U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Moores Creek National Battlefield

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Moores Creek National Battlefield

mocr_geology.pdf

Version: 3/5/2019

Geologic Resources Inventory Map Document for Moores Creek National Battlefield

Table of Contents

Geologic Resources Inventory Map Document 1
About the NPS Geologic Resources Inventory Program 3
GRI Digital Maps and Source Map Citations 5
Index Map 6
Map Unit List 7
Map Unit Descriptions 8
Qal - Alluvium (Quaternary) 8
Qh - Holocene deposits (Holocene) 8
Qwa - Wando Formation (upper Pleistocene) 8
Qs - Socastee Formation (upper Pleistocene) 10
Qph - Penholoway Formation (lower Pleistocene) 11
Qw - Waccamaw Formation (lower Pleistocene) 12
Tb - Bear Bluff Formation (upper Pliocene) 13
Td - Duplin Formation (lower Pliocene) 15
Ku - Cretaceous units, undifferentiated (Cretaceous) 16
Kpd - Peedee Formation (Upper Cretaceous) 16
Black Creek Group 17
Kdc - Donoho Formation (Upper Cretaceous) 18
Kb - Bladen Formation (Upper Cretaceous) 19
Kth - Tar Heel Formation (Upper Cretaceous) 19
Km - Middendorf Formation (Upper Cretaceous) 20
Geologic Cross Sections 22
Cross Section A-A' 22
Cross Section B-B' 22
Cross Section C-C' 23
Cross Section D-D' 23
Cross Section E-E' 23
GRI Ancillary Source Map Information 25
Lower Cape Fear River Valley 25
Map Legend 25
Report 25
Cape Fear Region 26
Correlation of Map Units 26
Explanation of Map Symbols 27
Index Map 27
Map Introduction 28
Map Figures 30
Figure 1 30
Figure 2 31
Figure 3 32
Acknowledgments 32
References 32
GRI Digital Data Credits 35

Geologic Resources Inventory Map Document

Moores Creek National Battlefield, Nort Carolina

Document to Accompany Digital Geologic-GIS Data

mocr_geology.pdf

Version: 3/5/2019

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Moores Creek National Battlefield, Nort Carolina (MOCR).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

This document contains the following information:

1) **About the NPS Geologic Resources Inventory Program** – A brief summary of the Geologic Resources Inventory (GRI) Program and its products. Included are web links to the GRI GIS data model, and to the GRI products page where digital geologic-GIS datasets, scoping reports and geology reports are available for download. In addition, web links to the NPS Data Store and GRI program home page, as well as contact information for the GRI coordinator, are also present.

2) **GRI Digital Maps and Source Map Citations** – A listing of all GRI digital geologic-GIS maps produced for this project along with sources used in their completion. In addition, a brief explanation of how each source map was used is provided.

3) **Map Unit List** – A listing of all geologic map units present on maps for this project, generally listed from youngest to oldest.

4) **Map Unit Descriptions** – Descriptions for all geologic map units. If a unit is present on multiple source maps the unit is listed with its source geologic unit symbol, unit name and unit age followed by the unit's description for each source map.

5) **Geologic Cross Sections** – Geologic cross section graphics with source geologic cross section abbreviations.

6) **Ancillary Source Map Information** – Additional source map information presented by source map. For each source map this may include a stratigraphic column, index map, map legend, map notes and/or a report.

7) **GRI Digital Data Credits** – GRI digital geologic-GIS data and ancillary map information document production credits.

For information about using GRI digital geologic-GIS data contact:

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
Fort Collins, CO 80523
phone: (970) 491-6655
e-mail: stephanie.omeara@colostate.edu

About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: https://www.nps.gov/articles/gri-geodatabase-model.htm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage: http://go.nps.gov/gri_products

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park(s), enter GRI as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: https://www.nps.gov/subjects/geology/gri.htm, or contact:

Jason Kenworthy
Inventory Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 987-6923
fax: (303) 987-6792
email: Jason_Kenworthy@nps.gov

The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Maps and Source Map Citations

The GRI digital geologic-GIS maps for Moores Creek National Battlefield, Nort Carolina (MOCR):

The source map for each GRI digital geologic-GIS map is also listed.

Digital Geologic-GIS Map of Moores Creek National Battlefield, North Carolina (*GRI MapCode MOCR*)

Owens, James P., 1989, Geologic Map of the Cape Fear Region, Florence 1 Degree x 2 Degrees Quadrangle, and Northern Half of the Georgetown 1 Degree x 2 Degrees Quadrangle, NC and SC: U.S. Geological Survey, Miscellaneous Investigations Series Map, I-1948-A, scale 1:250,000 (Cape Fear Region). (*GRI Source Map ID 1202*).

Only a partial extent of the above source map was used, however, all geologic features within this extent were captured.

Digital Geologic-GIS Map of the Moores Creek National Battlefield Area, North Carolina (*GRI MapCode MCNB*)

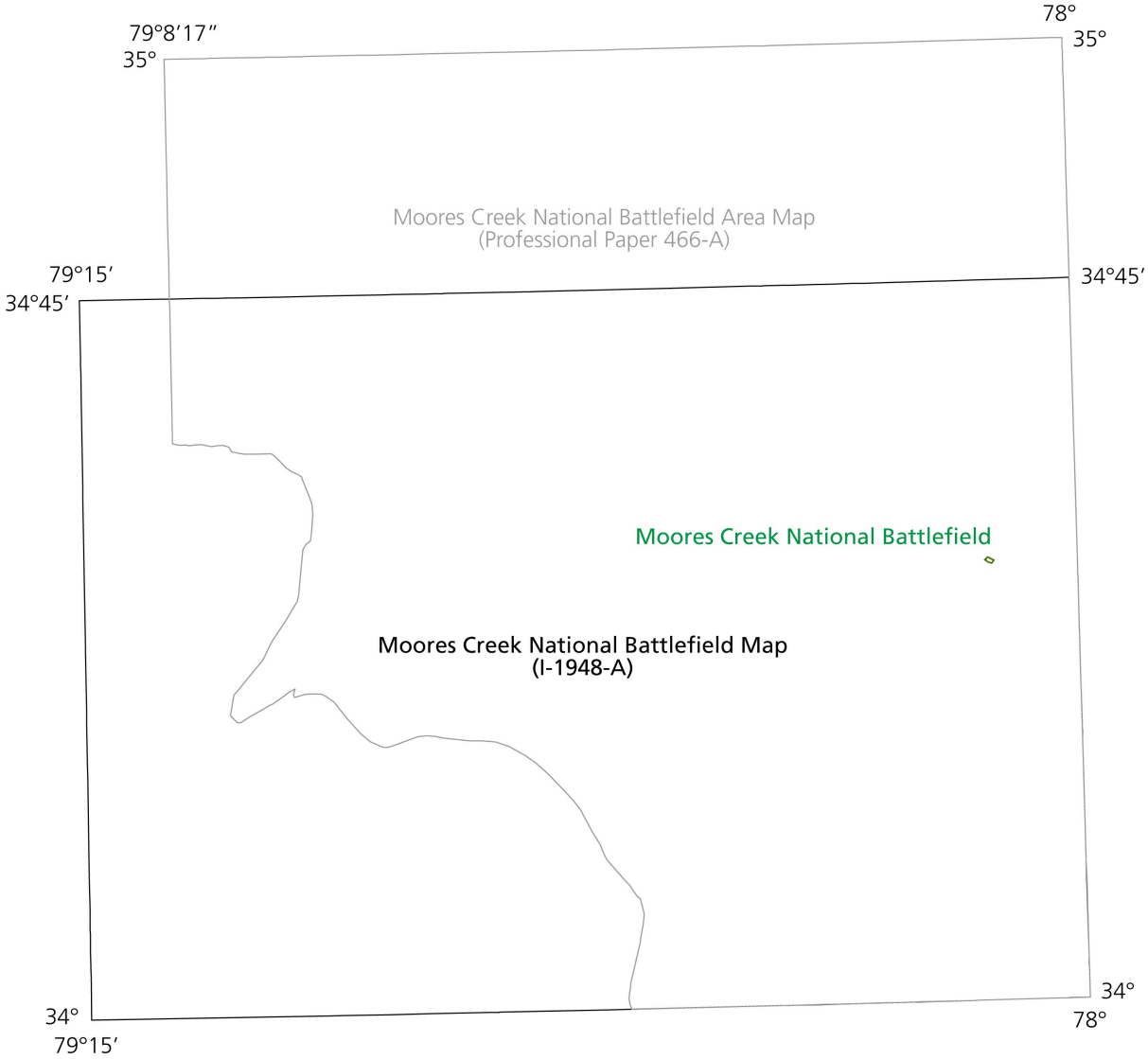
Soller, D.R., 1988, Geology and Tectonic History of the Lower Cape Fear River Valley, Southeastern North Carolina: U.S. Geological Survey, Professional Paper 1466-A, Plate 1, scale 1:250,000 (Lower Cape Fear River Valley). (*GRI Source Map ID 4143*).

The full extent of the above source map was used, and all geologic features within this extent were captured

Additional information pertaining to each source map is also presented in the GRI Source Map Information (MOCRMAP) table included with the GRI geologic-GIS data.

Index Map

The following index map displays the extent of GRI digital geologic-GIS maps produced for Moores Creek National Battlefield. The extent of the GRI Digital Geologic-GIS Map of Moores Creek National Battlefield (MOCR map) is outlined with a black line, whereas the extent of the GRI Digital Geologic-GIS Map of Moores Creek National Battlefield Area (MCNB map) is outlined in dark gray. The title abbreviation for each map, as well as each map's source map series number (e.g., I-1948-A) is also presented. The boundary for Moores Creek National Battlefield (as of January, 2019) is outlined in green.



Index map produced by Stephanie O'Meara (Colorado State University).

Map Unit List

The geologic units present in the digital geologic-GIS data produced for Moores Creek National Battlefield, Nort Carolina (MOCR) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qal - Alluvium). Units are listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (MOCRUNIT) table included with the GRI geologic-GIS data. Some source unit symbols, names and/ or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI the unit's source map symbol, name and/or age appears with the unit's source map description. Note that some units listed are only present in cross section. This is noted with a unit's description.

Cenozoic Era

Quaternary Period

Qal - Alluvium

Holocene Epoch

Qh - Holocene deposits

Pleistocene Epoch

Qwa - Wando Formation
Qs - Socastee Formation
Qph - Penholoway Formation
Qw - Waccamaw Formation

Tertiary Period

Pliocene Epoch

Tb - Bear Bluff Formation
Td - Duplin Formation

Mesozoic Era

Cretaceous Period

Ku - Cretaceous units, undifferentiated
Kpd - Peedee Formation
Black Creek Goup
  Kdc - Donoho Formation
  Kb - Bladen Formation
  Kth - Tar Heel Formation
Km - Middendorf Formation

Map Unit Descriptions

Descriptions of all geologic map units, generally listed from youngest to oldest, are presented below.

Qal - Alluvium (Quaternary)

No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Qh - Holocene deposits (Holocene)

Qh – Holocene deposits (Holocene)
Holocene sediments are confined to major drainage ways and L J small valleys, which are too small to be mapped at a scale of 1:250,000. The Holocene alluvial valley deposits are particularly widespread in the lower reaches of the Cape Fear and Pee Dee Rivers, where they overlap the older sediments of the valley. In addition, small sand dunes are widespread on most flood plains. The Holocene sediments vary in thickness from a feather edge to 15 m.

The riverine sediments typically are interbedded dark clays and light sand, commonly containing a thin gravel layer at the base. Woody materials are common throughout, especially in the lower reaches of the larger river valleys. Large logs, for example, are particularly abundant in the lower Cape Fear River.

Clay beds in the Holocene sections are typically dark gray to dark green peas and micaceous. Illite-smectite and, to a lesser degree, kaolinite are the major clay minerals. The sands are variable in composition, largely because of the mixing of reworked Coastal Plain sediments and much less weathered minerals from the crystalline rocks of the Piedmont. Quartz and feldspar are the major sand minerals. Feldspar tends to decrease rapidly down valley from 25 percent at Elizabethtown, NC., to 15 percent at Wilmington, NC. (east of the map area).

Wood from the base of the unit at Wilmington has a radiocarbon age of 7,270 years B.P., whereas upriver at Elizabethtown, ages of 3,540 years were obtained. Wood collected from dunes yielded ages between 5,000 and 7,000 years B.P.

Description from source map: Cape Fear Region.

