have accumulated in some areas and, judging from work by Dolman & Buol (1967) near Phelps Lake, the base of the organics may be at or below sea level. They found evidence of a Post-Pamlico soil under some of the organics. Thus, there is the possibility that parts of the Pamlico surface were eroded and weathered, and then this eroded surface was smoothed by filling the low areas with organics. Rising sea level may have been a primary cause of the organic accumulation.

The Talbot surface south of the Neuse Estuary is a transitional landscape from the smooth, nearly featureless flats to the north and the ridge and swale topography mapped by Du Bar (1971) in the Wilmington area. Highway 70 between Havelock and Morehead City cuts the northeast edge of some of this ridge and swale topography. Lin the Lower Coastal Plain, as in the middle, the characteristics of the surfaces and commonly the sediments appear to change considerably from north to south across the Neuse. Are these changes somehow related to the fact that the Neuse is the southern most estuary and this has somehow influenced past sedimentation?

Mineralogy

We have examined the very fine sand (0.05-0.10 mm) and the clay (<0.002 mm) in strata of the Talbot and Pamlico MSU at 9 sites. Seven sites are part of as 20-mile traverse extending westward from the Hobucken vicinity. The traverse spans the Minnesott Ridge. The other 2 sites are south of the Neuse River in Carteret County. Results and general site locations are given in Tables 2 and 3.

All the very fine sands have considerable feldspar (12-27%) and a small suite of ferromagnesian silicates (1-5%). Quartz ranges from 50-84%. Metamorphic minerals excluding muscovite are 1 to 3%, and muscovite is <1 to 4%. Iron oxides are predominantly magnetite with variable hematite and lesser ilmenite and goethite. They range from 1 to 15% outside the Minnesott Ridge; however, they are consistently more abundant (19 to 42%) in the sands of the Minnesott Ridge. Zircon follows somewhat the same pattern, ranging from <1 to 7% away from the ridge and from 7 to 10% in the parts of the ridge where iron oxides are most abundant. Plant opal occurs near the surface at 4 locations and at considerable depth in 2 samples. Its usefulness as a marker of surfaces has not been probed in this study.

These data suggest a provenance with large igneous and metamorphic components. The major inferred sediment sources would be the Piedmont and mountains of the Atlantic Slope.

There seems to have been little post-depositional weathering, considering the abundance of relatively easily weatherable minerals throughout the vertical profiles.

The striking mineralogical variability is related to local differences in sedimentary processes rather that to variability of provenance or weathering. The influence of sedimentary process is here exemplified by the high zircon and iron oxide content in the Minnesott Ridge sands. Presumably, this concentration of heavies is the result of sorting and can be related to depositional environment.

The clay minerals from the Talbot and Pamlico MSU are consistently dominated by montmorillonite (smectite). Exceptions occur in the sands of the Minnesott Ridge, and the sands of sites PR38 and PR10 where clay content is very low. At these sites allogenic montmorillonite or the building blocks for authigenic montmorillonite may be in short supply or slow in reacting compared to finer textured materials.

Deviation form the general montmorillonite dominance also occurs in some soil horizons. In these, vermiculite, interstratified montmorillonite-vermiculite and interstratified vermiculite-chlorite are more abundant. The deviation is noticeable in Table 2 in sites ST1E, TR4, ST20, and PR17D. This is taken to infer weathering of the original sediment from montmorillonite toward the less expandable clay minerals. Interestingly, this is a shift toward the kinds of 2:1 layer silicated more common in older morphostratigraphic units higher in the Coastal Plain.

The general dominance of montmorillonite is in sharp contrast to clays of the Upper Coastal Plain, Piedmont and mountains of the Atlantic slope. In these areas kaolinite, vermiculite, vermiculite-chlorite and to a lesser extent the micas are more widespread. It follows, therefore, that either the Pamlico and Talbot sediments were not derived from such areas or that montmorillonite formed after sedimentation. For the moment we favor the hypothesis of authigenic montmorillonite on the basis of the very fine sand mineralogy and the lack of an alternate montmorillonitic source area. Granted, we are uncertain what proportion of montmorillonite would result from reworked Middle Coastal Plain. But scattered petrographic analysis indicate that both Middle and Upper Coastal Plain have much lower feldspar content that the nine Pamlico and Talbot sites. Because this leaves the Piedmont and mountains as the most readily conceivable sources of sediment for the Talbot and Pamlico, the montmorillonite is thought to be largely authigenic.

The picture thus painted by the nine sites is one in which the very fine sand has undergone little diagenetic change, but extensive montmorillonite formation may have occurred in the clay mineralogy toward the regionally more abundant clay minerals. At this point, however, the clay mineral inferences and speculation as to origins of sediment must be held in abeyance until they can be tied into a more detailed picture of the Lower Coastal Plain. We are looking into the mineralogy of today's tidal marshes and of the sediment carried into them by the major streams. Another step will be more detailed mineralogical examination of the Middle Coastal Plain in localities where our geomorphic studies provide stratigraphic control.

MIDDLE COASTAL PLAIN

The Middle Coastal Plain morphostratigraphic units are those surficial deposits occupying the interstream divide area between the Coats and Surry scarps (Table 1). The surface altitudes range from about +275 to about +100 feet. Excluded from these MSU are the eolian sands found along river valleys (Daniels *et. al.*, 1969) modern alluvium, and the up-valley equivalents of the Wicomico MSU that may occur considerably above 100 feet. The distribution of scarps in the Middle Coastal Plain is shown in Figure 10.

Stratigraphy

The basal materials of interest to us in the Middle Coastal Plain are the Cretaceous Black Creek, Eocene Castle Hayne, Miocene Yorktown formations and saprolite of unknown age from various crystalline and metamorphic rocks. The Black Creek is found in the Goldsboro area and in the region to the southwest, whereas the Castle Hayne is encountered largely on the Neuse-Cape Fear divide from about Newton Grove to Mount Olive. Typical Yorktown is common on the Neuse-Tar divide from slightly west of Wilson to the Surry Scarp. These basal units seldom outcrop except in stream valleys, and nowhere do they come to the surface of the divides in significant area.

Morphostratigraphic Units

Three morphostratigraphic units make up the bulk of the surficial deposits in the Middle Coastal Plain. These are the Brandywine, Coharie, and Sunderland that Stephenson (1912) and Cook (*et. al.*, 1943) gave formational rank. These units disconformably overlie the Cretaceous to Miocene stratigraphic units. This contact may have considerable relief or be a gently sloping plane. The sediments of these MSU are extremely variable and make it difficult to characterize them as distinct lithologic units. In general, the coarsest sands and gravels occur near the base of each unit, and there is a gradual change upward to more clay and silt and finer sands. Most of the lower coarse units have less than 10 percent feldspar in the sand and the clay fraction is dominantly

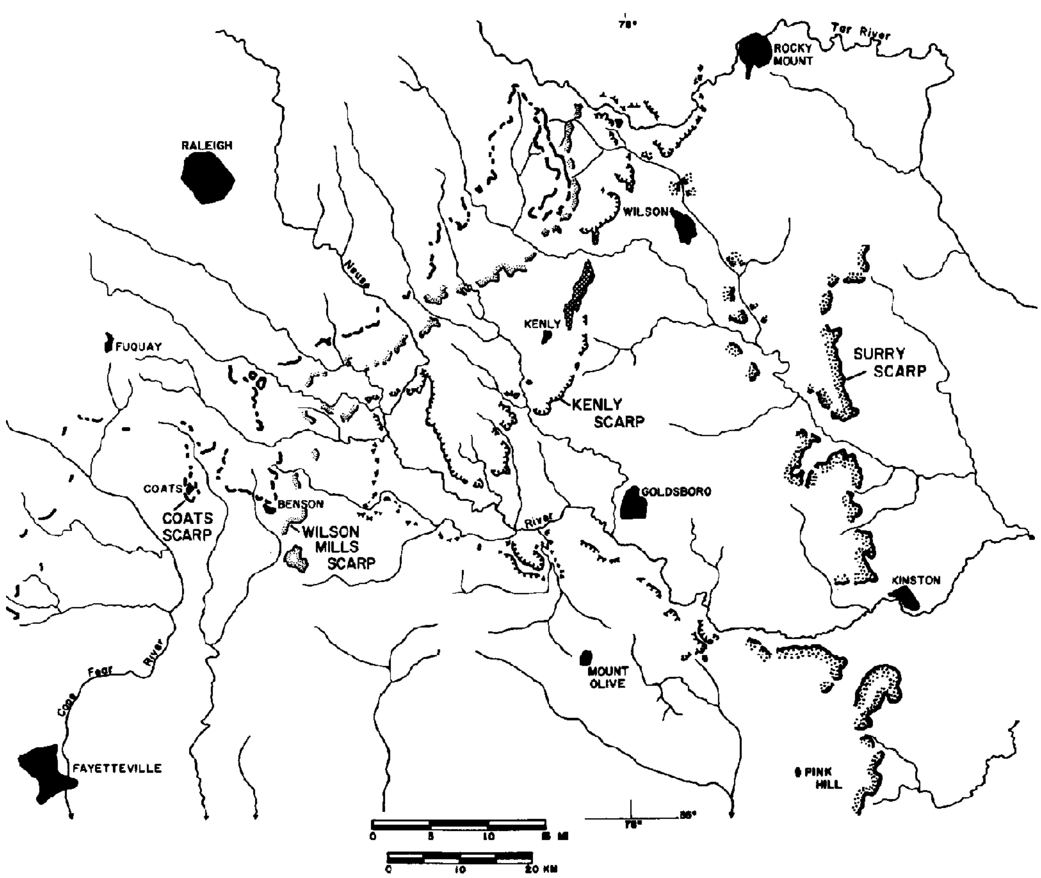

Figure 10.

kaolinite (Gamble and Daniels, in preparation). Only in very local areas, such as near Wilson, North Carolina, do these surficial sediments have more than 10 percent feldspar in the very fine sand fraction (Daniels *et. al.*, 1966c). The upper one-half of one-third of the section can be slightly finer sands with a little more clay than the underlying beds that interfinger horizontally with more sandy beds (Daniels *et. al.*, 1966C) that have no apparent pattern of surface expression. By contrast, there are large areas, the Newton Grove vicinity for example, where the upper sediments are a very uniform sandy clay loam with the major variation in particle size of the upper 6 feet being produced by soil formation.

We have done very little regional mapping of major sediment characteristics in the Middle Coastal Plain. A fine sand, a silty sand, and a medium sand unit have been mapped near the Surry Scarp (Daniels *et. al.*, 1966a) and a medium-fine sand unit has been recognized as being distinct from a more common updip mixed sand unit on the Neuse-Cape Fear Divide (Daniels and Gamble, in press).

The Brandywine, Coharie, and Sunderland MSU are delineated largely on the basis of the Kenly and Wilson Mills scarps (Table 1), which break the Middle Coastal Plain into three major surfaces. Earlier workers mapped these MSU as separate formations, but little proof has been presented that indicates one way or another what happens to the units across these scarps. Several detailed traverses (Fig. 11) have been drilled across the Kenly and Wilson Mills scarps in an attempt to establish these relations. The traverse across the Kenly Scarp indicates little or no change in sediments, or in the elevation at the base of the surficial unit. The traverses across the Wilson Mills Scarp indicate a similar relation on the Neuse-Cape Fear Divide. However, on the Neuse-Tar Divide the drill traverse suggests the possibility that these sediments are two units separated in time (Fig. 11b). Within the Black Creek Valley the Brandywine and Coharie are distinctly separated in altitude both at the top and the base (Fig. 12). There commonly is little change in sediments between these three MSU that can be described in a borehole or found in laboratory analyses. We have the impression that the sands become somewhat finer from the Coats to the Surry Scarp and that the gravels near the base become smaller and less abundant, but good quantitative proof is lacking. Based on the general characteristics of the sediments, and the absence of conclusive evidence of any significant lithologic changes of sediments across the scarps in all areas, we believe that the surface deposits in the Middle Coastal Plain in our area are one formation, not three as previously believed.

The Middle Coastal Plain MSU are sharply separated from the Upper and the Lower Coastal Plain. Considerable evidence has been presented by (Daniels *et. al.*, 1966b) showing that the Coats Scarp and its subsurface equivalent truncate the Pinehurst and Macks Formations that underlie the upper Coastal Plain (Fig. 12). The Surry Scarp can be seen to truncate the sediments of the Sunderland MSU both in the surface mapping and in cross section (Daniels *et. al.*, 1966a).

