U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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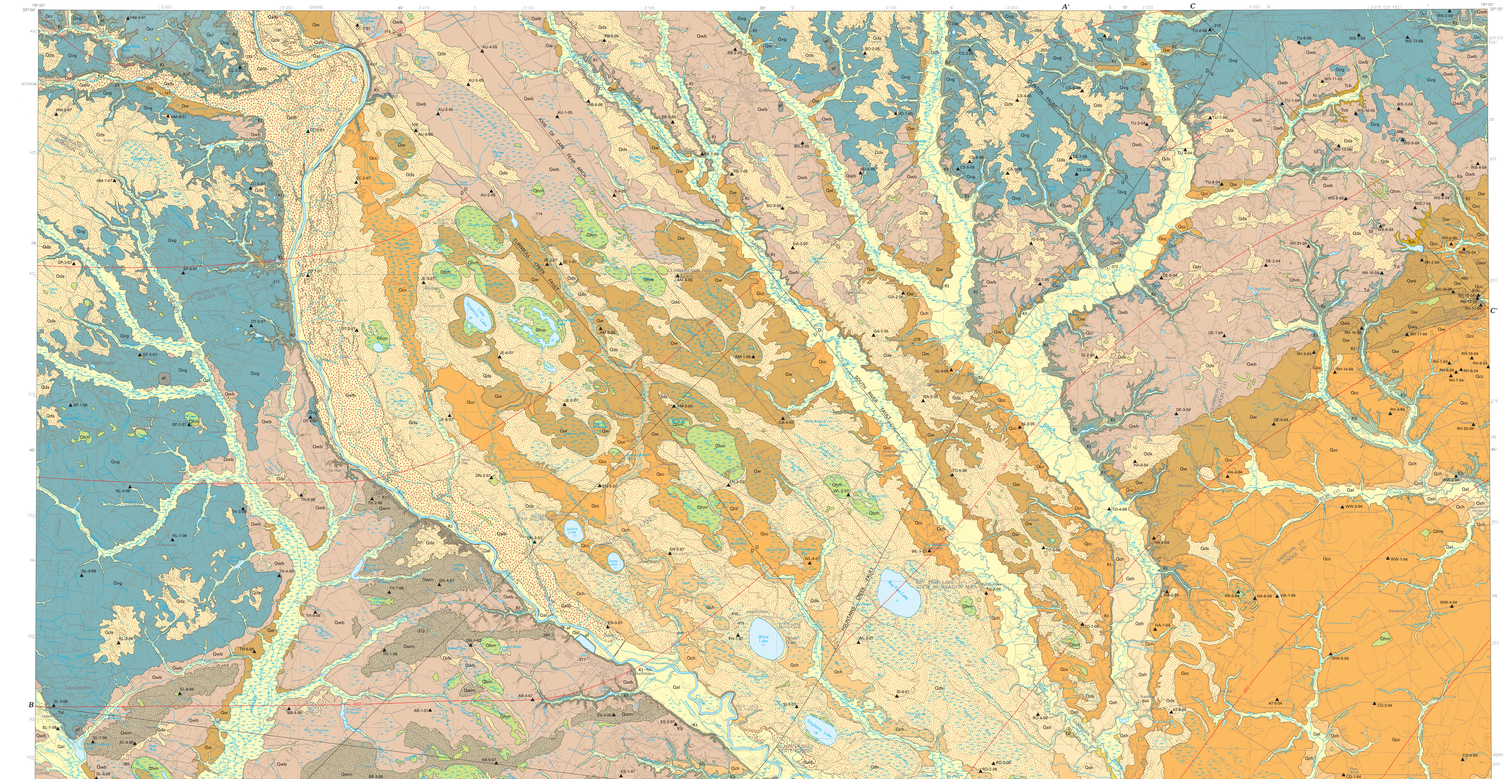
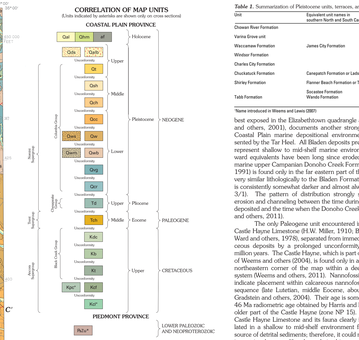


CORRELATION OF MAP UNITS



EXPLANATION OF MAP SYMBOLS

Contact—Approximately located

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

Axis of Cape Fear Arch—Approximately located

FAULTS
(Dashed where inferred)

