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

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
MAP I-1420 (NJ-15)

Prepared in cooperation with the
Missouri Department of Natural Resources, Division of Geology and Land Survey,
Kansas Geological Survey,
Arkansas Geological Commission,
Illinois State Geological Survey, and
Oklahoma Geological Survey

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

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

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 Therefore, an effort has been made to classify, map, and describe these deposits, based in large part on unpublished interpretations, published and unpublished subsoil data, and the distribution of bedrock parent materials.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

For scientific purposes, the map differentiates Quaternary surficial deposits on the basis of a combination of criteria, such as lithology, texture, genesis, stratigraphic relationships, and age, as shown on the correlation diagram and indicated in the map unit descriptions. Some geomorphic features, such as end moraines, are distinguished as map units. Erosional features, such as stream terraces, are not distinguished, and differentiation of sequences of alluvial deposits of different ages is rarely possible at a scale of 1:1,000,000. Most landslide deposits are too small to be shown at this scale.

For practical purposes, the map is a surficial materials map. Materials are distinguished on the basis of texture, composition, and local specific characteristics such as swelling clay. It is not a map of soils as soils are recognized and classified in pedology or agronomy. Rather it is a generalized map of soils as recognized in

engineering geology, or of subsoils or parent materials from which pedologic and agronomic soils are formed. As a materials map it serves as a base from which a wide variety of derivative maps for use in planning engineering, land use, or land management projects can be compiled.

The map contains the following illustrations:

An index map to the International Map of the World 1:100,000 topographic series showing the Quaternary geologic map of the Ozark Plateau 4°x 6° quadrangle and other published maps of the Miscellaneous Investigations Series (I-1420).

An illustration of loess distribution and thickness in the map area.

An illustration showing the responsibility for state compilation.

A chart showing correlation of map units.

LIST OF MAP UNITS

HOLOCENE

asa ALLUVIAL GRAVELLY SAND
ac ALLUVIUM CLAY

HOLOCENE AND LATE WISCONSIN

al ALLUVIUM
ale ALLUVIAL SILT AND CLAY
alg ALLUVIAL SILT AND CLAY
ed DUNE SAND
es EOLIAN SHEET SAND
el LOESS

HOLOCENE WISCONSIN

ask ALLUVIAL SAND, SILT, AND CLAY
cla SANDSTONE AND SHALE CLAST LOAMY COLLUVIUM
clk GRAVELLY SILTY CLAY COLLUVIUM
cls CHERT-CLAST CLAYEY SILT TO SILTY CLAY LOAM COLLUVIUM

HOLOCENE, WISCONSIN, AND ILLINOIAN

elb LOESS

LATE WISCONSIN

gg OUTWASH SAND AND GRAVEL
alb SILTY ALLUVIUM

WISCONSIN

lla LAKE CLAY AND SILT

EARLY WISCONSIN

asc ALLUVIAL SILTY SAND
asb ALLUVIAL SAND

WISCONSIN, ILLINOIAN, AND PRE-ILLINOIAN

agb ALLUVIAL CHERT GRAVEL AND SAND

ILLINOIAN

lci LAKE SILT AND CLAY
gsi OUTWASH SILT, SAND, AND GRAVEL
kgi ICE-CONTACT SAND AND GRAVEL
tkm LOAMY TILL

	LOAMY TILL
tkp	Ground moraine
tkp	End moraine

ILLINOIAN TO PRE-ILLINOIAN

alj	ALLUVIAL SILTY CLAY, SAND, AND GRAVEL
ggk	ALLUVIAL SILTY CLAY, SAND, AND GRAVEL

PRE-ILLINOIAN

lck	LAKE CLAY
gtk	OUTWASH SANDY GRAVEL AND TILL
tlk	LOAMY TILL
tck	CLAY LOAM TILL

EARLY PLEISTOCENE TO PLIOCENE(?)

agf	CHERT PEBBLE GRAVEL AND SAND
agh	UPLAND CHERT GRAVEL

QUATERNARY AND TERTIARY

zsd	SANDY DECOMPOSITION RESIDUUM
zsh	SILTY SAND AND SANDY SILT DECOMPOSITION RESIDUUM
zld	CLAYEY SILT TO SILTY CLAY DECOMPOSITION RESIDUUM
zcj	CLAY AND SILTY CLAY DECOMPOSITION RESIDUUM
zrc	THICK SAND AND SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM
zrd	THIN SAND AND SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM
zre	THICK CHERTY SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM
zrf	VERY THICK CHERTY SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM
zrh	THIN CHERTY SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM
zrg	SHALY CLAY AND CHERTY CLAY DECOMPOSITION AND SOLUTION RESIDUUM
zri	SILTY CLAY AND CHERTY CLAY DECOMPOSITION AND SOLUTION RESIDUUM
zrj	SANDY CLAY, SILTY CLAY, AND CLAY DECOMPOSITION AND SOLUTION RESIDUM
zrk	CHERTY LOAM TO SILTY CLAY LOAM DECOMPOSITION AND SOLUTION RESIDUUM
zrl	SILTY CLAY LOAM DECOMPOSITION AND SOLUTION RESIDUUM
rcc	CHERTY CLAY SOLUTION RESIDUUM
rca	THICK CHERTY CLAY SOLUTION RESIDUUM
rcb	THIN CHERTY CLAY SOLUTION RESIDUUM
rco	THICK CHERTY SILTY TO SANDY CLAY SOLUTION RESIDUUM
rcp	THIN CHERTY SILTY TO SANDY CLAY SOLUTION RESIDUUM
rcq	VERY THIN CHERTY SILTY TO SANDY CLAY SOLUTION RESIDUUM
rcs	VERY THICK CHERTY SILTY CLAY AND CLAYEY SILT SOLUTION RESIDUUM
rct	THICK CHERTY SILTY CLAY AND CLAYEY SILT SOLUTION RESIDUUM
rcu	THIN CHERTY SILTY CLAY AND CLAYEY SILT SOLUTION RESIDUUM
ssb	SANDY SILTY SAPROLITE

