WINDSOR FORMATION 1:1.000.000 TOPOGRAPHIC SERIES

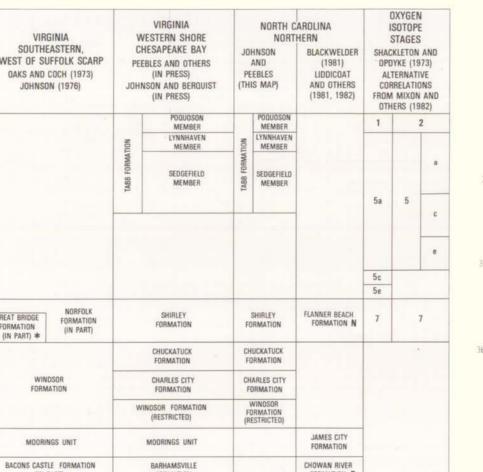
WALSTON

* Unit present in subsurface

2 Based on stratigraphic relations of units to major disconformities

R Reversed polarity

Showing location of the Quaternary Geologic Map of the Chesapeake Bay 4° x 6° Quadrangle in red [U.S. Geological Survey, Miscellaneous Investigations Series, Map I-1420 (NJ-18)] and other published maps in the Quaternary Geologic Atlas of the United States



AREAS OF RESPONSIBILITY (1) MARYLAND GEOLOGICAL SURVE (2) DEPARTMENT OF ENVIRONMENTAL SCIENCES, UNIVERSITY OF VIRGINIA (3) DEPARTMENT OF GEOLOGY, COLLEGE OF WILLIAM AND MARY (4) DEPARTMENT OF GEOLOGICAL AND GEOPHYSICAL SCIENCES, PRINCETON (5) PENNSYLVANIA GEOLOGICAL SURVEY (6) U.S. GEOLOGICAL SURVEY

(7) DEPARTMENT OF GEOLOGY. UNIVERSITY OF NORTH CAROLINA

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

Emery T. Cleaves, John D. Glaser, Alan D. Howard, Gerald H. Johnson, Walter H. Wheeler, William D. Sevon, Sheldon Judson, James P. Owens, and Pamela C. Peebles

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QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

Following a regional meeting of the State compilers with the coordinator to establish map units and related matters, separate Quaternary maps and map prior to its submittal for publication.

PREPARED IN COOPERATION WITH THE MARYLAND GEOLOGICAL SURVEY UNIVERSITY OF VIRGINIA COLLEGE OF WILLIAM AND MARY PRINCETON UNIVERSITY PENNSYLVANIA GEOLOGICAL SURVEY UNIVERSITY OF NORTH CAROLINA

LIST OF MAP UNITS

HOLOCENE agg ALLUVIAL SANDY GRAVEL asa ALLUVIAL GRAVELLY SAND ala ALLUVIAL SILT AND CLAY hps SALINE-MARSH DEPOSIT BEACH AND DUNE SAND

bd BEACH MUD HOLOCENE AND LATE WISCONSIN SWAMP DEPOSIT es EOLIAN SAND

LATE PLEISTOCEN cba GRANITIC-BOULDER COLLUVIUM CDD QUARTZITE-BLOCK LOAMY COLLUVIUM CARBONATE-BOULDER CLAYEY COLLUVIUM MAFIC-BOULDER LOAMY COLLUVIUM METARHYOLITE-BOULDER LOAMY COLLUVIUM ACID SHALE-CHIP CLAY LOAM COLLUVIUM BASALT-CLAST CLAY LOAM COLLUVIUM ALLUVIAL AND ESTUARINE SAND AND SILT BEACH AND NEARSHORE MARINE SAND

h MARINE SAND, SILT, AND CLAY ALLUVIAL AND ESTUARINE SAND AND SILT BEACH AND NEARSHORE MARINE SAND MARINE SAND, SILT, AND CLAY ALLUVIAL AND ESTUARINE SAND AND SILT MARINE SAND, SILT, AND CLAY BEACH AND NEARSHORE MARINE SAND aej ALLUVIAL AND ESTUARINE SAND AND SILT BEACH AND NEARSHORE MARINE SAND

MARINE SAND, SILT, AND CLAY MIDDLE PLEISTOCENE aed ALLUVIAL AND ESTUARINE SAND AND SILT BEACH AND NEARSHORE MARINE SAND MARINE SAND, SILT, AND CLAY ek ALLUVIAL AND ESTUARINE SAND AND SILT MARINE SAND, SILT, AND CLAY

MARINE SAND, SILT, AND CLAY EARLY PLEISTOCENE ael ALLUVIAL AND ESTUARINE SAND AND SILT MARINE SAND, SILT, AND CLAY

ALLUVIAL AND ESTUARINE SAND AND SILT

EARLY PLEISTOCENE TO PLIOCENE LUVIAL AND ESTUARINE SAND AND SILT BEACH AND NEARSHORE MARINE SAND MARINE SAND, SILT, AND CLAY MIDDLE PLEISTOCENE TO PLIOCENE

(INCLUDES MIDDLE PLEISTOCENE? AND MIOCENE?)

LOAMY DECOMPOSITION RESIDUUM AND GRAVELLY SAND

MIDDLE OR EARLY PLEISTOCENE

QUATERNARY AND TERTIARY CLAYEY SANDY GRAVEL DECOMPOSITION RESIDUUM SAND AND CLAY DECOMPOSITION RESIDUUM SANDY DECOMPOSITION RESIDUUM CLAYEY SAND DECOMPOSITION RESIDUUM RED SILTY SAND TO SILTY CLAY DECOMPOSITION RESIDUUM SANDY CLAY TO CLAYEY SAND DECOMPOSITION RESIDUUM

LOAMY DECOMPOSITION RESIDUUM LOAMY DECOMPOSITION RESIDUUM WITH CRUMBLY QUARTZ zcf CLAYEY SILT AND VERY FINE SAND DECOMPOSITION DOLOMITIC SAND SOLUTION RESIDUUM CHERTY CLAY SOLUTION RESIDUUM RED CLAY SOLUTION RESIDUUM

SANDY CLAYEY SAPROLITIZED GRAVEL CLAYEY SAPROLITIZED GRAVEL SILTY TO CLAYEY SANDY SAPROLITE, ROCK TORS, AND JOINT-BLOCK BOULDERS SILTY TO CLAYEY SANDY SAPROLITE

SANDY CLAY SAPROLITE sla CLAYEY SAPROLITE MICACEOUS SAPROLITE SILTY TO CLAYEY SAPROLITE THIN SILTY CLAY SAPROLITE ON SERPENTINITE CLAYEY SAPROLITE, ROCK TORS, AND JOINT-BLOCK BOUL-

CAROLINA BAY-Shallow, oval or elliptical, generally marshy closed

depression in Atlantic Coastal Plain; 100 m to many kilometers

long. Partly filled with mixed sand, silt, and clay containing

abundant organic matter, and overlain by surface swamp

deposits. Origin debated: attributed to meteorites, upwelling

springs, eddy currents, eolian erosion, solution, or thaw of

and estuarine sediments, soil, and construction debris that

ranges widely in texture, thickness, and color, and is commonl

unconsolidated. Underlies urban areas, airports, and filled land

MANMADE LAND-A varying mixture of rock fragments, marine

bordering Chesapeake Bay and associated estuaries

NOTE 2: The Pliocene-Pleistocene boundary defined by joint resolution of the

ene/ Pleistocene Boundary (the International Commission on Stratigraphy

nternational Union for Quaternary Research (INQUA) Subcommission 1-d on the

(ICS) Working Group on the Pliocene/Pleistocene Boundary) and the Workin

Neogene/Quaternary Boundary) is that at the Vrica section in southern Italy. T

oup of the International Geological Correlation Program (IGCP) Project No. 4

age of that boundary currently is inferred to be 1.65 Ma (Aguirre and Pasini,

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 Matuvama-

adiometric 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 reversa

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 (Fardley and others 1973). The terrestrial geologic record is

compatible with the astronomical age of 788 ka assigned to the reversal by Johnson

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 direct

It was assigned provisional ages of 127 ka by CLIMAP Project members (CLIMA

Project Members, 1984) and 128 ka by SPECMAP Project members (Ruddiman

and McIntyre, 1984), based on uranium-series ages of the substage 5e high eustation

sealevel stand. A sidereal age of 132 ka is derived by projection of the boundary

Subcommission on the Holocene. Currently in the United States, it is placed arbitrarily

Aguirre, Emiliano, and Pasini, Giancarlo, 1984, Proposal of the ICS Working

CLIMAP Project Members, 1984, The last interglacial ocean: Quaternary Research,

Eardley, A. J., Shuey, R. T., Gvosdetsky, V., Nash, W. P., Picard, M. D., Grey, D. C.