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

Oblique-slip fault—Arrows show relative movement; U, upthrown side; D, downthrown side; A, Arch; S, syncline

OTHER FEATURES

U.S. Geological Survey auger hole—see Weems and others (2011)

Other basement well data—Basement elevation in feet

DISCUSSION

GEOLOGIC UNITS

The Elizabethtown 30′ × 60′ quadrangle is located in southeastern North Carolina between Fayetteville and Wilmington. Most of the area is flat to gently rolling with steep slopes occurring locally along some of the larger streams. Total relief in the area is slightly over 210 feet (ft), with elevations ranging from slightly less than 10 ft above sea level along the Black River (east of Rowan in the southeastern corner of the map) to slightly over 220 ft in the northwestern corner northeast of Hope Mills. The principal streams in the area are the Cape Fear, Black, South, and Lumber Rivers, which on average flow from northwest to southeast across the map area. The principal north-south roads are Interstate Route 95, Interstate Route 40, U.S. Route 117, U.S. Route 301, U.S. Route 421, and U.S. Route 701, and the principal east-west roads are N.C. State Route 241 and N.C. State Route 41. This part of North Carolina is primarily rural and agricultural. The largest communities in and adjacent to the area are Elizabethtown, Hope Mills, Clinton, Warsaw, and Lumberton. The map lies entirely within the Atlantic Coastal Plain physiographic province. Outstanding features of this area are the large number of sand-rimmed Carolina bays, fair of which contain enough water to constitute natural lakes: Bay Tree Lake, Salter Lake, Little Singletary Lake, Singletary Lake, and White Lake. These are associated with widespread windblown sand deposits on which are grown abundant pines of Southern Pine plantations. The extent and distribution of these deposits have been estimated based on a combination of auger-hole, outcrop, and high-density aerial photo interpretation (LEMID data).

The geology of the Elizabethtown 30′ × 60′ quadrangle was originally mapped on 32 7.5-minute quadrangles at 1:24,000 scale and then compiled on this 1:100,000-scale base. The base-map topographic contours on this compilation map are shown in meters; the cross sections, structure contours, and well and borehole basement elevations have been carried over uncorrected from the 1:24,000-scale maps and are shown in feet.

A cornfield south of Elizabethtown in the south-central map area (BL244/BL-C-1-2003, described in Self-Trail, Wrege, and others, 2004) penetrated entirely through the Coastal Plain section and bottomed in highly fractured, probably cataclastic metamorphic rocks. These rocks are probably part of a major fault zone (the Fountains Creek fault) that crosses the area from north to southwest and produces subtle steep gradient anomalies across the area (Weems and others, 2011). Throughout the map region, igneous and metamorphic rocks similar to those exposed in the northwest in the Piedmont province underlie Coastal Plain strata at depth. This varied suite of greenschist amphibolite-grade metasedimentary and metaigneous rocks has been encountered at the bottom of deep wells throughout the map region (Lawrence and Hoffman, 1993). These folded, faulted, and metamorphosed rocks of Neoproterozoic and possibly Early Cambrian age are overlain by profound unconformity by Coastal Plain strata that are generally unlithified and tilted only gently toward the east. Upper Cretaceous, Paleogene, and Neogene strata are preserved in structure contours shown on the map give the best available estimate of the location of the base of the Coastal Plain throughout this region. These structure contours are based on data compiled in Weems and others (2011). The Coastal Plain sediments thin westward toward the eastern Piedmont, and some of the Upper Cretaceous units completely pinch out in that direction. 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 example, the Cape Fear Formation and the Castle Hayne Limestone), but regionally most of these units are defined primarily by their common stratigraphic location between recognizable regional unconformities.