PRE-TERTIARY

R	BEDROCK

LIST OF MAP SYMBOLS

CONTACT

STRIATIONS—Showing direction of glacier movement

ICE-PUSH STRUCTURE

ICE-PUSH STRUCTURE AND INFERRED DIRECTION OF GLACIER MOVEMENT

OUTER LIMIT OF GLACIAL ADVANCE—Solid where marked by distal edge of end moraine; dashed where inferred; dotted where buried

BURIED OUTER LIMIT OF OLDEST KNOWN PRE-ILLINOIAN GLACIAL ADVANCE IN MISSOURI

BURIED PLEISTOCENE RIVER CHANNEL

PEARLETTE FAMILY TEPHRA—Not identified individually

DEPOSIT OF UPLAND CHERT GRAVEL (**agh**) TOO SMALL TO MAP SEPARATELY

LOESS ISOPACH—Thickness in meters

LOESS—Peoria Loess, 2–6 m thick, overlying "Yarmouth- Sangamon" to late Sangamon paleosol developed in one or more pre-Illinoian tills and, locally, in decomposition and solution residua (**zld**, **zrj**, **zrk**, **rcb**) north of the Missouri River

LOESS—Peoria Loess, 6–10 m thick, overlying Sangamon paleosol developed in Loveland Loess, 2–6 m thick. The loesses overlie Yarmouth paleosol developed in one or more pre-Illinoian tills (**tck**, **tlk**) and, locally, in decomposition residuum (**zld**) north of the Missouri River

LOESS—Peoria Loess and underlying Roxana Silt, together less than 6 m thick. Commonly overlies Sangamon paleosol developed in deposits of Illinoian age (**tkm**, **tkp**, **kgi**, **gsi**, **lci**)

LOESS—Peoria Loess (Wisconsin) less than 2 m thick and eolian or loamy sediment less than 1 m thick over extensive erosion surface on pre-Illinoian till; paleosol generally absent

MANMADE LAND—Chiefly mine pits and spoil piles

LOCATION OF IMPORTANT STRATIGRAPHIC SECTION—Stratigraphic sequences listed from oldest to youngest

1. Iowa Point section, NE1/4SE1/4 sec. 6, T. 2 S., R. 20 E., Doniphan County, Kansas (from quarry face and auger holes; exposure now destroyed) (modified from Frye and Leonard, 1952)—Pre-Illinoian David City Formation, gravel, cobbles, and boulders of limestone, igneous rocks, and quartzite in silty sand matrix, upper part well-sorted sand; pre-Illinoian Iowa Point Till, fossiliferous at base, paleosol (not stratigraphically equivalent to type Afton paleosol) developed in uppermost part; pre-Illinoian "Kansan" till, fossiliferous at base, Yarmouth paleosol (not stratigraphically equivalent to type Afton paleosol) developed in uppermost part; Illinoian Loveland Loess, with Sangamon paleosol developed in uppermost part; Wisconsin Peoria Loess, with Brady paleosol developed in uppermost part; Holocene Bignell Loess
2. Wathena South No. 2 section, SW1/4NE1/4 sec. 33, T. 3 S., R. 22 E., Doniphan County, Kansas (modified from Bayne and others, 1971)—Fluvial gravel and sand containing a few erratic rock types; lacustrine silt, sand, and clay; paleosol (not stratigraphically equivalent to type Afton paleosol); pre-Illinoian Nickerson Till; outwash sand and gravel containing boulders of dark-gray till; pre-Illinoian Cedar Bluffs Till, paleosol poorly developed in uppermost part; Illinoian Loveland Loess
3. Type locality of Atchison Formation, SE1/4SW1/4 sec. 2, T. 6 S., R. 20 E., Atchison County Kansas (modified from Frye and Leonard, 1952)—Pre-Illinoian Atchison Formation, tan to orange-brown, fine to coarse downward, well-sorted, thin-bedded, crossbedded, locally cemented with calcium carbonate in gravelly basal part, 24 m thick; pre-Illinoian till, clasts of limestone, igneous rock types, and pink quartzite
4. Type locality Nortonville Clay, NE1/4NW1/4 sec. 12, T. 7 N., R. 18 E., Nortonville quadrangle, Atchison County, Kansas (modified from Frye and Leonard, 1952, and James Thorp and H.G. O'Connor, Kansas Geological Survey unpublished manuscript, 1966)—Pre-Illinoian till, oxidized, calcareous; pre-Illinoian Nortonville Clay, light-gray to pink, mottled, plastic clay including some silt, fine sand, and a few erratic pebbles, noncalcareous except for widely scattered calcium carbonate concretions; Wisconsin Peoria Loess. The Nortonville Clay is an important stratigraphic marker; it is correlative with the Ferrelview Formation (stratigraphic section 6) in Missouri (Howe and Heim, 1968)
5. Menoken Terrace section, center SW1/4 sec. 9, T. 11 S., R. 15 E., Shawnee County, Kansas (modified from Davis and Carlson, 1952, p. 275) —Pre-Illinoian Atchison Formation, clasts mostly limestone, a very few of granite and metamorphic rock types; "Kansan" till; fluvial pebbly sand (formerly Grand Island Member of Meade Formation)
6. Type locality of Ferrelview Formation, SE1/4SE1/4NE1/4 sec. 5, T. 52 N., R. 34 W., Platte County, Missouri (modified from unpublished log of Missouri Geological Survey Drill Hole No. 984 recorded by G.E. Heim, Jr., and R.B. McMillan,1958)—Pre-Illinoian till; Ferrelview Formation, brownish-gray clay including some silt and fine to coarse sand; Illinoian Loveland Loess, Sangamon paleosol developed in uppermost part; Wisconsin Peoria Loess. The Ferrelview Formation is an important stratigraphic marker; correlative with the Nortonville Clay in Kansas (Howe and Heim, 1968)
7. Mt. Hope Church section, SW1/4SE1/4 sec. 14, T. 49 N., R. 12 W., Boone County, Missouri (modified from Allen and Guccione,1973)—Pre-Illinoian sandy clay till, highly contorted, manganese stained, weakly calcareous; contorted clayey silt; sandy gravel, mostly of limestone, chert, and very scarce northern erratics; silt, bedded, locally contorted, leached, manganese stained, reversed paleomagnetism; clayey silt, leached; sand, yellowish brown, noncalcareous; till, manganese stained, leached; gravel of rotted granite, gabbro, greenstone and some chert, manganese stained; sand, brown, leached; clayey sand, locally till-like, with stone line at surface; paleosol; Illinoian(?) sandy silt, manganese stained; Wisconsin loess