Hopkins, D. M., 1975, Time stratigraphic nomenclature for the Holocene epoch:

Izett, G. A., 1982, The Bishop ash bed and some older, compositionally similar, ash

Johnson, R. G., 1982, Brunhes-Matuyama magnetic reversal dated at 790,000 yr

Mankinen, E. A., and Dalrymple, G. B., 1979, Revised geomagnetic polarity time

Ruddiman, W. F., and McIntyre, A., 1984, Ice-age thermal response and climatic

B.P. by marine-astronomical correlations: Quaternary Research v. 17, no. 2,

scale for the interval 0-5 m.y. B.P.: Journal of Geophysical Research, v. 84,

role of the surface Atlantic Ocean, 40° N. to 63° N.: Geological Society of

Group on the Pliocene/Pleistocene boundary concerning the definition of the

and Kukla, G. J., 1973, Lake cycles in the Bonneville Basin, Utah: Geological

beds in California, Nevada, and Utah: U.S. Geological Survey Open-File

The Pleistocene-Holocene boundary is being proposed by the INQUA

onto the astronomical time scale of Johnson (1982).

Pliocene/Pleistocene boundary stratotype: 6 p.

Geology, v. 3, no. 1, p. 10.

Report 82-582, 47 p., 1 pl.

America Bulletin, v. 95, p. 381-396.

no. B2, p. 615-626.

Society of America Bulletin, v. 84, no. 1, p. 211-215.

(1982). The boundary between the middle Pleistocene and late Pleistocene is

Brunhes magnetic polarity reversal. The reversal has not been dated directly by

Time boundaries between the early Pleistocene and middle Pleistocene and

CONTACT

MARINE SCARP

ocal tors and pinnacles on summit and crest areas. Thickness 2-5 m TARHYOLITE-BOULDER LOAMY COLLUVIUM1-Yellowish-brown to reddish-brown, unsorted, sandy silt loam; contains angular fragments and CLAYEY, SILTY, AND SANDY SAPROLITE, UNDIFFERENTIATED round to subround joint-block core boulders of massive metarhyolite. Sand consists of quartz and grains of rock. Deposit mantles steep slopes of ridges and hills just east of Valley and Ridge Province in Pennsylvania. Thickness RED, CLAY TO SILTY CLAY SAPROLITE ID SHALE-CHIP CLAY LOAM COLLUVIUM1—Dark-gray, grayish-brown, or yellowish-brown sandy to silty clay loam; contains slabs and chips of noncalcareous shale and thin-bedded sandstone. Deposit commonly grades into underlying bedrock through a creep zone in which shale and sandstone beds are bent downslope as they disintegrate. Upper part of deposit may be locally mantled with material derived from adjacent rock

> Clay is partly smectite and partly kaolinite. Deposits on steep slopes contain many boulders. Boulder fields present on some middle and lower slopes. Mapped areas include a few rock outcrops. Thickness 2-3 m ATLANTIC COASTAL PLAIN UNITS Quaternary deposits of the Atlantic Coastal Plain (bmb through aeg) are 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.

ALLUVIAL AND ESTUARINE SAND AND SILT (part of Sand Bridge

Formation of Oaks and Coch (1973), estuarine facies of Poquoson Member of Tabb Formation in Virginia) - Medium- to dark-gray silt and fin sand; massive to indistinctly bedded, slightly mottled, commonly unfos siliferous. Underlies terraces 0.5-3 m above sea level on outer Coastal ain. Mapped areas include small paludal deposits (hps, hp). Thickness 1–5 n HAND NEARSHORE MARINE SAND (part of Sand Bridge Formation of Oaks and Coch (1973) in Virginia; barrier island facies of Poquoson Member of Tabb Formation in Virginia and North Carolina) — Light-gray to light-vellowish-brown, very fine to coarse, micaceous quartz sand; planarbedded and crossbedded. Upper part chiefly fine to very fine sand; local fine pebble gravel at base. Underlies ridges 2-7 m above sea level on outer astal Plain. Thickness as much as 5 m RINE SAND, SILT, AND CLAY (part of Sand Bridge Formation of Oaks and och (1973) in Virginia; marine back-barrier and lagoonal facies of Poquoson Member of Tabb Formation in Virginia and North Carolina)-Light- to medium-gray, mottled yellowish-brown, clayey silt and silty clay; grades down into a basal medium- to dark-gray, massive, unfo silty fine sand. Mapped areas include small paludal deposits (hps, hp). Inderlies flat surfaces 0.5-3 m above sea level on outer Coastal Plain.

LUVIAL AND ESTUARINE SAND AND SILT (part of Sand Bridge Formation of Oaks and Coch (1973) in Virginia; alluvial and estuarine facies of Lynnhaven Member of Tabb Formation in Virginia and North Carolina)-Tan to medium-gray, slightly mottled yellowish-brown, fine quartz sand and fine sandy silt; mostly quartz. Thin bedded to massive, commonly crossbedded, unfossiliferous. Underlies terraces 3-6 m above sea level. Mapped areas include small alluvial deposits (asa, ala), paludal deposits (hp), and locally derived colluvium. Thickness 0.5-4 m. CHAND NEARSHORE MARINE SAND (part of Sand Bridge Formation of Daks and Coch (1973) in Virginia; barrier island facies of Lynnhaven Member of Tabb Formation in Virginia and North Carolina)-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. Mapped areas include small paludal deposits (hps). Thickness commonly 4-5 n ARINE SAND, SILT, AND CLAY (parts of Sand Bridge Formation of Oaks and Coch (1973) in Virginia; marine back-barrier and lagoon facies of Lynnhaven Member of Tabb Formation in Virginia and North Carolina)

Bluish-gray to vellowish-brown, mottled gray, silt, clay, and fine sand; this to thick bedded; crossbedded in places. Local basal coarse sand includes few pebbles and cobbles. Deposit contains burrows and traces of fossils Underlies flats 3-6 m above sea level. Thickness 0.5-6 m LUVIAL AND ESTUARINE SAND AND SILT (estuarine facies of Kent Island Formation of Maryland and Delaware on Delmarva Peninsula, part of Cape May Formation in New Jersey)-Brown to vellowish-brown interbedded sand, gravelly sand, and bouldery gravel. In New Jersey, sand and gravel locally are interbedded with clay. Sand commonly crossbedded interfingers with dark-gray clayer silt beds in southern areas; fossiliferous in places. Deposit underlies low terraces bordering Chesapeake Bay and Potomac River and fills channels on Delmarva Peninsula. In New Jersey, unit includes some areas of residuum (asm) and commonly is overlain by unmapped sheetwash alluvium, eolian sand, or loess. Thickness 1-25 n RINE SAND, SILT, AND CLAY (lagoonal facies of Sinepuxent Formation of Maryland and Delaware on Delmarva Peninsula)-Dark-gray to dark-

brown silt, very silty sand, and fine sand. Upper beds locally contain peat;

lower beds locally contain clay. Sand chiefly feldspar, muscovite, and

biotite. Clay chiefly illite, vermiculite, and kaolinite. Fossil bivalves QUATERNARY AND TERTIARY

CORRELATION OF MAP UNITS

LAYEY SANDY GRAVEL DECOMPOSITION RESIDUUM2-Yellowish-

alluvial deposits underlying dissected terraces and fans at various levels.

Sinkholes common where deposit overlies carbonate rocks. Highest

terraces covered by lag-boulder accumulations; deposits of lower terraces

become fine-grained upward. Clasts chiefly quartzite and sandstone.

