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Map of Surficial Deposits and Materials in the Eastern and Central United States (East of 102° West Longitude)

By David S. Fullerton, Charles A. Bush, and Jean N. Pennell

2003

U.S. Department of the Interior
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INTRODUCTION

The surficial geologic map of the Eastern and Central United States depicts the areal distribution of surficial geologic deposits and other materials that accumulated or formed during the past two million years, the period that includes all activities of the human species. These materials are at the surface of the Earth. They make up the "ground" on which we walk, the "dirt" in which we dig foundations, and the "soil" in which we grow crops. Most of our human activity is related in one way or another to these surface materials that are referred to collectively by many geologists as "regolith," the mantle of fragmental and generally unconsolidated material that overlies the bedrock foundation of our continent. The map was derived primarily from 31 published maps in the U.S. Geological Survey's Quaternary Geologic Atlas of the United States map series (U.S. Geological Survey Miscellaneous Investigations Series I–1420). It was compiled at 1:1,000,000 scale, to be viewed as a digital map at 1:2,000,000 nominal scale and to be printed as a conventional paper map at 1:2,500,000 scale.

The surficial geologic map provides a broad overview of the areal distribution of more than 150 types of surficial deposits and materials. Most of the map units are either surface deposits or residual materials. Surface deposits are sediments or materials that accumulated or were emplaced after component particles were transported by ice, water, wind, or gravity. The glacial sediments that mantle the Earth's surface in much of the Northern United States east of the Rocky Mountains are in this category, as are the gravel, sand, silt, and clay that were deposited in past and present streams, lakes, and oceans. In contrast, residual materials formed in place, without significant transport of component particles by ice, water, wind, or gravity. They are products of modification or alteration of pre-existing surficial deposits, surficial materials, or bedrock. For example, intense weathering of stream deposits, or even solid rock, by chemical processes during a long time interval produces a residual surficial material (residuum) that is greatly transformed from its original physical and chemical state.

The map does not show soils as recognized in agriculture, agronomy, or pedology. It is a generalized map of soils as recognized in engineering geology, or the substrata or parent materials in which agricultural soils formed. Where surficial deposits or materials are thick, agricultural soils are developed only in the upper part of a surficial deposit or material. Where they are thin, agricultural soils commonly are developed through the entire thickness of a surficial deposit or material.

In recent years, surficial deposits and materials have become a focus of much interest by scientists, environmentalists, governmental agencies, and the general public. They are the foundations of our ecosystems, the materials that support plant growth and animal habitat, and materials through which travels much of the water required for our agriculture, our industry, and our general well being. They also are materials that can be contaminated by pesticides, fertilizers, acid rain, and toxic wastes. In this context, the value of the surficial geologic map is evident.

The map unit descriptions provide information about (1) genesis (processes of origin) or environments of deposition: for example, deposits related to glaciation (glacial deposits), flowing water (alluvial deposits), lakes (lacustrine deposits), wind (eolian deposits), or gravity (mass-movement deposits); (2) age: for example, how long ago the deposits accumulated or were emplaced or how long specific processes have been acting on the materials; (3) properties: the physical, chemical, and mechanical or engineering characteristics of the materials; and (4) thickness or depth to underlying deposits or materials or to bedrock. This approach provides information appropriate for a broad user base. The map is useful to Federal, State, and other governmental agencies, to engineering and construction companies, to environmental organizations and consultants, to academic scientists and institutions, and to students or laymen who wish to learn more about the deposits and materials that conceal the bedrock. The map can facilitate regional and national overviews of (1) geologic hazards, including areas of swelling clay and areas of landslide deposits and landslide-prone materials; (2) natural resources, including aggregate for concrete and road building, peat, clay, and shallow sources for groundwater; and (3) areas of special environmental concern, including areas of intense erosion and areas of potential contamination of soil and groundwater.

The surficial deposits and materials mapped are distinguished in part on the basis of particle size or texture, particle lithology or composition, and other physical, chemical, and engineering characteristics. Several classification systems for engineering and agricultural soils are in use, and terminology differs. The textural or particle-size divisions (for example, clay, sand, pebbles, or boulders) and the matrix nomenclature (for example, loamy sand, clay loam, or silty clay) of the U.S. Department of Agriculture are used here to ensure uniformity of terminology.

Letter symbols in parentheses indicate map units that are distinguished on the basis of deposits or materials of two or more genetic categories. The significance of time divisions (for example, Holocene, Pleistocene, Wisconsin, Illinoian, or pre-Illinoian) is indicated in table 1.

Table 1. Time terminology applied to surficial deposits and materials in the Eastern and Central United States.

<table>
<tr><th>Time scale
(sidereal years)</th><th>Informal nomenclature based on mountain glaciation</th><th>Informal nomenclature based on continental glaciation</th><th>Informal time nomenclature</th><th colspan="2">Formal time nomenclature</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Holocene</td><td rowspan="8">QUATERNARY</td></tr>
<tr><td>≈11,680</td><td>Pinedale</td><td>Late Wisconsin</td><td rowspan="4">Late Pleistocene</td><td rowspan="7">Pleistocene</td></tr>
<tr><td>≈35,000</td><td rowspan="3"></td><td>Middle Wisconsin</td></tr>
<tr><td>≈55,000</td><td>Early Wisconsin</td></tr>
<tr><td>≈80,000</td><td>Sangamon</td></tr>
<tr><td>≈128,000</td><td>Bull Lake</td><td>Illinoian</td><td rowspan="2">Middle Pleistocene</td></tr>
<tr><td>≈310,000</td><td rowspan="3">Pre-Bull Lake</td><td rowspan="3">Pre-Illinoian</td></tr>
<tr><td>≈778,000</td><td>Early Pleistocene</td></tr>
<tr><td>≈1,806,000</td><td></td><td>Pliocene</td><td>TERTIARY</td></tr>
</table>

SURFICIAL DEPOSITS

GLACIAL DEPOSITS (TILL)

Till is a predominantly nonsorted and nonstratified, generally heterogeneous mixture of clay, silt, sand, granules, pebbles, cobbles, and boulders deposited directly by glacial ice. In some places, the till was modified by collapse, creep, flow, and other surface processes subsequent to deposition. The till that comprises the map unit in many areas overlies older till and stratified deposits that are not included in the map unit. The thicknesses cited generally apply only to the surface (youngest) till. The till **matrix** is the finer grained (clay, silt, and sand) material in which larger particles or clasts are embedded. The **texture** of till is the relative proportion of sand, silt, and clay in the matrix. The composition (for example, shale, sandstone, limestone, granite, gneiss) of **clasts** (granules, pebbles, cobbles, boulders, and blocks) in till varies greatly in some regions, and it varies both laterally and vertically in some exposures. It reflects the composition of the bedrock and surficial deposits and materials that were incorporated by the ice. **Ground moraine** is a sheet or layer of till that characteristically forms a gently rolling or undulating plain of low relief. In some areas, the map unit is thin, discontinuous patches of till separated by other kinds of deposits or materials or by numerous or extensive bedrock outcrops. Ground-moraine deposits include some glacial deposits that in the past were termed “sheet moraine,” “draped moraine,” and “attenuated moraine.” **End moraine** is (1) a thickened, broad, low, ridgelike accumulation of till; (2) a complex deposit of narrow, sharply defined, concentric or overlapping ridges of till; or (3) a thickened belt of till that formed at or near the margin of an active ice sheet. Some end-moraine deposits have hummocky surface topography and some are pitted by ice-block depressions. **Stagnation moraine** is a hummocky accumulation of till produced by collapse of till and associated stratified deposits. The sediments overlying stagnant or dead ice collapsed and moved laterally (chiefly by creep, sliding, and flow) into depressions. The surfaces of many stagnation-moraine deposits are pitted by ice-block depressions.

Till of late Wisconsin and Holocene(?) age[1]

Clayey till—The matrix is chiefly calcareous clay, silty clay, silty clay loam, or clay loam. In most areas, the clay was derived primarily from older off-shore glacial-lake deposits that were overridden and incorporated by glacial ice. The map unit includes relatively small areas of loamy till (units tl, tm) and sandy till (units ts, tt)

tc **Ground-moraine deposits—**The till is thick and continuous in some places and thin and discontinuous in others. In some areas, the deposit is a thin and discontinuous veneer or blanket of clayey till that is uniformly draped over older loamy till. In northeastern Indiana, northern Ohio, and some other regions, extensive areas of ground moraine deposits are overlain by unmapped glacial-lake clay and silt (unit lc). The thickness of the till generally is 0.5 to >20 m

td **End-moraine deposits—**The thickness of the till generally is 2 to >30 m

Loamy till—The matrix is chiefly calcareous loam, silt loam, sandy loam, sandy clay loam, silty clay loam, or clay loam. The clay minerals in most of the till in Iowa, South Dakota, North Dakota, and western and southwestern Minnesota are predominantly smectite (swelling clay). In some areas in Ohio, Pennsylvania, New York, New Jersey, and other States, the till was modified extensively by solifluction, colluviation, and other mass-wasting processes. The map unit includes relatively small areas of clayey till (units tc, td) and sandy till (units ts, tt)

tl **Ground-moraine deposits—**The till is thick and continuous in some places and thin and discontinuous in others. Extensive bedrock outcrops are common in rugged terrain. In northeastern Ohio and northwestern Pennsylvania, some deposits that previously were mapped as end-moraine deposits are overridden end-moraine or stagnation-moraine deposits; ground-moraine till 1–3 m thick is draped over older loamy end-moraine or stagnation-moraine deposits (units tm, tn, tk, tj) and the hummocky surface topography is inherited from the buried deposits. The overridden deposits here are shown as ground-moraine deposits. The thickness of the till generally is 1 to >30 m

tm **End-moraine deposits—**Some till end-moraine deposits are replaced laterally by kame end-moraine deposits (unit ke), which are included in the map unit. The thickness of the till generally is 2 to >100 m

tn **Stagnation-moraine deposits—**The thickness of the till generally is 2 to >30 m

[1]Some glacial, ice-contact, glaciofluvial, and glacial-lake deposits in northeastern Minnesota, northern Wisconsin, and northern Michigan may be earliest Holocene in age.

to **Flood-scoured till—**Till that was eroded by catastrophic, glacial-lake outburst floods. The map unit includes erosional remnants of the surface till and exhumed older till, erosional remnants of outwash sand and gravel (units gs, gg), catastrophic flood deposits (units ah, ak), and flood-scoured bedrock. The thickness of the till generally is 0.5–5 m. Mapped in North Dakota. Also see map unit ak

Sandy till—The matrix is chiefly calcareous or noncalcareous sandy loam, loamy sand, or sand. In most regions, the sand was derived primarily from igneous and metamorphic rocks that were eroded and transported by glacial ice. In some areas, the sand was derived primarily from coarse-grained sedimentary rocks (sandstone and conglomerate) or older surficial deposits (sand and gravel). The map unit includes relatively small areas of clayey till (units tc, td) and loamy till (units tl, tm, tn). The distinction between sandy till (units ts, tt) and loamy till (units tl, tm, tn) is arbitrary in some areas

ts **Ground-moraine deposits—**The till is thick and continuous in some places and thin and discontinuous in others. Extensive bedrock outcrops are widespread where the till is thin. The thickness of the till generally is 0.5 to >15 m

tt **End-moraine deposits—**The thickness of the till generally is 5 to >30 m

tx **Clayey to sandy till—**On Long Island, N.Y., the calcareous matrix ranges from clay to sand, and the grain size commonly varies markedly over short distances, laterally and vertically. The till commonly is interbedded with flow till and stratified sand, silt, and clay. Typically, it contains clasts of lake clay, silt, and sand (units lc, lf, ls) and marine clay, silt, and sand (units mc, me). In some places, the map unit includes clayey to sandy till that possibly is Illinoian in age.

West of the Missouri River in North Dakota, the calcareous matrix ranges from silty clay to loamy sand. The clay minerals are predominantly smectite (swelling clay). The till is thin and discontinuous; patches of till are separated by areas of residuum, colluvium, other deposits, and bedrock. Residual glacial erratic cobbles and boulders are scattered on the land surface. In some places, the map unit includes relatively small areas of exhumed older till of similar texture.

The thickness of the till in New York (including the interbedded and incorporated stratified sediments) is 1 to >30 m. The thickness in North Dakota is 0.5 to >8 m

(tq) **Collapsed till and glacial-lake deposits—**A complex map unit of till (unit tl), lake clay and silt (unit lc), and blocks of sand, gravel, and bedrock. In many areas, the deposit is either calcareous loamy till (unit tl) or massive or faintly bedded, calcareous lake silt and clay (unit lc). Locally, it is a nonsorted, nonbedded mixture of angular, subangular, and rounded blocks of sand, gravel, and bedrock in a loose, silty matrix. Many of the blocks were frozen clasts when they initially were deposited on ice. The map unit is chiefly till and off-shore glacial-lake sediments deposited on stagnant or dead ice that subsequently melted. The collapsed deposits commonly are deformed, tilted, and (or) faulted. The thickness of the deposits generally is >3 m. Mapped in North Dakota

(tg) **Till, ice-contact deposits, glaciofluvial deposits, and glaciolacustrine deposits of late Wisconsin and Illinoian age—**A complex of units tk, ka, gg, gs, ga, lc, lf, ls, and la in an area that was covered by ice during Illinoian glaciation and was surrounded by ice during maximum late Wisconsin glaciation. Mapped in northeastern Ohio

Till of Illinoian age

ta **Clayey to loamy till—**The matrix is chiefly calcareous clay, silty clay, silty clay loam, or clay loam. It is thick and continuous in some places and thin and discontinuous in others. The map unit includes areas of exhumed older surficial deposits and bedrock outcrops. The till commonly is overlain by <2 m of loess (units el, eb) or windblown sand (unit es). The thickness of the till generally is 0.5 to >20 m. Mapped in northwestern Illinois and southern Wisconsin

Loamy till—The matrix is chiefly calcareous loam, silt loam, sandy loam, silty clay loam, or clay loam. The till is intensely weathered where it was not eroded or buried by younger deposits. In Ohio, Pennsylvania, and New Jersey, commonly it is oxidized and leached throughout. In those States, the till in some areas is covered by 0.5–3 m of loess (unit el) or windblown sand (unit es), by 1–6 m of colluvium, or by 1–3 m of solifluction deposits. Farther west, commonly a buried soil is developed in the till and the paleosol is overlain by 1–10 m of loess (units el, eb) or eolian sand (unit es). The deposits possibly are products of more than one glaciation

tk **Ground-moraine deposits—**The till in many places is thin, discontinuous, and intensely dissected; patches of till are separated by extensive areas of colluvium, residuum, other deposits, and bedrock outcrops. Residual erratic cobbles and boulders are scattered on the land surface. Ground-moraine surfaces in Ohio, Indiana, Illinois, Iowa, and

Wisconsin commonly are characterized by subdued rolling topography. The ground-moraine deposits in north-central Pennsylvania include unmapped, subdued end-moraine deposits that have relief of 2–10 m and are as thick as 45 m. The thickness of the ground-moraine till generally is 0.5 to >20 m

tj **End-moraine deposits—**The till is in broad, low, smoothly sloping ridges or deeply eroded ridges. Locally, till end-moraine deposits are replaced laterally by kame end-moraine deposits (unit ka), which are included in the map unit. The thickness of the till generally is 5–15 m; locally, it is >20 m. Mapped in Illinois and Wisconsin

tf **Loamy till of Illinoian and pre-Illinoian age—**A complex of map units tk and tb in western Wisconsin. The areal distributions of till of Illinoian age (unit tk) and till of pre-Illinoian age (unit tb) in this region are not clearly defined

Till of pre-Illinoian age

tp **Clayey to loamy till—**The matrix is chiefly noncalcareous silty clay, clayey silt, silty clay loam, clay loam, or loam. In most areas, the deposits are discontinuous; extensive areas of colluvium, residuum, other deposits, and bedrock outcrops separate patches of till on uplands, and residual glacial erratic cobbles and boulders are scattered on the land surface. The till is intensely weathered; typically, it is oxidized and leached throughout. Commonly, it is a well-cemented ferruginous diamicton. The till in most areas was greatly modified by colluviation, solifluction, and other mass-wasting processes. The map unit possibly includes till units deposited during more than one pre-Illinoian glaciation. It includes some glaciofluvial deposits (unit gb) and channel and flood-plain alluvium (unit at) of pre-Illinoian age. The oldest till and associated (unmapped) ice-dammed lake deposits that are included in the map unit at some sites have reversed remanent geomagnetic polarity, indicating that they are older than ≈ 778,000 years. The till locally is overlain by <2 m of loess (unit el) or windblown sand (unit es) or by 1 to >10 m of colluvium or solifluction deposits. The thickness of the till generally is 0.5–3 m; locally, it is 6 m. Mapped in eastern Pennsylvania and New Jersey

th **Clayey to sandy till—**The matrix is chiefly noncalcareous clay, clayey sand, clay loam, or sandy loam. The till is discontinuous; extensive areas of colluvium and sheetwash alluvium (unit ca) and bedrock outcrops separate patches of till, and residual glacial erratic cobbles and boulders are scattered on the land surface. Much of the till is colluviated. The deposits are deeply weathered; most of the till on uplands is oxidized and leached throughout. The map unit possibly includes till units deposited during more than one pre-Illinoian glaciation. The oldest till included in the map unit has reversed remanent geomagnetic polarity, indicating that it is older than ≈ 778,000 years; it may be late Pliocene in age. The till commonly is overlain by 2–4 m of loess (units el, eb) or windblown sand (unit es). The thickness of the till generally is 0.5–5 m. Mapped in southeastern Minnesota and northeastern Iowa

tb **Loamy till—**The matrix is chiefly calcareous or noncalcareous loam, silt loam, sandy loam, or clay loam. The clay minerals in most regions are predominantly smectite (swelling clay). Where not intensely eroded, the till nearly everywhere is covered by loess (units el, eb), which locally is >20 m thick, or by 1–3 m of windblown sand (unit es). Where not covered by eolian deposits, the till typically is intensely weathered. It is thick and continuous in some areas and thin and discontinuous in others. In some regions (particularly near the mapped southern limit of the till in Iowa, Missouri, and Kansas), patches of till are separated by numerous or extensive areas of sheetwash alluvium, residuum, colluvium, or bedrock outcrops; residual glacial erratic cobbles and boulders are scattered on the land surface. In Wisconsin, the till locally overlies saprolite (similar to unit sa). The thickness of the till varies from 0.5 m where thin to >150 m in buried valleys.

The map unit includes till units deposited during five pre-Illinoian Pleistocene glaciations and at least one late Pliocene glaciation. Till units deposited during two or more glaciations are superposed at some sites, whereas only one till unit is present at some other sites. Where superposed, the till units in some places are separated by paleosols, weathered zones, or stratified deposits. Owing to a complex history of erosion and till deposition, the youngest tills exposed at different sites in an area may differ greatly in age. The youngest Pleistocene till included in the map unit is younger than the Lava Creek B tephra, an airfall volcanic ash layer produced by a catastrophic volcanic eruption in the Yellowstone National Park region ≈ 639,000 years ago (the till overlies the volcanic ash). All of the older tills included in the map unit are older than that tephra (they underlie the volcanic ash). The tills deposited during the latter three (of the five) Pleistocene glaciations have normal remanent geomagnetic polarity, indicating that they are younger than ≈ 778,000 years. The tills deposited during the earlier two (of the five) Pleistocene glaciations have reversed remanent polarity; they are older than ≈ 778,000 years and younger than ≈ 950,000 years

(tr) **Discontinuous till, discontinuous glaciofluvial deposits, and concentrations of erratic boulders and cobbles—**A complex map unit of glacial and glaciofluvial deposits on drainage divides and other upland bedrock surfaces high above the modern valley floors west of the Missouri River in North Dakota and South Dakota. The deposits possibly are products of more than one pre-Illinoian glaciation; most of them probably are late Pliocene in age. All of the deposits are discontinuous. In South Dakota, extensive areas of residuum, colluvium, sheetwash alluvium, and bedrock outcrops separate patches of intensely weathered till, glaciofluvial deposits (outwash), and "boulder belts." Residual glacial erratic cobbles and boulders are scattered widely on the land surface. In North Dakota, residual glacial erratic boulders on high-altitude bedrock erosion surfaces generally are the only remaining vestige of late Pliocene glaciation. The till and glaciofluvial deposits in South Dakota commonly are overlain by loess (units el, eb) or windblown sand (unit es) 0.2–1.5 m thick. The **till** matrix ranges from clay to loamy sand. The clay minerals are predominantly smectite (swelling clay). The till is extremely weathered; in most places it is preserved only where it is (or was) covered by loess. The noncalcareous or weakly calcareous **outwash silt, sand, and gravel** are intensely weathered; the granules, pebbles, cobbles, and boulders are predominantly very resistant igneous and metamorphic rocks from Minnesota or Canada. The **boulder concentrations** are rubbly deposits of cobbles and boulders as large as 3 m in diameter, in a silty or sandy matrix. Typically, nearly 100 percent of the cobbles and boulders are very resistant erratic igneous and metamorphic rocks from Minnesota or Canada. The thickness of the till generally is 0.2–2 m; locally, it is >3 m. The thickness of the outwash deposits generally is 0.2–2 m

GLACIOTECTONIC DEPOSITS

fa **Surficial deposits, surficial materials, and bedrock masses that were deformed and (or) transported intact by glacial ice—**Chiefly (1) steeply tilted bedrock blocks or rafts overlying till and (or) stratified sediments; (2) stacked or imbricated slices of bedrock, till, and stratified sediments forming parallel or concentric ridges; (3) deformed masses of bedrock and surficial deposits characterized by overturned folds; or (4) isolated blocks, isolated irregular masses, or isolated, relatively smooth, nearly equidimensional hills down-glacier from source depressions. Some deposits are covered by till deposited by overriding ice. The thickness of the deposits is 2 to >100 m. Relatively small deposits are mapped on Long Island, N.Y., and Martha's Vineyard, Mass.; large deposits are mapped in North Dakota and South Dakota

LACUSTRINE (LAKE) DEPOSITS

(lk) **Beach sand and dune sand of Holocene age (in beaches, spits, and barriers)—**A complex map unit along the shores of Lake Superior and Lake Erie. The calcareous **beach deposits** are chiefly (1) coarse to fine sand with minor gravel or (2) sand containing isolated granules and pebbles. Locally, the deposits include scattered shell fragments and plant debris. The **dune sand** is similar to unit ed. The thickness of the beach deposits generally is 0.5–10 m

Glacial and postglacial lake deposits of Holocene and late Wisconsin age[2,3]

lc **Clay and silt—**Chiefly off-shore and deep-water deposits of former glacial and postglacial lakes; some deposits are in small separate basins. In North Dakota and South Dakota, some deposits accumulated in ice-walled or ice-floored lakes. In North Dakota, South Dakota, and parts of Minnesota and Iowa, the clay minerals are predominantly smectite (swelling clay). In most regions, the sediment is very sticky and plastic when damp and

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[2]Some glacial, ice-contact, glaciofluvial, and glacial-lake deposits in northeastern Minnesota, northern Wisconsin, and northern Michigan may be earliest Holocene in age.

