DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
COLLEGE OF WILLIAM AND MARY

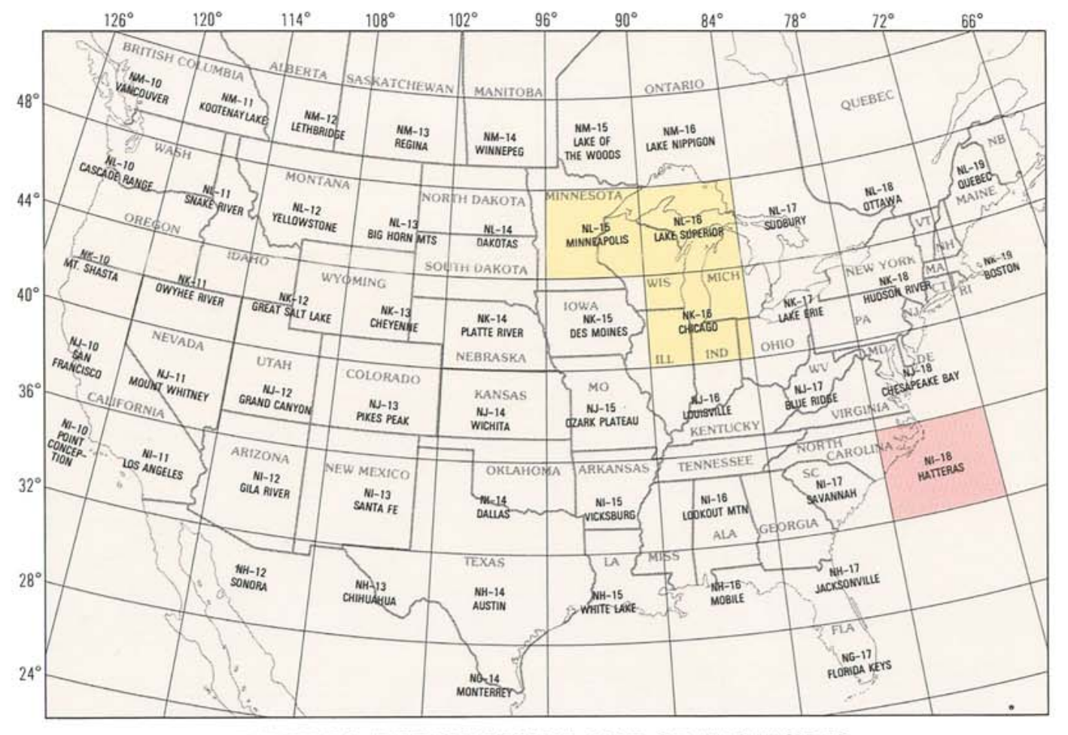
QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1420 (NI–18)

Base from U.S. Geological Survey
International Map of the World (IMW Series), 1976
Lambert Conformal Conic Projection

Compiled in 1978–1981
G.M. Richmond, Coordinator

SCALE 1:1 000 000
25 0 25 50 75 100 MILES
25 0 25 50 75 100 KILOMETERS

CONTOURS IN METERS ABOVE MEAN SEA LEVEL
NATIONAL GEODETIC VERTICAL DATUM OF 1929

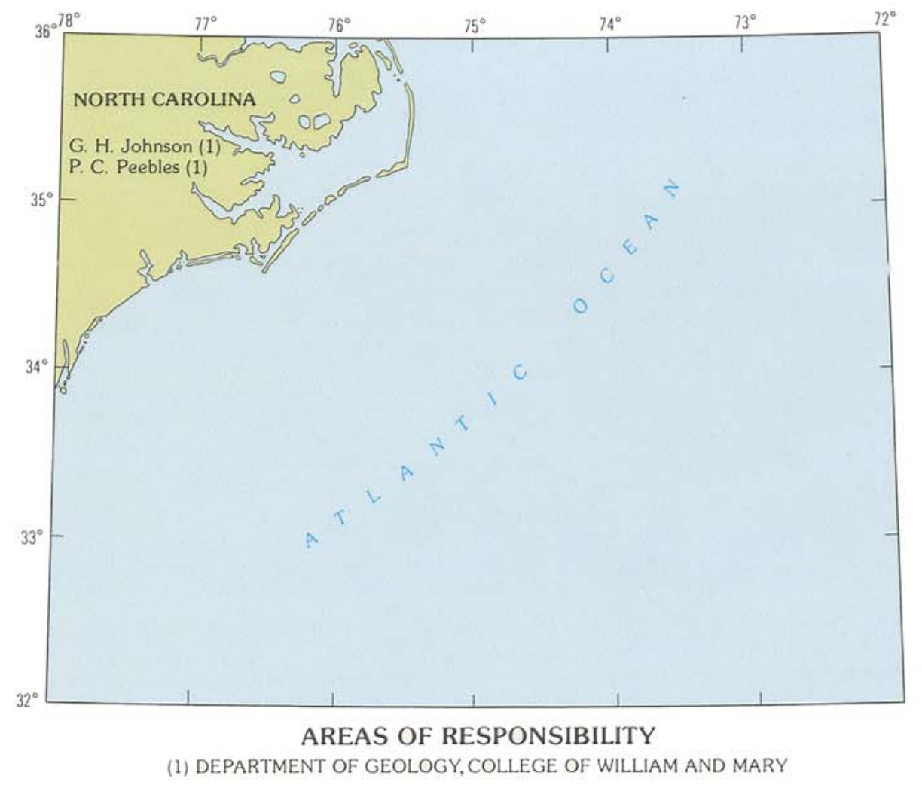


INDEX TO INTERNATIONAL MAP OF THE WORLD
1:1,000,000 TOPOGRAPHIC SERIES
Showing location of the Quaternary Geologic Map of the Hatteras 4° x 6° Quadrangle in red [U.S. Geological Survey, Miscellaneous Investigations Series, Map I-1420 (NI-18)] and other published maps in the Quaternary Geologic Atlas of the United States in yellow.