A number of Upper Cretaceous units are present near the surface and (or) crop out locally along river bluffs or in pits within the map area. All of these units belong to the Ancora Supergroup of Weems and Lewis (2004). The Clubhouse Formation (Exlr, 1992) is the oldest Coastal Plain unit known from southern North Carolina. The unit was not encountered in core holes in the map area, but dolo-mitization from a core hole to the southeast at Kure Beach, N.C., (Harris and Self-Trail, 2006), suggests that this unit probably extends in the deep subsurface into the southeastern portion of the map region (see cross section B–B′). The upper Coniacian to lower Santonian Pleasant Creek Formation, however, is known from the Elizabethtown core hole (Self-Trail, Powell, and Christopher, 2004; Self-Trail, Wrege, and others, 2004) and probably is widespread in the deeper eastern subsurface portion of the map area (see cross section B–B). The Pleasant Creek unconformably overlies the Clubhouse Formation in the southeastern part of the map area and elsewhere unconformably overlies basement rocks. The upslip onshore equivalent of the Pleasant Creek to the west is the fluvial Cape Fear Formation (Stephenson, 1907; Sohl, 1976), which is exposed locally in the far northwestern part of the map area in the vicinity of Hope Mills along the Cape Fear River and Rockfish Creek (to type area). Unconformably above this sequence is the Tar Heel Formation, which is named for bluffs within the map area along the Cape Fear River that are located northeast of the town of Tar Heel (Sohl and Owens, 1991). The interbedded sands and clays of the Tar Heel Formation formed in marginal marine deltaic environments and contain abundant woody material, local diverse marine vertebrate faunas, and occasional remains of terrestrial vertebrates, including dinosaurs (H.W. Miller, 1966, 1967, 1968; Baird and Horner, 1979; Robb, 1989; Self-Trail, Weege, and others, 2004). Glauconite sands of the Tar Heel Formation are the victim of subterranean oxidation to a marked westward expansion of the Coastal Plain marine depositional environment between Santonian and Campanian time. The marginal-marine Tar Heel Formation grades to the east into fully marine deposits, and several formations have been described from this interval to the south in South Carolina. These units are the Shepherd Grove, Cladds, Canaan, and Coachman Formations (Cohn, 1992). They are separated by unconformities, and these depositional breaks may well be present within the map area. If so, however, they could not be consistently recognized in auger holes without paleontological control, so subdivision of the Tar Heel has not been attempted here.

The upper Campanian Bladen Formation (Sohl and Owens, 1991) overlies the Tar Heel Formation and is widespread across the eastern and southeastern parts of the map area. This unit, which is

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

Unit	Equivalent unit names in southern North and South Carolina	Overlying surface (Virginia names)	Overlying surface (North and South Carolina names)	Maximum elevation (feet)	Intervening scarp
Croaan River Formation		Ashland plain[1]	Colharie terrace	235	Broad Rock scarp
Varina Grove unit		Sedgehill terrace	Sedgehill terrace	142	Parker scarp
Waccamaw Formation	James City Formation	Norge upland	Elsfleskow terrace	137	Surry scarp
Windsor Formation		Lacrisy plain	Wicomico terrace	105	Rutheville scarp
Charles City Formation		Grove plain	Pamlicoville terrace	70	Lee Hall scarp
Chuckatuck Formation	Canepatch Formation or Ladson Formation	Grafton plain	Upper Talbot terrace	42	Kings Mill scarp
Shirley Formation	Florence Beach Formation or Tan Mills Hill beds	Huntington flat	Lower Talbot terrace	49	Suffolk scarp
Tabb Formation	Socastee Formation Wando Formation	Tabbs flat	Pamlico terrace Princess Anne terrace Silver Beach terrace	28 [1] 7 [1]	

[1]Name introduced in Rhoads and Lewis (1997).

best exposed in the Elizabethtown quadrangle at Walkers Bluff (Farrell and others, 2001), documents another strong westward shift in the Coastal Plain marine depositional environment beyond that represented by the Tar Heel. All Bladen deposits preserved in this map area represent shallow to mid-shelf marine environments. Shallow-water wave-generated ripples have been long since eroded away. The overlying upper Upper Campanian Peedee Formation (Sohl and Owens, 1991) is found only in the far eastern part of the map area. Although very similar lithologically to the Bladen Formation, the Donoho Creek is consistently somewhat darker and almost always dark olive gray (5Y 3/1). The pattern of distribution strongly suggests an interval of erosion and channeling between the time during which the Bladen was deposited and the time when the Donoho Creek was deposited (Weems and others, 2011).

