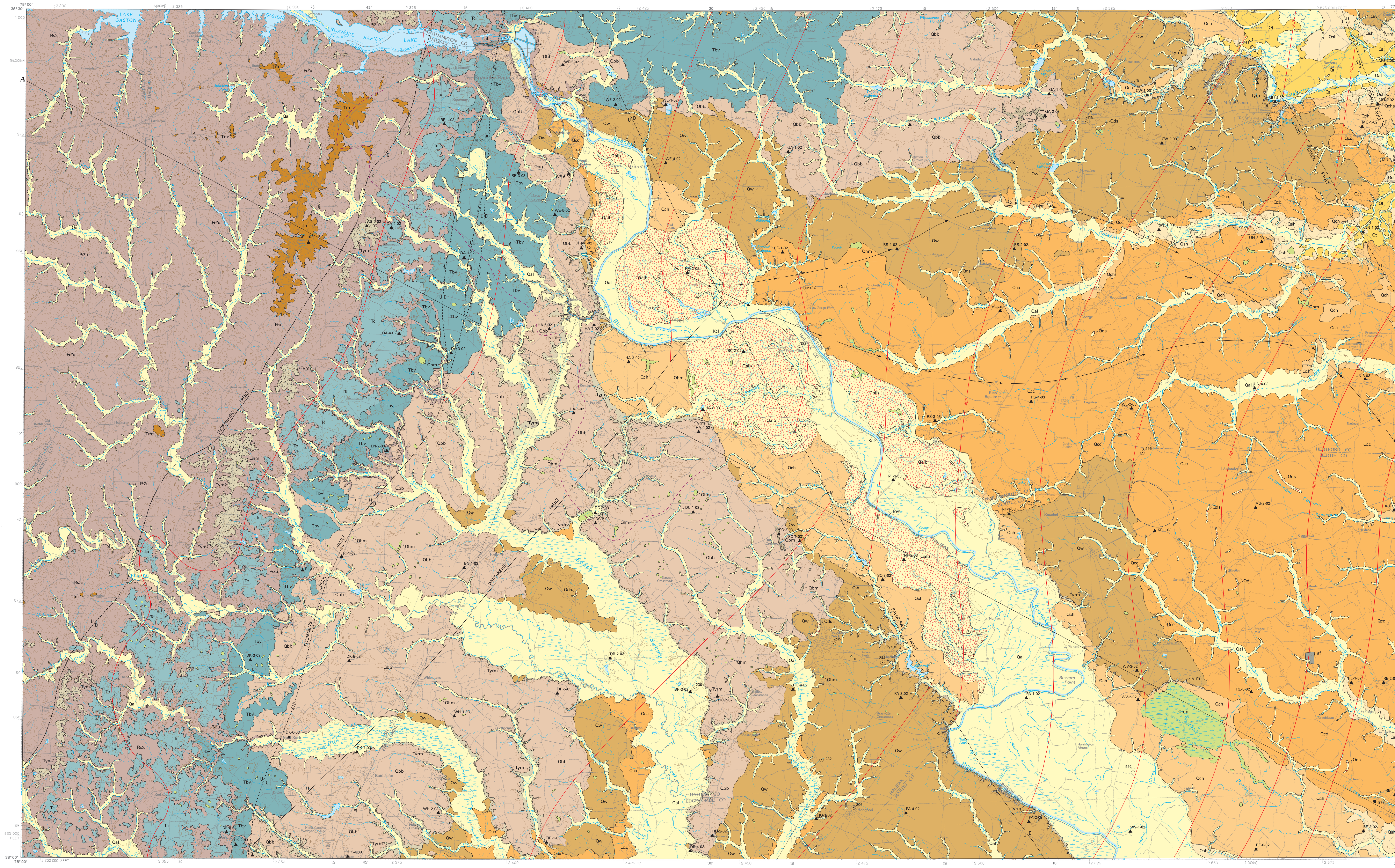


Base from U.S. Geological Survey, 1985
1927 North American datum
25,000-foot grid ticks based on North Carolina coordinate system
10,000-meter Universal Transverse Mercator grid ticks, zone 18N

APPROXIMATE MEAN DECLINATION, 2009

SCALE 1:100 000

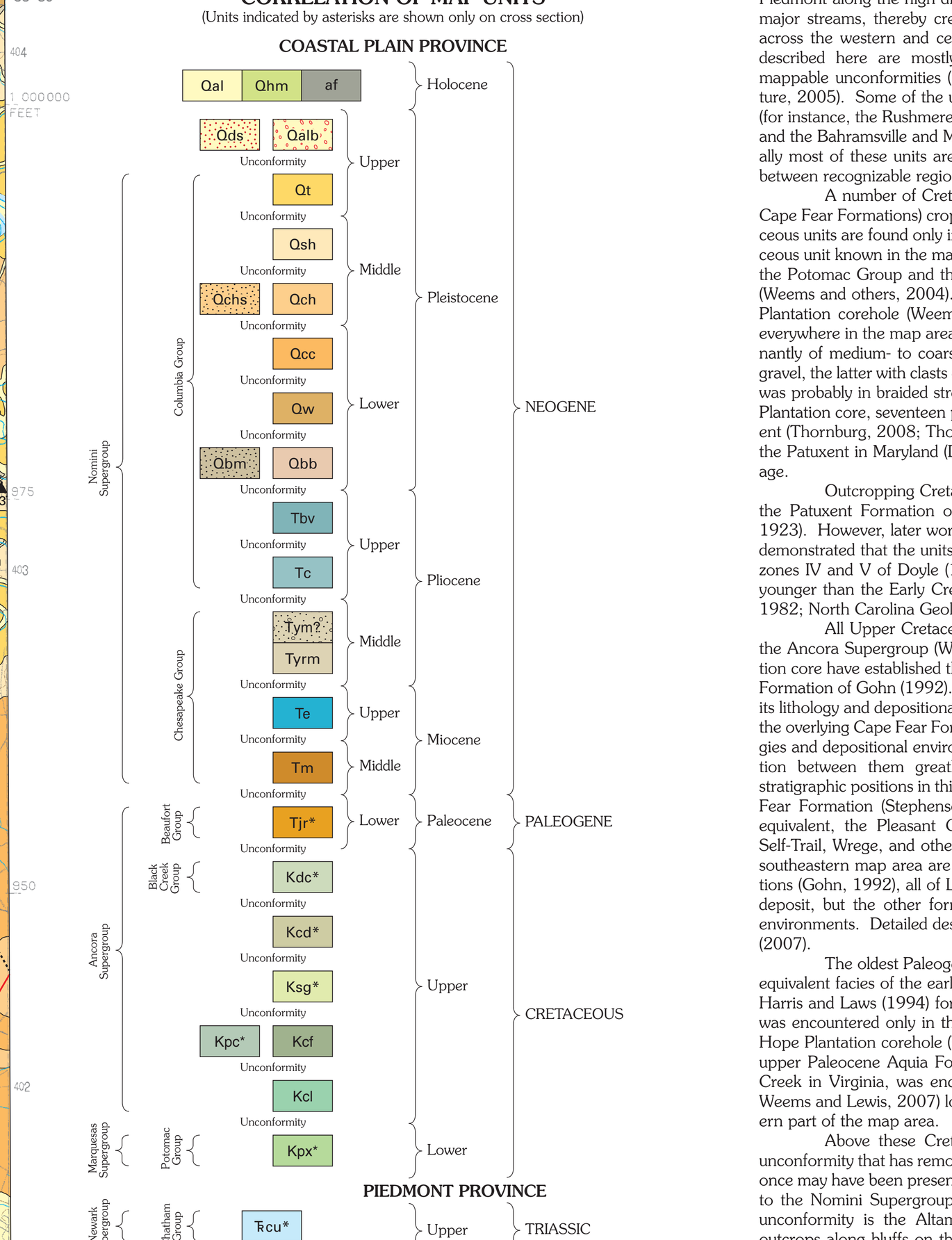
CONTOUR INTERVAL 10 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

NORTH CAROLINA
MAP LOCATION

Geology mapped by Robert E. Weems and William C. Lewis (2002-2008)
Digital compilation by Wilma B. Aléman-Gonzalez with E.A. Crider (2007-2008)
Cartography by E.A. Crider (2009)
Manuscript approved for publication July 9, 2009

CORRELATION OF MAP UNITS

(Units indicated by asterisks are shown only on cross section)



DESCRIPTION OF MAP UNITS

(In many areas, a veneer of colluvium 3 to 6 feet (ft) thick blankets hill slopes and obscures the underlying sediments. Most upland surfaces are mantled by residual soils 2 to 3 ft thick. These thin deposits are not mapped.)

af **Artificial fill**—Various sandy, silty, and gravelly materials, mainly of local origin, filled and compacted for construction of roads, bridges, and earth-filled dams. Materials up to 30 ft thick. Age less than 300 years (yr) old

CENOZOIC AND UPPER MESOZOIC DEPOSITS OF THE ATLANTIC COASTAL PLAIN

Qal **Alluvium (Holocene)**—Fine- to coarse-grained sand containing quartz pebbles, commonly with quartz-pebble conglomerate at base. Color typically a variable combination of yellowish brown (10YR 5/2), dark yellowish gray (5Y 6/2), dark yellowish orange (10YR 6/6), medium greenish gray (5G 5/1 or 5GY 5/1), and light olive gray (5Y 6/1). Deposits up to 25 ft thick. Age modern to perhaps as old as 20 thousand years (ka)