TENTATIVE CORRELATION OF QUATERNARY AND UPPER PLIOCENE STRATIGRAPHIC UNITS OF THE ATLANTIC COASTAL PLAIN IN THE HATTERAS QUADRANGLE

AGE		JOHNSON (1976) JOHNSON AND BERQUIST (1984) PEEBLES AND OTHERS (1984) (1)		RICHARDS (1950) (MORPHOSTRATIGRAPHIC UNITS) (2)	DUBAR AND SOLLIDAY (1963)	FALLAW AND WHEELER (1969)		DANIELS AND OTHERS (1972)	DUBAR, SOLLIDAY, AND HOWARD (1974)	DUBAR AND OTHERS (1974) LIDDICOAT AND OTHERS (1982)	MIXON AND PILKEY (1976)	BLACKWELDER (1981) LIDDICOAT AND OTHERS (1983) LIDDICOAT (1984)	WHEELER, DANIELS, AND GAMBLE (1983) HAZEL (1983)	OXYGEN ISOTOPE STAGES SHACKLETON AND OPDYKE (1973) TWO ALTERNATE CORRELATIONS FROM MIXON AND OTHERS (1982) 1	2
PLEISTOCENE	LATE	TABB FORMATION	POQUOSON MEMBER	PAMLICO FORMATION				PAMLICO FORMATION					PAMLICO FORMATION	5a	5 a
			LYNNHAVEN MEMBER												
			SEDGEFIELD MEMBER					MINNESOTT RIDGE SAND	CHERRY CREEK UNIT		MINNESOTT RIDGE SAND CORE CREEK SAND		MINNESOTT RIDGE SAND		c e
														5c 5e	
	MIDDLE	SHIRLEY FORMATION		TALBOT FORMATION	FLANNER BEACH FORMATION	NEUSE FORMATION AND HORRY CLAY			FLANNER BEACH FORMATION	SOCASTEE FORMATION	FLANNER BEACH FORMATION	N FLANNER BEACH FORMATION	TALBOT FORMATION	7	
		CHUCKATUCK FORMATION						WICOMICO FORMATION		N CANEPATCH FORMATION		WINDSOR FORMATION OF OAKS AND COCH (1973)			
	?	CHARLES CITY FORMATION													
	EARLY	WINDSOR FORMATION (RESTRICTED)		PENHOLOWAY AND WICOMICO FORMATIONS											
PLIOCENE		MOORINGS UNIT		SUNDERLAND FORMATION	JAMES CITY FORMATION	CROATAN FORMATION	UPPER PART	SUNDERLAND FORMATION	JAMES CITY FORMATION CROATAN FORMATION	R WACCAMAW FORMATION	JAMES CITY FORMATION	JAMES CITY FORMATION R CROATAN FORMATION	CROATAN FORMATION SMALL SEQUENCE		
	LATE			COHARIE FORMATION			LOWER PART			BEAR BLUFF FORMATION		R CHOWAN RIVER FORMATION			

N Normal polarity
R Reversed polarity
(1) Facies of named stratigraphic units defined in three cited references in Virginia were extended throughout the Hatteras quadrangle by Johnson and Peebles for purposes of this map.
(2) Correlations suggested for morphostratigraphic units are imprecise.



AREAS OF RESPONSIBILITY
(1) DEPARTMENT OF GEOLOGY, COLLEGE OF WILLIAM AND MARY

QUATERNARY GEOLOGIC MAP OF THE HATTERAS 4° x 6° QUADRANGLE, UNITED STATES

State compilation by
Gerald H. Johnson and Pamela C. Peebles
Edited and integrated by
Gerald M. Richmond, David S. Fullerton, and David L. Weide
1986

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

LIST OF MAP UNITS

HOLOCENE

asa	ALLUVIAL GRAVELLY SAND
ala	ALLUVIAL SILT AND CLAY
hps	SALINE-MARSH DEPOSIT
hp	PEAT
be	BEACH AND DUNE SAND

HOLOCENE AND LATE WISCONSIN

hs	SWAMP DEPOSIT
es	EOLIAN SAND

LATE PLEISTOCENE

bmh	BEACH AND NEARSHORE MARINE SAND
aei	ALLUVIAL AND ESTUARINE SAND AND SILT
bmi	BEACH AND NEARSHORE MARINE SAND
mli	MARINE SAND, SILT, AND CLAY
aej	ALLUVIAL AND ESTUARINE SAND AND SILT
bmj	BEACH AND NEARSHORE MARINE SAND
mlj	MARINE SAND, SILT, AND CLAY

MIDDLE PLEISTOCENE

aed	ALLUVIAL AND ESTUARINE SAND AND SILT
bmd	BEACH AND NEARSHORE MARINE SAND
mld	MARINE SAND, SILT, AND CLAY
aek	ALLUVIAL AND ESTUARINE SAND AND SILT
mlk	MARINE SAND, SILT, AND CLAY
mlm	MARINE SAND, SILT, AND CLAY

MIDDLE AND EARLY PLEISTOCENE

aef	ALLUVIAL AND ESTUARINE SAND AND SILT
mlf	MARINE SAND, SILT, AND CLAY
mln	MARINE SAND, SILT, AND CLAY

EARLY PLEISTOCENE TO PLIOCENE

bmg	BEACH AND NEARSHORE MARINE SAND
mlg	MARINE SAND, SILT, AND CLAY

QUATERNARY AND TERTIARY

zsc	SAND AND CLAY DECOMPOSITION RESIDUUM

―	CONTACT
―	MARINE SCARP
▨	THIN DEPOSIT OF EOLIAN SAND OVERLYING MAP UNIT
●	CAROLINA BAY—Shallow oval or elliptical, generally marshy, closed depressions in Atlantic Coastal Plain; 100 m to many kilometers in length. Origin debated: attributed to meteorites, upwelling springs, eddy currents, eolian erosion, solution, or thaw of permafrost

