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

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
MAP I-1420 (NJ-14)

Prepared in cooperation with
The Kansas Geological Survey,
The Oklahoma Geological Survey, and
The Texas Bureau of Economic Geology

State compilations by
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NOTE: This map is the product of collaboration between 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 that part of each State 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 the State compilers and from additional sources. Harold Dickey and H.G. O'Connor assisted J.E. Denne in the preparation of map unit descriptions in Kansas. R.M. Pratt prepared the loess distribution and thickness diagram and assisted in plotting volcanic ash localities.

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 been focused on glacial, alluvial, eolian, lacustrine, marine, and landslide deposits. Slope and upland deposits have been mapped in detail only in restricted areas. However, much engineering construction and many important problems of land use and land management occur in regions of extensive slope and upland deposits (colluvium and residuum, for example). Therefore, an effort has been made to classify, map, and describe these deposits on the basis of published and unpublished subsoil data and interpretations and the distribution of bedrock parent materials.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 lithology, texture, genesis, stratigraphic relationships, and age, as shown on the correlation diagram and indicated in the map unit descriptions. The gradual change in the character of subsoils from thick, predominantly decomposition residua of Tertiary and Quaternary age common to the unglaciated eastern States to thin, predominantly disintegration residua of middle and late Quaternary age common to the semiarid Western Interior takes place in a broad zone that lies along the eastern base of the High Plains escarpment. However, in this quadrangle, the disintegration residua are not sufficiently exposed to be mapped at 1:1,000,000 scale, owing to an extensive cover of loess on the uplands and to a mantle of colluvium on the slopes of valleys. In addition, both the decomposition and the disintegration residua appear to have been extensively thinned and, in places, stripped by middle and late Pleistocene deflation and sheetwash erosion, the effects of which increase from east to west across the quadrangle.

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 defined and classified by pedologists or agronomists. 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 for engineering, land-use, or land-management projects can be compiled. However, it does not replace detailed site study and analysis.

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 Wichita 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.

A chart showing deposits and local faunas included in map units **agl**, **asg**, and **agp** in four areas of Kansas and northwestern Oklahoma, their relative ages, magnetic polarity, and suggested relationship to pre-Illinoian glacial deposits in eastern Nebraska and western Iowa
[Bold-face numbers in column heads indicate sources of data. Volcanic ash bed occurrence shown by xxxx. Unconformity shown by wavy line. Dashed line at Pliocene-Pleistocene boundary]

FOOTNOTES

[1]Northwest Oklahoma.
[2]Till letter designation from Boellstorff (1973).
[3]Till nomenclature from Reed and Dreezen (1965).
[4]The Ballard Formation rests disconformably on the late Pliocene Rexroad Formation which contains the Bender l.f. and has normal magnetic polarity (Zakrzewski, 1967; Repenning, 1987).
[5]Central Kansas.
[6]Since this manuscript was submitted, dating of the Matuyama-Brunhes magnetic polarity boundary and the beginning and ending of the Jaramillo Normal Polarity Subchron has resulted in somewhat greater ages than those obtained by the K-Ar dating method. Most of these data were first published individually in abstracts, but are related in a summary paper by Izett, G.A., and Obradovich, J.D. 1992, ^{40}Ar-^{39}ar dating of the Jaramillo Normal Polarity Subchron and the Matuyama-Brunhes geomagnetic boundary: U.S. Geological Survey Open-File Report 92-699.

COLUMN	**SOURCE OF DATA**
1	Land mammal ages from Repenning (1987).
2	Land mammal ages from Lundelius and others (1987).
3	Magnetic polarity ages from Mankinen and Dalrymple (1979).
4	Volcanic ash chronostratigraphy from Naeser and others (1971), Boellstorff (1976), Naeser and others (1980), Izett (1981), Izett and others (1981), Izett and Wilcox (1982).
5	General papers on local faunas: Taylor (1960), Zakrzewski (1975), Bayne (1976), Miller (1976), Lundelius and others (1987), Repenning (1987).
6	Magnetic polarity symbols from Lindsay and others (1975). Local fauna references keyed to localities on map: 1, Boyd l.f.; Miller (1975). 2, Robert l.f.; Schultz (1967), Miller 1975). 3, Classen l.f.; Miller (1975). 4, Bar M I l.f.; Hibbard and Taylor (1960), Miller (1975). 5, Bar M II l.f.; Hibbard and Taylor (1960), Miller (1975). 6, Jones Ranch l.f.; Hibbard (1940, 1942, 1949), Hibbard and Taylor(1960), Miller (1975). 7, Bird locality l.f.; Miller (1975). 8, Jinglebob l.f.; Hibbard (1955), Hibbard and Taylor (1960). 9, Cragin Quarry l.f. (locality); Hibbard (1939, 1949), Hibbard and Taylor (1960), Schultz (1967, 1969). 10, Cragin Quarry l.f. (Butler Spring area); Schultz (1967, 1969). 11, Mt. Scott l.f.; Hibbard (1963), Miller (1966), Schultz (1967, 1969). 12, Butler Spring l.f.; Hibbard and Taylor (1960), Miller (1966), Schultz (1967, 1969).

