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

State compilations by Thomas M. Scott, Michael S. Knapp, Michael S. Friddell, and David L. Weide Edited and integrated by Gerald M. Richmond, David S. Fullerton, and David L. Weide

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

PREPARED IN COOPERATION WITH THE FLORIDA BUREAU OF GEOLOGY AND THE GEORGIA GEOLOGICAL SURVEY

> HOLOCENE asa ALLUVIAL GRAVELLY SAND ALLUVIAL CLAY AND SILT hs SWAMP DEPOSIT hpc FRESHWATER MARSH PEAT AND CLAY hps SALINE MARSH DEPOSIT hmm COASTAL MANGROVE SWAMP DEPOSIT he SWAMP DEPOSIT AND DUNE SAND

LIST OF MAP UNITS

BEACH AND DUNE SAND BEACH SHELL-FRAGMENT AND SHELL SAND BEACH MUD LATE PLEISTOCENE

ANASTASIA FORMATION bma BEACH AND NEAR-SHORE MARINE SAND BEACH AND NEAR-SHORE MARINE SAND MARINE SILT AND CLAY LATE PLEISTOCENE TO MIDDLE PLEISTOCENE

BEACH AND MARINE SAND, WEATHERED AND BEACH AND MARINE SAND AND LAGOONAL DEPOSITS, UNDIFFERENTIATED MIDDLE PLEISTOCENE BEACH AND NEAR-SHORE MARINE SAND MARINE SILT AND CLAY

BEACH AND NEAR-SHORE MARINE SAND mld MARINE SILT AND CLAY BEACH AND NEAR-SHORE MARINE SAND mle MARINE SILT AND CLAY MIDDLE PLEISTOCENE TO EARLY

PLEISTOCENE

BEACH AND MARINE SAND AND SANDY CLAY mbb BEACH AND MARINE SAND AND LAGOONAL DEPOSITS, UNDIFFERENTIATED EARLY PLEISTOCENE TO LATE PLIOCENE BEACH AND MARINE SAND mif MARINE SILT AND CLAY

EARLY PLEISTOCENE AND PLIOCENE BEACH AND NEAR-SHORE MARINE SAND AND nsa MARINE AND ALLUVIAL SAND LAND PEBBLE PHOSPHATE DEPOSIT

ase ALLUVIAL SAND QUATERNARY AND TERTIARY SAND AND CLAY DECOMPOSITION RESIDUUM MEDIUM TO FINE SILTY SAND AND SANDY SILT DECOMPOSITION RESIDUUM SANDY CLAY DECOMPOSITION RESIDUUM rsf CLAYEY SAND SOLUTION RESIDUUM WITH CHERT BLOCKS

BEACH RIDGES-Mapped along Atlantic coast and discontinuously along central carbonate CAROLINA BAY—Shallow, oval or elliptical closed depression, 100 m to many kilometers in length, in Atlantic Coastal Plain. Partly filled

SANDY CARBONACEOUS CLAY SOLUTION

with mixed sand, silt, and clay containing abundant organic matter and by surface swamp deposits. 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. Map units and related matters were established in general at a regional meeting of state compilers with the coordinator. Subsequently, Quaternary maps and map explanations of the part of each state included in the quadrangle were prepared by the state compilers. These were then integrated and supplemented by the editors to produce this geologic map and map explanation. Significant geologic problems were resolved by correspondence. The map was reviewed by the compilers prior to being submitted for publication. Other reviewers, to whom the editors are indebted, were W. A. White, Department of Geology, University of North Carolina, and J. B., Cathcart, U.S. Geological Survey.

NOTE 2: The Pliocene-Pleistocene boundary as 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 Geologica Correlation Program (IGCP) Project No. 41 on the (Neogene/ Quaternary Boundary) is 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 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,

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.