Qwa - Wando Formation (upper Pleistocene)

Wando Formation
No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Qwa – Wando Formation (upper Pleistocene)
This formation consists of sandy deposits that form a single barrier and a very large fluvial system. The Wando Formation was named by McCartan and others (1984) for deposits lying at a similar elevation in the Charleston, S.C., area. The barrier fades of the Wando is restricted to a thin zone along the coast in the southeastern corner of the map. At Holden Beach, west of Southport, NC. a single bather abuts against the older Socastee Formation. The barrier at Holden Beach has altitudes near 6.1 to 7.6 m above m. s. l. (mean sea level). Five miles to the northeast at Carolina Beach, a channel (Snows Cut) has been cut through a similar coastal barrier (surface altitude 8.6 m above m. s. l.). The lower part of this barrier contains massive to crudely bedded, very shelly strata. The shell

beds are extensively bleached, and the surrounding sand is stained a deep orange to rust brown. The shell beds rest unconformably on an indurated, massive, very shelly unit (Waccamaw or Bear Bluff Formation). The upper part of the Snows Cut baffler consists of thick to thin, humate-cemented sands. Most of the sand beds are internally structure less. In the humate-free sand beds, clay lamellae are common. No trace fossils were found in the upper sands, probably because this part of the baffler was formed principally by coastal dunes. No samples of these Wando bafflers were collected for mineralogic analyses.

A hole was drilled through another Wando baffler at Southport. The upper 7.6 m in this hole is basically a loose medium to coarse sand. The upper meter of this sand is stained dark brown by humate, whereas most of the rest is pale gray. At 7.6 m the loose sand overlies pale-green-gray clayey silt. Small amounts of wood are scattered throughout this 1.5-m interval. Between 9.1 to 11.8 m there is an increase in dark-gray clay and large shells of the oyster (Cmssostrea virginica) are abundant These large shells are absent from 11.8 to 15.2 m; this interval Is largely a medium-gray very clayey fine sand in which microfauna, mainly benthic foraminifera, are very common. From 15.2 to 16.8 m is fine-to coarse-grained slightly clayey sand. No fossils were observed in this interval. This lower sand is the basal part of the Wando Formation at this site. The Wando at this site, therefore, represents a shoaling sequence: shelf at the base, backbanier in the middle, and baffler at the top.

Quartz is the major mineral in the sands of the Wando Formation. Feldspar, mostly potassium feldspar, ranges from 1 to 6 percent of the sand fraction. The heavy minerals in the Wando are immature. Labile minerals, such as hornblende, epidote, and, to a lesser degree, garnet, are abundant within 1.5 m of the surface. This mineral distribution indicates a minimum depth of weathering in the Wando.

The fluvial fades of the Wando is widespread in the Pee Dee River valley and, to a lesser extent, in the Waccamaw and Cape Fear River valleys. The tops of the Wando terraces lie at altitudes ranging from 6.1 to 27.4 m above m. s. l. in the Cape Fear valley and from 3.0 to 33.5 m above m. s. l. in the Pee Dee valley. The elevation of the base of the terrace deposits is known only along the Cape Fear River, where the range is from 4.4 to 18.9 m above m.s.l. The upper surface of the Wando Formation is unique because original depositional features are intact A ridge-and-swale (scrollwork) topography is common. No Carolina bays (surface depressions) have formed on this surface and their absence distinguishes Wando terraces from the older, higher level terraces in the valleys.

The sands in the scrollwork terraces as a whole are characterized by high feldspar concentrations (typically greater than 20 percent of the sand fraction). The feldspar is entirely potassium feldspar and is largely altered. The non-opaque heavy minerals are characterized by large concentrations of epidote and, to a lesser degree, hornblende. Like the feldspar, the hornblende is commonly altered to varying degrees.

Studies of weathering profiles on the scrollwork terraces, particularly those in the Pee Dee River valley, show little alteration in the primary clay minerals. The surficial weathering, therefore, is slight to practically negligible. In the upper meter, the only significant change appears to be the partial transformation of illite-smectite to vermiculite. Hornblende persists into this zone, although the percentage is small, as compared with the unweathered part of the terraces below.

The age of the Wando Formation, as determined by uranium-disequilibrium studies on corals from this unit in the Charleston area, is about 90,000 years (McCartan and others, 1982). The Wando is, therefore, late Pleistocene in age.

Description from source map: Cape Fear Region.

Qs - Socastee Formation (upper Pleistocene)

Socastee Formation
No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Qs – Socastee Formation (upper Pleistocene)
The Socastee Formation, like the Wando, has both marine and non-marine fades. The marine fades of the Socastee, however, is much more widespread than that of the Wando. In fact, the Socastee Formation is the major coastal Pleistocene unit in the Cape Fear region (see map).

DuBar (1971) and DuBar and others (1974 and 1980) used the name Socastee to include all the coastal units occurring up to altitudes of 6.7 m above sea level. However, this definition would include part of my Wando Formation. My comparison of the Socastee at its type locality on the lower Waccamaw River and of the beds mapped by DuBar and others as both Wando and Socastee along the Intracoastal Waterway at and near Myrtle Beach, S.C., indicates that they are really part of the same formation. Hence, the name Socastee is retained and redefined in this report

The marine facies of the Socastee crops out from the coast to just south of Allen, S.C., a width of about 30 km. The surface in much of the area is characterized by a well-developed ridge-and-swale topography. The ridges, or barriers, are closely spaced, especially between Myrtle Beach and Conway. DuBar and others divided the Socastee bafflers into two systems, the Conway and Jaluco. Both are considered the same age by DuBar and others and me. The Conway and Jaluco bafflers are east of the Pee Dee River. A similar, but less widespread, ridge-and-swale topography occurs west of the Pee Dee, especially between Yauhannah and Allentown, S.C. This baffler sequence thins toward the southern border of the Georgetown quadrangle and apparently merges with the Bethera bafflers mapped by McCartan and others (1984). These authors considered the Bethera to be older than the Conway and Jaluco barriers, but I disagree. The Socastee has a maximum surface altitude of 15.2 m in the north and 9.1 m in the south. The base of the formation is irregular, ranging from about 2 m below m. s. l. to, less commonly, 5 m above m. s. l. In its up-dip area, the Socastee has eroded older formations and forms a low scarp with a base near 14 m above m. s. I. The scarp is developed best east of the Pee Dee River and indistinct west of the river. Elliptical bays, or depressions, are abundant on the sandy barrier fades. Some of these bays are large, up to 3 km long, and are oriented northeast-southwest.

The lithology of the Socastee was determined largely from the exceptional exposures along the Intracoastal Waterway. Here, cut banks as much as 10 m high occur at several localities between the U.S. Route 501 and State Route 9 bridges. The base of the Socastee is exposed at several localities and commonly consists of 0.3 to 1 m of reworked shells, fine gravel, coarse sand, and, occasionally, woody pieces. The rest of the formation consists of interbedded sands and clays. The clays are commonly very peaty and, in some areas, contain upright free trunks. Both the sands and clays are locally fossiliferous. Bioherrns of oysters (Crassostrea *virginica)* in growth position are present in some of the clays. In most cases, however, the shells in this formation are current oriented, which suggests water transport after deposition. The sands are commonly clayey and poorly sorted. The sands range from massive to well cross-stratified. Trace fossils, notably the *Ca!lianassa* type of crab, are present, but uncommon in these sands. The fossils in the formation are the types commonly found in restricted relatively low salinity environments *(Rangia* sp.., *Crassostrea virgfnica, Tagelus plebieus, Mulinia lateralis, Nassarius obsoletus,* and *Memeneria merceneria*).

Mineralogic studies of the sands in the Socastee, show that quartz is the major mineral, and feldspar, mostly potassium feldspar, is present in amounts less than 15 percent of the sand fraction. The heavy-mineral assemblages are relatively immature and contain significant concentrations of such labile constituents as homblende and epidote. X-ray studies of the clay fraction from a profile through the sands indicate that surfidal weathering, as indicated by a gibbsite-vermiculite-kaolinite mineral assemblage, occurs to depths of 1 to 3 m. This depth suggests only a moderate amount of weathering, but more weathering than in the Wando Formation. The clay minerals in the clay beds are

mostly illite-smectite. Smaller amounts of kaolinite and illite are also present. The nonmarine or fluvial system is best developed in the Cape Fear River valley, although erosional remnants are present In the Pee Dee, Lumber, and Waccamaw River valleys. In the Cape Fear River valley, the top of the fluvial fades slopes seaward from 32 m above m. s. l. in the upper part of the valley to 11 m above m. s. l. in the lower part of the valley. The base of the fluvial fades slopes from 18.3 to 1.5 m above m. s. l. From the upper valley seaward, younger terrace deposits of the Wando Formation bevel the Socastee deposits. In the lower valley, the fluvial and backbanier fades of the Socastee are interfingered. In general, the Socastee nonmarine sediments are mostly sand. Clays in beds are, for the most part, uncommon.

The sands of the Socastee Formation, whether in the fluvial, barrier, or back-barrier fades, has large concentrations of epidote and hornblende. The light minerals are characterized by high quartz and low (10 percent average or less) feldspar content. The age of the Socastee is about 200,000 years (McCartan and others, 1982). This unit, therefore, is an upper Pleistocene deposit.

Description from source map: Cape Fear Region.

Qph - Penholoway Formation (lower Pleistocene)

Penholoway Formation
No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Qph – Penholoway Formation (Lower Pleistocene)
The name Penholoway was used in South Carolina by Colquhoun (1974) to define a terrace that reached to 21 m above m. s. l. McCartan and others (1984) used the informal designation of lithostratigraphic unit Q5 for beds underlying this terrace in the Charleston area. The Penholoway is largely a baffler and back-barrier system, the top of which lies at altitudes between 15 and 21 m above m. s. l. The base of the Penholoway deposits ranges from 6 to 9 m above m. s. l. and commonly lies below the deposits of the older Waccamaw Formation.

The Penholoway bafflers are typically smaller than those associated with the Waccamaw. The bafflers west of the Pee Dee River include the Pleasant Hill barrier system and, southwest of Lake Waccamaw, the Nakina barrier system of DuBar (1971). The barrier sands are thin, typically about 3 to 4.5 m thick. The sand is mainly quartz and less than 10 percent feldspar. The heavy-mineral assemblages vary considerably, but typically have high concentrations of the more resistant minerals, such as staurolite, sillimartite, kyanite, zircon, tourmaline, and rutile.

Most of the Penholoway surface is underlain by the back-barrier fades. The backbanier deposits are thicker than the bather sands, some back-barrier deposits being as much as 15 m thick. The base of the backbarrier fades typically has a thin reworked sediment zone that consists of shells, wood, sparse shark's teeth, and other vertebrate remains. Most of the back-barrier sediments are interbedded clay, clayey sand, and sand. In the Green Swamp area in North Caroina, the barrier fades consist of thinly bedded sand and silty clay, which gradually thicken downdip. The beds downdip are mostly sand, but have fine gravel dispersed throughout. The sand in the back-barrier facies has more labile heavy minerals than sand in the barriers. Epidote and, to a lesser degree, hornblende are locally major constituents in the back-barrier beds. Light minerals are similar in both the back-barrier and baffler sands.

The fluvial fades of the Penholoway is widespread in the Cape Fear and Pee Dee River valleys. Along the Cape Fear River, the top of the fluvial fades slopes from nearly 40 to 15 m above m.s.l. In the upper part of the Cape Fear River valley, the Penholoway fluvial strata have been replaced by younger units. In the Pee Dee valley, the fluvial Penholoway slopes from about 41 m above m.s.l. in the upper valley to 12 m above m. s. l. in the lower valley. In general, the Penholoway fluvial facies

seems to lay at slightly higher altitudes In the Cape Fear valley than in the Pee Dee valley. In both valleys, the fluvial facies are about 15 m thick. Most of the Penholoway fluvial fades in the Cape Fear valley is sand. In the Pee Dee valley, the few exposures of this fades become finer upward in the sequence. In the upper one-third of the Pee Dee valley, gravel and gravelly sand in the lower half of the fluvial fades grade into sand; sand grades upward into a clayey silt In the upper half of the facies. In the middle and lower one-third of the valley, the gravel content decreases, but the same clay-silt to sand relationship exists. In both areas, the upper clay-silt fades is about 3 to 4.5 m thick.

X-ray studies of the clay and silt indicate the day is predominantly kaolinite plus lesser amounts of illite-smectite and even smaller amounts of vermiculite. The sand has large concentrations of the metamorphic minerals staurolite, sillimanite, and kyanite, as well as high concentrations of epidote. In the opaque fraction, ilmenite is the dominant mineral. In the light fraction, quartz is dominant, but feldspar is abundant (about 20 percent). Feldspar appears more abundant in the Pee Dee valley than in the Cape Fear valley.