The only Paleogene unit encountered in the map region is the Castle Hayne Limestone (R.W. Miller, 1910; Baum and others, 1978; Ward and others, 1978), separated from immediately underlying Cretaceous deposits by a prolonged unconformity that spans about 30 million years. The Castle Hayne, which is part the Trent Supergroup of Weems and others (2007), is a very limited area in the northeastern corner of the map within a deeply incised paleovalley (green Alluvium unit). Most of the fossils from these sediments indicate placement within calcareous nannofossil zone NP 16 for this sequence (late Lutetian, middle Eocene, about 42 Ma according to Gradstein and others, 2004). Their age is somewhat younger than the 46 Ma radiometric age obtained by Harris and Fullager (1989) from an older part of the Castle Hayne (zone NP 15). The mineralogy of the Castle Hayne Limestone and its fauna clearly indicate that it accumulated in a shallow to mid-shelf environment far from any significant source of detrital sediments; therefore, it could not have been deposited in restricted estuary-like channels in this area. Instead, the channels were filled only well after they were cut and possibly enlarged by subsurface erosion. The unit must have been continuous over much or all of the map area but was later removed from most of the area by erosion.

Another unconformity, representing a very prolonged erosional interval of almost 40 million years, occurs above the Castle Hayne Limestone. Above the unconformity is the middle to upper Pliocene Duplin Formation (Dall, 1898), which is named for deposits exposed along the sides of a collapsed bluff feature called Natural Well near Magnolia, Duplin County, in the northeastern corner of the map. The Duplin and all younger marine units belong to the Neuse Supergroup of Weems and others (2004). The Duplin is a very shelly sand deposit that generally has been considered to be the equivalent to the Brafferton and Morgarts Beach Members of the Yorktown Formation in northern North Carolina and Virginia (Ward and Blackwelder, 1980). The Brafferton and Morgarts Beach have been dated at between 3.5 and 3.0 Ma (Dowsett and Wiggs, 1992); however, more stratigraphic dating of shells from outcrops along the Lumber River in the southwestern corner of the map indicates that the age of the Duplin at that location is within the range of 2.6 Ma to 2.2 Ma (Ward and others, 2009), which is younger than previously assumed. The strontium dating suggests that the Duplin instead may be equivalent in age to the unit immediately overlying the Brafferton and Morgarts Beach Members in the Roanoke Rapids region (called "Tg3" by Weems and Lewis, 2007), and either or both units could be equivalent to the Moore House Member of the Yorktown; so, there is no way to firmly establish which of these possibilities is true. Like the Castle Hayne, the Duplin now has a very patchy distribution but must have been continuous at one time across all or most of the map area.

The map region lies astride a zone of relative uplift called the Cape Fear arch (for example, by Bonini, 1956) or the Great Carolina Ridge (for example, by Spangler, 1950), which has been intermittently upwarped throughout most of the Cenozoic Era. The presence of late Miocene and Quaternary marine deposits that are not perceptibly upwarped indicates that pronounced regional uplift across the Cape Fear arch ceased by late Pliocene (about 3 million years ago), though evidence for limited local uplift along the buried Fountains Creek fault is presented below in the section on structural geology.

Above the Duplin are a number of stratigraphic units that can be recognized in the area beneath geomorphic terraces that are originally mapped on the basis of elevation and erosional scarps. The oldest two of these units were considered in the past to be late Pliocene in age (for example, Weems and Lewis, 2007; Weems and others, 2009), but the Pliocene-Pleistocene boundary was moved downward from 1.8 Ma to 2.59 Ma (Riccardi, 2007; Walker and Geissman, 2009) which now places these two units completely within the Pleistocene. At one time, all of these units were described as terrace formations (for example, Clark and others, 1912; Cooke and others, 1943), but this concept was abandoned (Oaks and others, 1973; Oaks and others, 1974) and the terminology for the geomorphic terraces and scarps was separated from the terminology for the lithologic units that lie beneath them. The names and interrelationships among these various features recognizable in the map area are summarized in table 1.

The units above the Duplin mapped here were traced southward from southeastern Virginia (Johnson, Goodwin, and others, 1987; Mixon and others, 1989) into northeastern North Carolina but are also used here, partly for ease of correlation with the geologic map of the Roanoke Rapids 30′ × 60′ quadrangle (Weems and others, 2009) and partly because isoceet for the Bacons Castle their lithostratigraphic definitions are well constrained. A synonymous nomenclature (also shown in table 1) exists for some of these terrace units in southern North Carolina and northern South Carolina (DuBar and Solliday, 1963; DuBar, 1971; DuBar and others, 1974; W. Miller, 1985; Soller and Mills, 1991; Harris, 1996) and in central South Carolina (Colquhoun, 1969; Weems and Lewis, 1993; Weems and others, 1997). The sediments mapped by Owens (1989) as the Bear Bluff Formation plotted within the map area are younger than sediments at the type section of the Bear Bluff, a name now abandoned (Campbell, 1992), so continued use of that name is inappropriate. The units above the Duplin in this map area are lithologically defined, but mapping their locations is greatly aided by their geomorphic expression. Each stratigraphic unit consists of rather similar complexes of fluvial deposits in its western outcrop region that grade eastward into marginal-marine and barrier deposits.