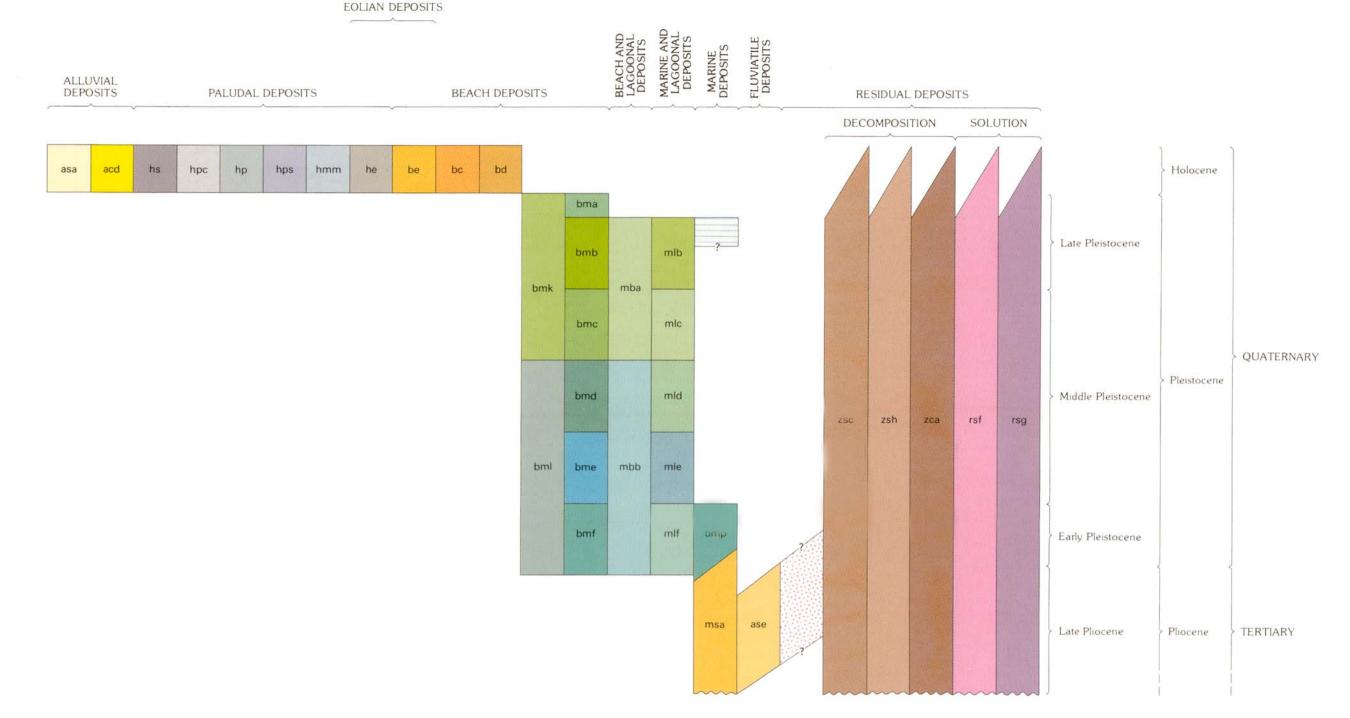
CLIMAP Project Members, 1984, The last interglacial ocean: Quaternary Research, v. 21, p. 123-224. Eardley, A. J., Shuey, R. T., Gvosdetsky, V., Nash, W. P., Picard, M. D., Grey, D. C., and Kukla, G. J., 1973, Lake cycles in the Bonneville Basin, Utah: Geological Society of America Bulletin, v. 84, no. 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-

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



LATE PLEISTOCENE TO MIDDLE PLEISTOCENE

fill structures common. Basal beds are coarse to very coarse sand.

DESCRIPTION OF MAP UNITS

intermittently covered by 0.5-1 m of standing water. Where these

Thickness 3-10 m

Thickness 2-5 m

hickness 0.5-1 m

reshwater vegetation. Thickness 1-3 m

he SWAMP DEPOSIT AND DUNE SAND—Swamp deposit consists of dark-

in eastern Florida. Thickness 5-15 m

deposits (hpc). Thickness 2-7 m

calcium carbonate. Thickness 1-5 m

gray to orange, mottled, silty, smectitic clay with abundant organic

debris, that is present in parallel, linear, interdune depressions along

Atlantic coast. Locally, deposit is compacted as a result of drainage

for agriculture. Dune sand is white, unconsolidated, and fine- to

medium-grained. It is composed of quartz mixed with moderate

amounts of crushed shell. Deposit forms linear beach and dune ridges

parallel to shore. Dunes are chiefly stabilized by vegetation although

some are locally active. Mapped unit overlies the Anastasia Formation

well sorted, crossbedded; mostly quartz, traces of heavy minerals.

Upper layers locally contain crushed shell that increases gradually in

proportion from north to south. Occurs along coast at and above

modern beach. Also present as thin deposits, too small to map, on

BEACH SHELL-FRAGMENT AND SHELL SAND—White to light-gray

bd BEACH MUD—Gray to black silt and clay; contains shell fragments and

along western coast of Florida. Thickness 0.5-1.5 m

coastal saline-marsh deposits (hps) and coastal freshwater-marsh

shell fragments and shell sand including minor amounts of fine quartz

sand, silt, and clay. Locally, deposit may be weakly cemented by

very fine grained organic matter; color darkens as amount of organic

matter increases. Underlies beaches bordering saline marshes,

estuaries, and lakes from which it has been transported. Present only

LATE PLEISTOCENE

ANASTASIA FORMATION—Present mostly in subsurface and shown by

pattern on map. Light-gray to yellow, complexly interbedded, sandy

marine limestone, calcareous sandstone, sand, and friable to variably

cemented coquina. Locally contains thin, discontinuous lenses of

black silty muck and decayed organic matter. The Anastasia

Formation has a Th²³⁰/U²³⁴ age of about 110,000 years (Osmond

and others, 1970). Exposures of the formation, too small to show at

scale of map, occur discontinuously along the Atlantic coastal ridge of

eastern Florida. However, most of unit is covered by younger late

Pleistocene beach sand or undifferentiated beach sand and lagoonal

sand (he, be) of Holocene age. Thickness as much as 30 m

bma BEACH AND NEAR-SHORE MARINE SAND (Barrier island facies of

bmb BEACH AND NEAR-SHORE MARINE SAND (Barrier island facies of

Thickness 18–20 m

deposits (bmk) and by thin swamp deposits, beach sand, and dune

Silver Bluff Formation in Georgia)—White to gray, light-tan to

yellowish-brown, well-sorted, fine to medium quartz sand; planar

bedded to crossbedded. Local humic layers at depths of 0.5-1 m.