Depositional Environment

One of the most difficult jobs in studying the Stratigraphy of the surficials of the Coastal Plain is determining their depositional environment. Road cuts usually are too shallow to get below the zone of disturbance produced by soil formation, and the few borrow pits or deep cuts available for study seldom show distinct bedding. The lower coarse unit so common in the Middle Coastal Plain MSU (see Daniels *et. al.*, 1966a; 1971a, Fig. 2) does show some conspicuous cross-bedding and repeated channeling that we interpret as evidence for a fluvial origin. These coarse basal units have not yielded any trace of marine fossils. Very small areas of

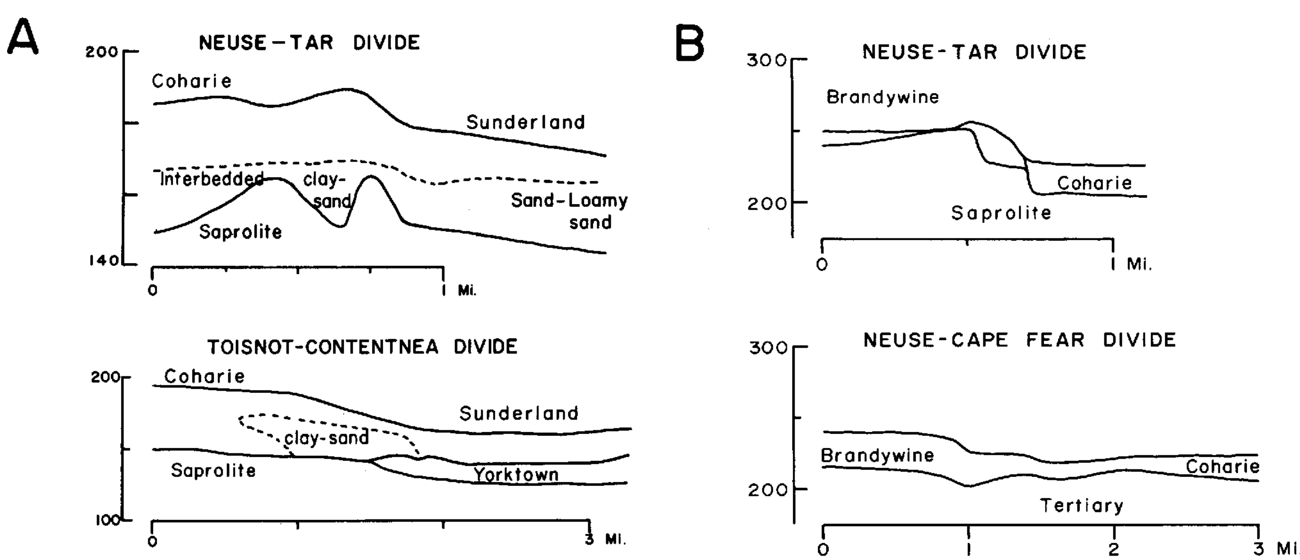

Figure 11.

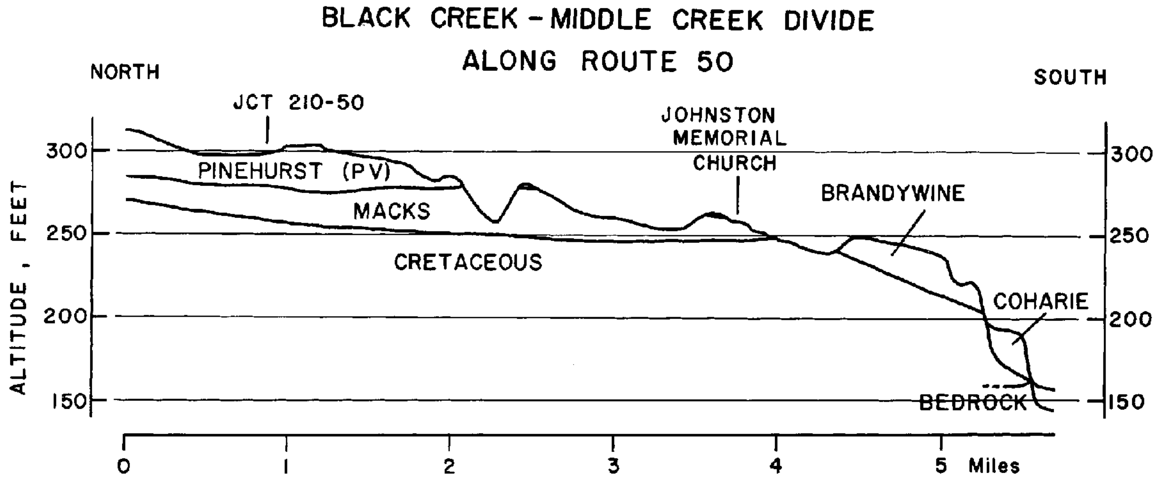

Figure 13.

the basal unit near Mount Olive and near Newton Grove are sulfide-rich, and these beds may indicate a brackish water environment (Daniels and Gamble, in press). A large area on the Neuse-Cape Fear Divide southeast of Mount Olive is composed of 30- to 90- foot thick medium to fine sands with a few basal pebbles. This is possibly a marine unit, but this interpretation is based largely on the thick section of clay-poor sand.

A fluvial origin for the basal part of much of the Middle Coastal Plain seems likely. But there is also the possibility of some brackish water and near-shore marine environments. The absence of fossils, even of a few molds, in the sand unit weakens the argument for a marine origin.

The origin of the upper fine portion of the MSU in the Middle Coastal Plain is even more in doubt than that of the basal portion. The upper part normally is massive or nearly so where it is exposed in cuts, and the bedding present usually is very weak and not indicative of any one environment. The clays, silts, and generally more clayey matrix of the upper portion (Daniels *et. al.*, 1966c, 1966a, 1966b; Daniels and Gamble, in press), plus the finer sand sizes show a lower energy environment than the basal part. Another possibility is an upward increase in clay from greater weathering of the near-surface beds. But there are few or not weatherable minerals in most sections to produce the clay, and where large quantities of feldspars are found there is no appreciable decrease in clay content at the point where the feldspars appear. Apparently, the fining upward of these sediments is a depositional, not a weathering, feature.

If the basal coarse zone is fluvial, is the upper fine of the same origin? The gradual change upward suggests a gradual change in energy of environment, but it is hard to visualize a fluvial unit overlain by a marine upper unit that would have a gradational contact. A marine transgression should leave a marked disconformity that is traceable. This disconformity has not been recognized. Yet, there is some evidence that suggests such a process has operated at least once.

The sediments of the basal Sunderland MSU in the Goldsboro area are coarse textured, conspicuously cross-bedded and channeled sands with common gravel layers and clay-ball conglomerates in the channel bottoms. These sands grade upward into massive clayey and silty beds with one nearly pure clay bed up to 11 feet thick. The Goldsboro Ridge, near Goldsboro, North Carolina, is a sandy ridge 5 miles long and ¾ miles wide, rising 20 to 30 feet above the surrounding Sunderland surface (Daniels *et. al.*, 1971a). The sand to sandy loam of the Goldsboro Ridge has an abrupt conformable contact to the clayey upper unit of the Sunderland (Fig. 13). There is very little evidence of channeling and no indication of pre-Goldsboro Ridge weathering of the underlying clay. The sands of the ridge have not yielded fossils, and cut for study of sedimentary structures do not exist. An eolian and fluvial origin for the ridge has been rejected (Daniels, *et. al.*, 1971a), and a lagoonal origin for the ridge suggested, with a sea level stand at about 145 feet, the level of toe of the nearby Kenly Scarp to the west.

It must be admitted that a marine origin for the ridge is not proven beyond any doubt, but at the present it seems to be a good working hypothesis. One difficulty is that the only disconformity that can be traced is at the base of the sand ridge where it overlies the fine upper part of the Sunderland. This suggests that at most places on the Sunderland surface near Goldsboro, the transgression resulting in the Goldsboro Ridge did not leave any other evidence behind.

The Coats and Wilson Mills scarps (Fig. 10) can be traced for miles in North Carolina with toe altitudes that vary about 5 feet. The Kenly Scarp has a uniform toe altitude of 145 feet except where it swings up into the Tar River Valley. Each of these scarps can be traced up into each major river valley a short distance, usually without a change in scarp altitude. These river valleys, therefore, must have been in existence when the scarps were formed. If the sediments to the east of these middle Coastal Plain scarps are fluvial, and fluvial processes formed these scarps, then we should expect

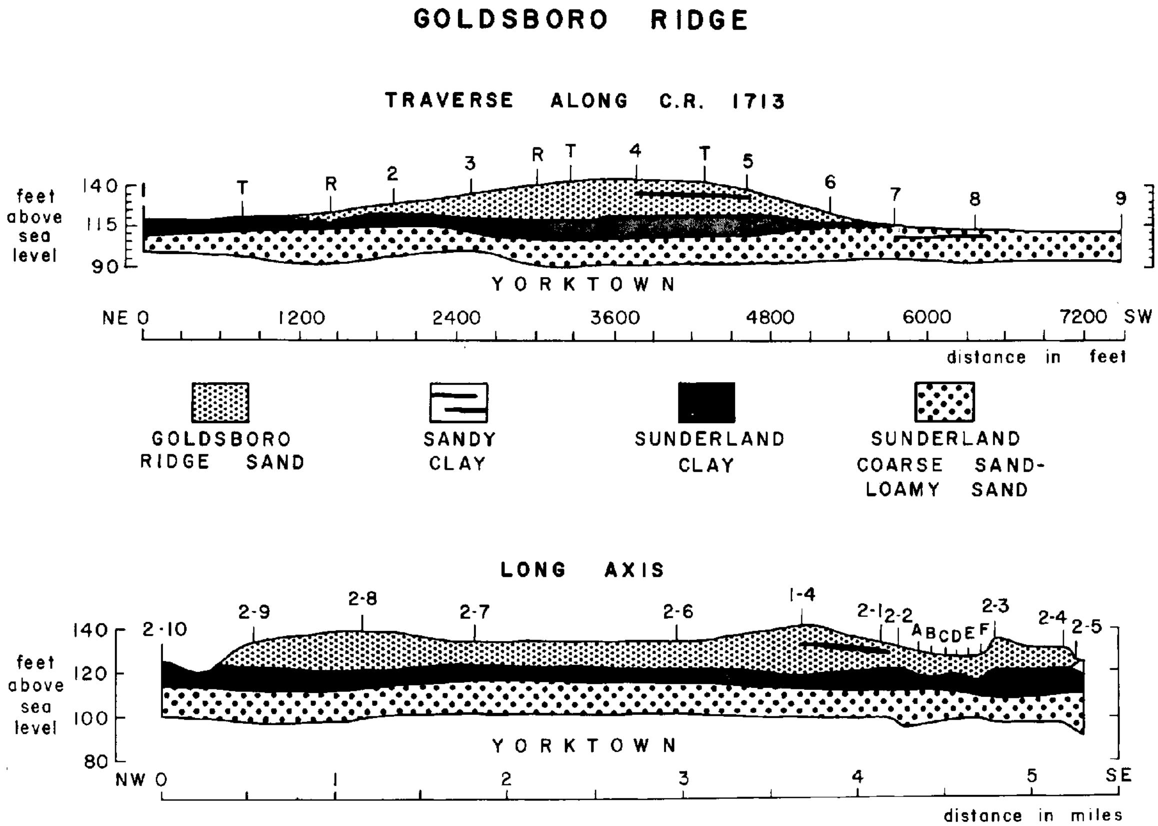

Figure 13.

the toe altitude of the scarp should increase to a maximum in the river valley. The altitude of the scarp should increase to a maximum in the river valley. The toes of the scarps increase in altitude up some of the river valleys, but there is little or no change in altitude of the toe from the mouth of one river system to the next. This indicates a common control for the scarp throughout the area and suggests either a marine origin or control.

