QUATERNARY GEOLOGIC MAP OF THE HUDSON RIVER 4° x 6° QUADRANGLE, UNITED STATES AND CANADA

State and Provincial compilations by
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Edited and Integrated by
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NOTE 1: This map is a product of collaboration of State and Provincial geological surveys, universities, and the U.S. Geological Survey and is designed for both scientific and practical purposes. It was prepared in two stages. First, separate maps and map explanations of the parts of States and Provinces included in the quadrangle were prepared by the compilers. Second, the maps were combined, integrated, and locally supplemented by the editor; map unit symbols were revised to a uniform system of classification; and map unit descriptions were prepared from information received from the compilers and from additional sources. Diagrams accompanying the map were prepared by the editor .

Differences in mapping or interpretation in different areas were resolved by correspondence to the extent possible. Most simply reflect differences in available information or philosophies of mapping, and should encourage further investigation.

Surficial deposits have been mapped and described in less than forty percent of the conterminous United States. Traditionally, mapping of surficial deposits has been focused on glacial, alluvial, eolian, lacustrine, marine, and landslide deposits. Slope and upland deposits have been mapped in detail only in restricted areas. However, an enormous amount of engineering construction and many important problems of land use and land management are associated with regions that have extensive slope and upland deposits (colluvium, residuum, saprolite, and solifluction deposits, for example). These materials have many different physical characteristics. Therefore, an effort has been made to classify, map, and describe these deposits, based in large part on unpublished interpretations, published and unpublished subsoil and substratum data, and the distribution of bedrock parent materials. The classification is crude, but it represents a first step toward a more refined and useful product.

For scientific purposes, the map differentiates Quaternary surficial deposits on the basis of a combination of criteria, such as lithology or composition, texture or particle size, structure, genesis, stratigraphic relationships, and age, as shown on the correlation diagram and indicated in the map unit descriptions. Some constructional geomorphic features, such as end moraines, are distinguished as map units. Erosional landforms, such as stream terraces, are not distinguished as map units, and differentiation of sequences of alluvial deposits of different ages in most regions is not possible at the scale of 1:1,000,000. Most landslide deposits are too small to be shown at this scale, but areas in which landslides are present are distinguished as a map unit in the southwestern part of the quadrangle.

For practical purposes, the map is a surficial materials map. Materials are distinguished on the basis of lithology or composition, texture or particle size, and local specific engineering characteristics. It is not a map of soils as soils are recognized and classified in pedology or agronomy. Rather, it is a generalized map of soils as recognized in engineering geology, or of substrata or parent materials in which pedologic and agronomic soils are formed. As a materials map it serves as a base from which a wide variety of derivative maps for use in planning engineering, land use, or land management projects can be compiled.

NOTE 2: The Pliocene-Pleistocene boundary defined by joint resolution of the International Union for Quaternary Research (INQUA) Subcommission 1-d on the Pliocene/Pleistocene Boundary [the International Commission on Stratigraphy (ICS) Working Group on the Pliocene/Pleistocene Boundary] and the Working Group of the International Geological Correlation Program (IGCP) Project No. 41 (Neogene/Quaternary Boundary) is that at the Vrica section in southern Italy. The age of that boundary currently is inferred to be 1.64 Ma (Aguirre and Pasini, 1985).

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 (in preparation). The boundary between the early Pleistocene and middle Pleistocene is placed tentatively at the Matuyama-Brunhes magnetic polarity reversal. That reversal has not been dated directly by radiometric methods. 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 Matuyama-Brunhes polarity reversal is recorded in lake sediments. The Bishop volcanic ash bed (K-Ar age 738 ka) overlies a major paleosol developed in normal-polarity lake sediments above the reversal horizon (Eardley and others, 1973). The terrestrial geologic record is compatible with the astronomical age of 788 ka assigned to the reversal by Johnson (1982); however, on the basis of terrestrial chronometric and stratigraphic data, the reversal may have occurred approximately 770 ka ago (Richmond and Fullerton, 1986).

The boundary between the middle Pleistocene and late Pleistocene is placed arbitrarily at the beginning of marine oxygen isotope substage 5*e* (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 by Imbrie and others (1984), and 128 ka by SPECMAP Project members (Ruddiman and McIntyre, 1984), based in part on uranium-series ages of deposits attributed to the substage 5*e* high eustatic sea-level stand. A provisional sidereal age of 132 ka (Richmond and Fullerton, 1986) is derived by projection of the boundary onto the astronomical time scale of Johnson (1982).

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

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The map layout includes

- An index to the International Map of the World 1:1,000,000 Topographic Series showing the location of the Quaternary geologic map of the Hudson River 4° x 6° quadrangle and other published maps in the Quaternary Geologic Atlas of the United States
- An illustration showing the Areas of Responsibility for compilation of the map with names and organizations of the compilers
- A chart showing the correlation of map units

DESCRIPTION OF MAP SYMBOLS ON PRINTED MAP

CONTACT

WIND DIRECTION INDICATED BY DUNE ORIENTATIONS

ERRATIC TRAIN OR DISPERSAL FAN—Apex at source

ESKER—Direction of transport indicated by chevrons

DIRECTION OF ICE MOVEMENT—Direction indicated by striated or grooved bedrock

ICE-MOLDED LANDFORM—Drumlin, rock drumlin, flute, or groove

OUTER LIMIT OF GLACIAL ADVANCE OR MAJOR STILLSTAND OF ICE MARGIN—Hachured line solid where known, dashed where inferred; ticks on side of advance

CREST OF SUBMERGED END MORAINE

GLACIAL LAKE SPILLWAY OR MELTWATER CHANNEL

ICE-THRUST MASS—Bedrock and surficial deposits that were thrust, stacked, imbricated, and deformed by glacial ice

MANMADE LAND—Chiefly filled land and strip mines

DESCRIPTION OF MAP UNITS

HOLOCENE

be BEACH AND DUNE SAND—Pale-yellowish-brown or light-gray, angular to rounded, coarse to fine sand with minor gravel, isolated granules and pebbles, and scattered fragments of mollusc shells and plant debris. Locally includes concentrations of cobbles and boulders. Generally well sorted; crossbedded or laminated. Deposits of beaches, spits, tombolos, baymouth bars, and barrier islands included in map unit. Also includes sheet sand overlying saline marsh deposits (**hps**) or freshwater swamp deposits (**hs**) landward from freshwater and marine deposits. Thickness 0.5-10 m

lm LAKE CLAY AND SILT (under Lake Ontario)—Brownish-gray, gray, or grayish-black calcareous clay, silty clay, and silt. Generally clay and silty clay in centers of basins and silt at basin margins. Soft, fluid, compressible. Locally porous; may contain gas bubbles. Faintly laminated to massive. In places contains mollusc tests, wood chips, and disseminated plant debris. Deep-water facies of modern lake deposits. Commonly overlain by lake sand 1-6 cm thick. Thickness generally 2-6 m near basin margins, 8-14 m in centers of basins

ls LAKE SAND AND GRAVEL (under Lake Ontario)—Brown or gray, calcareous fine sand, fine to coarse sand, and minor gravel. Poorly to well sorted; locally stratified. Mollusc-tests and fragments common. Shore and nearshore facies of modern lake deposits. Generally overlies lake silt and clay (**lc**), till (**tka**, **tlg**), or bedrock. Includes local accumulations of boulders and accumulations of coarse lag gravel. Where less than 15 km from shore, includes areas of thin till over bedrock and extensive areas of bedrock outcrop. Thickness generally 1-5 m, rarely 10 m

hps SALINE OR ESTUARINE MARSH DEPOSIT—Dark-brown, greenish-gray, brownish-gray, dark-gray, or black silty' clay to clayey fine sand and carbonaceous clay intertongued and interbedded with herbaceous peat composed chiefly of *Spartin*a sp. Commonly bioturbated. Tidal and estuarine marsh deposit. Thickness generally less than 3 m, locally 10 m

HOLOCENE AND LATE WISCONSIN

al ALLUVIUM-Yellowish-brown, reddish-brown, brown, olive, gray, or mottled silt, sand, and gravel. Calcareous or noncalcareous, reflecting composition of source materials. Poorly to well sorted. Poorly to well stratified; bedding generally horizontal, crossbedded, or with cut-and-fill structure. Textures vary laterally and vertically; contrasting textures may be interbedded. Upper part commonly silt and fine sand with minor lenses of clay and organic material; lower part generally sand and rounded gravel, in places cobble or boulder gravel. Clast lithologies vary, reflecting compositions of local bedrock and other surface materials. Overbank and stream channel deposit; underlies flood plains, stream terraces, and alluvial fans. Not mapped in Pennsylvania; elsewhere mapped only in largest valleys. Includes areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**), lake clay, silt, sand, and gravel (**lca**, **lsa**, **lsb**), till, and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness of overbank and channel alluvium generally 1-4 m, rarely more than 6 m; thickness in alluvial fans may exceed 25 m

asn ALLUVIAL SAND—Pale-yellow, yellowish-brown brown, or gray calcareous sand with scattered pebbles. Generally well sorted, well stratified. Contains thin layers and lenses of silty clay. Clast composition similar to that of outwash sand and gravel (**gg**, **ggc**) in vicinity. Chiefly redeposited outwash sand. Locally terraced. Mapped only in sluiceways on Long Island, New York. Thickness generally 2-3 m, locally 6-9 m

ed DUNE SAND—Pale-brown or light-gray calcareous fine to medium sand. Well sorted; crossbedded. Grains subrounded or rounded; commonly frosted. Ventifacts common locally. In coastal areas, chiefly massive ridges parallel to present shorelines; in inland areas chiefly broad, straight longitudinal ridges or parabolic and ovoid dunes in clusters, separated by flat areas thinly veneered by sheet sand and silt. Tallest dunes locally 10-22 m high. Includes areas of loess (**el**), sheet sand, and lake clay, silt, sand, and gravel (**lca**, **lsa**, **lsb**) between dunes. Some dune sand mapped in unit **be**. In Albany-Glens Falls region, New York, dune sand present in an area larger than 5,830 km^2; only largest areas of dunes mapped. Thin unmapped eolian sand and silt very extensive on eastern Long Island, New York. Most dunes stable and inactive; locally, where vegetation has been removed, dunes active and blowouts common. Thickness generally 1-10 m, locally more than 20 m

lc LAKE SILT AND CLAY (under Lake Ontario)—Light-brown, reddish-brown, reddish-gray, brownish-gray, or gray, very calcareous silty clay and clay. Generally well sorted. Massive to laminated; locally varved. Much more compact than unit **lm**. Ice-rafted clasts common; organic detritus absent. Offshore and deep-water facies of former glacial and postglacial lake deposits. Commonly overlain by well-sorted silt or sand 2-28 cm thick. Thickness generally 1-5 m, locally more than 20 m

hp PEAT—Black or dark-brown fibrous peat and decomposed organic residues or fibrous peat and clay and silt containing comminuted plant material and organic residues. Commonly underlain by gray or white marl, a very calcareous, soft, crumbly clay that contains mollusc tests and fragments. Commonly overlies lake clay, silt, sand, or gravel (**Ica**, **Isa**, **Isb**) or outwash gravel, sand, and silt (**gg**) in low, poorly drained areas or occurs as bogs in ice-block depressions. Mapped only where extensive. Included in swamp deposits (**hs**) where peat and swamp deposits have not been distinguished. Thickness 1-10 m