An updip facies of the Chowan River Formation underlies the Coharie terrace (Stephenson, 1912). This unit has been mapped at the surface in southern Virginia in the Emporia 30′ × 60′ map area to the north (Weems and others, 2010) and in northern North Carolina in the Roanoke Rapids 30′ × 60′ map area (Weems and others, 2009). Auger data (Weems and others, 2010) show that the outcrop belt in the western Coastal Plain of southern Virginia is connected in the subsurface along a buried valley that extends southeastward to the type area of the Chowan River Formation along the banks of the Chowan River (Mixon and others, 1989). The updip facies of the Chowan River Formation crops out extensively only in the northwestern corner of the Elizabethtown quadrangle in the vicinity of Hope Mills. In a few other areas, notably in the northeastern part of the map, leached shallow-marine strata that are closer in lithology to typical Chowan River beds occur along the edges of stream valleys beneath younger terrace units. The Chowan River Formation has been estimated to be between 2.4 and 1.9 Ma in age (Mallinckrodt, 1981).

Younger terrace deposits between the elevations of 185 and 105 ft previously were lumped together to the north in Virginia as the Bacons Castle Formation (Coch, 1965). There are, however, two distinct units represented within this formation that are separated by a scarp at 130 ± 17 ft. This scarp has been called the "Parler scarp" in South Carolina (Colquhoun, 1965) and the "Mechanicsville scarp" in northern South Carolina and southern North Carolina (DuBar and others, 1974). The older name, "Parler scarp" is used here. The older terrace deposit above the Parler scarp is here designated as the Varina Grove unit because it is equivalent to the Varina Grove unit of the Bacons Castle Formation in Virginia in its type area (Barnes, 1985; Johnson, Goodwin, and others, 1987) and because no other name has been proposed for it. No direct age estimate can be made for the Varina Grove unit, but its age here is placed at around 2.0 Ma, midway between the age of the next younger Waccamaw Formation and the next older Chowan River Formation.

The Waccamaw Formation includes the Bahnsmville and Moorings units, which also are units within the Bacons Castle Formation to the north (Oaks and Coch, 1973; Benpatel and Ramsey, 1985; Johnson, Goodwin, and others, 1987; Johnson, Ward, and Peebles, 1987; Weems and others, 2005, 2010). At Walker's Bluff, within the southern map area southeast of Elizabethtown on the Cape Fear River, a shallow-marine-shelf deposit is present directly beneath the Bahnsmville unit that has been biostratigraphically dated as early Pleistocene (Newton and Green, 1978; Graybill and others, 2009). This marine unit can be assigned to the Waccamaw Formation because it yields strontium ages that are virtually identical to ages obtained from the type area of the Waccamaw Formation along the Waccamaw River (W. Burleigh Harris, Department of North Carolina—Wilmington, oral commun., 2009). To avoid confusion, this shelly marine facies of the Waccamaw is here assigned to the James City Member of the Waccamaw Formation because the James City Member was named for marine strata that are age equivalent to the type Waccamaw (DuBar and Solliday, 1963; Blackwelder, 1981; Weems and others, 2011). The generally thin and patchy, marine Waccamaw lithologies appear to be conformable with the overlying and aerially more extensive estuarine and deltaic Bahnsmville lithologies; therefore both facies are here mapped together. Shallow-marine Waccamaw beds have been traced in auger holes westward as far as Abbottsburg and Dublin, almost to the toe of the westernmost barrier ridge of the Moorings unit sands. Local rapid infilling of the coastal region during the Waccamaw transgression appears to have allowed successive barrier ridges to form seaward of each other relatively rapidly, burying shallow-marine Waccamaw sediments beneath successive, slightly younger and more seaward barriers. In other areas where multiple barrier ridges did not develop, shallow-shelf Waccamaw deposits are not known to be preserved.