Another feature that seems to negate a strict fluvial origin for the scarps and associated geomorphic surfaces is the slope of the surface. The Sunderland, Coharis, and Brandywine geomorphic surfaces generally are highest in the center of the divides and slope gently toward the streams (see Wilson and Coharie Quadrangles). If these were truly fluvial depositional surfaces we would expect them to slope from the axis of stream at the time of deposition to the interstream area. It is possible that these surfaces are post-depositional erosional surfaces of low gradient, but if they were erosional, one should find a relatively smooth, depression free slope from the divide toward the stream valley. We find as many irregular-shaped depressions next to the stream valley as we do in the divide center. (see soil map, Daniels *et. al.*, 1967a). The same general kind of topography starts up into the major river valleys. Therefore, an erosional nature seems to be inconsistent with the available data. A drainage inversion after deposition also is unreasonable because the scarps go up present valleys, not the axis of the interfluves. We suggest that these surfaces sloping toward the river valleys are depositional in nature but that the exact mechanism of formation is unknown.

The relatively uniform toe altitudes of the Coats, Wilson Mills, and most of the Kenly Scarp can be interpreted as evidence of former stands of sea level. But there are no sand dunes or beach ridges at the tops of these scarps that would indicate an open ocean, and we have no evidence of offshore barriers. We suggest that this uniform toe altitude means a close sea level control of deposition, but not necessarily stands of sea at these precise elevations. The Wilson Mills and Kenly scarps can be interpreted as erosional features since there is no change in sediments across these scarps in many areas (Fig. 11). It is possible that these scarps represent still-stands or short-term transgressions.

UPPER COASTAL PLAIN

The Upper Coastal Plain is bounded on the west by the Piedmont and on the east by the Coats Scarp. The toe of the Coats Scarp has an altitude of 275 feet. The sediments in the Upper Coastal Plain include the Pinehurst, Macks, and Cretaceous (Black Creek and Tuscaloosa) formations (Fig. 14).

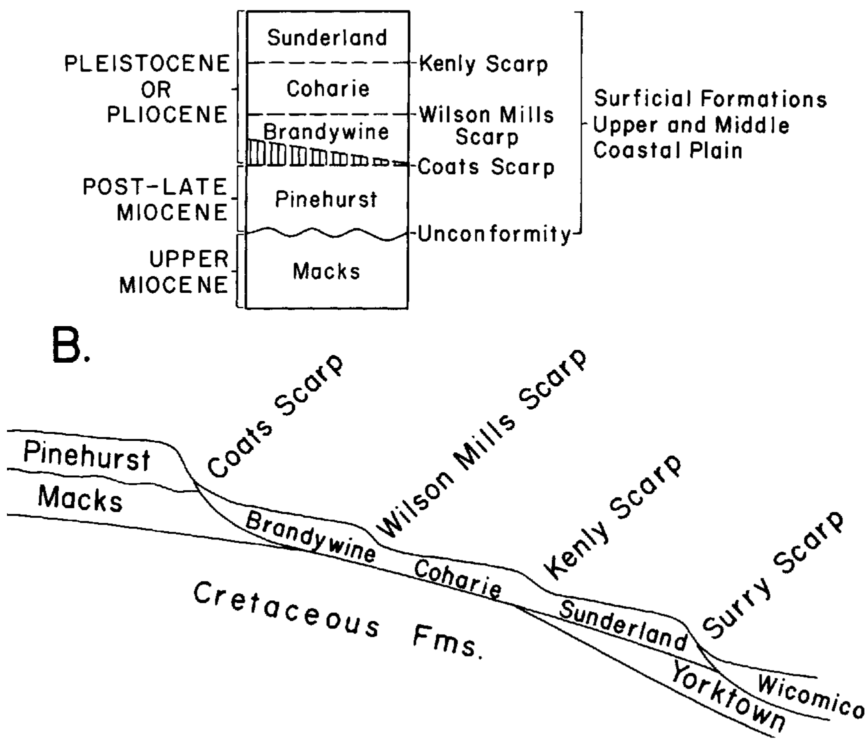

Figure 14.

Macks Formations

Much has been written about the Cretaceous Formations (Stephenson, 1923; Swift and Heron, 1969) and we have little to add here. The Macks is a sub-surface formation that holds the key position for dating some of the events in the Upper Coastal Plain. It has a distinctive lithology, and its outcrops are on valley slopes. The upper part of the Macks is a massive, micaceous, fine to very fine sandy loam to sandy clay loam. There are beds of clay with a purple cast that have limited areal extent near Benson. The upper micaceous materials grade downward to slightly coarser sediment. Near the southeast part of its distribution (Fig. 15) there are discoidal, rough surfaced, well-rounded pebbles at the base. These pebbles are almost duplicates of the beach gravels that Stephenson (1912) reported in the Coharie Formation near this area.

One of the best places to see a typical outcrop of Macks is about 1/8 mile north of Macks Crossroads on North Carolina Highway 50 north of Benson (Fig. 16). (Field tour stop 7). The nature of the contact to the overlying and underlying sediments can be examined, and the distinctive lithology of the formation is well expressed.

We have found the Macks in bore holes north of the Neuse River and have traced it to Bailey. Additional drill holes are needed to trace the formation to the Tar River and to establish its relations to other sub-surface units in that area. The south and western distribution of Macks is about that shown earlier (Fig. 15) (Daniels *et. al.*, 1966b, Fig. 5).

The Macks has external and internal molds of marine fossils. A significant number of identifiable fossils were found in a small creek that crosses Route 50 about 0.2 miles north of the junction of Route 50. A drill traverse near the creek (Fig. 17) shows the relations between the Cretaceous formations, a thin layer of probable Eocene material, the Macks, and the Pinehurst.

Pinehurst Formation

The Macks and Cretaceous Formations between the Piedmont and Benson, North Carolina, are generally overlain by sediments that are varying mixtures of gravel, sand, and clay with only minor amounts of silt (Daniels *et. al.*, Table 1, 1966b). The proportions of each component change abruptly both horizontally and vertically. But the coarser sands and gravels are near the base of the formation, and the finest sands and largest amounts of clay are near the top. The sediments of the Pinehurst are not as variable as those of the Cretaceous formation, but are much more variable than the intervening Macks. The lithology and geological setting are similar to the Pinehurst area mapped by Conley (1962).

Cooley (1970) has mapped three stratigraphic units in the central Sandhills region of North Carolina as the Citronelle, Pinehurst, and Brandywine Formations. Two of these units, the Citronelle and Brandywine, are typical coarse-grained fluvial sediments. However, the Citronelle is found exclusively above the Orangeburg Scarp (our Coats Scarp), and the Brandywine is found below the scarp at elevations of less than 270 feet. The Pinehurst, as restricted by Cooley, is an eolian unit with a coarse to medium sand with

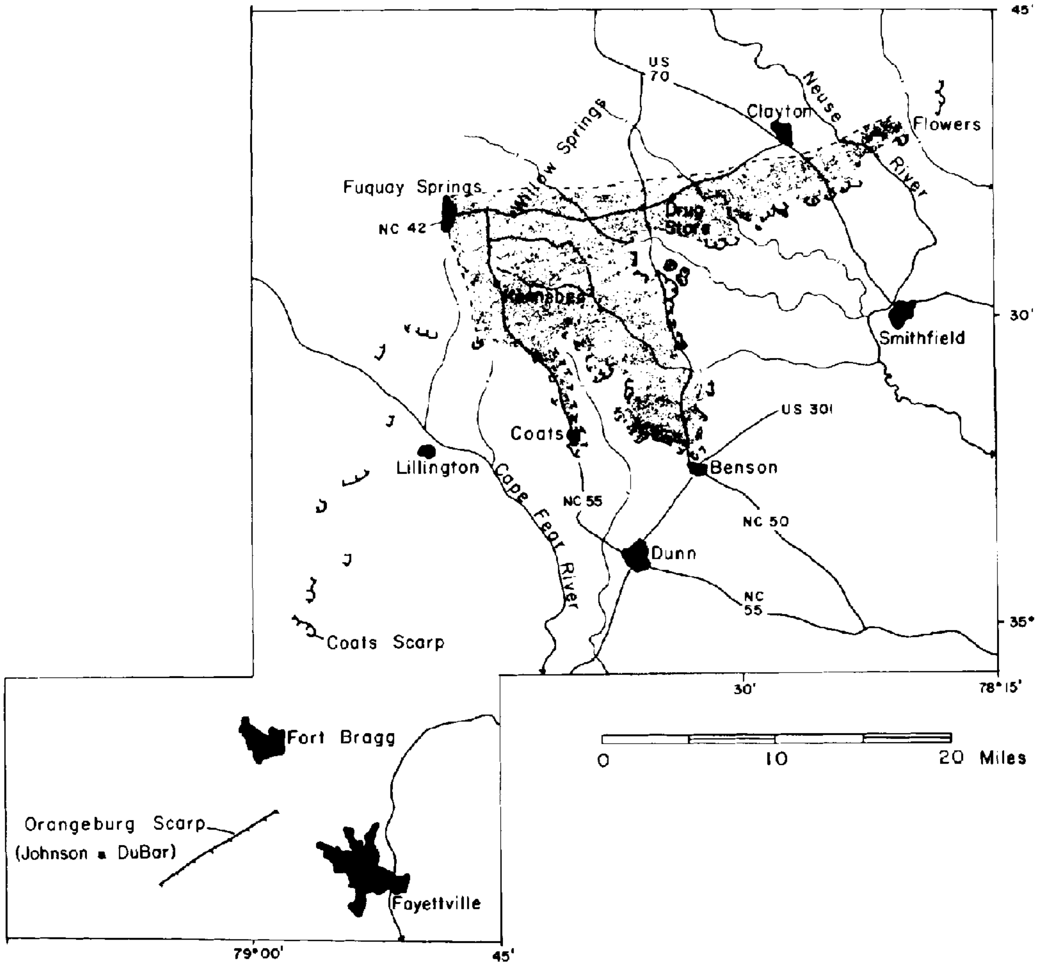

Figure 15.

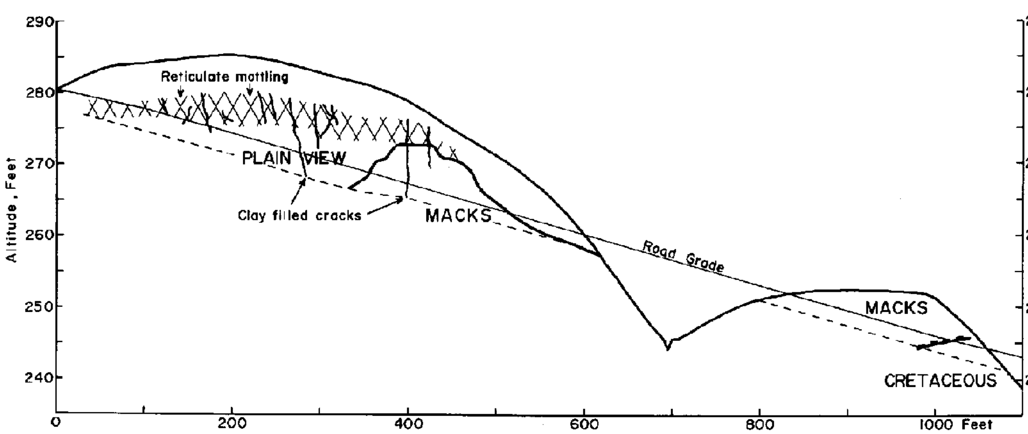

Figure 16.

rare pebbles and prominent cross-stratification. Clearly, our Pinehurst is similar in origin and elevation to Cooley's Citronelle. The problem goes somewhat to the fact that, in the description of his type section, Conley (1962) did not state precisely at what level in the quarry section the base of the Pinehurst Formation was. In that section, the upper sands are of the type called Pinehurst by Cooley; the lower gravels may be part of the Middendorf Formation (upper Tuscaloosa Group).

The resolution of this nomenclature problem is outside the scope of our present information. Drilling in the area between Wake and Moore counties and a more precise typing of Cooley's Citronelle with pre-Orangeburg scarp sediments in South Carolina is needed.