13, Adams l.f.; Miller (1966), Schultz (1967, 1969).
14, Doby Springs l.f.; Hibbard and Taylor (1960) Stephens (1960), Miller (1966).
15, Berends l.f.; Starrett (1956), Hibbard and Taylor (1960), Miller (1966).
16, Cudahy l.f.; Hibbard (1944, 1949, 1958), Paulson (1961).
17, Aries l.f.; J.G. Honey, personal commun. *in* Izett (1977).
18, Nash H.; Eschelman and Hibbard (1981).
19, Borchers l.f.; Hibbard (1941, 1942, 1949, 1954).
20, Arkalon l.f.; Hibbard (1953).
21, Seger l.f.; Hibbard (1951).
22, Dixon l.f. Hibbard (1956), Zakrzewski (1984).
23, Sanders l.f.; Hibbard (1956, 1958).
24, Deer Park l.f.; Hibbard (1949).
25, Spring Creek l.f.; Berry and Miller (1966).
26, Hart Draw l.f. (distinction from type Bender l.f.[4]); Hibbard (1956), Zakrzewski (1967), Lindsay and others (1975), Miller (1976), Repenning (1987).

7 Local fauna references keyed to localities on map:
27, Duck Creek l.f.; McMullen (1975), 1978), Holman (1984).
28, Williams l.f.; Holman (1984).
29, Rezabek l.f.; Hibbard (1943).
30, Kanopolis l.f.; Hibbard and others (1978).
31, Wilson Valley l.f.; Hibbard (1944), Zakrzewski and Kolb (1982).
32, Tobin l.f.; Hibbard (1944), Zakrzewski and Kolb (1982).
33, Holzinger l.f.; Zakrzewski and Kolb (1982).
34, Cedar Bluff Canal l.f.; Zakrzewski and Kolb (1982).

8 Local fauna references keyed to localities on map:
35, Sandahl l.f.; Semken (1966), Miller (1970).
36, Kentuck l.f.; Hibbard (1952), Semken (1966).

9 Local fauna references keyed to localities on map:
37, Hall Ash l.f.; Eshelman and Hager (1984).
38, Courtland Canal l.f.: Eschelman and Hager (1984).
39, White Rock l.f.; Eschelman (1975), Zakrzewski (1984).

10 Volcanic ash chronostratigraphy from Izett and others (1971), Boellstorff (1978a, 1978b), Hallberg and Boellstorff (1978).
Magnetic polarity data from Easterbrook and Boellstorff (1978, 1981), 1982), Hallberg (1986, chart 1).

LIST OF MAP SYMBOLS

CONTACT

LOESS (**elb**) OVERLIES GRAVEL (**agl**)

STRIATION—In northeast corner of quadrangle

OUTER LIMIT OF GLACIATION—Approximately located; dotted where concealed

BURIED PLEISTOCENE RIVER CHANNEL

UPLAND CHERT GRAVELS—Deposits of map unit **agh** too small to show at map scale

FAULT HAVING QUATERNARY DISPLACEMENT—Dotted where concealed. Bar and ball on downthrown side

LOESS ISOPACH—In meters. Thickness less than 2.5 m shown only on loess distribution and thickness map

LOCAL FAUNA LOCALITY—May be combined with volcanic ash bed locality. For local fauna name see number on chart

VOLCANIC ASH BED LOCALITY—May be combined with local fauna locality
Lava Creek B (Pearlette 0) volcanic ash bed
Cerro Toledo B and Huckleberry Ridge (Pearlette B) volcanic ash beds
Huckleberry Ridge (Pearlette B) volcanic ash bed
Pearlette family—Not individually identified
Pleistocene—Possibly belonging to Pearlette family