East of the Waccamaw outcrop belt, and below elevations of 110 ft, is the outcrop belt of the Windsor Formation. The Windsor includes some lagoonal deposits near Rose Hill and Costin that are fossiliferous, but they are more clayey than the Waccamaw marine beds, contain a distinctly more brackish fauna, and include taxa that clearly are younger than the Waccamaw Formation. All Pleistocene units in the map area younger than the Windsor (the Charles City, Chuckatuck, Shirley, and Tabb Formations) represent normaline, fluvial to estuarine marsh depositional environments. The estuarine to marine facies of those units occur only to the east and south of the map area. The ages of the Windsor, 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).

Extensive sheets of windblown sand are present across all but the southeastern part of the map area, and they have been mapped as a separate unit (dunes) from the terrace deposits. The Sand Hills region, to the west and northwest of the map area, is extensively capped by the same complex of windblown sands. These deposits were named the Pinehurst Formation in Moore County, N.C. (Conley, 1962; Bartlett, 1967), and the name is used here. Many of these deposits have weak or no soil-profile development and locally are often called "sugar sands" because they have only incipient soil profiles developed on them. More treated local deposits of this sort occur over a wide area in the Carolina and Georgia coastal plains (Markewitch and Markewitz, 1998), but they are exceptionally thick and widespread in the Sand Hills and in the Elizabethtown region. Two optically stimulated luminescence (OSL) ages from these windblown sands in the map region indicate that they range in age at least from 8,575±1,420 to 13,000±930 years before present (B.P.) (1σ standard deviation) (Shannon A. Mahan, U.S. Geological Survey, written commun.: concerning localities AU-5–05 and HA-6–04, 2005 and 2006, respectively). Radiocarbon ages from wood and peat samples taken from these windblown sand deposits in the map area yield ages ranging from 2,050±40 to greater than 51,800 years B.P. (John P. McGeehin, U.S. Geological Survey, written commun. concerning localities CC-1-07, CS-7-08, ES-4-08, HA-5-04, NL-2-06, SL-4-07, SL-6-07, and TO-3-08, 2005, 2007, 2008). These dates are consistent with other studies that indicate that these windblown sand sheets and associated Carolina bays mostly formed during the Wisconsin glacial interval (Frey, 1953, 1955; Whitehead, 1964; Soller, 1988; Markewitch, and Weems, 1994; Inster and others, 2004, 2007). Although the sands locally have been reactivated in Holocene time, these deposits are intimately associated with the "Carolina bays" (Johnson, 1942; Kaczorowski, 1977) that are prominent in this region, and the alignment of the sand deposits generally matches the long axis of the bays. The windblown sand sheets and Carolina bays both appear to have formed through the action of persistent strong winds that blew from northwest to southeast during the Wisconsin glacial interval. These winds paralleled the edge of the great ice sheet that then covered northern North America and probably also were responsible for the extensive windblown loess deposits of the central United States and the Sand Hills of Nebraska (Ziegler and Rutzla, 2001).

In the Cape Fear River valley, alluvium occurs beneath two distinct terrace surfaces that have been mapped separately. A similar stratigraphy has been documented in the Roanoke River valley (Weems and Lewis, 2007), and a sample from the basal sands beneath the higher (older) terrace deposit in the Roanoke River valley yielded a quartz blue-light OSL age of 17,200±780 years B.P. (1σ standard deviation). This age indicates that this unit in the Roanoke River valley is no older than late Wisconsin. The comparable terrace along the Cape Fear River also appears to represent a late Wisconsinan braided-river regime of the Cape Fear River that preceded a later post-Wisconsinan meandering-river regime (Leigh and others, 2004).

STRUCTURAL GEOLOGY

Five faults have been recognized in the Elizabethtown 30′ × 60′ map area based on offset anomalies in basement rocks. A northeast-trending fault, probably the southwestern extension of the Fountains Creek fault in the Roanoke Rapids region (Weems and Lewis, 2007), can be traced across the Elizabethtown quadrangle at the toe of subtle gradient anomalies along Six Runs Creek, South River, Cape Fear River, and Lumber River (immediately to the south of the map region). This northeast-trending fault obviously has a component of vertical offset with the downside to the east in all but the far northern map part of the map area. If this fault is part of the Fountains Creek transpressional fault system, it also has a significant component of right-lateral strike-slip motion. A component of strike-slip motion would explain the subtle compressional arch that crosses its trace between the Turnbull Creek and South River faults (see cross section A–A′).