Thickness of Tertiary alluvial deposits commonly less than 10 m, but

locally, at eastern front of mountains, is as much as 80 m. Thickness of

yellow, yellowish-orange or grayish-red, commonly mottled, silty to clayey,

fine to medium sand. 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 3-15 m

reddish-brown sandy loam that grades downward into light-yellow, pale-

green, or pale-bluish-gray feldspathic sand and minor gravel with reddish-

brown or orange-brown iron oxide stains. Rounded quartzite or quartzose

sandstone boulders having maximum diameters of 1 m are common

locally. Residuum is chiefly on broad upland surfaces. Mapped unit

includes sheetwash alluvium derived from both residuum and underlying

sand on slopes. Thickness of residuum generally 2-5 m, locally 7.5 n

LAYEY SAND DECOMPOSITION RESIDUUM2-Red, reddish-brown.

orange-red, or brown, massive; very clayey sand containing gibbsite.

halloysite, and endellite as products of mineral alteration. Grades

downward into intensely weathered coarse sand and gravel, irregularly

stained red to orange-brown by iron oxides. Upper part of sand is

commonly cemented by iron oxides. Feldspar grains and chert pebbles are

decomposed to soft silty blebs or ghosts. Clasts of granite, gneiss, and schist

are commonly saprolitized; arkosic sandstone clasts are chiefly ghosts.

well rounded. Present on broad upland divides or as isolated remnants a

multiple topographic levels on valley slopes. Mapped areas locally includ

small deposits of other residua (asm) and (zle). Residuum is locally overlai

by eolian sand or loess (not mapped). Thickness of residuum generally 4.5-8 m

reddish-gray, reddish-brown, or purplish-red silty sandy loam to silty cla

Lower part contains chips and larger fragments of red shale or red

also contains crumbly clasts of diorite along lineaments alined over

underlying diorite dikes. In areas of low relief, residuum is commonly

SANDY CLAY TO CLAYEY SAND DECOMPOSITION RESIDUUM2-

mantled by thin aluvial deposits derived from adjacent uplands. Thickness

Yellowish-orange to dark-red or light-brown, friable loamy sand, fine sandy

loam, or sandy clay. Mottled yellowish brown where developed in

quartzose sand; greenish hues where developed in glauconitic sand or cla

Commonly contains thin stringers, pods, or lenses of lag gravel an

scattered rounded pebbles or cobbles of quartz or quartzite introduce

from above by bioturbation. Thickness generally 1-3 m, rarely more than 5 r

OAMY DECOMPOSITION RESIDUUM2-Dark-yellowish-orange, grayish-

orange, pale- to moderate-brown, or mottled reddish-brown, massive,

siliceous silt loam, sandy loam, and gravelly loam. Grades downward into

pale- to dark-yellowish-orange, very pale orange, pale-yellowish-brown, or

mottled reddish-brown gravel and sandy gravel that has red silty matrix

and contains lenses of very pale orange gravelly clay. Gravel clasts are

are generally rotted. Cobbles as large as 25 cm are rare. Sand fraction is

DAMY DECOMPOSITION RESIDUUM WITH CRUMBLY QUARTZ

gravelly loam. Grades downward into reddish-brown to gray, intensely

weathered sand and pebble-gravel. Commonly cemented; sand grains

generally are coated by iron oxides. Clasts are well rounded and generall

smaller than 2.5 cm. Clasts of quartz, quartzite, and quartzose sandston

commonly crumble to silica powder. Chert pebbles are generally soft and

chalky or silt ghosts. Sand grains are entirely quartz. Present on upland

Olive-green to olive-brown, light-tan to pale-reddish-brown clayey silt and

very fine quartz sand. Silt commonly highly diatomaceous. Thickness 1-10 r

medium to fine sand residual after solution of marble. Solution core-stones

brown, or pale-brown to light-reddish-brown, commonly mottled, sandy or

silty clay; plastic, locally cherty. Chert is gray, yellowish brown to yellowish

orange, locally light green or black, and present in highly variable amounts

as angular to subround chunks or boulders. Lower part of deposit contains

solution-surfaced slabs of limestone, and clay extends along fractures into

underlying limestone bedrock. Contact with bedrock surface is abrupt and

pinnacled. Deposit underlies valleys in Valley and Ridge Province. Sinks

and karst features common. Mapped areas include colluvium derived from

D CLAY SOLUTION RESIDUUM3—Dark-red to reddish-brown clay, clay

deposit commonly contains smooth limestone slabs or boulders and is

loam, or silty clay loam, includes some zones of sandy clay. Lower part of

abrupt solution contact with underlying limestone bedrock, into which it

extends along fractures. Mapped areas include local bedrock exposures

AYEY SAPROLITIZED GRAVEL4-Dark-red to reddish-brown, sandy or

oamy clay. Contains scattered stained pebbles of quartz and ghost pebbles

and cobbles of other rock types now partly altered to clay. Underlies

dissected sloping ridgetops whose distribution suggests that deposits are

remnants of Tertiary alluvial fans. In places, the saprolite extends through

the gravel into underlying bedrock where it changes in character depending

on rock type. The gravel ranges in thickness from a few centimeters to 10 m

thickness of saprolitized gravel and underlying saprolitized bedrock 2-6

LTY TO CLAYEY SANDY SAPROLITE4, ROCK TORS, AND JOINT-

BLOCK BOULDERS—Dark-red, reddish-brown, reddish-yellow, or white,

slightly micaceous, sandy clay to silty or clayey medium sand. Developed in

massive granite, granite gneiss, or similar massive felsic igneous or

metamorphic rocks. Clay is mostly kaolinite in upper part, but gibbsite may

equal or exceed kaolinite in lower part. Feldspar is predominan

weatherable mineral in lower part; muscovite or its pseudomorphs

predominate in upper part. Saprolite is permeable and strongly acid. It

boulders. Abundant joint-block boulders are associated with bedrock knobs and tors in mountain and hill areas. Pavement-outcrop, as much as

LTY TO CLAYEY SANDY SAPROLITE4 - Dark-red, reddish-brown, reddish-

weatherable mineral in lower part, but muscovite or its pseudomorphs

into underlying bedrock through irregular zone of partly weathered slabby

bedrock exposures, commonly as micaceous rock ribs, and slabby to

bouldery colluvium, especially at base of steep slopes. Colluvium

commonly contains numerous vein-quartz fragments. Thickness of

SANDY CLAY SAPROLITE4—Red, yellowish-red, strong-brown, yellow, light

MICACEOUS SAPROLITE4—Red, reddish-brown, strong-brown, yellowish-

red, or gray, micaceous, clayey to slightly clayey sand to clayey sandy silt.

Developed in felsic, micaceous schists. Color intensity depends on

abundance of mafic minerals in parent rock. Clay is kaolinite and lesser

amounts of gibbsite. Mica mostly weathered to vermiculite and (or)

kaolinite near ground surface. Shrink and swell potential generally low.

Mapped areas include small deposits of locally derived colluvium

containing rock fragments, and bedrock exposures. Thickness less than 1 m

SILTY TO CLAYEY SAPROLITE4—Gray, greenish-gray, yellowish-brown, or

red, fine sandy silt to slightly clavey silt. Developed in phyllite, argillite, slate

and felsic metavolcanic rocks. Quartz clasts and slabs and splinters of

saprolite commonly less than 2 m but may exceed 6 m on well-drained

predominate in upper part. Unit is permeable and strongly acid. It grades

deposits. Thickness of saprolite commonly less than 2 m

grades into bedrock through a zone of partly decomposed joint-block

10 hectares in extent, is present in some upland areas. Saprolite is

adjacent sandstone ridges, and small areas of bedrock outcrops. Thickness

DOLOMITIC SAND SOLUTION RESIDUUM3—White, angular, dolomitic

and pinnacles common. Mapped only north of Baltimore, Md. Thickness

CHERTY CLAY SOLUTION RESIDUUM3-Reddish-yellow to yellowish-

surfaces. Thickness generally less than 6 m, rarely more than 9 m CLAYEY SILT AND VERY FINE SAND DECOMPOSITION RESIDUUM²-

mapped). Thickness of residuum commonly less than 5 m, locally

chiefly well-rounded quartz, chert, quartzite, and sandstone. Chert clasts

almost entirely quartz. Map unit commonly is overlain by eolian sand (no

CLASTS²—Orange or orange-brown clay loam, loam, sandy loam, and

loam. Locally includes rounded pebbles and cobbles, chiefly of quart

Clasts of quartz, quartzite, and quartzose sandstone are chiefly intact and

ANDY DECOMPOSITION RESIDUUM2-Orange, red, orange-brown, or

SAND AND CLAY DECOMPOSITION RESIDUUM2-White to gray, light-

brown to dark-red, decomposed clavey sandy gravel. Developed in Tertiary

DECOMPOSITION RESIDUAL DEPOSITS

SOLUTION RESIDUAL

zsc zsr zss zlc zle zlf zlg zcf rsj rcc rcj sga sqb ssa ssb ssd sla slb slc

areas, sand interfingers with dark-gray estuarine silty clay or clayey silt (aeb). aej ALLUVIAL AND ESTUARINE SAND AND SILT (parts of Norfolk Formation of Oaks and Coch (1973) in Virginia; alluvial and estuarine facies of Sedgefield Member of Tabb Formation in Virginia and North Carolina)— 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 terrace segments 6-11 m above sea level. Thickness 1-8 m EACH AND NEARSHORE MARINE SAND (parts of Norfolk and Kempsville Formations of Oaks and Coch (1973) in Virginia; barrier island facies of Sedgefield Member of Tabb Formation in Virginia) - Upper part is lightyellowish-brown to light-gray, interbedded gravelly sand, silty fine sand, and clayey silt; sand is crossbedded; chiefly quartz and lesser amounts of calcite, aragonite, feldspar and mica; clay chiefly kaolinite and illite. Middle part is medium to light-gray, fine sand; fossiliferous, bioturbated. Lower part is clayey, silty coarse sand containing boulders, cobbles, and pebbles of quartz, chert, quartzite, sandstone, gneiss, greenschist and other metamorphic ocks. Underlies broad ridges 6-11 m above sea level. Thickness 0.5-10m IARINE SAND, SILT, AND CLAY (parts of Sand Bridge, Kempsville, and Norfolk Formations of Oaks and Coch (1973) in Virginia; marine back-