HOLOCENE AND WISCONSIN

alk ALLUVIAL GRAVEL, SAND, SILT, AND CLAY—Complex deposit of alluvium (**al**), outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**), and lake clay, silt, sand, and gravel (**Ica**, **Isa**) in Pennsylvania where those deposits are not distinguished. Stratified; textures vary laterally and vertically; commonly terraced. Clast lithology generally reflects composition of local bedrock; sandstone, siltstone, and shale dominant; minor erratic crystalline igneous and metamorphic rocks. May include similar deposits of pre-Wisconsin age. Thickness varies; locally more than 50 m

hs SWAMP DEPOSIT—Dark-brown or black muck, mucky peat, and organic residues mixed with fine-grained mineral sediment. Locally underlain by gray or white marl, a very calcareous, soft, crumbly clay that contains mollusc tests and fragments, or by shelly gyttja, an anaerobic, pulpy, freshwater mud containing abundant organic material. Includes peat (**hp**) where peat and swamp deposits have not been distinguished. Overlies lake silt, clay, sand, or gravel (**Ica**, **Isa**, **Isb**) on former lake beds or outwash gravel, sand, and silt (**gg**) in abandoned glacial meltwater channels; also present in ice-block depressions and other shallow depressions and poorly drained areas. Mapped only where extensive. Thickness generally 1-5 m, rarely more than 15 m

HOLOCENE, LATE PLEISTOCENE, AND MIDDLE PLEISTOCENE

cbb BOULDERY COLLUVIUM AND ROCK WASTE[1]—Deposits of bouldery debris that accumulated on slopes by creep and deposits of rock debris that accumulated below cliffs or steeply sloping bedrock outcrops by rockfall. Clasts generally angular or subangular quartzitic sandstone, sandstone, or conglomerate. On upper part of slopes, generally rock waste; coarsely sorted vertically and laterally; average diameters of cobbles, boulders, and blocks increase both downslope and upward within deposit. Clasts in rock waste generally randomly oriented; crude imbrication, with long axes dipping upslope, where materials moved by secondary creep. Boulders and blocks in rock waste in point contact; individual boulders may be unstable. Size of largest blocks or boulders dependent on joint spacing and bedding thickness in parent rock upslope; maximum diameters of blocks locally more than 6 m. Forms talus or scree cones on steep slopes; locally forms block fields and block streams more than 850 m long. Rock waste generally grades downslope into bouldery colluvium with sandy or loamy matrix. On lower parts of slopes, chiefly yellowish brown, pale reddish brown, brown, brownish gray, gray, or mottled, noncalcareous, bouldery, loamy to clayey colluvium. Colors and textures reflect those of bedrock higher on slopes. Boulders in colluvium downslope from rock waste lack point contacts. Where rock waste is absent, entire slope is covered by bouldery colluvium. Colluvium occurs as cones and aprons and as continuous slope mantle. Colluvium generally more extensive on south-facing than on north-facing slopes. Most colluvium inactive; accumulated in a periglacial environment contemporaneous with glaciation farther north. Rock waste includes Holocene rockfall deposits and debris avalanche deposits locally superposed on periglacial deposits. Map unit includes some colluvium of pre-Wisconsin age on slopes and bedrock outcrops on ridge crests; bedrock seldom exposed on slopes. Thickness of colluvium on upper parts of slopes generally less than 3 m; thickness on lower parts of slopes commonly less than 15 m but may exceed 30 m; thickness of rock waste may exceed 30 m

cbe METARHYOLITE-BOULDER LOAMY COLLUVIUM[1]—Yellowish-brown, reddish-brown, brown, gray, or mottled noncalcareous, nonsorted sandy silt loam. Contains angular and subangular fragments and subrounded to rounded joint-block core boulders of massive metarhyolite. Sand fraction chiefly quartz and rock fragments. Includes solifluction deposits on moderate and gentle slopes and alluvium (**al**) in valleys. Thickness generally 2-5 m

cbj BOULDERY LOAMY COLLUVIUM[1]—Yellowish-brown, reddish-brown, brown, brownish-gray, gray, or mottled noncalcareous debris ranging from angular boulders and rock fragments with little or no matrix to silty clay loam with scattered boulders and rock fragments. Locally rubble. Clasts chiefly anorthosite, quartz monzonite, granodiorite, gneiss, and gabbro. Includes solifluction deposits on moderate and gentle slopes and alluvium (**al**) in valleys. Thickness generally 1-4 m, locally more than 20 m

clf ACID SHALE-CHIP CLAY LOAM COLLUVIUM[1]—Reddish-brown, orange brown, yellowish-brown, brown, grayish-brown, olive-gray, dark-gray, or mottled clay loam, silty clay loam, and sandy clay loam with angular and subangular chips of acid shale. Commonly well sorted, coarsely stratified clay loam with thin beds and lenses of shale chips; subangular and subrounded clasts of siltstone and sandstone locally. In places deposit is open-framework rubble of platy to pencil-shaped shale chips 0.6-10 cm long. Clasts in rubble coated by clay; frequently imbricated. Colluvium commonly grades downward to bedrock through a creep zone in which shale beds are deformed. Map unit includes some yellowish-brown clay loam residuum with decomposed shale chips and relic bedrock structure generally less than 1 m thick. Also includes solifluction deposits on moderate and gentle slopes and alluvium (**al**) in valleys. Thickness generally 1-3 m, locally more than 15 m

clj ACID SHALE-CHIP CLAY LOAM COLLUVIUM AND TILL[1]—Distinguished on basis of presence of discontinuous till (Illinoian and possibly pre-Illinoian) in addition to loamy decomposition residuum which is same as unit **clf**. Till generally exposed only on hilltops; modified by colluviation and solifluction activity on slopes. Till matrix yellowish-red, red, reddish-yellow, yellowish-orange, brown, or mottled clay loam and silty clay loam with minor clay. Strongly acid. Nonsorted; nonstratified; cohesive. Till sparingly to moderately pebbly; scattered cobbles and small boulders. Clasts chiefly shale, siltstone, and sandstone; erratic lithologies rare. Upper 4-5 m intensely weathered; gibbsite present locally in surface soil. Weathering rinds common on larger clasts. Includes thin residuum on flat areas and some ice-contact and outwash sand and gravel of Illinoian and possibly pre-Illinoian age. Thickness of colluvium generally 1-2 m; thickness of till generally less than 3 m, locally more than 25 m

cli DIABASE- AND BASALT-CLAST CLAY LOAM COLLUVIUM[1]—Yellowish-red, yellowish-brown, reddish-brown, gray, or mottled, noncalcareous clay loam and silty clay loam with abundant angular and subangular clasts of diabase or basalt. Nonsorted or poorly sorted; nonstratified or poorly stratified. Upper part intensely weathered; clay minerals chiefly smectite and kaolinite. Clasts commonly decomposed or have thick weathering rinds; iron and manganese oxide coatings common. Boulders as large as 3 m common on and below steep slopes; boulder fields locally on middle and lower slopes. Many cobbles and boulders on surface of colluvium; spheroidal weathering of buried clasts common; iron and manganese oxide stains abundant. Map unit includes some yellowish-red or reddish-brown clay loam residuum, generally less than 1 m thick, on flat areas. Also includes rock waste at bases of bedrock outcrops, solifluction deposits on moderate and gentle slopes, and areas of bedrock outcrops. Thickness generally 2-3 m

cl LOAMY COLLUVIUM[1]—Pale-yellow, yellowish-brown, brown, gray, black, or mottled sandy loam, loam, silt loam, silty clay loam, clay loam, and silty clay. Textures and colors vary, reflecting composition of bedrock higher on slopes. Generally noncalcareous or weakly calcareous; very calcareous where derived from limestone. Clasts dominantly angular and subangular quartzitic sandstone, sandstone, siltstone, and shale; limestone or conglomerate common locally. Most material on slopes is colluvium; included solifluction deposits are widespread in northern part of mapped area. Materials on flat upland surfaces or very gentle slopes commonly undifferentiated solifluction deposits and residuum. Colluvium dominantly pale brown, dark brown, gray, or mottled, poorly sorted to massive, pebbly to bouldery debris transported and deposited chiefly by creep. Included solifluction deposits chiefly yellowish-brown, brown, gray, or mottled, 1-3 m thick, similar to unit **nma**. Included residuum chiefly pale yellow, brown, gray, black, or mottled and stony to pebble free, generally 1-2 m thick on flat surfaces and less than 1 m on gentle slopes, similar to unit **nla**. Where derived from limestone, residuum is tough, plastic, silty clay loam or silty clay. Also included in unit are isolated landslide deposits, small areas of alluvium (**al**), and bedrock outcrops. Landslide deposits (**jlb**) consist of same materials but are distinguished on basis of a greater abundance of landslide deposits. Thickness 1-2 m on gentle slopes, 2-4 m of foot slopes, locally more than 10 m at toes of colluvial fans and aprons

jlb LANDSLIDE DEPOSITS—Material same as loamy colluvium (**cl**); map unit distinguished on basis of presence of scattered or localized landslide deposits in 2-10 percent of mapped area. Landslide deposits are products of downslope movement of colluvium, solifluction deposits, residuum, and bedrock as a result of earthflow or slump. Thickness of colluvium commonly 1-2 m on gentle slopes, 2-4 m on foot slopes, locally more than 10 m at toes of colluvial fans and aprons. Thickness of included solifluction deposits generally 1-3 m. Thickness of included residuum generally 1-2 m on flat surfaces, less than 1 m on very gentle slopes. Earthflow deposits typically are heterogeneous mixtures of clay, silt, and sand with scattered angular clasts of bedrock that were transported and deposited as a result of slow flow of wet, but not necessarily saturated, unconsolidated materials. Areal extent commonly less than 0.405 hm2 (1 acre), although some deposits are tens of meters to a few hundred meters wide and 15-30 m long. Slump deposits typically are masses of unconsolidated materials and bedrock that have rotated and slid downslope as a unit, with little or no flow; physical properties of transported materials are not altered greatly and textures, stratification, and bedding of slumped colluvium, solifluction deposits, residuum, and bedrock are retained; typically less than 120 m wide, with upslope lengths of 10-45 m and vertical crown scarp displacements of 1-5 m. Thickness of earthflow deposits generally less than 5 m; thickness of slump deposits generally 2-30 m