[3]Nonglacial lakes persisted in parts of some of the basins of former large glacial lakes long after meltwater ceased to enter those basins. The sediments deposited in the late Wisconsin glacial lakes and the Holocene postglacial lakes in the same basins have not been distinguished.

hard when dry. The deposits are thin and discontinuous in some areas. The map unit includes extensive areas of wave-washed or current-scoured till or areas of bedrock overlain by discontinuous lag gravel. Gullies are common adjacent to larger streams that are inset into the deposits; landslides are common where the deposits underlie terraces or are exposed along streams or on lake shores. In some regions, extensive areas of clay and silt are overlain by peat (unit hp), swamp deposits (unit hs), loess (unit el), windblown sand (units es, ed), or channel and flood-plain alluvium (unit al). The thickness of the lake clay and silt generally is 1–10 m; locally, it is >45 m. Mapped from New England to North Dakota and South Dakota

lf **Silt and sand—**Chiefly calcareous off-shore and near-shore deposits of former glacial and postglacial lakes. In North Dakota, some deposits accumulated in small ice-walled or ice-floored lakes. In some places, the map unit includes lake sand and gravel (unit ls) in beach ridges, spits, tombolos, and offshore bars. The surface topography is hummocky where the sediment was deposited on or against stagnant or dead ice (see unit tq). Blowouts are common in some areas. In some places, <2 m of loess (unit el) or windblown sand (units es, ed) overlies the lake deposits. The thickness of the lake silt and sand generally is 1–10 m; locally, it is >20 m. Mapped in North Dakota, South Dakota, and Minnesota. Similar deposits elsewhere are included in map units ls and lu

ls **Sand and gravel—**Chiefly calcareous strand, shallow-water near-shore, and delta deposits of former glacial and postglacial lakes. In most areas, the deposits are predominantly near-shore sheet sand; gravel is abundant in beach ridges, spits, tombolos, and off-shore bars, and in delta topset beds. The map unit includes lake silt and sand (unit lf) where units ls and lf were not differentiated. The deposits are thin and discontinuous in some areas. Locally, the map unit includes wave-washed and current-scoured till or bedrock overlain by discontinuous lag gravel deposits. The surface topography is hummocky where the sediment was deposited on or against stagnant or dead ice (see map unit tq). In some places, the lake deposits are covered by <2 m of loess (unit el) or windblown sand (units es, ed); blowouts are common in some areas. The thickness of the lake sand and gravel generally is 1–10 m; locally, it is >30 m. Mapped from New England to North Dakota

lu **Clay, silt, sand, and gravel—**A complex of clay and silt (unit lc), silt and sand (unit lf), and sand and gravel (unit ls). The thickness of the lake deposits generally is 1–10 m; locally, it is >15 m. Mapped in Ohio, Pennsylvania, and New York

lh **Density-current underflow-fan deposits—**Chiefly calcareous silt, sand, and gravel in subaqueous underflow fans that formed when catastrophic, glacial floodwater entered glacial lakes. The surface topography is hummocky where the sediments were deposited on or against stagnant or dead ice. Some underflow-fan deposits are overlain by lake sand and gravel (unit ls) in beaches and offshore bars or by off-shore sheet sand (unit ls) that was distributed by waves and currents after deposition of the underflow-fan sediments. The underflow-fan sediments (unit lh) and the lake sand and gravel (unit ls) in some places are overlain by <5 m of loess (unit el) or windblown sand (units es, ed). The thickness of the density-current underflow-fan deposits generally is 3–30 m; locally, it is 60 m. Mapped in North Dakota

ld **Delta deposits—**Gravel, sand, silt, and clay deposited in nearly flat-topped deltas that formed where rivers or melt-water streams entered glacial lakes. The bottomset beds and foreset beds were formed beneath the lake surface; the topset beds, composed of nonglacial alluvium or glaciofluvial sediments, were formed at or above the lake surface. The deltas commonly are perched on valley walls. Throughout the northern part of the United States that was covered by ice during the last (late Wisconsin) glaciation, small lake-delta deposits are included in lake sand and gravel (unit ls), glaciolacustrine kame-delta deposits (unit kd), ice-contact sand and gravel (unit kg), and outwash sand and gravel (units gs, gg). The delta deposits in many areas are overlain by <2 m of loess (unit el) or windblown sand (units es, ed). The thickness of the delta deposits generally is 3–20 m; locally, it is >30 m. Mapped in North Dakota, South Dakota, New York, and New England

(lo) **Slack-water lake deposits and alluvium of late Wisconsin age—**Slack-water lakes were shallow lakes that were impounded in tributary valleys by aggrading outwash in major valleys. The map unit is a complex of (1) channel and flood-plain alluvium (unit al) and (or) sheetwash alluvium (unit wb) in the upper parts of valleys and on the valley walls and (2) narrow ribbons of channel and flood-plain alluvium (unit al) inset into terraces that are underlain by slack-water lake clay, silt, and fine sand in the lower parts of the valleys. The lake deposits grade laterally into, or interfinger with, alluvium in the upper parts of the valleys and interfinger with outwash sand and gravel (units gs, gg) in the lower parts of the valleys. The deposits locally are thin and discontinuous; in some places, they are intensely dissected. The thickness of the deposits generally is 1–10 m; locally, it is >40 m. Mapped in Illinois, Indiana, Ohio, and Kentucky

Lake deposits of Illinoian age

la **Glacial-lake clay and silt—**Most of the deposits accumulated in basins occupied by glacial lakes. In Illinois and Indiana, the map unit includes some slack-water lake deposits (unit ln). The deposits underlie terrace remnants in valleys that were blocked by glacial ice, or they underlie terrace remnants in valleys that were occupied by slack-water lakes (see unit ln). The deposits are intensely weathered; commonly they are leached throughout. In southwestern Minnesota, the clay minerals are predominantly smectite (swelling clay). The lake sediments are thin and discontinuous in some areas. Commonly, they are dissected by deep gullies; locally, they are intensely dissected, forming miniature badlands. In many areas, an interglacial soil is developed in the lake deposits and the paleosol is overlain by l–6 m of loess (unit el). In other areas, the lake deposits are overlain by <1.5 m of colluvium or <6 m of loess (unit el) and the paleosol is absent. The thickness of the lake deposits generally is 1–10 m; locally, it is 20 m. Mapped in Minnesota, Wisconsin, Illinois, Indiana, and Ohio

(ln) **Slack-water lake deposits and alluvium—**Slack-water lakes were shallow lakes that were impounded in tributary valleys by aggrading outwash in main valleys. The map unit is a complex of (1) channel and flood-plain alluvium (unit at) in the upper parts of valleys and on valley walls and (2) ribbons of channel and flood-plain alluvium (unit al) inset into terraces that are underlain by slack-water lake silt and fine sand in the lower parts of the valleys. The lake deposits grade laterally into, or interfinger with, alluvium (unit at) in the upper parts of the valleys and interfinger with outwash sand and gravel (unit ga) in the lower parts of the valleys. The deposits are intensely weathered and dissected; in some places, they are thin and discontinuous. The deposits locally are overlain by <6 m of loess (unit el). The thickness of the deposits generally is 1–4 m; locally, it is >6 m. Mapped in Ohio

Lake deposits of pre-Illinoian age

lb **Glacial-lake clay and silt—**Pond or lake sediment in depressions on uplands in northeastern Kansas. The deposits are chiefly massive, noncalcareous, plastic clay overlying oxidized calcareous till and overlain by leached loess (unit el). The thickness of the clay and silt generally is 1–12 m; locally, it is 21 m

(lp) **Slack-water lake deposits and alluvium—**Slack-water lakes were shallow lakes that were impounded in tributary valleys by aggrading outwash in the major valleys. The map unit is a complex of clay, silt, sand, and gravel beneath terrace remnants, in fills in abandoned paleovalleys, and on upland surfaces in Kentucky, Ohio, West Virginia, and Pennsylvania. Intensely weathered slack-water lake deposits commonly overlie older alluvium in paleochannels. The deposits are thin and discontinuous in many areas; commonly, they are dissected by deep ravines or valleys. In Ohio and West Virginia, the lake deposits have reversed remanent geomagnetic polarity, indicating that they are older than ≈ 778,000 years. In Pennsylvania, slack-water lake sediments deposited during at least two glaciations underlie dissected terrace remnants. The sediments beneath the oldest (topographically highest) terrace remnants have reversed remanent polarity, indicating that they are older than ≈ 778,000 years; the sediments beneath younger (lower) remnants have normal polarity and are inferred to have been deposited during an Illinoian glaciation represented by till (unit tk) in northwestern Pennsylvania. The deposits commonly are overlain by 1–3 m of colluvium, sheetwash alluvium, loess (unit el), or windblown sand (units es, ed). The thickness of the deposits generally is 1–30 m

lm **Marl of Holocene and late and middle Wisconsin(?) age—**Fresh-water marl interbedded with silt and clay and thin layers of peat, muck, or other plant debris and residues. The very calcareous marl locally is overlain by swamp deposits (unit hs). The thickness of the marl generally is less than 3 m. Mapped in southern Florida

lg **Pluvial clay, silt, sand, and dolomite of late Pleistocene age—**Chiefly lake sediments that accumulated in deflation basins and in subsidence depressions produced by collapse following dissolution of salt or gypsum bedrock by underground water. The deposits commonly contain thin beds and lenses of dolomite; they are gypsiferous in some places. Shore deposits commonly are gravel. The thickness of the lake deposits generally is 1–8 m. Mapped in Texas

PALUDAL (MARSH AND SWAMP) DEPOSITS

Inland deposits of Holocene and late Wisconsin age

hp **Peat and muck—**Chiefly (1) woody peat; (2) fibrous peat and decomposed organic residues; (3) fibrous peat and clay and silt containing plant material and organic residues; or (4) peaty sand. The peat and muck forms (1) muskeg, swamp fens, and bogs in the basins of former lakes; (2) bogs in ice-block depressions and other poorly drained areas; and (3) blanketlike deposits in former and present drainageways characterized by surface outlets that control the water table. In some areas on the Atlantic Coastal Plain, the peat is compacted into thick mats interbedded with thin layers of sand and silt. Some peat deposits in Florida were drained for agriculture and urban development; burning, oxidation, and compaction of the drained peat resulted in as much as 4 m of subsidence. The map unit includes swamp deposits where swamp deposits (unit hs) and peat and muck (unit hp) were not differentiated. The thickness of the peat and muck generally is 1–10 m. The largest areas mapped are in Minnesota, Wisconsin, Virginia, North Carolina, and Florida

hs **Fresh-water swamp deposits—**Chiefly (1) muck, mucky peat, and organic residues mixed with fine sand, silt, and clay or (2) organic debris, muck, and, locally, peat mixed with fine sand, silt, and clay in areas that intermittently are covered by standing water. The deposits are on former lake beds, in abandoned glacial melt-water channels and sluiceways, in ice-block depressions and other shallow depressions, and in other poorly drained areas. Some deposits in Florida were drained for agriculture and urban development; oxidation and compaction of the drained deposits resulted in as much as 3 m of subsidence. The map unit includes peat and muck where peat and muck (unit hp) and swamp deposits (unit hs) were not differentiated. The thickness of the swamp deposits generally is 1–5 m; locally, it is 15 m. The largest areas mapped are in Georgia and Florida

Coastal deposits of Holocene age

hb **Fresh-water coastal-marsh peat and clay—**Herbaceous peat and clay, intermixed and interbedded. The map unit includes interbedded fresh-water and brackish-water marsh deposits and interbedded fresh-water and brackish-water carbonaceous clay. The thickness of the marsh deposits generally is 1–5 m

(hd) **Swamp deposits and dune sand—**A complex map unit. The swamp deposits are chiefly silty, smectitic clay (swelling clay) that contains abundant plant debris and residues in parallel, linear interdune swales and depressions. In Florida, the swamp deposits in some areas were compacted as a result of drainage for agriculture. The dune sand (unit ed), chiefly quartz grains mixed with moderate amounts of shell debris, forms linear dune ridges that commonly overlie beach deposits. Some beach deposits are included in the map unit. The thickness of the deposits generally is 3–15 m

ha **Mangrove-swamp deposits—**Organic muck, calcitic mud, and woody debris that are intermittently covered by as much as 1 m of sea water. The swamp deposits overlie mud and wave-beveled surfaces cut on soft, porous limestone. The thickness of the swamp deposits generally is 0.5–1 m. The deposits are mapped only in areas that support dense stands of both red and black mangrove along the Gulf of Mexico coast in western Florida

he **Algal mat and carbonate deposits—**Fresh-water algal mat, overlying algal calcitic mud that is interbedded with layers of crystalline low-magnesian calcite. The mud is massive and extremely sticky. The deposit forms a rhythmite produced by annual growth and death of calcite-secreting blue-green algae. Commonly, it overlies an irregular, cavernous, or nearly flat surface of dissolution on limestone bedrock. The thickness of the deposits generally is≈ 1 m. Mapped in southern Florida

hc **Fresh-water, brackish-water, and (or) saline-marsh deposits of Holocene and late Wisconsin age—**Tidal-, intertidal-, and estuarine-marsh deposits, chiefly (1) carbonaceous clay, silt, and fine sand mixed, intertongued, and interbedded with layers of herbaceous peat; (2) silt and clay mixed, intertongued, and interbedded with layers of organic-rich sand; or (3) sandy clay beds alternating with layers of peat composed of compressed mats of shoal grass. In some areas, the clay is predominantly smectite (swelling clay). The thickness of the deposits generally is 1–3 m; locally, it is 10 m

MARINE DEPOSITS

Marine erosional and depositional processes on the Atlantic coast and the Gulf of Mexico coast are (and have been) complex. Consequently, many different landforms are present and the deposits (sediments) associated with, and produced by, the depositional processes are complex. Many deposits attributed to specific processes (for example, to storm waves, wind tides, or hurricane surges) cannot be distinguished at the scale of this map

Glaciomarine deposits of late Wisconsin age—During the Wisconsin glaciation, the Laurentide ice sheet extended onto the continental shelf in New England. The Earth's crust beneath the ice was depressed by the weight of the ice, and sea level was lower than at present because a tremendous volume of water from the oceans had been converted to ice on land. During deglaciation, there was a complex interplay of sea level rise (caused by the return of water to the oceans), uplift or rebound of the Earth's crust (caused by thinning and disappearance of the ice load), and calving of the ice sheet margin where it was in contact with the sea. Along the east coast of New England, and also in the Champlain Lowland and the St. Lawrence Lowland in northeastern New York and northwestern Vermont, sea level rise initially was more rapid than uplift. The sea covered those regions, and glaciomarine sediments were deposited on, and in association with, glacial, ice-contact, glaciofluvial, and glaciolacustrine deposits. As the rate of uplift increased relative to the rate of sea level rise, the land emerged. The glaciomarine sediments now are above sea level

mc **Clay and silt—**Chiefly soft, calcareous clay and fine silt that is plastic and slippery when damp. Gullies are common to abundant. The deposits are particularly susceptible to landslide activity. In coastal Maine, glaciomarine clay and silt (unit mc) is included in unit mt (glaciomarine deposits and till). The thickness of the marine clay and silt generally is 1–10 m; locally, it is 30 m. Mapped in New England and northeastern New York

me **Sand and gravel—**Chiefly calcareous or noncalcareous near-shore deposits that accumulated near basin margins and on emerged shoals in coastal New England. The marine deposits locally are overlain by <l m of loess (unit el) or windblown sand (units es, ed). The map unit includes small marine kame-delta deposits (unit km). The thickness of the marine sand and gravel generally is 1–8 m

md **Delta deposits—**Calcareous or noncalcareous gravel, sand, silt, and clay in nearly flat-topped deltas that formed where rivers or melt-water streams entered the sea. The bottomset beds and foreset beds were formed below sea level; the topset beds, composed of nonglacial alluvium or glaciofluvial sediments, were formed at or above sea level. The deltas commonly are perched on hillslopes. The deposits locally are overlain by <1 m of loess (unit el) or windblown sand (units es, ed). The thickness of the delta deposits generally is 5–20 m; locally, it is >30 m. Mapped in New England and northeastern New York

(mt) **Glaciomarine deposits and till—**A complex of glaciomarine clay, silt, sand, and gravel (units mc, me) and till (unit ts) in coastal New England. In some areas, marine deposits cover only 5–20 percent of the surface; the glaciomarine sediments are emphasized here to indicate the areal extent of the marine sediments that were deposited during late Wisconsin deglaciation. Clay and silt (unit mc) generally overlies till in the central parts of broad valleys; sand and gravel (unit me) is chiefly along or near basin margins and on emerged shoals. In some areas, the map unit is discontinuous; patches of sandy till and local glaciomarine deposits are separated by numerous or extensive bedrock outcrops. The thickness of the glaciomarine deposits generally is 1–4 m; locally, it is >10 m. The thickness of the till generally is 0.5–4 m; locally, it is 10 m

Beach deposits of Holocene age (in beaches, spits, tombolos, hooks, and barriers)

bb **Quartz beach sand—**Medium to fine sand, chiefly quartz grains. The deposit is a thin layer of beach sand overlying saline marsh deposits (unit hc) in some areas; it is the wave-reworked part of a 20- to 30-m-thick layer of prograding delta-front sand in other areas. The thickness of the beach sand generally is 0.5–7 m. Mapped in Louisiana

ba **Beach shell-fragment and shell sand—**Chiefly shell debris; fine quartz sand, silt, and clay are minor components. In some areas too small to be distinguished, quartz sand (similar to unit bb) and shell-fragment and shell sand are in approximately equal proportions or the sand is predominantly quartz grains. Shell fragments form lag concentrates in some places. In the Florida Keys, the deposit is chiefly foraminifera tests. The map unit includes some back-island slope, wash-over channel, lagoon, and tidal-flat deposits (see unit mk and below) and some beach sand and dune sand (unit hd). Locally, it includes mangrove swamp deposits (unit ha) or fresh-water, brackish-water, and (or) saline-marsh deposits (units hb, hc). The thickness of the beach sand in most regions is 1–8 m.

In southeastern Texas, the map unit includes lagoon and wind-tidal-flat deposits landward from the beach deposits (also see unit mk). The lagoon sediments are chiefly clay, silt, and sand. Air-filled cavities and animal burrows are abundant. The tidal-flat deposits are chiefly clay and silt, in some places intermixed and interbedded with quartz sand, shell sand, foraminifera-rich sand, algal-bound sand, filamentous algal layers, shell fragments, microcrystalline aragonite, microcrystalline calcite, oolites, and (or) fecal pellets. The deposits accumulated on (1) alternately dry and flooded, barren tidal flats; (2) in tidal deltas; and (3) in wash-over fans along the inland margins of barrier beaches. The flats are flooded by wind tides (caused by the force of wind on the water surface) and by sporadic tropical storms, and the lagoon water is moved landward by onshore winds; astronomical tides do not produce significant deposits. When the flats are flooded, alternating laminae of clay and algae accumulate. Most of the time, the tidal flats are subaerially exposed and eolian sand (unit es), blown from nearby beaches and dunes, accumulates in thin beds on the clay and algae; the eolian sheet sand is included in the map unit. Most tidal-flat sediments overlie lagoon mud (clay and silt). Some of the deposits are alkaline; gypsum crystals are present locally. The deposits in some places are cut by tidal channels that are filled with sand mixed with broken clam and oyster shells and scattered fragments of bryozoa and coral. The thickness of the deposits in Texas generally is 0.5–5 m

bm **Beach mud—**Chiefly silt and clay mixed with shell fragments, very fine grained plant debris, and plant residues. The silt, clay, and organic matter were eroded from marsh, swamp, and estuarine deposits and redeposited by waves as beach mud. The thickness of the beach mud generally is 0.5–2 m. Mapped on the Atlantic coast and the Gulf of Mexico coast

(bd) **Beach sand and dune sand—**A complex of quartz beach sand (unit bb) and dune sand (unit ed). **Beach deposits** in most places are chiefly quartz sand, locally containing some plant debris, shell fragments, and scattered shells. In some places in Florida, the upper layers of the beach deposits are crushed shell. Where glacial, ice-contact, and glaciofluvial deposits have been eroded and reworked by waves in New England and New York, some beach deposits consist of (1) sand and isolated granules and pebbles; (2) sand and gravel; or (3) concentrations of cobbles and pebbles (cobble or boulder pavements). Winter storms remove the beach and dune sand, exposing the underlying pavements, till, or bedrock; beach sand and dune sand are redeposited during the summer. Most of the barrier islands in the Atlantic Ocean and the Gulf of Mexico are composed of unit bd. **Dune sand** commonly forms a narrow strip of fore-island dunes or back-island dunes adjacent to, and immediately inland from, the beach sand. Beach sand and dune sand are transported nearly continuously by waves and wind. On a decadal time scale, some of the landforms (for example, beaches, barriers, and dunes) shift geographically inland and (or) seaward hundreds of meters. Some barriers and dunes were virtually leveled by hurricanes in historic time. They were fully replaced by waves and wind in only a few years. In Mississippi and western Alabama, beach and dune sand as thick as 2 m in some places partly mantles older, weathered beach and dune deposits. The map unit includes areas of eolian sheet sand (unit es) on back-barrier flats and thin eolian or wash-over sheet sand that overlies marsh deposits. It also includes some back-island slope, wash-over channel, lagoon, and tidal-flat deposits (unit mk; also see description of unit ba). The total thickness of the deposits generally is 0.5–l5 m; locally, it is 25 m

(bc) **Beach sand, dune sand, and delta deposits of Holocene and late Pleistocene age—**A complex of beach sand and dune sand (unit bd) of Holocene age and delta deposits (unit da) of late Pleistocene age. The thickness of the beach sand and dune sand generally is 3–9 m; the thickness of the delta deposits generally is 3–20 m. Mapped in northwestern Florida

Coastal-plain marine deposits of Holocene age

mk **Back-island slope, wash-over channel, lagoon, and wind-tidal-flat deposits—**A complex map unit that includes (1) sheetlike back-island-slope deposits composed of interbedded quartz sand, silty sand, shelly sand, shell fragments, and oyster and clam shells that accumulated in fans over lagoon sediments when hurricane-driven waves surged over barrier islands; (2) wash-over channel deposits composed of quartz sand, silt, shell sand, shell fragments, and, locally, scattered fragments of bryozoa and coral that accumulated when hurricane-driven waves surged over barrier islands; and (3) lagoon mud (clay and silt) and wind-tidal-flat deposits composed of clay, silty clay, clayey fine quartz sand, and shell sand that accumulated on alternately dry and flooded barren flats (also see description of map unit ba). The back-island-slope and wind-tidal-flat deposits locally have been reworked to form dunes; the dune sand (unit ed) is included in the map unit. The thickness of the deposits generally is 0.5–8 m. Mapped in Texas

(db) **Delta deposits—**A complex of marine sediments and overlying fluvial sediments in modern and recent prograding deltas at the mouths of rivers on the Gulf Coastal Plain. The mapped sediments are subaerial fluvial sediments. The subsurface marine deposits in the deltas are chiefly coarse to fine sand, silt, and clay, intermixed and interbedded. The fluvial deposits include (1) channel and flood-plain alluvium (unit al); (2) point-bar gravel, sand, and silt; (3) distributary (natural-levee and crevasse-splay) clay, silt, and sand that accumulated sporadically during brief floods following intense tropical storms; (4) interdistributary flood-plain and back-swamp or flood-basin silt and clay that accumulated during major floods following very large, relatively infrequent tropical storms; and (5) discontinuous peat and muck (unit hp), fresh-water marsh deposits (unit hb), and fresh-water, brackish-water, and (or) saline-marsh deposits (unit hc). The thickness of channel sediments generally is 3–20 m; the thickness of point-bar deposits locally is 12 m; the thickness of distributary deposits generally is 5–9 m; the thickness of interdistributary flood-plain and back-swamp deposits generally is 2–6 m. The total thickness of the delta deposits in most places is not known; the deposits in some places extend to depths >43 m below the present sea level. Mapped on the Gulf of Mexico coast

Coastal-plain marine deposits of late and middle Pleistocene age

mo **Oolitic limestone—**Chiefly crystalline, oolitic limestone interbedded with thin layers of soft, unconsolidated oolitic sand. Solution holes and channels filled with quartz sand perforate the deposits in some places. The limestone commonly is brecciated and recemented as a result of solution. Most of the $^{230}Th/^{234}U$ ages for the limestone are between ≈ 90,000 and ≈ 145,000 years. In some places, thin, discontinuous patches of windblown quartz sand (unit es) or windblown oolitic sand overlie the deposit. The maximum thickness of the oolitic limestone is ≈ 20 m. Mapped in southern Florida and the Florida Keys

ml **Coralline limestone—**Chiefly coralline limestone; locally composed of coral heads and amorphous limestone, coral detritus, and limestone breccia. The deposits in some places include thin lenses of dense, hard fresh-water limestone. The upper part of the deposits commonly is brecciated and recemented as a result of solution. Most of the $^{230}Th/^{234}U$ ages for the coral are between ≈ 95,000 and ≈ 145,000 years. The maximum thickness of the coralline limestone is ≈ 20 m. Mapped in southern Florida

(mm) **Coastal-plain marine deposits (lagoon and beach deposits) of Pleistocene age—**A complex map unit. The lagoon and beach deposits in general are similar to those described for units mb and ma. The deposits in some places include abundant shell debris, lithified coquina fragments, and (or) soft limestone fragments; local stringers of quartz pebbles and shell hash are remnant deposits of old tidal channels. The deposits commonly are leached and intensely oxidized; locally, they are cemented by iron oxides. Downward translocation of leached humic matter in some places produced a shallow subsurface hardpan. Shell debris, swamp deposits (unit hs), or windblown sand (unit es) overlies the deposits in some places. The thickness of the deposits generally is 5–25 m. Mapped in eastern Florida

Coastal-plain marine deposits of Pleistocene and Pliocene age

mb **Beach and near-shore deposits—**Chiefly sand in narrow or broad linear ridges or sand underlying linear tracts or flats. The ridges are relict beaches, spits, offshore bars, and barrier islands 2–36 m above the present sea level. The relict landforms were elevated by crustal uplift after the sediments were deposited. The deposits in some areas are pebbly sand, gravelly sand, silty fine sand, or clayey silt. Deposits that are late Pleistocene in age typically are intensely oxidized and are leached to a depth of approximately 4 m; calcareous shell debris is present only at greater depths. Deposits that are middle Pleistocene in age and older in some places are leached throughout (to depths >10 m), are deeply weathered, and locally are cemented by secondary iron oxides. In some places, the beach and nearshore deposits interfinger with estuarine deposits (see map unit ae) that are included in the map unit.

In some areas in Florida, the deposits are phosphatic sand, clayey sand, and sandy clay that in some places fills karst depressions along limestone ridges; the phosphatic deposits commonly are intensely stained and cemented by iron oxides. In other areas in Florida, leached and intensely oxidized quartz sand is underlain at depth by consolidated sand that contains abundant whole, but rotted, shells. Leaching of shell material from the upper part of the deposits resulted in reduction in thickness of as much as 1.5 m; the dissolved carbonate in some places was redeposited, with compacted insoluble clay mixed with quartz sand, as a subsurface hardpan.

In Texas and Louisiana, "pimple mounds" commonly mark the surfaces of the deposits. The map unit includes wash-over sheet-fan deposits and tidal-inlet channel deposits (see units mk and ba); it also includes relict fore-island dune deposits, back-island dune deposits, and windblown sheet sand (units ed, es).