Fossil assemblages in the Penholoway are sporadically distributed throughout the outcrop belt and are exposed in some of the deeper pits near the coast. Fossil analyses indicate the Penholoway is younger than the Waccamaw Formation, but is still presumed to be early Pleistocene (older than 760,000 years) (T.M. Cronin, written commun., 1985).

Description from source map: Cape Fear Region.

Qw - Waccamaw Formation (lower Pleistocene)

Waccamaw Formation
No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Qw – Waccamaw Formation (lower Pleistocene)
The type locality of the Waccamaw Formation is a small fossil bed lying along the Waccamaw River near Conway, S.C. The history of the nomenclature pertaining to this formation is described by DuBar and others (1974). DuBar (1971) and DuBar and others (1974) expanded the definition of the Waccamaw Formation to Include a related bather fades. McCartan and others (1984) divided the Waccamaw of DuBar into the Penholoway (their lithostratigraphic unit Q5) and Waccamaw (their unit Q6) Formations, and this twofold separation is extended into the Cape Fear area.

In the coastal area, the Waccamaw is largely a baffler and back-barrier sequence that crops out at altitudes between 21 and 30 m above m. s. l. A shallow-shelf fades of the Waccamaw is exposed at depth along some of the larger rivers in the down-dip area, such as along the Waccamaw River, along the Intracoastal Waterway near Myrtle Beach, and in large, now Inactive pits near Little River and Calabash, NC. A fluvial sequence is particularly widespread in the Cape Fear and Lumber River valleys.

The Waccamaw bafflers are most abundant west of the Pee Dee River, where they reach altitudes near 27 m above m. s. l. (the Kingstree baffler of DuBar, 1971). Eastward, these bafflers form a headland a buffing against older units, and they include the Daisy strand and Nakina barrier of DuBar (1971). Northeast of the Cape Fear River, the bafflers are small, but near Rose Hill, NC. they reach the highest known level for the Waccamaw baffler system (30 m above m. s. l.).

The thickness of the baffler sands averages about 10.7 m near the Pee Dee River and about 6 m elsewhere along the outcrop belt. The bafflers are commonly fine to coarse interbeds of poorly to well-sorted sands. The lower few meters are commonly reworked sediments from the underlying units. Where the baffler overlies the shelly facies of the Bear Bluff or Duplin Formations, the basal beds of the Waccamaw contain shells from those units. Elsewhere, few indigenous fossils are associated with

the baffler sands except for some Mulinia-dominated assemblages (shallow-water fades) east of the Cape Fear River. Compositionally, the Waccamaw barrier sands are mostly quartz; feldspars are present only in the base of the baffler sands. Nonopaque heavy-mineral assemblages vary along outcrop, and the southwest bafflers are characterized by large amounts of metamorphic minerals (staurolite, sillimanite, and kyanite). Locally epidote is a constituent. A maximum depth of 8 m of sub aerial alteration was determined from weathering profiles on the bafflers by using the vermiculite-kaolinite-gibbsite mineral assemblage.

The Waccamaw back-barrier facies occur in broad flat areas, but locally they may fill channels lower than the general level of most of the formation. The sediments of the back-barrier facies are more complex than those of the baffler facies. In general, the back-barrier facies are interbeds of clayey silts and clayey sands, which may have reworked shells at the base. The sands in both the back-barrier and baffler fades are similar. The clays in the back-barriers are principally illite-smectite and small amounts of kaolinite. Abundant organic matter and logs are locally characteristic of the back-barriers. A peaty facies is particularly abundant northeast of the Cape Fear River. The back-barrier facies, averaging about 6 m in thickness, are thinner than the baffler sands. However, these deposits can be up to 12 m thick.

The marine or shelf facies of the Waccamaw occurs only down-dip beneath the younger Coastal Plain deposits. Down-dip exposures of the Waccamaw near Little River and Calabash, NC., reveal normal, open ocean faunas. The fossil assemblages in this unit are characterized by the following species: Ostrea *sculpturata, Noe.tia Iirnula,* and *Mulinia Iateralis.* On the basis of the macrofauna, Blackwelder (1981) believes that this unit was deposited during a subtropical interval of the Pleistocene. The microflora (pollen from one of the thickest organic-rich facies of this unit near Kingstree, S.C.) suggests that the climate during deposition was cooler in the lower part of the strata than in the warmer, subtropical, upper part.

The Waccamaw has a fluvial facies that is particularly widespread in the valleys of the Cape Fear and Lumber Rivers. There the Waccamaw riverine sediments form broad terraces that slope up valley and reach altitudes over 42.7 m above m. s. l. at the northeast edge of the map. The riverine, or fluvial, fades of the Waccamaw were best studied in the Cape Fear River valley, where a broad terrace is assigned to this unit The Cape Fear terrace ranges up to 13.7 m thick and is mostly sand. Small gravels, no larger than 2.5 cm in maximum dimension, are common in the basal part of the formation, especially in the up valley areas. The surface of the terrace has abundant, small to large surface depressions, or Carolina bays.

Description from source map: Cape Fear Region

Tb - Bear Bluff Formation (upper Pliocene)

Bear Bluff Formation
No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Tb – Bear Bluff Formation (upper Pliocene)
Originally, the Bear Bluff Formation was defined as those deposits lying immediately seaward of the Surry scam (below 30.5 m above m. s. l. of DuBar (1971). Later, DuBar and others (1974) tentatively correlated the Bear Bluff with their Marietta unit, a widespread subarkosic to quartzose sand that occurs between the Surry scam (30.5 m above m. s. l.) and the Mechanicsville scarp (40 m above m. s. l.). This correlation has been adopted with slight modifications in the Florence-Georgetown area. As mapped, the Bear Bluff includes all the baffler and back-barrier fades above 30.5 m in altitude between the Pee Dee and Cape Fear Rivers, and this includes the Horry, and Rosindale baffler systems of DuBar and others (1974) as well. The Mechanicsville scarp, which marks the updip limit of the Bear Bluff, is intermittent and, for the most part, poorly defined between the Pee Dee and Cape

Fear Rivers. West of the Pee Dee River, the scarp is very difficult to recognize. East of the Cape Fear River, most of the marginal marine facies of the formation were removed during the emplacement of the Waccamaw Formation.

The marine (shelf) facies of the Bear Bluff typically consists of a basal shelly horizon. The basal shelly beds locally occur in deep narrow trenches, particularly in the down-dip areas. These entrenched shelly beds are commonly leached and re-cemented by calcite into hard masses. An excellent exposure of this leached shelly facies of the Bear Bluff is in a large quarry near Cedar Grove, S.C. Here, the channels, or trenches, extend down at least 12 m below m. s. l., and the leached shell horizons are as much as 25.6 m thick.
The calcite-rich shell beds become thinner updip, and the shells are dominantly calcitic. Although widespread, the shelly horizons are not ubiquitous in the base of the formation. Some of the larger (up to 3 m thick) shell concentrations of this calcite-rich shell layer are present in the vicinity of Elizabethtown, NC. (Including the commonly cited, so called “Waccamaw” exposures at Walkers Bluff), Marietta. NC. and Sardis. S.C.

The shell beds in most areas grade up into thick beds of bluish-green to dark-gray, very clayey silt. These beds are largely known from subsurface sampling, but they are exposed in small outcrops in road cuts along U.S. Route 76 near Whiteville, NC. The very clayey silts are complex intercalations of sand and silty clay beds, which commonly contain abundant carbonaceous matter and locally contain light-brown uncarbonized wood fragments. DuBar (1971) referred to these beds as the Chadbourn shoal, which he considered to be a deltaic deposit. However, DuBar and others (1974) later redefined these beds as back-barrier (lagoon and marsh) deposits. DuBar and others (1974, 1980) also recognized another delta, called the Olanta delta, near Kingstree, S.C., which they considered to be younger than the Chadboum. I believe the two deposits are coeval and are part of the clayey silt facies of the Bear Bluff Formation.

X-ray studies of the clay fraction of the clayey silt fades show that illitesmectite is the major clay mineral and that kaolinite and illite are minor constituents. Studies show similar compositions for the heavy- and light-mineral fractions of the sands and the underlying shelly facies. The major heavy, resistant-to-weathering minerals include zircon, tourmaline, rutile, staurolite, sillimanite, and kyanite. The more labile epidote is abundant locally, and hornblende is common in some of the up shelly beds. Both the clay minerals and the heavy-sand minerals indicate moderate sediment maturity. Feldspar comprises about 10 percent of the light-mineral fraction and also substantiates a moderate sediment maturity.

The baffler facies of the Bear Bluff is very thin and averages about 4.5 m in thickness. The bafflers are poorly exposed for the most part, and their internal bedding characteristics are generally not known. However, in pits near Smithboro, S.C., laminated to thin-bedded, burrowed tidal-flat deposits overlie cross-bedded sands of tidal-inlet deposits. The tidal-inlet deposits have abundant *Ophiomorpha* burrows. Sand minerals in the bafflers are varied, largely because of deep postdepositional weathering. The less weathered deposits have a feldspar content of 15 to 35 percent the lowest values are in the bafflers, and the highest are in the fluvial fades of the formation. The opaque heavy minerals are dominated by the weathering products of ilmenite, pseudorutile, and leucoxene. The non-opaque heavy minerals are mostly zircon, tourmaline, rutile, staurolite, sillimanite, and kyanite. No hornblende, epidote, garnet, actinolite, or tremolite occurs in the deeply oxidized sands, but they do have particularly large concentrations of sillimanite.

The fluvial facies of the Bear Bluff can be traced up-dip in the Cape Fear and Pee Dee River valleys. The fluvial fades reach an altitude of about 40 m above m. s. l. in the Pee Dee valley, but are higher in the Cape Fear River valley where their up limit lies north of the Florence quadrangle. The thickness of the fluvial fades is variable due to extensive dissection. In both the Pee Dee and Cape Fear River valleys, the fluvial facies is a maximum of about 13 m thick, and the surface has abundant, small to large Carolina bays. The fluvial fades in the Pee Dee River valley has a thick clay-silt cap overlying a very gravelly unit at Cheraw, S.C.; the gravel becomes sandier down-valley. No such clay-silt cap is present in the Cape Fear valley. The light-mineral assemblage of the sand in both valleys is mostly quartz and feldspar. The non-opaque heavy minerals are also similar and are relatively immature

containing high concentrations of epidote. Monazite is notably abundant in the extreme updip areas near Cheraw, S.C.

Interfingering of the fluvial, baffler and back-barrier facies of the Bear Bluff is evident from borings in the Pee Dee valley. Interfingering of the fluvial fades with fossiliferous marine (shelf) beds of the Bear Bluff shows that the ancestral Pee Dee and Cape Fear Rivers are at least as old as the Bear Bluff, which is late Pliocene in age (DuBar and others, 1980). A fossil suite collected from the Bear Bluff at Elizabethtown, NC., has a relatively diverse assemblage that is similar to that of the Chowan River Formation (LW. Ward, written commun., 1984). Of particular note in the mega-invertebrate assemblage are *Noetio limula, Anadara irnprocera,* and *Ostrea scuipturata.* The ostracodes also suggest that the Bear Bluff is latest Pliocene (Cronin and others, 1984) and that it was deposited about 1.8 to 2.4 my. (Million years ago).

Description from source map: Cape Fear Region

Td - Duplin Formation (lower Pliocene)

Duplin Formation
No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Td – Duplin Formation (lower Pliocene)
DuBar and others (1974) restricted the Duplin Formation to the area between the Mechanicsville scarp (toe about 41 m above m. s. l.) and the Orangeburg scarp (toe between 55 and 67 m above m. s. l.). This definition has been applied in the florence-Georgetown area, although the Orangeburg scarp is higher than perceived by DuBar and others; it ranges between 76 and 88 m above m. s. l. Blackwelder and Ward (1979) recommended that the name Yorktown rather than Duplin he used in North and South Carolina. However, until the area between southern Virginia (the type locality of the Yorktown) and Florence is mapped, the use of the name Yorktown seems premature, and the name Duplin is retained herein.

The Duplin Formation underlies a broad, highly dissected plain that slopes from nearly 88 m above m. s. l. near Silver Hill, NC., to 30.5 m near Lumberton, N.C. The base of the unit near its updip limit is nearly 67 m above m. s. l., whereas at Lumberton, NC. , it is only 16.8 m above m. s. l. Carolina bays, some large, are very abundant on the Duplin sand plain. This presence of Carolina bays helps separate the Duplin from the adjacent older units along the Orangeburg scarp, where units are poorly exposed.