Qhm **Peat and muck (Holocene)**—Organic deposits accumulating in low areas with persistently high water tables. Color ranges from dusky yellowish brown (10YR 2/2) and dark yellowish brown (10YR 3/2) to dusky brown (5YR 2/2) and dark brown (5YR 2/4). Deposits usually less than 6 ft thick. Age typically several thousand to several hundred years (Weems and Lemon, 1993)

Qalb **Older alluvium (late Pleistocene)**—Gravel, with round to subrounded quartz clasts up to 6 cm in diameter in quartzose, medium- to very coarse grained sand matrix; silty. Color is typically dark grayish orange (10YR 6/4), dark yellowish orange (10YR 6/8), and pale olive (10Y 6/2). Grades upward to very fine to fine-grained, clayey, silty, micaceous, sand; color typically yellowish gray (5Y 7/2), moderate yellowish brown (10YR 5/6), and dark yellowish brown (10YR 4/4). Deposits up to 40 ft thick. Age probably 20 to 10 ka based on an optically stimulated luminesence date in map area

Qds **Quaternary dune sands (late Pleistocene)**—Sand, very fine to medium-grained, clean to occasionally silty; often humic with poorly developed soil horizons. Colors typically range from pale orange (10YR 7/2) to dusky yellowish brown (10YR 2/2). Deposits up to 10 ft thick. Age mostly 80 to 10 ka but a few deposits could be considerably older (Markewich and Markewich, 1994)

Qt **Tabb Formation (late Pleistocene)**—Sand, very fine to fine-grained, silty, and clayey; grades downward through fine- to medium- to coarse- and very coarse grained sand containing abundant granules and small pebbles of quartz. Colors typically range from yellowish brown (10YR 5/2), light grayish orange (10YR 8/4), and dark yellowish orange (10YR 6/6) grading downward to grayish orange (10YR 7/4), yellowish gray (5Y 7/2), and light greenish gray (5G 7/1). Deposits up to 18 ft thick. Age between 130 and 90 ka (Weems and Lemon, 1993)

Qsh **Shirley Formation (middle Pleistocene)**—Sand, very fine to fine-grained, silty, and clayey; generally grades downward through fine- to medium- to coarse- and very coarse grained sand containing abundant granules and pebbles of quartz up to 5 cm in diameter. Colors typically range from pale yellowish gray (5Y 8/2), grayish orange (10YR 7/4), dark yellowish orange (10YR 6/6), and pale grayish orange (10YR 8/4) grading downward to yellowish gray (5Y 7/2) and pale yellowish brown (10YR 6/2). Deposits up to 16 ft thick. Age ranges from about 250 to 200 ka (Weems and Lemon, 1993)

Chuckatuck Formation (middle Pleistocene)

Qch Sand, very fine to fine-grained, silty, and clayey; generally grades downward through fine- to medium- to coarse- and very coarse grained sand containing abundant granules and pebbles of quartz up to 5 cm in diameter. Colors typically range from yellowish gray (5Y 7/2), dark yellowish gray (5Y 6/2), grayish orange (10YR 7/4), dusky yellow (5Y 6/4), and dark yellowish orange (10YR 6/6) grading downward to greenish gray (5G 6/1), light greenish gray (5G 7/1), moderate greenish gray (5GY 7/1), olive (10Y 5/2), or medium brownish gray (10YR 5/1). Deposits up to 60 ft thick. Age probably about 450 to 400 ka (Weems and Lemon, 1993)

Qchs Sand, fine-grained, well-sorted; grades downward to fine- to medium-grained, clean sand containing 1 to 2 percent dark, heavy minerals. Colors ranges from yellowish orange (10YR 7/6), bright orange 10YR 6/8), and pale orange (10YR 8/8) grading downward to yellowish orange (10YR 7/6). Deposits up to 7 ft thick. Age probably about 450 to 400 ka (Weems and Lemon, 1993)

Qcc **Charles City Formation (early Pleistocene)**—Sand, very fine to fine-grained, silty and clayey, stiff; generally grades downward through fine- to medium- to coarse- and very coarse grained sand containing abundant granules and pebbles of quartz up to 5 cm in diameter. Colors typically range from dark yellowish orange (10YR 6/6), dark yellowish gray (5Y 6/2), dark yellowish brown (10YR 4/6 to 10YR 4/2), moderate yellowish brown (10YR 5/6), moderate reddish brown (10R 4/6), pale yellowish gray (5Y 8/2), light olive gray (5Y 6/1), and (or) light greenish gray (5G 7/1) grading downward to grayish orange (10YR 7/4), pale olive (10Y 6/2), light olive gray (5Y 6/1), medium greenish gray (5GY 5/1), and (or) very light gray (N 8). Deposits up to 65 ft thick. Age between 1.3 million years (Ma) and 730 ka (Weems and others, 1997)

Qw **Windsor Formation (early Pleistocene)**—Sand, very fine to fine-grained, silty and clayey, stiff; generally grades downward through fine- to medium- to coarse- and very coarse grained sand containing abundant granules and pebbles of quartz up to 5 cm in diameter. Colors typically range from medium yellowish brown (10YR 5/4), dark yellowish orange (10YR 6/6), dark grayish orange (10YR 6/4), dark yellowish gray (5Y 6/2), dusky yellow (5Y 6/4), and light yellowish gray (5Y 8/2) grading downward to moderate grayish green (10GY 6/2), medium greenish gray (5GY 5/1), dark greenish gray (5GY 4/1), olive gray (5Y 5/1), or olive (10Y 5/2). Deposits up to 80 ft thick. Age between 1.3 Ma and 730 ka (Weems and others, 1997)

Bacons Castle Formation (early Pleistocene to upper Pliocene)

Qbb **Bahramsville unit (early Pleistocene)**—Sand, very fine to fine-grained, silty and clayey, stiff; generally grades downward through fine- to medium- to coarse- and very coarse grained, subangular to angular sand containing abundant granules and pebbles of quartz up to 8 cm in diameter. Colors typically range from reddish brown (10R 5/6), moderate reddish brown (10R 4/6), dark yellowish brown (10YR 4/2), dusky yellowish brown (10YR 2/2), pale yellowish brown (10YR 6/2), dark yellowish orange (10YR 6/6), and medium brownish gray (5YR 5/1) grading downward to dark yellowish gray (5Y 6/2), greenish gray (5GY 6/1), and light greenish gray (5GY 7/1). Deposits up to 60 ft thick. Age between 1.7 and 1.6 Ma (Newton and others, 1978)

Qbm **Moorings unit (early Pleistocene)**—Sand, fine- to medium-grained, well-sorted, clean. Colors typically range from pale grayish orange (10YR 8/4), yellowish brown (10YR 5/2), or light yellowish gray (5Y 8/2) grading downward to dark yellowish orange (10YR 6/6). Deposits up to 9 ft thick. Age between 1.7 and 1.6 Ma (Newton and others, 1978)

Tbv **Varina Grove unit (upper Pliocene)**—Sand, very fine to fine-grained, silty and clayey, stiff, generally grades downward through fine- to medium- to coarse- and very coarse grained sand; subangular to angular sand containing abundant granules and pebbles of quartz up to 8 cm in diameter. Colors typically range from dark grayish orange (10YR 7/4), dark yellowish orange (10YR 6/6), dark yellowish brown (10YR 4/2), moderate orange (10YR 5/6), yellowish gray (5Y 7/2), reddish brown (10R 4/6), and yellowish gray (5Y 7/2) grading downward to pale olive gray (5Y 6/2), light olive brown (5Y 5/4), yellowish gray (5Y 7/2), dark grayish yellow (5Y 7/4), and medium brownish gray (5YR 5/1). Deposits up to 55 ft thick. Age about 2.0 Ma(?)

Tc **Chowan River Formation (upper Pliocene)**—Sand, very fine to fine-grained, silty and clayey, stiff; grades downward to fine- to medium-grained, silty sand with 1 to 2 percent dark very fine to fine-grained, heavy minerals, then grades to commonly to coarse- and very coarse grained sand with abundant granules and pebbles of quartz up to 5 cm in diameter. Colors range from reddish brown (10R 5/6), moderate reddish brown (10R 4/8), moderate yellowish brown (10YR 5/4), light brown (5YR 5/6), dark yellowish brown (10YR 4/2), dark yellowish orange (10YR 6/6), medium orange (10YR 5/6), and dusky yellow (5Y 6/4) grading downward to moderate orange pink (5YR 8/4), light orange pink (10R 8/4), light olive brown (10Y 5/4), dusky yellow (5Y 6/4), yellowish gray (5Y 7/2), medium olive gray (5Y 5/1), and medium greenish gray (5GY 5/1 and 5G 5/1). Deposits up to 60 ft thick. Age about 2.5 Ma (Blackwelder, 1981)

Yorktown Formation (middle Pliocene)

Tym? **Moore House Member(?) (middle Pliocene)**—Sand, fine- to medium-grained, well-sorted, upper beds silty to clayey and silty; grades downward to fine- to coarse-grained, poorly sorted sand with commonly abundant (2–5%) dark heavy minerals; base often marked by thin bed of quartz pebbles ranging from round to discoidal and up to 5 cm in diameter. Colors typically moderate brown (5YR 4/4 to 5YR 4/6) and moderate yellowish orange (10YR 7/6) grading downward to light reddish brown (10R 4/4). Deposits up to 35 ft thick. Age about 2.8 Ma(?)