zla LOAMY DECOMPOSITION RESIDUUM[1]—Pale-yellow, yellowish-brown, brown, or dark-brown, noncalcareous or weakly calcareous sandy loam, loam, and silt loam on ridge crests. Nonsorted; nonstratified. Chiefly residuum derived by in-place decomposition of sandstone and minor shale. Includes areas of heterogeneous, nonstratified, nonsorted rubble, locally 3-5 m thick, formed by frost shattering of sandstone and quartzitic sandstone. Rubble bouldery where derived from quartzitic sandstone; channery where derived from bedded sandstone; small sandstone and shale fragments common elsewhere. Residuum grades laterally into bouldery colluvium and rock waste (**cbb**) on slopes. Map unit includes extensive areas of bedrock outcrops. Thickness generally 1-2 m

zlb LOAMY DECOMPOSITION RESIDUUM[1]—Yellowish-brown, reddish-brown, brown, or maroon, noncalcareous loam, silt loam, and clay loam with clasts of acid shale and sandstone on flat or gentle slopes. Nonsorted; nonstratified. Includes channery colluvium 2-4 m thick on steeper foot slopes, alluvium (**al**) in valleys, and areas of bedrock outcrops. Thickness generally less than 1 m

zlh LOAMY DECOMPOSITION RESIDUUM[1]—Pale-yellow, yellowish-brown, brown, or mottled loam, silt loam, silty clay loam, and clay loam on sedimentary rocks of a variety of compositions. Colors, textures, and clast composition and abundance reflect the composition of underlying bedrock. Generally acid; calcareous where limestone is present. Nonsorted; nonstratified. Locally consists of thin layers of disintegrated shale fragments. Present on flat surfaces and gentle slopes. Includes colluvium on moderate to steep slopes (generally less than 4 m, locally more than 30 m thick) and debris-fan deposits on foot slopes. Colluvium generally yellowish red, red, reddish yellow, brownish yellow, yellow, yellowish brown, reddish brown, brown, yellowish gray, or mottled loam, silt loam, silty clay loam, and clay loam; locally sandy loam, silty clay or clay; generally acid. Colluvium poorly sorted; generally massive, locally weakly stratified. Clasts chiefly sandstone, quartzitic sandstone, and shale; limestone or conglomerate common locally. Clasts chiefly angular and subangular pebbles and cobbles; locally very bouldery; channery where bedrock is bedded sandstone. Colluvium generally weathered; yellowish-red rinds on sandstone clasts. Generally stable; well-developed soil profiles; buried soils locally. Colluvium deposited chiefly during episodes of glaciation farther north. Map unit also includes alluvium (**al**) in valleys and areas of bedrock outcrops. Thickness generally less than 1 m

zli LOAMY DECOMPOSITION RESIDUUM AND TILL[1]—Distinguished on basis of presence of discontinuous till (Illinoian and possibly pre-Illinoian) in addition to loamy decomposition residuum which is the same as unit **zlh**. Till is yellowish-red, red, yellowish-orange, grayish-orange, reddish-yellow, reddish-brown, yellowish-brown, grayish-brown, vermillion, gray, or mottled clay loam, silty clay loam, silty clay, and clay; locally loam. Generally acid. Nonsorted; nonstratified. Very compact; cohesive; prismatic structure common. Sparingly to moderately pebbly; cobbles and boulders locally abundant. Clasts chiefly shale and resistant quartzitic sandstone and siliceous siltstone; shale clasts generally decomposed; erratic lithologies rare. Till intensely weathered in upper 2.5-10 m; gibbsite present locally in surface soil; intense iron oxide stains. Larger resistant clasts commonly rubified, with rinds 0.6-1.3 cm thick. Till commonly modified by colluviation and solifluction activity. Occurs chiefly as erosional remnants on hilltops and in small tributary valleys. Includes some ice-contact and outwash sand and gravel of Illinoian and possibly pre-Illinoian age. Locally overlain by eolian sand and silt (**ed**, **el**). Thickness of till generally 1-3 m, locally 15 m; thickness of residuum generally less than 1 m

zlk LOAMY DECOMPOSITION RESIDUUM[1]—Reddish-brown, yellowish-brown, brown, gray, or mottled loam, silt loam, silty clay loam, and clay loam. Calcareous or acid. Nonsorted; nonstratifed. Locally

stony. Clasts chiefly granite, gneiss, schist, amphibolite, metagabbro, metaanorthosite, and marble. Schist locally decomposes to arkosic sand, loamy sand, and sandy loam. Intensely weathered; locally lateritic; gibbsite present locally in surface soil; intense iron oxide stains. Larger clasts rubified; less resistant clasts partly or completely decomposed. Local spheroidal weathering of cobbles and boulders. Includes colluvium on steep slopes and in debris fans on foot slopes. Colluvium intensely weathered in upper 3-4 m; intense iron oxide stains; cobbles commonly rubified; core boulders present locally. Colluvium, generally 2-6 m thick and locally more than 30 m thick, generally stable with well-developed soil profiles. Most colluvium deposited during episodes of glaciation farther north. Map unit also includes solifluction deposits on gentle slopes, alluvium (**al**) in valleys, and areas of bedrock outcrops. Thickness generally 1-4 m

zll LOAMY DECOMPOSITION RESIDUUM AND TILL[1]—Distinguished on basis of presence of discontinuous till (**tcm**) of Illinoian age and alluvium and outwash sand and gravel (**agq**) of Illinoian and pre-Illinoian age in addition to loamy decomposition residuum which is the same as unit **zlk**. Till commonly modified by colluviation or solifluction activity. Thickness of till generally less than 3 m; thickness of residuum generally 1-3 m

zlm LOAMY DECOMPOSITION RESIDUUM AND TILL[1]—Distinguished on basis of presence of discontinuous till (**tch**) of pre-Illinoian age and alluvium and outwash sand and gravel (**agq**) of Illinoian and pre-Illinoian age in addition to loamy decomposition residuum which is the same as unit **zlk**. Till commonly modified by colluviation or solifluction activity. Thickness of till generally less than 3 m; thickness of residuum generally less than 2 m

zlc SILTY SAND TO SILTY CLAY DECOMPOSITION RESIDUUM[1]—Purplish-red, red, brownish-yellow, yellow, yellowish-brown, reddish-brown, grayish-brown, brown, reddish-gray, olive-gray, gray, or mottled silty sand, sandy loam, loam, silt loam, silty clay loam, clay loam, and silty clay. Colors, textures, and clast lithology and abundance reflect composition of bedrock. Calcareous or acid. Nonsorted; nonstratified. Conglomerate decomposes to nonstratified earthy fine gravel; residuum porous where derived from sandstone. Commonly intensely weathered; locally lateritic. Includes some disintegration residuum in areas underlain by sandstone. Includes colluvium 1-3 m thick on steep to moderate slopes and foot slopes. Clasts in colluvium chiefly shale, sandstone, and argillite**;** some conglomerate, diabase, and basalt. Also includes widespread solifluction deposits 0.3-1 m thick on slopes, composed chiefly of shale rubble,. and alluvium (**al**) in valleys. Locally covered by thin loess (**el**). Thickness generally less than 1 m

zlj SILTY SAND TO SILTY CLAY DECOMPOSITION RESIDUUM AND TILL[1]—Distinguished on basis of presence of discontinuous till (**tcm**, **tch**) and alluvium and outwash sand and gravel (**agq**) of Illinoian and pre-Illinoian age in addition to silty sand to silty clay decomposition residuum which is the same as unit **zlc**. Till commonly modified by colluviation and solifluction activity. Thickness of till generally less than 3 m; thickness of residuum generally less

LATE WISCONSIN

CLAYEY TILL—Reddish-brown, yellowish-brown, brown, gray, or mottled calcareous clay loam, silty clay loam, and clay. Nonsorted or poorly sorted; nonstratified or very poorly stratified. Pebbles infrequent; scattered cobbles and boulders. Pebbles chiefly sandstone, limestone, dolomite, and shale; erratic cobbles and boulders of crystalline igneous and metamorphic rocks conspicuous locally. Includes small areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**) and alluvium (**al**). In places overlain by lake silt and clay (**Ica**) or eolian sand and silt (**ed**, **el**)

tc Ground moraine-Thickness generally 2-4 m

tc End moraine-Broad, low ridges, locally with hummocky topography. Thickness generally 6-20 m

LOAMY TILL—Yellowish-brown, reddish-brown, brown, olive-gray, bluish-gray, gray, or mottled calcareous loam and silt loam; locally sandy loam or clay loam. Nonsorted or poorly sorted; locally crudely stratified. Compact; horizontal platy structure typical, breaking into irregular pieces 1.5-4 cm thick. Moderately pebbly to pebbly; locally cobbly or bouldery. In places very stony with gritty matrix containing abundant granules of shale and siltstone. Gravel lenses and interbeds common. Clast lithology reflects composition of bedrock and other source materials. Clasts commonly sandstone, siltstone, shale, limestone, and dolomite; erratic crystalline igneous and metamorphic clasts common. Includes areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**), lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Isb**), alluvium (**al**), and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**)

tl Ground moraine—Thickness generally 1-3 m, rarely more than 10 m

tl End moraine—Broad, low ridges or complex areas of narrow, concentric or overlapping ridges with knob-and-kettle topography and undrained depressions. Thickness generally 8-30 m

tl Stagnation moraine—Broad, irregular areas of hummocky collapsed topography, locally with ice disintegration features and ice-block depressions. Thickness generally 3-10 m

tlr Discontinuous loamy till—Thin, discontinuous deposits of loamy till separated by numerous or extensive bedrock outcrops. Thickness generally less than 1 m

LOAMY TILL—Pale-yellow, brownish-yellow, yellowish-brown, brown, bluish-gray, gray, or mottled calcareous loam, silt loam, clay loam, and silty clay loam. Locally red or reddish brown where derived from red shale. Nonsorted or poorly sorted; nonstratified or weakly stratified. Compact; irregular horizontal platy structure typical. Sparingly pebbly to pebbly; generally less pebbly than unit **tl** and more pebbly than unit **tc**. Nearly pebble free where derived from incorporated lake sediments. Cobbles and boulders common to abundant; commonly concentrated in end moraine. Pebbles, cobbles, and small boulders chiefly limestone, dolomite, shale, siltstone, and sandstone; large boulders chiefly erratic crystalline igneous and metamorphic rocks and quartzite. Includes areas of older loamy till (**tl**). Also includes small areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**), lake clay, silt, sand, and gravel (**Ica**, **Isa**), alluvium (**al**), and bedrock outcrops. Locally overlain by peat (**hp**) or swamp deposits (**hs**)

tlg Ground moraine—Thickness generally 1-3 m, rarely 6 m

tlg Ground moraine under Lake Ontario—Includes areas of bedrock outcrop and local accumulations of boulders. Thickness generally 1-2 m

tlg End moraine—Broad low ridges, narrow sharply defined ridges, or complex areas of concentric or overlapping ridges with knob-and-kettle topography or irregular hummocks and undrained depressions. Till end moraine locally grades laterally into kame moraine deposits (**ke**) that are included in unit. Thickness generally 4-15 m

tlr Discontinuous loamy till—Thin, discontinous deposits of loamy till separated by numerous or extensive bedrock outcrops. Thickness generally less than 1 m