NOTE 1: This map is the product of interorganizational collaboration. Following a meeting of the State compiler with compilers of adjacent quadrangle maps and with the coordinator to establish map units and related matters, a preliminary map of this quadrangle was prepared. Subsequent meetings with the coordinator and compilers in North Carolina as well as field conferences with others were held to resolve problems of stratigraphic and material definition. The map and explanation were then integrated with those of adjacent quadrangles by the editors, who also compiled the associated diagrams. The tentative correlation chart of Coastal Plain formations was prepared by G. M. Richmond with the cooperation of G. H. Johnson. The compiler reviewed the map prior to its submittal for publication.

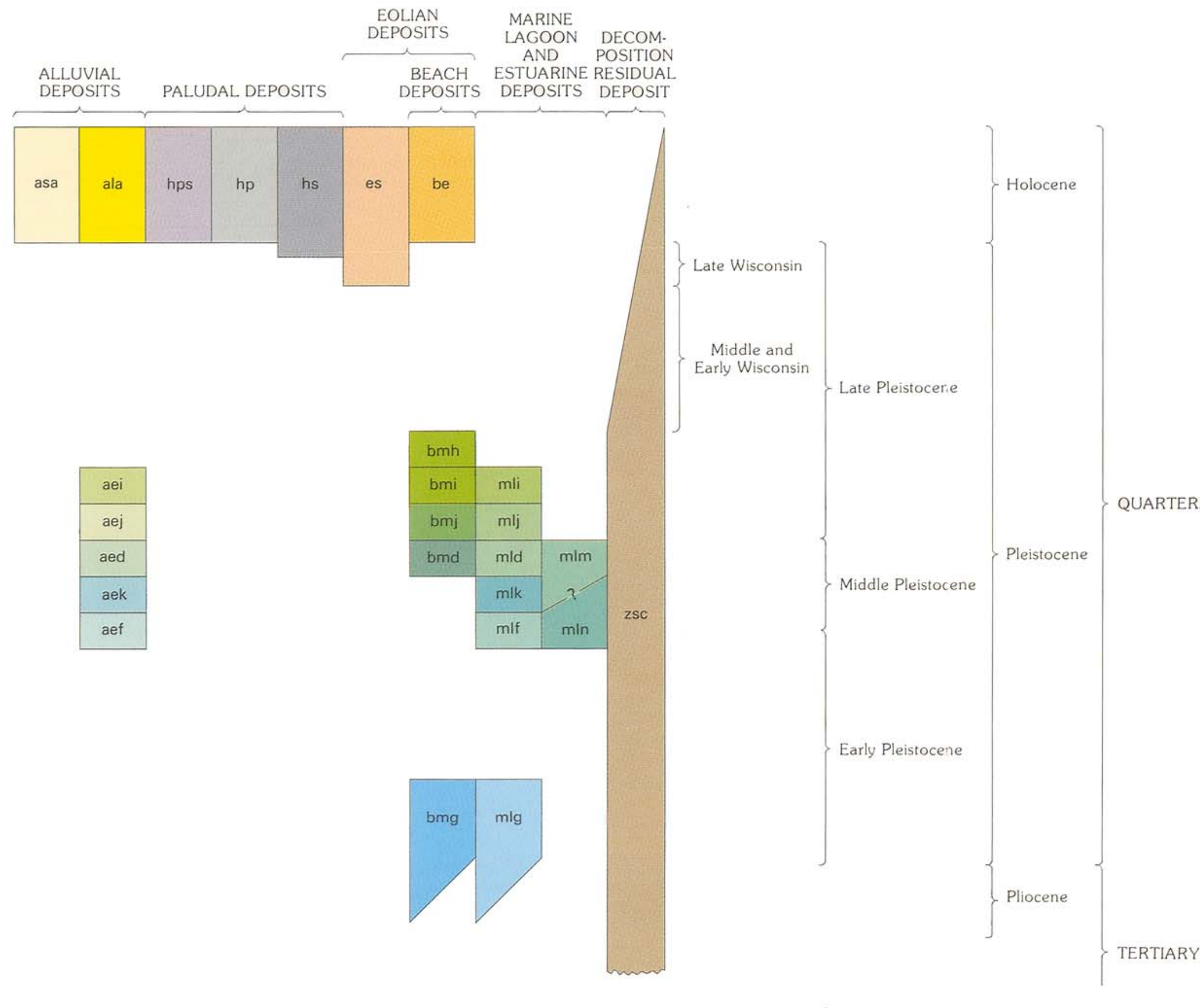
NOTE 2: The Pliocene-Pleistocene boundary defined by joint resolution of the International Union for Quaternary Research (INQUA) Subcommission 1–d on the Pliocene/Pleistocene Boundary (the International Commission on Stratigraphy (ICS) Working Group on the Pliocene/Pleistocene Boundary) and the Working Group of the International Geological Correlation Program (IGCP) Project No. 41 (Neogene/Quaternary Boundary) is that at the Vrica section in southern Italy. The age of that boundary currently is inferred to be 1.65 Ma (Aguirre and Pasini, 1984).