DESCRIPTION OF MAP UNITS

HOLOCENE

asa ALLUVIAL GRAVELLY SAND—Light-brown, gray, or grayish-brown sand, silt, and gravel intermixed and interbedded; local lenses of clay. Gravel component consists of pebbles less than 3 cm in diameter; pebbles chiefly chert and quartz, a few sandstone. Underlies flood plains and low terraces of Black River and its tributaries in northeastern Arkansas. On flood plains in northeastern Oklahoma and western Missouri, mostly sand with very minor gravel. Mapped areas include some locally derived colluvium and organic-rich swamp deposits. Thickness 3–30 m; in western Missouri, averages 6 m

ac ALLUVIAL CLAY—Gray, brown to reddish-brown, poorly to well-bedded clay, silt, and fine sand; represents overbank deposits of Mississippi River. Locally includes deposits of dark-brown to black organic clay in swamps and oxbow lakes. Overlies older fluvioglacial deposit, 10 m to more than 70 m thick, of gravel, sand, silt, and clay that becomes coarser with depth. Thickness 3–12 m

HOLOCENE AND LATE WISCONSIN

al ALLUVIUM (Cahokia Alluvium in Illinois; unnamed elsewhere)—Brown to gray silt, clay, sand, and gravel. Noncalcareous to calcareous, moderately to well sorted, stratified; upper part commonly silt and fine sand, lower part chiefly sand and, locally, rounded pebble gravel. Clasts primarily limestone, chert, and erratic igneous and metamorphic rock types derived from glacial deposits. Overlies older thick fluvial and fluvioglacial sand and gravel. Total thickness of both alluvium and older deposits is more than 60 m in Missouri and Mississippi River valleys, less than 30 m in Kansas River valley, and 5–10 m in tributary valleys

ale ALLUVIAL SILT AND CLAY—Black to dark-gray or dark- to light-brown silt, clay, and fine sand; includes local lenses of subrounded chert gravel; clasts 2–4 cm in diameter. Silt and clay commonly organic-rich and highly plastic. Underlies flood plains and low stream terraces. Thickness 0.5–10 m; locally as thick as 20 m in Kansas

alg ALLUVIAL SILT AND CLAY—Brown to dark-gray silt, clay, and sand with local lenses of gravel. Underlies terraces along Kansas River and its tributaries. Clasts chiefly chert, limestone, and erratic igneous and metamorphic rock types derived from older glacial deposits. Thickness 10–30 m

ed DUNE SAND—Pale-brown, crossbedded, well-sorted, weakly calcareous, medium to fine sand. Chiefly quartz and minor heavy minerals. Underlies low terraces along valley of Black River west of Crowleys Ridge; stabilized by vegetation except for small blowouts. Thickness 1–2 m

es EOLIAN SHEET SAND (included in Parkland Sand in Illinois)—Pale-brown, weakly calcareous, well-sorted, medium to fine sand; locally silty. Generally downwind from areas of outwash sand and gravel (**gg**). Commonly overlies lake deposits (**lla**). Mapped only in Illinois. Thickness 1–3 m

el LOESS (Peoria Loess in Illinois)—Gray to yellowish-brown, windblown silt and silt loam; calcareous where thick; weakly compacted and jointed. Mapped only where more than 6 m thick. Occurs chiefly on uplands adjacent to major outwash deposits. Commonly overlies a Farmdale paleosol developed in brown or reddish-brown to dark-gray, compact, leached, Roxana Silt, which in turn overlies lake deposits (**lla**) or bedrock. Elsewhere in Illinois, Peoria Loess and Roxana Silt overlie a Sangamon paleosol developed in tills of Illinoian age (**tkm**, **tkp**). (See loess distribution and thickness map.) Thickness 6–10 m