DESCRIPTION OF MAP UNITS

HOLOCENE AND LATE WISCONSIN

al ALLUVIUM (Mapped only along Kansas River and tributaries in glaciated northeast part of quadrangle)—Reddish-brown, brown, or gray silt, sand, gravel, and minor clay. Noncalcareous to calcareous, moderately to well sorted, stratified; upper part commonly silt and, fine sand; lower part chiefly sand, locally with rounded pebble gravel; commonly stained with iron or manganese oxide. Clasts primarily limestone, chert, and erratic igneous and metamorphic rock types derived from glacial deposits. Thickness less than 30 m in Kansas River valley; about 5-10 m in tributary valleys

ale ALLUVIAL SILT AND CLAY—Dark- to light-brown or gray silt, clay, and fine sand intermixed and interbedded; includes local lenses of subangular to subrounded gravel; clasts chiefly chert and limestone 2-4 cm in diameter derived from eastern escarpment of Flint Hills (area underlain by map unit **zri**) to west. Includes lenses of sheetwash alluvium and colluvium derived from valley sides; underlies flood plains and low stream terraces. Thickness 0.5-10 m; locally as much as 20 m

asa ALLUVIAL SAND, SILT, CLAY, AND GRAVEL—Light-brown, gray, or grayish-brown sand, silt, and gravel, intermixed and interbedded; commonly crossbedded. Locally includes lenses of clay and layers of slopewash alluvium and colluvium derived from valley slopes. Along Arkansas River, chiefly coarse arkosic sand with lenses of gravel. Clasts mostly granitic rock types, but include minor amounts of quartzite, porphyry, and dike rocks. Gravel becomes finer and increasingly confined to lower part of deposit eastward across quadrangle. Along Republican River, similar, but it also includes some clasts of

anorthosite from the Laramie Mountains in Wyoming. In other drainages, deposit mostly arkosic sand and silt; gravel chiefly pebbles to cobbles of granitic rocks and waterworn fragments of calcrete, both derived from the Ogallala Formation (Miocene). Thickness 3-30 m; mostly 5-6 m

ed DUNE SAND—Gray to yellowish- or reddish-brown, fine to medium sand; locally silty or loamy. Mostly quartz and feldspar; well sorted; moderately to well rounded; generally noncalcareous. Commonly overlies older alluvial deposits. Most dunes stabilized by vegetation. In Oklahoma, locally includes extensive sheet sand. Thickness 3-30 m; generally about 7 m

LATE WISCONSIN

alg ALLUVIUM (Vanhem Formation)—Brown to dark-gray, clayey to fine sandy silt and silty sand containing local lenses of coarse sand and gravel, mostly at base. Clasts chiefly granitic and waterworn fragments of calcrete. Includes layers of sheetwash alluvium and colluvium from valley sides. Commonly overlain by thin loess. In southwest Kansas and adjacent Oklahoma, underlies low terraces in entrenched valleys of Cimarron River, Crooked Creek, and their tributaries. Deposits consist of dark- to pale-brown or dark-gray to gray, poorly to well sorted, massive to well bedded, medium to fine sand containing local calcareous nodules and including some blue-gray, gray-green, or brown clay layers and dark organic zones. Contains sites of seven molluscan local fauna (l.f.) radiocarbon dated in years B.P.: Boyd l.f., 10,790±280 (I-5541), Robert l.f., 11,110±350 (SM-762); Classen l.f., 16,100±250 (I-4930); Bar M II l.f., 17,750±360 (I-3460); Bar M I l.f., 21,360± 1250 (SM-763); Jones Ranch l.f., 26,700±1500 (I-3641) and 29,000±1300 (I-3402); Bird locality l.f., 29,300±1250 (I-5136). All local fauna subsequent to Jones Ranch l.f. indicate increasing dryness; the Jones Ranch l.f. indicates a cool, moist paleoclimate. Thickness less than 15 m