Time boundaries between the early Pleistocene and middle Pleistocene and between the middle Pleistocene and late Pleistocene are being proposed by the INQUA Working Group on Major Subdivision of the Pleistocene. The boundary between the early Pleistocene and middle Pleistocene is placed at the Matuyama-Brunhes magnetic polarity reversal. The reversal has not been dated directly by radiometric controls. It is significantly older than the Bishop Tuff (revised K-Ar age 738 ka; Izett, 1982), and the estimated K-Ar age of 730 ka assigned to the reversal by Mankinen and Dalrymple (1979) is too young. In Utah, the Bishop volcanic ash bed overlies a major paleosol developed in sediments that record the Matuyama-Brunhes reversal (Eardley and others, 1973). The terrestrial geologic record is compatible with the astronomical age of 788 ka assigned to the reversal by Johnson (1982). The boundary between the middle Pleistocene and late Pleistocene is placed arbitrarily at the beginning of marine oxygen isotope substage 5e (at Termination II or the stage 6/5 transition). That boundary also is not dated directly. It was assigned provisional ages of 127 ka by CLIMAP Project members (CLIMAP Project Members, 1984) and 128 ka by SPECMAP Project members (Ruddiman and McIntyre, 1984), based on uranium-series ages of the substage 5e high eustatic sea level stand. A sidereal age of 132 ka is derived by projection of the boundary onto the astronomical time scale of Johnson (1982).

The Pleistocene-Holocene boundary is being proposed by the INQUA Subcommission on the Holocene. Currently in the United States, it is placed arbitrarily at 10,000 B.P. (Hopkins, 1975).

Aguirre, Emiliano, and Pasini, Giancarlo, 1984, Proposal of the ICS Working Group on the Pliocene/Pleistocene boundary concerning the definition of the Pliocene/Pleistocene boundary stratotype: 6 p.
CLIMAP Project Members, 1984, The last interglacial ocean: Quaternary Research, v. 21, p. 123–224.
Eardley, A. J., Shuey, R. T., Gvosdetsky, V., Nash, W. P., Picard, M. D., Grey, D. C., and Kukla, G. J., 1973, Lake cycles in the Bonneville Basin, Utah: Geological Society of America Bulletin, v. 84, no. 1, p. 211–215.
Hopkins, D. M., 1975, Time stratigraphic nomenclature for the Holocene epoch: Geology, v. 3, no. 1, p. 10.
Izett, G. A., 1982, The Bishop ash bed and some older, compositionally similar, ash beds in California, Nevada, and Utah: U.S. Geological Survey Open-File Report 82–582, 47 p., 1 pl.
Johnson, R. G., 1982, Brunhes-Matuyama magnetic reversal dated at 790,000 yr B.P. by marine-astronomical correlations: Quaternary Research, v. 17, no. 2, p. 135–147.
Mankinen, E. A., and Dalrymple, G. B., 1979, Revised geomagnetic polarity time scale for the interval 0–5 m.y. B.P.: Journal of Geophysical Research, v. 84, no. B2, p. 615–626.
Ruddiman, W. F., and McIntyre, A., 1984, Ice-age thermal response and climatic role of the surface Atlantic Ocean, 40° N. to 63° N.: Geological Society of America Bulletin, v. 95, p. 381–396.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

HOLOCENE

asa ALLUVIAL GRAVELLY SAND—Light- to dark-gray, fine to coarse sand and sandy silt, containing local layers of dark-gray peaty clay and basal lenses of pebble gravel. Both sand and gravel are chiefly quartz. Deposit is poorly sorted, thin to medium bedded, and locally crossbedded. Deposit forms a fill in broad valleys. Water table at or near surface. Mapped area includes small alluvial fan deposits at the mouths of tributary streams, deposits of locally derived colluvium, and swamp deposits (hs). Thickness 1–10 m

ala ALLUVIAL SILT AND CLAY—Medium- to dark-gray, highly organic fine sand, silt, and clay. Locally contains discontinuous thin beds of poorly sorted, medium to coarse sand, gravelly sand, layers of peat, and trunks of trees. Mapped areas include swamp deposits (hs), small channel deposits of alluvium (asa), and locally derived colluvium. Thickness 1–15 m

hps SALINE MARSH DEPOSIT—Black or greenish-gray, silty clay to clayey fine sand and carbonaceous clay, intermixed and interbedded. Upper part darkest and contains the most organic matter, including thin layers of herbaceous peat. Deposit commonly bioturbated. Locally includes interbedded brackish water deposits. Thickness 0.5–6 m

hp PEAT (Dismal Swamp Peat)—Dark-reddish-brown to black woody peat and reed-sedge peat; grades downward into black, highly decomposed, colloidal, sapric peat. Large deposits present in depressions within East Dismal Swamp. Map unit includes small areas of silty to clayey swamp deposits (hs). Thickness 0.5–4.5 m

be BEACH AND DUNE SAND—Light-gray to light-tan, alternating beds of coarse to fine sand; well-sorted, laminated, and crossbedded; mostly quartz, but contains thin discontinuous lenses of heavy minerals; includes subordinate organic matter and shells. Map unit comprises beach deposits, washover and tidal-channel deposits, and coastal dunes. Mapped areas include narrow tracts of interdune saline-marsh deposits (hps), commonly mantled with a thin layer of eolian sand. Thickness 0.5–25 m

HOLOCENE AND LATE WISCONSIN

hs SWAMP DEPOSIT—Dark-brown to black organic debris, muck, and local peat mixed with mud composed of fine sand, silt, and clay. Sand chiefly quartz. Deposit present in lowlands in middle and outer Coastal Plain and valleys along major streams. Locally includes areas of alluvial clay and silt (ala) and patches of colluvium. Thickness 0.5–4.5 m

es EOLIAN SAND—Tan to light-gray or yellowish-brown medium sand; massive to crossbedded, subrounded to well rounded; mostly quartz, but includes thin beds of organic matter. Commonly stabilized by vegetation. Present on valley floors and adjacent low terraces as sheets or irregularly spaced linear and crescentic dunes oriented southeast. Thickness 0.5–6 m

ATLANTIC COASTAL PLAIN UNITS

Quaternary deposits of the Atlantic Coastal Plain (bmh through mlg) are subdivided into three major depositional facies: (1) sand of beaches, barrier bars, and other nearshore deposits; (2) marine sand, silt, and clay deposited in lagoons, bays, and tidal marshes inland from barrier bars; and (3) alluvial and estuarine sand and silt deposited in stream channels and in estuaries tributary to shorelines during times of Quaternary high sea level. Owing to subsequent erosion, not all facies are equally well preserved. Furthermore, deposits of like facies at the same altitude may not be equivalent in age because the configuration of the coast changed considerably throughout the Quaternary.