LOAMY TILL (Olean Till in New York and Pennsylvania)—Brownish-red, brownish-orange, orange, reddish-brown, yellowish-brown, grayish-brown, brown, gray, or mottled loam, silt loam, sandy loam, clay loam, and silty clay loam. Colors and textures reflect composition of local bedrock. Calcareous or noncalcareous, depending on composition of bedrock and other source materials. Generally nonsorted, nonstratified; lenses and interbeds of silt, sand, and gravel common. Cohesive; moderately friable. Upper 0.5-1 m locally loose; firm to compact below 1 m. More clayey till has moderately developed platy structure; hard where dry, tacky to moderately plastic where moist. Moderately pebbly to bouldery; rubbly or channery where derived from jointed sandstone or conglomerate; end moraine commonly very stony. Clasts 80-90 percent sandstone and siltstone, with minor shale, conglomerate, and limestone. Erratic igneous and metamorphic rocks commonly comprise less than 1 percent of clasts. Shale clasts relatively unweathered; limestone clasts partly or completely decomposed. Thick till generally only on lower slopes. Includes extensive areas of loamy solifluction deposits (**nlc**) and colluvium. Also includes outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**), lake clay, silt, sand, and gravel (**Ica**, **Isa**), alluvium (**al**), and areas of bedrock outcrops. Locally overlain by peat (**hp**) or swamp deposits (**hs**). The Olean Till (**tld**) has been assigned a late Wisconsin age (Crowl and Sevon, 1980), a middle Wisconsin age (Calkin and others, 1982), and an early Wisconsin age (Muller, 1977). Stratigraphic data in New York (LaFleur, 1979, 1980; Braun and others, 1985) indicate the till is late Wisconsin in age (Fullerton, 1986)

tld Ground moraine—Thickness generally less than 1.5 m on uplands, 2-6 m in valleys

tld End moraine—Low ridges, generally with subdued constructional topography. Includes small areas of kame moraine deposits (**ke**). Thickness generally 5-10 m, locally 30 m

tlr Discontinuous loamy till—Thin, discontinuous deposits of loamy till separated by numerous or extensive bedrock outcrops. Thickness generally less than 1 m

LOAMY TILL—Pale-red, brownish-red, brownish-orange, reddish-brown, brown, gray, or mottled loam, silt loam, clay loam, and silty clay loam; locally sandy loam. Colors and textures reflect composition of local bedrock. Commonly weakly calcareous or noncalcareous on uplands, calcareous in valleys. Nonsorted; nonstratified. Moderately cohesive; moderately friable. Upper 0.5-1 m locally sandy and loose; more clayey and compact below 1 m. Moderately pebbly to stony; cobbles and boulders scattered to abundant; rubbly or channery where derived from jointed sandstone; end moraine commonly very stony. On uplands, clasts chiefly angular and subangular sandstone slabs and channers, and pebbles and cobbles of sandstone, siltstone, and shale; less than 5 percent of clasts erratic lithologies. In north-south-trending valleys in New York, till commonly gravelly and enriched in erratic clasts, 10-35 percent carbonate and crystalline igneous and metamorphic rocks. Generally much thicker on south-facing slopes than on north-facing slopes. Includes extensive loamy solifluction deposits (**nlc**) and colluvium. Also includes areas of outwash and ice-contact gravel, sand, and silt (**gg**,

kg, **ke**), lake clay, silt, sand, and gravel (**Ica**, **Isa**), alluvium (**al**), and bedrock outcrops. Locally overlain by peat (**hp**) or swamp deposits (**hs**)

tly Ground moraine—Thickness generally 2-18 m, locally more than 70 m

tlr Discontinuous loamy till—Thin, discontinuous deposits of loamy till separated by numerous or extensive bedrock outcrops. Thickness generally less than lm

LOAMY TILL—Yellowish-brown, light-olive-brown, grayish-brown, gray, or mottled calcareous loam and sandy loam; locally clayey silt or silty clay. Nonsorted; nonstratified; may contain local flow till units near lower and upper contacts. Low plasticity. Matrix carbonate content variable, chiefly calcite. Scattered pebbles; clasts chiefly limestone and shale; some erratic igneous and metamorphic rocks. Includes small areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**), lake gravel, sand, silt, and clay (**Isa**, **Ica**) and alluvium (**al**). Locally overlain by swamp deposits (**hs**)

tka Ground moraine-Thickness generally 1-2 m, locally more than 5 m

tka Ground moraine under Lake Ontario—Includes areas of bedrock outcrops and local accumulations of boulders. Thickness generally 1-2 m

LOAMY TILL—Red, reddish-brown, brown, yellow, yellowish-brown, gray, or mottled sandy loam, fine sandy loam, loam, and clay loam; locally silty clay loam or clay. Colors and textures vary, reflecting composition of local bedrock. Calcareous or noncalcareous, reflecting composition of bedrock and other source materials. Nonsorted; nonstratified. Compact where more clayey. Lenses and interbeds of sand and gravel common; clasts of red clay common locally. Moderately pebbly to stony. Pebbles chiefly sandstone, arkose, shale, argillite, conglomerate, diabase, and basalt; boulders chiefly diabase, basalt, and erratic limestone, gneiss, and granite. Locally free of boulders where clayey. Includes some solifluction deposits and colluvium. Also includes areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**, **kd**), lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Isb**), alluvium (**al**), and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), swamp deposits (**hs**), or saline marsh deposits (**hps**)

tlz Ground moraine—Thickness generally 2-10 m, locally more than 15 m

tlz End moraine—Broad, low ridges with knob-and-kettle topography and undrained depressions. Includes some kame moraine deposits (**ke**). Thickness generally 6-9 m, locally more than 40 m

tlv LOAMY TILL—Yellowish-brown, reddish-brown, brown, gray, or mottled loam, clay loam, and silty clay loam. Calcareous or noncalcareous, reflecting composition of source materials. Nonsorted; nonstratified. Loose to compact. Matrix derived chiefly from diabase- and basalt-clast clay loam colluvium (**cli**) and residuum. Pebbly; cobbles and boulders abundant. Boulders chiefly subangular blocks of diabase and basalt; some quartzitic sandstone, sandstone, limestone, gneiss, and granite. Some boulders were partly decomposed or disintegrated prior to transportation by glacial ice. Weathering rinds common on cobbles, boulders, and bedrock surfaces. Typically very discontinuous or absent on steep slopes. Includes local deposits of residuum on flat areas, extensive colluvium and solifluction deposits on moderate and gentle slopes, and rock waste on steep slopes. Also includes small areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**) and lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Isb**). Thickness generally less than 2 m on ridge crests, 2-6 m on slopes

SANDY LOAMY TILL—Reddish-brown, yellowish-brown, brown, olive, brownish-gray, olive-gray, gray, or mottled sandy loam and sandy clay loam; locally loamy sand, silt loam, or silt. Calcareous or noncalcareous, reflecting composition of bedrock and other source materials. Nonsorted or poorly sorted; nonstratified. Compact; cohesive; hard where dry. Pebbly; cobbles and boulders common to abundant; commonly channery, locally very stony. Clast lithology reflects composition of bedrock. Clasts generally quartzitic sandstone, sandstone, conglomerate, and quartz; minor siltstone and shale; local limestone or slate; some erratic crystalline igneous and metamorphic rocks. In southern half of quadrangle, includes extensive areas of colluvium on moderate to steep slopes and foot slopes, solifluction deposits on gentle slopes, and local deposits of rock waste. Also includes areas of clayey till (**tc**), loamy till (**tl**, **tld**, **tly**), sandy till (**ts**), outwash and ice-contact gravel, sand, and silt (**gg**, **k**g, **ke**), lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Isb**), alluvium (**al**), and extensive areas of bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**)

td Ground moraine—Thickness generally 1-3 m, locally more than 6 m

td Stagnation moraine—Broad areas of hummocky collapsed topography; distinct ridges generally lacking. Disintegration features and deep undrained ice-block depressions common. Thickness generally 5-20 m

td End moraine—Hummocky till ridges and irregular mounds with undrained ice-block depressions. Includes small areas of kame moraine deposits (**ke**). Thickness generally 5-15 m, locally 30 m

tdr Discontinuous sandy loamy till—Thin, discontinuous deposits of sandy loamy till separated by numerous or extensive bedrock outcrops. Thickness generally less than 2 m

SANDY LOAMY TILL—Yellowish-orange, yellow, reddish-brown, yellowish- brown, grayish-brown, olive-brown, brown, olive-gray, yellowish-gray, bluish-gray, gray, black, or mottled sandy loam and loam; locally loamy sand, silt loam, or silty clay loam. Colors and textures generally reflect those of local bedrock. Gritty where derived from gneiss or schist. Calcareous or noncalcareous, reflecting composition of bedrock and other source materials. Nonsorted or poorly sorted; nonstratified. Generally loose in upper part; compact, cohesive, and friable at depth. Locally partly indurated; hard, brittle. Foliated parting where bedrock is micaceous schist. Generally oxidized throughout. Clast lithology reflects composition of bedrock. Pebbly; cobbles and boulders common to abundant; locally stony. Boulder litter common on surface. Pebbles and small cobbles chiefly local bedrock; larger clasts commonly erratic lithologies. Clasts generally angular to subrounded quartzite, sandstone, conglomerate, siltstone, shale, limestone, dolomite, graywacke, phyllite, argillite, marble, slate, granite, diorite, gabbro, diabase, amphibolite, volcanic rocks, or metavolcanic rocks. Till commonly discontinuous, with scattered bedrock outcrops; continuous bedrock exposed on some steep slopes and ridge tops. In Vermont and New Hampshire, till typically thickest on north-facing and west-facing slopes and in valleys. Includes colluvium on and below steep slopes and local deposits of rock waste. In New Jersey, includes some solifluction deposits. Map unit also includes areas of loamy till (**tl**, **tlz**), sandy till (**ts**), outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **kd**, **ke**), lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Isb**), alluvium (**al**), and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**)

tda Ground moraine—Thickness generally 1-5 m, locally more than 15 m

tda Stagnation moraine—Broad areas of hummocky collapsed topography; distinct ridges generally lacking. Thickness generally 4-15 m

tda End moraine—Hummocky till ridges with undrained ice-block depressions. Includes small areas of kame moraine deposits (**ke**). Thickness generally 5-15 m, locally 30 m