But, in spite of difficulties, we believe that the Pinehurst as Conley conceived it and the surficial sediments above the Macks west of the Coats Scarp are the same. The Pinehurst is more applicable to these sediments that the term "high

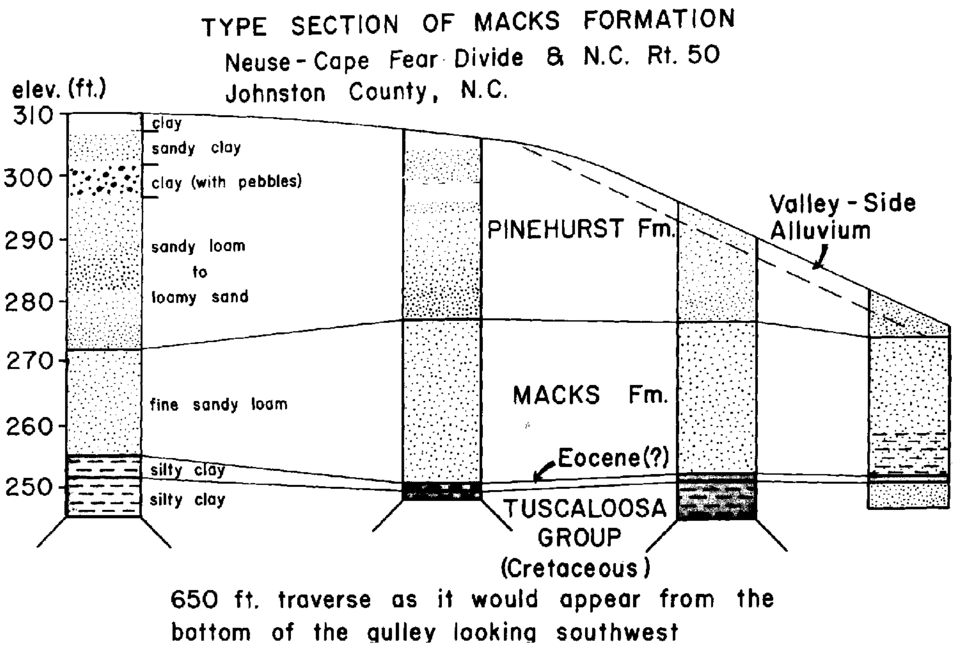

Figure 17.

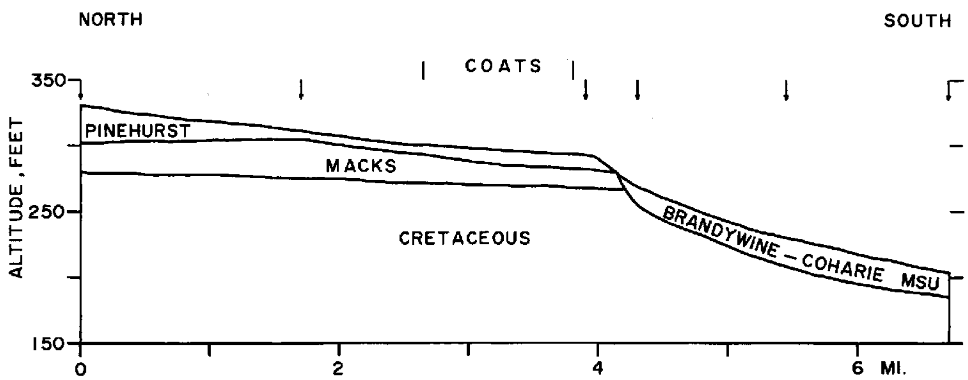

Figure 18,

level" or the Citronelle of Doering (1960) that included large areas of Coharie and Brandywine MSU. The Pinehurst apparently is the Lafayette of Stephenson, a name that was later abandoned.

Pusey (1960) believes that most of the post-Miocene sediments in this area are fluvial. The sediments are nearly massive, or have indistinct horizontal and cross-bedding. No clear-cut evidence of eolian activity has been found. Large cut and fill structures, the rough erosional contact at the base, and the stringers or thin lenses of gravel, and the variable occurrence of gravel beds near the base indicated a fluvial origin. The fact that no molds of fossils have been found also suggests a fluvial origin (see Grabau, 1925, p. 655).

Dating Surficial Deposits in the Upper, Middle, and Lower Coastal Plain

By being able to place the Macks Formation in the stratigraphic column, we can put a maximum date on the Pinehurst, or at least that part of the Pinehurst Formation that overlies the Macks. The Macks is upper Miocene, and there is an erosional disconformity between it and the overlying Pinehurst. There is not change in weathering across the contact, however, so it is possible that the Pinehurst could be a regression following the transgression that resulted in deposition of the Macks (Daniels *et. al.*, 1966b). The Pinehurst therefore, could be as old as late Miocene to as young as early Pleistocene. But a pre-Pleistocene age is indicated if the total stratigraphic section is considered.

The Coats Scarp truncates the Pinehurst and the Macks Formations (Fig. 18). If the Pinehurst is very late Miocene, then the Coats Scarp can be no older than early Pliocene.

The Coats and the Orangeburg scarps are the same in many places, but the Orangeburg may contain additional elements in other areas. The Coats has a toe altitude of 275 feet (plus or minus 5 feet) and has been traced to South Carolina where it essentially joins the Orangeburg as mapped by Johnson and Du Bar (1964). The difference between their mapping of the Orangeburg in southern North Carolina and our mapping of the Coats in the same area is more a matter of concept than actual difference. In South Carolina, the Orangeburg can have a toe altitude as low as 210 feet

(Colquhoun, 1965). Thus, it crosses the altitude range of the Coats and Wilson Mills scarps in North Carolina. We suggest the possibility that where the toe of the Orangeburg drops below 250 feet that a later scarp, such as our Wilson Mills, may actually swing into and truncate the Orangeburg. This happens at Sims, North Carolina, where the Wilson Mills Scarp truncates the Coats Scarp and the Pinehurst sediments. This leaves a scarp with a top of about 300 feet and a toe of 210-215 feet, a very prominent feature in this area of the Coastal Plain.

The sediments associated with the Brandywine MSU overlie the buried part of the Coats Scarp (Fig. 18), and therefore these sediments must be nearly contemporaneous with or younger than the erosion of the scarp. The Coharie and Sunderland MSU apparently are younger that the Brandywine (Figs. 11A, B, 15) but how much younger is questionable. The great similarities in sediments across the scarps separating these units, their surface form, the slopes of the non-eroded part of the surface (Daniels & Gamble, in press) and their relation to the underlying sediments (Fig.11) all suggest that the Middle Coastal Plain units are closely related in time and environment. The Surry Scarp truncates these MSU in much the same manner as the Coats Scarp truncated the Upper Coastal Plain units (Daniels *et. al.*, 1966a, 1966b; Fig. 18). Thus, time discontinuities of unknown magnitude separate the Middle Coastal Plain from the upper, and the Lower Coastal Plain form the middle. Because we have no fossils in the Middle Coastal Plain, we can only date it as being no older than early Pliocene and no younger than pre-Surry scarp erosion. We have no fossils to give the possible age of the Surry Scarp, but it probably is closely related to the Wicomico MSU. (Colquhoun *et. al.*, 1968) have dated the Wicomico in South Carolina as being Pleistocene.

In the Lower Coastal Plain, the evidence given in this paper and from other studies seems overwhelming that the Talbot and Pamlico MSU are Pleistocene. But there is little fossil evidence that can be used to separate these units in time, or to place them accurately within the Pleistocene. If the idea that the Wicomico and Talbot MSU are parts of the same formation were confirmed by additional studies, then it would be possible to definitely place the Wicomico within the Pleistocene. Part of this problem may be resolved when we are able to work out the relations between the Small sequence and the surficial morphostratigraphic units. If these surficial units postdate the Small Sequence, and the Small is early Pleistocene, then it is possible that the Wicomico and Talbot are somewhere in the mid-Pleistocene.

SOME RELATIONS BETWEEN COASTAL PLAIN STRATIGRAPHY, GEOMORPHOLOGY, AND SOILS

One of the primary purposes of our work has been to relate the geology of the Coastal Plain to soil formation. Stop 10, of the field tour is a soil pit (Fig. 19) in Pinehurst materi-

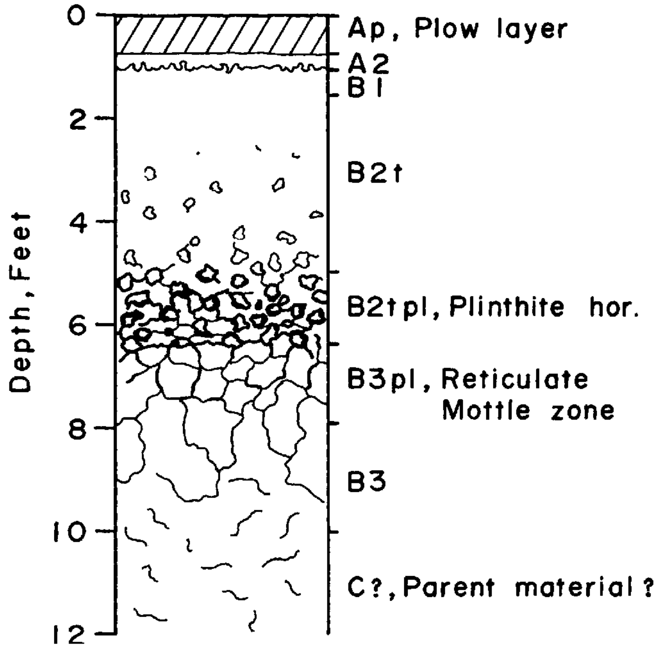

Figure 19.

als on the Plain View geomorphic surface. From the stratigraphic and geomorphic work done in the area; we believe that the site of the pit has been stable since pre-Brandywine time (Daniels *et. al.*, 1971b). Our soils investigations in the Upper and Middle Coastal Plain (Daniels and Gamble, 1967; Daniels *et. al.*, 1970) have strongly suggested that any one soil-forming process may be discontinuous over time, and that any one soil-forming process may be discontinuous over time, and that geologic events such as landscape dissection, operating through its control on water levels, may have considerable influence on the direction of soil formation. In areas of uniform lithology, there are major changes in process and in resultant soil morphology that are related to the micro-topography and subsequent slight changes in soil-water table.

The soil profile description and laboratory data for Stop 10, are in the appendix. The major features in the soil are the upper bleached sand A2 horizon, a sandy clay loam brown B horizon, and the plinthite- or sesquoxide-rich lower B horizon (Fig. 19). The development of each horizon is subject to several interpretations, but we believe they illustrate the close link between soils and geology.

The A2 horizon between 8 and 12 inches has been considered by some workers in soils and geology to be a separate deposit, frequently of unknown origin (Pirkle *et. al.*, 1964; Howard, 1955; Clark, 1912; Conley, 1962) whereas others consider the A2 horizon as part of soil development (Altschuler and Young, 1960; Hope, 1956; Rivers *et. al.*, 1963; Gamble, 1966; Daniels and Gamble, 1967; Daniels *et.*

al., 1967b; Gamble *et. al.*, 1970a).

Several areas in the Upper Coastal Plain were intensively studied by Gamble (1966), who found no change in the distribution of sand sizes between the A2 and B horizon. In the Middle Coastal Plain we have strong evidence that the thickness of the A2 horizon can be correlated with depth to water table (Daniels *et. al.,* 1967b), the thickest A2 horizon being associated with the area where water tables are deep, *i.e.,* the dry edge. In uniform materials, the clay content of the underlying B horizon increases as the clay content of the overlying A2 horizon decreases and as the A2 thickens. The contact between the A2 and B horizons is abrupt, but if carefully examined it has a micro-intertounged — rather than a sharp, smooth — contact. This suggests it has formed by weathering. Several other lines of evidence (Gamble *et. al.*, 1970a) indicate that the A2 horizon of most level to nearly level Coastal Plain soils is a weathering product. Influence of the sediment characteristics on A2 horizons is shown by the presence of thick A2 horizons on san deposits and thin horizons in silty or clayey deposits. The formation of an A2 horizon is much more than a simple weathering because it reflects the total geologic and biologic environment of the site.

The horizon of clay accumulation in the soil, the Bt at 12 to 50 inches, has been a focal point of many studies by soil scientists throughout the world. A textbook explanation for the development of a Bt horizon is that there has been translocation of clay from the A to the B horizon. Weathering of primary minerals in the B may add to the clay increase and result in a decrease in clay from the B to deeper C horizon where less weathering presumably has occurred. Because there are few or no weatherable minerals throughout the Pinehurst section in this area (Gamble and Daniels, in preparation), there probably is little clay formed by weathering of these minerals. Other evidence suggests that some translocation of clay from the A2 to the B horizon may account for the increase of clay in the B. Also, the gradual increase in clay from the base to the top, which is characteristic of all Middle and Upper Coastal Plain MSU, may account for most of the clay in the upper part of the soil. Thus the process of Bt horizon formation may require little more than the development of a less clayey A horizon. The geologic control of the character of many well-drained soils is shown by the fact that thick fine-textured soils occur largely on deposits with thick fine-textured upper sections. Conversely, sandy soils occur on sandy deposits. This does not deny, however, that weathering and certain transformations have not taken place in the B horizon. The C horizons are essentially kaolinitic clays and quartz sans, yet in the Bt horizon, there is nearly as much gibbsite as kaolinite (Table 2).