Basal part is commonly coarse to very course sand; deposit is leached

to a depth of about 4 m, below which is unleached calcareous shell

debris. Includes washover sheet-fan and tidal inlet channel deposits.

Princess Anne Formation in Georgia)—White to gray, light-tan to

sorted, planar bedded to low-angle crossbedded; washover sheet-fan

and tidal-inlet channel-and-fill structures common. Local humic

layers at depth of 0.5-1 m. Basal beds are coarse to very coarse sand.

unleached calcareous shell debris. Thickness 18–20 m

mlb MARINE SILT AND CLAY (Lagoon facies of Princess Anne Formation in

Deposit leached to a depth of about 4 m, below which it includes

Georgia)—Light-gray to tan silty sand or silt that grades down into

bluish-gray to gray silty clay or clay. Smectite is the predominant clay;

kaolinite is subordinate and illite is rare. Deposit is massive to finely

laminated, and contains thin laminae of silt, well-sorted fine quartz

sand, silty sand, and organic debris. Mapped areas include small

deposits of eolian sand and alluvium (asa). Thickness 1-15 m

BEACH AND DUNE SAND-Light-tan, angular, fine to medium sand;

BEACH AND MARINE SAND, WEATHERED AND OXIDIZED—Light-HOLOCENE yellow to dark-orange quartz sand mixed with and stained by organic asa ALLUVIAL GRAVELLY SAND—Pale-gray, yellowish-red, orange-red, or matter. Underlain at depths of as much as 0.5 m by fine quartz sand brownish-gray, poorly to well-stratified, coarse to fine sand and wellcompacted and mixed with insoluble clay; locally, weakly to strongly cemented with calcium carbonate. Basal part of unit consists of as rounded pebble gravel. Deposits locally include interbedded or much as 7 m of consolidated sand containing abundant whole but admixed silt and clay, the latter generally kaolinite; clay balls present rotted bivalve shells. Much shell material has been leached from in places. In northern part of quadrangle, gravel is primarily quartz upper part of the deposit, resulting in reduction of thickness by as and minor amounts of chert; in the central part of the quadrangle, much as 1.5 m. In places, the dissolved shell material has been chert is the major component. Deposits in eastern Florida are chiefly redeposited with insoluble clay to form a subsurface hardpan. medium to fine sand with only minor gravel. Mapped areas include local organic muck and swamp deposits (hs) on flood plains, and Deposit overlies sand, clayey sand, or shelly sand, of older, Pleistocene beach-ridge deposits (bml). Mapped only in Florida. colluvium along margins of valley floors. Thickness 5–10 m

Thickness 6-9 m acd ALLUVIAL CLAY AND SILT—Light- to dark-gray, yellow to brown, BEACH AND MARINE SAND AND LAGOONAL DEPOSITS, UNDIFpoorly to well-stratified, clayey silt and silty clay alluvium. Deposit FERENTIATED—Light-gray, yellowish-gray, light-green, and brownishcontains varying amounts of interbedded or admixed fine sand, gray, poorly to well-sorted sand, silt, and clay, intermixed and lenses of kaolinitic clay, and scattered phosphatic pellets. Mapped interbedded. Locally includes thin stringers of well-rounded quartz areas include organic muck and swamp deposits (hs) on flood plains pebbles and shell hash in remnants of old tidal channels. In places, and colluvium along margins of valley floors. Thickness 5-10 m also contains the insoluble residues of beach sand and sandy hs SWAMP DEPOSIT—Dark-brown to black muck, mucky peat, and organic lagoonal deposits associated with older Pleistocene shorelines. Mapped areas include small swamp deposits (hs), organic muck, shell clay, commonly thinly laminated; locally includes lenses of mottled debris, and eolian sand of Holocene age. Mapped only in Florida; in clay. Large deposits extensively bioturbated. In topographic depressions, general, correlative with units bma, bmb, mlb, bmc, and mlc in

areas have been drained for agriculture, oxidation of the swamp deposits has resulted in subsidence of as much as 3 m. Small, MIDDLE PLEISTOCENE discontinuous areas of slightly higher ground are covered with light-BEACH AND NEAR-SHORE MARINE SAND (Barrier island facies of to dark-brown, unconsolidated, medium to fine quartz sand. Pamlico Formation in Georgia)-Fine to medium quartz sand commonly leached throughout, deeply weathered to yellowish-red hpc FRESHWATER MARSH PEAT AND CLAY—Gray to black herbaceous with brown or gray mottled horizons, and locally cemented with iron peat and clay, intermixed and interbedded. Color darkens as content oxide. Where unweathered, white to gray, light-tan to yellowishof organic matter increases. Includes interbedded freshwater and brown. Sand is well sorted to very well sorted; planar bedded or lowbrackish-water deposits. Mapped in part from distribution of angle crossbedded; washover sheet-fan and tidal-inlet channel-and-