SANDY TILL—Red, pink, yellowish-orange, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, olive, olive-gray, reddish-gray, yellowish-gray, bluish-gray, gray, black, or mottled sand, loamy sand, and sandy loam; locally loam, sandy clay loam, or silt loam. Generally noncalcareous; locally calcareous. Typically very poorly sorted; nonstratified. Discontinuous interbeds and lenses of sand and gravel common. Upper part typically more sandy, loose, stony; crudely stratified, moderately compact, friable; platy structure. Lower part typically less sandy, homogeneous, very compact, hard; locally massive; jointed, with dark-brown iron oxide stains. Generally pebbly; cobbles and boulders common to abundant; locally gravelly, stony, or rubbly. Clast lithology varies greatly, reflecting composition of bedrock and other source materials. Clasts chiefly granite, pegmatite, granodiorite, diorite, monzonite, gabbro, diabase, basalt, gneiss, schist, phyllite, slate, marble, graywacke, argillite, amphibolite, metagabbro, metaanorthosite, charnokite, and quartzite. Map unit includes distinctive red and reddish-brown compact sandy till with clasts of arkose, conglomerate, shale, and basalt in Massachusetts and Connecticut which is similar to loamy till (**tlz**) in New Jersey and southeastern New York but is not distinguished as a map unit. Also includes areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**, **kd**), lake clay, silt, sand, and gravel (**Ica**, **Isa**), alluvium (**al**), and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), swamp deposits (**hs**), or saline marsh deposits (**hps**)

ts Ground moraine—Thickness generally 2-5 m, locally more than 10 m

ts End moraine—Narrow, sharply defined ridges with undrained ice-block depressions. Surface bouldery. Thickness generally 5-15 m, locally more than 30 m

tsr Discontinuous sandy till—Thin, discontinuous deposits of sandy till separated by numerous or extensive bedrock outcrops. Mapped only in Adirondack Mountains, New York. Thickness generally less than 2 m

SANDY TO CLAYEY TILL—Yellowish-brown, brown, gray, or mottled calcareous fine sand to clay on Long Island, New York. Texture may vary markedly in short distances, laterally and vertically. Generally loose where sandy, very compact where clayey. Poorly sorted; nonstratified or weakly stratified. Generally pebbly to very pebbly; locally gravelly. Cobbles and boulders common to abundant. Clast composition varies, reflecting bedrock lithologies in source areas to north; clasts chiefly crystalline igneous and metamorphic rocks similar to those in units **tda** and **ts**. Generally either a veneer of ground moraine draped over outwash fans and ice-contact ridges or end moraine superposed on coalesced outwash fans. Includes areas of outwash and ice-contact gravel, sand, and silt (**gg**, **ggc**, **kg**, **ke**, **kea**), lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Isb**), and alluvium (**al**). Locally overlain by thin but extensive eolian sand and silt (**ed**, **el**) and some peat (**hp**)

tx Ground moraine—Thickness genrally 0.5-4 m, locally 10 m

tx End moraine—Broad, low ridges with knob-and-kettle topography and undrained depressions. Thickness 4-45 m

kg ICE-CONTACT GRAVEL, SAND, AND SILT—Pale-yellow, yellowish-brown, reddish-brown, brown, brownish-gray, gray, or mottled sand and gravel. Textures vary laterally and vertically, ranging from fine sand with minor silt and scattered pebbles to cobble and boulder gravel. Calcareous or noncalcareous, reflecting composition of source materials. Poorly to well sorted; poorly to well stratified. Irregularly bedded to well bedded; beds thin to thick and discontinuous laterally. Locally interbedded with or contains lenses and masses of clay, silt, flow till, or till. Faults, folds, slump, and collapse structures common. Clasts locally intensely stained by iron oxides; gravel locally cemented by secondary calcium carbonate. Clasts subangular to rounded; composition similar to that of local till. Pebbles generally local bedrock lithologies; large boulders commonly erratic lithologies. Surfaces hummocky to knobby or with isolated mounds; commonly pitted with ice-block depressions and strewn with boulders. Occurs in kames, kame terraces, eskers, and ice-fracture fillings. Some eskers indicated by symbols. Not mapped in Pennsylvania. Includes kame moraine deposits (**ke**) and kame delta deposits (**kd**) where those deposits are not distinguished. Also includes areas of outwash gravel, sand and silt (**gg**), lake clay, silt, sand, and gravel (**lca**, **Isa**, **Isb**, **Ids**), alluvium (**al**), and till. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 5-20 m, locally more than 60 m

ke KAME MORAINE GRAVEL, SAND, AND SILT—Ice-contact deposit similar in color, texture, and composition to unit **kg**. Forms either massive linear or arcuate ridges or massive valley-filling plugs. In places gravel, sand, and silt interfingers with or is replaced laterally by till. On Long Island, New York, commonly consists of coalesced kames, locally thinly veneered by till; in places includes ice-thrust masses of diverse Quaternary and Cretaceous sediments. Elsewhere includes areas of kame delta deposits (**kd**), outwash gravel, sand, and silt (**gg**), lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Isb**), and alluvium (**al**). Locally overlain by eolian sand and. silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 5-30 m, locally more than 60 m

kd KAME DELTA GRAVEL, SAND, AND SILT—Pale-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, brownish-gray, gray, or mottled sand and pebble or cobble gravel with lenses of very fine sand and silt. Calcareous or noncalcareous, reflecting composition of source materials. Moderately to well sorted; well stratified. Topset beds typically pebble and cobble gravel or pebbly sand and silt; foreset beds typically sand and pebble gravel; bottomset beds typically horizontally bedded fine sand, silt, and clay. Clasts subrounded or rounded; clast composition similar to that of ice-contact sand and gravel (**kg**) in vicinity. Similar to lake delta sand and gravel (**Ids**), but characterized by steep headward ice-contact slopes, inward from which bedding is disturbed by faults, folds, and other collapse structures. Deposited by streams that flowed from ice into an ice-marginal lake. Commonly perched on slopes above valley floors. Many small kame delta deposits included in ice-contact gravel, sand, and silt (**kg**). Map unit includes deposits of lake delta sand and gravel (**Ids**) where the two kinds of delta deposits have not been distinguished. Locally overlain by dune sand (**ed**). Thickness generally 5-12 m, locally more than 20 m

gg OUTWASH GRAVEL, SAND, AND SILT—Pale-yellow, yellowish-brown, reddish-brown, brown, gray, or mottled sand and gravel. Calcareous or noncalcareous, reflecting composition of source materials. In areas of late Wisconsin glaciation, generally pebble or cobble gravel with lenses and interbeds of sand, silt, and clay and local lenses of boulders; south of the limit of late Wisconsin glaciation, chiefly sand and fine gravel with scattered cobbles and interbedded silt and clay. Poorly to well sorted. Well stratified; bedding varies from horizontal beds of well-sorted sand and gravel with local cut-and-fill structure to irregular beds of very well sorted cobble or boulder gravel. Clast lithology varies with that of local bedrock and other source materials. Cobbles and boulders abundant where outwash deposits head near end moraines or ice-contact deposits. Clasts generally subrounded to well rounded. Clasts

locally intensely stained by iron oxides; gravel locally cemented by secondary calcium carbonate. Surfaces typically smooth to undulating; locally pitted with ice-block depressions. Occurs in terrace remnants, valley trains, outwash plains, fans, aprons, delta topset beds, and fills in meltwater channels. Not mapped in Pennsylvania. Includes some till, ice-contact gravel, sand, and silt (**kg**, **ke**), lake clay, silt, sand, and gravel (**Ic**a, **Isa**, **Isb**), and alluvium (**al**). Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). On Long Island, New York, locally overlain by thin and discontinuous till (**tx**). Thickness generally 2-15 m, locally more than 60 m

mc MARINE CLAY AND SILT—Yellowish-brown, brown, bluish-gray, dark-gray, or mottled uniform, soft, calcareous clay and fine silt containing minor fine sand laminae. Calcareous. Generally massive; locally horizontally bedded. Lithologically indistinguishable from lake silt and clay (**Ic**a), but locally contains tests of saline or brackish-water molluscs. Mapped only in Champlain Valley at north edge of quadrangle. Thickness generally less than 5 m

el LOESS—Pale-yellow, yellow, yellowish-brown, pale-gray, or mottled windblown silt and very fine sand. Grain size and thickness decrease eastward. Generally leached throughout; porous. Well sorted. Generally nonstratified; local weak horizontal banding and weak vertical structure. Forms discontinuous mantle over older deposits and bedrock. Mapped only in New Jersey; elsewhere extensive areas of very thin loess included in other map units. Thickness generally less than 1 m, locally 3 m

lca LAKE SILT AND CLAY—Red, maroon, pale-yellow, yellowish-brown, reddish-brown, brown, olive, olive-gray, bluish-gray, gray, black, or mottled silt and clay; locally silt and very fine sand. Calcareous or noncalcareous, reflecting composition of source materials. Well bedded to massive; generally soft. Commonly laminated in lower part; locally varved. Ice-rafted clasts common locally. In places interbedded with sand and fine gravel or with flow till or till. Typically jointed or fractured where dry. Calcium carbonate concretions common locally. Chiefly in flat low areas formerly occupied by glacial and postglacial lakes. Not mapped in Pennsylvania. Includes many small areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **ke**, **kd**), lake sand and gravel (**Isa**, **Isb**, **Ids**), alluvium (**al**), till, and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-10 m, locally 30 m

lcr DISCONTINUOUS LAKE SILT AND CLAY—Thin and discontinuous lake silt and clay (**Ica**) over bedrock. Most of area is wave- or current-washed bedrock. Thickness generally less than 1 m

lsa LAKE SAND AND GRAVEL—Pale-yellow, yellowish-brown, reddish-brown, grayish-brown, olive-brown, brown, olive, gray, or mottled fine to coarse sand with lenses of rounded gravel or pebble layers; locally pebble or cobble gravel. Calcareous or noncalcareous, reflecting composition of source materials. Generally well sorted; commonly crossbedded; local lenticular bedding or tabular-foreset bedding. Clast lithology reflects composition of materials transported by waves and currents. Not mapped in Pennsylvania. Nearshore, strand, and deltaic deposits of former glacial and postglacial lakes; includes deposits of beach ridges, offshore bars, and spits. Also includes areas of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**, **kd**, **ke**), lake silt and clay (**Ica**), alluvium (**a**l), till, and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-10 m, locally 30 m

lsr DISCONTINUOUS LAKE SAND AND GRAVEL—Thin and discontinuous lake sand and gravel (**Isa**) over bedrock. Most of area is wave- or current-washed bedrock. Thickness generally less than 1 m

lsb LAKE, ICE-CONTACT, AND OUTWASH DEPOSITS—Complex deposit of lake clay, silt, sand, and gravel (**Ica**, **Isa**, **Ids**), ice-contact gravel, sand, and silt (**kg**, **kd**), and outwash gravel, sand, and silt (**gg**). In some areas, ice-contact and outwash deposits were modified by waves and currents in glacial lakes; lake sand and gravel, composed chiefly of redeposited older sediments, covers much of the older deposits. In other areas, outwash sand and gravel and finer-grained lake sediments filled or partly filled lakes that were dammed by kames or kame moraines. Mapped only in eastern New York and New Jersey. Similar deposits in New England included in unit **kg**. Map unit includes inset alluvium (**al**). Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness varies; locally more than 30 m