The plinthite horizon (from 58 to 94 inches at Stop 9) is an excellent example of the interaction between geologic processes and soil-forming processes. Plinthite is defined (Soil Survey Staff, 1960) as an accumulation of sesquioxides that will harden irreversible upon repeated wetting and drying. There are many concentrations of iron oxides that are red that never harden, and these are not plinthite. From our studies in the Middle Coastal Plain, we are reasonably sure that plinthite formation starts under a fluctuating water table in the B horizon (Daniels *et. al.*, 1961c). These conditions probably result in some localized reduction of iron on clay surfaces (Daniels *et. al.*, in press) and its migration and concentration into red mottles. These horizons become dry several times during the year; aging of the iron oxides is possible so that they are not easily reducible (Bloomfield, 1955). Once the plinthite makes up about 10 percent of a horizon by volume, plinthite perches water and the water regime of the horizon remains relatively stable even though dissection has lowered the main water table. The main water table may be several feet below the plinthite horizon, yet a perched soil-water table may be several feet below the plinthite horizon, yet a perched soil-water table on or above the plinthite horizons maintains a saturation very similar to that found in soils with incipient plinthite. The point to be emphasized is that the total sedimentary, hydrologic, and geomorphic system is involved in the formation of soil horizons. Soil formation is the outer skin of the total geologic environment, and integration of soils and geology is in the best interests of both disciplines.

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ROAD LOG FOR FIRST DAY – SATURDAY

OCTOBER 7, 1972

THE ASSEMBLY POINT FOR THE FIELD TRIP WILL BE IN BRIDGETON, NORTH CAROLINA, ALONG THE SHOULDER OF N.C. HIGHWAY 55 IMME-

APPENDIX

Table 1. Stratigraphic and geomorphic elements in the Neuse Drainage Basin.

LOWER COASTAL PLAIN		
Stratigraphy		
Pamlico MSU	Pleistocene	
Talbot MSU	Pleistocene	
Wicomico MSU	Pleistocene	
Small Sequence (Including James City)	Plio? - Pleistocene	
Yorktown	Miocene	
Castle Hayne	Eocene	
Geomorphic Elements		
Pamlico Surface	+ 2 - + 20	
Talbot Surface	+ 25 - + 45	
Wicomico Surface	? - + 94	
Suffolk Scarp, toe	+ 15 - + 20	
Walterboro Scarp, toe	+ 95	
Surry Scarp, tow	+ 95	
MIDDLE COASTAL PLAIN		
Stratigraphy		
Sunderland MSU	Pliocene	
Coharie, MSU, Brandywine MSU		
Yorktown FM	Miocene	
Castle Hayne FM	Eocene	
Black Creek FM, Tuscaloosa FM	Cretaceous	
Geomorphic Units		
Sunderland Surface	+ 100 - + 145 to + 170	
Coharie Surface	+ 155 - + 215	
Brandywine Surface	+ 220 - + 275	
Kenly Scarp, toe	+ 100 - + 145 to + 170	
Wilson Mills Scarp, toe	+ 145 to + 170 in Tar Valley	
Coats Scarp, toe	+ 275	
UPPER COASTAL PLAIN		
Stratigraphy		
Pinehurst Formation	? Miocene - Pliocene	
Plain View MSU	Upper Miocene	
Piney Grove MSU	Cretaceous	
Macks Formation	Cretaceous	
Black Creek Formation	Cretaceous	
Tuscaloosa Formation	Cretaceous	
Geomorphic Elements		
Plain View Surface	+ 290 - + 325	Surfaces are discontinuous and occupy <10% of the area west of the Coats Scarp
Pine Grove Surface	+ 290 - + 350	

TABLE 2

CLAY FRACTION[1] MINERALOGY FROM TRAVERSE NORTH OF NEUSE RIVER AND SITES IN CARTERET COUNTY

Site and Material	Depth (feet)	Minerals[2][3] MT	MV	VR	CL	VC	VM	MI	KK	QZ	FD	AS
ST1E Talbot[4]	4-9		5					2	3	1		
	13.5-18	5				1		3	2	1		
TR4 Talbot[4]	1-6		5					2	2			
	13.5-17	5						2	2			
ST1 Talbot[4]	3.5-5	1		5			2	2	2	1		
	13.5-17.5		4				2	4	2	1		
S306 Minnesott	1-2					5			2	2		
Ridge[4]	9-10						*			4	*	*
	19-20	2				4		2	2	2	2	
	34-35	1				3	2	4	2	2	2	
Talbot	35-42	2				2		4	3			
ST17 Pamlico[4]	1-4	5						2	2	1		
	4-5.5	5						2	1	1		
	11-13	5						2	2	1		
Talbot?	13-14	5						3	2			
ST20 Pamlico[4]	2-3.5		5					2	2	1		
	7.5-8.5	5						2	2	1		
	8.5-10.5	5						2	2	1		
PR10 Pamlico[4]	3.5-5					5		2	2	2		
	8.5-10				2	3		4	2	2		
	13.5-18	5			1		1	2		1	1	
PR17D Pamlico[5]	0.7-1					5		2	2	2		
	7-8	4	2		1			3	2	1		
	18.5-19.5	4	2				3	3	2	1		
PR38 Pamlico[5]	13.5-18.5	2			2		2	3	2	2	2	
Small	33.5-38.5					2	4	3	2	1	1	

[1] Size fraction less than 0.002 mm.
[2] Mineral code: MT = montmorillonite, MV = montmorillonite-vermiculite, VR = vermiculite, CL = chlorite, VC = vermiculite-chlorite, VM = vermiculite-mica, MI = mica, KK = kaolinite, QZ = quartz, FD = feldspar, AS = amorphous.
[3] Approximate weight fractions: 5 = >1/2, 4 = 1/2-1/3, 3 = 1/3-1/5, 2 = 1/5-1/20, 1 = <1/20, * = quantity uncertain.
[4] Twenty mile traverse north of Neuse River. ST1E, TR4, ST1 are west of Minnesott Ridge. ST17, ST20, PR10 are east of ridge.
[5] Sites south of Neuse River. PR17D is in the Harlowe vicinity. PR38 is near Cedar Island.

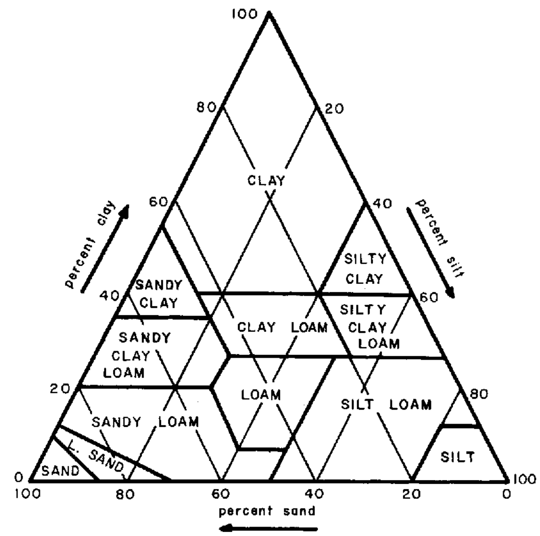
TABLE 3

VERY FINE SAND[1] MINERALOGY FROM TRAVERSE
NORTH OF NEUSE RIVER AND SITES IN CARTERET COUNTY

Site and Material	Depth (feet)	FD	QZ	FE	ZR	RU	SP	TM	ST	KY	GN	EP	CL	MS	TE	HN	AU	EN	PO	Other
		Minerals[2] number %																		
ST1E Talbot[3]	4-9	16	70	5	1		<1	<1			<1	<1	1	4		<1		1	<1	AG<1 GO<1
	13.5-18	15	73	4	2			<1			2					1		<1		SR2
TR4 Talbot[3]	1-6	10	84	2	<1	<1	<1	<1					<1	<1		<1		<1	<1	SR<1
	13.5-17	18	75	1	1		1	<1				<1		1		2				DI<1
ST1 Talbot[3]	3.5-5	24	50	15	7	<1	1	<1	<1					1		1				
	13.5-17.5	27	60	6	2		<1	<1			1		<1	2		1		<1		
S306 Minnesott Ridge[3]	1-2	14	35	42	7		<1			<1	<1			<1		<1		<1		
	9-10	13	39	36	7		<1		<1	1	1			<1		1	1	<1		
	19-20	14	52	19	10		1	<1			1					2		<1		
	34-35	17	46	22	9		<1	1			1		<1	<1		1	1	1		
Talbot	35-42	24	61	6	4		1	<1			1			<1		1	<1	<1	<1	MZ<1
ST17 Pamlico[3]	1-4	17	67	7	4		<1	<1			1			<1		2	<1	<1		MZ<1
	4.5-5	12	68	12	3		<1	<1			1			<1		2	<1	<1		
	11-13	13	69	4	2		1	1			3	<1		1		4	1	1		
Talbot?	13-14	17	76	3	2			<1			<1				<1	<1	<1	<1		DP<1
ST20 Pamlico[3]	2-3.5	17	78	2	<1			<1		<1	<1			1	<1	<1	<1	<1		
	7.5-8.5	15	65	11	3		<1	1		<1	1				<1	1	1	<1		HY1
	8.5-10.5	13	71	7	1		<1	1			1	<1		1	<1	2	1	<1		DP1
PR10 Pamlico[3]	3.5-5	17	76	3	<1			<1			1			1		<1		<1	<1	
	8.5-10	23	65	5	1			1		<1	1				<1	1	1	1		HY<1
	13.5-18	20	66	5	3		1	<1	<1		1	<1			1	2	<1			
PR17D Pamlico[4]	0.7-1	12	83	1	<1	<1	<1	<1			<1	<1		<1	<1	<1	<1	<1	<1	
	7-8	13	69	9	3	<1	<1	<1			1	1		<1	1	1	<1	<1		BZ<1
	18.5-19.5	13	66	10	6		1	1			1			1	<1	1	<1	<1	<1	
PR38 Pamlico[4]	13.5-18.5	15	75	2	2		<1	<1			2			1	<1	1	1	<1		
Small	33.5-38.5	16	71	4	1	1	<1	<1	<1		2			<1	<1	1	1	<1		

[1] Size fraction 0.05-0.10 mm.
[2] Mineral code: FD = feldspar, QZ = quartz, FE = iron oxides, ZR = zircon, RU = rutile, SP = sphene, TM = tourmaline, ST = staurolite, KY = kyanite, GN = garnet, EP = epidote, CL = chlorite, MS = muscovite, TE = tremolite, HN = hornblende, AU = augite, EN = enstatite, PO = plant opal, AG = antigorite, GO = goethite, SR = sericite, DI = diatomite, MZ = monazite, DP = diopside, HY = hypersthene, BZ = bronzite.
[3] Twenty mile traverse north of Neuse River. ST1E, TR4, ST1 are west of Minnesott Ridge. ST17, ST20, PR10 are east of ridge.
[4] Sites south of Neuse River. PR17D is in the Harlowe vicinity. PR38 is near Cedar Island.

U. S. D. A. TEXTURAL TRIANGLE



DIATELY NORTH OF ITS JUNCTION WITH U.S. 17.

This assembly point is 1.2 miles north of the corner of Broad and Front Streets (Holiday Inn) in New Bern, and is just north of the north end of the large bridge over the Neuse River which carries Highways U.S. 17 and N.C. 55 across the Neuse River.

Mileages have been corrected after checking the car against measured mileages.