HOLOCENE TO ILLINOIAN

oc PLAYA CLAY—Light-gray to pale-brown or brownish-gray, sandy clay and silt; massive, calcareous; hard when dry, sticky and plastic when wet. Occurs in circular to oval closed depressions and small intermittent playa lakes on High Plains in northern Texas, northwestern Oklahoma, and southwestern Kansas. Depressions formed by wind erosion, and as sinkholes due to subsidence and collapse following deep solution of underlying gypsum bedrock. Widespread but not extensively mapped in southwestern Kansas. Sand and silt in the sinkholes locally contains the Mt. Scott l.f., interpreted as Illinoian in age. Thickness 3-7 m

elb LOESS (Bignell, Peoria, and Loveland Formations of Kansas Geological Survey)—Grayish-, yellowish-, or reddish-brown silt loam, locally clayey in eastern part of quadrangle. In western part, gradational into fine to coarse alluvial sand and gravel in places. Brady soil locally present in upper part of Peoria Formation (Wisconsin); Sangamon soil locally preserved in upper part of Loveland Formation (Illinoian). Molluscan fauna common in Peoria Formation, sparse in Loveland Formation. Vertebrate fauna sparsely present in both. Loess is chiefly preserved on uplands. Bignell Formation is widespread in northwestern Kansas where it commonly is about 3 m thick. Peoria Formation locally is as thick as 30 m in northwestern Kansas but more commonly is 7-10 m thick, and is less than 3 m thick in central and eastern Kansas. Loveland Formation is as thick as 13 m in north-central Kansas, but thins and becomes discontinuous to south, west, and east. All mapped loess is more than 1 m thick. Unmapped thinner loess is widespread on many map units. Loess is not common and has not been mapped in Oklahoma. The upper 2-3 m of the "cover sand" of Frye and Leonard (1957) and underlying Blackwater Draw Formation of Reeves (1976) (**esa**) is loess in southwest part of quadrangle

esa LOESS, LOESSIAL ALLUVIUM, AND LOESSIAL COLLUVIUM[1] (Included in Vanhem and Kingsdown Formations in Oklahoma; “cover sand" of Frye and Leonard (1957) and Blackwater Draw Formation of Reeves (1976) in Texas)—Grayish-red to pink or reddish-brown clay, locally olive gray. Becomes loamy upward; increasingly sandy to south. Basal pebbly sand confined to channels. Upper layers of massive to bedded clay and loam include loess, alluviated loess (sheetwash), and colluviated loess. Mapped only in Oklahoma and Texas. Considered chiefly Wisconsin and Illinoian in age, but has not been extensively studied in this quadrangle. Average thickness 4-8 m

cga CALCRETE- AND GRANITIC-CLAST LOAMY TO GRAVELLY COLLUVIUM[1]—Reddish- to yellowish-brown, brown, or gray mixture of gravel, sand, silt, and clay. Clasts mostly pebble to cobble size, but include some boulders; chiefly granitic rock types and fragments of calcrete; in headwater areas some clasts are shale, chalk, and limestone. Sand is arkosic. Mapped areas include bedrock outcrops, small areas of locally derived alluvium, and disintegration residuum that grades down into underlying calcrete or conglomeratic bedrock. Thickness commonly less than 1 m; locally 2-4 m at base of slopes

cse SANDSTONE- AND SHALE-CLAST GYPSIFEROUS LOAMY COLLUVIUM[1]—Reddish- to grayish-brown silt loam to clay loam containing scattered angular clasts of siltstone, slabs and chips of shale, and partly dissolved blocky fragments of impure gypsum. Occurs downslope from outcrops of shale, siltstone, and gypsum in southeast- to northwest-trending escarpments in Oklahoma. Sinkholes common in areas underlain by gypsum. Mapped only in Oklahoma; included in map unit **clp** in Kansas. Thickness 0.3-1 m

csg SANDSTONE- AND SHALE-CLAST LOAMY COLLUVIUM[1]—Yellowish-brown, brown, or brownish-gray, sandy to clayey loam containing angular to subangular clasts of sandstone, shale, and minor siltstone, derived from residuum or bedrock upslope. Locally mantled with thin loess. Abrupt contact with underlying rock. Mapped areas include bedrock outcrops, local alluvium, and small areas of decomposition residuum, 0.5 to 2 m thick, that is more clayey than the colluvium and grades down through a fragmented zone into bedrock. Locally preserved on gently sloping uplands, but commonly partly stripped by mass wasting and deflation. Thickness 2-3 m; locally as thick as 5 m at base of slopes

cln SHALE-, LIMESTONE-, AND CHERT-CLAST SILTY TO CLAYEY COLLUVIUM[1]—Reddish- to dark-brown or brownish-gray silt loam to clay loam containing scattered subangular to angular fragments of shale, limestone, and chert. North of outer limit of glaciation, also contains clasts of erratic igneous and metamorphic rocks derived from till. Commonly mantled with thin loess. Abrupt contact with underlying bedrock. Mapped areas include local remnants of unmapped decomposition residuum (**zri**), patches of till (**tck**), local alluvium, and bedrock outcrops. Thickness commonly 0.5-1 m; locally as much as 5 m at base of slopes