HOLOCENE AND WISCONSIN

ask ALLUVIAL SAND, SILT, AND CLAY—Grayish- to yellowish-brown sand, silt, and clay, intermixed and interbedded, gravelly near base. Poorly to well stratified; poorly to well sorted. Clasts chiefly chert, locally derived from older alluvial gravel (**agf**); fine component chiefly reworked loess. Material becomes coarser and more gravelly in headwater areas. Underlies both flood plains and stream terraces. Mapped areas include local colluvium and slope-wash deposits. Thickness as much as 10 m in upland valleys; 10 m to more than 20 m in lower parts of valleys

cla SANDSTONE AND SHALE CLAST LOAMY COLLUVIUM[1]—Very dark grayish brown to yellowish-brown silt loam, silty clay loam, and fine sandy loam containing angular to subangular, pebble- to boulder-size fragments of sandstone and shale. Mapped only in Arkansas and Oklahoma. Mapped areas include a few bedrock exposures on steep slopes, local patches of eolian sand, and minor alluvium along streams. Thickness 0.5–1.5 m

clk GRAVELLY SILTY CLAY COLLUVIUM[1]—Grayish- to yellowish-brown, poorly consolidated, fine sandy silty clay containing chips and fragments of shale and sandstone, and pebbles to cobbles of

colluvially reworked chert gravel derived from older alluvial deposits (**agf**) upslope. Mapped only in southeastern Missouri. Thickness 0.5–2 m

cls CHERT-CLAST CLAYEY SILT TO SILTY CLAY LOAM COLLUVIUM[1]—Reddish-, dark- or grayish-brown, or gray fine sandy silt, silty clay, or clay; contains abundant angular fragments of chert and some of limestone, sandstone, and shale. Derived from decomposition residuum (unit **zld**) or bedrock upslope. Also contains erratics of igneous and metamorphic rocks derived from till (unit **tck**) upslope. Mapped only in northwesternmost part of quadrangle. Distribution based on extent of till dissection and slope. Mapped areas may include local eroded remnants of decomposition residuum (unit **zld**), especially on gentle upland slopes, minor local alluvium, and bedrock outcrops. Thickness 0.25–2 m

HOLOCENE, LATE WISCONSIN, AND ILLINOIAN

elb LOESS (Bignell Loess, Peoria Loess, and Loveland Loess; Bignell, Peoria, and Loveland Formations of Kansas Geological Survey; Bignell Loess not recognized in Missouri)—Grayish-, yellowish-, or reddish-brown silt loam; locally calcareous; locally includes deposits in low-lying areas of dark-gray silty clay (Gilman Canyon Formation in Kansas). A Sangamon paleosol commonly developed in uppermost Loveland Loess beneath Peoria Loess in Kansas and Missouri. Loess thickest near major rivers, thins away from them in a short distance. Thin Peoria Loess widespread on pre-Illinoian till in northern Missouri. South of the Kansas and Missouri Rivers, thin patchy loess commonly intermixed and interbedded with locally derived colluvial, residual, or alluvial deposits. Thickness 2–40 m along the Missouri River in Kansas, 3–23 m along the Missouri and Mississippi Rivers in Missouri

LATE WISCONSIN

gg OUTWASH SAND AND GRAVEL (Mackinaw Member of Henry Formation in Illinois)—Pale-brown to gray, fine to coarse sand or pebbly sand alternating with minor beds of silt and layers or beds of granule to cobble, locally bouldery, gravel. Mapped only in Illinois, east of confluence of Mississippi and Missouri Rivers. Clasts rounded. Texture varies laterally and vertically. Interlayered thick and thin beds commonly are well sorted and poorly to well stratified; locally crossbedded. Clasts chiefly dolomite, limestone, and sandstone with minor amounts of hard crystalline or metamorphic rock; locally, moderate amounts of shale. Deposit underlies terraces and extends beneath flood-plain alluvium. Commonly covered by thin, unmapped loess or windblown sand; locally by unmapped swamp deposits. Thickness 1–20 m

alb SILTY ALLUVIUM—Yellowish-gray to brown, poorly to well-sorted, poorly to well-stratified silt and minor clay intermixed and interbedded. Underlies terrace 3 of Saucier (1974) in northern part of Mississippi River plain; overlies older Wisconsin fluvioglacial deposits of gravel, sand, silt, and clay that become coarser and increase in gravel content with depth. Total thickness of both deposits 10 to more than 60 m; thickness of silty alluvium, 8–9 m