LATE PLEISTOCENE

bmh BEACH AND NEARSHORE MARINE SAND (Part of Pamlico Formation; barrier island facies of Poquoson Member of Tabb Formation)—Light-gray to light-yellowish-brown, very fine to coarse, micaceous quartz sand; planar-bedded and crossbedded. Upper part chiefly fine to very fine sand; local fine pebble gravel at base. Underlies linear ridges 5–7 m above sea level. Thickness commonly exceeds 4 m

aei ALLUVIAL AND ESTUARINE SAND AND SILT (Part of Pamlico Formation; alluvial and estuarine facies of Lynnhaven Member of Tabb Formation)—Tan to medium-gray, slightly mottled yellowish-brown, fine sand and sandy silt, mostly quartz. Thin bedded to massive crossbedded, unfossiliferous. Underlies stream terraces 1–6 m above sea level. Mapped areas include small alluvial deposits (asa, ala), swamp deposits (hs), and locally derived colluvium. Thickness 0.5–4 m

bmi BEACH AND NEARSHORE MARINE SAND (Part of Pamlico Formation; barrier island facies of Lynnhaven Member of Tabb Formation)—Light- to medium-gray, coarse to medium quartz sand, locally pebbly; massive to medium bedded, locally crossbedded; contains thin lenses of dark-gray silty clay and clayey silt. Underlies linear tracts 5–7 m above sea level on outer Coastal Plain. Mapped areas include small paludal deposits (hps). Thickness commonly exceeds 4 m

mli MARINE SAND, SILT, AND CLAY (Part of Pamlico Formation; marine back-barrier and lagoon facies of Lynnhaven Member of Tabb Formation)—Light-gray to tan, clayey fine sandy silt or silty fine sand; thin to thick bedded, crossbedded in places; basal coarse quartz sand includes a few cobbles and pebbles. Deposit contains burrows and traces of fossils. Underlies flats 0.5–6 m above sea level. Thickness 0.5–6 m

aej ALLUVIAL AND ESTUARINE SAND AND SILT (Part of Pamlico Formation; alluvial and estuarine facies of Sedgefield Member of Tabb Formation)—Light-yellowish-brown, fine sandy silt and clayey silt. Grades down into pale-brown to medium-gray, silty to gravelly quartz sand; thin to medium bedded, locally crossbedded; contains burrows. Underlies stream-terrace segments 6–11 m above sea level. Thickness commonly exceeds 8 m

bmj BEACH AND NEARSHORE MARINE SAND (Part of Pamlico Formation; Minnesott Ridge Sand; barrier island facies of Sedgefield Member of Tabb Formation)—Upper part is light-yellowish-brown to light-gray, gravelly sand, silty fine sand, and clayey silt. Sand chiefly quartz and lesser amounts of calcite, aragonite, feldspar, and mica; clay chiefly kaolinite and illite. Sand beds commonly crossbedded and extensively bioturbated. Local peat layers at base of deposit. Underlies low ridges 6–11 m above sea level on outer Coastal Plain. Thickness 0.5–15 m

mlj MARINE SAND, SILT, AND CLAY (Part of Pamlico Formation; Core Creek Sand; marine back-barrier and lagoon facies of Sedgefield Member of Tabb Formation)—Medium- to light-gray, mottled red, orange, or yellowish-brown, clayey, silty fine sand or clayey silt; grades down into silty fine sand and fine sand; chiefly quartz, moderately micaceous, calcareous; medium to thin bedded; locally crossbedded; locally fossiliferous. Basal beds contain isolated pebbles, cobbles, and boulders. Underlies flats 5–11 m above sea level on outer Coastal Plain. Thickness 1–7 m

MIDDLE PLEISTOCENE

aed ALLUVIAL AND ESTUARINE SAND AND SILT (Part of Talbot Formation; alluvial and estuarine facies of Shirley Formation)—Light-gray to yellowish-brown, silty fine sand to clayey sandy silt; grades down into light-tan to medium-gray, mottled yellowish-brown sand, mostly quartz. Massive to well-bedded, planar- to crossbedded; ferruginous; contains scattered lenses of clay and organic matter. Basal part is coarse to fine sand containing cobbles and scattered boulders of igneous and metamorphic rocks, many weathered. Deposit underlies stream terraces 10–15 m above sea level. Thickness as much as 24 m

bmd BEACH AND NEARSHORE MARINE SAND (Part of Talbot Formation; barrier island facies of Shirley Formation; also includes parts of the Flanner Beach, Neuse, and Socastee Formations)—Yellowish-brown or pale-brown, coarse to medium quartz sand; crossbedded to planar-bedded. Includes thin lenses of gravelly sand, burrows, and casts of fossils. Deposit grades down into bluish-gray, coarse to fine quartz sand; thin bedded to medium bedded, crossbedded, fossiliferous; interbedded with layers of silt. Underlies broad ridges 10–15 m above sea level. Thickness 1–8 m