Harris and others (1979) recognized a single elongate, northwest-trending fault in the map area that they named the Cape Fear fault. Southward, the Fountains Creek fault this feature is readily recognizable, but to the northwest there are three faults present, none of which can be clearly designated as a direct extension of the Cape Fear fault. Therefore, the name Cape Fear fault is restricted to the fault segment southeast of the Fountains Creek fault and the three faults to the northwest are named, respectively, the Turnbull Creek, South River, and Clinton faults (Weems and others, 2011). No seismicity has been reported in this region; however, the gradient anomalies immediately northwest of the Fountains Creek fault could not persist in unlithified sediments for a prolonged amount of geologic time, which indicates that some fairly recent fault motion has occurred at least along this fault. The Cape Fear fault, as here restricted to the area east of the Fountains Creek fault, appears to be a scissor fault with the throw on its southwest side increasing in magnitude toward the southeast beyond the map area. These contrasts indicate that the Cape Fear arch is a compressionally upwarped dome that is confined to the west of the Fountains Creek fault, whereas southeast of the Fountains Creek fault, the Cape Fear fault defines a hinge zone that dips to the southwest.

GEOMORPHOLOGY

The present geomorphology began to develop during a sea-level stand after 230 ft above present sea level in the earliest Pleistocene. This high-sea-level stand brought shallow coastal waters of the Atlantic Ocean northward for enough to cover the entire map area. Deposition associated with this transgression blanketed the northwestern corner of the map area with deposits of the Chowan River Formation, which effectively erased any earlier geomorphology that may have been present. After that, sequential higher-sea-level stands produced the other progressively lower terrace deposits that now blanket the map area. Although the major terrace-forming events are known, the terrace deposits probably were produced by changes in world sea level that have occurred since a major melting of most of the Antarctic ice sheet in the mid-Pliocene (Barrett and others, 1992; Wilson, 1995; Inglis-son, 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 ocean has been transported by air masses 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 also have some and gone 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 has produced a repetitive sea level fall in world sea level that has 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, has 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 has 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 area and also mark the shoreward limit of their associated sedimentary deposits. Because these paleoshorelines, like the shoreline today, rise northward from southeastern Georgia, the relative regional map patterns are conceptually simple but geographically complex.

A number of northeast-southwest-trending barrier-island sand deposits are present in the map area. They are mostly assigned to the Moorings unit of the Waccamaw Formation, but several barrier ridges in the west-central part of the map area are barrier sands that formed within a large lagoon that formed later during the time that the Windsor Formation was being deposited. Extensive late Pleistocene windblown-sand deposits, mostly oriented northwest-southeast along an axis that is almost orthogonal to the barrier-island sands, cover much of the landscape in this region and have partially obscured the geomorphology that resulted from the terrace deposits. In parts of the southwestern part of the map area, the sands of the northeast-trending