Near the Orangeburg scarp, the Duplin Formation is about 21.3 m thick, and basal beds of gravelly sand are typically about 3 to 4.5 m thick. These gravelly beds are capped locally by interbedded, thin, dark-gray clay and silt and light-yellow sand. Pollen studies indicate a Neogene age for these beds, and the abundance of dinoflagellates in the pollen samples indicates a strong marine influence during deposition. Farther down-dip, calcareous fossils are present in the base of the formation. West of florence, S.C., and near Lumberton, NC., these fossil beds are 3 m or less in thickness, but they are sporadically distributed north of the Cape Fear River at Magnolia and near Clinton, NC. Even farther downdip, the fossil beds thicken and are generally confined to channels cut into the underlying Cretaceous formations. The commonly cited fossil-rich localities at Davis and Bostick Landings (Cooke, 1936, for example) on the Pee Dee River are the best examples of the Duplin shell fades. There, the Duplin consists of light-gray, fine calcarenite containing large pectinoid shells. These shell beds differ from those in the younger shelf fades of the Bear Bluff Formation in that fossil beds in the Bear Bluff still contain aragonite.

Although widespread in the upper part of the formation, the sands of the Duplin typically are poorly exposed. Several pits have been dug into the sandy fades in the extreme updip areas near Cash, S.

C. , on the west side of the Pee Dee River. The sands there have a large gravel component and are characterized by long, low-angle, deltaic crossbeds, However, some sand beds are burrowed extensively and indicate deposition in a near shore environment. Near Mont Clare and in pits north of florence, S.C., the formation consists of intensely burrowed, thin interbeds of clay and sand that suggest some tidal-flat deposition. The sands of the Duplin probably were deposited in a complex marginal marine environment where both marine and non-marine sands were interfingered. In alt the pits examined in this sand plain, only a few widely scattered Ophiomorpha were observed. Although some geologists favor a baffler origin for this unit, the preserved Duplin sands appear to be more of a shelf system without major bafflers.

The sandy facies of the Duplin are very deeply weathered. X-ray studies of the clay-silt fraction of the sands indicate that kaolinite is the major clay mineral and that it is developed to a depth of 12 m. The local indicators of intense weathering, gibbsite and vermiculite, are well developed, but they are absent in most profiles. Apparently, the upper beds of the Duplin plain were stripped during the formation of the widespread Carolina bays.

The heavy minerals in the sandy fades have only the resistant zircon-tourrnaline-rutile and staurolite-sillimanite-kyanite mineral suites. The distribution of sillimanite seems important because it is more abundant nearer the Pee Dee River than the Cape Fear River. The light-mineral fraction of the Duplin sands is almost all quartz. Feldspars, if originally present, probably were removed by intrastratal solution. The Duplin deposits are much more mature than those of the Bear Bluff, probably because the permeable sands of the Duplin allowed water to percolate through the formation, which destroyed the labile minerals.

The age of the Duplin Formation is early Pliocene (DuBar and others, 1980). Cronin and others (1984) specifically indicated that this unit was deposited about 2.8 to 3.6 m.y. ago. The magainvertebrate fauna includes *Ostrea raveneli, Noetia* rigintinaria, *Glycemeris subovata,* and G. *americana,* all of which characterize the Yorktown Formation in Virginia (LW. Ward, written commun., 1984). Cronin and others (1981, 1984) put the Bear Bluff and Duplin in their *Paracytheridea mucra* zone, yet they assigned samples from Davis Landing and other Pee Dee River localities to their *Murrayina barclayi* zone (Bear Bluff). This is unlikely because the two formations are clearly separated in the field.

Description from source map: Cape Fear Region

Ku - Cretaceous units, undifferentiated (Cretaceous)

No additional unit description provided on source map. See the Lower Cape Fear River Valley map report for additional information.

Kpd - Peedee Formation (Upper Cretaceous)

Kpd – Peedee Formation (upper Cretaceous)
This formation is exposed in the banks cut along the Cape Fear and Pee Dee Rivers and their large tributaries. Most of the outcrops are small. (5 m in thickness or less), but the length of exposure provides a good opportunity to examine much of the formation. The formation is best exposed along the Pee Dee River from near Burches Ferry to Hemingway, S.C., a distance of about 40 km. Most of the Peedee is a massive to thick-bedded, dark-gray to gray-green, slightly to very clayey, micaceous, calcareous, glauconitic quartz sand. These deposits are extensively bioturbated. Locally, thin (30-100 cm) ledges of impure limestone are present Most of the glauconite-rich beds are massive, although some are crossbedded locally. The Peedee is abundantly fossiliferous and contains large macrofossils, notably *Exogyra costata* and *Belemnitella americana,* and a microfaunal suite, which belongs to the Globotruncana *ganserri* foraminifer zone (Sohl and Christopher, 1983).

The Peedee is separated from the underlying unit by a reworked zone containing abundant phosphatic pebbles and phosphatic organic remains (shells, for example). The best exposures of this contact are at Black Rock Landing on the Cape Fear River and at Burches Ferry on the Pee Dee River. The reworked bed varies in thickness, but locally is as much as 1 m thick. SohI and Christopher (1983) included in the Peedee Formation the beds between Donoho Creek Landing and Black Rock Landing along the Cape Fear River. Owens and Gohn (1985) favored returning this unit to the Black Creek, and I have done the same.

The thickness of the Peedee is difficult to determine because the dip is very low (estimated to be 3 m per km) and variable throughout the region. The Peedee is at least 37.4 m thick as measured in the corehole ***(MRN-78)*** near Britton Neck (fig. 2). However, only the lower part of the formation is present at that locality.

The light-sand fraction of the Peedee is mostly quartz. Feldspars typically occur in amount less than 10 percent. The non-opaque heavy-mineral assemblages are characterized by moderate concentrations of zircon, tourmaline, rutile, staurolite, and kyanite and an unusually high concentration of garnet. The clay minerals in the Peedee are principally illite-smectite, kaolinite, and illite.

The Peedee Formation in this area represents a complete sedimentary cycle if the Scotts Hill Member (Rocky Point Member of Wheeler and Curran, 1974) of the Peedee at Wilmington, NC., is included. The Scoffs Hill consists of interbedded quartz sands and massive limestone, which are interpreted as a nearshore deposit (barrier-back-barrier fades). The Peedee apparently represents a single marine transgressive-regressive sequence having deeper water facies at the base and shallower water fades at the top. N. F. Sohi (written commun. , 1982) notes, however, that facies changes within the upper part of the Peedee suggest several episodes of deepening and shallowing and that this formation consists of several transgressive-regressive cycles rather than one.

The Peedee is middle to late Maestrichtian as determined from the foraminifer species *Globotruncana aegyptiaca, Rugoglobigerina macrocephala,* and *Heterohelix glabrans,* which are near the base of the unit at the Burches Ferry locality. Pollen from this interval indicates that this unit falls within the CA6/ MA1 pollen zone (SohI and Christopher, 1983) of middle to late Maestrichtian age. Finally, the abundant megainvertebrate fauna indicates that the Peedee falls within the *Exogyra costata* zone (SohI and Christopher, 1983). The Peedee also contains *Haustator bilira,* which suggests a late Maestrichtian age.

Description from source map: Cape Fear Region

Black Creek Group

The long-established Black Creek Formation is characterized by intercalated thin beds of black clay and light-yellow sand at its type locality near Darlington, S.C., Sohi and Christopher (1983) studied the Black Creek Formation along the more or less continuous exposures on the Cape Fear River, and they found that the Black Creek spanned nearly all of the Campanian Stage, although several time gaps, some of significant length, occurred. Marine units of similar age north and south of the Cape Fear arch have at least two transgressive-regressive cycles (Owens and Gohn, 1985). Time breaks between these regionally recognized marine cycles appear to coincide with time breaks recognized in the Black Creek unconformities along the Cape Fear River. However, correlation of Black Creek lithofacies between the Cape Fear River and the Pee Dee River valley is difficult, primarily because the Black Creek is a complex deltaic deposit in which rapid vertical and lateral facies changes are common. Therefore, the Black Creek is redefined. In this framework, the Black Creek Formation is raised to group status and divided into three formations, the Donoho Creek, Bladen, and Tar Heel that are bounded by regionally synchronous unconformities. The regional distribution of the three formations and their depositional relationships between Greenville, NC., and Columbia, S.C. , are shown in figure 3.

Description from source map: Cape Fear Region.

Kdc - Donoho Formation (Upper Cretaceous)

The upper unit of the Black Creek Group is the newly named Donoho Creek Formation. Sohi and Christopher (1983) noted that, from Donoho Creek Landing to Browns Landing on the Cape Fear River, typical Black Creek beds (intercalated clays and sands) were overlain by a more massive, fossiliferous sand deposit. The base of this massive unit is marked by a thin zone of small reworked quartz and phosphate pebbles. This massive unit can be traced downstream to Black Rock Landing, where it is overlain by a second pebble bed at the base of the Peedee Formation. This lithologic association can be traced from the Cape Fear River northeastward into the Neuse River valley and its tributaries, a distance of about 100 km. Farther northeast, the Donoho Creek Formation is buried beneath Tertiary formations. Sohl and Christopher (1983) had assigned this unit to the basal part of the Peedee Formation. However, to the southwest in the Pee Dee River valley, this massive unit is not present. Instead, the stratigraphic interval between the unconformities at Browns Landing and Black Rock Landing has laminated to thinly bedded, intercalated sands and clays or thin cross-bedded sands that are typical of the Black Creek. These deposits are best exposed at Mars Bluff and can be followed intermittently downstream from Mars Bluff to Burches Ferry, where they are overlain unconformably by the massive Peedee Formation. In the Pee Dee River valley, therefore, the Donoho Creek Formation has more lithic affinities to the Black Creek Formation than to the Peedee Formation. For this reason, the Donoho Creek Formation is included as the upper formation of the Black Creek Group.

The Donoho Creek deposits in the Cape Fear River valley are largely dark-gray, medium-grained sands. Large megainvertebrates are scattered throughout this unit. Much of the formation has a mottled appearance resulting from bioturbation. The non-opaque heavy minerals are dominated by the more resistant types: zircon, tourmaline, rutile, staurolite, and kyanite. Garnet, chioritoid, and, to a lesser extent, epidote and monazite are accessory minerals. Ilmenite is the major opaque mineral, followed by its weathering products, pseudorutile and leucoxene. Quartz is by far the major light mineral; feldspar is present in amounts less than 5 percent X-ray studies of the clays show that illite-smectite is the major clay mineral, and kaolinite and illite are accessory minerals.

In the Pee Dee River valley, the Donoho Creek Formation has a variable lithology. At Mars Bluff near the base of the formation, well-sorted crossbedded beach sands interfinger with intercalated thin beds of dark clay and light sand, which represent the delta front. Downriver, the delta-front facies dominate, as can be seen at the top of the formation exposed at Burches Ferry. There, the beds are shelly and extensively burrowed. In the Britton Neck corehole about 24 km downvalley from Burches Ferry, the Donoho Creek lithology is the same as that exposed along the Cape Fear River.

The heavy-mineral fraction of the sand in the outcropping Pee Dee River beds is similar to that of the Cape Fear River deposits, but feldspar is much more abundant in the former, in some cases half of the light-mineral sand fraction. There is more kaolinite in the Pee Dee River facies than in the deposits in the Cape Fear River area. Similar sand and clay mineralogies are found in the top of the formation at Burches Ferry.

The Donoho Creek marine sequences are about 18 m thick in the corehole near Britton Neck (fig. 2). The delta-front and beach facies exposed in the river sections are at least this thick.

The fossils in the Donoho Creek Formation indicate this unit represents the *Exogyra cancellata* zone of Sohi and Christopher (1983) and is essentially early
Maestrichtian in age.

Description from source map: Cape Fear Region.

Kb - Bladen Formation (Upper Cretaceous)

The Bladen Formation as originally defined by Stephenson (1907) consisted of intercalated, thin, dark clays and light sands found along the Cape Fear River. The name was replaced by Black Creek when it was found this name had priority. The Bladen was later used as a member of the Black Creek Formation by Heron (1958). The name Bladen is raised here to formation rank, now that the Black Creek has been raised to group status. As defined in this report, the Bladen Formation consists of the intercalated sand-clay sequences that occur between Donoho Creek Landing on the south and Dawsons Landing on the north. This definition fits the description of Stephenson (1907) and applies to both the Cape Fear River and Pee Dee River valleys. The unit is about 44 m thick.