hp PEAT—Dark-gray to black undecomposed to partially decomposed Thickness 6-10 m MARINE SILT AND CLAY (Lagoon facies of Pamlico Formation in organic matter compacted into thick, fibrous mats, interbedded with thin layers of fine sand and silt. Mapped areas confined to deposits in Georgia)—Light-gray to tan silty sand or silt that grades down into which the volume of organic matter exceeds that of mineral matter. bluish-gray or gray silty clay or clay. Smectite is predominant clay; kaolinite is subordinate and illite rare. Deposit is massive to finely SALINE MARSH DEPOSIT—Gray to black mud and silty mud containing laminated, and contains thin laminae of well-sorted fine quartz sand, silty sand, and organic debris. Mapped areas include small deposits of numerous intermixed and interbedded layers of silt, fine sand, eolian sand and alluvium (asa). Thickness 1-15 m

herbaceous peat, and clay. Color darkens as content of organic BEACH AND NEAR-SHORE MARINE SAND (Barrier island facies of matter increases. Deposit commonly intensively bioturbated. Includes Talbot Formation in Georgia)—Fine to medium quartz sand, interbedded brackish-water deposits in places. Mapped in part from commonly leached throughout; deeply weathered to yellowish-red distribution of salt-tolerant vegetation. Thickness 1-3 m with brown or gray mottled horizons, and locally cemented with iron hmm COASTAL MANGROVE SWAMP DEPOSIT—Dark-gray to black organic oxide, where unweathered, it is white to gray, light-tan to yellowishmuck and woody debris intermittently covered by as much as 1 m of brown. Sand is well-sorted to very well sorted; planar or low-angle sea water. Overlies wave-beveled surfaces cut on soft, porous, shelly crossbedded; Washover sheet-fan and tidal-inlet channel-and-fill limestone. Mapped only in areas that support dense stands of both structures common. Basal beds are coarse to very coarse sand. red and black mangrove along the Gulf of Mexico south of lat 30°.

Georgia. Thickness 10-25 m

Thickness 6-10 m mid MARINE SILT AND CLAY (Lagoon facies of Talbot Formation in Georgia)-Uppermost layers of light-gray to tan silty sand or silt grade down into bluish-gray or gray silty clay or clay. Smectite is predominant clay; kaolinite is subordinate, illite rare. Deposit is massive to thin bedded, and contains thin laminae of silt, well-sorted fine quartz sand, silty sand, and organic debris. Upper layers commonly leached of organic matter that has been translocated downward and redeposited as a compact humate layer 30-50 cm below surface. Mapped areas include small deposits of eolian sand and alluvium (asa). Thickness 1-15 m

BEACH AND NEAR-SHORE MARINE SAND (Barrier island facies of Penholoway Formation in Georgia)—Fine to medium quartz sand; commonly leached throughout; deeply weathered to yellowish-red with brown or gray mottled horizons, and locally cemented with iron oxide. Where unweathered, it is white to gray, light tan to yellowish brown. Sand is well sorted to very well sorted; planar bedded or lowangle crossbedded. Washover sheet-fan bedding and tidal-inlet channel-and-fill structures common. Basal beds are coarse to very coarse sand. Thickness 6-10 m

ARINE SILT AND CLAY (Lagoon facies of Penholoway Formation in Georgia)—Bluish-gray or gray silty clay or clay that grades upward into loamy sand or loam near ground surface. Smectite is predominant clay; kaolinite is surbordinate, and illite rare. Deposit is massive to thin bedded, and contains thin laminae of silt, well-sorted fine quartz sand, silty sand, and organic debris. Upper layers commonly leached of organic matter that has been translocated downward and redeposited as a compact humate layer 20-50 cm below surface. Mapped areas include small deposits of eolian sand and alluvium (asa). Thickness 1-15 m

MIDDLE PLEISTOCENE TO EARLY PLEISTOCENE BEACH AND MARINE SAND AND SANDY CLAY-White, yellow, reddish-yellow to reddish-orange, well-sorted phosphatic sand and clayey sand. Locally contains lenses of red to orange-red, well-sorted, coarse sand, stained and cemented with iron. Deposit overlies older Tertiary rocks and fills karst depressions, which are abundant along the crests of resistant limestone ridges. Locally overlain by small deposits of white, very well sorted, quartz sand and thin deposits of

black to blue-gray organic muck. Thickness 1-10 m BEACH AND MARINE SAND AND LAGOONAL DEPOSITS, UNDIF-FERENTIATED—Fine to medium sand with abundant shell and soft limestone fragments; commonly deeply weathered to yellowish red or reddish orange and cemented with iron oxide in places. Where unweathered, deposit is white to greenish gray, or dark green. Locally includes lithified coquina fragments and pockets of organic-rich clay. Sandy layers support well-developed podzolic soils and in places include a shallow hardpan of translocated humic material. Mapped only in Florida. Generally correlative with units bmd, mld, bme, mle,