0.0 Assembly point in Bridgeton, N.C., on N.C. 55 at its junction with U.S. 17. Hard, wide shoulder here.

0.2 Blueberry farm on left of Pamlico Surface, Elevation 9 ft.

2.4 Craven-Pamlico County line, Upper Broad Creek.

6.5 Bear left at country store, continuing on N.C. 55.

8.9 Sign advertising Hookerland Shopping Center.

9.4 Creek (Not named).

9.7 Talbot surface. Ahead, you are looking at the back slope of the Minnesott Ridge.

10.3 Western base of the Minnesott Ridge.

10.7 Grantsboro. Turn left (north) onto N.C. Highway 306.

10.75 Railroad crossing and feel mill.

For about the next 8 miles you will be driving along the crest of the Minnesott Ridge with the Suffolk Scarp to the right (east). Note the nearly continuous strip of houses, yards, and small farms on both sides of the highway. These man made features serve to emphasize the differences already present because of the well drained sandy soil of the Minnesott Ridge and make the ridge very conspicuous from the air. In fact, this trip at the top of the Minnesott Ridge is very conspicuous even in the famous photography taken by astronauts over eastern North Carolina. This photograph is reproduced in part on the road map handed out with this guidebook.

11.3 Power line overhead. To left (west) you can look down the back slope of the Minnesott Ridge onto the Minnesott Ridge onto the Talbot surface.

12.8 County Road 1200. Suffolk Scarp visible down road to right (east).

16.05 Pamlico-Beaufort County line.

18.2 County Road 1926. Suffolk Scarp visible down road to right (east).

22.0 Turn left (west) on County Road 1927.

22.15 Start down back slope of Minnesott Ridge.

22.25 Site of Hole 1B. Note the generally wetland vegetation occurring at the foot of this site.

22.3 Western base of Minnesott Ridge. Talbot surface.

22.5 Junction. Bear left on County Road 1931.

22.65 Creek.

22.75 Road bends to left and then a sharp right.

23.0 **STOP 1**

Site of Drill Hole 1A. The U.S. Dept. of Agriculture, Soil Science Division will be auguring a hole as we drive up. The elevation of this site is 34.2 feet and is on the Talbot surface. See Cross Section of Figure 8.

23.05 Turn around at one of two places as indicated by traffic directors. We will retrace our route back to N.C. 306.

23.65 Junction with County Road 1927. Stop sign. Turn right.

24.0 **STOP 2**

Site of Drill Hole 1B. This site is at 47 feet, and is about half way up the back (western) side of the Minnesott Ridge. An auger hole will have been drilled prior to our arrival here. The purpose is to show the sediments of the Minnesott Ridge, the h horizons (humate) and the peat at the top of the Talbot.

24.2 Junction with N.C. 305. Continue straight ahead on County Road 1927, but *please* watch out for cars on 305!

24.5 County Road 1930 to left.

24.7 Bend in road. Top of Suffolk Scarp. Look ahead to the east, fasten your seat belts, take a deep breath and hold your hands over your ears. You are going down the scarp face!

24.9 Toe of scarp. Continue ahead on the Pamlico MSU fossiliferous Talbot MSU, and the upper part of the Small sequence. The ditch on the right side (south) of the road has Pamlico fossils usually below the water line.

25.0 **STOP 3**

Hole 1C of Figure 8. The section consists of Pamlico MSU fossiliferous Talbot MSU, and the upper part of the Small sequence. Note the extreme smoothness of the Pamlico surface with lack of depressions.

25.1 Turn around on side roads as indicated by traffic director.

26.0 Intersection with N.C. 305. Turn to left (south).

37.2 Junction with N.C. 55. Turn right (to west).

43.4 Pamlico-Craven County Line.

46.2 Junction with U.S. 17.

47.3 Holiday Inn in New Bern. Junction with U.S. 70. Turn left on U.S. 70.

47.55 North end of Trent River Bridge.

47.95 South end of Trent Bridge. Go past stoplight and cross railroad tracks.

48.75 Turn right onto service road. Wait for caravan to regroup by Craven Animal Hospital and James City School.

49.5 Return to dual highway at yellow blinker. Typical flat Talbot surface between here and Croatan.

55.8 Croatan National Forest sign.

57.3 Sign for village of Croatan.

57.5 Haywood's store.

58.2 Turn left on County Road 1107 into Neuse River Recreation Area.

59.8 **STOP 4 AND LUNCH STOP**

Paving ends. Enter campground and park. Unconformable contact of Talbot MSU (Neuse Formation of Fallaw and Wheeler or the Flanner Beach Fm. of DuBar and Solliday) on top of the Small-James City Sequence. Walk down steps to beach and turn right (to southeast). Excellent exposures, with abundant shells in the Talbot MSU and abundant fossil wood in the Small Sequence.

61.5 Junction with U.S. 70. Turn right toward New Bern.

71.6 South end of Trent River Bridge.

72.0 North end of Trent River Bridge.

72.25 Holiday Inn. Junction with U.S. 17. Turn left on U.S. 70 and 17. Go through New Bern Business district.

For the next 56 miles you need not pay close attention to the rest of the caravan. We will regroup on Wayne County Road 1719. There will be someone at that corner to call attention to it.

73.9 Junction with U.S. 17 south. BE SURE TO BEAR RIGHT AND REMAIN ON U.S. 70 toward Kinston.

77.6 Note depressions (sinks) on either side of the road. These are probably form solution of Castle Hayne limestones. There are a number of the apparent sinks for the next half-mile.

79.1 Junction with N.C. 55. Bear left and remain on U.S. 70. Notice the pine trees with hardwood understory that is typical of timber growth on medium and fine textured soils. Contrast this with the growth on the Wicomico surface just west of the Surry Scarp.

83.75 Hamlet of Tuscarora.

84.4 Base of Walterboro Scarp.

84.85 Top of Walterboro Scarp and Tuscarora Fire Tower. Note that the tower was placed at the top of the scarp so that they could see so much farther. Notice how your car engine labors as you go up the scarp. Look back (east) and the scarp can be clearly (?) seen.

85.1 Note crooked pine trees with flattened tops. This is very typical of sandy soils with Bh (humate) horizons.

89.5 Cove City. Textural character of sediments under the Wicomico surface have not been mapped, but there appears to be a somewhat indistinct pattern of bands of sandy sediment alternating with bands of sediments of finer texture. There appears to be no topographic expression to the crudely banded belts, but they are very important to any agricultural or other use of the area. Remote sensing techniques might help in delimiting these areas.

97.9 Craven-Jones County Line.

101.9 Jones-Lenoir County Line.

105.9 Junction with U.S. 258 from south at Kinston.

109.5 Continue ahead on U.S. 70. U.S. 258 turns north. The scarp ahead separates an unknown surface from the Talbot surface. The Talbot surface in this area has an altitude of about 60 feet, but it is a distinct surface within the Neuse River Valley. The Talbot surface has been traced downstream to the vicinity of Grifton where the altitude is between 45 and 50 feet.

112.7 Typical smooth to gently undulating topography of the in-valley Talbot surface. This surface is extensively cultivated in the valley where it ranges from 50 to 70 feet. It is much more intensively farmed than it is on the interstream divide between the Neuse and Pamlico Rivers.

115.2 Round curve. Walterboro Scarp ahead.

115.55 Toe of Walterboro Scarp. The scarp rises to the Sunderland surface here. The Wicomico surface has been completely cut out by the Walterboro Scarp at this point.

116.0 Top of Walterboro Scarp. This surface is a part of the Sunderland surface that has a number of Carolina Bays and sandy flats. Here the topography and sediments have a greater resemblance to the Sunderland south of the Neuse River than to the rest of this surface north of the river.

116.6 Carolina Bays to left and right.

121.3 Lenoir-Wayne County Line. Be alert; in another 1.5 miles you will turn right onto a County Road.

122.85 TURN RIGHT onto County Road 1719 (north). (A Union Oil Station is across Highway 70). This is typical flat Sunderland surface.

124.7 Cross railroad track at Best and turn left on Wayne County Rd. 1003.

126.0 Slight bend in road to right. This is the eastern terminus of the Goldsboro Ridge, a possible marine feature. Note the very sandy soil typical of a Carolina Bay rim. There are bays in the woods to the left (south). Note soil is very sandy to the left (south) but clayey to the right (north). Note smooth Sunderland surface toward northwest.

127.7 TURN LEFT on Wayne County Rd.1713, (south).

127.9 Goldsboro Ridge starts to rise slowly.

128.8 Cross railroad tracks. Large grain elevator to left (east). The Carolina Bay shown in the traverse in our Goldsboro Ridge article is about 1 mile to the east along these railroad tracks, and hence on the Goldsboro Ridge. Note that we now go down the steeper south face of the ridge.

129.0 Base of Goldsboro Ridge.

130.6 Junction with U.S. 70 By-Pass. Turn right onto U.S. 70. The Goldsboro Ridge is in the trees to the right all along here.

132.8 Turn right onto U.S. 13 to north. Sign says to “Snow Hill.”

133.0 Junction with U.S. 13. Continue ahead to north.

133.2 Note very conspicuous south slope of Goldsboro Ridge ahead.

133.75 Base of steep part of ridge.

134.05 Junction with Wayne County Rd. 1003. Turn left along crest of ridge. Elevation about 140’.

135.0 Western terminus of Goldsboro Ridge. Elevation on Sunderland surface is about 120’ on very silty material here. There are irregularly shaped depressions on these silty surface but we have yet to find Carolina Bays.

135.1 Junction with Wayne County Rd. 1565. Turn left.

136.2 **STOP 5**

Turn left on surface road adjacent to U.S. 13. Park. Typical development of course facies of Sunderland MSU with medium to coarse sands with many pebbles tending to be concentrated in layers. Fluvial cross-bedding.

Very good development of an A2 horizon overlying a medium textured Bt horizon. Weathering and soil formation have obliterated many primary structures to depth of cut.

136.7 Turn right on U.S. 13.

136.9 Stream valley. Outcrops of Black Creek Fm. lie unconformably beneath the Sunderland MSU in this valley.

138.85 Turn right to Business U.S. 117 north.

137.1 Merge with U.S. 117. Bus. toward Wilson.

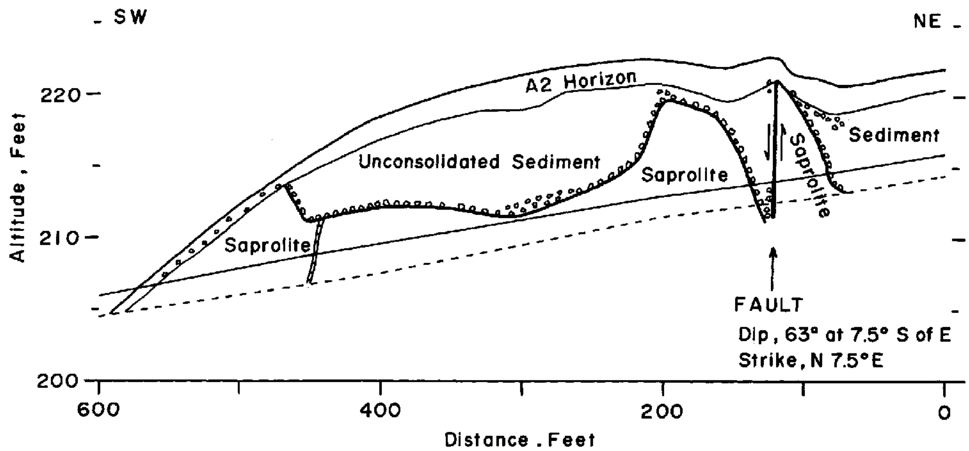
140.8 Belfest School on right (east).

141.4 Pineview Baptist Church on left (west).

141.5 Turn left on Wayne County Rd. 1316, (west).

141.7 **STOP 6**

Cross railroad tracks. Park as best you can. Belfast Bedrock Outcrop. Walk along the tracks about 0.1 mile north of the road. Here the railroad cut is in a



Stop 6.

knoll of slate or phyllite. This conspicuous knoll rises about 20 feet higher than any other natural features in the vincinity and is interposed between the western terminus of the Goldsboro Ridge about 5 miles to the southeast and the Kenly Scarp about 3 miles to the northwest. This knoll lies further east than any other known outcrop of crystallines at this latitude. Except along the Kenly and Wilson Mills scarps, outcrops of crystallines are found in areas of lower elevation such as stream valleys and not on "monadnocks" such as this one. The slate or phyllite is very typical of many of the metashales and metatuffs of the Carolina Slate Belt.