In the Cape Fear valley, the basal beds consist of thin intercalated sand and clay beds; woody fragments, some burrows, and coarse mica flakes are common. Near Little and Big Sugar Loaf Landings on the Cape Fear River, the thinly bedded fades change to thick, cross-bedded sand and massive black clay beds. Large lignitic logs are present in the clay, and a few *Ophiomorpha* are present in the sand. The Bladen is best exposed farther downstream at Walkers Bluff. There, several fades show rapid vertical arid horizontal changes. One of the more striking fades has finely bedded to laminated, horizontal intercalations of sand and clay. The sand here has a small, but persistent, concentration of glauconite. Scattered megainvertebrates are present; although not abundant. The beds have extensive, small, short burrows. This laminated sequence is in sharp contact with an overlying, crossbedded, fine to coarse sand unit, which contains local concentrations of small pebbles, scattered fossils, and small burrows. The same lithic variability continues downstream to Donoho Creek Landing. Fossil beds are present at Deep Point and Donoho Creek Landing on the Cape Fear River at Fair Bluff, NC., and along the Lumber River drainage at Hodges Mill near Mullin, S.C.

In the Pee Dee River valley, the Bladen is exposed intermittently from the bluff north of Florence to near Hurricane Branch and along Black Creek at Darlington. The same lithic variability noted in the Cape Fear valley is present here, except that there are no megainvertebrates, burrows, or glauconitic sand indicative of marine deposition. In the corehole near Britton Neck in the lower Pee Dee valley, the Bladen is characterized by abundant shelly layers (fig. 2). These beds are more marine than those of the upper Pee Dee valley and are more like the beds in the Cape Fear River valley.

In the Cape Fear valley, the sand is mostly quartz, but feldspar comprises up to 15 percent. The nonopaque heavy minerals are dominated by the resistant types: zircon, tourmaline, ruffle, staurolite, and kyanite. Garnet is present locally in moderate amounts and epidote in lesser amounts. Chloritoid, monazite, and andalusite are accessory minerals. In general, chloritoid is less abundant in the Bladen than in the Donoho Creek Formation

The age of the Bladen Formation is latest Campanian to earliest Maestrichtian or the uppermost part of the *Exogyra ponderosa* zone of SohI and Christopher (1983). The Bladen Formation can be correlated with the Marshalltown-Wenonah-Mount Laurel marine cycle of New Jersey (Owens and Gohn, 1985).

Description from source map: Cape Fear Region.

Kth - Tar Heel Formation (Upper Cretaceous)

The basal unit of the Black Creek Group is the Tar Heel Formation. The Tar Heel beds, like the other units in this group, are characterized by rapid fades changes in the Cape Fear River valley. The best exposures of the Tar Heel occur in the type area between Tar Heel and Court House Landing on the Cape Fear River. The many fades within the Tar Heel include thin- to thick-bedded, black clays and thin to thick, light-colored sand beds. Carbonaceous matter ranges from finely dispersed grains through log-sized pieces. The sands are massive to cross-bedded and are mostly very micaceous. No burrows were observed, although dinoflagellates suggesting some marine influence have been found

in a few clay samples. The Tar Heel beds overlie the Cape Fear Formation with a sharp contact, which is exposed at several localities along the Cape Fear River, mainly between Cedar Creek and Lena, NC. One interesting aspect is that there is no reworked material along the surface of the contact, even though a large time interval is represented by this unconformity. The upper contact with the Bladen Formation is not exposed in this area and is buried beneath the late Tertiary onlap between the Cape Fear River and the Pee Dee River valleys. The Bladen and Tar Heel Formations in this region are separated largely on the presence or absence of burrows and, less reliably, on the amount of sand, the Bladen being far more sandy.

However, in the Pee Dee valley, the Tar Heel beds are mainly sandy. Here, the unit consists of thick, red-to-white, typically cross-bedded sands and white-to-black, thick-bedded clays. The well-laminated facies of the Cape Fear valley are not present in the Pee Dee region. The Tar Heel sands underlying the Sand Hills near Cash, S.C., commonly have been mapped as the Middendorf Formation. In general, however, the Tar Heel sands have fewer clay breccias, more burrow, and more mica than the Middendorf. The well-burrowed sands, suggesting some marine influence, of the Tar Heel are exposed in several road cuts west and north of Society Hill. The sand fades can be traced northeastward from the hills near Hamlet to Raeford, NC., at the northern boundary of the map area. Downdip in the Britton Neck corehole, the sand facies of the Tar Heel changes fades to a largely shallow marine shelf-delta-front fades (fig. 2). In the Sand Hills area, the Tar Heel is at least 60 m thick. In the corehole near Britton Neck, the unit is 55 m thick.

A mature heavy-mineral assemblage of the sand is characterized by the more resistant minerals (zircon and others) and, locally, large concentrations of garnet. Much of the maturity of the sand, however, can be attributed to the deep weathering in the Sand Hills region. Probably because of this deep weathering, no feldspars were found in these weathered samples. Where fresh, the clay-mineral suites are mixtures of illite-smectite and kaolinite. Where weathered, lcaolinite is the only major clay mineral.

As with the Donoho and Bladen Formations, the Tar Heel Formation tends to become more marine from the Pee Dee valley to the Cape Fear valley and toward the ocean. In the Pee Dee valley, the Tar Heel Formation appears to be a delta-plain deposit that has some shallow-shelf intrusions, whereas in the Cape Fear valley, the strata are more characteristic of a delta front The most marine fades of this formation occurs in the subsurface at the Britton Neck corehole, where beds containing marine fossils and glauconite are intercalated with thin-bedded, clay-sand sequences (also delta-front deposits, but more marine than those in the Cape Fear valley).

The age of the Tar Heel Formation is early Campanian as determined by pollen (zones CA2 and CM, R.A. Christopher, written commun., 1980) and by ostracodes (G.S. Gohn, oral commun., 1985) in the downdip beds at Britton Neck. These beds, therefore, correlate with the Merchantsville-Englishtown marine cycle in the Raritan embaymerit in New Jersey or the Blufftown marine cycle in Georgia (Owens and Gohn, 1985).

Description from source map: Cape Fear Region

Km - Middendorf Formation (Upper Cretaceous)

Unit appears only in cross section.

The Middendorf Formation crops out over a large area in the northwest corner of the Florence quadrangle. Most outcrops are in pits, especially in the vidnity of Rockingham, N.C. Because of the nonindurated, sandy nature of the formation, natural exposures are few. Differentiation of the Middendorf from the overlying Tar Heel Formation is locally difficult, especially near Cheraw where the Middendorf has marine-influenced beds overlain by the marine facies of the Tar Heel Formation.

Most of the Middendorf consists of interbedded black-weathering to chocolate-brown or white clayey

beds and clayey crossbedded micaceous sands. Commonly, the sands are stained extensively by iron oxides, which impart a mottled deep-red appearance, especially where the Middendorf sands occur near the surface. At Rockingham, NC., the Middendorf lies within broad channels cut into the underlying saprolite. The channel fill typically consists of interbedded thick, white, clay-silt and clayey, coarse-grained, crossbedded sands. Small pebbles (0.6 cm in diameter) are abundant in the coarse-grained beds, and clasts are common.

The Middendorf ranges between 45 to 60 m in thickness in outcrop and is nearly 110 m thick in the Britton Neck corehole (fig. 2). The sands of the Middendorf are exclusively quartz. Heavy-mineral assemblages are mature and have high concentrations of the nonopaque resistant minerals such as zircon, tourmaline, rutile, staurolite, and kyanite. Monazite is locally abundant Brown ilmenite and leucoxene are the major opaque minerals. The clay minerals in the Middendorf are mainly kaolinite, plus small amounts of illite and, in a few samples, small amounts of illite-smectite.

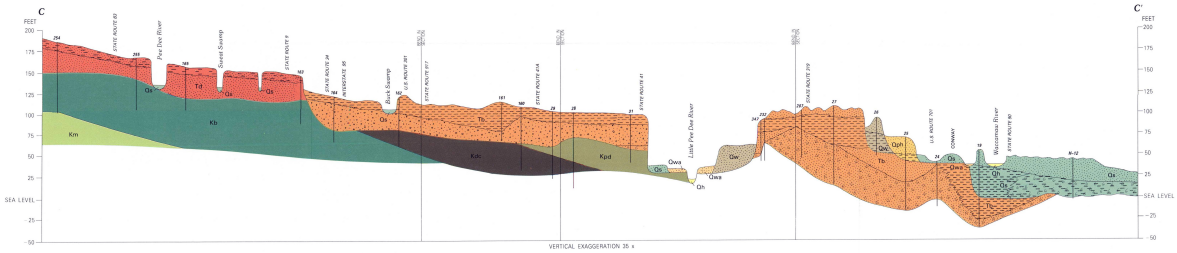
The Middendorf appears to be largely a deltaic deposit (mainly upper delta-plain facies in outcrop) that prograded into the Florence area from the west or northwest and overlapped the Cape Fear Formation. Some marginal-marine beds containing foraminifers occur at Cheraw, NC., (Siple, 1959). In the Britton Neck corehole, the Middendorl is typically a lower delta-plain to perhaps delta-front deposit similar in many respects to the Black Creek lithology.
Age determination from the pollen and spore assemblage of the Middendorf indicates a Santonian age, zone V of the palynozonal age classification (R.A. Christopher, written commun., 1983).

Description from source map: Cape Fear Region.

Geologic Cross Sections

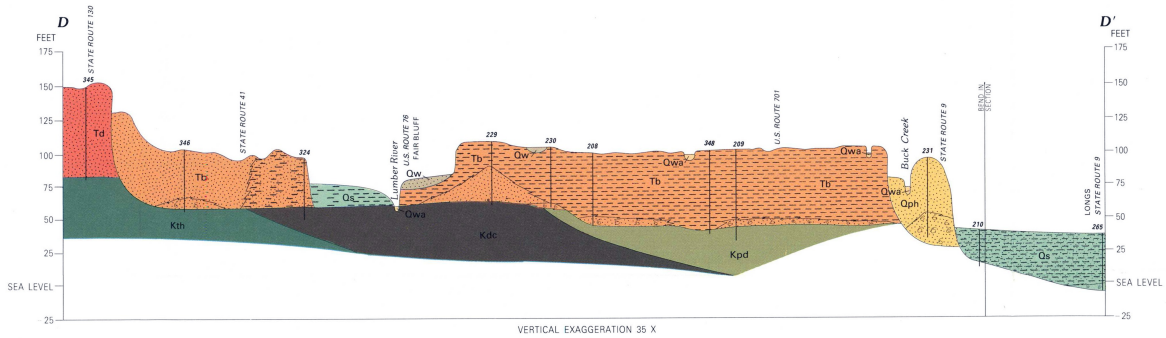
The geologic cross sections present in the GRI digital geologic-GIS data produced for Moores Creek National Battlefield, Nort Carolina (MOCR) are presented below. Note that cross section abbreviations (e.g., A - A') where changed from their source map abbreviation in the GRI data so that the cross section abbreviation start with A-A'. Cross section graphics were scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

Cross Section A-A'



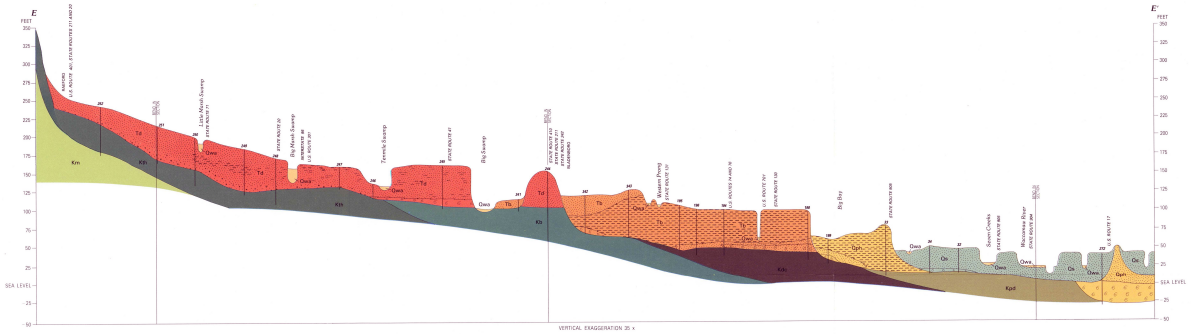
Graphic from source map: Cape Fear Region. Cross section abbreviation C-C' on source map. x35 vertical exaggeration denoted on source map.