EARLY PLEISTOCENE TO LATE PLIOCENE bmf BEACH AND MARINE SAND (Barrier island facies of Wicomico leached throughout; deeply weathered to yellowish-red with brown and gray mottled horizons; locally cemented with iron oxide. Where unweathered, deposit is white to gray, light-tan or yellowish-brown. Sand is well sorted to very well sorted; planar bedded to low-angle

predominant clay, kaolinite is subordinate, and illite rare. Deposit is

massive to thin bedded and contains laminae of well-sorted fine

crossbedded. Washover sheet-fan and tidal-inlet channel-and-fill structures common. Basal beds are coarse to very coarse sand. Thickness 6-10 m MARINE SILT AND CLAY (Lagoon facies of Wicomico Formation in Georgia)—Light-gray to yellowish-brown silty sand or silt that grades down into bluish-gray to gray silty clay or clay. Smectite is

bmf, and mlf in Georgia. Thickness 5-35 m

small deposits of eolian sand and alluvium (asa). Thickness 1-15 m

EARLY PLEISTOCENE AND PLIOCENE Hawthorne Formation. Thickness of peat 4–9 m. Pleistocene but possibly in part late Pliocene in age. It may represent

Thickness 12-15 m beach sand and clayey sand (bml). Thickness 2-18 m

QUATERNARY AND TERTIARY

outcrops. Thickness 1-3 m only in Florida. Thickness 1-2 m

reddish-orange or greenish-gray mottled, poorly sorted, fine sandy clay, clayey fine sand, and clay. Locally contains lenses of medium to coarse pebbly sand, chiefly of quartz with minor amounts of chert. Mapped only in Florida. Mapped areas include some locally derived colluvium and outcrops of unconsolidated bedrock. Thickness 1-3 m CLAYEY SAND SOLUTION RESIDUUM WITH CHERT BLOCKS1— Yellowish-gray, grayish-pink to reddish-brown, ferruginous, clayey, fine to medium quartz and calcareous sand. Locally contains small lenses and stringers of subrounded to subangular chert pebbles which increase in quantity and size to the northwest. Deposit develops on

sinkholes, are common. Mapped areas include bedrock outcrops and deposits of locally derived colluvium and alluvium. Thickness 1.5-4 m: SANDY CARBONACEOUS CLAY SOLUTION RESIDUUM2-Yellowish orange to grayish-red, commonly mottled, limonitic, mediumgrained, subangular to subrounded quartz sand with traces of heavy minerals mixed with clay and small fragments of carbonate and chert residual following solution and development of karst features in the underlying limestone. Mapped areas include deposits of eolian sand, locally derived colluvium, and bedrock outcrops. Mapped only in

 1 Decomposition residuum, for purpose of this map, is defined as material derived primarily by in-place chemical decay of clastic rock with no appreciable subsequent lateral transport.

²Solution residuum, for purposes of this map, is defined as material derived by in-place solution of carbonate rock or carbonate-cemented rock with no appreciable subsequent lateral

quartz sand and thin lenses of organic debris. Mapped areas include

BEACH AND NEAR-SHORE MARINE SAND AND PEAT (Trail Ridge sequence of Florida)-Comprises a thick surface sand and an underlying peat. The sand is white to light-yellow near surface, but becomes yellow, orange, and red or brown downward. Sand is very uniformly textured, medium to fine grained, crossbedded in a southerly direction, and loose to slightly cemented with iron oxide. Deposit is chiefly quartz, but locally included 3-4 percent of heavy minerals: ilmenite, leucoxene, zircon, and monazite. Contains no garnet, epidote, or hornblende, which are common constituents of marine sands at lower altitudes to east. The sand underlies Trail Ridge, a well-preserved broad high ridge that trends south from Georgia for about 215 km along the axis of the Florida Peninsula. Shape of ridge and direction of crossbedding of sand indicates deposition as a spit or bar by southerly longshore currents. On west slope of ridge, sand is locally overlain by younger high-level sand (included in unit mbb) that contains a marine fauna representing a variety of species living in coastal waters today but no extinct species, thus clearly Pleistocene in older, and considered correlative with the high shoreline deposit (bmf) of the Wicomico Formation in Georgia. Thickness of sand 12–22m. The peat beneath the sand consists of woody peat and sapropel, and locally contains trunks, branches, and roots of trees, some in upright position. Its age is late Pliocene or early Pleistocene (Pirkle and Czel, 1983). The peat overlies a sequence of Pliocene deposits consisting, from top downward, of lagoonal clays, a bed of poorly preserved molluscan shells, and a basal marine sand that overlies the Miocene The Trail Ridge sequence as a whole is considered to be mostly early