REFERENCES CITED

Baird, D., and Horner, J.R., 1979, Cretaceous dinosaurs of North Carolina: Brimleyana, v. 2, p. 1–28.
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.
Bartlett, C.S., Jr., 1967, Geology of the Southern Pines quadrangle: Chapel Hill, N.C., University of North Carolina, unpublished M.S. thesis, 101 p.
Baum, G.R., Harris, W.B., and Zullo, V.A., 1978, Stratigraphic revision of the exposed middle Eocene to lower Miocene formations of North Carolina: Southeastern Geology, v. 20, no. 1, p. 1–19.
Benpatel, C.R., Jr., and Ramsey, K.W., 1985, The Bahnsmville unit, an interstitial to fluvial sequence between Yorktown and Windsor formations, southeastern Virginia: American Association of Petroleum Geologists Bulletin, v. 69, no. 9, p. 1433.
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.
Bonini, W.E., 1957, Subsurface geology in the area of the Cape Fear arch as determined by seismic-refraction measurements: Madison, University of Wisconsin, unpublished Ph.D. dissertation, 218 p.
Campbell, M.R., 1992, Mollusan biostratigraphy of the Pliocene beds of eastern South Carolina and southeastern North Carolina, in Dennison, J.M., and Stewart, K.G., eds., Geologic field guides to North Carolina and vicinity, Joint annual meeting of Geological Society of America, Southeastern Section, Society of Economic Paleontologists and Mineralogists, Eastern Section, and Paleontological Society, Southeastern Section, Winston-Salem, N.C., March, 1992: University of North Carolina-Chapel Hill, Department of Geology, Geologic Guidebook 1, p. 145–151.
Clark, W.B., Miller, B.L., Stephenson, L.W., Johnson, B.L., and Parker, H.N., 1912, The coastal plain of North Carolina: Maryland 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, Geographic Branch Technical Report 6, 97 p.
Colquhoun, D.J., 1965, Terrace sediment complexes in central South Carolina, Atlantic Coastal Plain Geological Association field conference 1965 Guidebook, 6th Annual Field Conference Guidebook, Columbia, S.C.: Columbia S.C., University of South Carolina, 62 p.
Colquhoun, D.J., 1969, Geomorphology of the lower coastal plain of South Carolina: Division of Geology: South Carolina State Development Board Publication MS-15, 36 p.
Conley, J.F., 1962, Geology and mineral resources of Moore County, North Carolina: North Carolina Division of Mineral Resources, Department of Conservation and Development Bulletin, v. 76, 40 p.
Conrad, T.A., 1845, Fossils of the medial Tertiary of Moccine Formations of the United States: Philadelphia, Pa., J. Dobson, 80 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., 1898, A table of North American Tertiary horizons, correlated with one another and with those of western Europe, with annotations, in Wolcott, C.D., ed., Eighteenth annual report of the United States Geological Survey to the Secretary of the Interior, 1896–1897, part II, Papers chiefly of a theoretical nature: U.S. Geological Survey Annual Report, v. 18, p. 323–348.
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.
DuBar, J.R., 1971, Neogene stratigraphy of the lower Coastal Plain of the Carolinas, 12th Annual Field Conference, Atlantic Coastal Plain Association, Myrtle Beach, S.C., October 23-24, 1971: Myrtle Beach, S.C., Atlantic Coastal Plain Geological Association, v. 12, 128 p.
DuBar, J.R., Johnson, H.S., Jr., Thom, B., 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., Post-Miocene stratigraphy, Central and southern Atlantic Coastal Plain: Logan, Utah, Utah State University Press, p. 139–173.
DuBar, J.R., and Solliday, J.R., 1963, Stratigraphy of the Neogene deposits, Inner Neuse Estuary, North Carolina, in Contributions to stratigraphy, art geology of the coastal plain of North Carolina: North Carolina Geological and Economic Survey (Report), v. 3, p. 73-177, 258–290.
Walker, J.D., and Geissman, J.W., compilers, 2009, Geologic time scale: Boulder, Colo., Geological Society of America, 2 p., doi: 10.1130/2009.CTS004R2C.
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.
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, 1979: U.S. Geological Survey Bulletin, 1457-F, p. 1–23.
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., 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.
Weems, R.E., and Lewis, W.C., 2007, Detailed sections from auger holes in the Roanoke Rapids 30′ × 60′ quadrangle, North Carolina: U.S. Geological Survey Open-File Report 2007-1149, 155 p.
Weems, R.E., Lewis, W.C., and Aleman-Gonzalez, W.B., 2009, Surficial geologic map of the Roanoke Rapids 30′ × 60′ quadrangle, North Carolina: U.S. Geological Survey Open-File Report 2009-1149, 1 sheet, scale 1:100,000.
Weems, R.E., Lewis W.C., Murray, J., Quan, D., Grey, J.B., and DeJong, B.D., 2011, Detailed sections from auger holes in the Elizabethtown 1:100,000 map sheet: U.S. Geological Survey Open-File Report Number 2011-1115, 286 p.
Weems, R.E., Schindler, J.S., and Lewis, W.C., 2010, Detailed sections from auger holes in the Emporia 1:100,000 scale quadrangle, Virginia: U.S. Geological Survey Open-File Report 2010-1121, 258 p., available online at http://pubs.usgs.gov/of/2010/1121.
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.
White, W.A., 1966, Drainage asymmetry and the Carolina capes: Geological Society of America Bulletin, v. 77, p. 223–240.
Whitehead, D.R., 1964, Fossil pine pollen and full-glacial vegetation in southeastern North Carolina: Ecology, v. 45, no. 4, p. 767–777.
Wilson, G.S., 1995, The Neogene East Antarctic ice sheet–A dynamic or stable feature: Quaternary Science Reviews, v. 14, p. 101–123.
Zarner, C.W., and Rutzla, M.S., 2001, Nebraska's Carolina bays: Geological Society of America Abstracts with Programs, v. 33, no. 6, p. 438.

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

By
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