Cross Section B-B'



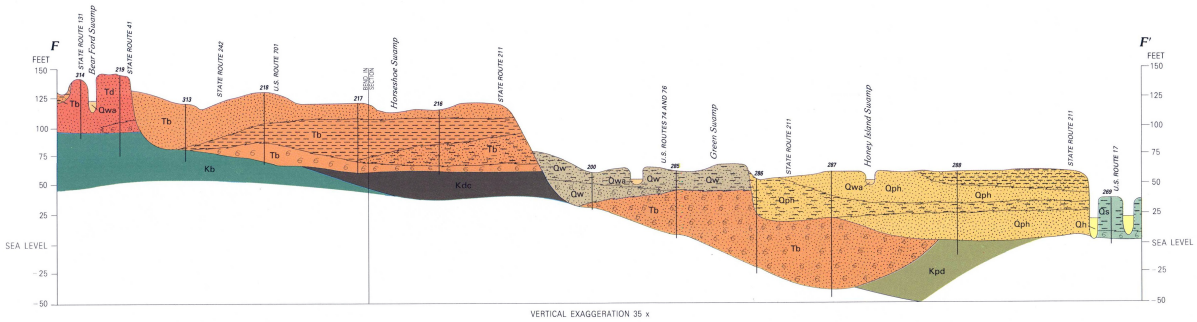
Graphic from source map: Cape Fear Region. Cross section abbreviation D-D' on source map. x35 vertical exaggeration denoted on source map.

Cross Section C-C'



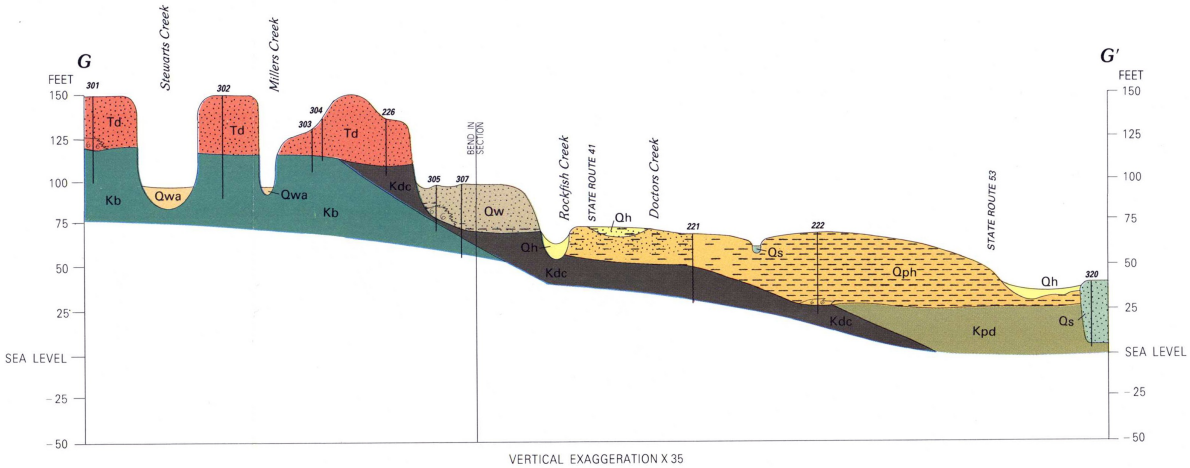
Graphic from source map: Cape Fear Region. Cross section abbreviation E-E' on source map. x35 vertical exaggeration denoted on source map.

Cross Section D-D'



Graphic from source map: Cape Fear Region. Cross section abbreviation F-F' on source map. x35 vertical exaggeration denoted on source map.

Cross Section E-E'



Graphic from source map: Cape Fear Region. Cross section abbreviation G-G' on source map. x35 vertical exaggeration denoted on source map.

GRI Ancillary Source Map Information

The following section(s) present ancillary source map information associated with source(s) used for this project.

Lower Cape Fear River Valley

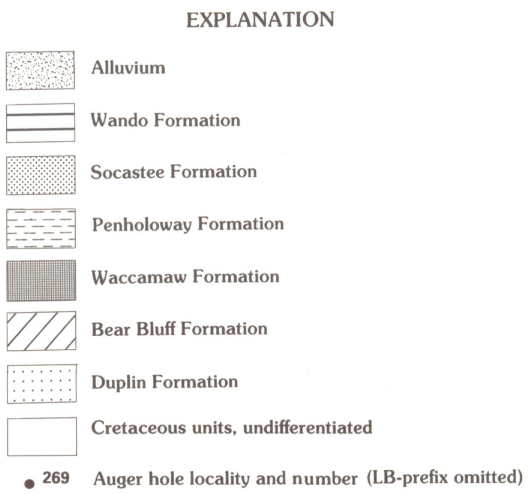
The formal citation for this source.

Soller, D.R., 1988, Geology and tectonic history of the Lower Cape Fear River Valley, Southeastern North Carolina: U.S. Geological Survey, Professional Paper 1466-A, Plate 1, scale 1:250,000 (*GRI Source Map ID 4143*).

The full extent of the above source map was used, and all geologic features within this extent were captured

Prominent graphics and text associated with this source.

Map Legend



Graphic from source map: Lower Cape Fear River Valley

Report

The report associated with this source publication is available by double-clicking the following link: pp-1466a_report.pdf. The report contents include information pertaining the the geologic setting, stratigraphy, sample localities, identification and correlation of terraces, lithology, weathering, age of dunes and Carolina Bays, and geomorphology of the map area at the time the map and report were published.

Cape Fear Region

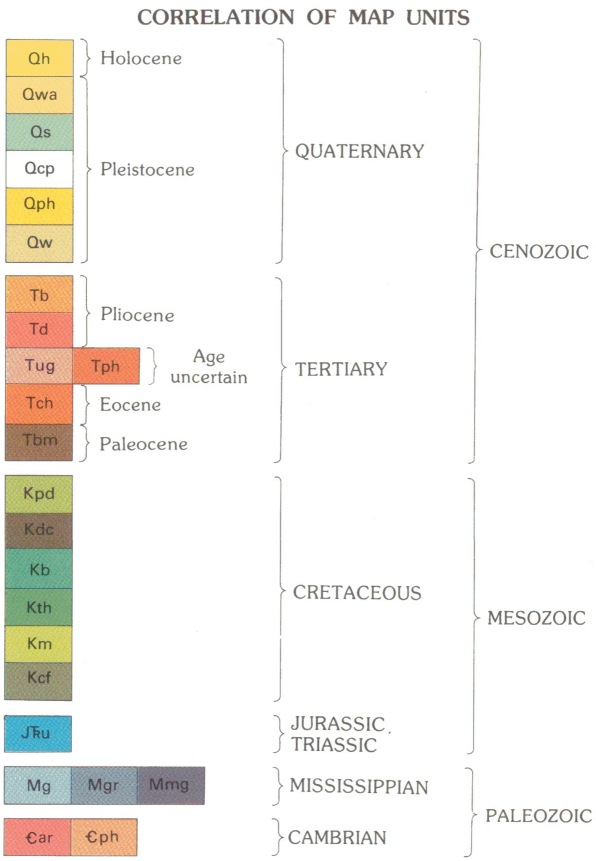
The formal citation for this source.

Owens, James P., 1989, Geologic Map of the Cape Fear Region, Florence 1 Degree x 2 Degrees Quadrangle, and Northern Half of the Georgetown 1 Degree x 2 Degrees Quadrangle, NC and SC: U. S. Geological Survey, Miscellaneous Investigations Series Map I-1948-A, scale 1:250,000 (*GRI Source Map ID 1202*).

Only a partial extent of the above source map was used, however, all geologic features within this extent were captured.

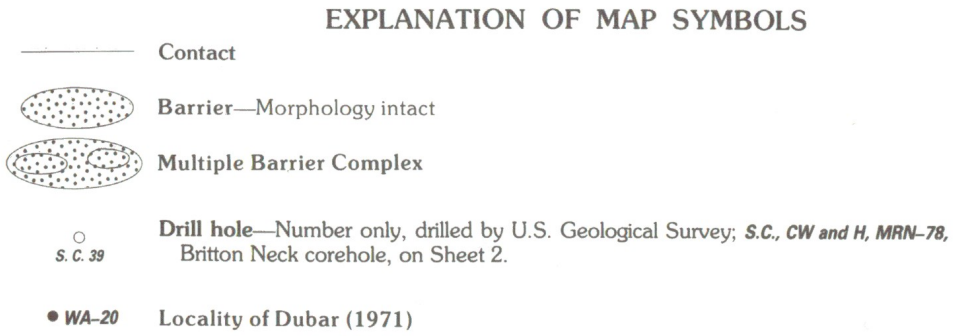
Prominent graphics and text associated with this source.

Correlation of Map Units



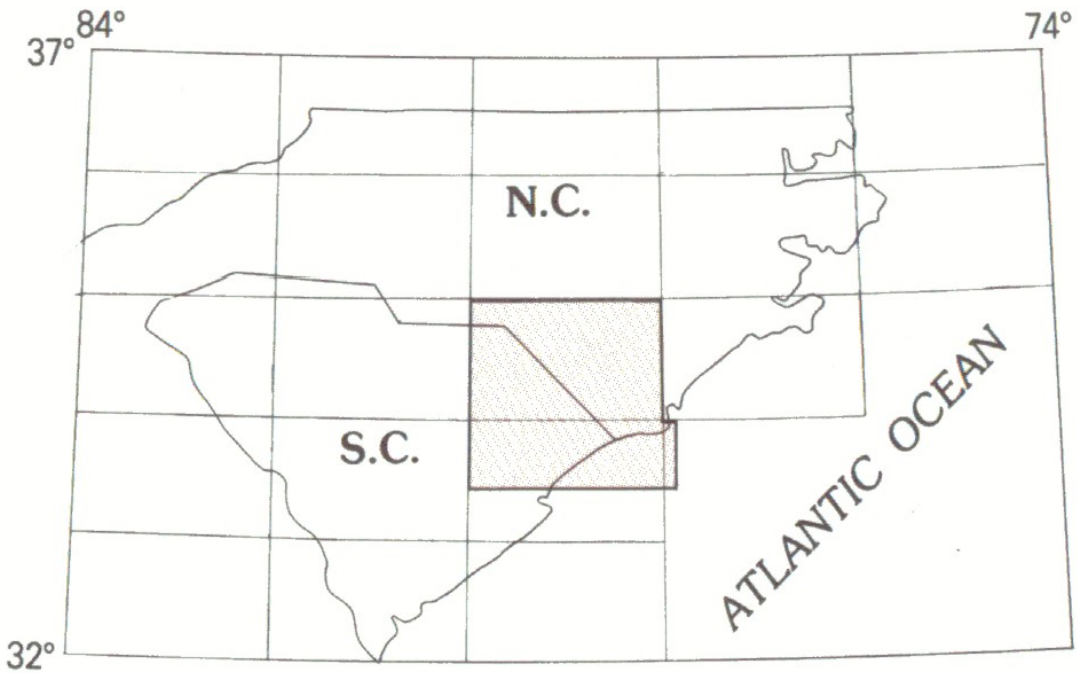
Graphic from source map: Cape Fear Region. As only a partial extent of the full source map was used not all units present in the above figure are present in the GRI digital geologic-GIS data. Units Qcp, Tug, Tph, Tch and units older than and including Kcf are not present in the GRI digital geologic-GIS data.

Explanation of Map Symbols



Graphic from source map: Cape Fear Region. Barrier and multiple barrier complex areas do not appear in the map extent used from this source map, and thus do not appear in the GRI digital geologic-GIS data.

Index Map



INDEX MAP SHOWING LOCATION OF MAP AREA

Graphic from source map: Cape Fear Region. As noted in the GRI Digital Maps and Source Map Citations only a partial extent of the full map extent was used for the GRI digital geologic-GIS data.

Map Introduction

The Florence 1°x 2° quadrangle and the northern part of the Georgetown 1°x 2° quadrangle span part of the Coastal Plain of North Carolina and South Carolina. The area was mapped to delineate the geologic units across the Coastal Plain from the Fall Line to the coast. A primary objective of the mapping was to determine the tectonic history of the Cape Fear arch, a structural high that underlies the Coastal Plain in this area. The rocks are poorly exposed, and many auger holes were made to supplement the natural exposures found along the larger waterways to produce the map and geologic sections shown herein. A generalized small-scale map showing the location of the Cape Fear arch and its flanking basins is shown in figure 1.

Previous maps that include the Florence-Georgetown area were made at a scale of 1:500,000 by Cooke (1936) for South Carolina and by Stuckey (1958) for North Carolina. Cooke produced two maps, one shows the Quaternary geology and the other shows the pre-Quaternary (Cretaceous and Tertiary) geology, Stuckey (1958) mapped the same formations as Cooke, although Stuckey exaggerated the distribution of the pre-Quaternary units. DuBar (1971) and DuBar and others (1974, 1980) concentrated on the definition and distribution of the Miocene to Holocene beds in northern South Carolina, where they emphasized the excellent and nearly continuous exposures along the Intracoastal Waterway between State Route 9 and U.S. Route 501 in the Myrtle Beach area. However, all of their illustrations were page sized and, therefore, small scale. In addition, DuBar and others (1974, 1980) investigated the subsurface distribution of formations throughout this region because successive on laps, mainly by Pleistocene units, obscure the Neogene and older beds.