141.9 Junction with U.S. 117. TURN LEFT (north).

145.7 Village of Pikeville.

148.5 Village of Fremont, N.C. 222 joins us.

148.6 Left turn one block later on N.C. 222.

149.8 Horizontally bedded clayey sand, probably Yorktown Fm.

153.2 Intersection with N.C. 581. Continue ahead on N.C. 222.

154.6 Toe of Kenly Scarp.

154.7 Wayne-Johnston County Line.

155.1 Top of Kenly Scarp.

158.4 Kenly, N.C. Cross U.S. 301.

163.2 Typical expression of Coharie surface in its least dissected part.

163.6 Wilson Mills Scarp ahead.

163.85 Toe of Wilson Mills Scarp.

164.4 On Brandywine surface at top of scarp.

165.8 Junction with N.C. 42. TURN LEFT.

167.1 Exposure of saprolite.

167.4Exposure of saprolite.

168.3 **STOP 7**

Fault showing Coharie MSU against Paleozoic crystallines. Junction with N.C. 39. Park around the junction. Walk o.05 to 0.1 mile west on N.C. 42 to outcrop showing a fault in the Coharie "Formation".

170.5 Junction with N.C. 96. Continue on N.C. 42.

171.8 Riding on upper edge of Brandywine MSU; the hill ahead to the west rises to the upper Coats Scarp off to the right. The scarps are discontinuous.

173.3 Buffalo Creek. In this area are typical examples of Upper Coastal Plain morphostratigraphic units north of the Neuse River. These units are thin and extremely variable.

176.3 Outcrop of Macks Fm. on left side of road.

176.5 Fault or left side of highway now covered by slump. The fault involves Coastal Plain units and saprolite. There are rounded pebbles smeared along the gouge.

176.6 Upper Coastal Plain morphostratigraphic units and saprolite.

177.2 Neuse River.

177.7 Junction with U.S. 70. Turn right (west) toward Raleigh. This is the area of transition from Coastal Plain to Piedmont. Some of the higher hill tops have Pinehurst Formation on them as far west as Garner.

183.7 Johnston-Wake County line.

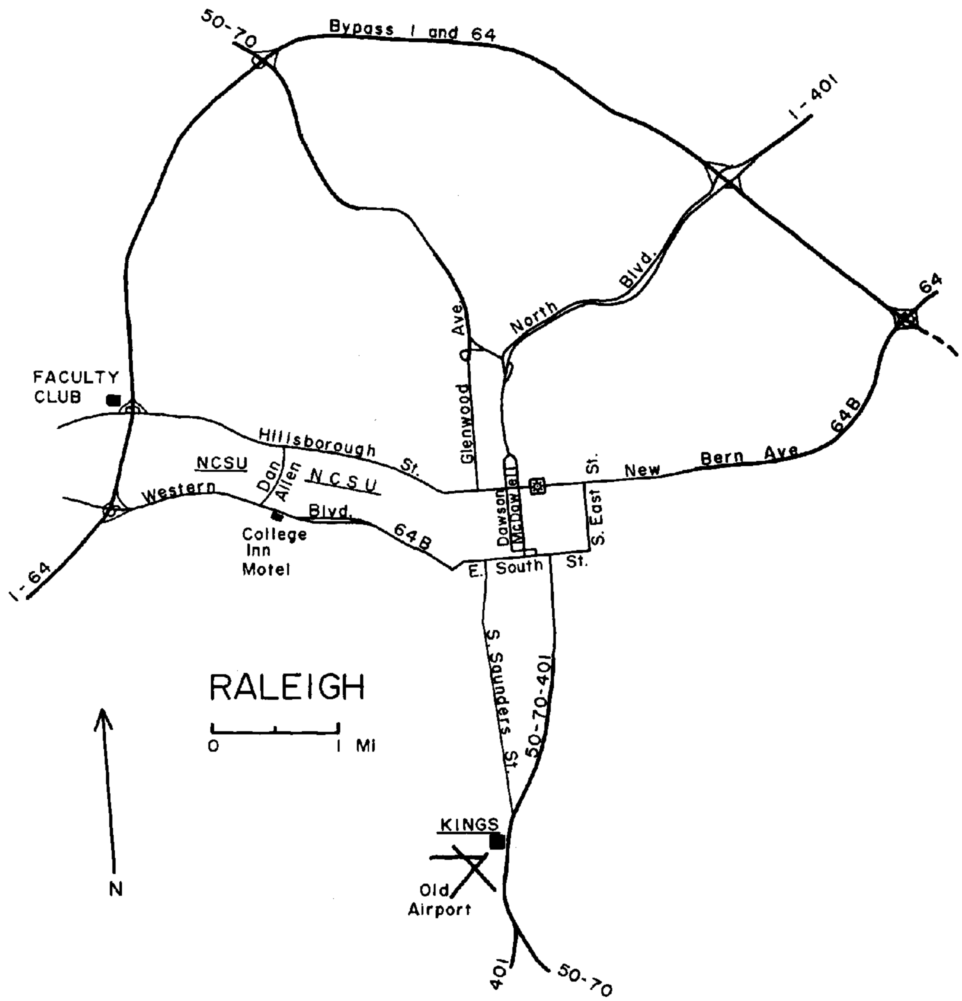
188.1 Fault on right bank involving unconsolidated material and saprolite. There are pebbles along the gauge zone.

193.1 Junction with U.S. 401 South. Continue on U.S. 70.

194.0 First traffic light. Get into left hand lane.

194.2 Second traffic light at King's.

End of field trip for first day. The location map furnished you shows King's, College Inn Motel and faculty club. The Raleigh inset on the North Carolina



map should also help you.

ROAD LOG FOR SECOND DAY – SUNDAY, OCTOBER 8, 1972

The assembly point for the field trip will be the Kings and Winn-Dixie parking lot on U.S. Highway 70-401 and N.C. Highway 50 near the south edge of the city of Raleigh. Assembly point, Kings parking lot in south Raleigh.

0.05 Turn right onto Highway 70-401-50. Get into middle lane.

0.35 Stop light.

0.6 Bear left on Highway 70 and 50.

2.6 Underpass.

2.9 Get into right lane.

3.1 Turn right (to south) on N.C. 50 toward Benson.

5.8 New Bethel Baptist Church. We start to drop down into Swift Creek Valley.

6.45 Swift Creek.

7.5 Piedmont-Coastal Plain contact at top of slope up from Swift Creek Valley. Note sandy surface so characteristic of Coastal Plain soils.

10.6 Wake-Johnston County Line. Note that the stream valley has cut down into the red saprolite typical of areas underlain by the crystalline rocks of the Piedmont. We are passing across the innermost part of the Coastal Plain. The cover of sediments is sufficiently thin, so that streams of even modest size will typically cut through the thin covered Cenozoic and/or Mesocoic materials and incise slightly into the Paleozoic crystallines. The pattern on a map is an interdigitation of Coastal Plain and Piedmont rocks with the latter cropping out in the valleys.

11.45 Intersection with N.C. 42.

11.17 Several "Carolina Bays" off to right.

12.0 Note the stoneline between the Coastal Plain sediments and the underlying saprolites.

13.0 Middle Creek.

13.15 Brandywine MSU unconformable on saprolite.

13.45 Elevation 270 ft. on the Brandywine surface. Off to the right (to southwest) the Coats Scarp can be seen through gaps in the trees.

15.3 Isolated hill with roadcut of Macks Fm.

17.1 Junction with N.C. 210. This is the Plainview surface which is underlain by typical Pinehurst sediments. Elevation 300 ft.

19.3 Begin descent into Black Creek Valley.

20.5 Eroded remnant of Brandywine terrace in Black Creek Valley.

21.25 Black Creek (the name of the stream, NOT the formation).

22.05 Northern edge of Stop 4. Contact of Macks Fm. unconformably overlying Tuscaloosa-Black Creek Formation.

22.15 Unconformable contact with the non-marine Pinehurst Fm. on the underlying marine Macks Fm.

22.25 **STOP 8** Macks Crossroads. Park car and walk back (to north). Pinehurst Formation (Plainview MSU) unconformably overlying Macks Fm.

22,7 Typical Upper Coastal Plain topography (especially of the Plainview surface), with good development of plinthite.

23.2 "Carolina Bay" on Plainview surface to left (east) behind Godwin grocery store.

23.5 Prominent draw off to right (west). Fossiliferous Macks Formation is exposed in this draw.

23.7 Turn right on County Road 1305.

23.95 Turn right (north) through fence gate into fields. Follow along fence to wooded area.

24.15 **STOP 9** Macks Formation**.** Fossiliferous outcrops of Macks Formation occur along the channel of the small stream in the wooded area. Downstream the Macks Formation unconformably overlies gray loamy sands of Middendorf (Upper Tuscaloosa) lithology.

24.55 Turn left on County Road 1305.

24.8 Turn right on N.C. 50.

24.85 Turn left almost immediately onto County Road 1168.

24.95 Turn left onto a farm lane. Park car in road.

25.1 **STOP 10.** Soil profile demonstration to illustrate a typical thick highly weathered old Upper Coastal Plain soil with plinthite.

25.4 Turn left on N.C. 50.

25.6 Turn right on County Road 1168.

27.3 Stop sign. Cross County Road 1303. The Denning homestead is off to your left. Both farms that you have just been on are part of the Denning properties.

28.1 Johnston-Harnett County Line. Road becomes County Road 1703.

28.25 Stop sign. Cross County Road 1551.

28.55 Turn right (west) at J.L. Adams grocery onto Highway 27 towards Coats.

31.2 Middle of Black River Valley.

32.4 "City" limit of Coats.

32.9 Turn left (south) on N.C. 55.

33.65 City limits at south edge of town of Coats.

34.5 Top of Coats Scarp. You are on the surface (Pinehurst Fm.) looking down onto the Brandywine surface and "Formation."

36.5 Toe of Coats Scarp.

36.55 **STOP 11.** Turn left onto dirt road. Cross railroad tracks and park.

End of Field Trip!

Stop 10
Plinthic Paleudult; fine loamy, siliceous, thermic
Profile S62-NC-51-7

Location: One-fourth mile east on road no. 1168 from junction of road no. 1168 and state route 50 and 871 feet north from road no. 1168, Johnston County, North Carolina.

Slope: 0 to 1/2 percent.

Vegetation: Cultivated.

Geomorphic Surface: Depositional (?) Plain View surface at top of Pinehurst formation.

Sampled By: W. D. Nettleton; E. E. Gamble; R. J. McCracken; L. E. Aull; and R. B. Daniels, 3/1/62.