Ids LAKE DELTA SAND AND GRAVEL—Pale-yellow, yellowish-brown, reddish-brown, olive-brown, grayish-brown, brown, brownish-gray, gray, or mottled sand and pebble or cobble gravel with lenses of fine sand and silt. Calcareous or noncalcareous, reflecting composition of source materials. Moderately or well sorted; well stratified. Topset beds typically pebble and cobble gravel or pebbly sand and silt; foreset beds typically sand and pebble gravel; bottomset beds typically horizontally bedded fine sand, silt, and clay. Clasts subrounded or rounded; clast composition similar to that of outwash and ice-contact gravel, sand, and silt (**gg**, **kg**) and till in vicinity. Deposited in glacial and post-glacial lakes; commonly perched on slopes above valley floors. Many small lake delta deposits

included in kame delta deposits (**kd**) and ice-contact sand and gravel (**kg**). Locally overlain by eolian sand and silt (**ed**, **el**). Thickness generally 5-20 m, locally more than 20 m

nlc LOAMY SOLIFLUCTION DEPOSITS AND TILL[1]—Yellowish-brown, pale-brown, brown, gray, or mottled sandy loam, loam, silt loam, silty clay loam, and clay loam. Generally noncalcareous or very weakly calcareous. Solifluction deposits comprise approximately half of area mapped as unit **nlc**; thin, discontinuous, loamy till (**tl**d, **tly**) on summits of small knolls and hills and in poorly drained areas, and colluvium 1-3 m thick on steeper slopes comprise remainder of area. Solifluction and associated periglacial deposits are similar to those in unit **nma**; however, block fields, boulder rings, and boulder stripes are uncommon and solifluction deposits locally are composed of redeposited till. Included colluvium similar to that in unit **nla**; locally consists of till redeposited by creep. Map unit includes valley-bottom deposits of alluvium (**al**), landslide deposits, and areas of bedrock outcrops. Thickness of solifluction deposits generally 1-3 m on upper parts of slopes, locally more than 6 m at bases of slopes; thickness of included till generally less than 2 m

WISCONSIN

txa SANDY TO CLAYEY TILL—Complex deposit of late Wisconsin sandy to clayey till (**tx**) and early Wisconsin sandy to clayey till (Montauk Till) on Long Island, New York. Late Wisonsin till is thin and discontinuous and early Wisconsin till is at surface in much of area. Early Wisconsin till is red, reddish-brown, yellowish-brown, brown, brownish-gray, gray, or mottled calcareous sand to clay; chiefly sand and loamy sand in west and clay loam and clay in southeast; locally gravelly. Texture may vary markedly in short distances, laterally and vertically. Nonstratified or stratified; poorly sorted or moderately sorted; generally compact. Early Wisconsin till commonly interbedded with flow till and sand, silt, and clay; locally contains lenses and masses of incorporated lake and marine clay and silt; locally interbedded with lake sand, silt, and clay with dropstones. Flow structures and shear planes common; in places till was deformed by later ice-shove tectonics. Sparingly pebbly to very pebbly; cobbles and boulders common to abundant. Clasts chiefly erratic igneous and metamorphic rocks from New England. Map unit includes some outwash and ice-contact gravel, sand, and silt **(gg, ggc, kg, ke, kea),** lake clay, silt, sand, and gravel (**Ica**, **Isa, Isb),** ice-thrust blocks of bedrock and other unconsolidated sediments (**IT**), and alluvium (**al**). Commonly overlain by thin eolian sand and silt (**ed**, **el**); locally overlain by peat (**hp**) or saline marsh deposits (**hps**). Thickness of late Wisconsin till generally 1-2 m; thickness of early Wisconsin till generally 3-5 m, locally 15-30 m

kea KAME MORAINE GRAVEL, SAND, AND SILT—Broad belt of coalesced kame and outwash-fan deposits on Long Island, New York. Similar in composition to late Wisconsin kame moraine deposits (**ke**) to north, but includes ice-contact sand and gravel, outwash sand and gravel, and till of early Wisconsin age. Locally veneered by thin or discontinuous late Wisconsin till (**tx**) and by eolian sand and silt (**ed**, **el**). Thickness generally 10-20 m, locally more than 60 m

ggc OUTWASH SAND AND GRAVEL—Extensive area of outwash-plain and outwash-fan and apron deposits on Long Island, New York. Similar in composition to late Wisconsin outwash gravel, sand, and silt (**gg**) to north, but includes outwash sand and gravel and minor till of early Wisconsin age. Ice-block depressions rare or absent, in contrast to pitted topography common on late Wisconsin depositional surfaces to north. Multiple topographic surfaces. Includes alluvial-fan deposits on south shore of Long Island. Commonly overlain by thin eolian sand and silt (**ed**, **el**). Thickness generally 10-25 m, locally more than 35 m

cbk BOULDERY COLLUVIUM AND BOULDER-FIELD DEPOSITS[1]—Reddish-brown and brown acid sand to loam colluvium with abundant angular and subangular cobbles and boulders of hard sandstone and conglomerate. Boulders may or may not be in point contact; surface boulders commonly embedded in soil matrix. Occurs chiefly as continuous slope mantle. Boulder-field deposits generally on gentle slopes (1-5°). Clasts subangular to well-rounded cobbles, boulders, and blocks of hard sandstone and conglomerate 10 cm to 11 m long. Generally coarsely sorted vertically and laterally; average diameter of clasts increases downslope and increases upward within deposit. Matrix absent in upper part, but sandy matrix present at depths of 1.2-2 m. Boulders imbricated. Distal margins lobate. Colluvium and boulder-field deposits inactive; transportation and deposition occurred contemporaneous with glaciation farther north. Minor downslope movement by secondary creep locally. Map unit includes rock waste, in places more than 30 m thick, in Holocene and Wisconsin rock-stream and talus-cone deposits on slopes as steep as 42° at bases of extensive bedrock outcrops. Boulders were released from outcrops by disintegration (chiefly frost activity). Rock waste generally coarsely sorted vertically and laterally; average diameter of clasts increases downslope and increases upward within deposit. Clasts generally randomly oriented; crude imbrication, with long axes dipping upslope, where materials moved by secondary creep. Boulders and blocks in rock waste in point contact; individual boulders

may be unstable. Size of largest blocks or boulders dependent on joint spacing and bedding thickness in parent rock upslope; maximum diameters of blocks locally more than 6 m. Rock waste grades downslope into bouldery colluvium or boulder-field deposits. Thickness of colluvium generally 1-6 m, locally more than 10 m; thickness of boulder-field deposits generally 2-10 m

WISCONSIN AND ILLINOIAN

nla LOAMY SOLIFLUCTION DEPOSITS[1]—Yellowish-brown, pale-brown, dark-brown, gray, black, or mottled, generally noncalcareous or very weakly calcareous sandy loam, loam, silt loam, silty clay loam, and clay loam on uplands. Solifluction deposits comprise 50-70 percent of mapped area; remainder is colluvium and residuum. Solifluction deposits chiefly either (1) faintly stratified sandy loam, loam, silt loam, silty clay loam, or clay loam with scattered clasts of sandstone, siltstone, shale, and limestone; or (2) massive silty clay loam or clay loam with few or no rock fragments. Small block fields less than 10 m thick, boulder rings, boulder stripes, areas of patterned ground, and other phenomena indicative of periglacial frost activity common in north, near southern limit of glacial deposits. Colluvium included is pale-brown, dark-brown, gray, or mottled, poorly sorted to massive, pebbly to bouldery debris that was transported and deposited by creep on slopes; thickness 1-2 m on upper parts of slopes and 2-3 m on lower parts of slopes. Residuum included is yellowish-brown, pale-brown, or brown, stony to pebble-free loamy material that is a product of in-place decomposition of sandstone, siltstone, shale, and minor limestone on flat or gentle slopes; thickness less than 1 m on flat surfaces and 1-2 m on gentle slopes. Map unit includes areas of alluvium (**al**), bedrock outcrops, and landslide deposits. Thickness generally 1-3 m

nma CLAYEY TO SANDY SOLIFLUCTION DEPOSITS[1]—Yellowish-brown, brown, gray, or mottled, generally noncalcareous or very weakly calcareous clayey to sandy debris on moderate to steep slopes. Rock fragments may comprise less than 2 percent to nearly 100 percent of deposits. Matrix may vary from clay to sand, reflecting composition of bedrock higher on slopes. In north, solifluction deposits chiefly either (1) heterogeneous, nonsorted, nonstratified rubble, consisting of angular or subangular flagstones or channers with voids and little or no matrix; or (2) imbricated subangular or angular flagstones or channers in a silty or sandy matrix. Farther south, solifluction deposits are chiefly either (1) faintly stratified silty clay loam with scattered fragments of sand-stone, siltstone, shale; or (2) massive silty clay with few or no rock fragments. Clasts chiefly sandstone, siltstone, and shale, locally limestone or conglomerate, derived from bedrock higher on slopes. Transportation and deposition occurred contemporaneously with glaciation farther north. Small block fields less than 10 m thick, boulder stripes, colluvial fans, and other phenomena indicative of severe periglacial frost activity common locally. Deposits generally stable with well-developed soil profiles; modified by creep and landslide activity locally. Included landslide deposits have hummocky topography and occur mainly in short, steeply sloping tributary valleys. Landslide deposits generally 100-500 m wide and less than 500 m long; thickness generally less than 5 m, locally 10 m. Landslide deposits generally comprise less than 5 percent of mapped unit and are more abundant in north, near southern limit of glacial deposits. Map unit includes areas of colluvium, residuum, alluvium (**al**), and bedrock outcrops. Thickness generally 1-3, m on gentle slopes, locally 6-10 m at bases of slopes

EARLY WISCONSIN

tle LOAMY TILL (Warrensville Till in Pennsylvania)—Red, grayish-red, vermillion, reddish-brown, orange-brown, yellowish-brown, light-gray, or mottled, weakly calcareous or acid loam, silt loam, and sandy loam; locally clayey. Color commonly same as that of parent bedrock. Nonsorted; nonstratified. Generally moderately compact. Depth and intensity of weathering varies; till commonly unoxidized at depths of 1.8-5 m. In places, however, weathered deeply; shale clasts decomposed and sandstone cobbles have weathering rinds as thick as 6 mm. Till typically not rubified. Sparingly to moderately pebbly; generally channery; locally bouldery or stony. Clasts chiefly angular to well-rounded pebbles and cobbles of sandstone, siltstone, and sandy shale; minor limestone and conglomerate. Boulders chiefly quartzitic sandstone, sandstone, and conglomerate; erratic igneous and metamorphic lithologies rare. Commonly modified by colluviation and solifluction activity to depths of 0.6-1.2 m. Discontinuous; till typically covers less than 25 percent of mapped area. Surface generally smooth or rolling; local hummocky constructional topography with shallow depressions. Includes recessional end moraines and local hummocky linear ridges 2-10 m high. Most of mapped area is colluvium (1-2 m thick, locally more than 6 m thick), solifluction deposits (1-3 m thick), and residuum (1-2 m thick), as well as minor outwash gravel, sand, and silt (**gg**), alluvium (**al**), and bedrock outcrops. Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness of ground moraine generally 2-5 m, locally more than 25 m; thickness of end moraine as great as 45 m