EACH AND NEARSHORE MARINE SAND (barrier island facies of Ironshire

May Formation in New Jersey)—Light-yellow, orange, or red, medium to

coarse sand and gravelly sand; crossbedded and bioturbated. In northern

barrier and lagoon facies of Sedgefield Member of Tabb Formation in

Virginia; Occohannock Member of Nassawadox Formation in Virginia and

Maryland on Delmarva Peninsula)-Medium- to light-gray, mottled red,

orange, or yellowish brown, clayey, silty fine sand or clayey silt; grades

ormation of Maryland and Delaware on Delmarva Peninsula; part of Cape

COLLUVIAL DEPOSITS

down into silty fine sand and fine sand; chiefly quartz, moderately micaceous, calcareous; medium to thin bedded; locally crossbedded; fossiliferous. Basal beds contain isolated pebbles, cobbles, and boulders. Underlies flats 5-11 m above sea level. Thickness at least 7 m MIDDLE PLEISTOCENE ALLUVIAL AND ESTUARINE SAND AND SILT (part of) Oaks and Coch (1973) in Virginia; alluvial and estuarine facies of Shirley Formation in Virginia and North Carolina)—Light-gray to yellowish-brow silty fine sand to clavey sandy silt; grades down into light-tan to mediumgray, mottled yellowish-brown, quartz sand; thin- to thick-bedded, planarto crossbedded ferruginous fossiliferous contains scattered lenses of clau organic-rich silt and clay, peat, and fossil tree trunks. Basal part is coarse to fine sand containing cobbles and scattered boulders of quartzite, quartz gneiss, greenschist, and ferruginous quartz sandstone; many crystalline rock clasts are weathered. Deposit underlies terraces 10-15 m above sea

EOLIAN DEPOSITS

ALLUVIAL AND

DESCRIPTION OF MAP UNITS

HOLOCENE

sandy pebble- to boulder-gravel; grades upward into sandy to silty clay;

sand Gravel consists predominantly of quartz and quartzite but in place

flood plains, alluvial fans, and low terraces. Thickness 3-10 m

sandy silt containing thin beds of dark-gray peaty clay and lenses of pebble-

to cobble-gravel. Both sand and gravel are chiefly quartz. Deposit is poorly

sorted, thin to medium bedded, and locally crossbedded. Mapped areas

include local organic muck and swamp deposits (hs) on flood plains, small

silt, and clay. Includes thin lenses of poorly sorted, medium to coarse sand

and gravelly sand. Peat or peaty layers abundant. Deposit brackish at head:

of estuaries. Mapped areas include swamp deposits (hs), small channel

deposits of alluvial gravelly sand (asa), and locally derived colluvium.

SALINE-MARSH DEPOSIT—Dark-gray, black, or greenish-gray silty clay to

clayey fine sand, carbonaceous clay, and some layers of herbaceous peat,

intermixed and interbedded. Color darkens as organic content increases.

Deposit commonly bioturbated. Locally includes interbedded brackish-

AT (Dismal Swamp Peat in Virginia and North Carolina)-Dark-reddish-

brown to black woody peat, partly decomposed; grades downward into

compacted into thick mats. Deposit interbedded locally with thin layers of

silty clay to clayey sand, most common at base. Confined to deposits in

which volume of organic matter exceeds that of mineral matter. Thickness

coarse to fine sand; well-sorted, laminated, and crossbedded; mostly

BEACH MUD—Gray to black silt and clay; commonly contains abundant shell

HOLOCENE AND LATE WISCONSIN

quartz; locally includes some organic matter and shells. Deposit forms

fragments and very fine grained organic matter. Underlies beaches

bordering saline-marsh and estuarine deposits along Chesapeake Bay.

WAMP DEPOSIT—Dark-brown to black organic debris, muck, and local peat.

mixed with mud composed of fine sand, silt, and kaolinitic clay. Sand

chiefly quartz and feldspar. Local marl in calcareous clay at depth. In New

ersey deposits overlie older peat in places. Thickness commonly 1 to 2 :

massive to crossbedded, subrounded to well rounded; mostly quartz, bu

includes thin beds of organic matter commonly stabilized by vegetation

LATE PLEISTOCENE

GRANITIC-BOULDER COLLUVIUM¹—Pale- to dark-brown, yellowish-red, or

Occurs on valley floors and adjacent low terraces as sheets or irregularly

spaced linear and crescentic dunes oriented southeast. Dunes are active

near the coast; inland they are stabilized by vegetation. Thickness 0.5–6 m

grayish-yellow, poorly sorted, silty, sandy loam to sandy clay. Angular clasts

and round to subround cobble- to boulder-size joint-block core stones of

partly weathered feldspathic crystalline rocks make up 15-60 percent o

deposit. Material mantles steep slopes and includes creep, mudflow

landslide, and possibly solifluction deposits. Unit as mapped includes some

rock outcrops, small areas of saprolite, and bouldery alluvial-fan deposits.

he colluvium overlies saprolite in places, especially at the base of slopes

Thickness ranges from about 2 m on upper slopes to as much as 20 m at the

pale-reddish-brown, unsorted sand, silt, and clay. Contains angular to

subround blocks and cobble-size detritus of hard sandstone as large as 1 m

and Ridge Province. On steep slopes, it tends to form talus and debris

cones; commonly contains shale fragments and is more clayey where shale

underlies sandstone. On gently sloping uplands, it overlies thin decomposi-

above 600-m elevation. Mapped areas contain numerous rock outcrops.

reddish-brown, locally brick red, unsorted sandy to silty clay. Contains

abundant angular to subangular or rounded cobble- to boulder-size clasts

of limestone or dolomite. Deposit mantles slopes of knobs and ridges

AFIC-BOULDER LOAMY COLLUVIUM-Yellowish-brown to dark-red.

nderlain by carbonate rock in Valley and Ridge Province. Thickness 2–5 m

unsorted, sandy to silty clay loam; contains angular clasts and round to

subround joint-block core boulders of mafic rock, commonly partly

weathered. Locally overlies saprolite (sla, slg). Deposit mantles slopes of

knobs and ridges underlain by mafic rock, commonly diabase, which forms

ALT-CLAST CLAY LOAM COLLUVIUM1 - Yellowish-brown to reddish-

brown clay loam to silty clay loam; contains numerous small angular chunks

of basalt and some partly weathered cobble- to boulder- size basalt clasts

ARBONATE-BOULDER CLAYEY COLLUVIUM1-Yellowish-brown to

UARTZITE-BLOCK LOAMY COLLUVIUM1-Gray to yellowish-brown or

eaches and dunes along coast: also forms washover and tidal-channel

deposits, and locally is present as a thin layer, too small to map, on coastal

BEACH AND DUNE SAND-Light-gray to light-tan, angular to subangular,

saline-marsh deposits (hps). Thickness 0.5-25 m

es EOLIAN SAND—Tan to light-gray, pale-yellow to brown, medium sand

black, highly decomposed, colloidal, sapric, woody and reed sedge peat

alluvial fans at mouths of tributary streams, and colluvium along margins of

locally contains lenses of angular, moderately to well-sorted micaceous

includes some granitic crystalline rock or limestone. Deposit underlies

agg ALLUVIAL SANDY GRAVEL—White, light-gray to dark-brown, poorly sorted,

asa ALLUVIAL GRAVELLY SAND—Light- to dark-gray, fine to coarse sand and

ala ALLUVIAL SILT AND CLAY—Medium to dark-gray, highly organic fine sand,

valley floors Thickness 1-15 m

water deposits. Thickness 0.5-6 m

ESTUARINE

ALLUVIAL

DEPOSITS

MARINE AND

BEACH LAGOONAL

DEPOSITS DEPOSITS

ACH AND NEARSHORE MARINE SAND (parts of Norfolk Formation of Oaks and Coch (1973) in Virginia; barrier island facies of Shirley Formation in Virginia and North Carolina) — Yellowish-brown to 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 grayish-blue, fine to coarse quartz sand; thin bedded to medium bedded, crossbedded; fossiliferous; interbedded with layers of silt. Underlies flats and broad ridges 10-15 m above sea level. Thickness 1-8 m ARINE SAND, SILT, AND CLAY (parts of Norfolk Formation of Oaks and Coch (1973) in Virginia; marine back-barrier and lagoon facies of the lateral Accomack Member in Maryland and Delaware on the Delmarva Peninsula)-Medium-gray, mottled yellowish-brown, 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. Underlies flat to gently sloping surfaces 10–15 m above