WISCONSIN

lla LAKE CLAY AND SILT (Carmi Member of Equality Formation in Illinois)—Yellowish-brown to brown or bluish-gray to gray clay and silt. Mapped only in Illinois. Deposits well bedded, soft, commonly thin bedded, and locally varved. Silt component resembles massive loess in places. Most deposits underlie extensive, flat, low-lying areas formerly occupied by slackwater lakes dammed by aggrading glacial outwash deposits in the principal meltwater stream valleys. Deposits locally thin and discontinuous. Mapped areas include some undifferentiated lake sand and fine gravel, and wave-washed or current-scoured till. Commonly covered by thin unmapped loess, eolian sheet sand, swamp deposits, or alluvium. Thickness 1–10 m

EARLY WISCONSIN

asc ALLUVIAL SILTY SAND—Yellowish-gray to yellowish-brown, poorly to well-sorted, poorly to well-stratified sand intermixed and interbedded with silt. Underlies terrace 2 of Saucier (1974) in northern part of Mississippi River plain. Deposit locally is overlain by small areas of dune sand (**ed**). Overlies older Wisconsin fluvioglacial deposits of gravel, sand, silt, and clay that become coarser and increase in gravel content with depth and are 5 m to more than 60 m thick. Thickness of map unit 5–6 m

asb ALLUVIAL SAND (deposits of "Braided Stream Terraces" of Saucier, 1974)—White to gray or brown, poorly to well-sorted, fine to coarse quartz sand and minor silt and clay; locally contains some relict channels filled with interbedded silt and clay. Underlies uppermost terraces along Black River flood plain in Arkansas and Missouri; locally overlain by dune sand (**ed**). Mapped areas include both glacial

outwash and nonglacial alluvium. Thickness 3–8 m

WISCONSIN, ILLINOIAN, AND PRE-ILLINOIAN

agb ALLUVIAL CHERT GRAVEL AND SAND—Light-brown, yellowish- to reddish-brown, and dark-red, medium to coarse sand containing abundant pebbles and cobbles of chert; massive to crossbedded. Some chert clasts contain fusulinids indicating a source area to the west in north-central Oklahoma. Terraces 10–12 m above present flood plains. Mapped only along Arkansas River in Oklahoma (southwest corner of quadrangle). Thickness 2–5 m

ILLINOIAN

lci LAKE SILT AND CLAY (Teneriffe Silt in Illinois)—Yellowish-brown to brown or gray, massive silt and clayey silt containing interbeds of sand and clay. Mapped only in Illinois and near St. Louis, Missouri. Generally leached, but calcareous in lower part where thick. Locally, mapped areas include some outwash silt, sand, and gravel (**gsi**) and sheetwash alluvium. Sangamon paleosol developed in upper part. Commonly covered by loess (Peoria Loess and Roxana Silt, shown by overprint pattern) less than 6 m thick. Thickness less than 1 m to more than 10 m

gsi OUTWASH SILT, SAND, AND GRAVEL (Pearl Formation in Illinois; gravel at Oakwood, in Missouri)—Yellowish-brown to gray silt and pebbly sand. Weakly to well bedded. Mapped only west of Illinois River near Pearl, Illinois, and west of Mississippi River south of Hannibal, Missouri. Deposits in Illinois similar in composition to younger outwash sand and gravel (**gg**), but more oxidized and more cemented. Sangamon paleosol developed in uppermost part. Covered by less than 6 m of loess (Peoria Loess and Roxana Silt, shown by overprint pattern). In Missouri, consists of poorly stratified sand, gravel, cobbles, and boulders, probably eroded from pre-Illinoian till (**tlk**) on adjacent uplands in Illinoian time. Thickness about 12 m, locally thicker

kgi ICE-CONTACT SAND AND GRAVEL (Hagarstown Member of Glasford Formation in Illinois)—Chiefly well sorted, bedded sand and gravel; includes some gravelly till. Mapped only in Illinois; forms kames, eskers, and crevasse fillings. Overlies Vandalia Till Member of Glasford Formation (**tkm**). Sangamon paleosol developed in upper-most part. Generally covered by loess less than 6 m thick (Peoria Loess and Roxana Silt, shown by overprint pattern). Thickness commonly 10–15 m; probably greater than 30 m in places

tkm LOAMY TILL (Vandalia Till Member of Glasford Formation in Illinois)—Brown or brownish-gray to gray, calcareous, pebbly to cobbly, loamy till containing numerous thin lenticular beds of silt, sand, and gravel. Mapped only in Illinois. Clasts chiefly limestone and dolomite, with a few of sandstone, siltstone, shale, or chert; scattered erratic clasts of igneous and metamorphic rocks. Till compact and jointed; secondary iron oxide accumulations present on joint surfaces. Sangamon paleosol developed in upper part of till; overlain by loess less than 6 m thick (Roxana Silt and Peoria Loess, shown by overprint pattern). Thickness 2–15 m

LOAMY TILL (Kellerville Till Member of Glasford Formation in Illinois)—Reddish- to yellowish-brown, brownish-yellow, olive-green, or gray, calcareous clay loam and loam. Texture highly variable; ranges from sandy loam to clay loam. Nonsorted to poorly sorted; locally exhibits faint pseudostratification. Commonly contains intercalated or inter-stratified pods or zones of silt, sand, or gravel; locally very sandy or gravelly in lower part. Generally massive and compact; jointed; crude horizontal partings common. Generally sparsely pebbly; locally very pebbly. Clasts chiefly shale and dolomite, with a few of limestone or sandstone; coal fragments abundant locally. A Sangamon paleosol commonly developed in upper part; overlain by loess less than 6 m thick (Peoria Loess and Roxana Silt, shown by overprint pattern)

tkp Ground moraine—Thickness 1–7 m; locally more than 20 m in buried valleys eroded in bedrock

tkp End moraine—Forms broad, deeply eroded ridges; includes some unmapped ice-contact sand and gravel. Thickness locally more than 20 m