mld MARINE SAND, SILT, AND CLAY (Part of Talbot Formation; marine back-barrier and lagoon facies of the Shirley Formation; parts of Flanner Beach, Neuse, and Socastee Formations)—Light-to medium-gray, silty clay and fine sand, chiefly quartz; bedding indistinct. Grades down into pale-brown or light- to medium-gray, silty fine sand containing local lenses of gravelly sand; fossiliferous. Thickness 1–6 m

aek ALLUVIAL AND ESTUARINE SAND AND SILT (Part of Wicomico Formation; alluvial and estuarine facies of Chuckatuck Formation)—Pale-brown to mottled light-gray, thin sandy clayey silt and silty clay; massive to indistinctly bedded, unfossiliferous. Grades down into light- to medium-gray, thin- to thick-bedded, medium to fine sand, containing thin lenses of silt and silty clay. Basal beds contain scattered pebbles and cobbles of quartz. Underlies upland terrace segments 14–18 m above sea level. Mapped areas locally include small deposits of sandy alluvium (asa) and locally derived colluvium. Thickness 1–8 m

mlk MARINE SAND, SILT, AND CLAY (Part of Wicomico Formation; marine back-barrier and lagoon facies of Chuckatuck Formation; Canepatch Formation)—Light-gray to pale-brown, clayey, fine sandy silt or very silty clay; grades down into beds of light-gray to tan, fine to coarse quartz sand, containing sparse cobbles and pebbles; these beds are intercalated with lenses and thin layers of silt and silty fine sand. Contains burrows and ghosts of fossils. Underlies coastal terraces 14–19 m above sea level. Thickness 1–6 m

mlm MARINE SAND, SILT, AND CLAY—Map units mld and mlk, undifferentiated

MIDDLE AND EARLY PLEISTOCENE

aef ALLUVIAL AND ESTUARINE SAND AND SILT (Part of Wicomico Formation; alluvial and estuarine facies of Charles City Formation and the Windsor Formation (restricted))—Light-gray to pale-brown, mottled yellowish- or reddish-brown, silty fine sand and clayey silt; grades down into clayey, feldspathic, coarse to fine sand, intercalated with thin beds of silt and clay; planar-bedded to crossbedded, unfossiliferous, locally cemented with iron oxide. Basal clayey coarse sand contains pebbles and boulders of crystalline and metamorphic rocks as large as 1 m in diameter. Deposit underlies upland terrace segments 18–28 m above sea level along major streams. Thickness as much as 10 m

mlf MARINE SAND, SILT, AND CLAY (Part of Wicomico Formation; marine back-barrier and lagoon facies of Charles City and Windsor (restricted) Formations)—Light-gray to pale-yellowish-brown, mottled yellowish- to reddish-brown, fine sandy silt and clayey, silty fine sand; grades down into medium-gray to brown, fine to medium sand, chiefly quartz and feldspar; massive to medium bedded; contains burrows. Local richly organic silt and peat at base. Underlies interfluves 18–24 m above sea level. Mapped areas include small deposits of alluvium (ala), swamp deposits (hs), and residuum (zsc) on Tertiary deposits. Thickness as much as 24 m

mln MARINE SAND, SILT, AND CLAY—Map units mlk and mlf, undifferentiated

EARLY PLEISTOCENE TO PLIOCENE

bmg BEACH AND NEARSHORE MARINE SAND (Barrier island facies of Moorings unit)—Yellowish-brown, mottled reddish-brown, clayey fine sand. Grades down into yellowish-brown to medium-gray fine sand; massive to crossbedded, unfossiliferous; includes some silt layers. Underlies broad linear ridges 30–36 m above sea level. Thickness as much as 4 m

mlg MARINE SAND, SILT, AND CLAY (Part of Sunderland Formation; marine back-barrier and lagoon facies of Moorings unit; James City Formation; part of Croatan and Waccamaw Formations)—Yellowish-brown to medium-gray, mottled reddish-brown, clayey silt and silty clayey fine sand; grades down into massive to weakly stratified, gravelly sand containing local lenses of clayey sand. Underlies flats 33–39 m above sea level. Mapped areas include small deposits of residuum (zsc) on Tertiary deposits and colluvium. Thickness 2–6 m

QUATERNARY AND TERTIARY

zsc SAND AND CLAY DECOMPOSITION RESIDUUM[1]—White to gray, light-yellow, yellowish-orange or grayish-red, commonly mottled, silty to clayey, fine to medium sand; poorly sorted. Contains small deposits of lag gravel and zones of light-gray to greenish-gray kaolinite. Upper 3 m intensely weathered. At depths of 10–15 m, residuum grades down into medium to coarse sand containing kaolinite, glauconite, and opaline silicate clays. Thickness 2–15 m

[1] DECOMPOSITION RESIDUUM, for purposes of this map, is defined as material derived primarily by in-place chemical decay of clastic rock with no appreciable subsequent lateral transport