level along major streams. Total thickness of unit as much as 24 m

sea level. Thickness 1-6 m LLUVIAL AND ESTUARINE SAND AND SILT (alluvial and estuarine facies of Chuckatuck Formation in Virginia and North Carolina)—Pale-brown to mottled light-gray, fine sandy clavey 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 terrace segments 14-18 m above sea level along major streams. Mapped areas include small deposits of alluvium (asa) and locally derived colluvium. ARINE SAND, SILT, AND CLAY (part of Windsor Formation of Oaks and Coch (1973) in Virginia; marine back-barrier and lagoon facies of Chuckatuck Formation in Virginia)—Light-gray to pale-brown, clayey, fine sandy silt or very silty clay, grades down into beds of fine to coarse quartz

sand containing sparse pebbles and cobbles; these beds are intercalated

and clayey, silty fine sand; grades down into medium-gray to brown, fine to

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. MIDDLE OR EARLY PLEISTOCENE aef ALLUVIAL AND ESTUARINE SAND AND SILT (alluvial and estuarine facies of Charles City Formation in Virginia and North Carolina) — Gray to palebrown, mottled yellowish- to reddish-brown, silty fine sand and clayey sil grades down into clavey, feldspathic, coarse to fine sand intercalated with thin beds of silt and clay; planar-bedded to crossbedded, unfossiliferous. Basal clayey coarse sand contains pebbles and cobbles of crystalline and metamorphic rocks, sandstone, quartzite, chert, and quartz, and some boulders of crystalline rock as large as 1 m in diameter. Deposit underlies terrace segments 18-24 m above sea level. Thickness as much as 10 m ARINE SAND, SILT, AND CLAY (parts of Windsor Formation of Oaks and Coch (1973) in Virginia; marine back-barrier and lagoon facies of the Charles City Formation in Virginia and North Carolina)-Light-gray to pale-yellowish-brown, mottled yellowish- to reddish-brown, fine sandy silt

medium sand, chiefly quartz and feldspar; massive to medium bedded; contains burrows. Local richly organic silt and peat at base. Underlies include small deposits of alluvium (ala), paludal deposits (hs), and residuum (zsc) on Tertiary deposits. Thickness 1-10 m EARLY PLEISTOCENE LLUVIAL AND ESTUARINE SAND AND SILT (part of the Windsor Formation of Oaks and Coch (1973) in southeastern Virginia; alluvial and estuarine facies of the restricted Windsor Formation in Virginia and North Carolina)—Medium to light-gray or yellowish- to reddish-brown, mottled massive silty clay to clayey sand; grades down into compact clayey quartz sand, locally cemented to ferricrete; thick-bedded, planarbedded, and crossbedded. Basal beds are of coarse sand containing pebbles, cobbles, and boulders. Deposit underlies upland terrace segments 24-28 m above sea level along major rivers. Mapped areas include small deposits of alluvium (asa), colluvium, and of residuum (zsc) on Tertiary deposits. MARINE SAND, SILT, AND CLAY (part of the Windsor Formation of Oaks and Coch (1973) in southeastern Virginia; marine back-barrier and lagoon

medium, feldspathic quartz sand containing scattered pebbles and cobble Deposit underlies coastal terrace 23-28 m above sea level. Feldspars commonly weathered to clay. Underlies coastal terraces 23-30 m above sea level. Mapped areas include small deposits of residuum (zsc) on Tertiary deposits. Thickness 0.5-8 m EARLY PLEISTOCENE TO PLIOCENE LUVIAL AND ESTUARINE SAND AND SILT (alluvial and estuarine facies of the Moorings unit in Virginia)—Medium-gray, yellowish- to reddishbrown, mottled, clayer silt and fine sand; grades down into medium-gray, coarse to fine quartz sand; feldspathic, medium- to thick-bedded crossbedded; locally pebbly at base. Underlies terrace segments 26-38 m

facies of the restricted Windsor Formation in Virginia and North Carolina)-

Reddish-brown to yellowish-brown, massive, clayey sand and silty clay

medium-gray, mottled reddish-brown at depth; basal clayey fine to

above sea level along major streams. Mapped areas include small deposits of colluvium, younger alluvium (asa), and residuum (zsc) on Tertiary ACH AND NEARSHORE MARINE SAND (barrier island facies of Moorings unit in Virginia)-Yellowish-brown to medium-gray, mottled reddishbecomes coarse downward. Underlies linear ridges 30-36 m above sea MARINE SAND, SILT, AND CLAY (marine back-barrier and lagoon facies of Moorings unit in Virginia; part of the Walston Silt in Maryland and Delaware on the Delmarva Peninsula)-Pale-yellowish-brown to medium-gray. mottled reddish-brown, clayey silt and silty clayey fine sand; massive to weakly stratified. Underlies upland flats 33-39 m above sea level. Mapped

gray, or greenish-gray slightly clayey sand to sandy clay. Developed in areas include small deposits of colluvium and residuum (zsc) on Tertiary metamorphic or igneous rocks of intermediate composition. Clays are deposits. Thickness 2-6 m mixed smectite and kaolinite in saprolite developed on more mafic rocks and have moderate shrink and swell potential. Where source rocks are MIDDLE PLEISTOCENE TO PLIOCENE more felsic, clay is predominantly kaolinite. Sand is principally feldspar an LOAMY DECOMPOSITION RESIDUUM AND GRAVELLY SAND² (Pensauken quartz, with biotite, hornblende, and vermiculite in more mafic varieties. Formation in New Jersey)-Dark-red, reddish-brown, orange-brown, or Soft rock fragments or ghosts of fragments abundant in places. Mapped brown, massive to faintly stratified loam and clay loam. Grades downward areas include locally derived colluvium and rock exposures. Thickness into sand and gravel deposited at several topographic levels. Residuum CLAYEY SAPROLITE4—Greenish-gray, pale-yellowish-orange, moderatetends to be thicker and more intensely weathered in older deposits at higher levels, and thinner and less intensely weathered in younger deposits yellow or dark-red, slightly micaceous to micaceous, clayey sand to sandy at lower levels. Gibbsite, halloysite, and endellite are common alteration clay or clayey silt. Developed in mafic metamorphic, mafic metavolcanic, and ultramafic rocks. Where rocks are massive to weakly gneissic, the products, especially in residuum at higher topographic levels. Clasts in residuum are chiefly well-rounded quartz, quartzite, quartzose sandstone saprolite commonly includes joint-block core-stones ranging in size from boulder to pebble, and is characterized by a pinnacled bedrock base. Cla component is a mixture of smectite and kaolinite having a shrink and swe potential ranging from low to high. Sand is chiefly calcic feldspar, biotite, vermiculite, hornblende, and a little quartz. Mapped areas include small deposits of locally derived colluvium commonly containing bedrock fragments, and widely scattered bedrock exposures. Thickness less than

and chert. Clasts of granite, gneiss, schist, gabbro, diabase, and basalt generally are saprolitized or have weathering rinds. Most clasts have clay coatings. Chert pebbles commonly have chalky white coatings. Secondary concretions are common. Locally may be as old as Miocene. In general, composition and structure of gravelly sand deposits ar broadly similar. However, clasts of red shale, red arkosic sandstone, diabase, and basalt, derived from Triassic rocks, and of ironstone derived from cemented sand and gravel at high topographic levels or from residuum (zsr), are increasingly abundant in gravelly sand at lower topographic levels. Cobbles and rare boulders are also present in deposit at lower levels. Deposits at each topographic level consist largely of materials reworked from older deposits at higher levels. Deposits at higher levels are mainly remnants on drainage divides and in terrace segments those at lower levels are mostly in terrace segments or former valley tills. Mapped areas locally include small deposits of sand and silt (aeb), and residuum (zss) and (zle). In places residuum and sand and gravel are overlain by unmapped alluvium, eolian sand, loess, or locally derived sheetwash deposits. Thickness of residuum generally 1-4 m. Thickness of