ILLINOIAN TO PRE-ILLINOIAN

alj ALLUVIAL SILTY CLAY, SAND, AND GRAVEL—Reddish-brown to dark-gray silty clay, locally including lenses of sand and gravel at base. Gravel mostly chert and limestone. Mapped only in Kansas and Oklahoma where underlies a sequence of terraces along drainages south of the Kansas River. Contains Pleistocene vertebrate fossils in places. Thickness 3–15 m

ggk ALLUVIAL SILTY CLAY, SAND, AND GRAVEL—Reddish-brown to dark-gray silty clay, locally including lenses of sand and gravel at base. Clasts mostly chert and limestone from local sources but some

erratics of igneous and metamorphic rocks reworked from older glacial deposits. Mapped north of and in drainage of the Kansas River in Kansas. Locally contains Pleistocene vertebrate fossils and, at least at one locality, a lens of undifferentiated Pearlette family volcanic ash. Thickness 3–20 m

PRE-ILLINOIAN

lck LAKE CLAY (Nortonville Clay in Kansas)—Dark- to pinkish-gray noncalcareous lake clay; overlies clay loam till (**tck**) on uplands. Mapped only in Kansas. Locally covered by thin, unmapped loess. Thickness less than 12 m

gtk OUTWASH SANDY GRAVEL AND TILL—Reddish- and yellowish-brown, clayey to loamy till containing pebble- to boulder-size clasts of chert, limestone, dolomite and erratic igneous and metamorphic rock types; may include deposits of more than one glaciation. Mapped only in Kansas on uplands and in terrace deposits along the Kansas River and its tributaries; included in unit **tck** elsewhere. Commonly intermixed and interbedded with stratified drift—sand, gravel, and silt—that is moderately well sorted and locally cemented with calcium carbonate. Contains local lenses of varved lacustrine silt and fine sand. Thickness generally 9–16 m; locally 33 m

tlk LOAMY TILL—Light-yellowish-brown to dark-greenish-gray, calcareous loamy till containing pebbles of limestone, chert, and quartzite. Occurs only in a small area of Missouri along Mississippi River plain at northern edge of quadrangle. A fine-textured "Yarmouth-Sangamon" paleosol developed in the till overlain locally by 1–3 m of Peoria Loess (shown by overprint pattern). Thickness 3–10 m

tck CLAY LOAM TILL—Red to brown or dark-gray clay loam till; poorly sorted, unstratified, and locally jointed. Contains pebble- to boulder-size clasts of limestone, chert, shale, and erratic igneous and metamorphic rocks. Locally includes glaciofluvial deposits of sand and silt, lenses of gravel, and glaciolacustrine medium to fine sand and silt. Probably represents more than one pre-Illinoian glaciation. In northwest Missouri and Kansas, a Yarmouth paleosol developed in the till is overlain by loess (shown by overprint pattern) consisting successively of Loveland Loess (in upper part of which a clay-rich Sangamon paleosol is developed), Peoria Loess, and, in addition, Bignell Loess in Kansas. In north-central and northeast Missouri, a "Yarmouth- Sangamon" paleosol developed in the till is overlain by Peoria Loess (shown by overprint pattern). Thickness 3–33 m; locally as much as 110 m where till fills buried valleys in underlying bedrock

EARLY PLEISTOCENE TO PLIOCENE(?)

agf CHERT PEBBLE GRAVEL AND SAND (gravel of Crowleys Ridge in Arkansas and Missouri)—Pale-buff, light- to dark-brown pebbles, cobbles, and a few boulders, locally stained with iron or manganese oxide. Matrix unconsolidated fine sand and minor amounts of silt and clay that increase in abundance in upper part of deposit. Clasts mostly well rounded, some are angular; chiefly chert, but some nonmetamorphic quartzite, sandstone, and claystone. Sand mostly quartz; includes heavy minerals that indicate source in headwater drainage of Mississippi River. Poorly sorted and characterized by channel cut-and-fill crossbedding; foreset beds dip predominantly to west or south. Deposit covered by 4–6 m of loess (Peoria Loess and Loveland Loess). Thickness as much as 20 m

agh UPLAND CHERT GRAVEL—Brown chert gravel in reddish-brown leached and oxidized clay matrix; chert reworked from widespread decomposition residuum (**zrg**, **zld**). Mapped only in Kansas, chiefly in drainage of Neosho River and on uplands near west edge of quadrangle. Small deposits shown by symbol. Thickness 1–6 m