The thickness of the beach and near-shore deposits generally is 1–10 m; locally, it is 12–25 m

ma **Back-barrier and lagoon deposits—**Chiefly clay, silt, and sand on interfluves, beneath coastal terraces, and beneath other flat or gently sloping surfaces. Smectite (swelling clay) is the predominant clay mineral in parts of the southern Atlantic Coastal Plain. In some older (topographically higher) deposits, feldspar grains are completely altered to clay minerals. Where the sediments are predominantly sand, they commonly are intensely weathered. In Georgia, in some places the plant debris and residues in the upper part of the deposits have been leached, translocated downward, and redeposited as a compact humate layer 30–50 cm below the surface. The map unit locally includes wash-over channel and tidal-channel deposits. The marine sediments in some places are overlain by windblown sheet sand (unit es). The thickness of the deposits generally is 1–l5 m; locally, it is 24 m

ms **Sand—**Chiefly quartz sand. Carbonate grains and shell fragments commonly have been leached throughout. However, lenses of coquina and shell-hash limestone locally are present in the lower part of the deposit. The thickness of the sand generally is 0.5–3 m. Mapped in South Carolina and North Carolina

(da) **Delta deposits—**A complex of marine sediments and overlying fluvial sediments that comprise ancient deltas. The map unit includes fluvial delta-plain or flood-basin deposits, marine pro-delta and lagoon deposits, and marsh and swamp deposits. On the Atlantic Coastal Plain, it also includes estuarine sediments. On the Atlantic Coastal Plain, the sediments are chiefly kaolinitic marine clay and arkosic or quartzose fluvial silt, sand, and gravel. On the Gulf Coastal Plain, the sediments commonly are clay, silt, and sand, intermixed and interbedded. In some places, the delta deposits include fine gravel, scattered shell debris, and (or) thin, discontinuous lenses of peat or decayed plant material; locally, they contain buried, oxidized, organic-rich soil (?) zones or ferruginous or calcareous nodules. In Texas, the delta deposits locally are cemented by secondary calcium carbonate in layers 0.25–2.5 m thick. In Texas and Louisiana, "pimple mounds" commonly mark the surfaces of the deposits. The total thickness of the delta deposits on the Atlantic Coastal Plain generally is 5–20 m; locally, it is 30 m. The deposits on the Gulf Coastal Plain are much thicker—in Louisiana and Mississippi the maximum thickness is >150 m

(mh) **Coastal-plain marine deposits (marine sand and alluvial sand) of early Pleistocene and Pliocene age—**A complex map unit of intensely weathered marine shore deposits, delta deposits, and alluvium. Similar alluvium elsewhere is mapped as decomposition residuum that is developed on alluvium (unit zl). In most areas, the map unit is leached, intensely oxidized kaolinitic quartz sand that commonly is case-hardened by iron oxide. Locally, it includes pockets of kaolinitic clay and stringers of quartz and quartzite pebbles, most of which are <2 cm in diameter. The sand was deposited on, and in places has collapsed into, a karst surface on limestone bedrock. The map unit is coextensive with the central divide of the Florida peninsula. The thickness of the deposit generally is 12–15 m

EOLIAN (WINDBLOWN) DEPOSITS

More than 10 percent of the surface of the Earth that is not covered by water, ice, or snow is mantled or veneered by windblown surficial deposits. Sand is transported primarily by surface creep and by rolling and bouncing of grains. Consequently, the grains generally are not transported great distances during a single period of high winds. In contrast, silt is transported primarily by suspension in the atmosphere. Particles may remain in suspension for long periods of time and may be transported great distances without touching the Earth's surface. A distinction between deposits of windblown sand and windblown silt is arbitrary in some regions. Also, where eolian sand and silt are intermixed, interlayered, or intertongued, a distinction is arbitrary.

Loess is chiefly windblown silt (particles 0.002–0.05 mm in diameter). Typically, it is homogeneous, porous, nonstratified, and slightly indurated. Loess is the most widely distributed surficial sediment in some states (for example, more than 50 percent of the land surface in Iowa and more than 70 percent of the upland surfaces in Illinois have a cover of loess). The loess mantle is an economically important double-edged sword. Some of the country's most productive agricultural soils are developed in the loess blanket (for example, in the corn and wheat belt in Illinois and Iowa). On the other hand, the physical and chemical properties of the loess cause problems in construction, foundation engineering, and other aspects of applied engineering. When loess is saturated with water, it is subject to subsidence, collapse, seepage, flow, sliding, or consolidation. Building foundations settle, heave, or stretch, and structures must be stabilized accordingly. Loess also is subject to intense gullying, to solifluction, to soil creep, and to landslide processes. In the Central United States and in parts of the Eastern United States, loess is present as (1) a thin, discontinuous veneer of silt that in some places is within the modern agricultural soil profiles that are developed in other surficial deposits and residual materials that underlie the loess (consequently, the loess commonly is not recognized); (2) a blanketlike deposit that is draped over other surficial deposits, residual materials, or bedrock (the surface topography mimics the underlying topography); (3) a thick mantle that buries older surficial deposits, residual materials, or bedrock and obscures the underlying topography; or (4) a sequence of superposed windblown deposits and one or more intervening buried soils (paleosols) that masks a buried landscape of other surficial deposits, residual materials, or bedrock.

The widespread occurrence of loess over other deposits and materials presents problems in compilation of the surficial geologic map. If loess were to be mapped wherever it is more than 1 m thick, then northern Missouri, northeastern Kansas, eastern Nebraska, most of Iowa and Illinois, and significant parts of Indiana, Kentucky, Ohio, Tennessee, Mississippi, and other States would be mapped as loess deposits. The underlying glacial, ice-contact, glaciofluvial, fluvial, lacustrine, and colluvial deposits or the underlying residuum would not be indicated on the map. On maps of surficial geology that have been manually drafted and released only on paper, the **underlying deposits** commonly have been mapped and the characteristics of, and differences in, the loess cover have been depicted by overprints of the map units (for example, by dot or line patterns). In that way, both the loess and the underlying deposits and materials are represented on the map. Because this map is being released as a printed paper map and also as a digital database, overprinting of map units to show the loess cover is impractical: representation of sequences of deposits (for example, loess-over-till, loess-over-alluvium, or loess-over-colluvium sequences) as separate map units would increase greatly both the complexity of the map detail and the number of map units. **On this map, in many regions the underlying surficial deposits and materials are mapped** (even though those deposits and materials are completely covered by loess). The presence of significant unmapped loess overlying those deposits and materials is noted in the map unit descriptions.

ee **"Clay dune" deposits of Holocene age—**The deposits in southern Florida are fine to medium sand or sand-size aggregates of silt and clay. The sediments in Florida form a complex of large dunes on the northeast, east, and southeast shores of Lake Okeechobee, produced by intense storms. Most of the deposits in Texas are silty clay, clayey silt, and silty, very fine quartz sand. The sediments form dunes 2–12 m high, downwind from deflated flats that are underlain by saline clay and silt. Buried soils are common within the deposits, and the deposits locally include laminae of ostracodes or contain fragments of clam shells. In some places in Texas, the dune deposits overlie a buried soil developed in older delta deposits (unit da). In Texas, active dunes are predominantly elongate, crescent-shaped lunette dunes; inactive dune complexes are roughly circular, low vegetated hills. The term "clay dune" is a misnomer because the sediment is not clay. The thickness of "clay dune" deposits in Florida generally is 5–10 m; the thickness in Texas generally is 1.5–12 m

el **Loess of Holocene and late Wisconsin age—**Chiefly silt and silt loam; 5–10 percent of the loess is very fine sand in some places. Typically, the loess is massive and stands in nearly vertical faces in exposures; dry loess commonly has conspicuous columnar joints. In some places, the deposits are fossiliferous. Where less than 2 m thick, the loess generally is oxidized and leached throughout. In Illinois and adjacent States, where the loess (unit el) has been distinguished from other loess units, the loess generally overlies and masks older loess deposits in which one or more buried soils (paleosols) are developed. Where unit el has not been distinguished as a separate map unit, the loess constitutes the upper part of map units eb and ea and it is included in those units.

In North Dakota and South Dakota, the loess generally is a thin veneer of silt draped over older topography and deposits. It commonly overlies till or glaciofluvial deposits of late Wisconsin age; thin humic zones (paleosols) are present within the loess in some places. In that region, in some places the loess is intermixed, intercalated, or interbedded with sheetwash alluvium (unit wb) or colluvium, and it has been modified by creep, colluviation, solifluction, and other mass-movement processes.

In New Jersey, the thickness of the loess generally is less than 1 m; locally, it is 3 m. In North Dakota, the thickness generally is 1–3 m; locally, it is 15 m. In Illinois and adjacent States (where it commonly overlies older loess deposits), the thickness generally is 2–10 m; locally, it is more than 20 m eb **Loess of Holocene and late and middle Pleistocene age—**A sequence of superposed loess deposits of Illinoian and younger ages, separated by two or more buried soils (paleosols). The loess is chiefly silt, silt loam, and very fine sand; locally, 5 to >10 percent of the sediment is clay. Typically, the loess is massive and it stands in vertical faces in exposures; dry loess commonly has conspicuous columnar joints. The upper part of the sequence generally is similar to unit el. In some places, thin, patchy loess is intermixed, intercalated, or interbedded with sheetwash alluvium or colluvium and the deposit has been modified by creep, colluviation, solifluction, and other mass-movement processes. The loess is overlain by eolian sand (units ed, es) in some areas in Nebraska and southern South Dakota. Mapped west of the Mississippi River.

Unmapped loess similar to units eb and el is widespread westward from southwestern Ohio and northern Kentucky, wherever the surficial deposits on the map are primarily till (units ta, tk) of Illinoian age and till (unit tb) of pre-Illinoian age. As noted in the general comments about loess (above), **in those regions the deposits that underlie the loess are mapped** and the thickness of the overlying loess is noted in the map unit descriptions.

The thickness of the mapped loess sequence in South Dakota generally is 1–30 m. In Nebraska, Kansas, and Missouri the thickness generally is 2 m to > 10 m; locally, it is 45 m

(ea) **Loess, loessal alluvium, and loessal colluvium of late and middle Pleistocene age—**A sequence of superposed loess deposits and buried soils (paleosols) that has been extensively modified by erosion, weathering, and other surface processes. The sediments are chiefly (1) massive to bedded silt loam or (2) silt mixed with clay and fine sand, in some places containing lenses of very fine to fine quartz sand. In some areas, vertical sequences of loess deposits are welded to one another by soil-forming processes to form a single composite paleosol. The map unit includes loess (similar to unit eb), sheetwash alluvium (unit wb) derived in large part from eroded loess, and colluvium derived from eroded loess, alluvium, residuum, and bedrock. The deposits are intensely dissected in some areas near rivers—gullies and ravines as deep as 30 m are present locally. In many areas, the deposits overlie decomposition residuum developed in alluvium [see discussion of "ALLUVIAL DEPOSITS (ALLUVIUM)" and also unit zl] or they overlie intensely weathered colluvium derived from the alluvium. East of the region shown as unit ea, thin, patchy deposits of loess (units ea and el) overlie decomposition residuum and are intermixed, interbedded, and intercalated with other surficial deposits. Decomposition residuum that developed on very old loess in some areas has properties similar to those of decomposition residuum that developed on the local fine-grained sedimentary bedrock. Consequently, the eolian origin of the parent material of some residuum has not been recognized. The thickness of the loess and loess-derived deposits generally decreases eastward, from ≈ 20 to ≈ 30 m on bluffs east of the Mississippi River to 1–2 m at the eastern limit of the map unit. Mapped from Kentucky to Mississippi, east of the Mississippi Embayment

eu **Sand and silt of Holocene and late Wisconsin age—**Undifferentiated windblown sand (units es, ed) and silt (unit el). The deposits generally are stable. Blowouts (deflation basins) and small dunes are active where the vegetation has been removed. The thickness of the deposits generally is 1–5 m; locally, it is 10 m. The largest areas mapped are in North Dakota

Sand of Holocene and late Pleistocene age

ed **Dune sand—**Chiefly very fine to medium sand; locally coarse sand. In some areas, weakly developed buried soils (humic zones) are present and shallow depressions are floored by thin organic matter, clay, and silt; interdune depressions are sites of temporary fresh-water marshes in wet years. In coastal areas, the dune ridges generally are oriented parallel to the present shores. In inland areas, the dune forms vary widely (for example, linear, longitudinal, parabolic, barchan, ovoid, or irregular dunes; coalesced dunes or dune clusters). Linear or longitudinal dunes in some places are separated by flat areas veneered by sheet sand (unit es) or are sites of blowouts or deflation basins. The relief of the dunes varies greatly (<5 m in some areas and 45–50 m in some other areas). The dunes generally are stable; blowouts and dunes are active locally where the vegetation has been removed. In Oklahoma and parts of some other States, the map unit includes sheet sand where dune sand (unit ed) and sheet sand (unit es) are not differentiated. The extensive deposits of dune sand in Nebraska in many areas overlie thick fluvial and lacustrine deposits (unit aj). The thickness of the dune sand varies greatly (1–2 m in some areas and >50 m in other areas) es **Sheet sand—**Chiefly blanketlike deposits of windblown sand; locally, silty sand. In some areas, the deposits contain weakly developed buried soils (humic horizons) or thin beds of plant material; shallow surface depressions in some places contain organic matter. The deposits commonly are downwind from dune sand (unit ed), outwash sand and gravel (units gs, gg), lake deposits (units lf, ls), or terraced alluvium (units al, an, at). In some areas, the sheet sand grades in a downwind direction into loess (unit el). In many regions, the map unit includes some dune sand (unit ed). Most of the deposits are stable; blowouts and dunes are active locally where the vegetation has been removed. In Texas, in some places, the deposits are nearly flat, actively deflating sand sheets and low-relief active dunes. The thickness of the sheet sand generally is 1–6 m; locally, it is 10 m

(ec) **Sheet sand, loess, loessal alluvium, and loessal colluvium of Holocene and Pleistocene age—**A sequence of superposed layers of eolian deposits that mantles most of the nearly featureless plateau of the Southern High Plains in Texas and Oklahoma. In general, the eolian sediments are more sandy in the west and southwest and more silty and clayey in the east and northeast, indicating that they were deposited by westerly and southwesterly winds. In most places, the sediments are oxidized throughout, indicating that they are relatively old. In many large areas, the sediments are more silty and clayey than is typical sheet sand and more sandy than is typical loess. In the southwestern and west-central parts of the region mapped as unit ec, the deposits are chiefly stratified to massive, silty and clayey, fine to medium sand. The deposits in some places include discontinuous, thin lenses of organic silt and clay (playa pond sediments). In the northern and eastern parts of the region, the upper layers of the deposits generally are massive to bedded loam, clay loam, silty clay loam, and clay comprising loess, sheetwash alluvium derived in large part from eroded loess, and colluvium derived from eroded loess. The map unit generally consists of multiple layers of windblown sediment separated by buried argillic, calcic, and petrocalcic soils (paleosols). The number of layers of windblown sediment and the number of paleosols differ from place to place. Fourteen paleosols were identified in one drill core in Texas. In some exposures, layers of windblown sediment are welded to one another by soil-forming processes to form a single composite buried soil. Commonly, the modern surface soil and one or more paleosols are welded. At several sites, the Guaje tephra, a layer of wind-deposited volcanic ash, is present in the lower part of the map unit. A $^{40}Ar/^{39}Ar$ age of ≈ 1,613,000 years for the Guaje volcanic eruption (in the Jemez Mountains, N. Mex.) and the reversed remanent geomagnetic polarity of the tephra and the eolian sediments underlying the tephra indicate that the oldest sediments included in unit ec are earliest Pleistocene in age. The Lava Creek B tephra, another layer of windblown volcanic ash, is associated with younger eolian sediments included in the map unit. $^{40}Ar/^{39}Ar$ ages indicate that the Lava Creek B volcanic eruption (in the Yellowstone National Park region) occurred ≈ 639,000 years ago. The sand sheets or loess sheets and the buried soils that constitute unit ec accumulated episodically. Surfaces were deflated and then covered by windblown deposits. Rapid eolian sedimentation was followed by a prolonged interval of landscape stability marked by soil development and ephemeral-pond (playa-lake) deposition. Then the cycle was repeated, presumably in response to changes of climate. The map unit includes relatively small areas of other surficial deposits and bedrock outcrops. The thickness of the eolian deposits generally is 2–6 m in the south and 4–8 m in the north; the maximum thickness is >25 m

ALLUVIAL DEPOSITS (ALLUVIUM)

Alluvial deposits are sediments that were deposited by running water (as opposed to standing water in lakes or oceans). **Fluvial deposits** are alluvial sediments or alluvium deposited by rivers or streams. All fluvial deposits are alluvial deposits, but the reverse is not true. Most alluvial sediments were deposited by confined or channeled flow (by rivers and streams). However, some alluvial sediments (for example, sheetwash alluvium) were deposited by unconfined sheet flow (overland flow), and thus they are not fluvial in origin. Alluvial deposits of different origins commonly merge laterally and vertically, or they are areally interspersed. They also merge, or are areally interspersed, with windblown deposits, lacustrine deposits, marine deposits, colluvium, or other deposits. At the scale of this map, it is misleading to relegate the mapped deposits in some areas to a single genetic category. Consequently, many of the alluvial map units are complex units (indicated by letter symbols in parentheses).

Some surficial materials that previously were mapped as alluvium here are mapped as **decomposition residuum** (see units zb, zk, zn, zg, zc, and zl). The surface materials are residuum that was formed by chemical alteration of alluvium. The physical, chemical, and engineering properties of the decomposition residuum differ markedly from the properties of the parent alluvium.

Ice-contact deposits consist of stratified gravel, sand, and silt deposited in melt-water streams, in lakes, or in the sea on, against, or adjacent to glacial ice. Characteristically, the sediments are folded, faulted, and tilted, indicating that collapse, slump, sliding, and flow occurred when the ice subsequently melted. Landforms composed of ice-contact sediments include kames, kame end moraines and interlobate moraines, kame terraces, kame deltas, kame fans, eskers, and crevasse fillings. The **lithology,** or **composition** (for example, shale, sandstone, limestone, granite, gneiss), of **clasts** (granules, pebbles, cobbles, and boulders) in ice-contact sediments is extremely variable; in most places it is similar to that of the associated till.

Glaciofluvial (outwash) deposits consist of stratified gravel, sand, and silt deposited in melt-water streams. The sediments were not deposited on or against active or stagnant glacial ice as were ice-contact sediments. However, in some areas not far from glacial ice, blocks of floating ice in the streams were grounded and then buried by the outwash sediments. In some places, ice-block depressions pockmark the outwash surfaces (the deposits in those areas are referred to as pitted outwash). The materials transported by, and deposited in, the streams were derived chiefly from melting glacial ice upstream. In some regions, the distinction between glacially derived outwash and either nonglacial alluvium or alluvium that was derived from reworking and redeposition of outwash is arbitrary. The lithology of clasts in outwash is extremely variable. In most places it reflects the composition of clasts in the till and ice-contact sediments and the composition of bedrock upstream in the drainage basin.

Ice-contact deposits of late Wisconsin and Holocene(?) age[4]

ks **Ice-contact silt and sand—**Chiefly in fields of small kame ridges and mounds; ice-block depressions are common locally. In some places, kame silt and sand is overlain by <2 m of loess (unit el) or windblown sand (units es, ed). The thickness of the ice-contact deposits generally is 5–10 m; locally, it is 30 m. Ice-contact silt and sand is distinguished as a map unit only in Minnesota and Wisconsin; it is included in unit kg elsewhere

kg **Ice-contact sand and gravel—**Chiefly in kames, kame end moraines, interlobate moraines, kame deltas, kame fans, eskers, and ice-fracture fillings. Hummocks, mounds, ridges, and knobs typically characterize the landscape. Ice-block depressions are common in some areas. In some places, boulders litter the surface. Locally, the ice-contact sediments are overlain by till or flow till as thick as 5 m, or by <2 m of loess (unit el) or windblown sand (units es, ed). The thickness of the ice-contact deposits generally is 2–30 m; locally, it is 60 m. Mapped from New England to North Dakota and South Dakota

ke **Kame end-moraine or kame interlobate-moraine deposits—Kame end-moraine deposits** are (1) linear or arcuate, ridgelike accumulations of ice-contact deposits similar to unit kg; (2) complex accumulations of ice-contact deposits in mounds, knobs, and hummocks or in irregular, imbricated, or overlapping ridges; or (3) ice-contact deposits in belts of any or all of the latter landforms. The sediments were deposited at or near a stagnating glacial ice margin. Kame end-moraine deposits in some places grade laterally into, or are abruptly replaced by, till end-moraine deposits (units tm or tt) that are included in unit ke. **Kame interlobate-moraine deposits** are kame end moraine deposits that accumulated between two adjacent stagnating ice lobes or ice tongues. In southern New England and on Long Island, N.Y., in some places, the map unit includes glaciotectonic deposits (unit fa). The thickness of the kame end-moraine deposits generally is 5–30 m; the maximum thickness is >80 m. Mapped in Ohio, Pennsylvania, New York, and New England

(kf) **Subaerial and submarine kame-fan deposits—Subaerial kame-fan deposits** are fan-shaped or terracelike accumulations of ice-contact sand and gravel, commonly along the distal margins of kame end-moraine deposits (unit ke). **Submarine kame-fan deposits** are fan-shaped or terracelike accumulations of sand and gravel emplaced below sea level at terminations of eskers or esker systems (eskers are ridges of ice-contact sediments that were deposited in tunnels that formed in or beneath stagnant ice). Because the latter deposits accumulated below sea level, they are distinguished from marine kame-delta deposits (unit km). Small marine kame-delta deposits (unit km) are included in the map unit. The thickness of the kame-fan deposits generally is 5–20 m. Mapped in coastal Maine

(kd) **Glaciolacustrine kame-delta deposits—**Ice-contact gravel, sand, and silt deposited by melt-water streams that entered glacial lakes. Sediments on the proximal margins of the nearly flat-topped, steep-sided deltas were deposited on or against glacial ice. The deposits locally are overlain by <1 m of loess (unit el) or windblown sand (units es, ed). The thickness of the kame-delta deposits generally is 5–20 m; locally, it is 40 m. Mapped in New York and New England

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[4]Some glacial, ice-contact, glaciofluvial, and glacial-lake deposits in northeastern Minnesota, northern Wisconsin, and northern Michigan may be earliest Holocene in age.

(km) **Marine kame-delta deposits—**Ice-contact gravel, sand, and silt deposited by melt-water streams that entered the sea. Sediments on the proximal margins of the nearly flat topped, steep-sided deltas were deposited on or against glacial ice. The deposits locally are overlain by <2 m of loess (unit el) or windblown sand (units es, ed). The thickness of the kame-delta deposits generally is 5–20 m; locally, it is 40 m. Mapped in coastal New Hampshire and northeastern Massachusetts

(kt) **Ice-contact deposits and till—**A complex of ice-contact sand and gravel (unit kg) and till (unit tl). Mapped in southern Michigan, northern Indiana, and southeastern Wisconsin

(kl) **Ice-contact deposits and glacial-lake deposits—**A complex of ice-contact sand and gravel (unit kg) and glacial-lake sediments (units lc, lf, ls, ld). Mapped in northwestern Pennsylvania, northern New Jersey, and New York

ka **Ice-contact sand and gravel of Illinoian age—**Ice-contact deposits in kames, kame deltas, dissected kame-terrace remnants, eskers, and crevasse fillings, all having subdued surface topography. Ice-block depressions are filled or nearly filled with alluvium, swamp deposits, peat, eolian deposits, or solifluction deposits. In Illinois, an interglacial buried soil is commonly developed in the ice-contact deposits, and the paleosol is overlain by 3–6 m of loess (unit el). Elsewhere, the ice-contact deposits commonly are overlain by 1–3 m of loess (unit el) or windblown sand (units es, ed). The thickness of the ice-contact deposits generally is 2–30 m; locally, it is >60 m. Mapped in Illinois, Indiana, Ohio, and Pennsylvania

Glaciofluvial (outwash) deposits of late Wisconsin and Holocene(?) age[5]

gs **Outwash sand—**Chiefly sand or sand and silt containing scattered pebbles and small cobbles. In many regions, outwash sand is not distinguished as a map unit; it is included in outwash sand and gravel (unit gg). Outwash sand occurs principally as sheet deposits beneath terrace remnants, as valley trains and beneath outwash plains, in fans and aprons, as delta topset beds, and as fills in abandoned meltwater channels. The surfaces of the deposits generally are smooth or undulating; in some areas, they are pitted with ice-block depressions. In many areas, the sand is overlain by <2 m of loess (unit el) or windblown sand (units es, ed). The thickness of outwash sand generally is 1–20 m; the maximum thickness is >100 m. Mapped in Minnesota, Iowa, Wisconsin, and Indiana

gg **Outwash sand and gravel—**Chiefly sand and gravel beneath terrace remnants; as valley trains and beneath outwash plains; as fans and aprons; as delta topset beds; and as fills in abandoned meltwater channels. The surfaces of the deposits generally are smooth, undulating, or gently rolling; locally, they are pitted with ice-block depressions. On northern Long Island, N.Y., the outwash in some places is overlain by thin till (unit tx). In many regions, outwash was eroded, reworked, and redeposited as early deglacial and postglacial alluvial fills. The alluvial-fill deposits are included in the map unit. In some regions, <2 m of loess (unit el) or windblown sand (units es, ed) overlies the outwash. In some areas, outwash was modified and reworked by waves and currents in lakes, and it is overlain by lake sediments (units lc, lf, ls, ld). The thickness of the outwash sand and gravel generally is 1–25 m; the maximum thickness is >100 m. Mapped from North Dakota and South Dakota to New England

(gt) **Outwash deposits and till—**A complex of outwash sand and gravel (unit gg) and till (unit tl). Mapped in northwestern New York

(gl) **Outwash deposits and ice-contact deposits—**A complex of outwash sand and gravel (units gs, gg) and ice-contact sand and gravel (units ks, kg, ke). Mapped in southeastern Wisconsin and southern Ohio

(gk) **Outwash deposits, ice-contact deposits, and glacial-lake deposits—**A complex of outwash sand and gravel (unit gg), ice-contact sand and gravel (unit kg), and glacial-lake sediments (units lc, lf, ls, ld). Mapped in northeastern Ohio and northwestern Pennsylvania

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[5]Some glacial, ice-contact, glaciofluvial, and glacial-lake deposits in northeastern Minnesota, northern Wisconsin, and northern Michigan may be earliest Holocene in age.