Colquhoun (1974), similar to DuBar, refined Cooke's Quaternary map, but essentially left the earlier map unaltered. Colquhoun, more than DuBar, concentrated on extensive subsurface investigations to understand better the internal composition and organization within the Quaternary units of Cooke.

McCartan and others (1984) remapped the coastal parts of Cooke's Quaternary map at a scale of 1:250,000. These authors drilled the surficial units extensively and, unlike Coiquhoun, abandoned much of Cooke's terminology. Cooke mapped mainly geomorphic units, whereas McCartan and others mapped depositional units. Their map abuts the southern boundary of the Florence-Georgetown map, and the terminology used by these authors is used in this report wherever it is appropriate.

Extensive topical investigations of the Cretaceous and lower Tertiary units in this area also have been published over the years. The most notable of these concerned the age and depositional environments of the Cretaceous Cape Fear, Middendorf, Black Creek, and Peedee Formations. These studies prompted an interpretation that the Middendorf, Black Creek, and Peedee Formations formed one major transgressive cycle (Brett and Wheeler, 1961; Heron and Wheeler, 1964; Swift and Heron, 1969). This concept became generally accepted; however, elsewhere in the Coastal Plain, these units represent the time interval of at least four transgressive-regressive cycles (Owens and Gohn, 1985). The unfossiliferous Cape Fear Formation was considered originally to be Early Cretaceous. However, the use of paleontology since 1963 has helped to subdivide this and other apparently non fossiliferous rocks into discrete time-stratigraphic units. When paleontology was used initially in the Carolinas, the Cape Fear and Middendorf Formations were shown to be of similar Santonian age (zone V of the pollen zonation scheme; Christopher and others, 1979); hence, the Cape Fear was Late Cretaceous, not Early Cretaceous. Sohl and Christopher (1983) later assigned the Black Creek to paleozones CA2, CM, CA4, and CA5A and the Peedee Formation to zones CA5B and CA6/MA1. These pollen zones indicate that the Black Creek and Peedee span most of the Campanian and Maestrichtian Stages, but that they have significant unconformities within them. In general, these unconformities correlate with the boundaries of Cretaceous marine cycles noted elsewhere (Owens and Gohn, 1985). In addition, the use of palynology has allowed correlations between markedly different lithofacies that formed in both marine and nonmarine environments. This biostratigraphic paleontology is particularly useful in studying the beds previously mapped as the Black Creek Formation, a complex delta-shelf depositional unit.

For the most part, the lower Tertiary units in the map area are hidden beneath a cover of younger

alluvium and are known only from a few outcrops found along waterways. The lower Tertiary beds include the Black Mingo Formation of Paleocene age, which underlies the southwestern corner of the map area, and the Castle Hayne Limestone of middle Eocene age, which mainly underlies the eastern most part of the map. The best outcrops of the Castle Hayne occur in deep pits north of Wallace, N. C., in the northeastern comer of the map.

A 374 m-deep corehole (MRN-.78) near Britton Neck, S.C., penetrated nearly the entire Cretaceous section (see fig. 2). Thicknesses for the Cretaceous units in this region were obtained from this hole, because the extremely low dip of units across the Cape Fear arch makes thickness determinations very difficult from outcrop sections. In addition, depositional environments were identified from bedding forms and faunas retrieved from the core. Lithology, geophysical logs, and some pollen determinations made by Raymond A. Christopher are shown in figure 2.

Finally, because most of the sedimentary systems of the upper Tertiary and Quaternary units are relatively intact, several different depositional lithofacies occur within each of the map units. McCartan and others (1984) presented a schematic diagram that showed these depositional facies within the Quaternary formations in the Charleston-Orangeburg area, S.C. Four major lithofacies were distinguished: river (fluvial), beach (barrier), back-barrier, and offshore (shelf or marine). Each of these lithofacies was shown with a different color and symbol on their map. In the Florence-Georgetown area, no such separation is shown on the map because of the paucity of outcrops and drill holes. Nonetheless, the formations in this area contain all the facies shown by McCartan and others (1984). However, some of these lithofacies are shown in the cross sections where general lithologies have been extrapolated from drill holes, in the Britton Neck core hole (fig. 2), and in the regional paleoenvironments of the Black Creek Group and lower Peedee Formation (fig. 3). The clayey units are interpreted as dominantly back-barrier facies, the sands as barrier or beach deposits, and the thick shelly units as offshore, marine, or shelf deposits. It should be noted that the river deposits appear to be more widespread and thicker in the Florence-Georgetown area than in the Charleston area. The riverine deposits of the Cape Fear River valley were extensively studied by Soller (1988).

Text from source map: Cape Fear Region.

Map Figures

Figure 1

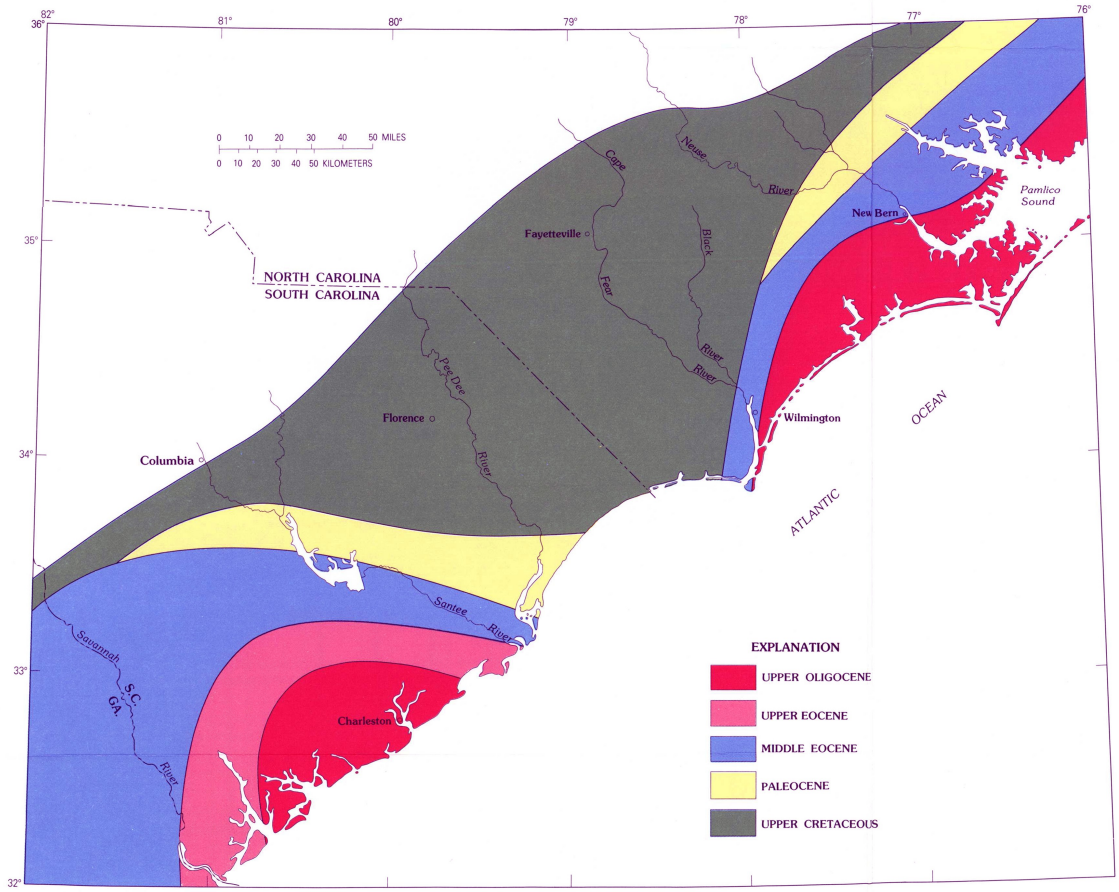


Figure 1. Generalized map of the pre-Miocene geology from central North Carolina to the Georgia-South Carolina border. The Cape Fear arch, primarily between the Cape Fear River and the Pee Dee River, is underlain by Upper Cretaceous sediments and is flanked by two Tertiary basins, one to the northeast in North Carolina and the other to the southwest in South Carolina.

Graphic from source map: Cape Fear Region.

Figure 2

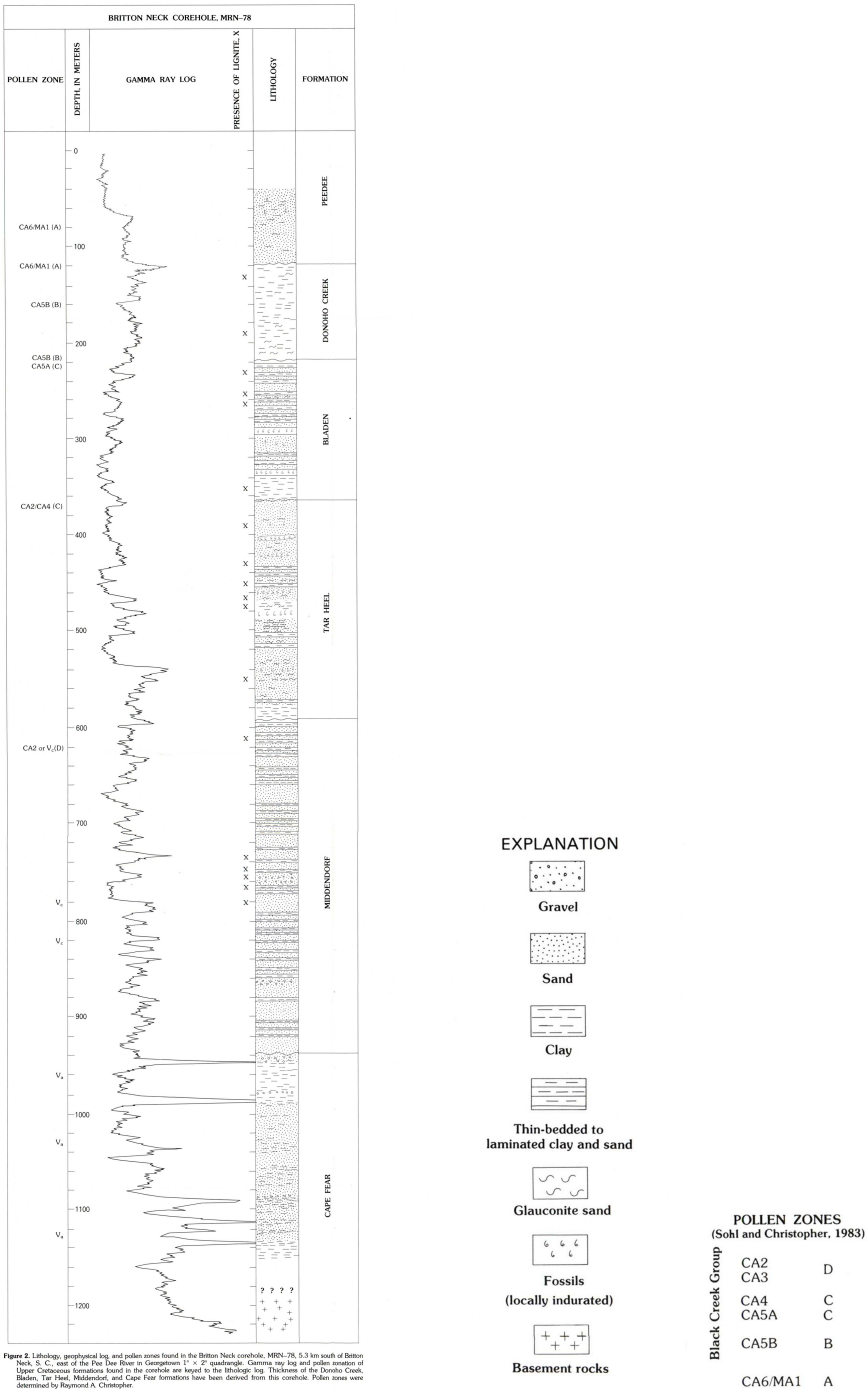


Figure 2. Lithology, geophysical log, and pollen zones found in the Britton Neck corehole, MRN–78, 5.3 km south of Britton Neck, S. C., east of the Pee Dee River in Georgetown 1° × 2° quadrangle. Gamma ray log and pollen zonation of Upper Cretaceous formations found in the corehole are keyed to the lithologic log. Thickness of the Donoho Creek, Bladen, Tar Heel, Middendorf, and Cape Fear formations have been derived from this corehole. Pollen zones were determined by Raymond A. Christopher.

Graphics from source map: Cape Fear Region.