sand and gravel commonly 4-10 m

parent rock common in lower part. Clay predominantly kaolinite but gibbsite present in places. Mapped areas include bedrock exposures on slopes and hill crests, and deposits of locally derived colluvium, especially at base of slopes. Thickness ranges from less than 0.5 m on steep slopes to as much as 5 m on gentle lowland slopes N SILTY CLAY SAPROLITE4 ON SERPENTINITE—Pale-greenish-gray to pale-yellowish-brown silty clay. Contains small fragments and slabs of serpentinite. Extensive smooth pavement outcrops of serpentinite are

common. Thickness of saprolite less than 1 m, commonly less than 0.5 m

ED, CLAY TO SILTY CLAY SAPROLITE4—Dark-red clay to silty clay;

developed in metavolcanic greenstone. Clay chiefly kaolinitic. Mapped

¹COLLUVIUM is a general term applied for purposes of this map to material

only in Virginia. Thickness 10-30 m

SAPROLITES

AYEY SAPROLITE⁴, ROCK TORS, AND JOINT-BLOCK BOULDERSale-yellowish-orange, orange-brown, or dark-red, sandy to silty clay. Developed on massive mafic rock, commonly diabase. Clay is mixed kaolinite and smectite; smectite particularly common in areas of poor drainage. Unit has broad range of shrink and swell potential. Sand chiefly partly altered calcic feldspar. Angular pea-size gruss present in places. Bedrock knobs or tors common and generally surrounded by saprolite containing abundant partly weathered joint-core boulders. Mapped areas include small deposits of locally derived boulder colluvium, especially at AYEY, SILTY, AND SANDY SAPROLITE4, UNDIFFERENTIATED-Varieties of saprolite developed on interlayered phyllite, marble, metabasalt, and metarhyolite, not separately mappable at 1:1,000,000 scale. On phyllite, saprolite is gray, greenish-gray, yellowish-brown, or red, silty to clayey fine sand, containing splinters of parent rock in lower part. On marble it is reddish-brown, sandy to silty clay of extremely variable thickness, containing abundant solution core-stones, and underlain by solution-pinnacled bedrock. Saprolite on metavolcanic rock is reddish brown, orange-red, or yellowish-brown bouldery clay. Unit mapped only o Piedmont in Maryland and Pennsylvania. Thickness commonly as much as 6 m on ridges and uplands; thinner on slopes and in valleys

chiefly creep, solifluction, mudflow, frost heave, and locally landslide. ²DECOMPOSITION RESIDUUM, for purposes of this map, is defined as material ³SOLUTION RESIDUUM, for purposes of this map, is defined as material derived by n-place solution of carbonate rock or carbonate-cemented rock with no appreciable subsequent lateral transport

ocks. The color of saprolite depends on the abundance of dark minerals in the parent rock and on the drainage. Bright reds and vellows are produced above the water table: grav whitish grays, and greenish blues are produced below. Saprolite grades down through partly weathered rock into fresh parent rock. The structure and texture of the bedrock are characteristically preserved in saprolite However, in places structureless saprolite may occur between structured saprolite below and colluvium or modern soil above. Replication of bedrock features in saprolite results from isovolumetric chemical alteration of weatherable minerals. In weathering, the aluminosilicate minerals alter to clay minerals, density decreases as much as 50 percer and porosity increases greatly. Saprolite texture ranges from sandy to clayey depending ipon the abundance of minerals, such as quartz, in the parent rock that are resistant The clay mineralogy of saprolite depends on the kinds of rock-forming aluminosilicate ninerals in the parent rock and the drainage regimen. For example, the clay minerals aprolite developed in mafic rocks, in which hornblende and plagioclase are the primary areas, and kaolinite and gibbsite in very well drained areas. In contrast, the clay minerals in aprolite developed on felsic rocks are chiefly kaolinite and illite in both poorly and drained areas; gibbsite develops as a persistent minor component only where internal Saprolite thickness is directly related to slope angle and to the lithology and

thickness of saprolite developed on felsic gneiss or schist on gently sloping upland commonly exceeds 6 m (and locally may exceed 30 m), on slopes of 6-12", the thickness m. In contrast, saprolite developed in quartzite and serpentinite is commonly less than m thick regardless of slope angle. nap, it is subdivided in accordance with the distribution of different kinds of bedrock ch differing varieties of saprolite are derived. Differences due to slope angle could not be effectively shown at the scale of this map. Information on rock permeability suitable for mapping varieties of saprolite is not regionally available.

SOURCES OF INFORMATION

Bascom, Florence, Clark, W. B., Darton, N. H., Kümmel, H. B., Salisbury, R. D., Miller, B. L. and Knapp, G. N., 1909, Description of the Philadelphia district: U.S. Geological Survey Bascom, Florence, and Miller, B. L., 1920, Description of the Elkton-Wilmington quadrangles: U.S. Geological Survey Geologic Atlas, Folio 211, 22 p. Denny, C. S., and Owens, J. P., 1979 [1980], Sand dunes on the central Delmarva Peninsul Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-C, p. C1-C1 Denny, C. S., Owens, J. P., Sirkin, L. A., and Rubin, Meyer, 1979, The Parsonsburg Sand in the central Delmarva Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-B, p. B1-B16.

Jordan, R. R., 1964, Columbia (Pleistocene) sediments of Delaware: Delaware Geological Survey Bulletin 12, 69 p. __1967, Delaware: Atlantic Coastal Plain Geological Association, 8th Annual Field Conference, Guidebook; Newark, Delaware Geological Survey, 21 p. _1974, Pleistocene deposits of Delaware, 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. 30–52. Miller, B. L., 1906, Description of the Dover quadrangle: U.S. Geological Survey Geologic

and large amounts of colluvium derived from the residuum. Deposit present only in Valley and Ridge Province in Virginia. Thickness irregular, Owens, J. P., and Denny, C. S., 1979 [1980], Upper Cenozoic deposits of the central Delmarva ANDY CLAYEY SAPROLITIZED GRAVEL4—Dark-red to reddish-brown Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-A, sandy clay. Contains scattered stained pebbles of quartz and ghost pebbles and cobbles of other rock types now completely altered to clay. Deposit Owens, J. P., and Minard, J. P., 1979, Upper Cenozoic sediments of the lower Delaware caps flat ridgetops whose distribution suggests a former Tertiary alluvial Valley and the northern Delmarva Peninsula, New Jersey, Pennsylvania, Delaware, and Maryland: U.S. Geological Survey Professional Paper 1067–D, p. D1–D47. terrace system. Saprolitized gravel is exposed at numerous localities too small to map, particularly within incised meander loops along rivers. Parker, G. G., Hely, A. G., Keighton, W. B., Olmsted, F. H., and others, 1964, Water resources of the Delaware River basin: U.S. Geological Survey Professional Paper 381, 200 p.

MARYLAND

Bascom, Florence, and Miller, B. L., 1920, Description of the Elkton-Wilmington quadrangles: U.S. Geological Survey Geologic Atlas, Folio 211, 22 p. Cleaves, E. T., 1968, Piedmont and Coastal Plain geology along the Susquehanna aqueduct, Baltimore to Aberdeen, Maryland: Maryland Geological Survey Report of Investigations ___1974. Petrologic and chemical investigations of chemical weathering in mafic rocks, eastern Piedmont of Maryland: Maryland Geological Survey Report of Investigations

U.S. Geological Survey, 1967, Engineering geology of the northeast corridor, Washington,

Survey Miscellaneous Geologic Investigations Map I-514-B, scale 1:250,000

D.C., to Boston, Massachusetts-Coastal Plain and surficial deposits: U.S. Geological

Denny, C. S., and Owens, J. P., 1979 [1980], Sand dunes on the central Delmarva Peninsul. Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-C, p. C1-C15 Denny, C. S., Owens, J. P., Sirkin, L. A., and Rubin, Meyer, 1979, The Parsonsburg Sand in the central Delmarva Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-B, p. B1-B16. Glaser, J. D., ed., 1976, Anne Arundel County-Geology, mineral resources, land modification, and shoreline conditions: Maryland Geological Survey County Atlas 1, scale 1:62.500. 4 sheets

interspersed with both. Mapped areas of saprolite commonly include deposits of locally derived colluvium, containing boulders, especially at base of steep slopes. Fragments of vein quartz are locally abundant in such Godfrey, A. E., 1975, Chemical and physical erosion in the South Mountain anticlinorium, Maryland: Maryland Geological Survey Information Circular 19, 35 p. Hack, J. T., 1955, Geology of the Brandywine area and origin of the upland of southern yellow, or white silty sand to slightly clayey sand. Developed in gneissic Maryland: U.S. Geological Survey Professional Paper 267-A, 42 p. granite, felsic schist interlayered with gneiss, foliated granitic rocks, and Johnston, P. M., 1964, Geology and ground-water resources of Washington, D. C., and elsic metavolcanic rocks. Clay predominantly kaolinite in upper part of vicinity: U.S. Geological Survey Water-Supply Paper 1776, 97 p. unit, but gibbsite may equal or exceed kaolinite in lower part. Illite and Maryland Geological Survey, 1968, Geologic map of Maryland; scale 1:250,000.