Glaciofluvial (outwash) deposits of Illinoian age

ga **Outwash silt, sand, and gravel—**Glaciofluvial deposits beneath terrace remnants and outwash plains. Ice-block depressions are filled or nearly filled with alluvium, peat, swamp deposits, or windblown sand and silt. In some areas, the map unit includes alluvial-fill deposits that consist of reworked and redeposited outwash. Commonly, an interglacial buried soil is developed in the glaciofluvial deposits and 0.5–6 m of loess (unit el) or windblown sand (units es, ed) overlies the paleosol. The thickness of the outwash deposits generally is 1–12 m; the maximum thickness is >30 m. Mapped in Ohio, Indiana, Illinois, and Iowa

(gd) **Outwash silt, outwash sand, and alluvium—**A complex of glaciofluvial deposits and alluvium beneath terrace remnants that represent two depositional surfaces. The mapped deposits overlie older stratified deposits, and the terrace surfaces in some places retain relict braided channel patterns. The deposits commonly are overlain by <2 m of loess (unit el) or windblown sand (units es, ed). The thickness of the outwash and alluvium generally is 3–8 m; locally, it is 10–40 m. Mapped in the northern part of the Mississippi Embayment, in Missouri and Arkansas. Temporally equivalent fluvial deposits farther south are mapped as channel and flood-plain alluvium (unit at)

Glaciofluvial (outwash) deposits of pre-Illinoian age

gb **Outwash sand and gravel—**Glaciofluvial deposits beneath terrace remnants and outwash plains and as fills in buried valleys. Many of the deposits have been exhumed by erosion. Some deposits interfinger with till (unit tb); some include alluvium that is reworked and redeposited outwash. The map unit includes outwash deposited during more than one pre-Illinoian glaciation. The deposits are intensely weathered where they were not covered by eolian deposits. In outcrops in northeastern Iowa, all clasts of limestone and dolomite and all primary matrix carbonate have been leached to a depth of≈ 6 m, locally to a depth of 16 m. A silt bed in terraced outwash deposits at the west end of the Wisconsin River valley, in southwestern Wisconsin, has reversed remanent geomagnetic polarity, indicating that the sand and gravel at that site is older than ≈ 778,000 years. The reversed-polarity outwash deposits are overlain by two loess deposits and an intervening buried soil (map unit eb). Some deposits that are included in the map unit elsewhere are overlain only by loess (unit el) or windblown sand (unit es). The thickness of the outwash sand and gravel generally is 2–10 m; locally, it is 20 m. Mapped in Kansas, Iowa, Minnesota, and Wisconsin

(gc) **Outwash sand and gravel and till—**A complex of outwash sand and gravel (unit gb) and till (unit tb). The thickness of the deposits generally is 9–16 m; locally, it is 33 m. Mapped in northeastern Kansas

Catastrophic glacial outburst-flood deposits of late Wisconsin age—Deposits of catastrophic outburst floods from glacial lakes in Canada that triggered floods in the basins of other, topographically lower, glacial lakes in North Dakota and Minnesota

ah **Flood deposits—**Bouldery sand and gravel beneath terraces. Commonly, there are two terraces, an outer (higher) flood bar and an inner (lower) channel bar. The thickness of the flood deposits generally is 1.5–25 m. Mapped in North Dakota

(ak) **Flood deposits and flood-scoured till—**Braided or anastomosing flood-channel gravel and sand and intervening broad areas of current-scoured till or intervening low, streamlined hills of current-scoured till or bedrock. The thickness of the flood deposits generally is 0.5–6 m. Mapped in North Dakota

(ag) **Alluvial, outwash, ice-contact, and glacial-lake deposits of Holocene and late Wisconsin age—**A complex of channel and flood-plain alluvium (unit al), glaciofluvial deposits (unit gg), ice-contact deposits (unit kg), and glacial-lake deposits (units lc, ls). In Pennsylvania, in some places the map unit includes some glaciofluvial deposits of Illinoian age. The thickness of the deposits varies greatly; the maximum thickness is >50 m. Mapped from Illinois eastward to Massachusetts

(ab) **Alluvial, outwash, ice-contact, and glacial-lake deposits of middle Pleistocene age—**On Long Island, N.Y., the map unit is a complex of preglacial alluvial sand and gravel, glaciofluvial and ice-contact sand and gravel, and glaciolacustrine sand, silt, and clay. Locally, the map unit includes till and flow till. In some places, it is glaciotectonically folded and faulted. In New Jersey, the deposits generally are alluvial sand and gravel derived chiefly from reworking of older fluvial deposits (see map unit zc). In some places in New Jersey and Pennsylvania, alluvium overlies, underlies, or is intertongued or interbedded with, glaciofluvial sand and gravel or glaciolacustrine sand, silt, and clay. The glacial, glaciofluvial, ice-contact, and glaciolacustrine components are inferred to be Illinoian and (or) pre-Illinoian in age. The deposits in many areas in New Jersey and

Pennsylvania are intensely and deeply weathered. Those deposits in some places are overlain by decomposition residuum (see unit zc). The thickness of the deposits on Long Island generally is >50 m; locally, it is >72 m. The thickness in New Jersey and Pennsylvania (including the overlying unmapped decomposition residuum) generally is 1–10 m; locally, it is more than 20 m

al **Channel and flood-plain alluvium of Holocene and late Wisconsin age—**Stream-deposited gravel, sand, silt, and clay. In most regions, the map unit is alluvium beneath flood plains and low terraces and in stream channels and small alluvial fans. In the Mississippi Embayment (the most extensive region of alluvium on the map), it includes deposits in point bars, chute bars, channel splays, and natural levees. In some regions, the stream alluvium is intertongued with, or overlapped by, sheetwash alluvium and (or) colluvium. In the southern Mississippi River valley and in some other major valleys, in some places peat, muck, and organic clay and silt in sloughs, oxbow lakes, swamps, and marshes overlie the alluvium. The thickness of the channel and flood-plain alluvium generally is 1–10 m; locally, it is >50 m. The thickness of the included alluvial-fan deposits locally is >25 m

(ai) **Alluvial deposits, lake deposits, and eolian deposits of Holocene and late and middle Pleistocene age—**Fluvial sand and gravel overlain by lenses of lacustrine clay and marl, in turn overlain by eolian sheet sand and silt (unit es) that contain buried soils (paleosols) and (or) overlain by channel and flood-plain sediments (units al or at) composed of silt, sand, and gravel. The basal gravel locally contains Irvingtonian-age vertebrate fossils that indicate that the gravel is older than ≈ 500,000 years. The thickness of the deposits generally is 30–40 m; locally, it is 75 m where the deposit collapsed in depressions that formed as a result of dissolution of the underlying gypsum bedrock. Mapped in Texas

an **Channel and flood-plain alluvium of Holocene and Pleistocene age—**Undivided alluvium (units al and at). Mapped west of the Mississippi River south of the limit of glaciation

(ae) **Alluvial deposits and estuarine marine deposits of Holocene, Pleistocene, and Pliocene age—**A complex of alluvial and estuarine gravel, sand, silt, and clay beneath terraces and as channel fills on the Atlantic Coastal Plain. In New Jersey, the map unit in some places consists of interbedded gravel, sand, silt, and clay; it locally includes some glaciofluvial sand and gravel. In Maryland and Delaware, in some places it consists of interbedded sand and bouldery gravel. In general, the deposits at progressively higher altitudes (farther inland and farther from major streams) are more intensely weathered. In some places, several meters of decomposition residuum overlies the highest (oldest) deposits (see unit zc). The combined thickness of the alluvial deposits and estuarine marine deposits and the overlying decomposition residuum generally is 1–25 m

Channel and flood-plain alluvium of late and middle Pleistocene age

(ao) **Cemented channel and flood-plain alluvium, fan alluvium, sheetwash alluvium, and pediment(?) alluvium—**A complex map unit of gravel, sand, silt, and clay cemented by secondary calcium carbonate. The alluvial deposits commonly interfinger with cemented colluvium that mantles the lower parts of hillslopes, and the colluvium is included in the map unit. The thickness of the deposits commonly is 2–30 m; locally, it is 80 m. Mapped in Texas

ap **Alluvial-delta deposits—**Fluvial sand, silt, clay, and minor gravel on the headward parts of deltas. The most extensive deposits are inland from marine-delta deposits (unit da) in Texas and Louisiana. Boundaries between map units ap and da are arbitrary because the deposits have similar sedimentologic and geomorphic characteristics. The alluvial-delta deposits include sediments of meander channels, braided channels, distributary channels, point bars, channel splays, and natural levees. Also included in the map unit are interdistributary mud and flood basin, backswamp, pond, and lake sediments. In general, the deposits at higher altitudes (farther inland) are more intensely weathered. In some places, several meters of decomposition residuum overlies the highest (oldest) delta deposits. The combined thickness of the delta deposits and the decomposition residuum generally is 5–65 m; locally, it is >100 m

at **Alluvium of Pleistocene age beneath terraces, in paleovalleys, and on upland surfaces—**Stream-deposited gravel, sand, silt, and clay beneath terraces, in abandoned stream channels and paleovalleys, and on upland surfaces and drainage divides. In many regions, the map unit consists of alluvium beneath vertical sequences of dissected terrace remnants. The deposits are separated by areas of bedrock, colluvium, and other surficial deposits and materials that are too small to be distinguished at this scale and are included in the map unit. In the Great Plains, the terrace deposits commonly are covered by eolian deposits or are partly or completely covered by sheetwash alluvium and (or) colluvium derived from adjacent hillslopes. The map unit locally includes slack-water lake deposits (see map units lo, ln, and lp) that underlie terraces. Some of the older (topographically higher) deposits are overlain by decomposition residuum. The thickness of the terrace alluvium generally is 2–15 m; the maximum thickness in paleovalley fills is >170 m

ac **Arkosic alluvium of middle and early Pleistocene and Pliocene age—**Bedded arkosic sand containing thin, discontinuous lenses and layers of well-rounded granules and pebbles of granite, gneiss, schist, quartz, and petrified wood. Cobbles of siliceous arkose commonly are scattered throughout the upper part of the deposit. Vertebrate fossils (horse and proboscidian fossils) in the sand and gravel indicate that most of the deposits are Pliocene in age. The youngest sand and gravel included in the map unit locally is reworked. At one site, it contained a fragment of a caribou antler of middle Pleistocene age. Commonly, the alluvium is overlain by thin loess (units el, eb). The thickness of the channel alluvium generally is 11–12 m; locally, it is 16 m. Mapped in northeastern Nebraska and southeastern South Dakota, west of the Missouri River

Channel and flood-plain alluvium of early Pleistocene and Pliocene age

aa **Cemented alluvium—**Sand and gravel, commonly cemented by secondary calcium carbonate in the the upper few meters. The map unit is channel and flood-plain deposits on upland drainage divides and flats, in rounded ridges, and beneath high terrace remnants. Deep ravines commonly dissect the terrace deposits. The thickness of the deposits generally is 0.5–6 m. Mapped in Texas

(aj) **Alluvial deposits and lake deposits—**Fluvial gravel, arkosic fluvial sand, and lacustrine silt and clay. The pebbles are predominantly bedrock from mountain ranges in Wyoming. Alluvial sediments in the lower part of the deposits contain Blancan-age vertebrate fossils (for example, horse, camel, sabre-tooth cat, ground sloth, and proboscidian fossils) that indicate an age older than ≈ 1,900,000 years. The map unit includes some Illinoian-age and younger alluvial-fan deposits. In most places, the deposits are covered by 2 to >21 m of loess (unit eb) or eolian sand (units ed, es). The thickness of the alluvial and lake deposits generally is 60–110 m. Mapped in Nebraska

(af) **Alluvial-fan and sheetwash-fan deposits of Holocene and late and middle Pleistocene age—**A complex of gravel, sand, silt, and clay deposited as fans and aprons by ephemeral streams (alluvial-fan deposits) or sand, silt, and clay deposited as fans and aprons by unconfined overland flow (sheetwash alluvium). The map unit in some places includes debris-flow deposits and mudflow deposits. In Texas, the map unit includes fan and apron deposits of several different ages. The deposits in eastern Nebraska are chiefly gravelly arkosic sand interbedded with silt, derived in part by reworking of older alluvial deposits and lake deposits (unit aj). East of the limit of Quaternary glaciation in Nebraska, relatively young fan deposits overlie till (unit tb); west of that limit, relatively older fan deposits overlie 5–20 m of proglacial glaciolacustrine sand, silt, and clay in some places. The thickness of the fan deposits in Nebraska generally is 5–30 m; the thickness in Texas generally is 1–12 m

Sheetwash alluvium of Holocene and late Wisconsin age

wb **Sheetwash alluvium—**Fine sand, silt, and clay containing scattered granules and small pebbles or containing stringers, pods, or lenses of granule and pebble gravel, deposited by overland flow (sheet wash and rill wash). Weakly developed buried soils (humic horizons) are common locally. The deposits commonly are alkaline; they are saline in some areas. The sheetwash alluvium blankets the floors and walls of abandoned glacial meltwater channels. In some channels, the alluvium overlies a complex fill that includes glaciofluvial and glaciolacustrine deposits, till, and older sheetwash alluvium. The thickness of the deposits generally is 1–4 m; locally, it is 10 m. Mapped in North Dakota; sheetwash alluvium is included in other map units in other States

wa **Sheetwash alluvium in badland terrain—**Sheetwash alluvium (unit wb) in fans and aprons, deposited by sheet wash and sheet floods. The areas mapped are predominantly dissected, barren bedrock. The erosional topography consists of narrow-crested ridges, rounded ridges, or isolated, rounded hills of bedrock. Thin, discontinuous, grass-covered disintegration residuum commonly veneers rounded ridge and hill summits. The sod-covered residuum is more resistant than the bedrock, and it protects the summits from erosion. Narrow, steep gullies and ravines that are graded to broader valley floors separate the erosional landforms. All minor streams are intermittent. Hillslopes more gentle than 8° commonly are covered by sheetwash alluvium or by small alluvial-fan deposits composed chiefly of silt, sand, and fine gravel. Narrow deposits of channel and flood-plain alluvium (unit al) are inset into the sheetwash alluvium on the floors of broader gullies and ravines and on broad valley floors. The thickness of the sheetwash alluvium generally is 0.5–8 m. Mapped in South Dakota (wc) **Sheetwash alluvium and lake deposits—**A complex of sheetwash alluvium (unit wb) and glacial-lake and postglacial-lake deposits (units lc, lf, ls). The sheetwash alluvium is chiefly in fans and aprons that overlap the lake sediments. The thickness of the sheetwash alluvium generally is 1–5 m; locally, it is 15 m. The thickness of the lake sediments generally is 2–10 m; locally, it is >30 m. Mapped in North Dakota

MASS-MOVEMENT DEPOSITS

Mass movement (a surficial process) is a general term for downslope movement of surficial deposits, surficial materials, and (or) rock, due to gravity. **Mass-movement deposits** are earth materials accumulated primarily as a result of mass movement. **Landsliding** (a surficial process) is visually perceptible downslope movement of a mass of surficial deposits, surficial materials, and (or) rock as a result of failure along a relatively confined zone or surface of shear. **Landslide deposits** are earth materials deposited as a result of that process. On the basis of this restrictive definition, slump-block deposits are landslide deposits, but earthflow deposits and mudflow deposits are not. **Slump-block deposits** are masses of unconsolidated materials and (or) rock that have rotated backward or slid downslope as a unit, over a confined zone or surface of shear, with little or no flow. The physical properties of the transported materials are not altered greatly, and original textures, stratification, bedding, and other structures of the transported materials are retained. **Earthflow deposits** are masses of clayey or silty unconsolidated materials that are products of slow to moderately rapid movement downslope of wet (but not necessarily saturated) material that flowed as a plastic, viscous fluid. In some places, blocks or boulders of rock that are carried along on the flowing debris litter the surface. Earthflow deposits generally have well defined lateral boundaries, and they terminate downslope in lobate landforms. Many earthflow deposits are on foot slopes; commonly, they are in gullies or at the mouths of gullies in dissected slump-block deposits. Earthflow deposits commonly grade downslope into mudflow deposits. **Mudflow deposits** are heterogeneous masses of clayey or silty unconsolidated materials that are products of rapid, confined flow of saturated, predominantly fine grained, surficial material. Mudflow sediments are more fluid (less viscous) than earthflow sediments during flow; the water content during mud flow commonly ranges from 10 percent to >50 percent. In some places, blocks and boulders of rock that are carried along on the flowing debris litter the surface. Mud flow (the process) typically is confined, with well-defined margins; commonly, the slurry flows in former ephemeral stream channels or gullies. The deposits commonly are on foot slopes or in fans at the mouths of gullies and ravines. Landslide deposits are distinguished as a map unit only in North Dakota, South Dakota, and Nebraska. Landslide deposits are associated with many other surficial deposits and residual materials in other regions, and they are included in those map units. In some of those regions, the landslide deposits are rock-fall deposits, rock-slide deposits, debris-flow deposits, debris-slide deposits, and debris-avalanche deposits. Individual landslide deposits in the Eastern and Central United States are too small to be shown at the scale of this map. **Solifluction** (a surficial process) is imperceptible, unconfined, plastic, viscous flow caused by gravity acting on saturated, heterogeneous, earth materials that overlie frozen ground. **Solifluction deposits** are sediments transported and deposited primarily by that process. Solifluction is inferred to have been an active process during times of glaciation and deglaciation. **Colluvium** is a general term for a surficial mantle of heterogeneous, nonsorted and nonstratified or poorly stratified, unconsolidated earth materials and (or) rock fragments that were transported and deposited on hillslopes primarily by gravity. Most colluvium was deposited by **creep**, a process of visually imperceptible, more or less continuous movement of debris on hillslopes. The **matrix** of the colluvium is the finer grained (clay, silt, and sand) material in which the larger particles are embedded. The **lithology**, or **composition** (for example, shale, sandstone, limestone, granite, gneiss), of **clasts** (granules, pebbles, cobbles, boulders, and blocks) in colluvium reflects the compositions of the bedrock, surficial deposits, and residual materials in the vicinity that were eroded and transported.

ja **Slump-block, earthflow, and mudflow deposits of Holocene age—**The map unit includes bedrock, colluvium, residuum, and sheetwash alluvium, all of which were modified by mass movement. The **slump-block deposits** typically are single or compound, rotated blocks or multiple, concentric or parallel, hummocky ridges that are separated by elongate closed depressions. Some deposits are stable and covered with grass, with a discontinuous veneer of windblown silt (unit el) on hummocks and sheetwash alluvium (unit wb) in depressions. In some areas, the **earthflow deposits** are derived chiefly from slump-block deposits. In others, they are derived chiefly from reworking of till (units tl, tn), eolian silt (units el, eb), sheetwash alluvium (unit wb), and (or) colluvium (units co, cl). The **mudflow deposits** typically are disintegrated shale washed from exposed shale bedrock surfaces or disintegrated shale and surficial deposits derived from collapse of gully walls. The thickness of the slump-block deposits generally is 3–20 m; locally, it is >35 m. The thickness of the earthflow deposits generally is 1–5 m; locally, it is >10 m. The thickness of the mudflow deposits generally is 1–5 m. Mapped in North Dakota, South Dakota, and Nebraska

Landslide deposits of Holocene and late Wisconsin age

(jc) **Landslide deposits, bouldery colluvium, and sheetwash alluvium—**A complex map unit on hillslopes along escarpments in North Dakota and South Dakota. The **landslide deposits** are chiefly slump-block deposits, earthflow deposits, and mudflow deposits (unit ja). The **colluvium** is gravelly clay, gravelly sand, or sandy gravel containing cobbles and boulders. It was derived chiefly from eroded till (units tl, tn), dissected landslide deposits (unit ja), and, in some places, dissected glaciotectonic deposits (unit fa). The map unit includes some solifluction deposits (unit nb) derived chiefly from till. The **sheetwash alluvium** is similar to unit wb. The thickness of the landslide deposits generally is 2–10 m; locally, it is 30 m. The thickness of the colluvium generally is <15 m. The thickness of the sheetwash alluvium generally is 1–3 m; locally, it is >5 m

(jb) **Landslide deposits, disintegration residuum, and sheetwash alluvium—**A complex map unit on shale "breaks" in the drainage basins of the Missouri River and four of its major tributaries. **Landslide deposits** (unit ja) or coalesced landslide deposits are abundant in areas otherwise characterized by clayey disintegration residuum and sheetwash alluvium (unit xm) and, locally, by discontinuous patches of till (units tl, tn, tr) <2 m thick. The map unit includes colluvium, 0.5–3 m thick, consisting of bedrock float blocks and other materials that were transported and deposited on hillslopes, primarily by creep. Shale bedrock outcrops are extensive in some areas. The thickness of the landslide deposits generally is 1–20 m; locally, it is 35 m. The thickness of the disintegration residuum generally is <1 m. The thickness of the sheetwash alluvium generally is 0.5–2 m; locally, it is >4 m. Mapped in South Dakota and Nebraska

(na) **Loamy solifluction deposits, colluvium, and decomposition residuum of Holocene and late and middle Pleistocene age—**A complex map unit. **Solifluction deposits** comprise 50–70 percent of the map unit on uplands in Pennsylvania and New York. In the northern part of the mapped area, solifluction deposits are chiefly (1) heterogeneous, nonstratified rubble or (2) imbricated flagstones and channers in a silty or sandy matrix. **Flagstones** are relatively thin, flat fragments of sandstone, limestone, or shale 15–38 cm long; **channers** are fragments <15 cm long. Farther south, the deposits are chiefly (1) stratified sandy loam, loam, silt loam, silty clay loam, or clay containing scattered rock fragments or (2) massive silty clay loam or clay loam containing few or no rock fragments. Rock fragments comprise <2 percent to nearly 100 percent of the deposits. Small block-field deposits, boulder-stripe deposits, and other deposits and phenomena indicative of severe frost activity are common locally and are included in the map unit. The solifluction deposits generally are stable; they have been modified by creep and landslide activity locally. Landslide deposits generally comprise <5 percent of the area mapped, and they are more abundant in the north, near the southern limits of glacial deposits. Between the limit of late Wisconsin glaciation and limits of earlier glaciations farther south, the solifluction deposits in some places consist of reworked till; the map unit includes discontinuous patches of thin, intensely weathered till (units tk, tp). Glacial erratic boulders, cobbles, and pebbles are scattered widely on upland surfaces. Transportation and accumulation of the solifluction deposits are inferred to have occurred in a periglacial environment, contemporaneous with glaciation farther north. The **colluvium** is nonsorted, pebbly to bouldery debris transported and deposited primarily by creep. Buried soils (paleosols) are present locally in the colluvium. The **decomposition residuum**, on more gentle hillslopes, is stony to pebbly material that is a product of in-place decomposition of sandstone, conglomerate, siltstone, shale, and minor limestone. The **colluviumn** and **decomposition residuum** are similar to the colluvium in unit cl and the residuum in unit zm. The thickness of the solifluction deposits generally is 1–3 m on gentle slopes; locally, it is 6–10 m at the bases of hillslopes. The thickness of the colluvium generally is 1–2 m on the upper parts of slopes and 2–3 m on the lower parts; locally, it is >10 m in colluvial fans and aprons. The thickness of the decomposition residuum generally is <1 m to 2 m. The thickness of the included block-field deposits generally is <10 m. The thickness of the included landslide deposits generally is <5 m; locally, it is 10 m

(nb) **Loamy solifluction deposits of late Wisconsin age—**Sandy loam, loam, silt loam, clay loam, or silty clay, commonly containing scattered granules and pebbles and locally containing cobbles and boulders. In some places, the deposits are massive, containing few or no rock fragments. The deposits are chiefly reworked till (units tn, tm). Typically, they are in apronlike landforms on and at the bases of hillslopes. The map unit includes areas of till (units tn, tm), sheetwash alluvium (unit wb), and mudflow deposits similar to those in unit ja. The thickness of the solifluction deposits generally is 2–6 m. Mapped in South Dakota

(cp) **Colluvium, sheetwash alluvium, and landslide deposits of Holocene and late Wisconsin age—** A complex map unit on the walls and floors of glacial-meltwater sluiceways and glacial-flood channels. Where derived from bedrock, the **colluvium** is angular and subangular blocks, boulders, cobbles, pebbles, and granules of shale or sandstone and shale in a loamy matrix. Where derived from glacial drift, many of the cobbles and boulders are erratic bedrock from Minnesota and (or) Canada, in a clayey to sandy matrix. The **sheetwash alluvium** is similar to unit wb and the **landslide deposits** are similar to unit ja. The thickness of the colluvium generally is 0.3–15 m. The thickness of the sheetwash alluvium generally is 1–4 m; locally, it is 10 m. The thickness of the landslide deposits generally is 5 to >50 m. Mapped in North Dakota

Colluvium of Holocene and late Pleistocene age

cj **Clayey chert-clast colluvium—**Clay containing abundant angular chert clasts. On the basis of regional bedrock stratigraphy, the volume of cherty limestone required to produce the present cherty clay as solution residuum is thought not to have been available. The clay is interpreted by some geologists to be chiefly cherty colluvium derived from topographically higher sedimentary rocks and transported laterally onto the limestone bedrock. Much of the material included in this map unit possibly is solution residuum and (or) decomposition residuum that developed on older colluvium parent material and on limestone bedrock. If that is the case, the material should be classified as residuum, rather than colluvium. Sinkholes and other karst phenomena are common to abundant. North of the limit of Quaternary glaciation, residual glacial erratic cobbles and boulders derived from eroded older glacial deposits are scattered widely on the land surface in some places. The thickness of the colluvium generally is 1–15 m. Mapped in Indiana

cg **Gravelly colluvium—**Silty clay loam or fine sandy loam containing (1) scattered well-rounded granules, pebbles, and cobbles of colluvially reworked chert gravel derived from older alluvial deposits upslope and (2) chips and fragments of shale and sandstone. The map unit includes large landslide blocks of shale, sandstone, and gravel along the bases of some slopes. The colluvium is overlain by loess (units el, eb) in some places. The thickness of the colluvium generally is 0.5–10 m. Mapped in southeastern Missouri

Colluvium of Holocene and late and middle Pleistocene age

cd **Crystalline-boulder colluvium—**A complex map unit in the Appalachian Mountains that is a product of several surficial processes. In most areas, the debris was transported and deposited primarily by creep. However, slump-block landslide, rock-fall, debris-avalanche, debris-flow, earthflow, mudflow, and (or) solifluction deposits are widespread in many areas and those deposits are included in the map unit. The colluvium typically contains angular boulders and rounded to subrounded joint-block core boulders of mafic igneous rocks (for example, diabase, basalt, gabbro) and (or) feldspathic igneous and metamorphic rocks (for example, granite, granodiorite, quartz diorite, quartz monzonite, anorthosite, gneiss). The deposits range from rubble or rock waste having little or no matrix to silty clay loam containing scattered boulders and smaller clasts. Boulders commonly constitute 15–60 percent of the colluvium. The matrix generally is sandy loam, silt loam, clay loam, or sandy clay. The deposits mantle slopes of ridges and knobs. In some places, tors and pinnacles of bedrock project through the colluvium. Locally, the colluvium overlies saprolite at the bases of hillslopes. The thickness of the colluvium generally is 1–5 m; locally, it is 30 m. Mapped in Pennsylvania, Maryland, West Virginia, and Virginia

ce **Diabase- and basalt-clast colluvium—**In Pennsylvania and New Jersey, the deposits are chiefly clay loam or silty clay loam containing angular or subangular chunks of unaltered diabase or basalt and granules, pebbles, cobbles, and boulders of partly weathered diabase or basalt. The colluvium commonly contains boulders >3 m in diameter. Boulder fields are present on some middle and lower slopes. Clasts in the colluvium commonly have thick weathering rinds; spheroidal weathering of buried boulders and cobbles is common. The upper part of the deposits commonly is intensely weathered; the clay minerals are primarily smectite (swelling clay) and kaolinite. The map unit includes areas of clay loam decomposition residuum (unit zt). North of the limit of Quaternary glaciation, the colluvium in some places contains scattered glacial erratics derived from eroded glacial deposits. Residual glacial erratic cobbles and boulders are scattered widely on the land surface. In some places, the bedrock surface is veneered by a colluvial pebble and cobble lag deposit that includes glacial erratics. The lag was derived from a former mantle of till of Illinoian and (or) pre-Illinoian age (units tk, tp) that now is preserved only locally. Thin, discontinuous patches of weathered till are included in the map unit.