the maximum stand of sea level during deposition of the Caloosahatchee Formation in southern Florida. Total thickness 16-30 m MARINE AND ALLUVIAL SAND (Facies of Citronelle Formation)— Upper part is white to light-yellow, fine to coarse, loose quartz sand, but most of unit is red, orange, yellow, or brown, crossbedded, pebbly, coarse to fine sand, and thin beds of white, highly kaolinitic, wellsorted fine quartz sand containing numerous shrimp burrows. Locally includes pockets of white, kaolinitic clay, and thin stringers of discoid quartz and quartzite pebbles; most are less than 2 cm in diameter, a few as much as 8 cm. The sand was deposited on, and in places is collapsed into, karst terrain developed on limestone. Its distribution is coextensive with and forms an important part of Lake Wales Ridge (Pirkle and Yoho, 1970), a major topographic feature that forms the central divide of the Florida peninsula for 250-300 km. The sand is considered in part of marine littoral and delta origin, in part of alluvial origin; it has been correlated with the Pliocene Citronelle Formation (Grogan and others, 1964; Pirkle and others, 1963; White, 1970) which, at its type locality at Citronelle, Alabama, contains a vertebrate fauna assigned a Pliocene Hemphillian age by F. C. Whitmore (Isphording and Lamb, 1971), and fossil leaves of Pleistocene age (Berry, 1916; Stringfield and LaMoreaux, 1957; Doering, 1958).

LAND PEBBLE PHOSPHATE DEPOSIT-Present only in subsurface and shown by pattern on map. Phosphatic pellets and nodules, quartz sand, and smectitic clay; chiefly massive and structureless but locally crossbedded or with horizontal laminations. Locally includes pockets of clay that fill sinkholes in underlying limestone. Phosphate deposit is believed by Cathcart and others (1952) to be a residuum derived from the underlying Pliocene Bone Valley Formation and by Sellards (1915) to have been deposited in a shallow marine environment following erosion of the Miocene Hawthorn Formation. Phosphate deposit is overlain by as much as 10 m of younger wave-reworked

ALLUVIAL SAND-White, light-gray to light-yellow, coarse to fine, poorly to well-sorted, slightly clayey sand. Locally contains lenses and beds of angular to rounded quartz-pebble gravel and sandy kaolinitic clay. Grain size decreases gradually and deposit becomes increasingly sorted from northwest to southeast. Mapped areas include extensive, locally derived, thin surface deposits of eolian sand of late Pleistocene and Holocene age. Thickness 5-15 m

SAND AND CLAY DECOMPOSITION RESIDUUM1-White, lightyellow, yellowish-orange or grayish-red, commonly mottled, poorly sorted, fine to medium sand. Chiefly subangular to subrounded, quartz. Sand locally grades into areas of light-gray to greenish-gray clay and in places contains small lenses of silt and very fine gravel. Mapped areas include some locally derived colluvium and bedrock

MEDIUM TO FINE SILTY SAND AND SANDY SILT DECOMPOSITION RESIDUUM¹—Yellowish-gray to grayish-white, medium to fine calcareous sand mixed with silt and minor smectitic clay. Mapped areas include numerous small patches of eolian sand and locally derived alluvium and colluvium. Bedrock exposures of sandy limestone with well-developed karst structures are common. Mapped ANDY CLAY DECOMPOSITION RESIDUUM¹—Pale-yellow, orange,

limestone and dolomite; karst features, including small, clay-filled

Florida. Thickness 1-2 m

of Geology Map Series 79, scale 1:250,000. _____1979, Environmental geology series, Valdosta Sheet: Florida Bureau of Geology Map Series 88, scale 1:250,000. Leve, G. W., 1966, Ground water in Duval and Nassau Counties, Florida: Florida Bureau of Geology Report of Investigation 43, 91 p.

> Lichtler, W. F., 1968, Water resources of Orange County, Florida: Florida Bureau of Geology Report of Investigation 50, 150 p. Meyer, F. W., 1962, Reconnaissance of the geology and ground water resources of Columbia County, Florida: Florida Bureau of Geology Report of Investigation 30,

> QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

SOURCES OF INFORMATION

Barraclough, J. T., 1962, The ground water resources of Seminole County, Florida:

Beeres. B. J., Leve, G. W., and Tarver, G. R., 1963, Geology and ground water

Berry, E. W., 1916, The flora of the Citronelle Formation: U.S. Geological Survey

Brown, D. W., Kenner, W. E., Crooks, J. W., and Foster, J. B., 1962, Water resources of

Cathcart, J. B., Blade, L. V., Davidson, D. F., and Ketner, K. B., 1952, The geology of the Florida Land Pebble phosphate deposit: International Geological Congress,

Clark, E. W., Musgrove, R. H., Menke, C. G., and Cagle, J. W., Jr., 1964, Water resources of Alachua, Bradford, Clay, and Union Counties, Florida: Florida

Cronin, T. M., 1980, Biostratigraphic correlation of Pleistocene marine deposits and

Doering, J. A., 1958, Citronelle age problem: American Association of Petroleum

Grogan, R. M., Few, W. G., Garnar, T. E., and Hager, C. R., 1964, Milling at Dupont's