Miller, B. L., 1906, Description of the Dover quadrangle: U.S. Geological Survey Geologic Mixon, R. B., in press, Stratigraphic and geomorphic framework of uppermost Cenozoic Mixon, R. B., Southwick, D. L., and Reed, J. C., Jr., 1972 [1973], Geologic map of the Quantico quadrangle, Prince William and Stafford Counties, Virginia, and Charles County, Maryland: U.S. Geological Survey Geological Quadrangle Map GQ-1044, scale

Mixon, R. B., Szabo, B. J., and Owens, J. P., 1982, Uranium-series dating of mollusks and corals, and age of Pleistocene deposits, Chesapeake Bay area, Virginia and Maryland: S. Geological Survey Professional Paper 1067-E, 18 p. Iwens, J. P., and Denny, C. S., 1979 [1980], Upper Cenozoic deposits of the central Delmarva

Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-A. _1979. Geologic map of Wicomico County, Maryland: Baltimore, Maryland _1979, Geologic map of Worcester County, Maryland: Baltimore, Maryland Owens, J. P., and Minard, J. P., 1979, Upper Cenozoic sediments of the lower Delaware Valley and the northern Delmarva Peninsula, New Jersey, Pennsylvania, Delaware, and Maryland: U.S. Geological Survey Professional Paper 1067-D, p. D1-D47. Schlee, J. S., 1957, Upland gravels of southern Maryland: Geological Society of America

Bulletin, v. 68, no. 10, p. 1371-1409. J.S. Geological Survey, 1967. Engineering geology of the northeast corridor, Washington, D.C., to Boston, Massachusetts-Coastal Plain and surficial deposits: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-514-B, scale 1:250,000. **NEW JERSEY**

Bascom, Florence, Clark, W. B., Darton, N. H., Kümmel, H. B., Salisbury, R. D., Miller, B. L., and Knapp, G. N., 1909, Description of the Philadelphia district: U.S. Geological Survey Bascom, Florence, and Miller, B. L., 1920, Description of the Elkton-Wilmington quadrangles U.S. Geological Survey Geologic Atlas, Folio 211, 22 p. Bowman, J. F., II, and Lodding, William, 1969. The Pensauken Formation—a Pleistocene fluvial deposit in New Jersey, in Subitzky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions; Geological Society of America, annual meeting, Atlantic City, N.J. 1969; New Brunswick, N.J., Rutgers

Gill, H. E., 1962, Ground-water resources of Cape May County, New Jersey-salt water nvasion of principal aquifers: New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply Special Report 18, 171 p. Lewis, J. V., and Kümmel, H. B., 1912, Geologic map of New Jersey: New Jersey Department

- Middle Pleistocene Early Pleistocene

- Late Pleistocene

QUARTERNARY GEOLOGIC ATLAS OF THE UNITED STATES

MISCELLANEOUS INVESTIGATIONS SERIES

MAP I-1420 (NJ-18)

Johnson), scale 1:250,000.

MacClintock, Paul, 1943, Marine topography of the Cape May Formation [N.J.]: Journal of Geology, v. 51, no. 7, p. 458-472. Miller, B. L., 1906, Description of the Dover quadrangle: U.S. Geological Survey Geologic Minard, J. P., and Rhodehamel, E. C., 1969, Quaternary geology of part of northern New Jersey and the Trenton area, Field Trip 3, in Subitsky, Seymour, ed., Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions: Geological Society of America, annual meeting, Atlantic City, N.J. 1969; New Brunswick, N.J.

Owens, J. P., and Minard, J. P., 1975, Geologic map of the surficial deposits in the Trenton area, New Jersey and Pennsylvania: U.S. Geological Survey Miscellaneous Investigations Map I-884, scale 1:48,000. Delmarva Peninsula, New Jersey, Pennsylvania, Delaware, and Maryland: U.S. eological Survey Professional Paper 1067-D. 47 p. Parker, G. G., Hely, A. G., Keighton, W.B., Olmsted, F. H., and others, 1964, Water resources of the Delaware River basin: U.S. Geological Survey Professional Paper 381, 200 p. Quackenbush, G. A., Tedrow, J. C. F., and others, 1954, Land type areas of New Jersey: New

Jersey Agricultural Experiment Station, scale 1 in. = 8 mi. Salisbury, R. D., and Knapp, G. N., 1917, The Quaternary formations of southern New Jersey. New Jersey Department of Conservation, Division of Mining and Geology, Final Report Series of the State Geologist, v. 8, 218 p. . Geological Survey, 1967, Engineering geology of the northeast corridor, Washington, D. C., to Boston, Massachusetts-Coastal Plain and surficial deposits: U. S. Geological Survey Miscellaneous Geologic Investigations Map I-514-B, scale 1:250,000. NORTH CAROLINA

Blackwelder, B. W., 1981, Stratigraphy of upper Pliocene and lower Pleistocene marine and estuarine deposits of northeastern North Carolina and southeastern Virginia. U.S. eological Survey Bulletin 1502-B, 16 p. Daniels, R. B., and Gamble, E. E., 1974, Surficial deposits of the Neuse-Cape Fear divide bove the Surry scarp, 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. 88–101 Daniels, R. B., Gamble, E. E., Wheeler, W. H., and Holzhey, C. S., 1972, Field trip quidebook: Meetings and Field trip 1972; Raleigh, N.C., Carolina Geological Society-Atlantic pastal Plain Geological Association, 44 p.

Darton, N. H., 1894, Description of the Fredericksburg sheet [Va.-Md.]: U.S. Geological Survey Geologic Atlas, Folio 13, 6 p. _1896, Description of the Nomini sheet [Md.-Va.]: U.S. Geological Survey Geolog DuBar, J. R., Solliday, J. R., and Howard, J. F., 1974, Stratigraphy and morphology o 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, Jtah, Utah State University Press, p. 102-122.

Goodwin, B. K., 1970, Geology of the Hylas and Midlothian quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigations 23, 51 p. Liddicoat, J. C., 1984. Magnetostratigraphy of the Quaternary of the eastern United States EOS, v. 65, no. 16, p. 200. North Carolina Department of Conservation and Development, Division of Mineral Resources, 1958, Geologic map of North Carolina, scale 1:500,000. Oaks, R. Q., Jr., and DuBar, J. R., 1974. Tentative correlation of post-Miocene units, central and southern Atlantic Coastal Plain, in Oaks, R. Q., Jr., and DuBar, J. R., eds., Post-Miocene stratigraphy, central and southern Atlantic Coastal Plain: Logan, Utah, Utah Wheeler, W. H., Daniels, R. B., and Gamble, E. E., 1983, The post-Yorktown stratigraphy and

geomorphology of the Neuse-Pamlico area, eastern North Carolina: Smithsonian ontributions to Paleobiology, in Ray, C. E., ed., Geology and paleontology of the Lee Creek mine, North Carolina, v. 1: Smithsonian contributions to Paleobiology, no. 53 PENNSYLVANIA

Bascom, Florence, Clark, W. B., Darton, N. H., Kümmel, H. B., Salisbury, R. D., Miller, B. L. and Knapp, G. N., 1909, Description of the Philadelphia district: U.S. Geological Survey eologic Atlas, Folio 162, 24 p om, Florence, and Miller, B. L., 1920, Description of the Elkton-Wilmington quadrangles Geological Survey Geologic Atlas, Folio 211, 22 p.