The relatively small deposits in Texas are chiefly clay containing clasts of weathered basalt, phonolite, and pyroclastic rock. In some places, angular to subrounded cobbles and pebbles cover 25–50 percent of the surface. The clay minerals are chiefly smectite (swelling clay).

The thickness of the colluvium in all regions generally is 1–3 m

cb **Resistant-block or resistant-boulder colluvium and rock waste—**A complex map unit. In the Eastern States, the **colluvium** is primarily (1) sand, silt, and clay containing angular to subrounded blocks, boulders, and cobbles of hard sandstone, quartzitic sandstone, or conglomerate or (2) sandy loam or silt loam containing angular fragments and round to subrounded joint-block core boulders of massive metarhyolite. The deposits mantle ridges composed of those resistant bedrock types. The colluvium generally is thicker and more extensive on south-facing slopes than on north-facing slopes. Debris cones, composed of debris-avalanche deposits, are widespread and are included in the map unit. **Rock waste** is an accumulation of coarsely sorted blocks, boulders, and cobbles having little or no matrix. Generally, it grades downslope into bouldery colluvium having a sandy or silty matrix. In many areas, rock waste accumulated below cliffs or bedrock outcrops as talus, primarily by rock fall and creep. On uplands, in some places the colluvium overlies decomposition residuum (unit zm) and block streams and block fields locally are conspicuous landforms. Also see unit zm.

In Pennsylvania, the map unit includes some solifluction deposits (unit na). Most of the solifluction deposits are inactive. Most of the colluvium, rock waste, and solifluction deposits are inferred to have accumulated in a periglacial environment, contemporaneous with glaciation farther north. Buried soils (paleosols) are present within the colluvium in some places.

In the Ouachita Mountains in Arkansas and Oklahoma, the map unit is chiefly nonsorted sandy loam, loam, clay loam, silty clay loam, or silty clay containing abundant fragments of milky quartz and blocks of quartzite and either phyllite or sandstone (also see unit cq).

The thickness of the colluvium in the Eastern States generally is 1–15 m; locally, it is >30 m. The thickness of the rock waste in many places is >30 m. The thickness in Arkansas and Oklahoma generally is 0.5 to >3 m

cq **Sandstone-block or sandstone-boulder colluvium—**Nonsorted, medium to fine sand, silt, and minor clay containing angular to subrounded blocks, boulders, and cobbles of sandstone. The map unit in some areas includes sandy clay colluvium containing fragments of milky quartz (see unit cb). The colluvium is on or at the bases of hillslopes that are underlain by intensely folded and faulted sandstone and shale. Boulder fields are present locally. The thickness of the colluvium generally is 0.5–1.5 m. Mapped in the Ouachita Mountains in Arkansas and Oklahoma

cc **Carbonate-boulder or carbonate-clast colluvium—**In West Virginia, Virginia, and Maryland, the colluvium, on slopes of knobs and ridges, is chiefly (1) sand, sandy loam, loam, clay loam, silty clay loam, or silty clay containing abundant angular, subangular, or rounded granules, pebbles, cobbles, and boulders of limestone or dolomite or (2) silty clay containing scattered to abundant cobble- to boulder-size, subangular to subrounded limestone slabs and, locally, shale chips. Also see unit zm.

In Indiana, Ohio, and Kentucky, the colluvium on or at the bases of hillslopes is chiefly silty clay or silty clay loam containing abundant angular or subangular granule- to boulder-size fragments or slabs of limestone and angular chips to slabs of shale. North of the limit of Quaternary glaciation in that region, in some places the colluvium contains scattered glacial erratics derived from eroded glacial deposits. Residual erratic cobbles and boulders are scattered widely on the land surface. In some places, exposed bedrock is veneered by a colluvial pebble and cobble lag deposit that includes glacial erratics. Some erratic boulders are >2 m in diameter. The lag was derived from a former mantle of till of Illinoian and (or) pre-Illinoian age that now is preserved only locally. Thin, discontinuous patches of till (unit tk) or loess-mantled till are included in the map unit. In that region, the upper part of the colluvium locally includes admixed loess. Loess (units el, eb) <1 m thick locally overlies the colluvium. Isolated sinkholes are present locally where the underlying bedrock is limestone.

In Texas, the colluvium is moderately alkaline clay loam or loam containing (1) scattered to abundant, angular, blocky to platy fragments of hard limestone; (2) shale chips; (3) hard particles of calcium carbonate cement or petrocalcic carbonate; (4) soft masses of calcium carbonate and, in some places, (5) sparce chert clasts. The colluvium is derived primarily from interbedded marl, limestone, shale, chalk, and minor sandstone and claystone (bedrock). On or at the bases of hillslopes, the colluvium in some places consists of more than 50 percent pebble- to boulder-size angular clasts. In other places, it is limestone rubble with very little matrix. On the rolling plateau in southern Texas, clasts commonly mantle 10–50 percent of the surface on 3°–27° slopes; clayey decomposition residuum mantles wide, gently undulating divides. The smectitic (swelling) clay is extremely hard when dry and sticky and plastic when wet. Karst features are developed in some areas; broad, shallow sinkholes contain smectite (swelling clay).

The thickness of the colluvium generally is 1–5 m in the Eastern States. Generally, it is 0.1–2.5 m in Texas

cl **Clastic-clast colluvium—**A general category of colluvium derived from a variety of clastic sedimentary bedrock types. In the Eastern States, the matrix of the deposits is chiefly sandy loam, loam, silt loam, silty clay loam, clay loam, or silty clay; locally, it is loamy sand or sand. Clasts in the colluvium are chiefly angular, subangular, or subrounded granules, pebbles, cobbles, and boulders of sandstone, quartzitic sandstone, conglomeratic sandstone, siltstone, and (or) shale; clasts of limestone or conglomerate are common locally. Boulders are rare or absent where the bedrock is poorly cemented sandstone, siltstone, and (or) shale. On some slopes on plateau uplands (in Tennessee, in particular), the colluvium includes angular blocks or slabs of sandstone, some of which are 10–15 m in diameter. Most of the deposits on hillslopes are colluvium. However, in some areas the map unit includes solifluction deposits (unit na) 1–3 m thick, clayey solution residuum (unit ra) 0.5–2 m thick, and (or) rock waste (see unit cb). Clayey colluvium generally is unstable on steep slopes. Isolated slump-block landslide deposits (unit ja) are widespread and in some areas are common to abundant; locally, 20–50 percent of the land surface is landslide deposits. In some regions, the colluvium is mixed with loess; it is covered by≈ 1 m of loess (unit el) in some places. Locally, the colluvium overlies older decomposition residuum (unit zd). Included in the areas mapped as clastic-clast colluvium are many strip mines, mine-spoil deposits, and areas of reclaimed land.

North of the limit of Quaternary glaciation in Ohio and Pennsylvania, the colluvium in some places contains scattered glacial erratics derived from eroded glacial deposits. Residual erratic cobbles and boulders are scattered widely on the land surface. Some erratic boulders are >2 m in diameter. Exposed bedrock in some places is veneered by a colluvial pebble-lag and cobble-lag deposit that contains glacial erratics. The lag was derived from a former mantle of till of Illinoian and (or) pre-Illinoian till age that now is preserved only locally. Thin, discontinuous patches of till or loess-mantled till are included in the map unit.

In eastern Oklahoma and Arkansas, the matrix of the colluvium is chiefly loamy sand, sandy loam, loam, silt loam, or clay loam. Clasts are chiefly angular and subangular granules, pebbles, and cobbles of sandstone, siltstone, and shale. In some areas, the map unit includes solution residuum (unit ra) or decomposition residuum (unit zd). Locally, the colluvium overlies older decomposition residuum (unit zd).

In some areas in Kansas and western Oklahoma, the matrix is chiefly sandy loam, loam, or clay loam. Gypsiferous rubble or colluvium containing clasts of sandstone, siltstone, shale, dolomite, and impure, partly dissolved gypsum fragments mantle hillslopes in the heads of drainages. The colluvium locally is veneered by thin, discontinuous loess (units el, eb). In some areas, the colluvium and a former cover of loess have been partly stripped from uplands by mass-wasting processes and deflation. On uplands, the map unit includes areas of clayey decomposition residuum (unit zd) 0.5–2 m thick.

In southern South Dakota, the colluvium is chiefly fine sand, loamy sand, or sandy loam containing angular granules, pebbles, and cobbles of volcaniclastic sandstone and, locally, arkosic sandstone. In some places, it is overlain by loess (units el, eb) or windblown sand (units es, ed).

The thickness of the colluvium in the Eastern States generally is 0.5–2 m on hillslopes and 15–30 m on foot slopes. The thickness in eastern Oklahoma and Arkansas generally is 0.5–1.5 m, and in western Oklahoma and Kansas it generally is 0.2–3 m. The thickness in South Dakota generally is 1–3 m

(cv) **Locally gypsiferous clastic-clast colluvium and solution residuum—**A complex map unit. The **colluvium** is chiefly sandy loam, loam, silt loam, clay loam, silty clay loam, silty clay, or clay containing angular clasts of sandstone and siltstone and slabs and chips of shale and dolomite. In some places, it includes zones of partly dissolved chunks and blocks of impure gypsum in a granular silty clay matrix and (or) it includes zones or sheets of impure gypsum rubble. The rubble is derived from beds of gypsum (bedrock) that are undergoing mass wasting following subsurface dissolution and collapse. Sinkholes are common in areas underlain by gypsum bedrock. Zones of **gypsiferous solution residuum** or partly stripped solution residuum underlie the colluvium in some areas, and gypsiferous residuum is exposed at the surface locally. Some areas of locally gypsiferous clastic-clast colluvium are included in unit cl.

Near the southern extent of the map unit in Texas, the colluvium in some areas is sandy loam or sandy clay containing fragments of sandstone, siliceous pebbles derived from local pebble conglomerate (bedrock), and (or) gravel derived from alluvium (unit at) higher on the hillslopes. Lag gravel deposits overlie the colluvium in some places.

The thickness of the colluvium generally is 0.3–1 m. The thickness of the solution residuum generally is 0.3–0.5 m. Mapped in Oklahoma and Texas

cf **Acid shale–chip colluvium—**In Pennsylvania, Maryland, and West Virginia, the colluvium is chiefly sandy clay loam, clay loam, or silty clay loam containing slabs and angular and subangular chips of noncalcareous shale; in some places, it also contains subangular and subrounded granules, pebbles, cobbles, and boulders of siltstone and sandstone. Commonly, the deposit is coarsely stratified clay loam containing thin beds and lenses of shale chips. In some places, the deposit is an open-framework rubble of platy to pencil-shape shale chips 0.6–10 cm long; clasts in the rubble are coated by clay and frequently are imbricated. The colluvium commonly grades downward to bedrock through a creep zone in which the bedding in the bedrock is deformed and the bedrock is partly disintegrated. Buried soils are present in the colluvium in some places. The map unit includes areas of loamy decomposition residuum (unit zm) <1 m thick, containing decomposed shale chips and preserved relic bedrock structure. In some areas, it also includes solifluction deposits (unit na). The upper part of the deposit in some places is mantled by younger colluvium of different composition, derived from adjacent hillslopes.

In the glaciated part of eastern Pennsylvania, the colluvium in some areas contains scattered glacial erratics derived from older glacial deposits. Residual erratic cobbles and boulders are scattered widely on the land surface. In some places, exposed bedrock is veneered by a colluvial lag deposit that contains glacial erratics. Locally, till of Illinoian and (or) pre-Illinoian age (units tk, tp), 1 to >25 m thick, overlies colluvium. The till generally is exposed only on hilltops; it is intensely weathered and has been modified by colluviation and solifluction on hillslopes. The till is included in the map unit. The map unit also includes some ice-contact and outwash sand and gravel of Illinoian and (or) pre-Illinoian age (units ka, ga, gb).

In Arkansas and Oklahoma, the colluvium is chiefly sandy clay, clay loam, silty clay loam, or silty clay containing noncalcareous shale chips and subangular to well-rounded granules, pebbles, and cobbles of sandstone and minor chert and quartzite. In that region, the map unit includes rock waste (see unit cb).

The thickness of the colluvium in the Eastern States generally is 1–3 m; locally, it is >25 m. The thickness in Arkansas and Oklahoma generally is 0.5–1 m

cs **Calcareous shale–chip and siltstone-clast colluvium—**In the Eastern States, the colluvium is chiefly silt loam, loam, clay loam, or silty clay loam containing angular and subangular fragments of shale and siltstone. Locally, it consists of blocks and chips of shale and siltstone in a matrix of disintegrated shale. The colluvium commonly grades downward to bedrock through a creep zone in which the bedding in the bedrock is deformed and the bedrock is partly disintegrated. Slump-block landslide deposits (unit ja) are common in some areas. In Indiana, some deposits on uplands are overlain by≈ 1 m of loess (unit el).

In western Oklahoma, the colluvium is chiefly (1) silt loam, loam, or clay loam containing angular or subangular fragments of siltstone and shale or (2) silt loam, clay loam, or clay containing chips and slabs of shale and, in some places, angular fragments of siltstone, sandstone, limestone, dolomite, and gypsiferous rubble.

In some areas in Oklahoma and Nebraska, shale-chip and sandstone-clast colluvium (unit cs) is included in unit cl. Locally, the colluvium is overlain by thin loess (unit el).

The thickness of the colluvium in the Eastern States generally is 1–6 m; locally, it is 12 m. The thickness in Oklahoma and Nebraska generally is 0.5–3 m; locally, it is 5 m

co **Shale-clast, chalk-clast, and chalky limestone–clast colluvium—**Chiefly silt loam, loam, or clay loam containing chips and slabs of shale and also angular and subangular pebbles, cobbles, and boulders of chalk and chalky limestone. The clay minerals are predominantly smectite (swelling clay). In some places, the map unit includes disintegration residuum that grades downward to shale, chalk, or limestone bedrock, and it also includes sheetwash alluvium. The colluvium in some areas is overlain by thin loess (unit el). The thickness of the colluvium generally is 0.5–5 m. The thickness of the included residuum generally is≈ 1 m (over chalk) to 3 m (over shale). Mapped in Kansas and Nebraska

ci **Calcrete-clast colluvium—**In South Dakota, Nebraska, and Kansas, the colluvium in most places is chiefly a nonsorted mixture of gravel, sand, silt, and clay containing fragments of calcrete and granules and pebbles of granite and metamorphic rocks (**calcrete** is conglomerate formed by cementation of gravel and sand by calcium carbonate). In headwater areas of major streams, some clasts are shale, chalk, and limestone. The sand fraction of the matrix is arkosic. The map unit includes small areas of disintegration residuum that grades downward to calcrete or conglomerate bedrock, and it also includes sheetwash alluvium.

In Oklahoma and northern Texas, the matrix in some areas is chiefly quartzose sand; in others silt and clay are locally mixed with sand. The clasts are chiefly granules, pebbles, and cobbles of calcrete. In some areas, the colluvium is moderately cemented by secondary calcium carbonate; in others, the colluvium is chiefly sandy loam containing scattered angular to subrounded granules, pebbles, and cobbles of calcrete, limestone, shale, and sandstone, and, locally, granules and pebbles of chert and quartz. In some places, the map unit includes talus composed of rock waste (see unit cb) and sheetwash alluvium.

The thickness of the colluvium generally is 0.5–2 m; locally, it is 3–4 m

ck **Chert-clast colluvium—**Sandy loam, silt loam, loam, clay loam, silty clay loam, silty clay, or clay containing angular to subrounded fragments of chert and, in some areas, granules, pebbles, and cobbles of limestone, sandstone, and shale. Locally, the colluvium contains fragments of novaculite, 7–22 cm in diameter. The colluvium is derived chiefly from eroded decomposition residuum and bedrock. However, north of the limit of Quaternary glaciation, it also contains scattered clasts of erratic igneous and metamorphic rocks eroded from till. Locally, the map unit includes talus composed of rock waste (see unit cb). The map unit includes small areas of eroded decomposition residuum (unit zs), particularly on gentle upland hillslopes. It also includes patches of till of pre-Illinoian age (unit tb) and small areas of sheetwash alluvium. In some areas, the colluvium is overlain by thin loess (unit el). The thickness of the colluvium generally is 0.25–2 m; locally, it is 3–4 m. Mapped in southeastern Nebraska and northeastern Kansas

ch **Sandy to clayey colluvium—**In Indiana, Illinois, and Kentucky, the deposit is chiefly sandy loam, sandy clay loam, or sandy clay—a mixture of colluvium and loess containing scattered angular and subangular, slabby clasts of limestone and sandstone and slabs and chips of shale. The colluvium commonly grades downward to bedrock through a creep zone in which the bedding in the bedrock is deformed. Slump-block landslide deposits (unit ja) are common in some areas. Sinkholes and other karst features are present locally where the colluvium overlies limestone bedrock. On uplands, in some places the colluvium is overlain by 1–6 m of loess (unit el).

In north-central Texas, the colluvium generally is sandy clay loam, clay loam, loam, or silt loam containing granules, pebbles, and cobbles of sandstone, dolomite, and limestone. In the Llano area in Texas, it is chiefly pebbly, micaceous clay loam or loam containing fragments of hornblende schist. On some upland slopes in Texas, the colluvium overlies a zone of pedogenic calcium carbonate. The map unit includes areas of sheetwash alluvium. Locally, a lag deposit of quartz or chert granules and pebbles veneers the surface.

The thickness of the colluvium in Indiana, Illinois, and Kentucky varies from≈ 3 m in the west to a maximum thickness of≈ 25 m in the east. The thickness in Texas generally is 0.2–2 m

cu **Colluvium complex—**A complex of units cc, ci, and ch, and also calcium carbonate–cemented colluvium. The cemented colluvium is stratified or massive clay, silt, sand, and gravel characterized by local concentration of secondary calcium carbonate, either in laminated, indurated, horizontal layers or in massive, soft zones and nodules. The map unit includes remnants of sheetwash fan and apron (coalesced fan) deposits, remnants of alluvial-fan and apron (coalesced fan) deposits (see units af and ao), and sparse deposits of lacustrine clay (unit lg) and marl. The thickness of the cemented colluvium generally is 3–8 m; locally, it is 12 m. Mapped in Texas

(cx) **Colluvium and loess—**A complex of units ci, co, and eb. Mapped in northern Nebraska

(cr) **Colluvium and solution residuum—**A complex of units cs, cc, and ra. Mapped in Kentucky (cm) **Colluvium, decomposition residuum, and solution residuum—**A complex of units cb, cd, cf, cl, zb, zd, zm, and ra, and also (1) shale- and limestone-chip colluvium and (2) felsic- and mafic-boulder colluvium and alluvium. The shale- and limestone-chip colluvium is chiefly clay loam or silty clay loam containing weathered chips of shale and rotted fragments of thin-bedded limestone. In some places, the uppermost part of the deposit consists of abundant angular to rounded fragments of sandstone and quartzite that form a resistant mantle on the surface of the weathered colluvium; the underlying shale or carbonate bedrock locally is weathered to depths of more than 30 m. Sinkholes are common locally where the colluvium overlies carbonate bedrock. The felsic- and mafic-boulder colluvium is chiefly intensely weathered, kaolinitic, silty clay loam containing scattered angular to rounded granules, pebbles, cobbles, and boulders of felsic and mafic rocks. Stone lines and layers of saprolitized colluvial gravel are common within the deposits. Most of the deposits are deeply dissected colluvial fan deposits; locally, some are dissected alluvial fan deposits. The deposits commonly overlie saprolite, which is exposed at the surface between lobes or tongues of the colluvium or alluvium. The thickness of the shale- and limestone-chip colluvium generally is 0.3–2 m. The thickness of the felsic- and mafic-boulder colluvium and alluvium generally is 1–10 m. Mapped in Tennessee, Virginia, West Virginia, Maryland, and Pennsylvania

Colluvium of Quaternary age

(ca) **Colluvium and sheetwash alluvium—**Deposits primarily on hillslopes in the "driftless area," an unglaciated area in Wisconsin, Minnesota, Iowa, and Illinois. The map unit includes solifluction deposits, solution residuum that is a product of weathering of dolomite and limestone, and decomposition residuum that is a product of intense chemical weathering of loess. Bedrock outcrops are scattered to extensive. The **colluvium** is nonsorted to well-sorted, massive to well-stratified sandy clay loam, sandy loam, sandy clay, clay loam, silty clay loam, silty clay, or clay. In some places, it is clast free; in others it contains angular or subangular granules, pebbles, cobbles, boulders, and slabs of sandstone, dolomite, limestone, chert, and minor quartz, or it is boulder rubble. Where it is derived from sandstone and quartzite bedrock, the colluvium is chiefly sandy clay loam or sandy clay containing angular and subangular granules, pebbles, cobbles, and boulders of sandstone and quartzite. Block fields, block streams, and talus in some areas are composed of blocks, boulders, and cobbles of chert, sandstone, quartzite, dolomite, and limestone. Locally, the clasts in the colluvium include angular and subangular, granule-size to boulder-size fragments of limonite, limonite-cemented chert breccia, and limonite-cemented sandstone. The matrix in some places is chiefly colluvially transported loess or clay derived from weathered loess. In many areas, much of the clayey colluvium is reworked residuum that moved downslope by creep and solifluction. Discontinuous, fissile, blocky or stiff, structureless residual clay containing scattered chert fragments underlies the colluvium and overlies dolomite and limestone bedrock locally. Chert fragments in clayey colluvium commonly are in lenses, layers, or pebble bands parallel to hillslope surfaces. Colluvium is present on nearly all valley sides and upland slopes steeper than 3°–5°. The colluvium commonly is mantled by loess (unit el) that locally is 6–8 m thick. In some places, the colluvium and the loess both are overlain by eolian sand (unit es) <5 m thick. West of the Mississippi River, in some places the colluvium contains scattered glacial erratics, and residual glacial erratic cobbles and boulders are scattered on the land surface. In some places, exposed bedrock is veneered by a lag deposit that contains glacial erratics. The erratic granules, pebbles, cobbles, and boulders were eroded from till of Illinoian or pre-Illinoian age (units tk, tf, tb, th, gb) or eroded from ice-dammed lake deposits. The **sheetwash alluvium** (see unit wb), chiefly on the lower slopes of valley sides and on valley floors, is a mixture of sand, silt, and clay that in some places is interbedded with lenses or layers of colluvium. Locally, it is overlain by >2 m of loess (unit el). The thickness of the colluvium generally is 0.5–3 m. The thickness of the sheetwash alluvium generally is 0.5–3 m

(cz) **Colluvium, decomposition residuum, and solution residuum—**A complex of units cs and zh. Mapped in Kentucky

(cw) **Colluvium and decomposition residuum of Quaternary and Tertiary age—**A complex of units cc, ch, za, and ze. Mapped in Texas

(ct) **Colluvium and alluvium of Pleistocene age—**Granule and pebble gravel, sand, and minor silt, intermixed and interbedded. The gravel-size clasts are chiefly quartz and chert. The deposits include colluvially reworked gravel, sand, and silt eroded from older alluvium and decomposition residuum (unit zl), and sand and gravel in alluvial fans (unit af). The thickness of the colluvium and the alluvium generally is 0.5–5 m. Mapped in Texas