SOURCES OF INFORMATION

Barnhill, W. L., 1977, Soil survey of Lenoir County, North Carolina: U.S. Department of Agriculture, Soil Conservation Service.
Barnhill, W. L., and others, 1974, Soil survey of Wayne County, North Carolina: U.S. Department of Agriculture, Soil Conservation Service.
Belknap, D. F., and Wehmiller, J. F., 1982, Aminostratigraphy in the lower Coastal Plain of North and South Carolina [abs.]: Geological Society of America Abstracts with Programs, v. 14, no. 7, p. 441.
Belt, E. S., Frey, R. W., and Welch, J. S., 1983, Pleistocene coastal marine and estuarine sequences, Lee Creek mine, *in* Ray, C. E., ed., Geology and paleontology of the Lee Creek mine, North Carolina, I: Smithsonian Contributions to Paleobiology, no. 53, p. 229.
Blackwelder, B. W., 1981, Stratigraphy of upper Pliocene and lower Pleistocene marine and estuarine deposits of northeastern North Carolina and southeastern Virginia: U.S. Geological Survey Bulletin 4502–B, p. B1–B16.
Blackwelder, B. W., and Ward, L. W., 1978, Inland limit of the Croatan sea; Pliocene and Pleistocene beds at Fountain, North Carolina: U.S. Geological Survey Professional Paper 1100, p. 228.
Brown, P. M., 1959, Geology and ground-water resources in the Greenville area, North Carolina: North Carolina Division of Mineral Resources Bulletin 73, 87 p.
———1963, The geology of northeastern North Carolina: Atlantic Coastal Plain Geological Association, 4th annual field conference, 1963, Guidebook; Raleigh, N.C., North Carolina Department of Conservation and Development, Division of Mineral Resources, 43 p.
Clark, W. B., 1912, The Tertiary formations, *in* Clark, W. B., and others, eds., The Coastal Plain of North Carolina: North Carolina Geologic and Economic Survey, v. 3, p. 171–266.
Cooke, C. W., 1931, Seven coastal terraces in the southeastern states: Washington Academy of Sciences Journal, v. 21, no. 21, p. 503–513.
Cronin, T. M., Szabo, B. J., Ager, T. A., Hazel, J. E., and Owens, J. P., 1981, Quaternary climates and sea levels of the U.S. Atlantic Coastal Plain: Science, v. 211, no. 4479, p. 233–239.
Daniels, R. B., Gamble, E. E., and Boul, S. W., 1969, Eolian sands associated with Coastal Plain river valleys—some problems in their age and source: Southeastern Geology, v. 11, no. 2, p. 97–110.
Daniels, R. B., Gamble, E. E., and Nettleton, W. D., 1966, The Surry scarp from Fountain to Potters Hill, North Carolina: Southeastern Geology, v. 7, no. 2, p. 41–50.
Daniels, R. B., Gamble, E. E., and Wheeler, W. H., 1971, The Goldsboro Ridge, an enigma: Southeastern Geology, v. 12, no. 3, p. 151–158.
———1972, Buried pre-Talbot organic horizons related to changing sea level in eastern North Carolina [abs.]: Geological Society of America Abstracts with Programs, v. 4, no. 2, p. 68–69.
Daniels, R. B., Gamble, E. E., Wheeler, W. H., and Holzhey, C. S., 1972, Guidebook, Carolina Geological Society and Atlantic Coastal Plain Geological Association, Annual Meeting and Field Trip, 1972: Raleigh, N.C., 44 p.
Davis, W. A., Goodman, K. V., and Foster, Z. C., 1928, Soil survey of Jones County, North Carolina: U.S. Department of Agriculture, Bureau of Chemistry and Soils, series 19, 27 p.
Doering, J. A., 1960, Quaternary surface formations of the southern part of the Atlantic Coastal Plain: Journal of Geology, v. 68, no. 2, p. 182–202.
DuBar, J. R., 1959, The Waccamaw and Croatan deposits of the Carolinas: South Carolina State Development Board, Division of Geology, Geologic Notes, v. 3, no. 6, 9 p.
———1971, Neogene stratigraphy of the lower Coastal Plain of the Carolinas: Atlantic Coastal Plain Geological Association Guidebook, 12th annual field conference, 1971, 128 p.
DuBar, J. R., Johnson, H. S., Thorn, 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., eds., 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, lower Neuse Estuary, North Carolina: Southeastern Geology, v. 4, no. 4, p. 213–233.
DuBar, J. R., Solliday, J. R., and Howard, J. F., 1974, Stratigraphy and morphology of Neogene deposits, Neuse River Estuary, North Carolina, *in* Oaks, R. Q., Jr., and DuBar, J. R., eds., Post-Miocene stratigraphy, central and southern Atlantic Coastal Plain: Logan, Utah, Utah State University Press, p. 102–122.
El-Ashry, M. T., and Wanless, H. R., 1968, Photo interpretation of shoreline changes between Capes Hatteras and Fear (North Carolina): Marine Geology, v. 6, no. 5, p. 347–379.
Fallaw, W. C., and Wheeler, W. H., 1969, Marine fossiliferous Pleistocene deposits in southeastern North Carolina: Southeastern Geology, v. 10, no. 1, p. 35–54.
Floyd, E. O., 1969 [1970], Ground-water resources of Craven County, North Carolina: U.S. Geological Survey Hydrologic Investigations Atlas HA–343, 2 sheets.
Goldston, E. F., Kaster, D. L., King, J. A., and Robinson, G. H., 1954, Soil survey of Duplin County, North Carolina: U.S. Department of Agriculture, Soil Conservation Service, 75 p.; 65 soil map sheets, scale 1:20,000.
Goodwin, R. A., 1979, Soil survey of Edgecombe County, North Carolina: U.S. Department of Agriculture, Soil Conservation Service, 118 p.; general soil map, scale 1:253,440.
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, no. 53, p. 81–200.
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, 72 p.
Johnson, G. H., and Berquist, C. R., in press, Geology of the Brandon and Norge quadrangles, Virginia: Virginia Division of Mineral Resources, Report of Investigations.