Healey, H. G., 1975, Terraces and shorelines of Florida: Florida Bureau of Geology,

Isphording, W. C., and Lamb, G. M., 1971, Age and origin of the Citronelle formation

in Alabama: Geological Society of America Bulletin, v. 82, p. 775-780. Knapp, M. S., 1978, Environmental geology series, Gainesville Sheet: Florida Bureau

heavy mineral mines in Florida, in Aribiter, Nathaniel, editor, Milling methods in the Americas: 7th International Milling Processing Congress, New York, Gordon

sea levels, Atlantic coastal plain of the southeastern United States: Quaternary

Brevard County, Florida: Florida Bureau of Geology Report of Investigation 28,

resources of Flagler, Putnam, and St. Johns Counties, Florida: Florida Bureau of

Florida Bureau of Geology Report of Investigation 27, 91 p.

Geology Report of Investigation 32, 97 p.

19th, Algiers, 1952, Section 11, p. 77-91.

Geologists Bulletin, v. 42, p. 1816-1862.

and Breach Science Publishers, p. 205-229.

Map Series no. 71, scale 1:980,000.

Bureau of Geology Report of Investigation 35, 170 p.

Professional Paper 98, p. 193-208.

Research, v. 13, p. 213-229.

MISCELLANEOUS INVESTIGATIONS SERIES

MAP I-1420 (NH-17)

Mittere, R. M., 1975, Ages and diagenetic temperatures of Pleistocene deposits of Florida based on isoleucine epimerization in Mercenaria: Earth and Planetary Science Letters, v. 28, p. 275-282. Pirkle, E. C., and Yoho, W. H., 1970, The heavy mineral ore body of Trail Ridge,

Florida: Economic Geology, v. 65, p. 17-30. Pirkle, E. C., Yoho, W. H., Allen, A. T., and Edgar, A. C., 1963, Citronelle sediments of Peninsular Florida: Florida Academy of Science Quarterly Journal, v. 26, no. 2,

Pirkle, F. L., and Czel, L. J., 1983, Marine fossils from region of Trail Ridge, a Georgia-Florida Landform: Southeastern Geology, v. 24, p. 31-38. Puri, H. S., and Vernon, R. O., 1964, Summary of the geology of Florida and a guidebook to the classic exposures: Florida Bureau of Geology Special

Puri, H. S., Yon, J. W., and Oglesby, W. R., 1967, Geology of Dixie and Gilchrist Counties, Florida: Florida Bureau of Geology Bulletin 49, 155 p. Scott, T. M., 1978, Environmental geology series, Orlando Sheet: Florida Bureau of Geology Map Series 85, scale 1:250,000. _1979a, Environmental geology series, Jacksonville Sheet: Florida Bureau of

Geology Map Series 89, scale 1:250,000. ____1979b, Environmental geology series, Daytona Beach Sheet: Florida Bureau of Geology Map Series 93, scale 1:250,000. Sellards, E. H., 1915, The pebble phosphates of Florida: Florida Geological Survey Annual Report 7, p. 25-116.

Stringfield, V. T., and LaMoreaux, P. E., 1957, Age of the Citronelle Formation in the Gulf coastal plain: American Association of Petroleum Geologists Bulletin, v. 41, Vernon, R. O., 1951, Geology of Citrus and Levy Counties, Florida: Florida Bureau of

Geology Bulletin 33, 256 p. White, W. A., 1970, The geomorphology of the Florida peninsula: Florida Bureau of Geology Bulletin 51, 164 p. Winkler, C. D., and Howard, J. D., 1977, Correlation of tectonically deformed shorelines on the south Atlantic coastal plain: Geology, v. 5, p. 123–12

Wyrick, G. G., 1960, The ground water resources of Volusia County, Florida: Florida Bureau of Geology Report of Investigation 22, 65 p. Yon, J. W., 1966, The geology of Jefferson County, Florida: Florida Bureau of Geology Bulletin 48, 119 p.

Cooke, C. W., 1943, Geology of the coastal plain of Georgia: U. S. Geological Survey Bulletin 941, 121 p. Georgia Geological Survey, 1976, Geologic map of Georgia: Georgia Geological Survey, scale, 1:500.000.

Hoyt, J. H., and Hails, J. R., 1967, Pleistocene shoreline sediments in coastal Georgia-Deposition and modification: Science, v. 155, p. 1541–1543. _1974, Pleistocene stratigraphy of southeast Georgia, in Oaks, R. W., Jr., and DuBar, J. R., editors, Post-Miocene stratigraphy, central and southern Atlantic coastal plain: Logan, Utah State University Press, p. 191-205. MacNeil, F. S., 1947, Geologic map of the Tertiary and Quaternary formations of

Georgia: U. S. Geological Survey Oil and Gas Investigations Preliminary Map 72, Opdyke, N. D., Spangler, D. P., Smith, D. L., Jones, D. S., and Lindquist, R. C., 1984, Origin of the epeirogenic uplift of Pliocene-Pleistocene beach-ridges in Florida and development of the Florida karst: Geology, v. 12, no. 4, p. 226-232.