RESIDUAL MATERIALS

Residual materials formed in place, without significant transport by ice, water, wind, or gravity, as a result of modification of pre-existing surficial deposits, surficial materials, or bedrock. As such, they are not deposits. **Grus** is a nonstratified accumulation of resistant, coarse crystal grains and angular rock fragments produced primarily by in-place disaggregration of granite and other macrocrystalline igneous and metamorphic rocks. Less resistant minerals were chemically altered to clay minerals, and the resulting volume increase caused the rock to fracture and shatter. **Disintegration residuum** is nonstratified or poorly stratified material derived primarily by in-place mechanical disaggregation of bedrock, with no appreciable subsequent lateral transport. **Decomposition residuum** is generally nonstratified material derived primarily by in-place chemical decay of rock or other earth materials with no appreciable subsequent lateral transport. The distinction between decomposition residuum and disintegration residuum is arbitrary in some regions. Some surficial materials that previously were mapped as alluvium or as undivided alluvium and marine deposits here are mapped as decomposition residuum. Decomposition residuum is developed on weathered fluvial and (or) marine deposits, just as it is developed on weathered bedrock. The alluvial or marine sand and gravel is the **parent material** on which residuum developed. Residuum on sand and (or) gravel of early Pleistocene and Tertiary age is widespread in some regions. Most of the original sediments (parent materials) were deposited by streams (for example, as channel alluvium or as alluvial-fan deposits); some of the sediments were deposited in a deltaic or coastal marine environment. Most of the sand and gravel deposits were altered greatly by postdepositional weathering processes. The physical, chemical, and engineering properties of the residuum differ greatly from the properties of the original sediments. The clasts (granules, pebbles, cobbles, and boulders) typically are very resistant chert, quartzite, quartzitic sandstone, and (or) vein quartz; soluble and unstable minerals and clasts were removed by weathering processes. Some former clasts are recognized only as “ghosts,” and only relict sedimentary structures remain. The residuum commonly is intensely stained by iron and manganese oxides; it is cemented by oxides in some places. Where the surface materials are thick, the intensely weathered residuum may grade downward to sand and (or) gravel containing minerals that are readily altered by weathering processes; the unaltered or partly altered sediments are the parent materials on which the residuum developed. Gravelly residuum commonly is overlain by silt or “loam” that contains scattered granules and pebbles. The “loam” commonly is ignored on geologic maps because it has no economic value. In some regions, the parent sand and (or) gravel are interpreted to have been deposited as channel alluvium and the “loam” is interpreted to have been deposited as flood-plain alluvium. In other regions, the “loam” is interpreted to be chiefly sheetwash alluvium and (or) windblown deposits. The “loam” in many areas is decomposition residuum derived from intense weathering of alluvium, marine sediments, and (or) eolian sediments. A former cover of “loam” was removed by erosion in some areas, and gravelly residuum is at the surface. **Solution residuum** is generally nonstratified material derived by in-place solution of carbonate rock, gypsum, or carbonate- or gypsum-cemented rock, with no appreciable subsequent lateral transport. **Saprolite** is earthy, clay-rich, decomposed rock that formed in place by long-term chemical weathering of igneous, metamorphic, and sedimentary rocks or surficial deposits. Typically, it grades downward from thoroughly decomposed rock, through partly weathered rock, to fresh parent rock. A characteristic feature of saprolite is preservation of the structure and texture of the parent bedrock. Preservation results from essentially isovolumetric chemical alteration of minerals. During weathering, the aluminosilicate minerals were altered to clay minerals, density decreased by as much as 50 percent, and porosity increased greatly. Saprolite texture ranges from clay to sand, depending on the abundance of minerals in the parent rock that were resistant to weathering. Quartz veins commonly are preserved in place in saprolite. Colors are related to the minerals in the parent rock, to the minerals produced by chemical alteration, and to drainage—bright reds and yellows were produced above the water table; grays, whitish grays, and greenish blues were produced below. Much of the “red clay” terrain in the Southeastern and South-Central United States is bedrock mantled by saprolite

Grus of Quaternary and Tertiary age

ua **Glaciated granitic grus—**Coarse granitic grus, locally overlain by patches of thin sandy till (unit ts), sand, and scattered granules, pebbles, cobbles, and boulders from local and distant sources (glacial erratics). The grus is a loose aggregate of feldspar, quartz, and biotite or muscovite mica crystals, crystal fragments, and rock fragments produced by preglacial disaggregation of coarse granite along intercrystal faces and cleavage planes. Commonly, it extends into the underlying bedrock along joint planes and around joint-block core boulders. The thickness of the exhumed grus generally is 0.5–3 m. Mapped in Rhode Island

ub **Feldspathic sandy grus—**Angular particles, 2–4 mm in diameter, of quartz, feldspar, and biotite as (1) individual crystals, (2) crystal or rock fragments, or (3) both, in a sandy clay and sandy clay loam matrix. The particles were produced in place by weathering of granite, gneiss, and schist bedrock. The map unit includes some colluvium (units cc, ch, cw). The thickness of the grus generally is 1–2 m. Mapped in Texas

Disintegration residuum of Holocene and late Wisconsin age

(xm) **Smectitic disintegration residuum and sheetwash alluvium on bentonitic shale, micaceous shale, and soft clayey shale—**Weakly to highly calcareous, mildly to strongly alkaline loam, clay loam, silty clay, or clay. The clasts are predominantly angular or subangular fragments of bentonitic shale, micaceous shale, or soft clayey shale; fragments of siltstone and sandstone are common in some areas. The clay minerals are predominantly smectite (swelling clay). Selenite (gypsum) crystals, ironstone concretions, and pyrite, marcasite, or siderite crystals are common in many areas. The residual materials and surficial deposits are hard and blocky when dry and plastic, sticky, and slippery when wet. Landslide deposits (units ja, jb) are common to abundant, and the map unit includes some colluvium. The map unit in some areas includes shale bedrock "breaks" in highly dissected terrain. On uplands, the map unit includes areas of loess (unit eb). East of the limit of Quaternary glaciation, in some places the sheetwash alluvium contains scattered glacial erratics derived from older glacial deposits and glaciofluvial deposits. Residual glacial erratic cobbles and boulders are scattered on the land surface. In some places, exposed bedrock is veneered by a residual pebble and cobble lag deposit that contains glacial erratics. Isolated patches of thin till (units tx, tr) are included in the map unit. The **disintegration residuum** is nonsorted; it is massive or it has faint relict stratification, and it is loosely consolidated or compact. Shale fragments are common to abundant, particularly in the lower part; locally, it consists of thin layers of platy shale fragments. It grades downward through a basal zone of rock fragments to bedrock. The **sheetwash alluvium**, similar to unit wb, was derived from eroded shale bedrock and eroded disintegration residuum. Alkali "slick spots" are common on the alluvium. "Slick spots" are areas in which the leached surface layer of the pedogenic soil has been removed by deflation, exposing the hard clay of the B soil horizon. The clay is slippery when moist. The thickness of the disintegration residuum generally is <1 m. The thickness of the sheetwash alluvium generally is 1–3 m; locally, it is >9 m. Mapped in South Dakota

(xh) **Silty clay loam disintegration residuum and sheetwash alluvium—**Weakly to highly calcareous, mildly to strongly alkaline silty clay loam containing clasts of calcrete, carbonate-cemented sandstone and, in some places, reworked fluvial gravel. **Calcrete** is conglomerate formed by cementation of gravel and sand by calcium carbonate. On uplands, the map unit includes areas of loess (unit eb). The **disintegration residuum** is nonstratified, nonsorted, massive, and loosely consolidated. It grades downward through a basal zone of rock fragments to bedrock. The **sheetwash alluvium**, similar to unit wb, was derived from eroded bedrock and eroded residuum. The thickness of the disintegration residuum generally is <1 m. The thickness of the sheetwash alluvium generally is 0.2–2 m. Mapped in South Dakota

(xi) **Loamy disintegration residuum and sheetwash alluvium on clayey shale—**Weakly to highly calcareous, mildly to very strongly alkaline loam, clay loam, silt loam, or silty clay loam containing clasts of clayey shale. Locally, the matrix is very fine sand, silty clay, or clay. In some areas, the map unit is chiefly sheetwash alluvium. The map unit includes landslide deposits (unit ja) and colluvium. The **disintegration residuum** is nonsorted and loosely consolidated or compact; it is massive or it has faint relict stratification. The **sheetwash alluvium**, similar to unit wb, was derived from eroded shale bedrock and eroded residuum. Alkali "slick spots" are common on the alluvium. "Slick spots" are areas in which the leached surface layer of the pedogenic soil has been removed by deflation, exposing the hard clay of the B soil horizon. The clay is slippery when moist. The thickness of the disintegration residuum generally is <1 m. The thickness of the sheetwash alluvium generally is 0.5–2 m; locally, it is 6–9 m. Mapped in South Dakota

(xk) **Loamy disintegration residuum, sheetwash alluvium, and colluvium on sandstone, siltstone, and shale—**Weakly to very calcareous, moderately alkaline loam, silt loam, clay loam, silty clay loam, or sandy loam containing clasts of sandstone, siltstone, shale, and minor limestone. The map unit includes landslide deposits (unit ja), thin or discontinuous till (units tl, tx, tr), ice-contact deposits (unit kg), glaciofluvial deposits (unit gg), and small areas of clinker (unit qa). West of the Missouri River, in many places the disintegration residuum and the surficial deposits are overlain by thin or discontinuous eolian sand and silt (units ed, es, el); locally, lag glacial erratic boulders and cobbles are conspicuous on the land surface. The **disintegration residuum** is nonstratified or faintly stratified; faint relict stratification and other relict sedimentary structures are common. It is nonsorted and loosely consolidated or compact. Bedrock fragments are common to abundant, particularly in the lower part. The surface locally is littered with wind-abraded blocks or boulders of quartzitic sandstone or sandstone. The **sheetwash alluvium**, similar to unit wb, was derived from eroded bedrock and eroded residuum. The **colluvium** is nonstratified or faintly stratified and loosely consolidated or compact. The clasts typically are angular or subangular boulders, cobbles, pebbles, and granules of sandstone, siltstone, and shale in a loamy or sandy matrix; locally, it is rubble of sandstone cobbles and boulders. In some places, the colluvium includes large float blocks of bedrock. The colluvium is chiefly on slopes in hilly terrain, on hillslopes below bedrock ledges, along escarpments, and on terrace and bench risers. The thickness of the disintegration residuum generally is <1 m. The thickness of the sheetwash alluvium generally is 0.5–2 m; locally, it is >4 m. The thickness of the colluvium generally is 0.3–4 m; locally, it is >8 m. Mapped in North Dakota and South Dakota

(xl) **Loamy disintegration residuum, sheetwash alluvium, and colluvium on sandstone, siltstone, mudstone, claystone, shale, and lignite—**Noncalcareous to highly calcareous, mildly to very strongly alkaline loam, silt loam, clay loam, or silty clay loam; in some areas, clay, silty clay, sandy loam, or loamy sand. The clasts typically are angular or subangular boulders, cobbles, pebbles, and granules of sandstone, siltstone, claystone, and soft clayey shale, fissile or platy shale, or micaceous shale; clasts or fragments of limestone, glauconitic sandstone, silcrete, clinker, silicified wood, or lignite are common locally. (**Silcrete** is conglomerate formed by cementation of gravel and sand by silica. **Clinker** is bedrock that was baked and fused as a result of natural burning of subsurface lignite beds.) The clay minerals in most places are predominantly smectite (swelling clay). The map unit includes landslide deposits (unit ja), eolian sand and silt (units ed, es, el, eb), and small areas of clinker (unit qa). Between the limit of pre-Illinoian glaciation and the limit of late Wisconsin glaciation farther east, the sheetwash alluvium in some places contains scattered glacial erratics derived from eroded glacial deposits and glaciofluvial deposits. Residual glacial erratic cobbles and boulders are scattered on the land surface. In some places, exposed bedrock is veneered by a residual pebble and cobble lag deposit that contains glacial erratics. Some of the isolated erratic boulders that are conspicuous features of the landscape west of the limit of late Wisconsin glaciation may be residual products of late Pliocene continental glaciation (also see units tr and xj). East of the limit of late Wisconsin glaciation, the map unit includes areas of thin or discontinuous till (units tl, tx). The **disintegration residuum** is nonsorted; it is massive or it has faint relict stratification and is loosely consolidated or compact. Bedrock fragments are common to abundant, particularly in the lower part. Where the residuum is derived from bentonite or bentonitic clay, it is “gumbo” that is hard when dry and sticky, plastic, and slippery when moist. Calcium-carbonate concretions 1 cm in diameter are present locally; small concretions of limonite or marcasite are common in some areas. Residual crystals or crystallized spheres and rosettes of selenite (gypsum) locally are common in the residuum. In some areas, the surface is littered with residual boulders, cobbles, and pebbles of silcrete or case-hardened bentonite or siltstone; the boulders in some places are wind abraded and polished. Locally, residual silicified (petrified) logs as long as 5 m are present on the surface. The **sheetwash alluvium**, similar to unit wb, was derived from eroded bedrock and eroded residuum and colluvium. The **colluvium** is nonstratified or has faint relict stratification, and it is loosely consolidated or compact. The clasts commonly are angular and subangular boulders, cobbles, pebbles, and granules of sandstone, siltstone, claystone, and shale; the colluvium locally is rubble of silcrete, sandstone, siltstone, limestone, and (or) clinker boulders, cobbles, and pebbles. In some places, the colluvium includes large float blocks of bedrock. Typically, the colluvium is on slopes in hilly terrain, on hillslopes below bedrock ledges and along escarpments, and on terrace and bench risers. The thickness of the disintegration residuum generally is <1 m. The thickness of the sheetwash alluvium generally is 0.5–4 m; locally, it is >8 m. The thickness of the colluvium generally is 0.3–4 m; locally, it is >8 m. Mapped in North Dakota and South Dakota

(xj) **Sandy disintegration residuum, sheetwash alluvium, and colluvium on soft sandstone, siltstone, and shale—**Weakly to highly calcareous, mildly to very strongly alkaline sand, loamy sand, or sandy loam; locally includes loam, silt loam, clay loam, silty clay loam, or clay. Commonly, the clasts are soft sandstone and siltstone; locally, clasts of shale and (or) limestone also are abundant. In some places east of the limit of pre-Illinoian glaciation, the sheetwash alluvium contains scattered glacial erratic clasts that were derived from eroded glacial deposits and glaciofluvial deposits. Residual glacial erratic cobbles and boulders are scattered widely on the land surface. In some places, exposed bedrock is veneered by a pebble and cobble lag deposit that contains glacial erratics. Isolated remnants of thin and discontinuous till and (or) glaciofluvial deposits (unit tr) are included in the map unit (also see description of unit xl). The map unit includes landslide deposits (unit ja) and eolian sand and silt (units ed, es, el, eb). The **disintegration residuum** is nonsorted; it is massive or has faint relict stratification, and generally it is loosely compact. The **sheetwash alluvium**, similar to unit wb, was derived from eroded bedrock and eroded residuum and colluvium. The **colluvium** is stony or cobbly debris derived from bedrock outcrops higher on the hillslopes. The thickness of the disintegration residuum generally is <1 m. The thickness of the sheetwash alluvium generally is 0.3–2 m; locally, it is >4 m. The thickness of the colluvium generally is 0.3–2 m; locally, it is >6 m. Mapped in South Dakota

Disintegration residuum of Holocene and late and middle Pleistocene age

xg **Cemented, gravelly disintegration residuum—**Calcareous, friable, pebbly fine to very coarse quartz sand, sandy clay, sandy clay loam, loam, or clay loam. The clasts commonly are predominantly angular, pebble-size fragments of platy secondary calcium carbonate, chert, and, locally, quartzose sandstone. Where it is developed on conglomerate, 20–50 percent of the residuum is rounded chert, quartz, and quartzite pebbles and granules in discontinuous beds 5 cm to 1 m thick or admixed in gravelly sandy clay. In some areas, the residuum is chiefly sandy gravel composed of well-rounded quartz, quartzite, and chert granules and pebbles. Commonly, the residuum is cemented by secondary calcium carbonate 0.2–2.5 m below the surface. The carbonate is platy, massive, laminar and hard, chalky and soft, nodular, or brecciated. The disintegration residuum commonly overlies quartz sand, claystone, sandstone, marl, calcrete, and (or) limestone. (**Calcrete** is conglomerate formed by cementation of gravel and sand by calcium carbonate.) In some areas, it is overlain by thin eolian sand (units ed, es). On some gently undulating uplands and plains, the residuum surface is pocked or pitted by shallow, nearly circular or elongate, closed depressions that are 50–300 m in diameter and spaced 1–3 km apart. The depressions are partly filled with calcareous clay, silty clay, or sandy clay, with or without scattered chert pebbles. The thickness of the disintegration residuum generally is 0.5–5 m. Mapped in southern Texas

xc **Quartz-sand disintegration residuum—**Chiefly calcareous, very fine to coarse quartz sand, loamy sand, sandy loam, loam, or silt loam containing angular chunks and fragments of sandstone. Locally, the residuum contains abundant muscovite (mica) fragments; in some places, it is stained by limonite. The residuum grades downward to sandstone bedrock through a zone of broken fragments of weakly cemented sandstone, irregular, hard limonite- and calcium carbonate–cemented masses, and nodules and veins of calcium carbonate. The cemented zones form resistant escarpments and rolling uplands. On uplands, the residuum is chiefly on interbedded sandstone, sandy clay, and tuffaceous siltstone and claystone. Locally, lag deposits of chert pebbles and granules on the surface are derived from disintegration of conglomerate bedrock. On valley walls, in some places the disintegration residuum is developed on colluvium. The map unit includes areas of calcium carbonate–cemented decomposition residuum and colluvium. Locally, the residuum is overlain by eolian sand (units ed, es). The thickness of the disintegration residuum generally is 0.5–3 m. Mapped in southern Texas

xa **Disintegration residuum on clastic rocks—**Noncalcareous or calcareous fine sand, sandy loam, sandy clay loam, sandy clay, clay loam, silty clay loam, or silty clay containing chips of shale and small fragments of mudstone, siltstone, and (or) sandstone. Fragments of limestone or lignite are abundant locally. The sandy residuum commonly is stained by limonite. The clayey residuum generally is calcareous and alkaline; locally, it contains smectite (swelling clay). Veins or seams of small gypsum crystals and amorphous calcium carbonate locally transect the clayey residuum. In some places, the residuum contains limonite platelets and nodules, soft concretions and amorphous masses of secondary calcium carbonate, and (or) hard laminar masses of calcium carbonate. The residuum commonly grades downward to bedrock through a zone of bedrock fragments and fractured bedrock. In some places, the matrix is sparse and a thin lag rubble of bedrock fragments mantles the bedrock. The map unit includes some colluvium and sheetwash alluvium on hillslopes, terraced alluvial deposits (unit at), and also extensive deposits of unmapped fluvial silt, sand, and gravel on uplands. Near the Rio Grande, sand and gravel caps drainage divides. The granules, pebbles, cobbles, and boulders in the included gravel on uplands are predominantly limestone; clasts of quartz, quartzite, sandstone, siltstone, and (or) mudstone are common in some areas. The thickness of the disintegration residuum generally is 5 cm to 3 m. Mapped in Oklahoma and Texas

xb **Disintegration residuum on clastic rocks and carbonate rocks—**Calcareous sandy loam, sandy clay loam, sandy clay, silty clay loam, silty clay, or clay on shale, sandstone, gypsum, limestone, and (or) dolomite. In many areas, the residuum grades downward to bedrock through a zone of fresh rock fragments. Locally, it includes zones of dolomite and gypsum clasts. Where it is developed on fractured limestone, clayey residuum in some places contains chert rubble or limestone rubble. Where it is developed on shale, the lower part commonly consists of shale chips. In some places, a discontinuous layer of indurated secondary calcium carbonate, 2–3 cm thick, coats the bedrock surface. The map unit includes some limestone rubble and colluvium composed of shale or sandstone debris; in some places, it includes gravelly colluvium derived from older alluvial deposits (units at, ao, af). Areas underlain by dolomite and gypsum bedrock commonly are characterized by dissolution sinkholes and by caves and caverns filled with collapsed rubbly residuum. The thickness of the disintegration residuum generally is 0.5–l m. Mapped in Texas

xd **Stony, gypsiferous disintegration residuum—**Noncalcareous or calcareous silty clay loam, loam, or silt loam containing abundant rubble of dolomite, sandstone, mudstone, and partly dissolved gypsum clasts. The material grades downward to bedrock through a zone of rock fragments. The map unit includes some rubbly colluvium. The thickness of the disintegration residuum generally is 0.5–1 m. Mapped in Texas south of southwesternmost Oklahoma

(xe) **Silty-clay disintegration residuum and gypsiferous solution residuum—**Noncalcareous to highly calcareous silt loam, loam, or clay loam derived from shale, siltstone, gypsum, and thin beds of dolomite. The **disintegration residuum** commonly includes blocky fragments or slabs of siltstone and chips of shale in the lower part. The matrix in the lower part of the **solution residuum** also includes zones of gypsum fragments. Sinkholes formed by subsurface dissolution and collapse of gypsum bedrock are common. The map unit includes some gypsiferous colluvium (unit cv). The thickness of the disintegration residuum generally is <1 m. The thickness of the solution residuum generally is 0.5–1 m. Mapped in southwestern Oklahoma

(zx) **Decomposition residuum and colluvium of Holocene and late and middle Pleistocene age on igneous and metamorphic rocks—**Calcareous or noncalcareous, nonsorted and nonstratified loam, silt loam, silty clay loam, or clay loam. The **decomposition residuum** locally is very stony; the clasts are chiefly granite, gneiss, schist, amphibolite, metagabbro, meta-anorthosite, and marble. Schist commonly decomposes to arkosic sand, loamy sand, and sandy loam. The decomposition residuum is intensely weathered; iron oxide stains are pervasive. Locally, it is lateritic; the clay mineral gibbsite is present in the surface soil in some places. The larger clasts in the residuum typically are altered; smaller or less resistant clasts are partly or completely decomposed. Locally, cobbles and boulders are spheroidally weathered. The **colluvium**, on hillslopes and in debris fans on foot slopes, is intensely weathered in the upper 3–4 m; intense iron-oxide stains are pervasive. Cobbles commonly are altered; core boulders are present locally. The colluvium generally is stable; most of it was deposited contemporaneously with late Pleistocene and middle Pleistocene glaciations farther north. The map unit includes some solifluction deposits (unit na). North of the limit of pre-Illinoian glaciation in Pennsylvania, in some places the colluvium contains scattered glacial erratics derived from eroded glacial deposits. Residual erratic cobbles and pebbles are scattered widely on the land surface. In some places, bedrock is veneered by a pebble and cobble lag deposit that contains glacial erratics. The lag was derived from a former mantle of till of pre-Illinoian age (unit tp) and (or) till of Illinoian age (unit tk) that is preserved only locally. The map unit includes thin, discontinuous, patches of till (units tp, tk), ice-contact deposits (unit ka), and glaciofluvial deposits (unit ga). The till generally has been modified by colluviation and solifluction. The thickness of the decomposition residuum generally is 1–4 m. The thickness of the colluvium generally is 2–6 m; locally, it is >30 m. Mapped in New Jersey and Pennsylvania

Decomposition residuum of Quaternary and Tertiary age on sand and gravel

zb **Decomposition residuum on sand and gravel beneath high stream terraces and in alluvial fans—**Granules, pebbles, cobbles, and boulders in a sandy clay loam, sandy clay, loam, silty clay loam, or silty clay matrix. The clasts are chiefly quartzite and quartzitic sandstone. The decomposition residuum is developed on a sequence of alluvial-terrace and alluvial-fan deposits at different topographic positions in the landscape. The surfaces of the highest (oldest) alluvial deposits commonly are characterized by boulder lag accumulations. In general, the average particle size in the matrix of the deposits beneath lower (younger) terraces becomes finer (smaller) upward. The alluvial deposits are increasingly dissected and weathered with increasing height above the present streams (the older deposits generally are more eroded and more intensely weathered). Where the parent alluvium was thick, the residuum commonly grades downward to unaltered alluvium. Sinkholes are common where the residuum and (or) alluvium overlie limestone bedrock. The map unit in many areas is characterized by small areas of residuum and (or) alluvium separated by other surficial deposits or materials or by extensive bedrock outcrops; the intervening deposits, materials, and bedrock outcrops are included in the map unit. The thickness of the decomposition residuum generally is 2–10 m. The thickness of the underlying parent alluvium generally is <10 m; locally, it is 80 m. Mapped in Virginia and West Virginia

zk **Decomposition residuum on upland sand and gravel and on paleochannel fill deposits—** The deeply weathered decomposition residuum is chiefly intermixed and interbedded gravel, sand, silt, and clay that locally is cemented by limonite. At depth, the residuum grades downward to gravel, sand, silt, and clay that contains angular to rounded, cobble-size and pebble-size, slabs and chips of limestone, siltstone, and dolomite; pebbles and granules of limonite and limonite-cemented sandstone; cobbles and pebbles of chert, silicified limestone, and quartz; and fragments of coal. The deposits are in remnant channel segments of high-level courses of the ancestral Licking River and its tributaries. The combined thickness of the decomposition residuum and the parent material alluvium generally is 8–22 m. Mapped in northern Kentucky

zn **Chert-pebble decomposition residuum on channel gravel and sand—**Granules, pebbles, cobbles, and boulders in a matrix that is predominantly fine sand. The matrix clay and silt content increases upward. Most of the clasts are well-rounded chert; some are quartzite, sandstone, or claystone. Iron and manganese oxides locally stain the chert fragments. The sand is predominantly quartz grains. The residuum grades downward to the parent channel alluvium. Heavy minerals in the parent alluvial sand indicate a source in the headwater area of the ancestral Mississippi River. In some areas, the residuum is overlain by 4–6 m of loess (units el, ea). The combined thickness of the decomposition residuum and the fluvial deposits locally is 20 m. Mapped in northeastern Arkansas and southeastern Missouri

zg **Crumbly quartz-clast decomposition residuum on sand and gravel—**Massive or faintly stratified, compact clay loam, sandy loam, or gravelly loam that grades downward to intensely weathered, well-stratified parent sand and pebbly gravel. The decomposition residuum commonly is intensely stained and cemented by iron and manganese oxides; sand grains generally are coated by iron oxides. Generally, it is intensely altered—the clay minerals gibbsite, halloysite, and endallite are abundant as mineral alteration products. The clasts are chiefly well-rounded granules and pebbles of quartz, quartzite, sandstone, and chert. Quartz, quartzite, and quartzose sandstone clasts commonly crumble to tripoli, a friable silica powder. Chert clasts generally are soft and chalky or are represented only by soft silt residues (“ghosts”). The combined thickness of the decomposition residuum and the parent alluvium generally is 6–9 m. Mapped in southeastern Pennsylvania

zc **Decomposition residuum on sand or mixed-composition sand and gravel on upland surfaces—**Decomposition residuum on fluvial (and marine?) deposits of different ages at several topographic positions in the landscape, generally on broad drainage divides and upland surfaces. The residuum tends to be thicker and more intensely weathered on older (topographically higher) deposits, and thinner and less intensely weathered on younger (topographically lower) deposits. In all regions, the map unit includes some colluvium, sheetwash alluvium, and other residual materials.