Jurney, R. C., Davis, W. A., and Morgan, J. J., 1929, Soil survey of Craven County, North Carolina: U.S. Department of Agriculture, Bureau of Chemistry and Soils, series 1929, no. 23, 27 p.; soil map, scale 1:62,500.
Karnowski, E. H., Newman, J. B., Dunn, J., and Meadows, J. A., 1974, Soil survey of Pitt County, North Carolina: U.S. Department of Agriculture, Soil Conservation Service, 73 p.; general soil map, scale 1:253,440.
Lee, W. D., and Bacon, S. R., 1930, Soil survey of Nash County, North Carolina: U.S. Department of Agriculture, Bureau of Chemistry and Soils, series 1926, no. 6, 47 p.; soil map, scale 1 in.=1 mi.
Liddicoat, J. C., 1984, Magnetostratigraphy of the Quaternary of the eastern United States [abs.]: EOS (Transactions of the American Geophysical Union), v. 65, no. 16, p. 200.
Liddicoat, J. C., Belknap, D. F., and Wehmiller, J. F., 1982, Paleomagnetic and amino acid dating of sediment in the Atlantic Coastal Plain [abs.]: Geological Society of America Abstracts with Programs, v. 14, no. 7, p. 546–547.
Liddicoat, J. C., Blackwelder, B. W., Cronin, T. C., and Ward, L. W., 1979, Magnetostratigraphy of upper Tertiary and Quaternary sediment in the central and southeastern Atlantic Coastal Plain [abs.]: Geological Society of America Abstracts with Programs, v. 11, no. 4, p. 187.
Liddicoat, J. C., Blackwelder, B. W., Ward, L. W., and Cronin, T. M., 1983, Paleomagnetism of the Great Bridge and Chowan River Formations, central Atlantic Coastal Plain [abs.]: Geological Society of America Abstracts with Programs, v. 15, no. 3, p. 198.
Mansfield, W. C., 1928, Notes on Pleistocene faunas from Maryland and Virginia, and Pliocene and Pleistocene faunas from North Carolina: U.S. Geological Survey Professional Paper 150–F, p. 129–140.
Miller, J. T., and Taylor, A. E., 1937, Soil survey of Pamlico County, North Carolina: U.S. Department of Agriculture, Bureau of Chemistry and Soils, series 1934, no. 2, 29 p.
Mixon, R. B., and Pilkey, O. H., 1976, Reconnaissance geology of the submerged and emerged Coastal Plain Province, Cape Lookout area, North Carolina: U.S. Geological Survey Professional Paper 859, 41 p.
Oaks, R. Q., Jr., and Coch, N. K., 1973, Post-Miocene stratigraphy and morphology, southeastern Virginia: Virginia Division of Mineral Resources Bulletin 82, 135 p.
Otte, L. J., and Ingram, R. L., 1980, Peat resources of North Carolina: North Carolina Energy Institute, 1980 Annual Report; Washington, D.C., U.S. Department of Energy, 60 p.
Peebles, P. C., Johnson, G. H., and Berquist, C. R., 1984, The middle and late Pleistocene stratigraphy of the outer Coastal Plain, southeastern Virginia: Virginia Minerals, v. 30, no. 2, p. 13–22.
Pierce, J. W., and Colquhoun, D. J., 1970, Holocene evolution of a portion of the North Carolina coast: Geological Society of America Bulletin, v. 81, no. 12, p. 3697–3714.
Perkins, S. O., and Bacon, S. R., 1929, Soil survey of Martin County, North Carolina: U.S. Department of Agriculture, Bureau of Chemistry and Soils, series 19, 32 p.
Perkins, S. O., Beck, M. W., Goldston, E. F., Sutton, J. A., and Gettys, W., 1938, Soil survey of Carteret County, North Carolina: U.S. Department of Agriculture, Bureau of Chemistry and Soils, series 1935, no. 3, 34 p.
Perkins, S. O., and Lewis, H. G., 1930, Soil survey of Greene County, North Carolina: U.S. Department of Agriculture, Bureau of Chemistry and Soils, series 19, 30 p.
Pusey, R. D., 1960, Geology and ground water in the Goldsboro area, North Carolina: North Carolina Department of Water Resources Ground Water Bulletin 2, 77 p.
Richards, H. G., 1950, Geology of the Coastal Plain of North Carolina: American Philosophical Society Transactions, v. 40, pt. 1, 83 p.
Shackleton, N. J., and Opdike, N. D., 1973, Oxygen isotope and paleomagnetic stratigraphy of equatorial Pacific core V28–238—Oxygen isotope temperature and ice volumes on a 10^5 and 10^6 year scale: Quaternary Research, v. 3, no. 1, p. 39–55.
Stuckey, J. L., and Conrad, S. G., 1958, Geologic map of North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources, scale 1:500,000.
Tant, P. L., 1981, Soil survey of Washington County, North Carolina: U.S. Department of Agriculture, Soil Conservation Service, 99 p.; general soil map, scale 1:190,080.
U.S. Department of Agriculture, Soil Conservation Service, [undated], Soil survey maps and interpretations for Nash County, North Carolina.
———1977, Soil survey of the Outer Banks, North Carolina.
Weaver, A., Brandon, C., and Lynn, W. E., Jr., 1977, Soil survey of New Hanover County, North Carolina: U.S. Department of Agriculture, Soil Conservation Service, 69 p.; general soil map, scale 1:253,440.
Wheeler, W. H., Daniels, R. B., and Gamble, E. E., 1979, Some stratigraphic problems of the Pleistocene strata in the area from Neuse River Estuary to Hofmann Forest, 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 and Atlantic Coastal Plain Geological Association, field trip guidebook, p. 41–50.
———1983, The post-Yorktown stratigraphy and geomorphology of the Neuse-Pamlico area, eastern North Carolina, *in* Ray, C. E., ed., Geology and paleontology of the Lee Creek mine, North Carolina, I.: Smithsonian Contributions to Paleobiology 53, p. 201–218.

OXYGEN ISOTOPE STAGES

Mixon, R. B., Szabo, B. J., and Owens, J. P., 1982, Uranium-series dating of molluscs and corals, and age of Pleistocene deposits, Chesapeake Bay area, Virginia and Maryland: U.S. Geological Survey Professional Paper 1067–E, 18 p.

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