SANGAMON

aeb ALLUVIAL, ESTUARINE, AND MARINE GRAVEL, SAND, SILT, AND CLAY (Cape May Formation in New Jersey)—Alluvial facies dark-red, yellowish-red, orange, orange-pink, orange-yellow, reddish-yellow, yellow, yellowish-brown, reddish-brown, grayish-brown, brown, olive, greenish-gray, gray, or mottled stratified bouldery gravel, gravelly sand, and sand, locally interbedded with silt and clay. Calcareous or noncalcareous. Gravel generally horizontally bedded; sand generally crossbedded. Sand chiefly quartz grains; locally greensand or graywacke. Estuarine-marine facies yellow, yellowish-brown, gray, black, or mottled interbedded sand, silt, and clay. Silt and clay fossiliferous locally. Alluvial sand and gravel cemented by iron oxides locally; typically stained by iron oxides throughout mapped area; gibbsite rare or absent in surface soils. Clast composition in alluvial facies varies greatly, reflecting source materials; chiefly rounded quartz, quartzite, chert, ironstone, sandstone; local arkose, argillite, shale, basalt, diabase, gneiss, schist, and granite. Clasts generally smaller than 5 cm; rare boulders as large as 1.5 m. Alluvial facies underlies low terraces and occurs as channel fills; includes areas of older gravelly sand and loamy decomposition residuum (**asm**) and alluvium (**al**). In Delaware River valley, alluvial facies includes outwash sand and gravel of late Wisconsin age (**gg**) and rubified quartzose sand and gravel that may be outwash of Illinoian age. Alluvial, esturine, and marine facies locally overlain by eolian sand and silt (**ed**, **el**), alluvial-fan deposits, natural-levee deposits, or swamp deposits (**hs**). Thickness of alluvial facies generally 1-3 m, locally more than 50 m; thickness of estuarine-marine facies generally 3-5 m, locally 10 m

ILLINOIAN

tcm CLAYEY TO LOAMY TILL—Red, reddish-brown, yellow, yellowish-brown, brown, or mottled silty clay, clay loam, silt loam, and loam. Generally noncalcareous; locally calcareous at depth. Nonsorted; nonstratified or weakly stratified. Generally sparingly pebbly; scattered cobbles and boulders. Clast lithology varies, reflecting composition of source materials. Clasts chiefly angular to well-rounded quartzite, sandstone, arkose, conglomerate, chert, gneiss, and granite; local siltstone, shale, limestone, slate, diabase, basalt, gabbro, amphibolite, and alaskite. Clasts of cemented gravel common locally. Erratic clasts very rare in places. Where weakly stratified, deposit locally cemented to ferruginous conglomerate. Intensely weathered in upper 3-4 m; 61-66 percent of clasts partly or completely weathered, 10-27 percent crumble to powder. Sandstone clasts porous and spongy. Gibbsite present in surface soil locally. Generally discontinuous; scattered cobbles and boulders on surfaces where till absent. Present chiefly on uplands and valley walls. Commonly modified by colluviation and solifluction activity in upper 1 m. Weakly stratified deposits in some areas may be outwash sand and gravel (**agq**). Includes areas of alluvium and outwash sand and gravel (**agq**), residuum (**zlk**, **zlc**), colluvium, solifluction deposits, and alluvium (**al**). Thickness generally 1-6 m

ILLINOIAN AND PRE-ILLINOIAN

agq ALLUVIUM AND OUTWASH SAND AND GRAVEL—Red, orange, yellow, reddish-brown, or brown pebble, cobble, and boulder gravel and pebbly sand. Noncalcareous. Poorly sorted to well sorted; poorly stratified to well stratified. Clasts chiefly well rounded quartzite and quartz; minor sandstone, conglomerate, and chert. Erratic clasts rare or absent in many places. Intensely weathered; commonly cemented to ferruginous conglomerate; clasts stained by iron and manganese oxides. Chiefly in terrace remnants or former drainageways. In places, reworked from older gravelly sand (part of unit **asm**); in other places partly or entirely outwash sand and gravel of lllinoian or pre-Illinoian age. Includes inset deposits of outwash gravel, sand, and silt (**gg**), alluvium (**al**), and small areas of till (**tcm**, **tch**). Mapped only in New Jersey. Thickness generally 0.5-2 m, locally more than 4 m

asm GRAVELLY SAND AND LOAMY DECOMPOSITION RESIDUUMI[1] (Pensauken Formation in New Jersey)—Red, pale-yellow, yellowish-orange, reddish-brown, orange-brown, brown, or mottled loam and clay loam decomposition residuum that grades down into yellow, yellowish-brown, orange-brown, reddish-brown, brown, or white gravelly sand and sand. Residuum massive or faintly stratified, compact, noncalcareous. Generally thicker and more intensely weathered beneath higher topographic surfaces. Topographically highest deposits rubified; gibbsite, halloysite, and endellite common as mineral alteration products, but not as abundant as in unit **zss**. Gravelly sand and sand beneath residuum poorly to well sorted, poorly to well stratified, generally noncalcareous. Gravelly sand typically horizontally bedded; some lenticular, trough, and tabular-planar crossbeds. Gravel typically fine, with local beds or lenses of cobbles. Sand typically horizontally bedded or crossbedded. Gravel commonly stained by iron oxides; locally cemented to ferruginous conglomerate. Sand chiefly quartz grains; locally arkosic or glauconitic. Clasts chiefly well

rounded pebbles of quartz, quartzite, quartzose sandstone, and chert; ironstone, arkosic sandstone, argillite, conglomerate, diabase, basalt, gneiss, schist, gabbro, amphibolite, and serpentinite present locally; secondary ferruginous concretions common. Igneous and metamorphic clasts generally saprolitized in residuum or with weathering rinds in gravelly sand. Most clasts have clay coatings; chert fragments soft or with chalky white coating. Cobbles and boulders more common in north and in deposits beneath lower topographic surfaces. Alluvium deposited on several topographic surfaces; in general, deposits of each surface are chiefly materials reworked from topographically higher deposits of same unit or older units (**zss**, **zlg**). Beneath low topographic surfaces in New Jersey, map unit locally consists of as many as four superposed disconformable gravelly sand units of Pensauken Formation; each unit was deformed by involutions and ice-wedge casts prior to deposition of overlying gravely sand or formation of residuum in upper unit. Deposits beneath highest topographic surfaces present only on drainage divides; those beneath lower surfaces occur chiefly in terrace remnants and valley fills. Locally includes small areas of alluvium, estuarine, and marine deposits (**aeb**), loamy or clayey sand decomposition residuum with crumbly quartz clasts (**zlg**, **zss**), sandy clay to clayey sand decomposition residuum (**zle**), or alluvium (**al**). In north includes some pre-Wisconsin outwash sand and gravel. Locally overlain by eolian sand and silt (**ed**, **el**) or swamp deposits (**hs**). Thickness of residuum generally 2.5-5 m; thickness of underlying gravelly sand commonly 3-10 m, locally more than 20 m

PRE-ILLINOIAN

tch CLAYEY TO LOAMY TILL—Red, reddish-yellow, yellow, reddish-brown, yellowish-brown, brown, or mottled silty clay, silty clay loam, and clay loam with minor clayey silt and loam. Noncalcareous; generally leached throughout. Nonsorted or poorly sorted; nonstratified or partly stratified. Friable; commonly cemented to ferruginous conglomerate. In some areas deposit is a poorly stratified gravelly diamicton that in part may be alluvium and outwash sand and gravel (**agq**). Sparingly pebbly to gravelly; scattered cobbles; boulders rare. Clast lithology varies, reflecting composition of bedrock and other source materials; clasts dominantly local bedrock. Pebbles and cobbles chiefly subangular to well-rounded quartzite, sandstone, conglomerate, chert, gneiss, and granite; local arkose, argillite, siltstone, shale, slate, diabase, and basalt; limestone very rare. Boulders chiefly quartzite, sandstone, gneiss, and granite. Clasts of cemented gravel common locally. Intensely weathered in upper 4-5 m; 70-80 percent of clasts weathered, 30-60 percent crumble to powder. Chert fragments partly decomposed; gneiss commonly disintegrated; quartzite cobbles have thin glassy patina. Intense iron oxide stains on quartzite clasts; gibbsite common in surface soil. Very discontinuous; present only on uplands; eroded from valleys. Scattered cobbles and boulders on surfaces where till absent. Commonly modified by colluviation and solifluction activity in upper 1-2 m. Includes some residuum (**zlm**, **zlj**), colluvium, solifluction deposits, and, alluvium (**al**). Thickness generally 0.5-3 m, locally 6 m

PLEISTOCENE AND TERTIARY

agr ALLUVIUM, OUTWASH, AND LAKE DEPOSITS (Mannetto Gravel on Long Island, New York)—Complex deposit of unconsolidated sediments of varied compositions, genesis, and ages. Commonly horizontally bedded reddish-yellow, orange, orange-brown, yellowish-brown, brown, or mottled fine to coarse quartz-pebble gravel with interbeds and lenses of yellow, yellowish-brown, light-gray, or white sand or gray clayey silt; scattered intensely weathered pebbles, cobbles, and boulders of igneous and metamorphic rocks and ferruginous sandstone. In some areas, entirely reddish-yellow, yellow, yellowish-brown, or brown quartz sand. In other areas, intensely weathered quartz-pebble gravel with no erratic clasts; pebbles pitted and stained by iron oxides. At one locality consists of upper unit (12 m) of very weathered red and reddish-yellow sand and pebble gravel with intense iron oxide stains, middle unit (30 m) of light-gray crossbedded sand, and lower unit (12 m) of alternating thin beds of glaciolacustrine(?) sand and silt. At another locality consists of unweathered cobbly gravel with abundant granitic clasts overlying 6 m of oxidized clay and 4 m of unoxidized clay. In some places in north, unit apparently is entirely a complex deposit of outwash, ice-contact(?), and deltaic(?) sand and gravel with some till and flow till; locally glaciotectonically folded and thrust faulted. Although entire deposit was interpreted to consist of late Wisconsin glaciofluvial and glaciolacustrine sediments (Sirkin, 1982, 1986), some of the glaciofluvial and glaciolacustrine sediments may be early Wisconsin and Illinoian in age (Stone and Borns, 1986). Some of the erratic-free quartz-pebble gravel and sand probably is preglacial alluvium. Thickness commonly more than 50 m, locally more than 72 m