In New Jersey, in some areas the residuum is similar to unit zg. Elsewhere, the matrix is chiefly massive or faintly stratified, compact gravelly sand, sand, sandy clay loam, sandy clay, sandy loam, loam, clay loam, or clay. The clay minerals gibbsite, halloysite, and endellite are common mineral alteration products, particularly in residuum at higher topographic positions in the landscape. Feldspar grains, chert pebbles, and arkosic sandstone clasts generally are decomposed to soft, silty residues (“ghosts”). Where not intensely weathered, the chert clasts commonly have chalky coatings. Granite, gneiss, schist, gabbro, diabase, and basalt clasts are saprolitized (see the discussion of saprolite) or they have thick weathering rinds. Shale and arkose clasts generally are decomposed. Quartz and quartzite pebbles and granules commonly crumble to tripoli, a friable silica powder. Quartz, quartzite, and quartzose sandstone cobbles and rare boulders are chiefly intact and are well rounded. Most of the clasts have clay coatings. Secondary ironstone concretions are common locally. The residuum grades downward to intensely weathered parent quartzose or arkosic gravelly sand and sand that is irregularly stained by iron and manganese oxides. Where the parent alluvium is predominantly sand, the upper part of the sand commonly is cemented by iron oxides to form ironstone; where predominantly gravel, the upper part commonly is cemented to ferruginous conglomerate. Eolian silt and sand (units el, es, ed) locally overlie the residuum.

In Delaware and eastern Maryland, the residuum generally is sandy loam that grades downward to feldspathic sand and minor gravel stained by iron oxides. Rounded quartzite or quartzose sandstone boulders as large as 1 m in diameter are common locally. In western Maryland, the residuum is chiefly massive, siliceous silt loam, sandy loam, or gravelly loam that grades downward to parent fluvial gravel and sandy gravel that has a silty matrix and contains lenses of gravelly clay. Cobbles as large as 25 cm are rare in the residuum and in the underlying fluvial deposits. Clasts are chiefly granules and pebbles of chert, quartz, quartzite, and quartzose sandstone. The sand fraction is predominantly quartz. The residuum commonly is overlain by eolian sand (unit es).

In Virginia and North Carolina, the residuum is chiefly sand, sandy loam, sandy clay, or sandy clay loam that contains lenses of gravel and zones of kaolinite. The upper 3 m of the residuum is intensely weathered; at depths of 10–15 m, the residuum grades downward to sand that in some places contains kaolinite, glauconite, and opaline silicate clay minerals.

In South Carolina, the residuum is chiefly silt loam that contains local zones of clay and, in some places, some well-rounded granule, pebble, and cobble gravel. The clasts are predominantly intensely weathered crystalline igneous and metamorphic rocks and quartz.

In Georgia and Florida, the residuum is chiefly quartz sand or micaceous sand that locally grades downward to clay and in some places contains lenses of silt and gravel. In the western part of the Florida Peninsula, the residuum locally includes lenses of kaolinite that contain leached and partly decomposed oyster shell fragments.

The thickness of the decomposition residuum varies: it is 1–3 m in Florida and 1–9 m in New Jersey. The thickness of the underlying parent material alluvium in New Jersey locally is >15 m

zl **Quartz-pebble, chert-pebble, and quartzite-pebble decomposition residuum on sand and gravel on upland surfaces—**Decomposition residuum on fluvial (and marine?) deposits of different ages at several diferent topographic positions in the landscape; generally on broad drainage divides and upland surfaces.

In North Carolina, the residuum is chiefly gravelly sandy clay loam, sandy clay, or sandy loam. The sand is chiefly quartz grains; the granules and pebbles are predominantly well-rounded quartz. In some places, the gravel in the residuum and in the parent alluvium is uniformly pea-size; in others it includes clasts as large as 6 cm in diameter. Commonly, it is predominantly pebbles. The residuum is intensely weathered in the upper 1.5–3 m; it grades downward to parent alluvium where the parent alluvium was thick. In the upper 1–2 m of the residuum, the clay minerals are predominantly gibbsite and kaolinite; at greater depth they are predominantly kaolinite. In some areas, hematite nodules 1–2 cm in diameter are abundant; nodules are absent in others. The residuum is on uplands and hillslopes underlain by alluvium of Tertiary age. Locally, it is overlain by eolian sand (unit es).

In Georgia, the residuum is chiefly sandy clay loam that contains local lenses and beds of angular to rounded quartz-pebble gravel and kaolinitic clay. Extensive, but thin deposits of windblown sand (unit es) overlie the residuum.

In northeastern Mississippi and northwestern and central Alabama, the residuum is chiefly gravelly quartz sand, sandy loam, or sandy clay loam. Lenses of clay are present in some places. The granules, pebbles, and cobbles are chiefly chert; quartz clasts are abundant in some areas. Weathered clasts of hard, resistant plutonic and metamorphic rocks are present in some places in Alabama. In some areas in Mississippi, the residuum includes irregular masses of sand and gravel cemented by limonite. In both States, the residuum locally contains admixed loess or is developed in part on loess.

In southern Illinois and southwestern Kentucky, the decomposition residuum is chiefly gravelly sand mixed with minor silt and clay; the clay generally is more abundant in the uppermost part of the residuum. Granules, pebbles, cobbles, and rare boulders are chiefly chert; some are quartzite and, locally, sandstone or claystone derived from the underlying bedrock. Commonly, the clasts are predominantly pebbles and granules. The residuum locally is stained or cemented by iron and manganese oxides. In most places, it is overlain by loess (units el, eb). The parent alluvium in Illinois and Kentucky is interpreted to be predominantly alluvial-fan deposits of Tertiary age.

In westernmost Tennessee, the residuum is chiefly massive to weakly bedded gravelly sand, loamy sand, sandy loam, or sandy clay loam. The clasts are predominantly chert pebbles. Some granules, pebbles, cobbles, and rare boulders are quartz, quartzite, and (or) sandstone in some places. Clasts of iron-cemented gravel derived from the parent gravel are common. The residuum grades downward to pebble gravel or to sheet sand or loamy sand that disconformably overlies gravel. The parent gravel and sand is predominantly channel alluvium of Tertiary age; it comprises an areally extensive valley fill. The residuum and parent gravel in the fill in some places are as thick as 30 m. The residuum generally is overlain by 2–8 m of colluvially and alluvially reworked loess (unit ea).

In northwestern Florida, southeastern Alabama, and southeastern Mississippi, the residuum is chiefly gravelly quartz sand containing lenses of sandy clay, sandy loam, silt loam, or clay. In Florida, the clasts are chiefly granules and pebbles of quartz and some chert; in Mississippi and Alabama, chert generally is more abundant than quartz. The residuum grades downward to alluvial sand and gravel. It contains admixed loess in some places, and the map unit includes some gravelly colluvium. Plant and vertebrate fossils in the parent alluvium and in clay beneath the alluvium indicate that the alluvium in some areas is early Pleistocene and Pliocene in age.

In southwestern Mississippi and Louisiana and in the eastern part of the area mapped in Texas, the decomposition residuum is chiefly gravelly sand containing lenses of sandy loam or clay. The clasts are predominantly chert granules and pebbles; quartz clasts are common locally. In most places, the residuum grades downward to parent alluvial channel or fan sand and gravel. In some areas, the residuum is intermixed and interbedded sand, silt, and clay that contains ferruginous nodules in the upper part; the parent material is chiefly flood-plain and overbank deposits.

In the western part of the area mapped in Texas, the residuum is chiefly gravelly sandy loam, loam, sandy clay loam, or clay loam. Quartz, quartzite, and chert pebbles and granules, in some places in beds 5 cm to 1 m thick, constitute 30–90 percent of the residuum. Fragments of secondary calcium carbonate are common; sandstone fragments are common in some places. In that part of Texas, the residuum commonly is cemented by platy, massive, laminar, brecciated, chalky, or nodular secondary calcium carbonate 0.2–2 m below the surface. On gently undulating uplands, the surface locally is pock marked by shallow, nearly circular, clay-filled depressions that are 50–300 m in diameter and 1–3 km apart.

The thickness of the decomposition residuum in North Carolina generally is 3–6 m, and in Georgia it is 5–15 m. The thickness in northeastern Mississippi and northwestern and central Alabama generally is 2–5 m; locally, it is 15 m. In Illinois, Kentucky, and Tennessee, the thickness is 2–30 m. In Florida, southern Alabama, southern Mississippi, and Louisiana the thickness of the decomposition residuum generally is 5–40 m; the maximum thickness is 60 m. The thickness in Texas in some areas is 0.3–5 m; in general it is 5–30 m; locally, it is 60 m

Decomposition residuum of Quaternary age on sedimentary rocks that contain swelling-clay minerals or that weather to form swelling-clay minerals—The residuum is subject to large-volume shrinkage and expansion as a result of changes in moisture content

ze **Smectitic-clay decomposition residuum—**The clay minerals are predominantly smectite (swelling clay). In some areas, the residuum contains calcareous nodules or limonite nodules or platelets. The map unit includes some colluvium.

East of the Mississippi River, the residuum is chiefly massive, plastic clay, sandy clay, or sandy loam. In some areas, it includes zones of quartz sand or ferruginous quartz sand. The residuum grades downward to marine clay or marl or to limestone or sandstone bedrock. In Tennessee and Mississippi, the residuum in some places contains admixed loess and it is overlain by loess (units el, ea) in some areas.

West of the Mississippi River, the residuum is chiefly clay, sandy clay, silty clay, silt, or fine sand that locally contains calcareous nodules. It grades downward to (1) tuffaceous clay, marine clay, or marl or (2) sandstone, limestone, shale, lignite, or chalk bedrock. Sandy residuum commonly is stained by limonite. Gilgai, a crack structure, commonly develops on clayey surfaces when the residuum dries. In Arkansas, in some places the map unit includes some decomposition residuum on sand and chert-pebble gravel (unit zl).

On the coastal plain in Texas, the residuum is chiefly decomposed chalk and marl or decomposed clayey limestone and shale. In some areas, it is clay or sandy clay containing calcium carbonate concretions; at 0.6–1.0 m depth the residuum overlies a zone of hard secondary carbonate or calcium carbonate–impregnated sandy clay at the contact with bedrock. In some areas in southern Texas, the residuum contains relict gravel clasts derived from alluvium (units at, af).

The thickness of the decomposition residuum in all regions generally is 0.1–3 m zp **Sand, silt, and smectitic-clay decomposition residuum—**Calcareous or noncalcareous fine sand mixed with silt and minor smectitic clay. The map unit includes areas of eolian sand (unit es) and locally derived colluvium and alluvium. Sinkholes and other karst phenomena associated with the underlying limestone bedrock are common. The thickness of the decomposition residuum generally is 1–2 m. Mapped in Florida

zu **Gravel, sand, silt, and smectitic-clay decomposition residuum—**Gravel, sand, sandy clay loam, loam, or silt loam containing secondary carbonate concretions and limonite concretions. The sand is chiefly quartz grains; clasts 2–10 cm in diameter are predominantly novaculite, quartz, quartzite, and sandstone. The clay minerals are predominantly smectite (swelling clay). The map unit includes some colluvium. The thickness of the decomposition residuum generally is 0.5–2 m. Mapped in southeastern Oklahoma and southwestern Arkansas

zj **Decomposition residuum complex—**A complex of units zc, ze, and zf. Mapped in Texas, southwestern Arkansas, and northwestern Louisiana

zv **Decomposition residuum complex—**A complex of units ze and zs. Mapped in northern Texas

Decomposition residuum of Quaternary and Tertiary age on other sedimentary rocks

za **Clayey to sandy decomposition residuum—**Noncalcareous sand, loamy sand, sandy loam, sandy clay, loam, silt loam, silty clay loam, or silty clay. The map unit includes areas of other classes of decomposition residuum (units zc, zl, zf, ze) and some colluvium.

In New Jersey and Maryland, the residuum is loosely consolidated; it is massive or it has faint relic stratification. It grades downward to quartzose sand or glauconitic sand or clay; locally, it overlies diatomaceous silt. Commonly, it contains stringers, pods, or lenses of gravel and scattered, rounded granules, pebbles, and cobbles (chiefly quartz and quartzite) introduced from above by bioturbation. The map unit includes areas of gravelly decomposition residuum (units zg, zc) and alluvium and estuarine marine deposits (ae).

From North Carolina to the Mississippi Embayment, the residuum in some areas is micaceous. In most areas, the clay minerals are predominantly kaolinite; however, in some places they are chiefly smectite (swelling clay). Locally, the residuum contains zones of kaolinitic clay or sandy clay, leached and partly decomposed oyster-shell fragments, or subrounded quartz-pebble gravel. The sand grains, granules, and small pebbles are chiefly quartz. The residuum commonly grades downward to quartzose sand, glauconitic clay or sand, or weakly consolidated sandstone. Locally, the upper 0.5–4 m of the residuum includes intermixed loess and (or) eolian sand, and the residuum locally is overlain by eolian sand (unit es).

West of the Mississippi Embayment, the residuum in some places is chiefly coarse pebbly sand. In Louisiana, it contains fragments of lignite in some places. In parts of Texas, it is very micaceous; it contains hard, limonite-cemented masses and limonite nodules and veins, and it forms resistant escarpments and rolling uplands. In some areas, it grades downward to sandstone, conglomerate, shale, or claystone that is cemented in some places. In some areas, the residuum contains granules and pebbles of limestone, gneiss, and schist or subrounded pebbles of sandstone or hard volcanic tuff. In Texas, the map unit includes areas of calcium carbonate–cemented sandy clay decomposition residuum that in some places is gypsiferous and saline, and it includes areas of colluvium composed of limonite-cemented rubble. The residuum is overlain by eolian sand (units ed, es) in some areas.

The thickness of the decomposition residuum from New Jersey to Georgia generally is 1–3 m; locally, it is >5 m. The thickness westward to the Mississippi Embayment generally is 0.5–3 m; the maximum thickness is 7 m. West of the Mississippi Embayment, the thickness generally is 1–3 m; locally, it is 6–8 m

zf **Ferruginous sand and clay decomposition residuum—**The map unit in most areas is quartz sand, sandy clay loam, sandy clay, silty clay, or clay. The sand commonly is irregularly cemented to form hard, limonitic masses; veins and nodules of limonite or masses of limonite-cemented sandstone are abundant. The residuum grades downward to sandstone, siltstone, or shale bedrock. In some regions, ferruginous quartz sand is cemented by iron oxide to form tubules, boxwork structures, and corrugated masses, and the residuum grades downward to ferruginous uncemented bedrock. In Alabama, residuum that overlies weakly cemented calcareous sandstone in some areas is sandy clay loam or sandy clay containing limonite pebbles; locally, the pebbles are sufficiently abundant that the residuum constitutes commercial-grade iron ore. In Tennessee and Mississippi, the residuum in some places contains admixed loess; it is overlain by loess (unit ea) in some areas. The thickness of the decomposition residuum generally is 1–5 m; locally, it is l5 m

(zd) **Decomposition residuum and colluvium on shale, siltstone, and sandstone—**On the Cumberland Plateau and in the Ridge and Valley Province east of the Mississippi Embayment, the **decomposition residuum** generally is sand, sandy loam, sandy clay loam, loam, or clay loam, chiefly on flat or gently sloping upland surfaces and broad ridge crests. The residuum grades downward to shale or sandstone bedrock; the lower part commonly includes shale chips or fragments or angular slabs of rotted sandstone. In Alabama, the residuum in some places is clayey and the clay minerals are predominantly smectite (swelling clay). The residuum is subject to subsidence where it overlies underground coal mines. The **colluvium** generally is stony loam, clay loam, or sandy clay on hillslopes. In part, it is derived from associated residuum. Where the colluvium is clayey, slope failure is common. Landslide deposits (unit ja) are common to abundant in some areas; in general, the abundance of landslide deposits increases northward.

In eastern Missouri and Arkansas west of the Mississippi Embayment, the **decomposition residuum** is sandy loam, silt loam, silty clay loam, or clay containing angular fragments of sandstone, siltstone, or limestone or chips of shale. Commonly, it grades downward through a zone of bedrock fragments to bedrock. In some areas, the residuum contains, or is intermixed with, eolian silt or fine sand. Locally, it is overlain by thin loess (unit el). The associated **colluvium** is derived primarily from sandstone, siltstone, and shale.

In Oklahoma, Kansas, and western Missouri, the **decomposition residuum** generally is sandy loam, silt loam, or clay loam that grades downward through a zone of weathered fragments of sandstone, siltstone, and shale to bedrock. In some areas, it has been thinned by deflation and slope wash. The **colluvium** contains clasts of sandstone, siltstone, and shale.

The thickness of the decomposition residuum in all regions generally is 0.5–2 m; locally, it is 5–7 m. The thickness of the colluvium generally is 1–12 m

zs **Decomposition residuum on sandstone, siltstone, shale, limestone, and dolomite—**Sandy loam, loam, silt loam, silty clay loam, silty clay, or clay containing chips of shale and (or) fragments of sandstone, siltstone, chert, limestone, and (or) dolomite. Secondary iron and manganese oxide concretions and (or) carbonate nodules are common locally. In many areas, the residuum grades downward through a zone of bedrock fragments to bedrock. The map unit includes some solution residuum and colluvium. On upland surfaces in Kansas, the map unit includes residual lag deposits of chert clasts. South and southwest of the Ouachita Mountains in Arkansas and Texas, the residuum in some places is developed in fine sand and gravel. In the westernmost region mapped as unit zs in Oklahoma, Kansas, and Missouri, sinkholes, areas of partly dissolved gypsum bedrock, and deposits of gypsum rubble are common locally. In some regions, the decomposition residuum contains, or is intermixed with, eolian silt or fine sand. Locally, it is overlain by thin loess (unit el). In northeastern Kansas and northwestern Missouri north of the limit of pre-Illinoian glaciation, the residuum locally is overlain by till (unit tb), scattered residual glacial erratics, and (or) thin loess (units el, eb). The thickness of the decomposition residuum generally is 0.5–3 m; locally, it is 4–5 m

(zt) **Decomposition residuum and colluvium on arkose, sandstone, argillite, shale, and conglomerate—**Loamy sand, sandy loam, loam, silt loam, silty clay loam, clay loam, or silty clay. The **decomposition residuum** locally contains rounded pebbles and cobbles, chiefly of quartz. The lower part commonly contains chips of shale and (or) fragments of shale and sandstone. Conglomerate bedrock is decomposed to nonstratified, earthy, fine gravel. The residuum commonly is porous where derived from sandstone. Locally, the residuum contains crumbly, weathered clasts of diabase, basalt, and (or) diorite. It commonly is intensely weathered; locally, it is lateritic. In areas of low relief, it is overlain by thin loess (el) or sheetwash alluvium in some places. North of the southern limit of pre-Illinoian glaciation in New Jersey and Pennsylvania, the map unit includes some till (units tk, tp) of Illinoian and pre-Illinoian age. In some places, the residuum is developed in and through intensely weathered till, glaciofluvial deposits, and (or) lag deposits derived from till or glaciofluvial deposits. The till in most places has been modified by colluviation, solifluction activity, and other mass-wasting processes. The **colluvium** locally contains large cobbles, boulders, and (or) blocks of arkose, sandstone, argillite, conglomerate, diabase, and (or) basalt. In Pennsylvania, Maryland, and Virginia, the map unit includes some solifluction deposits (unit na) 0.3–3 m thick, composed chiefly of shale rubble. The thickness of the decomposition residuum generally is 0.5–3 m. The thickness of the colluvium generally is l–5 m (zo) **Clayey to sandy decomposition residuum and solution residuum—**Sandy loam, sandy clay loam, sandy clay, or clay decomposition residuum and cherty solution residuum. The **decomposition residuum** is derived chiefly from interbedded thin layers of shale and sandstone. The clasts are predominantly shale chips and fragments of sandstone and chert. The **solution residuum** is similar to unit ra. Locally, it contains abundant iron-stained, angular and subangular chert fragments as long as 20 cm. The base of the solution residuum commonly is irregular—the residuum extends deeply into the underlying limestone bedrock, along fractures and solution fissures. The map unit includes some colluvium and sheetwash alluvium. The thickness of the decomposition residuum and solution residuum generally is 0.5–2 m. Mapped in northern Arkansas

(zh) **Cherty decomposition residuum, solution residuum, and colluvium on limestone, shale, and sandstone—**In northwestern Alabama and in the Ridge and Valley Province in Tennessee, Georgia, and Alabama, the **decomposition residuum** generally is sandy or clayey. The sandy residuum is sandy loam, sandy clay loam, sandy clay, loam, or silt loam containing abundant angular to subrounded slabs or chunks of sandstone. Commonly, it is porous and ferruginous; in Georgia, it locally includes limonitic boxwork and commercial-grade iron ore. The clayey decomposition residuum is clay or silty clay containing shale chips and local hematitic zones. The **solution residuum** is cherty clay similar to unit ra. The **colluvium**, on hillslopes and foot slopes, generally contains abundant clasts of sandstone, shale, and (or) limestone. In Alabama, the residuum and colluvium are subject to subsidence where they overlie shallow underground mines.

In Kentucky, the **decomposition residuum** is sandy or clayey. The sandy residuum is sandy clay that is porous and either ferruginous or calcareous. Generally, it contains slabs of sandstone. The clayey decomposition residuum is clay or silty clay that contains shale chips. In some areas, the residuum was modified by creep. The **solution residuum** is cherty clay that contains slabs of limestone in the lower part. Sinkholes and other karst phenomena are common. The **colluvium** generally contains abundant clasts of sandstone, shale, and (or) limestone. Locally, the residuum and colluvium are intermixed with loess or overlain by thin loess (unit el).

In northeastern Missouri, the **decomposition residuum** is chiefly silt loam containing abundant siltstone fragments. The **solution residuum** is clay loam or silty clay loam. The clay loam solution residuum, similar to unit ra, generally contains scattered chert fragments. The lower part contains partly dissolved fragments of cherty limestone, and it extends downward along fractures and solution fissures into limestone bedrock. The silt loam solution residuum, derived chiefly from shale, is plastic and sticky when moist and hard when dry; shale chips are abundant in the lower part. The **colluvium** generally contains abundant fragments of shale, siltstone, and (or) cherty limestone.

In southern Oklahoma, the residuum is loam, clay loam, or channery loam. **Channers** are thin, flat or platy, rock fragments as long as 15 cm in the longest dimension. The channery loam **decomposition residuum** is developed primarily from shale and conglomerate. In some places, it contains rounded limestone pebbles derived from limestone conglomerate. Locally, it contains pebbles of granite, feldspar, and vein quartz derived from conglomerate. The clay loam **solution residuum** overlies limestone. It contains partly dissolved fragments of limestone, and it extends downward along solution-enlarged fractures into the underlying limestone bedrock. Clasts in the **colluvium** generally reflect the composition of the local bedrock.

In Kansas and northern Oklahoma, the residuum is silty clay, silty clay loam, silt loam, clay loam, or loam derived from alternating beds of shale and locally cherty limestone. The **decomposition residuum** commonly contains chert and shale fragments. The **solution residuum** commonly contains abundant chert fragments and partly dissolved limestone fragments. In some areas, the crests of drainage divides are veneered by angular residual chert clasts in a matrix of clay. The **colluvium** generally contains fragments of shale and limestone. North of the limit of pre-Illinoian glaciation in Kansas, the map unit includes some till (unit tb). Glacial erratics derived from eroded glacial and glaciofluvial deposits locally are present in the colluvium. Residual glacial erratic cobbles and boulders are scattered widely on the land surface. Commonly, the residuum and colluvium are intermixed with loess or overlain by loess (unit el).