QUATERNARY AND TERTIARY

zsd SANDY DECOMPOSITION RESIDUUM[2]—Brown to dark-grayish-brown, medium to fine sand to silty clay; contains angular fragments of sandstone and limestone and chips of shale in lower part; occurs principally on flat to gently sloping uplands. In southeastern Kansas and Missouri, locally covered with thin loess. North of the pre-Illinoian glacial advance limit, commonly mantled with thin till (**tck**) or scattered erratics. Mapped areas include some locally derived colluvium and, in southeastern Kansas, many strip mines and spoil piles too small to map separately. Thickness generally 0.5–2 m, locally as much as 5 m

zsh SILTY SAND AND SANDY SILT DECOMPOSITION RESIDUUM[2]—Tan to light-brown silty fine sand, locally reddish brown silty to sandy clay; sand chiefly quartz. Mapped only in northern Arkansas. Thickness 0.5–2 m

zld CLAYEY SILT TO SILTY CLAY DECOMPOSITION RESIDUUM[2]—Reddish-, dark-, olive-, or grayish-brown, or dark-gray, fine sandy silt to silty clay or clay. Contains small chips of shale and fragments of limestone, chert, and sandstone; local iron-manganese concretions in Oklahoma. Mapped areas include locally derived colluvium and bedrock exposures on steep slopes and, on uplands in Kansas, small zones of residual chert clasts. In northeast Kansas and north of the Missouri River in Missouri, locally overlain by unmapped thin till and thin loess. Thickness commonly 0.25–2 m; locally as thick as 5 m where developed from shale on gentle slopes in Kansas

zcj CLAY AND SILTY CLAY DECOMPOSITION RESIDUUM[2]—Grayish- to yellowish-brown, or brown clay to silty loam, locally mottled yellowish brown or gray; in places, fine sandy loam; grades down into soft shale or fractured fine-grained sandstone. Mapped areas include bedrock outcrops and colluvium. Colluvium, as thick as 2 m on lower slopes, contains as much as 15 percent fragments of sandstone and shale less than 25 cm in long dimension. Thickness 0.5–1 m

zrc THICK SAND AND SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Red to reddish-brown sand and sandy clay containing abundant fragments of sandstone, sandy dolomite, and chert. Locally includes relict layers of sandstone or chert. Where developed on sandstone, is a sandy decomposition residuum that grades down into bedrock through a zone of partly decomposed fragments. Where developed on dolomite, is a sandy, silty, or clayey material containing chert fragments that is residual after solution of dolomite. Mapped only in southeastern and central southern Missouri. Mapped areas include local bedrock outcrops, cherty colluvium on moderate to steep slopes, and minor alluvium along streams. Thickness 10–60 m

zrd THIN SAND AND SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Material same as unit zrc. Mapped only in central southern Missouri. Thickness 2–10 m

zre THICK CHERTY SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Red to yellowish-red and gray sandy clay containing abundant clasts of angular to subangular, gray to grayish-black chert and quartzite. Mapped only in Missouri. Decomposition residuum developed from sandstone, quartzite, and shale; solution residuum from cherty dolomite. In central and southern Missouri, solution residuum consists mostly of chert fragments in a blocky-structured red clay matrix; locally chert boulders in the clay are more than 1 m in diameter. In eastern Missouri, residuum contains fewer rock fragments and is chiefly clay. Mapped areas commonly include coarse cherty colluvium and, on steep slopes, local bedrock outcrops. Thickness 10–55 m

zrf VERY THICK CHERTY SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Material same as unit **zre**. Thickness greater than 55 m

zrh THIN CHERTY SANDY CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Material same as unit **zre**. Thickness 2–10 m

zrg SHALY CLAY AND CHERTY CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Yellowish- to reddish-orange or reddish-brown clay and minor amounts of sand and silt. Decomposition residuum derived from shale and interbedded thin sandstone layers; contains abundant shale fragments. Solution residuum derived from limestone and locally contains abundant iron-stained chert fragments that are angular to subangular and as long as 20 cm. Mapped areas include locally derived sheetwash, colluvium, and bedrock outcrops on steep slopes. Mapped only in small areas in northeast Arkansas near south border of quadrangle. Thickness 0.5–2 m

zri SILTY CLAY AND CHERTY CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Dark-grayish-brown to light-brown silty to clayey, locally calcareous residuum derived from extensive alternating beds of locally cherty limestone and shale. Decomposition residuum commonly contains shale fragments; solution residuum, chert and limestone fragments. Mapped only in Kansas. On steep slopes, mapped areas include bedrock outcrops and locally derived colluvium. North of the Kansas River, include small, thin deposits of till (**tck**) and loess (**elb**). Thickness 0.5–5 m

zrj SANDY CLAY, SILTY CLAY, AND CLAY DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Brownish-yellow to dark-gray sandy to silty clay decomposition residuum derived from widespread shale and lesser channel sandstone, clay, and coal; contains chips of shale and fragments of sandstone. Clay solution residuum derived from massive limestone contains solution-surfaced limestone fragments and overlies sharp solution surface on limestone bedrock into which it extends along fractures. Distinguished only in Missouri. North of pre-Illinoian glacial limit commonly mantled with pre-Illinoian till (**tck**) or erratics, covered by less than 2 m of Illinoian, Wisconsin, and Holocene loess (**elb**). Near and immediately south of pre-Illinoian glacial limit, mapped areas include scattered small deposits of till and outwash sand and gravel similar to unit **gtk** in Kansas, and lake clay similar to unit **lck** in Kansas. Thickness 0.5–3 m

zrk CHERTY LOAM TO SILTY CLAY LOAM DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Brownish-red to dark-gray clay loam solution residuum developed from limestone contains scattered chert fragments;