Tyrm **Rushmere and Morgarts Beach Members, undivided (middle Pliocene)**—Silt, clayey, very fine grained sandy to silty and clayey very fine grained sand; coarsens near base to fine- to medium-grained and often gravelly sand. Fossiliferous where fresh, including clams (*Mulinia*), snails (*Turritella*), and other mollusks. At top where weathered, colors typically dark yellowish orange (10YR 6/6), dark orange (10YR 6/8), moderate reddish brown (10R 4/6), or yellowish gray (5Y 7/2); below that, typically medium greenish gray (5G 5/1 to 5GY 5/1) or medium gray (N 5). Deposits up to 70 ft thick. Age between 3.5 and 3.0 Ma (Dowsett and Wiggs, 1992)

Te **Eastover Formation (upper Miocene)**—Sand, fine-grained, well-sorted, silty and clayey; commonly shelly where exceptionally fresh; grades downward in basal 1 to 2 ft to medium- to coarse-grained, quartz- and phosphate-rich, pebbly sand. Color medium greenish gray (5G 5/1) or grayish olive (10Y 4/2) near top where weathered grading downward to dark greenish gray (5GY 4/1 to 5G 4/1) where fresh. Deposits up to 32 ft thick. Age is between 7 and 6 Ma (Ward and Blackwelder, 1980)

Tm **Altamaha Formation (middle Miocene)**—Gravel, pebble- to cobble-sized, in coarse sand matrix; interbedded with medium- to coarse-grained sand often containing abundant dark, very fine to fine-grained heavy minerals. Colors range from moderate red (5R 5/4) to light red (5R 6/4), dark grayish orange (10YR 6/4), and light gray (N 7.5). Deposits up to 50 ft thick. Age is between 12 and 11 Ma (Weems and Edwards, 2007)

Tjr **Jericho Run Formation (lower Paleocene)**—Shown only on cross section A-A′. Sand, very fine to coarse-grained, subangular to angular, silty, calcareous and glauconitic, sparsely shelly; interbedded with fine- to very coarse-grained, calcite-cemented sandstone. Colors range from olive gray (5Y 4/1) to greenish black (5GY 2/1) and medium bluish gray (5B 5/1). Deposits up to 26 ft thick. Age about 64 Ma (Harris and Laws, 1994)

Kdc **Donoho Creek Formation (Upper Cretaceous)**—Shown only on cross section A-A′. Sand, dark-greenish-gray (5G 4/1), dominantly fine- to medium-grained, quartzose and glauconitic, silty, sparsely shelly,. Deposits up to 6 ft thick. Age about 69 Ma (Gohn, 1992)

Kcd **Caddin Formation (Upper Cretaceous)**—Shown only on cross section A-A′. Silt, clayey; contains very fine grained sand; grades downward near base to olive-black (5Y 2/1) to greenish-black (5GY 2/1), fine- to medium-grained, silty and clayey, carbonaceous, pyritic sand. Deposits up to 40 ft thick. Age about 80 Ma (Gohn, 1992)

Ksg **Shepherd Grove Formation (Late Cretaceous)**—Shown only on cross section A-A′. Sand, very fine- to very coarse-grained, very poorly sorted, light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1), quartzose, silty and clayey, carbonaceous, locally granular and pebbly. Deposits up to 28 ft thick. Age about 84 Ma (Gohn, 1992)

Kpc **Pleasant Creek Formation (Upper Cretaceous)**—Shown only on cross section A-A′. Sand, fine- to coarse-grained, silty, and clayey; interbedded with very fine- to fine-grained, sandy, clayey, lignitic, micaceous, locally glauconitic silt. Color variable, ranging from light olive gray (5Y 5/2) to olive gray (5Y 4/1), dark greenish gray (5GY 4/1), greenish gray (5G 6/1), and medium dark gray (N 4). Deposits up to 77 ft thick. Age about 87 Ma (Self-Trail, Prowell, and others, 2004; Self-Trail, Wrege, and others, 2004)

Kcf **Cape Fear Formation (Upper Cretaceous)**—Silt, clayey; contains very fine to medium-grained sand; interbedded with fine- to coarse-grained, silty, clayey sand containing abundant root "ghosts" and rare wood fragments. Colors varied, including dark reddish brown (10R 3/4), very dusky red (10R 2/2), grayish red (10R 4/2), moderate yellowish brown (10YR 5/4), olive gray (5Y 4/1), dark greenish gray (5GY 4/1), greenish gray (5GY 6/1), and dusky yellowish green (5GY 5/2). Deposits up to 135 ft thick. Age about 87 Ma (Self-Trail, Prowell, and others, 2004; Self-Trail, Wrege and others, 2004)

Kcl **Clubhouse Formation (Upper Cretaceous)**—Sand, very fine to medium-grained, silty, calcareous and glauconitic; interbedded with very fine to fine-grained, clayey, sparsely shelly silt. Color ranges from greenish black (5G 2/1) to dark greenish gray (5G 4/1), greenish gray (5GY 6/1), olive gray (5Y 4/1), and dark gray (N 3). Deposits up to 187 ft thick. Age about 95 Ma (Gohn, 1992)

Kpx **Patuxent Formation (Lower Cretaceous)**—Shown only on cross section A-A′. Sand, fine- to very coarse grained, clayey and silty; interbedded with thin layers of quartz gravel with clasts up to 4 cm in diameter and dense, silty clay. Color variable, including grayish black (N 2), medium gray (N 5), olive gray (5Y 4/1), light olive gray (5Y 6/1), yellowish gray (5Y 7/2), dusky yellow (5Y 6/4), dusky yellow green (5GY 5/2), dark greenish gray (5GY 4/1), greenish gray (5GY 6/2), moderate brown (5Y 4/4), moderate yellowish brown (10YR 5/4), moderate brown (5YR 3/4), dark yellowish brown (10YR 4/2), and moderate reddish brown (10R 4/6). Deposits up to 270 ft thick. Age between 120 and 115 Ma (Doyle, 1969, 1983)

MESOZOIC, LOWER PALEOZOIC, AND NEOPROTEROZOIC ROCKS OF THE PIEDMONT PROVINCE

T̄rcu **Chatham Group, undivided (Upper Triassic)**—Shown only on cross section A-A′. Silt, very clayey; interbedded with fine- to very coarse grained, clayey and silty sandstone and angular to subrounded pebble-to-cobble conglomerate with clasts ranging from foliated schist and metasandstone to granite. Colors range from moderate reddish brown (10R 4/6) to dark reddish brown (10R 3/4), dusky red (5R 3/4), and grayish red (5R 4/2). Deposits greater (probably much greater) than 70 ft. Age between 225 and 205 Ma (Weems and Olson, 1997)

PzZu **Metamorphic and igneous basement rocks, undifferentiated (early Paleozoic and Neoproterozoic)**—Complex sequence of upper greenschist to lower amphibolite facies rocks that define the Roanoke Rapids terrane. Thickness unknown. Age between 800 Ma and 500 Ma (Horton and Stoddard, 1986; Secor and others, 1993)

EXPLANATION OF MAP SYMBOLS

Contact—Approximately located

Structure contour—Drawn on the base of the Coastal Plain. Contour interval 100 ft

Lineation

FAULTS
(Dashed where inferred; dotted where concealed)

High-angle fault—U, upthrown side; D, downthrown side

Oblique-slip fault—Arrows show relative movement; U, upthrown side; D, downthrown side; A, away, T, toward

OTHER FEATURES

U.S. Geological Survey corehole—Basement elevation in feet

U.S. Geological Survey auger hole—See Weems and Lewis (2007)

Other basement well data—Basement elevation in feet

Carolina bay rim

Roanoke River paleochannels—Arrows indicate flow direction

Southwest extent of stream drainages pirated by Roanoke River from Fishing Creek

DISCUSSION

GEOLOGIC UNITS

The Roanoke Rapids 1:100,000 map sheet is located in northeastern North Carolina. Most of the area is flat to gently rolling, though steep slopes occur occasionally along some of the larger streams. Total relief in the area is slightly less than 400 feet (ft), with elevations ranging from sea level east of Murfreesboro in the far northeastern corner of the map to 384 ft near the northwestern map border near Littleton. The principal streams are the Roanoke River and Fishing Creek, which on average flow from northwest to southeast in the map area. The principal north-south roads are Interstate Route 95, U.S. Route 258, and U.S. Route 301. Two lines of the CSX railroad also cross the area in a north-south and northeast-southwest direction. This part of North Carolina is primarily rural and agricultural. The only large community in the area is Roanoke Rapids. The map lies astride the Tidewater Fall Line (Weems, 1998), a prominent physiographic feature marked by rapids and waterfalls that separate the rocky streams of the eastern Piedmont physiographic province from the sandy and alluviated streams of the western Atlantic Coastal Plain physiographic province. The energy from the Roanoke River descending the Tidewater Fall Line has been harnessed by dams to produce hydroelectric power, and this source of energy was a major factor in the growth and development of Roanoke Rapids.