The thickness of the decomposition residuum generally is <5 m; the maximum thickness in some places is 15–20 m. The thickness of the solution residuum generally is 0.5–6 m. The thickness of the colluvium generally is 1–10 m; locally, it is >20 m (zi) **Clayey to sandy decomposition residuum and solution residuum on sandstone, quartzite, shale, dolomite, and cherty limestone—**Sand, loamy sand, sandy loam, sandy clay loam, sandy clay, or silty clay containing fragments of sandstone, quartzite, shale, sandy dolomite, and (or) chert. In some places, it contains relict layers of sandstone or chert. In many areas, the residuum is overlain by thin loess (units el, eb); locally, the loess is >6 m thick. The map unit includes some colluvium on steep and moderate slopes; in some areas, clasts in the colluvium are chiefly pebbles, cobbles, and boulders of chert. The **decomposition residuum** on sandstone is chiefly sand; on dolomite it is sandy, loamy, or clayey and it contains chert fragments. Where developed from shale, it is silty clay; it is sticky and plastic when damp and hard when dry; it contains shale chips and grades downward through fragmented shale to bedrock. The **solution residuum** in some areas is chiefly chert fragments in a blocky-structure clay matrix; chert boulders in the clay in some places are >1 m in diameter. In some other areas, the solution residuum is chiefly clay containing only scattered clasts. Solution residuum derived from dolomite is more sandy than residuum derived from limestone, and it contains fragments of partly dissolved dolomite. The thickness of the residuum generally is 2–10 m; locally, it is 55 m to >60 m. Mapped in Missouri

(zr) **Clayey to sandy decomposition residuum and solution residuum on clay, shale, coal, sandstone, and limestone—**The **decomposition residuum** is sandy clay, sandy clay loam, or sandy loam containing chips of shale and fragments of sandstone and, locally, coal or limestone. The **solution residuum** is clay containing partly dissolved limestone fragments. It overlies a solution surface on limestone bedrock, into which it extends along fractures and fissures. North of the limit of pre-Illinoian glaciation in Missouri, the map unit includes some till (unit tb), outwash sand and gravel (unit gc), and glacial-lake deposits. Residual glacial erratics are scattered on surfaces mantled by residuum in some areas. Commonly, the residuum is mixed with loess and (or) overlain by loess (units el, eb). The thickness of the residuum generally is 0.5–3 m. Mapped in Missouri and southeastern Kansas

(zm) **Loamy decomposition residuum and colluvium on sedimentary rocks of mixed composition—**The **decomposition residuum** on flat and gentle slopes generally is loam, silt loam, silty clay loam, or clay loam containing clasts of acid shale and sandstone; locally, the clasts are limestone. In some areas, it consists of thin layers of disintegrated shale fragments. On ridge crests, it is commonly sandy loam, loam, or silt loam derived from sandstone and minor shale bedrock. The residuum commonly grades laterally into **colluvium**, chiefly resistant-block or resistant-boulder colluvium (unit cb), carbonate-boulder or carbonate-clast colluvium (unit cc), or acid shale–chip colluvium (unit cf). In some areas, the colluvium is sand, loamy sand, sandy loam, or loam containing abundant angular and subangular cobbles and boulders of hard sandstone and conglomerate. In general, it is weathered. Well-developed weathering rinds are present on sandstone clasts. Surface soil profiles are well developed, and buried soils are present within some deposits. The colluvium generally is stable (slopes are not subject to landslide processes). The map unit includes local relict boulder-field deposits, 2–10 m thick, on gentle (1°–5°) slopes. The clasts in boulder-field deposits are subangular to well-rounded cobbles, boulders, and blocks of hard sandstone and (or) conglomerate 10 cm to 11 m in length. The larger cobbles and boulders typically are imbricated. The distal margins of the boulder-field deposits are lobate. The map unit also includes heterogeneous, nonstratified, nonsorted rubble, locally 3–5 m thick, formed by frost shattering of sandstone and quartzitic sandstone. The rubble is bouldery where derived from quartzitic sandstone, and bouldery and channery where derived from bedded sandstone (**channers** are thin, flat or platy rock fragments as long as 15 cm in the longest dimension). Elsewhere, the rubble clasts are primarily sandstone and shale. The map unit also includes extensive deposits of rock waste, locally >30 m thick (see description of unit cb). Rock waste grades downslope into bouldery colluvium or boulder-field deposits. Rock-stream and talus-cone deposits composed of rock waste are present on slopes as steep as 42° at the bases of extensive bedrock outcrops. The maximum diameter of blocks in some places is >6 m. The rock debris was released from the outcrops by disintegration (chiefly frost activity). Debris-fan deposits on foot slopes also are included in the map unit. The boulder-field deposits and many of the other mass-movement deposits in the northern part of the region mapped as unit zm are inactive; transportation and deposition occurred primarily in a periglacial environment, contemporaneous with glaciation farther north. In some areas, the map unit includes some solution residuum (unit ra). The thickness of the decomposition residuum generally is 0.5–2 m; locally, it is

3–4 m. The thickness of the colluvium generally is 3–5 m; locally, it is >10 m. Mapped in central and south-central Pennsylvania

Solution residuum of Quaternary and Tertiary age

rc **Chert-poor or chert-free, clayey to sandy solution residuum—**Distinction between chert-poor or chert-free solution residuum (unit rc) and cherty solution residuum (unit ra) is arbitrary in some areas; the map unit includes areas of unit ra. In all regions, the map unit includes areas of colluvium (the maximum thickness in some places is >12 m). In some regions, it includes areas of decomposition residuum.

In Kentucky, the solution residuum is nonsorted and nonstratified clay or clay loam, in some places containing subangular slabs of solution-surfaced limestone. The contact with the underlying limestone bedrock is irregular; locally, the bedrock surface is pinnacled. Sinkholes and other karst phenomena are scattered to abundant.

In the Ridge and Valley Province in Alabama and Georgia, the solution residuum is nonsorted and nonstratified clay, clay loam, sandy clay, or sand. In general, it is moderately plastic and has a high potential for shrinking and swelling. The contact with underlying limestone or dolomite bedrock generally is sharp and irregular. Locally, the residuum grades downward to shale or sandstone bedrock through a zone of shale chips or sandstone slabs. In Georgia, the solution residuum locally includes commercial-grade iron ore, barite, ocher, and manganese oxide minerals. The residuum is subject to landslide activity; it is unstable on slopes steeper than 30°.

In a broad arcuate belt in Tennessee, Mississippi, and Alabama, the solution residuum is plastic clay, clay loam, or sandy clay loam containing scattered, powdery calcium carbonate nodules and marcasite concretions. The base generally is an abrupt contact with underlying limestone bedrock.

In southwestern Arkansas, the solution residuum is nonsorted and nonstratified, plastic sandy clay containing scattered chalky calcium carbonate nodules and marcasite concretions. The contact with the underlying limestone bedrock is abrupt.

In Texas, the solution residuum generally is nonsorted and nonstratified clay or loam. Where underlain by limestone, the lower part of the residuum is clay containing abundant solution-rounded limestone fragments. The fragment zone grades downward to fractured limestone bedrock. Where the residuum is underlain by shale, the residuum and shale are in abrupt contact. Where it is underlain by chalk or marl, the contact is gradational.

The thickness of the solution residuum generally is 0.5–5 m; locally, it is 30 m

ra **Cherty, clayey to sandy solution residuum—**Distinction between cherty solution residuum (unit ra) and chert-poor or chert-free solution residuum (unit rc) is arbitrary in some areas; the map unit includes areas of unit rc. In all regions, the map unit includes areas of colluvium (the maximum thickness in some places is >12 m). In some regions, it locally includes areas of decomposition residuum.

In Maryland north of Baltimore, the solution residuum is angular, dolomitic, medium to fine sand derived from marble. Solution core stones and pinnacles are common.

In central Pennsylvania on the west side of the Valley and Ridge Province, the solution residuum is nonsorted, nonstratified silt loam, silty clay loam, clay loam, silty clay, or clay derived from limestone and dolomite bedrock that contains thin interbeds of shale and sandstone. Generally, it is tough and moderately plastic or plastic. It contains fragments of chert where it overlies siliceous carbonate bedrock, and fragments of chert, shale, and sandstone where it overlies interbedded carbonate and clastic rocks. Sinkholes, underground caverns, and other karst phenomena are common where the residuum overlies limestone or dolomite.

Elsewhere in the Ridge and Valley Province in New Jersey, Pennsylvania, Maryland, West Virginia, Virginia, and Tennessee, the solution residuum is nonsorted, nonstratified, generally massive clay, silty clay, silty clay loam, clay loam, sandy clay, or silt loam. Where it overlies siliceous carbonate bedrock, it contains chert fragments; where it overlies interbedded carbonate and clastic rocks, it contains fragments of chert, shale, and sandstone. In some areas, it is plastic and sticky when wet. Chert commonly is present as angular to subround granules, pebbles, cobbles, and boulders; locally, it is present as irregular blocks or chunks. Commonly, the lower part contains solution-surfaced slabs of limestone or dolomite; locally, the lower part contains smooth limestone slabs or boulders. In some places, the residuum contains solution-surfaced slabs of limestone and (or) dolomite in both the lower and upper parts, indicating that the upper part of the residuum was modified by colluvial processes. The residuum is in abrupt solution contact with bedrock; pinnacles are common. It extends downward into fractures and solution fissures in the underlying bedrock. Sinkholes and other karst phenomena are common. Colluvium overlies the residuum on some hillslopes, and sheetwash alluvium overlies the residuum on some slopes. Where colluvium overlies the residuum, slope failure is common and landslide deposits (unit ja) are widespread. North of the limit of pre-Illinoian glaciation in Pennsylvania and New Jersey, the map unit includes some till (units tk, tp); residual glacial erratic cobbles and boulders are scattered on the land surface.

In southwestern Kentucky, central Tennessee, and northern Alabama, the solution residuum typically is sandy loam, sandy clay, sandy clay loam, silty clay, or clay containing chert fragments, shale chips, and, locally, scattered quartz geodes. In some areas, the residuum contains angular to subround chunks and boulders of chert. In some places, slabs of sandstone, siltstone, and, locally, limestone and (or) dolomite in the upper part of the residuum indicate that the residuum was modified by colluvial processes. Colluvium overlies residuum on some slopes, and sheetwash alluvium overlies residuum on some other slopes. Where colluvium overlies residuum, slope failure is common and landslide deposits (unit ja) are widespread. The residuum generally grades downward through a zone of rock fragments to limestone, shale, or sandstone bedrock. Commonly, the contact with underlying limestone is abrupt and pinnacled and the residuum extends downward into the bedrock along fractures and solution fissures. Sinkholes and other karst phenomena are common to abundant. In the western part of the area mapped in Tennessee, the solution residuum is phosphatic. In Kentucky and Tennessee, the residuum commonly contains admixed loess or is overlain by loess (unit el) that locally is 6 m thick.

In southern Missouri, northern Arkansas, and northeastern Oklahoma, the solution residuum is nonsorted, nonstratified clay loam, silty clay loam, sandy clay loam, silty clay, or silt loam containing fragments of chert; locally, it contains layers of relict chert fragments, scattered fragments of rotted sandstone, or scattered fragments of chert, chalcedony, and drusy quartz. In some areas, the residuum is 35 percent to >50 percent chert fragments. The contact with underlying limestone or dolomite bedrock generally is abrupt and pinnacled, and the residuum extends downward into the bedrock along fractures and solution fissures. In southeastern Missouri, barite is present locally in the residuum and the underlying weathered bedrock. Sinkholes and other karst phenomena are common. Colluvium overlies the residuum on some hillslopes, and sheetwash alluvium overlies the residuum on some other slopes. Where colluvium overlies residuum, slope failure is common and landslide deposits (unit ja) are widespread. The residuum commonly contains admixed loess or is overlain by loess (unit el) that locally is >6 m thick. Included in the area mapped as unit ra are mine pits and spoil piles. North of the limit of pre-Illinoian glaciation in Missouri and southwestern Illinois, the map unit includes some till (units tk, tb). Residual glacial erratic cobbles and boulders are scattered on the land surface.

In Texas, the solution residuum is clay, silty clay, or sandy clay developed from limestone, marl, clay, or soft sandstone. Where underlain by limestone, it contains abundant solution-etched, subangular fragments of limestone and scattered chert fragments and it penetrates the bedrock along fractures. Commonly, the residuum consists of horizontally banded layers of stony and stone-free clay residuum on steplike benches underlain by flat-lying, alternating, thin beds of hard limestone and softer rocks. In some places, platy secondary calcium carbonate is present in the lower part of the residuum. The map unit includes stony colluvium on the frontal slopes of benches and on hillslopes in valleys that dissect the limestone.

The thickness of the solution residuum on marble in Maryland is <1 to >30 m. The thickness on limestone and dolomite in the Ridge and Valley Province generally is <1 to 15 m; locally, it is 25 m in Tennessee, 50 m in Alabama, and 100 m in Georgia. The thickness in Kentucky, central Tennessee, and northern Alabama generally is 3–15 m; locally, it is >60 m. The thickness of solution residuum in Missouri, Arkansas, and Kansas generally is 0.5–10 m; locally, it is >60 m. The thickness in Texas generally is 0.2–2 m

rb **Solution residuum complex—**A complex of units rc and ra. Mapped in Texas

rd **Cherty, quartz-sand solution residuum—**Chiefly clayey quartz sand or calcareous sand that locally contains small lenses and stringers of subangular to subround chert pebbles. In some places, it contains cobble- and boulder-size blocks of chert and minor limestone. In general, the chert fragments increase in quantity and size toward the northwest. In some places, the lower part of the residuum contains contorted and disarranged masses of shale and poorly compacted limonitic sandstone that collapsed from formerly overlying beds of soft sandstone and shale as solution of the limestone progressed. Locally, the residuum contains scattered pebbles and small cobbles of quartz and quartzite that collapsed from formerly overlying alluvium. In some areas, the residuum is cemented by limonite. The solution residuum is developed on sandy, cherty limestone or on dolomite and limestone. In Florida, the residuum grades laterally into unit re. Small clay-filled sinkholes and other karst features are common. The map unit includes some colluvium and decomposition residuum. The thickness of the solution residuum generally is 1.5–4 m; in karst depressions, locally, it is 10 m. Mapped in Alabama, Georgia, and Florida

re **Sandy solution residuum—**Chiefly quartz sand or calcareous sand on soft sandy limestone and shell-hash limestone. It is limonitic in some areas. The residuum grades laterally into unit rd. The map unit includes some eolian sand (unit es) and colluvium. Clay-filled sinkholes and other karst phenomena are common. The thickness of the solution residuum generally is 1–3 m. Mapped in Florida

(rg) **Plastic-clay solution residuum and cherty colluvium—**The **solution residuum** is clay that contains fragments of carbonate rock, chiefly limestone. It has low to moderate permeability and a moderate potential to shrink and swell. The clay is plastic when moist. It tends to be unstable on slopes steeper than 30°. Chert fragments in the upper part of the residuum indicate that the upper part was modified by colluvial processes; in some areas, much of the clay probably is **colluvium derived from residuum**. The base of the solution residuum is a smooth, irregular solution contact on predominantly limestone bedrock. Sinkholes and other karst phenomena are common. The thickness of the solution residuum and colluvium generally is <1 m to 30 m. Mapped in northern Alabama and southern Tennessee

(rh) **Solution residuum and decomposition residuum—**A complex of units ra, rc, and za. Mapped in Texas

sg **Clayey to sandy, saprolitized sand and gravel of Quaternary and Tertiary age—**Sandy clay, sandy clay loam, clay loam, silty clay loam, silty clay, or clay containing scattered stained pebbles of quartz and “ghost” pebbles and cobbles of other rock types that are partly or completely altered. The saprolite is developed in gravel on ridge crests. The areal distribution of the saprolite in some areas indicates that the original sand and gravel deposits on flat ridge tops were part of a former Tertiary alluvial terrace system, and the original gravel deposits on dissected sloping ridge tops were Tertiary alluvial fan deposits. In some places, the saprolite extends through the gravel into the underlying bedrock, where it changes character reflecting the composition of the bedrock. The areas mapped commonly represent numerous areas of saprolitized gravel that are too small to map individually; colluvium, residuum, alluvium, other deposits and materials, and bedrock outcrops between the small areas of saprolitized gravel are included in the map unit. The thickness of the saprolitized gravel generally is 1–10 m; where the gravel and underlying bedrock are saprolitized, the thickness generally is 2–6 m

Saprolite of Quaternary and Tertiary age on crystalline igneous and metamorphic rocks

sa **Clayey to sandy saprolite on granite, gneiss, schist, and other felsic, mafic, and ultramafic igneous and metamorphic rocks—**Distinction between units sa and sb is arbitrary in some areas. The map unit includes bouldery or slabby colluvium, especially at the bases of steep slopes. The colluvium commonly contains fragments of vein quartz. In some areas, the saprolite is overlain by colluvium. On the inner edge of the Atlantic Coastal Plain, the map unit in some places includes thin marine and (or) fluvial deposits.

In some areas in the Eastern States, the saprolite is sandy clay, clayey sand, sandy clay loam, or sandy loam on (1) massive granite, granite gneiss, or similar massive felsic igneous or metamorphic rocks or (2) gneissic granite, interlayered felsic schist and gneiss, foliated granitic rocks, and felsic metavolcanic rocks. Kaolinite is the predominant clay mineral in the upper part of the saprolite; gibbsite commonly equals or exceeds kaolinite in the lower part. In some areas, illite and vermiculite are minor clay mineral components. Feldspar is the predominant weatherable mineral in the lower part; muscovite or its pseudomorphs are predominant in the upper part. Quartz grains are abundant. The saprolite is permeable and strongly acid. It grades downward to bedrock through a zone of partly decomposed joint-block boulders or an irregular zone of partly weathered slabby bedrock fragments. Abundant joint-block boulders are associated with bedrock knobs and tors in some mountainous and hilly areas.

In other areas in the Eastern States, the saprolite is sandy loam, sandy clay loam, or sandy clay on metamorphic or igneous rocks of intermediate composition. Where it is developed on more mafic rocks, the clay minerals are predominantly mixed smectite (swelling clay) and kaolinite and the saprolite has a moderate potential to shrink and swell. Where developed on more felsic rocks, the clay is predominantly kaolinite. The sand fraction is predominantly quartz and partly altered feldspar; biotite, hornblende, and vermiculite grains or fragments are common where the bedrock is mafic. The saprolite grades downward to bedrock through a zone of partly weathered core stones where the bedrock is massive, and through a zone of slabby rock fragments where it is foliated. Soft rock fragments or “ghost” fragments locally are abundant.

In other areas in the Eastern States, the saprolite is slightly micaceous to micaceous sandy loam, sandy clay loam, sandy clay, or silt loam on mafic metamorphic, mafic metavolcanic, and ultramafic rocks. Where the bedrock is massive or weakly gneissic, the saprolite commonly contains joint-block core stones that range in size from pebbles to boulders and the bedrock surface commonly is pinnacled. The clay minerals are predominantly mixed smectite (swelling clay) and kaolinite; vermiculite generally is minor. Smectite is particularly abundant in poorly drained areas. The saprolite has a low to high potential to shrink and swell. The sand fraction is chiefly calcic feldspar and lesser amounts of biotite, vermiculite, and hornblende; quartz is a minor component. The saprolite is relatively impermeable. It grades downward to bedrock through an irregular zone of partly saprolitized slabs and blocks of rock.

In southeastern Missouri, the saprolite is sand, silt, and kaolinitic clay that locally contains rounded or subrounded core boulders of alkali granite, rhyolite ash-flow tuff, or trachyte. Structures of the original bedrock commonly are preserved. The saprolite grades downward to bedrock through a zone of partly weathered rock.

In the Eastern States, the thickness of the saprolite on felsic rocks generally is <2 m; it is >6 m on some well-drained uplands. The thickness on intermediate rocks generally is <5 m. The thickness on mafic and ultramafic rocks generally is <1 to 15 m; the maximum thickness is >30 m. The thickness of saprolite in Missouri generally is 0.5–2 m

sb **Micaceous saprolite on felsic micaceous schist or rocks of mixed composition—** Distinction between units sb and sa is arbitrary in some areas. The map unit includes extensive areas of bouldery colluvium; in some areas, the saprolite is overlain by colluvium. Most of the saprolite is micaceous clayey sand, sandy clay loam, loam, and silt loam on felsic micaceous schist. The clay minerals are predominantly kaolinite; gibbsite and (or) vermiculite are less abundant. Mica is mostly altered to kaolinite and (or) vermiculite in the upper part of the saprolite. The potential to shrink and swell generally is low.

In Alabama and Georgia, the saprolite in some areas is micaceous to very micaceous silt loam on felsic micaceous schist, aluminous schist, graphitic schist, and phyllitic rock. The clay minerals are predominantly kaolinite and illite; gibbsite and vermiculite are less abundant. The potential to shrink and swell is low. The sand fraction is chiefly feldspar and mica grains. Locally, the saprolite is graphitic.

In some areas in Georgia, the saprolite is micaceous clay, sandy clay, or sandy clay loam on metagraywacke, feldspathic sandstone, conglomerate, fine-grained biotite gneiss, other gneisses, marble, mylonite, and felsic metavolcanic rocks. It is graphitic where it is on carbonaceous metamorphic rocks. The saprolite grades downward through a zone of relict, thick slabby boulders.

The thickness of the saprolite generally is <1 to 10 m on hillslopes and 15–30 m on well-drained uplands and flat ridge crests

se **Clayey saprolite on diabase and basalt—**The saprolite is sandy clay, sandy clay loam, loam, or silty clay loam on massive mafic rock, commonly diabase. The clay minerals are predominantly mixed kaolinite and smectite (swelling clay); smectite is particularly abundant in poorly drained areas. The saprolite has a broad range of potential to shrink and swell. The sand fraction is chiefly partly altered calcic feldspar. Bedrock knobs or tors are common; generally, they are surrounded by saprolite that contains abundant, partly weathered core boulders. The map unit includes extensive areas of bouldery colluvium, particularly at the bases of steep hillslopes. Locally, it includes some grus. The thickness of the saprolite generally is <2 to >5 m

sf **Clayey saprolite on nephelene syenite—**The saprolite is clay containing residual angular, subangular, and rounded boulders and joint-block core stones. It grades downward to nephelene syenite bedrock. The map unit includes some bauxite, grus, and colluvium. The thickness of the saprolite generally is 0.5–3 m. Mapped in three small areas in central Arkansas

sc **Clayey to sandy saprolite on phyllite, argillite, slate, marble, greenstone, serpentinite, metabasalt, metarhyolite, and other felsic metavolcanic rocks—**The map unit includes extensive areas of colluvium, particularly at the bases of hillslopes.

In many areas, the saprolite is silt loam and silty clay loam on phyllite, argillite, slate, and felsic metavolcanic rocks. Quartz fragments and slabs and splinters of bedrock are common in the lower part. The clay minerals are predominantly kaolinite; gibbsite is present locally. Very locally, the saprolite is silty clay on serpentinite; it contains small fragments and slabs of serpentinite.

In some areas in Maryland and Pennsylvania, the saprolite is loamy sand, sandy loam, sandy clay loam, clay loam, or silty clay on interlayered phyllite, marble, metabasalt, and metarhyolite. Splinters of bedrock are common in the lower part. On marble, the saprolite is sandy clay, clay loam, or silty clay of variable thickness, containing abundant solution core stones and underlain by solution-pinnacled bedrock. Saprolite on metavolcanic rock is bouldery clay.

In some areas in Virginia, the saprolite is clay or silty clay on metavolcanic greenstone. The clay minerals are predominantly kaolinite.

The thickness of the saprolite generally ranges from <0.5 to 5 m on slopes; locally, it is 6 m on well-drained uplands and on flat ridge crests. The thickness on metavolcanic greenstone generally is 10–30 m. The thickness on serpentinite generally is <1 m

sd **Quartz-rich saprolite of Quaternary and Tertiary age—**The saprolite, on quartzite, quartz-rich metasedimentary rocks, or quartz-mica schist, ranges from clay to sand. The clay minerals are predominantly kaolinite. Angular or irregular, partly disintegrated chunks or slabs of rock are common in the lower part. The map unit includes stony colluvium, especially at the bases of steep hillslopes. The thickness of the saprolite generally is <0.5 m to 3 m

OTHER MATERIALS

BAKED AND FUSED BEDROCK (CLINKER) OF QUATERNARY AGE

Clinker is bedrock that was baked and fused as a result of natural burning of subsurface lignite beds. The physical, chemical, and engineering properties of clinker differ markedly from those of the unaltered bedrock. The lower part of the clinker commonly is massive, with flow structures; the bedding and sedimentary structures of the original bedrock were destroyed. The upper part typically retains the bedding and sedimentary structures of the original bedrock. In some places, the clinker consists of slaglike masses of rock that have ropy surfaces, or low-density rock having open fissures, pores, and pockets, and it resembles volcanic pahoehoe or scoria. In some places, it is brecciated by collapse caused by removal of underlying lignite. Flow structures generally are absent, except for chimneys that vented hot gases upward through the bedrock. Where the original bedrock was clayey, the clinker is hard and commonly it breaks into plates or brittle chips having conchoidal fracture. Polygonal columnar jointing is common in some places; the jointed clinker breaks into short columnar fragments or chunky blocks. Colors typically are brick red, dark red, salmon pink, orange, yellow, green, brown, gray, or white. Clinker is very resistant to weathering and erosion. It forms ledges and caps buttes and hills

(qa) **Clinker and colluvium—**Outcrops of clinker and associated colluvium in small areas south of the Missouri River in North Dakota, near the west margin of the map area. Weathered clinker and boulders of clinker commonly are covered by lichens. The map unit includes thin, discontinuous till (unit tl) that overlies clinker in some places. Locally, granules and sand-size particles of clinker are common in till that overlies clinker. In some places, the map unit includes **clinkered till** (till that was baked and fused during the burning of the lignite). Most of the till that was metamorphosed is inferred to have been Illinoian or pre-Illinoian in age (older than most of the till mapped as unit tl). **Colluvium**, in some places composed predominantly of boulders, cobbles, pebbles, and granules of clinker, mantles steep hillslopes and foot slopes and is a thin and discontinuous veneer on some clinker outcrops. The thickness of the clinker generally is 2–30 m. The thickness of the colluvium generally is 0.5–3 m

MAN-MADE LAND

f **Man-made land—**A causeway in western Florida, shown on the hydrographic base map