Figure 3

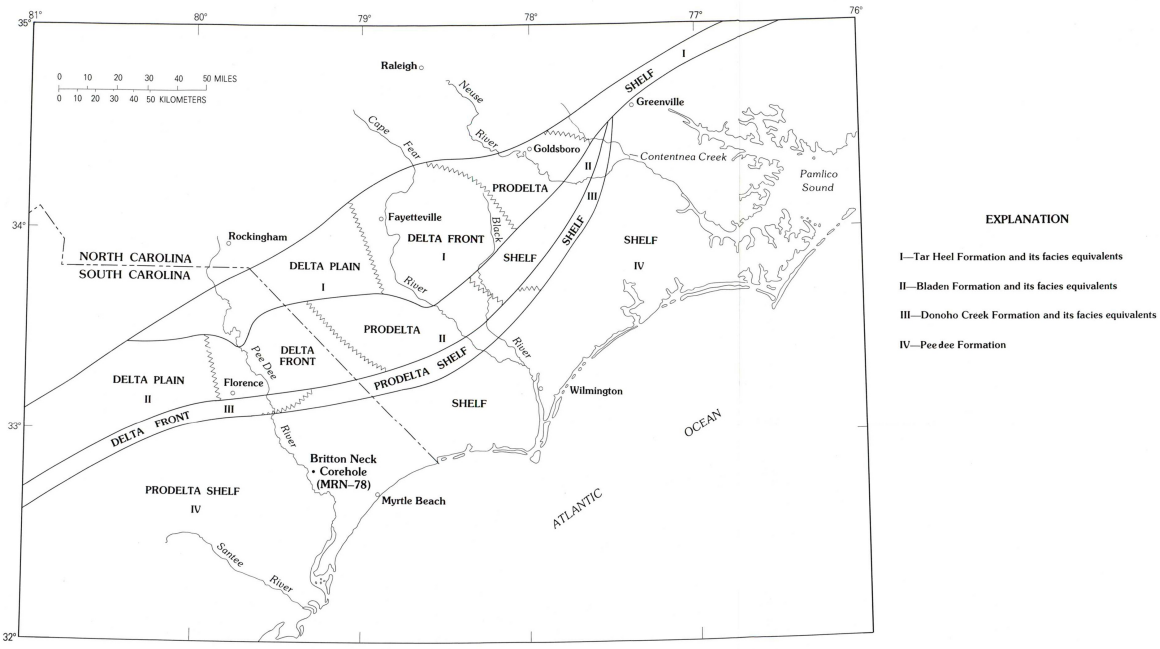


Figure 3. Generalized paleoenvironmental facies analysis of the Black Creek Group and lower Peedee Formation between Columbia, S. C., and Greenville, N. C. The general facies progression in all the formations is from less marine in the southwest to more marine in the northeast. Regionally, the formations overlap and cut obliquely across each other. Note that the Bladen Formation completely overlaps the Tar Heel Formation west of the Pee Dee River. Also the Bladen Formation is progressively overlapped by the Donoho Creek Formation from the Cape Fear River to Contentnea Creek. These overlapping relationships indicate unconformities between the formations in this region.

Graphic from source map: Cape Fear Region.

Acknowledgments

The author wishes to acknowledge the help and advice from a number of geologists who participated in various aspects of the fieldwork and in discussions regarding the geology of the Cape Fear region. From the U.S. Geological Survey, Lawrence V. Blade was an original member of the Cape Fear geologic mapping program, but retired in the early phases. Lucy McCartan, Earl M. Lemon, Jr., and Robert E. Weems from the Charleston, S.C., mapping program visited the Cape Fear area and discussed the correlation of units between the two areas. David R. Soller, Helaine W. Markewich, and I mapped the Quaternary sediments in the Cape Fear valley within and beyond this map. Gregory S. Gohn provided the lithologic data from the Britton Neck core hole. Norman F. Sohl, Raymond A. Christopher, Thomas M. Cronin, Blake W. Blackwelder, and Lauck W. Ward provided paleontologic data from the various formations. Finally, field trips were held in the region with members of the North and South Carolina geological surveys.

References

Blackwelder, B.W., 1981, Late Cenozoic stages and molluscan zones of the U.S. middle Atlantic Coastal Plain: Journal of Paleontology, v. 55, no. 5 supplement, p. 1-34.

Blackwelder, B.W., and Ward, L.W., 1979, Stratigraphic revision of the Pliocene deposits of North and South Carolina: Geologic Notes, v. 23, no. 1, p. 33-49.

Brett, CE, and Wheeler, W.H., 1961, A biostratigraphic evaluation of the Snow Hill member, Upper Cretaceous of North Carolina: Southeastern Geology, v. 3, no. 2, p. 49-132.

Burt, E.R., 1981, Geologic map of region H, North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources, Open File 8-14, scale 1:250,000.

Christopher, R.A., Owens, J.P., and SohI, N.F., 1979, Late Cretaceous polymorphs from the Cape Fear Formation of North Carolina: Southeastern Geology, v. 20, no. 3, p. 145-159.

Colquhoun, D.J., 1974, Cyclic surficial stratigraphic units of the middle and lower Coastal Plains, central South Carolina, *in* Oaks, R.Q., Jr., and DuBar, J.R., eds., Post-Miocene stratigraphy central and southern Atlantic Coastal Plain: Logan, Utah, Utah State University Press, p. 179-190.

Cooke, C.W., 1936, Geology of the Coastal Plain of South Carolina: U.S. Geological Survey Bulletin 867, 196 p., scale 1: 500,000.

Cronin, T.M., Bybell, L.M., Poore, R.Z., Blackwelder, B.W., Liddicoat, J.C., and Hazel, J.E., 1984, Age and correlation of emerged Pliocene and Pleistocene deposits, U.S. Atlantic Coastal Plain: Palaeogeography, Palaeocimatology, Palaeoecology, v. 47, p. 21-51.

Cronin, T.M., Szabo, B.J., Ager, T.A., Hazel, J.E., and Owens, J.P., 1981, Quaternary climates and sea levels of the U.S. Atlantic Coastal Plain: Science, v. 211, no. 4479, p. 233-240.

Daniels, R.B., Gamble, E.E., and Wheeler, W.H., 1978, Upper Coastal Plain surficial sediments between the Tar and Cape Fear Rivers, North Carolina: Southeastern Geology, v. 19, no. 2, p. 69-81.

Daniels, R.B., Gamble, E.E., Wheeler, W.H., and Nettleton, W.D., 1966, Coastal Plain stratigraphy and geomorphology near Benson, North Carolina: Southeastern Geology, v. 7, no. 4, p. 159-182.

DuBar, J.R., 1971, Neogene stratigraphy of the lower Coastal Plain of the Carolinas: Atlantic Coastal Plain Geological Association, 12th Annual Field Conference, Myrtle Beach, S.C., 1971, 128 p.

DuBar, J.R., DuBar, S.S., Ward, L.W., Blackwelder, B.W., 1980, Cenozoic biostratigraphy of the Carolina outer Coastal Plain, Field Trip 9, in Frey, R.W., ed., Excursions in southeastern geology, v. 1 -Geological Society of America, 1980 Annual Meeting, Atlanta, Ga.: Falls Church, Va., American Geological Institute, p. 179-236.

DuBar, J.R., Johnson, H.S., Jr., Thom, Bruce, and Hatchell, W.O., 1974, Neogene stratigraphy and morphology, south flank of the Cape Fear arch, North and South Carolina, in Oaks, R. Q., Jr., and DuBar, J. R., eds., Post-Miocene stratigraphy central and southern Atlantic Coastal Plain: Logan, Utah, Utah State University Press, p. 139-173.

Gohn, G.S., Hazel, J.E., Bybell, L.M., and Edwards, L.E., 1983, The Fishbume Formation (lower Eocene), a newly defined subsurface unit in the South Carolina Coastal Plain: U.S. Geological Survey Bulletin 1537-C, p. C1-C16.

Heron, S.D., Jr., 1958, History of terminology and correlations of the basal Cretaceous formations of the Carolinas: South Carolina State Development Board, Division of Geology Bulletin, v. 2, no. 11-12, p. 77-88.

Heron, S.D., Jr., and Wheeler, W.H., 1964, The Cretaceous formations along the Cape Fear River, North Carolina: Atlantic Coastal Plain Geological Association, 5th Annual Field Excursion, 1964, 53 p.

McCartan, Lucy, Lemon, E.M., Jr., and Weems, R.E., 1984, Geologic map of the area between Charleston and Orangeburg, South Carolina: U.S. Geological Survey Miscellaneous Investigations Series Map 1-1472, scale 1:250,000.

McCartan, Lucy, Owens, J.P., Blackwelder, B.W., Szabo, B.J., Belknap, D.F., Kriausakul, Nivat, Mitterer, R.M., and Wehmiller, J.F., 1982, Comparison of amino add racemization geochronometry with lithostratigraphy, biostratigraphy, uranium-series coral dating, and magnetostratigraphy in the Atlantic Coastal Plain of the southeastern United States: Quaternary Research, v. 18, p. 337-359.

Owens, J.P., and Gohn, G.S., 1985, Depositional history of the Cretaceous series in the United States Atlantic Coastal Plain; stratigraphy, paleoenvironments, and tectonic controls of sedimentation, in Poag, C.W., ed., Geologic evolution of the United States Atlantic margin: New York, N.Y., Van Nostrand Reinhold Co., p. 25-86.

Reinemund, J.A., 1955, Geology of the Deep River coal field, North Carolina: U.S. Geological Survey Professional Paper 24.6, 159 p.

Siple, G.E., 1959, Guidebook for South Carolina Coastal Plain field trip of the Carolina Geological Society, November 16-17, 1957: South Carolina State Development Board Division of Geology Bulletin 24, 27 p.

SohI, N.F., and Christopher, R.A., 1983, The Black Creek-Peedee formational contact (Upper Cretaceous) in the Cape Fear River region of North Carolina: U.S. Geological Survey Professional Paper 1285, 37 p.

Soller, D. R., 1988, Geology and tectonic history of the lower Cape Fear River valley, southeastern North Carolina: U.S. Geological Survey Professional Paper 1466-A, 60p.

Stephenson, L.W., 1907, “Some facts relating to the Mesozoic deposits of the Coastal Plain of North Carolina”: Johns Hopkins University Circular 71, p. 93-99.

Stuckey, J.L., 1958, Explanatory text for geologic map of North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources Bulletin 71, 51 p., scale 1:500,000.

Swift, D.J.P., and Heron, S.D., Jr., 1969, Stratigraphy of the Carolina Cretaceous: Southeastern Geology, v. 10, no. 4, p. 201-245.

Szabo, B.J., 1985, Uranium-series dating of fossil corals from marine sediments of southeastern United States Atlantic Coastal Plain: Geological Society of America Bulletin, v. 96, no. 3, p. 398-406.

Van Nieuwenhuise, D.S., and Colquhoun, D.J., 1982, The Paleocene-lower Eocene Black Mingo Group of the east-central Coastal Plain of South Carolina: South Carolina Division of Geology Bulletin, v. 26, no. 2, p. 46-67.

Ward, L.W., Lawrence, D.R., and Blackwelder, B.W., 1978, Stratigraphic revision of the middle Eocene, Oligocene, and lower Miocene-Atlantic Coastal Plain of North Carolina, in Contributions to stratigraphy: U.S. Geological Survey Bulletin 1457-F, 23 p.

Waskom, J.D., and Butler, J.R., 1971, Geology and gravity of Lilesville granite batholith, North Carolina: Geological Society of America Bulletin, v. 82, no. 10, p. 2827-2843.

Wheeler, W.H., and Curran, H.A., 1974, Relation of Rocky Point Member (Peedee Formation) to Cretaceous-Tertiary boundary in North Carolina: American Association of Petroleum Geologists Bulletin, v. 58, no. 9, p. 1751-1757.

Text from source map: Cape Fear Region.

GRI Digital Data Credits

This document was developed and completed by Stephanie O'Meara (Colorado State University) for the NPS Geologic Resources Division (GRD) Geologic Resources Inventory(GRI) Program. Quality control of this document by Stephanie O'Meara. Index map graphic produced by Stephanie O'Meara.

The information in this document was compiled from GRI source maps, and is intended to accompany the digital geologic-GIS map and other digital data for Moores Creek National Battlefield, Nort Carolina (MOCR) developed by Stephanie O'Meara and Dalton Meyer (Colorado State University) (see the GRI Digital Maps and Source Map Citations section of this document for all sources used by the GRI in the completion of this document and related GRI digital geologic-GIS maps).

GRI finalization by Stephanie O'Meara.

GRI program coordination and scoping provided by Bruce Heise (NPS GRD, Lakewood, Colorado).