The Piedmont in the western part of the map area is underlain by Neoproterozoic to Cambrian metavolcanic and metasedimentary rocks that are intruded by granite in some areas (Sacks, 1999). The volcanic and sedimentary rocks are parts of four fault-bounded terranes. From west to east, these are the Raleigh terrane, the Spring Hope terrane, the Triplet terrane, and the Roanoke Rapids terrane (Horton and others, 1989; Sacks, 1999). The Raleigh and Triplet terranes contain rocks of amphibolite-grade metamorphism, while the Spring Hope and Roanoke Rapids terranes contain rocks of greenschist- to amphibolite-grade metamorphism (Sacks, 1999). These rocks represent volcanic flows, pyroclastic debris, and interbedded sediments that accumulated in a volcanic-arc setting (Rankin, 1975; Kish and Black, 1982; Kite and Stoddard, 1984). All of these terranes probably represent parts of one or more exotic terranes that formed far from North America and were accreted onto this continent sometime during the Paleozoic (Horton and others, 1989). The Neoproterozoic to Cambrian rocks in the map area have yielded no fossils, but similar rocks elsewhere in the Carolinas have locally yielded fossils that indicate a Neoproterozoic to Cambrian age for this sequence (Secor and others, 1983). Roanoke Rapids terrane felsic metavolcanic rocks near Princeton, N.C., have yielded a Cambrian rubidium-strontium whole-rock age (P.D. Fullagar, cited in Horton and Stoddard, 1986), which is in accord with the fossil evidence. This complex suite of metamorphic, igneous, and cataclastic rocks is shown on this map only as an undifferentiated basement complex.

A corehole at Hope Plantation in the southeastern map region (BE-110, described in Weems and others, 2007) penetrated entirely through the Coastal Plain section and bottomed in lithified, slightly thermally metamorphosed red bed sandstones and conglomerates referable to the Upper Triassic (Carnian to Norian) Chatham Group of the Newark Supergroup (Weems and Olsen, 1997; Kozur and Weems, 2007). Rocks of this age attest to the presence of an early Mesozoic fault-bordered basin buried beneath the Coastal Plain in the extreme southeastern map area. This basin here is assumed to be bounded on its southwestern side by a master fault, because it lies within a cluster of northeast-side-down faults that trend northwestward toward the fault-bounded Upper Triassic Richmond basin. However, because the Hope Plantation corehole is the only direct control available, this basin could be bounded on its northwest or southeast side by the subsurface northeastward-trending Graingers wrench zone (Brown and others, 1977; Harris and others, 1979). Won and others (1979) postulated that a considerable volume of Triassic strata might be present immediately to the southeast of the Graingers wrench zone, but later they concluded that the buried strata they were studying were low-grade Paleozoic(?) metamorphic rocks (Won and Leith, 1979). A more limited occurrence of Triassic strata adjacent to the Graingers wrench zone remains possible. The intersection of these two fracture systems possibly may be the reason for the occurrence of a Triassic basin at this particular location.

In the central and eastern part of the map area, both the folded and faulted igneous and metamorphic rocks of the Roanoke Rapids terrane and the lithified and strongly tilted sedimentary rocks of the Triassic basin are overlain with profound unconformity by generally unlithified and only slightly eastward-tilting Cretaceous, Paleogene, and Neogene sediments of the Atlantic Coastal Plain. Structure contours shown on the map give the best present estimate of the location of the base of the Coastal Plain throughout this area. These structure contours are based on data compiled in Weems and Lewis (2007). The Coastal Plain sediments lap westward onto the eastern Piedmont along the high divides between streams and locally along the valley walls of major streams, thereby creating a complex erosional and depositional map pattern across the western and central map area. The Coastal Plain sedimentary deposits described here are mostly allostratigraphic units, bounded above and below by mappable unconformities (North American Commission on Stratigraphic Nomenclature, 2005). Some of the units can be recognized in the map area by their lithologies (for instance, the Rushmere and Morgarts Beach Members of the Yorktown Formation and the Bahramsville and Moorings units of the Bacons Castle Formation), but regionally most of these units are defined primarily by their common stratigraphic location between recognizable regional unconformities.

A number of Cretaceous units are present, but only two (the Clubhouse and Cape Fear Formations) crop out in a few bluffs along the Roanoke River. Other Cretaceous units are found only in the subsurface (see cross section A-A′). The oldest Cretaceous unit known in the map area is the Patuxent Formation, which is the basal unit of the Potomac Group and the only member of the Marquesas Supergroup in this area (Weems and others, 2004). This unit was encountered in the lower part of the Hope Plantation corehole (Weems and others, 2007) and it is probably present at depth everywhere in the map area east of the Palmyra fault. The Patuxent consists predominantly of medium- to coarse-grained, feldspathic, prominently crossbedded sand and gravel, the latter with clasts composed mostly of quartz. The environment of deposition was probably in braided streams and adjacent overbanks (Glaser, 1969). In the Hope Plantation core, seventeen paleosols have been identified and studied within the Patuxent (Thornburg, 2008; Thornburg and Terry, 2008). Pollen analyses of samples from the Patuxent in Maryland (Doyle, 1983, p. 500) indicate that it is of Early Cretaceous age.

Outcropping Cretaceous strata in the map area at one time were assigned to the Patuxent Formation on the basis of their lithology (for example, Stephenson, 1923). However, later work on the Cretaceous geology and palynology in this region demonstrated that the units near the surface instead belong to Late Cretaceous pollen zones IV and V of Doyle (1969) and Sirkin (1974). This means that they are much younger than the Early Cretaceous Patuxent (Brown and others, 1972; Christopher, 1982; North Carolina Geological Survey, 1985).

All Upper Cretaceous and lower Paleogene units in the map area belong to the Ancora Supergroup (Weems and others, 2004). Samples from the Hope Plantation core have established that the pollen zone IV strata are referable to the Clubhouse Formation of Gohn (1992). This marginal-marine to marine unit contrasts markedly in its lithology and depositional environment with the underlying Patuxent Formation and the overlying Cape Fear Formation, which are very similar to each other in their lithologies and depositional environments of origin. The presence of the Clubhouse Formation between them greatly helps in making clear their separate identities and stratigraphic positions in this region. The Clubhouse Formation is overlain by the Cape Fear Formation (Stephenson, 1907; Sohl, 1976) and its lateral, down-dip marine equivalent, the Pleasant Creek Formation (Self-Trail, Prowell, and others, 2004; Self-Trail, Wrege, and others, 2004) (see cross section A-A′). Above them in the far southeastern map area are the Shepherd Grove, Caddin, and Donoho Creek Formations (Gohn, 1992), all of Late Cretaceous age. The Cape Fear Formation is a fluvial deposit, but the other formations all formed in deltaic to shallow-marine depositional environments. Detailed descriptions of these units can be found in Weems and others (2007).

The oldest Paleogene deposit in the area is an updip sand unit that is a time-equivalent facies of the early Paleocene Jericho Run Formation, which was named by Harris and Laws (1994) for outcrops along Jericho Run in North Carolina. This unit was encountered only in the southeastern part of the map in auger holes and in the Hope Plantation corehole (Weems and Lewis, 2007; Weems and others, 2007). The upper Paleocene Aquia Formation, named by Clark (1895) from bluffs along Aquia Creek in Virginia, was encountered only in one auger hole (MU-03-5, described in Weems and Lewis, 2007) located east of the City Point fault in the extreme northeastern part of the map area.

Above these Cretaceous and lower Paleogene units, there is a profound unconformity that has removed any Eocene, Oligocene, or lower Miocene deposits that once may have been present in the map area. All units above this unconformity belong to the Nomini Supergroup (Weems and others, 2004). The oldest unit above this unconformity is the Altamaha Formation, named by Dall and Harris (1892) for outcrops along the Altamaha River in eastern Georgia. This unit has been called the Bon Air gravels in the vicinity of Midlothian, Va. (Goodwin, 1970, 1980, 1981; Johnson and others, 1987), but recent regional mapping (Weems and Edwards, 2007) shows that this unit correlates with the Altamaha Formation of Georgia and South Carolina. The Altamaha crops out along the eastern border of the Piedmont province, where it caps many of the highest hills in that area as discontinuous patches of gravel and sand. Almost certainly, this unit once was widespread and continuous in that area. Gravel clasts observed in this unit are mostly vein quartz, quartzite, and quartz sandstone (which is commonly very friable). Saprolitized clasts of igneous and metamorphic rocks commonly occur where recent excavations reveal relatively undisturbed textures in this unit, indicating that the original suite of gravels was much more lithologically diverse than what is seen today after intense weathering. The age of these high-level Altamaha sands and gravels has been controversial, but recent discoveries of fossiliferous marine strata beneath this unit in Virginia (Weems and Edwards, 2007) indicate that the Altamaha represents onshore deposits that correlate with the upper part of the upper middle Miocene Choptank Formation of Maryland and Virginia (Shattuck, 1902).

The next younger unit encountered in the Roanoke Rapids map area is the St. Marys Formation, which was named by Shattuck (1902, 1904) for exposures along the St. Marys River in southern Maryland. This shallow-marine unit was encountered only in one auger hole (MU-03-5, described in Weems and Lewis, 2007) in the far northeastern part of the quadrangle, east of the City Point fault. This is the southernmost documented occurrence of this unit. The age of the St. Marys is Serravallian (late middle Miocene) to Tortonian (early late Miocene) (Mixon, Powars, and others, 1989), or about 11 to 9 Ma (Berggren and others, 1985). Above the St. Marys is the upper Miocene Eastover Formation (Ward and Blackwelder, 1980), which is Messinian or about 7 to 6 Ma. The Eastover was named for exposures on the south side of the lower James River near Eastover, Va. The Eastover occurs more or less continuously across the north-central and northeastern part of the map area and also was encountered in a small outlying area southeast of Roanoke Rapids (auger hole HA-02-1, described in Weems and Lewis, 2007).