QUATERNARY AND TERTIARY

zss CLAYEY SAND DECOMPOSITION RESIDUUM WITH CRUMBLY QUARTZ CLASTS[1] (Bridgeton Formation in New Jersey)—Orange-red, red, yellowish-orange, orange-brown, reddish-brown, brown, or mottled clayey sand decomposition residuum that grades down into yellow, yellowish-brown, reddish-brown, orange-brown, brown, or white gravelly sand and sand. Residuum massive or faintly stratified, compact, noncalcareous. Rubified; gibbsite, halloysite, and endellite abundant as mineral alteration products; iron and manganese oxide stains common. Underlying gravelly sand and sand poorly to well sorted, poorly to well stratified, generally 3-8 m thick but locally more than 15 m thick. Commonly crossbedded quartzose or arkosic sand with scattered pebbles, pebble lenses, or thin beds of gravel; locally horizontal alternating beds of sand and gravel. Sand and gravel commonly stained by intense iron and manganese oxides; upper part commonly cemented to ferruginous conglomerate. Clasts rounded to very well rounded. Rare boulders and large cobbles chiefly quartzite and sandstone; small cobbles and pebbles chiefly quartzite, sandstone, and chert; local shale, arkose, conglomerate, diabase, basalt, gneiss, schist, or granite. Average size of clasts decreases southward. Map unit intensely weathered; granite, gneiss, and schist clasts saprolitized in residuum, rubified or with thick weathering rinds in sand and gravel; arkosic sandstone and shale pebbles decomposed; chert fragments soft and chalky; quartz and quartzite pebbles commonly crumble to tripoli, a friable silica powder. Alluvium deposited on at least two topographic surfaces. Present only on broad drainage divides. In places map unit includes small areas of sandy clay to clayey sand decomposition residuum (**zle**) and gravelly sand and loamy decomposition residuum (**asm**). Locally overlain by eolian sand and silt (**ed**, **el**). Thickness generally 5-9 m

zlg LOAMY DECOMPOSITION RESIDUUM WITH CRUMBLY QUARTZ CLASTS[1] (Beacon Hill Gravel in New Jersey and Bryn Mawr Gravel in Pennsylvania)—Orange, orange-brown, reddish-brown, brown, or mottled gravelly loam, sandy loam, loam, clay loam, and minor clay decomposition residuum that grades down into orange-brown, reddish-brown, brown, or light-gray sand and gravel. Residuum massive or faintly stratified, compact, noncalcareous. Rubified; gibbsite, halloysite, and endellite abundant as mineral alteration products; intense iron and manganese oxide stains. Underlying sand and gravel generally well sorted, well stratified; typically horizontally bedded sandy gravel or crossbedded sand stained by iron and manganese oxides. Upper part commonly cemented to ironstone. Sand almost exclusively quartz grains coated by iron oxides. Clasts chiefly rounded to very well rounded quartz, quartzite, and chert. In New Jersey, most clasts are smaller than 2.7 cm, locally 10-30 cm; in Pennsylvania, deposit locally contains cobbles and boulders as large as 1 m. Map unit very intensely weathered; chert fragments soft and chalky or represented only by silt residues; quartz and quartzite pebbles commonly crumble to tripoli, a friable silica powder. Alluvium occurs only as isolated erosional remnants of channel fills on uplands. Total thickness of residuum and underlying sand and gravel typically 6-9 m in New Jersey, 6-15 m in Pennsylvania

zle SANDY CLAY TO CLAYEY SAND DECOMPOSITION RESIDUUM[1]—Red, yellowish-orange, orange, reddish-yellow, greenish-yellow, yellow, bluish-green, green, olive, reddish-brown, yellowish-brown, greenish-brown, brown, greenish-gray, brownish-gray, or mottled sandy clay, clayey sand, fine sandy loam, and loamy fine sand decomposition residuum that grades down into Tertiary and Cretaceous bedrock. Noncalcareous. Nonsorted; massive or with faint relic stratification. Loosely consolidated; friable. Generally quartzose, locally glauconitic. Pods or lenses of lag gravel, chiefly small rounded pebbles of quartz and quartzite, locally introduced from above in upper part by bioturbation. Includes some areas of clayey sand and loamy decomposition residuum with crumbly quartz clasts (**zss**, **zlg**), gravelly sand and loamy decomposition residuum (**asm**), alluvial, estuarine, and marine gravel, sand, silt, and clay (**aeb**), and alluvium (**a**l). Locally overlain by eolian sand and silt (**ed**, **el**), peat (**hp**), or swamp deposits (**hs**). Thickness generally 1-3 m, rarely more than 6 m

rcc CHERTY CLAY SOLUTION RESIDUUM[1]—Reddish-yellow, reddish-brown, yellowish-brown, brown, or mottled silty clay, sandy clay, and silt loam. Noncalcareous or calcareous. Nonsorted; nonstratified; generally massive. Plastic; sticky where damp. Chert commonly present as angular to subrounded granules, pebbles, cobbles, and boulders and locally as irregular blocks. Lower part contains solution-eroded slabs of limestone or dolomite; residuum extends into fractures in underlying limestone or dolomite bedrock. Contact with bedrock abrupt; bedrock surface commonly pinnacled. Sinks and other karst features common. Chiefly in valleys and lowland areas. Includes areas of red, reddish-yellow, brownish-yellow, yellowish-brown, brown, or mottled clay loam, silty clay loam, silt loam, or sandy loam colluvium on slopes, generally 2-6 m thick but locally more than 12 m thick. Colluvium generally calcareous; poorly sorted; chiefly on steep to moderate slopes and foot slopes. Clasts in colluvium generally chert, limestone,, and dolomite; locally sandstone or shale

from adjacent ridges. Also includes alluvium (**al**) in valleys. Thickness generally less than 2 m, locally more than 10 m

rcr CHERTY CLAY SOLUTION RESIDUUM AND TILL[1]—Distinguished on basis of presence of thin and discontinuous till (Illinoian and possibly pre-Illinoian) in addition to cherty clay solution residuum which is the same as unit **rcc**. Till is red, reddish-yellow, reddish-brown, yellowish-brown, or mottled clay loam and silty clay loam. Till calcareous or noncalcareous; nonsorted; nonstratified. Clasts rare, chiefly chert and sandstone. Intensely weathered in upper 4-5 m, less weathered below. Gibbsite present in surface soil locally. Till generally modified by colluviation and solifluction activity. Included colluvium locally consists of redeposited till. Thickness of till generally 0.5-3 m; thickness of residuum less than 2 m

rcj CLAYEY SOLUTION RESIDUUM[1]—Red, orange, reddish-brown, brown, or mottled clay, clay loam, and silty clay loam; locally sandy clay. Noncalcareous or calcareous. Poorly sorted; nonstratified; generally massive. Plastic; sticky where damp. Lower part contains smooth slabs of limestone or dolomite; residuum extends into fractures in underlying limestone or dolomite bedrock. Sinks and other karst features common. Includes areas of red, reddish-yellow, brownish-yellow, brown, or mottled clay loam, silty clay loam, silt loam, loam, and sandy loam colluvium, generally 2-6 m thick and locally 12 m thick. Clasts in colluvium chiefly limestone, dolomite, and chert; locally sandstone and shale. Also includes alluvium (**al**) in valleys. Thickness generally 1-3 m, locally more than 10 m

rci LOAMY TO CLAYEY SOLUTION RESIDUUM[1]—Yellowish-red, pale-yellow, yellowish-brown, reddish-brown, or mottled noncalcareous or weakly calcareous silt loam, silty clay loam, clay loam, silty clay, and clay. Chiefly derived by in-place solution of limestone and dolomite that locally contain thin interbeds of shale and sandstone. Moderately plastic to plastic. Contains fragments of chert where developed on siliceous carbonate rocks; clasts are chert, shale, and sandstone where developed on interbedded carbonate and clastic rocks. Includes colluvium, generally 2-4 m thick but locally 10 m thick, on moderate slopes and foot slopes. Colluvium poorly sorted, poorly stratified material with angular or subangular fragments of limestone, dolomite, chert, shale, and sandstone. Bedrock outcrops common locally. Sinkholes and underground caverns common. Map unit includes alluvium (**al**) in valleys. Thickness generally less than 2 m

slb MICACEOUS SAPROLITE[1]—Yellowish-red, red, reddish-brown, brown, or gray micaceous clayey sand and clayey sandy silt. Developed in felsic micaceous schist. Colors reflect abundance of mafic minerals in parent rock. Clay minerals chiefly kaolinite with minor gibbsite; mica mostly weathered to vermiculite and (or) kaolinite in surface soil. Shrink-swell potential generally low. Includes areas of colluvium, alluvium (**al**), and bedrock outcrops. Thickness less than 1 m to more than 10 m

slc SILTY TO CLAYEY SAPROLITE[1]—Red, reddish-brown, yellowish-brown, brown, greenish-gray, or gray fine sandy silt and clayey silt. Developed in phyllite, argillite, slate, and felsic volcanic rocks. Quartz clasts and slabs or splinters of parent rock common in lower part. Kaolinite dominant clay mineral; gibbsite present locally. Includes colluvium on slopes and foot slopes, alluvium (**al**) in valleys, and areas of bedrock outcrops. Thickness 0.5-5 m

ssb SILTY TO CLAYEY SANDY SAPROLITE[1]—Red, reddish-yellow, reddish-brown, or white silty sand and clayey sand. Developed in gneissic granite, felsic schist interlayered with gneiss, foliated granitic rocks, and felsic gneiss. Kaolinite dominant clay mineral in upper part, either kaolinite or gibbsite dominant in lower part; minor vermiculite and illite. Dominant weatherable mineral in lower part partly weathered feldspar; muscovite or its pseudomorphs dominant in upper part. Strongly acid; permeable. Grades into bedrock through an irregular zone of partly weathered slabby rock fragments in a matrix of micaceous silt to clayey sand. Includes slabby to bouldery colluvium, especially on foot slopes, alluvium (**al**), and areas of bedrock outcrops. Colluvium commonly contains abundant fragments of vein quartz. Thickness typically less than 2 m, locally more than 6 m

PRE-TERTIARY

R BEDROCK

[1]For purposes of this map, colluvium is material transported and deposited by slow mass-wasting processes, chiefly creep. Rock waste is loose rock debris derived by frost shattering of hard clastic rocks and accumulated at the bases of steep slopes by gravitational forces. Solifluction deposit is a general term for material transported and deposited by viscous flow of unconsolidated debris saturated with water. Decomposition residuum is material derived by in-place decomposition of clastic bedrock, with no appreciable subsequent lateral transport. Disintegration residuum is material derived by in-place mechanical disintegration of clastic bedrock, with no appreciable subsequent lateral transport. Solution residuum is insoluble residues derived chiefly by in-

place solution of carbonate rocks, with no appreciable subsequent lateral transport. Saprolite is earthy material derived by in-place decomposition of igneous and metamorphic rocks, with no appreciable subsequent transport.

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