Pirkle, F. L., and Czel, L. J., 1983, Marine fossils from region of Trail Ridge, a Georgia-Florida landform: Southeastern Geology, v. 24, no. 1, p. 31-38. Prouty, W. F., 1952, Carolina Bays and their origin: Geological Society of America Bulletin, v. 63, p. 167-224. Veatch, J. O., and Stephenson, L. W., 1911, Preliminary report on the geology of the

coastal plain of Georgia: Georgia Geological Survey Bulletin 26, 466 p. Winker, C. D., and Howard, J. D., 1977, Correlation of tectonically deformed shorelines on the southern Atlantic Coastal Plain: Geology, v. 5, p. 123-127.

CORRELATION CHART OF STRATIGRAPHIC AND MORPHOSTRATI-GRAPHIC UNITS

Bender, M. L., 1973, Helium-uranium dating of corals: Geochimica Cosmochimica Acta, v. 37, p. 1229-1247. Broecker, W. S., and Thurber, D. L., 1965, Uranium series dating of corals and oolites from Bahaman and Florida Key limestones: Science, v. 149, p. 58-60. Cooke, C. W., 1943, Geology of the coastal plain of Georgia: U.S. Geological Survey

DuBar, J. R., 1958a, Stratigraphy and paleontology of the late Neogene strata of the Caloosahatchee River area of southern Florida: Florida Geological Survey Bulletin 40, 267 p. ____1958b, Neogene stratigraphy of southwestern Florida: Transactions, Gulf

Coast Associated Geological Societies, v. 8, p. 129-155. —1974, Summary of the Neogene stratigraphy of southern Florida, in Oaks, R. Q., Jr., and DuBar, J. R., editors, Post Miocene stratigraphy Central and Southern Atlantic Coastal Plain: Utah University Press, p. 206–231. DuBar, J. R., DuBar, S. S., Ward, L. W., and Blackwelder, B. W., with contributions by W. H. Abbott and P. F. Huddleston, 1980, Cenozoic biostratigraphy of the

Carolina outer Coastal Plain, in R. W., Frey and T. L. Neathery, editors, Excursions in Southeastern Geology, v. 1, Geological Society of America 1980 Annual Meeting Atlanta, Georgia: American Geological Institute, p. 179–236. Harmon, R. S., Ku, T. L., Matthews, R. K., and Smart, P. L., 1979, Limits of U-series analysis: Phase 1, results of Uranium series intercomparison Project: Geology,

Hoyt, J. H., Weimer, R. J., and Henry, V. J., 1965, Age of late Pleistocene coastal deposits, central Georgia: Abstracts, International Association for Quaternary Research 7th Congress, p. 228. Liddicoat, J. C., Belknap, D. F., and Wehmiller, J. F., 1982, Paleomagnetic and amino

acid dating of sediment in the Atlantic Coastal Plain: Geological Society of America Abstracts with Programs, v. 14, no. 7, p. 546. McCartan, Lucy, Owens, J. P., Blackwelder, B. W., Szabo, B. J., Belknap, D. F.,

Kriausakul, D. F., Mitterer, R. M., and Wehmiller, J. F., 1982, Comparison of amino acid racemization geochronometry with lithostratigraphy, biostratigraphy, ranium-series coral dating, and magnetostratigraphy in the Atlantic Coastal Plain of the southeastern United States: Quaternary Research, v. 18, p. 337-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., editors, Post-Miocene stratigraphy central and southern Atlantic Coastal Plain: Utah State University Press, p. 232–246. Osmond, J. K., Carpenter, J. R., Windon, H. L., 1965, Thorjum²³⁰/Uranjum²³⁴ age of Pleistocene corals and oolites of Florida: Journal of Geophysical Research, v. 70,

Osmond, J. K., May, J. P., and Tanner, W. F., 1970, Age of the Cape Kennedy barrier and lagoon complex: Journal of Geophysical Research, v. 75, p. 469-479. Puri H S, and Vanstrom V V, 1969, Geologic history of the Mioc

sediments in south Florida, in DuBar, J. R., and DuBar, S. S., editors, Late Cenozoic stratigraphy of southwestern Florida: Gulf Coast Association of Geological Societies-Society Economic Paleontologists and Mineralogists, Second Annual Meeting, 1969, Field Trip No. 4, p. 70-86. Shackleton, N. J., and Opdyke, N. D., 1973, Oxygen isotope and paleomagnetic

stratigraphy of equatorial Pacific core V28-238: Oxygen isotope temperatures and ice volumes on a 10⁵ year and 10⁶ year scale: Quaternary Research, v. 79, van Donk, Jan, 1976, 018 record of the Atlantic Ocean for the entire Pleistocene Epoch in R. M. Cline and J. D. Hays, editors, Investigations of Quaternary Paleoceanography and Paleoclimatology: Geological Society of America Memoir 14,