The Yorktown Formation is the most widely encountered marine unit in this region. The formation was named by Clark and Miller (1906; Clark, Miller, Berry, and Watson, 1912) for shell-rich sand beds along the banks of the York River near Yorktown, Va., and is middle Pliocene (early Piacenzian) in age (Akers, 1972; Ward and Blackwelder, 1980; Gibson 1983a,b; Hazel, 1983; Snyder and others, 1983). In the map area, the lower part of the Yorktown is marine and fossiliferous. This unit (Tyrm) includes two members of the Yorktown: the Rushmere Member (mostly coarse sand and gravel with diverse mollusk shells scattered among the gravel clasts) and the conformably overlying Morgarts Beach Member (a sandy and clayey silt that often contains abundant, small clam shells, mostly *Mulinia*). Above this unit is a well sorted, heavy-mineral-rich, shallow-marine sand unit (Tym?) that appears to be slightly younger than the Rushmere and Morgarts Beach Members and possibly represents the Moorehouse Member of the Yorktown, although this is far from certain. This unit, in a few places where it is fossiliferous to the north in the Emporia, Va., quadrangle, contains a molluscan fauna essentially identical to that in the Yorktown (Schindler and others, 1994). For that reason, it has commonly been included in the Yorktown along with the Rushmere and Morgarts Beach Members (for example, Ward and Blackwelder, 1980, figure 16), but it is lithologically distinct from those units. No direct age estimate can be made for Moorehouse Member of the Yorktown Formation, but its age here is placed midway between the age of the next younger unit (Chowan River Formation) and the next older unit (undivided Rushmere and Morgarts Beach Members of the Yorktown Formation), which probably were deposited between 3.0 and 3.5 Ma (Dowsett and Wiggs, 1992).

Above the Yorktown, each of the upper Pliocene and Pleistocene stratigraphic units recognized in the area (Chowan River, Bacons Castle, Windsor, Charles City, Chuckatuck, Shirley, and Tabb Formations) lies beneath a geomorphic terrace that is bounded both landward and seaward by erosional scarps. At one time, these units were described as terrace formations (for example, Clark, Miller, Stephenson, and others, 1912; Cooke and others, 1943), but this concept has been abandoned (Oaks and Coch, 1973; Oaks and others, 1974) and the terminology for the geomorphic terraces and scarps has been separated from the terminology for the lithologic units that lie beneath them. The names and interrelationships among the various geomorphic features recognizable in the map area are summarized in table 1.

Table 1. Summarization of upper Pliocene and Pleistocene units, terraces, and scarps.

Unit	Overlying surface	Maximum elevation (feet)	Intervening scarp
Altamaha Formation	Midlothian uplands	410	
			Thornburg scarp
Yorktown Formation (Tym?)	Richmond plain	275	
			Chippenham scarp
Chowan River Formation	Ashland plain	235	
			Broad Rock scarp
Lower Bacons Castle Formation	Essex plain	182	
			Parler scarp
Upper Bacons Castle Formation	Norge uplands	137	
			Surry scarp
Windsor Formation	Lackey plain	105	
			Ruthville scarp
Charles City Formation	Grove plain	80	
			Lee Hall scarp
Chuckatuck Formation	Grafton plain	62	
			Kings Mill scarp
Shirley Formation	Huntington flat	49	
			Suffolk scarp
Tabb Formation	Todds flat	26	

The lithologic units mapped here were traced southward into the map area from southeastern Virginia (Johnson and others, 1987; Mixon, Berquist, and others, 1989) and the same names used there have been applied here. Although defined on the basis of lithology, mapping these units is greatly aided by their geomorphic expression. Each stratigraphic unit consists of rather similar complexes of fluvial deposits in the western outcrop region grading eastward into back-barrier estuary and marsh deposits toward the east.

The Chowan River Formation, a downdip marine deposit, has an updip terrace deposit component that crops out intermittently in a north-south-trending band in the western part of the quadrangle. This unit also has been encountered in the subsurface by auger drilling in the Emporia 1:100,000-scale quadrangle immediately to the north. The unit can be traced in the subsurface to the type area of the Chowan River Formation, where it crops out along the banks of the Chowan River to the east of the Roanoke Rapids 1:100,000 scale map (Blackwelder, 1981). Mapping farther south in the Elizabethtown quadrangle also indicates that this updip terrace unit is equivalent to the Coharie Formation of Stephenson (1912), which is here considered to be an onshore facies of the Chowan River Formation. The Chowan River Formation has been estimated to be about 2.5 Ma in age (Blackwelder, 1981).

No direct age estimate can be made for the Varina Grove unit of the Bacons Castle Formation, but its age here is placed midway between the age of the next younger Bahramsville and Mooring units (which are time-equivalent) and the next older Chowan River Formation. This age estimate suggests that the Varina Grove may be the updip equivalent of the James City Formation, which is dated at 1.9 to 2.1 Ma (Campbell, 1993). The age of the Bahramsville and Mooring units of the Bacons Castle Formation (Coch, 1965; Johnson and others, 1987) is based on work done along the Cape Fear River beneath the same terrace that overlies these units (Newton and others, 1978). The ages of the Charles City, Chuckatuck, Shirley, and Tabb Formations (Johnson, 1976; Johnson and Berquist, 1989) have been estimated based on studies of units in coastal South Carolina that have different formational names but underlie the same terrace surfaces (Weems and Lemon, 1993; Weems and others, 1997).

One exceptional terrace unit is the older alluvium deposit mapped as Qalb. This is a braided-stream fluvial unit that dips downstream along a gradient steeper than that of the modern Roanoke River and disappears beneath (and is buried by) late Holocene Roanoke River flood-plain deposits. All of the other terrace deposits formed during interglacial intervals when sea level was well above today's sea level, but the older alluvium unit clearly formed when sea level was lower than at present. A sample (taken beneath the south end of the U.S. Route 258 bridge over the Roanoke River, near Halifax, N.C.) from the basal sands beneath the higher (older) alluvial deposit yielded a quartz blue-light OSL age of 17,200±780 years before present (BP) (1 σ standard deviation) (Shannon A. Mahan, U.S. Geological Survey, written commun., 2006). This age indicates that this unit is very late Pleistocene and dates from around the Wisconsin glacial maximum. Similar deposits recently have been described along other major Coastal Plain rivers in southern North Carolina, South Carolina, and Georgia (Leigh and others, 2004).

The fact that the Roanoke River was a braided stream in the late Pleistocene, in contrast to its present meandering stream dynamic, attests to the markedly different climatic regime that prevailed in the area toward the end of the last glacial stage. Late Pleistocene dune sands of similar age, which are also unlike any deposits being formed today, are widespread farther to the south in southern North Carolina, South Carolina, and Georgia (Markewich and Markewich, 1994); a few patches of these sands also have been reported to the north in the Nottoway River valley (Wagner and McAvoy, 2004). Scattered dunes attributable to this kind of origin were mapped based on light detection and ranging (LIDAR) imagery of the Roanoke Rapids quadrangle, and it is likely that sporadic thin patches of this material remain to be discovered capping older parts of the larger alluvial flood plains.

Modern deposits include extensive areas of alluvial sand and gravel, found along nearly all streams in the central and eastern parts of the map. This material is Holocene in age near the present land surface, where it is being deposited and reworked along river and creek flood plains. The volume of sand and gravel is large, however, and may be too large to have accumulated entirely within Holocene time (the last 10,800 years). Therefore, at depth this material may include a complex of lithologically similar late Pleistocene deposits.

A number of low-lying ovoid to irregularly shaped depressions in the Pliocene and Pleistocene terrace units contain accumulated deposits of peat and muck. These swampy areas are probably best termed "pocosins" (Richardson, 1981) because they do not fully fit the definition of "Carolina bays" (Thornbury, 1965; Kaczorowski, 1977), which are large, sand-rimmed, ovoid depressions that occur in the Coastal Plain on surficial units older than the late Pleistocene (Soller, 1988). These pocosins accumulate peaty material when water tables are high and oxidation is impeded. During droughts, however, these peat deposits may dry out and be burned by forest fires. After burning, the subsequent rise in the water table allows the accumulation of peat and muck to begin again. Because these deposits re-form repeatedly, most are geologically young (late Holocene to modern). The exceptional abundance of pocosins in the south-central part of the map area possibly indicates that the surficial sediments of the Bahramsville unit of the Bacons Castle Formation were disrupted in that area by earthquake-induced paleoliquefaction.

Only two features in the map area have been identified as Carolina bays. One occurs about 0.5 mi northwest of Scotland Neck in the south-central part of the map area, where it is developed along the boundary between the Bahramsville unit of the Bacons Castle Formation and the Windsor Formation. Its size, shape, orientation, and eastern raised border rim are typical of Carolina bays, but it appears to be quite old and geomorphically degraded. It is here mapped as part of the Windsor Formation, though this assignment is far from certain, and its shape is indicated on the map by an outline. The second, much larger bay is located about 4 mi west-southwest of Aulander, N.C., on the terrace surface overlying the Charles City Formation.