lower part contains solution-surfaced fragments of limestone and extends along fractures into limestone bedrock; generally stable. Silty clay loam solution residuum developed from shale; plastic and sticky when wet, hard when dry; shale chips abundant in lower part; commonly characterized by landslides and extensive creep on steep slopes; grades down through zone of shale fragments into shale. Silty loam decomposition residuum developed from siltstone contains abundant siltstone fragments and generally is more stable than the residuum on shale. Mapped only in Missouri; commonly mantled with loess. Mapped areas include rock outcrops and colluvium. Thickness 0.5–6 m

zrl SILTY CLAY LOAM DECOMPOSITION AND SOLUTION RESIDUUM[2,3]—Reddish brown to yellowish red silty clay decomposition residuum developed from shale; very sticky and plastic when wet; contains shale chips and grades down through zone of fragmented shale into bedrock. Solution residuum derived from dolomite is more sandy and more stable; contains partially dissolved dolomite fragments. Mapped only in Missouri; commonly mantled with thin loess. Mapped areas include bedrock outcrops and colluvium. Thickness 0.5–3 m

rcc CHERTY CLAY SOLUTION RESIDUUM[3]—Yellowish- to reddish-orange, reddish-brown to brown, or grayish-brown clay loam to silty clay loam, locally sandy clay loam containing subangular to angular fragments of white, tan, black, green, or gray chert, as much as 30 cm in diameter. Contact with underlying limestone bedrock is an abrupt, locally pinnacled, karst surface. Mapped only in Arkansas and Oklahoma. Mapped areas include locally derived colluvium and alluvium (**ale**) commonly covered by thin to thick loess, bedrock exposures, and, in places, mine pits and spoil piles. Thickness mostly 0.5–1.5 m, locally more than 10 m

rca THICK CHERTY CLAY SOLUTION RESIDUUM[3]—Material same as unit **rcc**. Mapped only in Missouri; boundaries approximate. Contains abundant chert clasts and relict chert layers. Thickness 10–60 m

rcb THIN CHERTY CLAY SOLUTION RESIDUUM[3]—Material same as unit **rcc**. Mapped only in Missouri; boundaries approximate; contains relatively less chert in northern Missouri. Near southern limit of pre-Illinoian glaciation, mapped areas include scattered small deposits of till and outwash sand and gravel similar to unit **ggk** in Kansas, and lake clay similar to unit **lck** in Kansas. Thickness 2–10 m

rco THICK CHERTY SILTY TO SANDY CLAY SOLUTION RESIDUUM[3]—Yellowish-brown to brown silty to sandy clay containing gray, grayish-black, or blue chert fragments; local layers of broken relict chert, a few of rotted sandstone. Residuum derived chiefly from extensive cherty silty dolomite bedrock that is commonly fractured and highly soluble. Commonly contains as much as 35 percent chert fragments, in places more than 50 percent. On broad uplands residuum is mantled with less than 0.5 m of loess. Mapped only in Missouri. On steep slopes, mapped areas include bedrock outcrops and colluvium. Thickness 10–60 m

rcp THIN CHERTY SILTY TO SANDY CLAY SOLUTION RESIDUUM[3]—Material same as unit **rco**, but includes small areas of stony clay residuum in southern Missouri. Thickness 2–10 m

rcq VERY THIN CHERTY SILTY TO SANDY CLAY SOLUTION RESIDUUM[3]—Material same as unit **rco**, but mapped areas include bedrock outcrops that commonly form broad gently sloping glades. Thickness less than 2 m

rcs VERY THICK CHERTY SILTY CLAY AND CLAYEY SILT SOLUTION RESIDUUM[3]—Red to reddish brown; blocky structure; contains scattered fragments of chert, chalcedony, and quartz druse. Contact with underlying limestone commonly an irregular smooth solution surface, locally weathered. Mapped only in Missouri. In northern part of mapped area barite occurs in the residuum and the weathered bedrock. Thickness commonly more than 60 m

rct THICK CHERTY SILTY CLAY AND CLAYEY SILT SOLUTION RESIDUUM[3]—Material same as unit **rcs**. Thickness 10–60 m

rcu THIN CHERTY SILTY CLAY AND CLAYEY SILT SOLUTION RESIDUUM[3]—Material same as unit **rcs**. Thickness 2–10 m

ssb SANDY SILTY SAPROLITE—Brown to brownish-red and red sand, silt, and kaolinitic clay; locally contains rounded to subrounded core-boulders of underlying alkali granite, rhyolite ash-flow tuffs, or trachyte. Where saprolite has formed on relatively flat surfaces, structures and textures of the bedrock commonly preserved. Grades down through partly weathered rock into fresh parent rock. Thickness highly variable depending on slope; on gently sloping uplands rarely exceeds 2 m; on slopes of 6°–12° commonly ranges from 0.5 m to 2 m; on slopes exceeding 12° generally less than 0.5 m

PRE-TERTIARY

R BEDROCK

[1]COLLUVIUM is a general term applied, for purposes of this map, to material transported and deposited by mass-

wasting processes. For unit **cla**, these are chiefly frost heave, creep, and landslide; for unit **clk**, they are chiefly creep, solifluction, mudflow, frost heave, and, locally, landslide.

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

[3]SOLUTION RESIDUUM, for purposes of this map, is defined as material derived by in-place solution of carbonate rock or carbonate-cemented rock, and no appreciable subsequent lateral transport.

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