Owens, J. P., and Minard, J. P., 1979, Upper Cenozoic sediments of the lower Delaware Valley and the northern Delmarva Peninsula, New Jersey, Pennsylvania, Delaware, and Maryland: U.S. Geological Survey Professional Paper 1067-D, p. D1-D47. Parker, G. G., Hely, A. G., Keighton, W. B., Olmsted, F. H., and others, 1964, Water resources of the Delaware River basin: U.S. Geological Survey Professional Paper 381, 200 p. Pennsylvania Topographic and Geologic Survey. 1960, Geologic map of Pennsylvania: scale

1:250.000, 2 sheets. Bick, K. F., and Coch, N. K., 1969, Geology of the Williamsburg, Hog Island, and Bacons Castle quadrangles, Virginia: Virginia Division of Mineral Resources Report of Blackwelder, B. W., 1981, Stratigraphy of upper Pliocene and lower Pleistocene marine and

estuarine deposits of northeastern North Carolina and southeastern Virginia: U.S. ological Survey Bulletin 1502-B, 16 p. Clark, W. B., and Miller, B. L., 1906. The geology of the Virginia Coastal Plain, in Ries Heinrich, Clay deposits of the Virginia Coastal Plain: Virginia Geological Survey Bulletin 2. ____1912. The physiography and geology of the Coastal Plain Province of Virginia, with chapters on The lower Cretaceous, by E. W. Berry, and Economic geology, by T. L. Watson: Virginia Geological Survey Bulletin 4, p. 13–222. Coch, N. K., 1965, Post-Miocene stratigraphy and morphology, inner Coastal Plain NONR 609(40), Technical Report 6, [146 p.]

southeastern Virginia: U.S. Office of Naval Research, Geography Branch, Contract _____1968, Geology of the Benns Church, Smithfield, Windsor, and Chuckatuck quadrangles. Virginia: Virginia Division of Mineral Resources Report of Investigations __1971, Geology of the Newport News South and Bowers Hill quadrangles, Virginia /irginia Division of Mineral Resources Report of Investigations 28, 26 p. Daniels, P. A., Jr., and Onuschak, Emil, 1974, Geology of the Studley, Yellow Tavern Richmond, and Seven Pines quadrangles, Virginia: Virginia Division of Mineral esources Report of Investigations 38, 75 p. Drake, A. A., Jr., and Froelich, A. J., 1977, Bedrock map of Fairfax County, Virginia: U.S.

Geological Survey Open-File Report 77-523, scale 1:48,000. Froelich, A. J., 1975, Thickness of overburden map of Montgomery County, Maryland: U.S. Geological Survey Miscellaneous Investigations Map I-920-B, scale 1:62,500. Froelich, A. J., and Heironimus, T. L., 1977, Thickness of overburden map of Fairfax County Virginia: U.S. Geological Survey Open-File Report 77-797, scale 1:48,000. Goodwin, B. K., 1970, Geology of the Hylas and Midlothian quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigations 23, 51 p. Googins, R. L., and others, in press, Soil association map of Virginia: U.S. Department of Agriculture, Soil Conservation Service. Hack, J. T., 1965, Geomorphology of the Shenandoah Valley, Virginia and West Virginia, and origin of the residual ore deposits: U.S. Geological Survey Professional Paper 484.

Johnson, G. H., 1969, Geology of the lower York-James Peninsula and south bank of the James River [Virginia]: Atlantic Coastal Plain Geological Association, 10th Field Conference, 1969; Williamsburg, Va., College of William and Mary, Guidebook 1, 33 p __1972, Geology of the Yorktown, Poquoson West, and Poquoson East quadrangle Virginia: Virginia Division of Mineral Resources Report of Investigations 30, 57 p. _1976. Geology of the Mulberry Island. Newport News North, and Hampton quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigations 41 Johnson, G. H., and Berquist, C. H., in press, Geology of the Brandon and Norge quadrangles.

Virginia. Virginia Division of Mineral Resources Report of Investigations. Johnson, P. M., 1962, Geology and ground-water resources of the Fairfax quadrangle, Virginia: U.S. Geological Survey Water-Supply Paper 1539-L, 61 p. Langer, W. H., 1978, Surface materials map of Fairfax County, Virginia: U.S. Geological Survey Open-File Report 78-78, scale 1:48,000. Liddicoat, J. C., 1984, Magnetostratigraphy of the Quaternary of the eastern United State EOS (Transactions of the American Geophysical Union), v. 65, no. 16, p. 200. Liddicoat, J. C., Blackwelder, B. W., Ward, L. W., and Cronin, T. M., 1981, Paleomagnetism of

the Great Bridge and Chowan River Formations, central Atlantic Coastal Plain: Geological Society of America Abstracts with Programs, v. 15, no. 3, p. 198. Liddicoat, J. C., and Mixon, R. B., 1980. Paleomagnetic investigation of Pleistocene sediments in the Delmarva Peninsula, central Atlantic Coastal Plain: Geological Society of America Abstracts with Programs, v. 12, no. 2, p. 70.

Mixon, R. B., in press, Stratigraphic and geomorphic framework of upper Cenozoic deposits in the southern Delmarva Peninsula, Virginia and Maryland: U.S. Geological Survey Mixon, R. B., Southwick, D. L., and Reed, J. C., Jr., 1973. Geologic map of the Quantico

quadrangle, Prince William and Stafford Counties, Virginia, and Charles Counties yland: U.S. Geological Survey Geologic Quadrangle Map GQ–1044, scale 1:24,000. Mixon, R. B., Szabo, B. J., and Owens, J. P., 1982, Uranium-series dating of mollusks and corals, and age of Pleistocene deposits, Chesapeake Bay area, Virginia and Maryland; U.S. Geological Survey Professional Paper 1067-E, 18 p. Oaks, R. Q., Jr., 1965, Post-Miocene stratigraphy and morphology, outer Coastal Plain,

southeastern Virginia: U.S. Office of Naval Research, Geography Branch, Technical 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.

Oaks, R. Q., Jr., Coch, N. K., Sanders, J. E., and Flint, R. F., 1974, Post-Miocene shorelines and sea levels, southeastern Virginia, in Oaks, R. Q., Jr., and DuBar, J. R., eds., Post-Miocene stratigraphy, central and southern Atlantic Coastal Plain: Logan, Utah, Utah State Oaks, R. Q., Jr., and Dubar, J. R., 1974, Tentative correlation of post-Miocene units, centr and southern Atlantic Coastal Plain, 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. 232–245. Peebles, P. C., Johnson, G. H., and Berquist, C. H., 1984, The middle and late Pleistocene

stratigraphy of the outer Coastal Plain, southeastern Virginia: Virginia Minerals, v. 30, no. 2, U.S. Department of Agriculture, Published and unpublished soil surveys, soil association maps, and preliminary reports on soils of individual counties. Virginia Department of Conservation and Economic Development, Division of Minera Resources, 1963, Geologic map of Virginia: Charlottesville, Va., scale 1:500,000. Wentworth, C. K., 1930, Sand and gravel resources of the Coastal Plain of Virginia: Virginia Geological Survey Bulletin 32, 146 p.

Cardwell, D. H., Erwin, R. B., and Woodward, H. P., 1968. Geologic map of West Virginia: Morgantown, West Virginia Geologic and Economic Survey, scale 1:250,000, 2 sheets. OXYGEN ISOTOPE STAGES Mixon, R. B., Szabo, B. J., and Owens, J. P., 1982, Uranium-series dating of mollusks and

corals, and age of Pleistocene deposits, Chesapeake Bay area, Virginia and Maryland U.S. Geological Survey Professional Paper 1067-E. 18 p. Shackleton, N. J., and Opdyke, N. D., 1973, Oxygen isotope and paleomagnetic stratigraphy of equatorial Pacific core V28-238-Oxygen isotope temperature and ice volumes on a of Conservation and Economic Development, Atlas Sheet 40 (revised 1950 by M. E. 105 year and 106 year scale: Quaternary Research, v. 3, no. 1, p. 39-55.

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explanations of the part of each State included in the quadrangle were prepared by the State compilers. These maps and explanations were then assembled, integrated, and supplemented by the editors to produce the quadrangle map and map explanation. Problems related to differentiation and description of saprolite units, and to correlation of Pleistocene formations of the Coastal Plain, were resolved at additional meetings as well as by correspondence. The footnote or saprolite was prepared by E. T. Cleaves, Maryland Geological Survey, and R. B. Daniels, North Carolina State University. The correlation chart of Coastal Plain formations was prepared by G. M. Richmond with the cooperation of G. H. Johnson, College of William and Mary, and R. B. Mixon, U.S. Geological Survey. The other diagrams were prepared by the editors. The compilers reviewed the map

NOTE 1: This map is the product of interorganizational collaboration.