STRUCTURAL GEOLOGY

Four faults in the Roanoke Rapids map area have been traced southward from the Emporia 1:100,000-scale quadrangle. They are the Thornburg fault (and scarp), the Fountains Creek fault, the Stony Creek fault, and the City Point fault. Two additional faults, named the Palmyra fault and the Whitakers fault (Weems and Lewis, 2007), juxtapose Cretaceous strata against basement rocks with apparent offsets of 100 ft or more. The Palmyra fault bounds the southwestern (updip) margin of the Lower Cretaceous Patuxent Formation, while the Whitakers fault bounds the northwestern (updip) limit of the Upper Cretaceous Cape Fear and Clubhouse Formations in the central part of the map (see Weems and Lewis, 2007, fig. 3). No recent movement on either of these faults can be demonstrated directly, but the Palmyra fault seems to control the trend of the Roanoke River valley in the southern part of this map area. In addition, stream lineaments developed in Pliocene strata between the Palmyra and Whitakers faults suggest that joints are present in that area that probably were formed by differential movement along these two faults. These observations suggest that there has been at least minor Neogene reactivation of these faults. The Stony Creek fault was active during the Early Cretaceous, but no recent motion has been demonstrated along it. The City Point fault truncates the Lower Cretaceous Patapsco Formation, the upper Paleocene Aquia Formation, and the lower upper Miocene St. Marys Formation across the Emporia 1:100,000-scale quadrangle to the north, thereby demarcating their updip limit, but the uppermost upper Miocene Eastover Formation crosses this feature with no discernible offset. The lack of offset suggests that the City Point fault has not been active since the middle of the late Miocene (about 8 Ma). The Thornburg fault also was active during the late Miocene, because uppermost middle Miocene strata to its west were uplifted and tilted at that time, but no recent movement has been recognized. The Fountains Creek fault cuts the middle Pliocene Yorktown Formation and thus has been active at least as recently as the middle Pliocene. All of these faults are steeply dipping and show a considerable degree of vertical offset, but whether they are predominantly normal or high-angle reverse faults could not be ascertained. The apparent trifurcation of the Fountains Creek fault just north of a bend in its strike suggests that it has undergone at least some component of strike-slip motion. Similarly, the strikingly different strike directions and dip slopes of the basement structure contours on either side of the Palmyra fault indicate that the northeast side of that fault has been rotated downward toward the southeast relative to the southwest side of the fault. Most of this motion probably occurred during the Cretaceous, because Neogene strata show little or no offset.

GEOMORPHOLOGY

On the basis of mappable relationships, it is possible to interpret the geomorphic history and landscape change that has occurred since a late middle Miocene sea-level high stand brought shallow coastal waters of the Atlantic Ocean westward far enough to cover the entire quadrangle area (Weems and Edwards, 2007). Deposits associated with this transgression blanketed the map area and effectively erased any earlier geomorphological features that were present. Remnants of these deposits, the Altamaha Formation, still cap some of the highest hills in the western map region (see cross section A-A′).

At the end of the middle Miocene, world sea level dropped considerably and the entire map area was subjected to erosion. During the late Miocene, the southeastern United States became tectonically reactivated (Weems, 1998; Weems and Edwards, 2007), resulting in the uplift of the Appalachian and Piedmont regions to roughly their present geomorphic configuration. In the map area, movement along the Thornburg fault caused uplift and tilting of the region west of that fault, and no transgression of the Atlantic Ocean has topped this uplifted region since then. In the late Miocene, the sea twice advanced into the eastern and central parts of the quadrangle area, as demonstrated by the presence of sediments referable to the St. Marys and Eastover Formations. At about 3 Ma, in the middle Pliocene, a major rise in world sea level brought the Atlantic Ocean back into the map area as far west as the eastern toe of the Thornburg scarp, and the Yorktown Formation was thus deposited. Although the matter remains controversial, this rise in world sea level probably was caused by a major meltdown of most of the Antarctic ice sheet (Barrett and others, 1992; Wilson, 1995; Ingólfsson, 2004). Since then, the East Antarctic ice sheet has grown more or less continuously, bringing net world sea level steadily downward as water vapor derived from the world's ocean has been transported by air currents and dropped in the form of snow upon the East Antarctic polar ice cap. In contrast, during this same time interval, northern polar ice sheets in northern North America, Europe, and Siberia have come and gone periodically on time scales of about 100,000 years, and the modern West Antarctic and Greenland ice sheets probably have come and gone as well at longer intervals. When these ice caps melted, world sea level went up; when they reformed, world sea level went down. The melting and reforming of these ice sheets produced a repetitive rise and fall in world sea level that moved the level of the world ocean up and down to nearly the same degree time after time. The steady growth of the East Antarctic ice sheet, however, when added to this oscillatory pattern of sea level rise and fall, prevented each successive oscillatory rise in world sea level from quite reaching the height of the one before it. The interaction of these two effects resulted in the preservation of a number of prehistoric high-sea-level shorelines across the Atlantic Coastal Plain region at successively lower elevations, and no tectonic uplift over the last several million years has been necessary to cause this phenomenon. These paleoshorelines mark the toe of each of the geomorphic erosional scarps that are found across the map region and also mark the shoreward limit of their associated sedimentary deposits. Because these paleoshorelines, like the shoreline today, run far upstream along drowned estuaries, the resultant regional map patterns are conceptually simple but geographically complex.

A curious geomorphic aspect of the Roanoke River, the largest stream in this area, is the fact that most of the small streams flow away from and not toward the river east and south of the city of Roanoke Rapids. This change in direction appears to have happened because a low delta was built out in front of the ancestral Roanoke River as it advanced eastward into the coastal region during the late Neogene. The resulting channels formed by the ancestral Roanoke River were therefore distributary channels that carried water away from the Roanoke River as it meandered back and forth across its delta front. After the formation of this delta, sea level dropped. This caused the river to entrench within the last channel it was flowing through at the time sea level dropped, and the surrounding abandoned distributary channels thus were left with gradients still oriented to carry water away from the river and not toward it. In a limited area west and southeast of Halifax, N.C., in the northern west-central part of the map, some of this lost drainage has been recaptured. Two branches of Beech Swamp have been incorporated partially into the modern Roanoke River drainage system by piracy on the part of Conoconnara Swamp and Quankey Creek. This area is bounded on its southwest extent by a purple dashed line on the geologic map. Stream capture by the Roanoke River has been severely limited, however, because of the very low regional stream gradients that are present over most of the area.

The presence of the Palmyra fault in the central map region appears to have strongly influenced the location of the Roanoke River and caused it to flow relatively straight in a south-southeast direction. Just south and east of the map area, the Roanoke River abandons this trend and turns toward the east. Two partially interconnected, buried channels of the Roanoke River (shown on map) are present beneath the Windsor and the Charles City Formations. The older channel runs eastward slightly north of Boones Crossroads and then northeastward toward Creeksville beneath the Windsor Formation, then southeastward through the vicinity of Menola and Earleys to beyond the quadrangle boundary. The northern part of this channel was buried during the transgression that formed the Windsor Formation. During the subsequent regression, the Roanoke River re-established itself along a course beneath the younger Charles City Formation by running slightly south of Boones Crossroads, southeastward through the vicinity of Rich Square, and then northeastward to a few miles southeast of Menola, where it rejoined the path of the older channel. These paleochannels show that there has been a progressive shift in the course of the Roanoke River in the eastern part of the quadrangle toward its modern south-southeast trend. The absence of deposits referable to the Charles City Formation along the modern course of the Roanoke River south of Roxobel indicates that the change to the modern course of the river in the southern map area occurred either very late during the deposition of the Charles City Formation or during the time between the deposition of the Charles City Formation and the deposition of the younger Chuckatuck Formation.

Several of the smaller streams in the central part of the quadrangle also have unusually straight channel segments that are not associated with buried faults but still define distinct geomorphic lineaments. The Deep Creek lineament in the south-central part of the quadrangle seems unexplained, but the other two lineaments are confined to the region between the Palmyra, Fountains Creek, and Whitakers faults. The cause of these lineaments likely was stress induced by the interaction of these three faults.

REFERENCES CITED

Akers, W.H., 1972, Planktonic foraminifera and biostratigraphy of some Neogene formations, northern Florida and Atlantic Coastal Plain: Tulane Studies in Geology and Paleontology, v. 9, nos. 1–4, p. 1–139.

Barrett, P.J., Adams, C.J., McIntosh, W.C., Swisher, C.C., and Wilson, G.S., 1992, Geochronological evidence supporting Antarctic deglaciation three million years ago: Nature, v. 359, p. 816–818.

Berggren, W.A., Kent, D.V., Flynn, J.J., and Van Couvering, J.A., 1985, Cenozoic geochronology: Geological Society of America Bulletin, v. 96, p. 1407–1418.

Blackwelder, B.W., 1981, Stratigraphy of upper Pliocene and lower Pleistocene marine and estuarine deposits of northeastern North Carolina, *in* Contributions to stratigraphy: U.S. Geological Survey Bulletin 1502–B, p. B1–B16.

Brown, P.H., Brown, D.L., Shufflebarger, T.E., and Sampair, J.L., 1977, Wrench-style deformation in rocks of Cretaceous and Paleocene age, North Carolina Coastal Plain: North Carolina Department of Natural Resources, Division of Earth Sciences, Special Publication 5, p. 1–47.

Brown, P.M., Miller, J.A., and Swain, F.M., 1972, Structural and stratigraphic framework, and spatial distribution of permeability of the Atlantic Coastal Plain, North Carolina to New York: U.S. Geological Survey Professional Paper 796, 79 p.

Campbell, L.D., 1993, Pliocene mollusks from the Yorktown and Chowan River formations in Virginia: Virginia Division of Mineral Resources Publication 127, 259 p.

Christopher, R.A., 1982, Palynostratigraphy of the basal Cretaceous units of the eastern Gulf and southern Atlantic Coastal Plains, *in* Arden, D.D., Beck, B.F., and Morrow, E., eds., Proceedings; Second symposium on the geology of the southeastern coastal plain: Georgia Geologic Survey Information Circular 53, p. 10–23, plates 1–3.