Horizon & Beltsville Lab. No.		
Ap 62145	0-8"	Grayish brown (2.5Y 5/2) loamy sand; single grain; loose; few extremely firm sesquioxide nodules less than 1/4-inch with rough exterior; Pinehurst formation; abrupt wavy boundary.
A2 62146	8-12"	Light yellowish brown (2.5Y 6/4) loamy sand; single grain; loose; very few extremely firm subrounded, sesquioxide nodules < 1/4-inch diameter; gradual wavy macro boundary; micro boundary - irregular with tongues 1/2-to 1-inch wide and 1 to 2 inches long extending into the lower horizon between 11 and 13 inches, but the boundary between the tongues of A2 and the B1 is not sharp.
B11 62147	12-18"	Brownish yellow (10YR 6/6) sandy clay loam; massive breaking out as fragmental; fraible; common fine and medium pores; gradual smooth boundary.
B12t 62148	18-27"	Brownish yellow (10YR 6/6) sandy clay loam with more clay than the overlying horizon; massive breaking to fragmental; friable; few fine and medium pores; few subrounded extremely firm sesquioxide nodules averaging 1/4-inch in diameter with smooth shiny exteriors; interior colors are dusky red and dark red (10R 3/4 and 3/6); a dense rind 1/16-to 1/32-inch thick surrounds a less dense slightly softer interior; the nodules increase in number below 22 inches; gradual smooth boundary.
B21t 62149	27-34"	Brownish yellow (10YR 6/6) sandy clay loam with more clay than horizon above; fragmental; very few clay films on fragment faces and on sesquioxide nodules; friable; few fine and medium pores; few medium strong brown (7.5YR 5/8) mottles; few to common 1/4- to 1/2-inch subrounded extremely firm red (2.5YR 4/6) sesquioxide nodules; clear smooth boundary.
B22t 62150	34-42"	Brownish yellow (10YR 6/6) sandy clay loam; fragmental with few thin discontinuous clay skins and common clay films around soft nodules; slightly firm; common medium distinct yellowish red (5YR 5/8) mottles; common friable red (2.5YR 4/8) sesquioxide nodules; few extremely firm subrounded red (2.5YR 4/8) nodules; few fine quartz pebbles; clear wavy boundary with a relief of 2 to 3 inches.
B23t 62151	42-50"	Variegated brownish yellow, light gray and reddish yellow (10YR 6/6, 7/2 and 7.5YR 6/8) sandy clay loam; fragmental; common thin discontinuous clay films around soft sesquioxide nodules; slightly firm with locally brittle (moist) bodies; clean sand grains in few large pores; many < 1/4-inch friable red (2.5YR 4/8) irregular shaped sesquioxide nodules with reddish yellow exteriors; common extremely firm 1/4-to 1/2-inch red (2.5YR 4/6) sesquioxide nodules; clear irregular boundary from 48 to 52 inches.
A'2(?) 62152	50-58"	Light gray (2.5Y 7/2) sandy clay loam ranging to sandy clay; fragmental; friable to firm; many coarse brownish yellow (10YR 6/8) mottles surrounding red (2.5YR 5/8) sandy clay loam irregularly shaped bodies up to 3/4-inch long; 2/3rds of the red bodies brittle to extremely firm and 1/3rd soft; common discontinuous coatings around soft red bodies; few extremely firm yellowish red (5YR 4/8) irregularly shaped sesquioxide nodules; clear smooth boundary. A tongue of coarse material from 48 to 58 inches was sampled (sample no. 62157).
B'2tpl1/ 62153	58-79"	Light gray (2.5Y 7/2) sandy clay; many very coarse dark red (10R 3/6) extremely firm nodules bounded by yellow (10YR 7/8) mottles 1/16-to 1/8-inch wide; few fine friable red (2.5YR 4/8) mottles; fragmental; many coatings on red nodules and mottles; gray bodies are firm; gradual smooth boundary.
B'31pl 62154	79-94"	Reticulately mottled light gray (2.5Y 7/2) and red (10R 4/6) bounded by brownish yellow (10YR 6/8) mottles less than 1/8-inch wide; gray bodies are sandy clay; red bodies sandy clay loam; fragmental; few to common thin discontinuous coatings around red bodies; slightly firm with few slightly brittle bodies; few extremely firm red (10R 5/8) sesquioxide nodules with dense 1/8-inch thick rinds; nodules are subrounded and 1/8- to 1/2-inch in diameter; few fine and medium quartz pebbles; few medium and coarse pores lined with clean sand grains; gradual smooth boundary.
B'32 62155	94-120"	Variegated red and brownish yellow (2.5YR 4/8 and 10YR 6/8) sandy clay loam; fragmental; few thin discontinuous clay films in pores; slightly firm; common medium light gray (2.5Y 7/2) sandy clay mottles; few extremely firm dark red (10R 3/6) irregularly shaped nodules 1/4- to 1/2-inch in diameter; few medium pores; clear smooth boundary.
IIC1 62156	120"+	Variegated white, red and brownish yellow (2.5Y 8/2, 10R 4/6 and 10YR 6/8) clay; massive; firm; base of observation 135 inches.

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL ____ SOIL Nos. S62NC-51-7 LOCATION Johnston County, North Carolina

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 62145-62157

Depth (In.)	Horizon	1B1b Total: Sand (2–0.05)	Silt (0.05–0.002)	Clay (< 0.002)	Size class and particle diameter (mm) 3A1 — Sand: Very coarse (2–1)	Coarse (1–0.5)	Medium (0.5–0.25)	Fine (0.25–0.1)	Very fine (0.1–0.05)	Silt: 0.05–0.02	Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1: 2A2 > 2 <76 Pct.	2 – 19 Pct. of < 76mm	19 – 76
		← Pct. of < 2 mm											→					
0-8		87.7	9.8	2.5	3.6	30.9	24.5	21.0	7.7	3.6	6.2	19.4	80.0			tr.		
8-12		77.9	15.7	6.4	5.0	24.3	21.5	19.9	7.2	4.0	11.7	19.2	70.7			tr.		
12-18		59.3	11.9	28.8	3.4	16.7	16.7	16.3	6.2	3.3	8.6	16.4	53.1			tr.		
18-27		61.5	9.3	29.2	5.7	19.0	16.5	14.8	5.5	2.7	6.6	13.9	56.0			2		
27-34		58.0	8.5	33.5	4.5	19.9	16.2	12.8	4.6	2.2	6.3	11.6	53.4			tr.		
34-42		58.0	7.3	34.7	4.7	20.1	16.7	12.2	4.3	2.0	5.3	10.8	53.7			3		
42-50		58.2	8.0	33.8	4.9	20.3	16.9	11.6	4.5	2.6	5.4	11.6	53.7			2		
50-58		60.8	7.8	31.4	5.1	21.6	17.6	11.9	4.6	2.3	5.5	11.5	56.2			1		
48-54a		65.5	6.4	28.1	4.4	22.5	20.0	14.2	4.4	1.8	4.6	11.3	61.1			1		
58-79		58.9	6.2	34.9	5.0	17.6	16.1	14.9	5.3	4.2	2.0	15.6	53.6			1		
79-94		60.2	5.9	33.9	4.2	16.6	17.0	16.6	5.8	2.4	3.5	15.3	54.4			9		

Depth (In.)	6A1a Organic carbon Pct.	6B2a Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density g/cc	4A1e 1/3 bar g/cc	4A1h Oven dry g/cc	4D1 COLE	Water content Pct.	4B1c 1/3 bar Pct.	4B2 15 bar Pct.		4C1 WRD in/in		pH 8C1c (1:1) KCl	8C1a (1:1) H_2O
0-8	0.48	0.016	30			0.1												5.3
8-12	0.12	0.006				0.1												5.3
12-18	0.25					1.4												4.8
18-27	0.08					1.6												5.0
27-34	0.06					2.2												5.0
34-42	0.06					2.7												5.0
42-50	0.04					3.2												5.1
50-58	0.04					3.3												5.0
48-54	0.04					1.7												5.0
58-79	0.02					2.7												4.8
79-94	0.02					2.3												4.7

Depth (In.)	Extractable bases 5B1a: 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC: 5A3a Sum cations		6G1d Ext. Al			Ratios to clay 8D1: CEC Sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation: 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	← meq/100 g								→									
0-8	0.9	tr.	tr.	0.1	1.0	2.0	3.0		0			1.20	0.04				33	
8-12	0.6	tr.	tr.	0.1	0.7	1.0	1.7		0.2			0.26	0.02				41	
12-18	1.1	0.3	tr.	0.3	1.7	5.3	7.0		0.9			0.24	0.05				24	
18-27	1.2	0.3	0.1	0.2	1.8	5.0	6.8		0.7			0.23	0.05				26	
27-34	1.6	0.3	tr.	0.1	2.0	5.4	7.4		0.6			0.22	0.06				27	
34-42	1.7	0.3	tr.	0.1	2.1	5.2	7.3		0.6			0.21	0.08				29	
42-50	1.7	0.3	tr.	tr.	2.0	5.2	6.2		0.6			0.18	0.09				16	
50-58	0.4	0.2	tr.	tr.	0.6	5.2	5.8		0.8			0.18	0.10				10	
48-54	0.5	0.2	tr.	tr.	0.7	4.5	5.2		0.8			0.18	0.06				13	
58-79	0.5	0.2	tr.	tr.	0.7	5.0	5.7		1.4			0.16	0.08				12	
79-94	tr.	0.2	tr.	tr.	0.2	5.2	5.4		1.2			0.16	0.07				4	

Depth (In.)	Clay Fraction Analysis 7A1b-d: Mt.	Chl.	Vm.	Mi.	Int. Al-Vm.	Qtz.	Kl.	Gibbsite	X-ray Spectrographic analysis of 0.25-0.05mm sand fraction: ZrO_2 Pct.	TiO_2 Pct.	K_2O Pct.	CaO Pct.
	← 7A2 X-ray					→	DTA 7A3					
0-8	-	-	x	-	tr.	-	15	12	0.10	0.44	0.016	0.041
8-12	-	-	xx	-	x	-	10	8	0.06	0.33	0.011	0.007
12-18	-	-	xxx	-	x	-	13	20				
18-27	-	-	xxx	-	tr.	-	11	18	0.11	0.42	0.011	0.008
27-34	-	-	xxx	-	-	-	30	31				
34-42	-	-	xxx	-	tr.	-	25	20	0.09	0.33	0.008	0.009
42-50	-	-	xxx	-	x	-	26	14	0.10	0.34	0.006	0.005
50-58	-	-	xx	-	x	-	25	14	0.09	0.36	0.005	0.006
48-54	-	-	xxx	-	x	-	30	16	0.08	0.38	0.011	0.007
58-79	-	-	xx	-	-	-	52	10	0.10	0.36	0.004	0.005
79-94	-	-	xx	-	tr.	-	35	7	0.12	0.41	0.004	0.005

Vm. = Vermiculite, mi = mica, Al = Aluminum
Mt. = Montmorillonite, Chl. = chlorite,
Int. = Interstratified layer, Qtz. = quartz, Kl. = Kaolinite

Relative amounts: blank = not determined, dash = not detected, tr. = trace, x = small, xx = moderate, xxx = abundant, xxxx = dominant.

a tongue of A'2

USDA-SCS-HYATTSVILLE, MD. 1966

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SOIL ______ SOIL Nos. S62NC-51-7 LOCATION Johnston County, North Carolina

SOIL SURVEY LABORATORY Beltsville, Maryland LAB. Nos. 62145-62157

Depth (In.)	Horizon	1B1b Total Sand (2–0.05)	Total Silt (0.05–0.002)	Total Clay (< 0.002)	Sand Very coarse (2–1)	Sand Coarse (1–0.5)	Sand Medium (0.5–0.25)	Sand Fine (0.25–0.1)	Sand Very fine (0.1–0.05)	Silt 0.05–0.02	Silt Int. III (0.02–0.002)	Int. II (0.2–0.02)	(2–0.1)		3B2 Cm	Coarse fragments 3B1 2A2 > 2 <76 Pct.	2 - 19 Pct. of < 76mm	19 - 76 Pct. of < 76mm
		← Pct. of < 2 mm																
94-120		61.9	5.1	33.0	3.2	16.1	18.8	17.9	5.9	2.2	2.9	15.4	56.0			2		
120-135		47.6	10.8	41.6	3.2	11.7	12.8	15.1	4.8	2.1	8.7	12.9	42.8			tr.		

Depth (In.)	6A1a Organic carbon Pct.	Nitrogen Pct.	C/N		Carbonate as $CaCO_3$ Pct.	6C2a Ext. iron as Fe Pct.	Bulk density g/cc	Bulk density 4A1e ⅓ bar g/cc	Bulk density 4A1h Oven dry g/cc	4D1 COLE	Water content Pct.	Water content 4B1c ⅓ bar Pct.	Water content 4B2 15 bar Pct.		4C1 WRD in/in	pH	pH 8C1c (1:1) KCl	pH 8C1a (1:1) H_2O
94-120	0.02					2.2												4.7
120-135	0.02					1.3												4.7

Depth (In.)	Extractable bases 5B1a 6N2d Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H2a Ext. acidity	CEC 5A3a Sum cations	CEC	6G1d Ext. Al			Ratios to clay 8D1 CEC Sum	Ext. iron	15-bar water	8D3 Ca/Mg		Base saturation 5C3 Sum cations Pct.	5C1 NH_4OAc Pct.
	← meq/100 g →																	
94-120	tr.	0.2	tr.	tr.	0.2	5.1	5.3		1.5			0.16	0.07				4	
120-135	tr.	0.3	tr.	tr.	0.3	6.3	6.6		4.2			0.16	0.03				4	

Depth (In.)	Clay Fraction Analysis 7A1b-d Mt.	Chl.	Vm.	Mi.	Int. Al-Vm.	Qtz.	Kl.	Gibbsite	
	← 7A2 X-ray					→	← DTA 7A3	→	
94-120	-	-	xx	-	x	-	45	3	
120-135	-	-	-	-	x	-	44	tr.	

X-ray Spectrographic analysis of 0.25-0.05mm sand fraction

ZrO_2 Pct.	TiO_2 Pct.	K_2O Pct.	CaO Pct.
0.09	0.37	0.004	0.005
0.07	0.57	0.013	0.008

Mt. = Montmorillonite, Chl. = chlorite, Vm. = Vermiculite, mi = mica,
Int. = Interstratified layer, Qtz. = quartz, Kl. = Kaolinite
Al = aluminum
Relative amounts: blank = not determined, dash = not detected,
tr. = trace, x = small, xx = moderate, xxx = abundant, xxxx = dominant.

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