Clark, W.B., 1895, Contributions to the Eocene fauna of the middle Atlantic Slope: Johns Hopkins University Circular, v. 15, no. 121, p. 3–6.

Clark, W.B., and Miller, B.L., 1906, A brief summary of geology of the Virginia Coastal Plain: Virginia Geological Survey Bulletin 2, pt. 1, p. 11–24.

Clark, W.B., Miller, B.L., Berry, E.W., and Watson, T.L., 1912, The physiography and geology of the Coastal Plain province of Virginia: Virginia Geological Survey Bulletin 4, p. 1–58, 88–222.

Clark, W.B., Miller, B.L., Stephenson, L.W., Johnson, B.L., and Parker, H.N., 1912, The coastal plain of North Carolina: North Carolina Geological and Economic Survey, v. 3, 342 p., 29 plates.

Coch, N.K., 1965, Post-Miocene stratigraphy and morphology, inner coastal plain, southeastern Virginia: Office of Naval Research, Geography Branch Technical Report 6, 97 p.

Cooke, C.W., Gardner, J.A., and Woodring, W.P., 1943, Correlation of the Cenozoic formations of the Atlantic and Gulf Coastal Plain and the Caribbean region: Geological Society of America Bulletin, v. 54, p. 1713–1723.

Dall, W.H., and Harris, G.D., 1892, Correlation papers; Neocene: U.S. Geological Survey Bulletin, v. 84, 349 p.

Dowsett, H.J., and Wiggs, L.B., 1992, Planktonic foraminiferal assemblage of the Yorktown Formation, Virginia, USA: Micropaleontology, v. 38, no. 1, p. 75–86.

Doyle, J.A., 1969, Angiosperm pollen evolution and biostratigraphy of the basal Cretaceous formations of Maryland, Delaware, and New Jersey: Geological Society of America, Abstracts with Program, part 7, p. 51.

Doyle, J.A., 1983, Palynological evidence for Berriasian age of basal Potomac Group sediments, Crisfield well, eastern Maryland: Pollen et Spores, v. 25, p. 499–530.

Gibson, T.G., 1983a, Stratigraphy of Miocene through lower Pleistocene strata of the United States Central Atlantic Coastal Plain, *in* Ray, C.E., ed., Geology and paleontology of the Lee Creek Mine, North Carolina, I: Smithsonian Contributions to Paleobiology 53, p. 35–80.

Gibson, T.G., 1983b, Key foraminifera from upper Oligocene to lower Pleistocene strata of the central Atlantic Coastal Plain, *in* Ray, C.E., ed., Geology and paleontology of the Lee Creek Mine, North Carolina, I: Smithsonian Contributions to Paleobiology 53, p. 355–454.

Glaser, J.D., 1969, Petrology and origin of Potomac and Magothy (Cretaceous) sediments, middle Atlantic Coastal Plain: Maryland Geological Survey Report of Investigations 11, 101 p.

Gohn, G.S., 1992, Revised stratigraphic nomenclature, definitions, and correlations for the Cretaceous formations in USGS-Clubhouse Crossroads #1, Dorchester County, South Carolina: U.S. Geological Survey Professional Paper 1518, p. 1–39.

Goodwin, B.K., 1970, Geology of the Hylas and Midlothian quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigation 23, 51 p., 2 maps (scale 1:24,000).

Goodwin, B.K., 1980, Geology of the Bon Air quadrangle, Virginia: Virginia Division of Mineral Resources Publication 18, text and 1:24,000 scale map.

Goodwin, B.K., 1981, Geology of the Glen Allen quadrangle, Virginia: Virginia Division of Mineral Resources Publication 31, text and 1:24,000 scale map.

Harris, W.B., Zullo, V.A., and Baum, G.R., 1979, Tectonic effects on Cretaceous, Paleogene, and early Neogene sedimentation, North Carolina, *in* Baum, G.R., Harris, W.B., and Zullo, V.A., eds., Structural and stratigraphic framework for the coastal plain of North Carolina, Carolina Geological Society Field Trip Guidebook (October 19–21, 1979), Wrightsville Beach, N.C.: Raleigh, N. C., Geological Survey Section, Dept. of Natural Resources and Community Development, p. 17–29.

Harris, W.B., and Laws, R.A., 1994, Paleogene sediments on the axis of the Cape Fear Arch, Long Bay, North Carolina: Southeastern Geology, v. 34, no. 4, p.185–199.

Hazel, J.E., 1983, Age and correlation of the Yorktown (Pliocene) and Croatan (Pliocene and Pleistocene) Formations at the Lee Creek Mine, *in* Ray, C.E., ed., Geology and paleontology of the Lee Creek Mine, North Carolina, I: Smithsonian Contributions to Paleobiology 53, p. 81–199.

Horton, J.W., Jr., and Stoddard, E.F., 1986, The Roanoke Rapids complex of the Eastern slate belt, Halifax and Northampton counties, North Carolina, *in* Neathery, T.L., ed., Southeastern Section of the Geological Society of America, Centennial Field Guide, volume 6: Boulder, Colo., Geological Society of America, p. 217–222.

Horton, J.W., Jr., Drake, A.A., Jr., and Rankin, D.W., 1989, Tectonostratigraphic terranes and their Paleozoic boundaries in the central and southern Appalachian: Geological Society of America Special Paper 230, p. 213–245.

Ingólfsson, Ó., 2004, Quaternary glacial and climate history of Antarctica, *in* Ehlers, J., and Gibbard, P.L., eds., Quaternary glaciations—Extent and chronology, part III; South America, Asia, Australia, Antarctica: Amsterdam, Elsevier, p. 3–43.

Johnson, G.H., 1976, Geology of the Mulberry Island, Newport News North, and Hampton quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigations 41, p. 1–72, with 1:24,000 scale geologic maps.

Johnson, G.H., and Berquist, C.R., Jr., 1989, Geology and mineral resources of the Brandon and Norge quadrangles, Virginia: Virginia Division of Mineral Resources Publication 87, p. 1–28, with 1:24,000 scale geologic maps.

Johnson, G.H., Goodwin, B.K., Ward, L.W., and Ramsey, K.W., 1987, Tertiary and Quaternary stratigraphy across the Fall Zone and western Coastal Plain, southern Virginia, Trip 3 *in* Whittecar, G.R., ed., Geological excursions in Virginia and North Carolina—Geological Society of America, Southeast Section, 36th Annual Meeting, 1987, Guidebook: Norfolk, Va., Old Dominion University, p. 87–144.

Kaczorowski, R.T., 1977, The Carolina bays; a comparison with modern oriented lakes: South Carolina University, Coastal Research Division, Technical Report Number 13, 124 p.

Kish, S.A., and Black, W.W., 1982, The Carolina slate belt—Origin and evolution of an ancient volcanic are; Introduction: Geological Society of America Special Paper 191, p. 93–98.

Kite, L.E., and Stoddard, E.F., 1984, The Halifax County complex—Oceanic lithosphere in the eastern North Carolina Piedmont: Geological Society of America Bulletin, v. 195, p. 422–432.

Kozur, H.W., and Weems, R.E., 2007, Upper Triassic conchostracan biostratigraphy of the continental rift basins of Eastern North America—Its importance for correlating Newark Supergroup events with the Germanic Basin and the international geologic time scale, *in* Lucas, S.G., and Spielmann, J.A., eds., The global Triassic: New Mexico Museum of Natural History and Science Bulletin, v. 41, p. 137–188.

Leigh, D.S., Srivastava, P., and Brook, G.A., 2004, Late Pleistocene braided rivers of the Atlantic Coastal Plain, USA: Quaternary Science Reviews, v., 23, p. 65–84.

Markewich, H.W., and Markewich, M., 1994, An overview of Pleistocene and Holocene inland dunes in Georgia and the Carolinas; morphology, distribution, age, and paleoclimate: U.S. Geological Survey Bulletin 206, 932 p.

Mixon, R.B., Berquist, C.R., Jr., Newell, W.L., Johnson, G.H., Powars, D.S., Schindler, J.S., and Rader, E.K., 1989, Geologic map and generalized cross sections of the coastal plain and adjacent parts of the Piedmont, Virginia: U.S. Geological Survey Miscellaneous Investigations Series, Map I–2033.

Mixon, R.B., Powars, D.S., Ward, L.W., and Andrews, G.W., 1989, Lithostratigraphy and molluscan and diatom biostratigraphy of the Haynesville cores—Outer Coastal Plain of Virginia, *in* Mixon, R.B., ed., Geology and paleontology of the Haynesville cores—northeastern Virginia Coastal Plain: U.S. Geological Survey Professional Paper 1489, p. A1–A48.

Newton, C.R., Belknap, D.F., and Lynts, G.W., 1978, Early Pleistocene (Calabrian) age of the Waccamaw Formation at Walker's Bluff, Elizabethtown, N.C.: Geological Society of America, Abstracts with Programs, v. 10, no. 4, p. 194.

North American Commission on Stratigraphic Nomenclature, 2005, North American Stratigraphic Code: American Association of Petroleum Geologists Bulletin, v. 89, no. 11, p. 1547–1591.

North Carolina Geological Survey, 1985, Geologic map of North Carolina: North Carolina Geological Survey, 1:500,000 scale.

Oaks, R.Q., and Coch, N.K., 1973, Post-Miocene stratigraphy and morphology, southeastern Virginia: Virginia Division of Mineral Resources Bulletin 82, p. 1–135, 2 plates.

Oaks, R.Q., Coch, N.K., Sanders, J.E., and Flint, R.F., 1974, Post-Miocene shorelines and sea levels, southeastern Virginia, *in* Oaks, R.Q., and DuBar, J.R., eds., Post-Miocene stratigraphy, central and southern Atlantic Coastal Plain: Utah State University Press, Logan Utah, 275 p.

Rankin, D.W., 1975, The continental margin of eastern North America in the southern Appalachians—The opening and closing of the proto-Atlantic Ocean: American Journal of Science, v. 275–A, p. 298–336.

Richardson, C.J., 1981, Pocosin wetlands: Stroudsburg, Pa., Hutchinson Ross Publishing Company, 364 p.

Sacks, P.E., 1999, Geologic overview of the eastern Appalachian Piedmont along Lake Gaston, North Carolina and Virginia, *in* Sacks, P.E., ed., Geology of the fall zone region along the North Carolina-Virginia state line, Guidebook for the 1999 meeting of the Carolina Geological Society, Emporia, Va. (November 6-7, 1999): Raleigh, N.C., Carolina Geological Society, p. 1–15.

Schindler, J.S., Cronin, T.M., Weems, R.E., Mixon, R.B., Stettner, S.N., and Powars, D.S., 1994, Late Pliocene shoreline in Virginia; implications for eustatic sea level: Geological Society of America, Abstracts with Program, v. 26, no. 7, p. A145.

Secor, D.T., Jr., Samson, S.L., Snoke, A.W., and Palmer, A.R., 1983, Confirmation of the Carolina slate belt as an exotic terrane: Science, v. 221, no. 4611, p. 649–651.

Self-Trail, J.M., Prowell, D.C., and Christopher, R.A., 2004, The Collins Creek and Pleasant Creek Formations—Two new subsurface units in the Atlantic Coastal Plain: Southeastern Geology, v. 42, no. 4, p. 237–252.

Self-Trail, J.M., Wrege, B.M., Prowell, D.C., Seefelt, E.M., and Weems, R.E., 2004, Preliminary physical stratigraphy and geophysical data of the USGS Elizabethtown core (BL244/BL-C-1-2003), Bladen County, North Carolina: U.S. Geological Survey Open-File Report 2004–1301, 297 p.

Shattuck, G.B., 1902, The Miocene problem of Maryland: Science, v. 15, no. 388, p. 906.

Shattuck, G.B., 1904, Geological and paleontological relations, with a review of earlier investigations, *in* Clark, W.B., Shattuck, G.B., and Dall, W.H., The Miocene deposits of Maryland: Maryland Geological Survey, p. 33–94.

Sirkin, L.A., 1974, Palynology and stratigraphy of Cretaceous strata in Long Island, New York, and Block Island, Rhode Island: U.S. Geological Survey Journal of Research, v. 2, no. 4, p. 431–440.

Snyder, S.W., Mauger, L.L., and Akers, W.H., 1983, Planktonic foraminifera and biostratigraphy of the Yorktown Formation, Lee Creek Mine, *in* Ray, C.E., ed., Geology and paleontology of the Lee Creek Mine, North Carolina, I: Smithsonian Contributions to Paleobiology 53, p. 455–482.

Sohl, N.F., 1976, Reinstatement of the name Cape Fear Formation in North and South Carolina, *in* Cohee, G.V., and Wright, W.B., eds., Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1975: U.S. Geological Survey Bulletin 1422–A, p. A68.

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, p. A1–A60.

Stephenson, L.W., 1907, Some facts relating to the Mesozoic deposits of the coastal plain of North Carolina, *in* Notes from the Geological Laboratory, 1906–1907: Johns Hopkins University Circular 7, p. 93–99.

Stephenson, L.W., 1912, The Cretaceous, Lafayette, and Quaternary formations, *in* The coastal plain of North Carolina; Part 1, The physiography and geology of the coastal plain of North Carolina: North Carolina Geological and Economic Survey [Report], v. 3, p. 73–171, 258–290.

Stephenson, L.W., 1923, The Cretaceous Formations of North Carolina; Part 1, Invertebrate fossils of the Upper Cretaceous Formations: North Carolina Geological and Economic Survey, v. V, 604 p.

Thornburg, J.D., 2008, Temporal variations in the paleopedology of the Early Cretaceous Potomac Group, Hope Plantation core, Bertie County, N.C.: Philadelphia, Pa., Temple University, unpublished M.S. thesis, 85 p.

Thornburg, J.D., and Terry, D.O., 2008, Temporal variations in the paleopedology of the mid-Cretaceous Hope Plantation core, Bertie County, North Carolina: Geological Society of America, Abstracts with Programs, v. 40, no. 4, p. 10.

Thornbury, W.D., 1965, Regional geomorphology of the United States: New York, John Wiley and Sons, 609 p.

Wagner, D.P., and McAvoy, J.M., 2004, Pedoarchaelogy of Cactus Hill, a sandy Paleoindian site in southeastern Virginia, U.S.A.: Geoarchaeology, v. 19, no. 4, p. 297-322.

Ward, L.W., and Blackwelder, B.W., 1980, Stratigraphic revision of upper Miocene and lower Pliocene beds of the Chesapeake Group, middle Atlantic Coastal Plain: U.S. Geological Survey Bulletin 1482–D, 61 p.

Weems, R.E., 1998, Newly recognized en echelon fall lines in the Piedmont and Blue Ridge provinces of North Carolina and Virginia, with a discussion of their possible ages and origins: U.S. Geological Survey Open-File Report 98–374, 28 p., 12 figs.

Weems, R.E., and Edwards, L.E., 2007, Post-middle Miocene origin of modern landforms in the eastern Piedmont of Virginia: Stratigraphy, v. 4, no. 1, p. 35–48.

Weems, R.E., and Lemon, E.M., Jr., 1993, Geology of the Cainhoy, Charleston, Fort Moultrie, and North Charleston quadrangles, Charleston and Berkeley Counties, South Carolina: U.S. Geological Survey Miscellaneous Investigations Series, Map I–1935, scale 1:24,000.

Weems, R.E., and Lewis, W.C., 2007, Detailed sections from auger holes in the Roanoke Rapids 1:100,000 map sheet: U.S. Geological Survey Open-File Report 2007–1092, 155 p.

Weems, R.E., and Olsen, P.E., 1997, Synthesis and revision of groups within the Newark Supergroup, eastern North America: Geological Society of America Bulletin, v. 109, no. 2, p. 195–209.

Weems, R.E., Lemon, E.M., Jr., and Nelson, M.S., 1997, Geology of the Pringletown, Ridgeville, Summerville, and Summerville Northwest 7.5-minute quadrangles, Berkeley, Charleston, and Dorchester Counties, South Carolina: U.S. Geological Survey Miscellaneous Investigations Series, Map I–2502, scale 1:24,000.

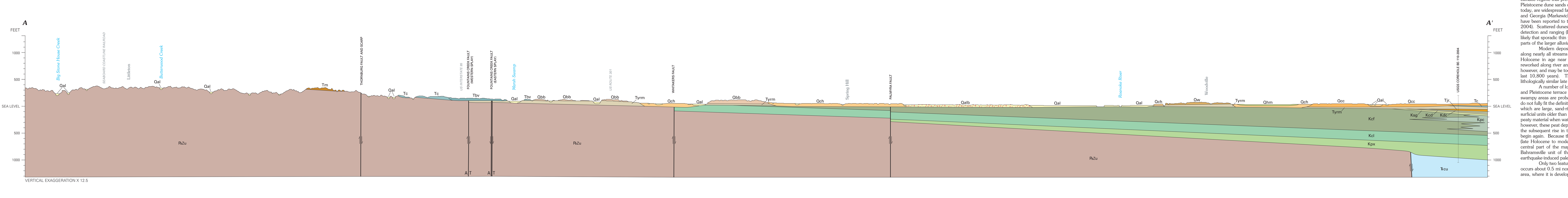
Weems, R.E., Seefelt, E.L., Wrege, B.M., Self-Trail, J.M., Prowell, D.C., Durand, C., Cobbs, E.F., III, and McKinney, K.C., 2007, Preliminary physical stratigraphy and geophysical data of the USGS Hope Plantation core (BE–110), Bertie County, North Carolina: U.S. Geological Survey Open-File Report 2007–1251, 163 p.

Weems, R.E., Self-Trail, J.M., and Edwards, L.E., 2004, Supergroup stratigraphy of the Atlantic and Gulf Coastal Plains (Middle? Jurassic through Holocene, eastern North America): Southeastern Geology, v. 42, no. 4, p. 191–216.

Wilson, G.S., 1995, The Neogene East Antarctic ice sheet—A dynamic or stable feature: Quaternary Science Reviews, v. 14, p. 101–123.

Won, I.J., and Leith, C.J., 1979, Geophysical exploration of coal and gas resources associated with a buried Triassic basin in the N.C. coastal plains—Final report to U.S. Department of Commerce: National Technical Information Service Report NCEI 0001, p. 1–14.

Won, I.J., Leith, C.J., and Washburn, D.S., 1979, Geophysical investigation of a possible Triassic basin in the North Carolina Coastal Plain: Geological Society of America, Abstracts with Programs, v. 11, no. 4, p. 218.



SURFICIAL GEOLOGIC MAP OF THE ROANOKE RAPIDS 30′ × 60′ QUADRANGLE, NORTH CAROLINA

By
Robert E. Weems, William C. Lewis, and Wilma B. Aléman-Gonzalez

2009

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