clo SHALE-, CHALK-, AND CHALKY LIMESTONE-CLAST LOAMY COLLUVIUMI[1]—Reddish- to yellowish-brown or gray silt loam to clay loam containing chips and slabs of shale, and angular to subangular pebble- to boulder-size clasts of chalk and chalky limestone derived from upslope. Clay is smectitic; shrinks and swells with changes in moisture content. Abrupt contact with bedrock. Locally mantled with thin loess. On gently sloping uplands, mapped areas include some fragmental disintegration residuum that grades down into underlying shale, chalk, or limestone bedrock. Mapped areas also include bedrock outcrops and minor locally derived alluvium. Thickness of colluvium 0.5-5 m; thickness of residuum ranges from 1 m (over chalk) to less than 3 m (over shale)

clp SHALE-, SILTSTONE-, AND SANDSTONE-CLAST RED LOAMY COLLUVIUM[1]—Reddish-brown to brown, clayey, silty, or sandy loam containing small to large fragments of shale, siltstone, and sandstone, and, locally, dolomite and impure gypsum, the latter commonly partly dissolved. Abrupt contact with bedrock. Locally overlain by thin loess. On gently sloping uplands, mapped areas include some unmapped decomposition residuum characterized by clasts of subjacent bedrock into which the residuum is gradational. Includes zones of partly dissolved gypsum rubble locally marked by dissolution and collapse depressions. Mapped areas also include bedrock outcrops and small areas of local alluvium. Mapped only in Kansas; equivalent to map units **clq**, **cse**, and **clr** in Oklahoma. Thickness 0.5-1 m; as much as 3 m at base of slopes

clq SANDSTONE- AND SILTSTONE-CLAST LOAMY COLLUVIUM[1]—Reddish-brown to brown, very fine sand to silt containing clasts of red sandstone, siltstone, and shale; local dolomite and gypsum rubble in heads of drainages from west. Mapped areas include rock outcrops, local alluvium, and minor remnants of decomposition residuum (**zlq**). Mapped only in Oklahoma; included in map unit **clp** in Kansas. Thickness less than 0.6 m

clr SANDSTONE- AND SHALE-CLAST CLAY LOAM COLLUVIUM[1]—Reddish- to dark-brown or brown sandy clay loam containing angular to subangular clasts of red fine-grained sandstone, siltstone, and shale. Abrupt contact with bedrock; may overlie thin decomposition residuum (**zlr**). Mapped areas include minor remnants of decomposition residuum, locally derived alluvium, and rock outcrops. Mapped only in Oklahoma; included in map unit **clp** in Kansas. Thickness 0.2-2 m; commonly thicker on lower slopes

cls CHERT-CLAST CLAYEY SILT TO SILTY CLAY LOAM COLLUVIUM[1]—Reddish-, dark-, 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 (**zld**) or bedrock upslope. Also contains erratics of igneous and metamorphic rocks derived from till (**tck**) upslope. Mapped only in northeasternmost part of quadrangle where till is deeply dissected by steep slopes. Mapped areas may include local eroded remnants of decomposition residuum (**zld**), minor local alluvium, and bedrock outcrops. Thickness 0.25-2 m

clt SHALE-CLAST CLAYEY COLLUVIUM[1]—Yellowish-brown to gray clay to clay loam containing chips and slabs of shale and, in places, angular fragments of limestone, dolomite, siltstone, fine-grained sandstone,

and gypsiferous rubble. Abrupt contact with bedrock. Locally mantled with thin loess. Mapped areas include rock outcrops, minor alluvium, and small areas of decomposition residuum (**zlt**). Thickness generally less than 3 m; may be as much as 5 m at base of slopes

ILLINOIAN(?)

ali SILTY TO CLAYEY ALLUVIUM—Reddish-brown to dark-gray, leached, silty to clayey sediment; contains sand and gravel in lenses and at base. Sand chiefly quartz; gravel mostly chert and limestone. Similar to map unit **alj**, but underlies a distinctly separate, lower terrace 3-10 m above valley floor. Mapped only in Kansas along drainage of Cottonwood River near east margin of quadrangle. Thickness 13-20 m. Terrace deposits of sand, silt, and clay at local fauna locality 27 along Smoky Hill River contain the Duck Creek l.f. At local fauna locality 28, 38 km west-northwest of McPherson, Kans., contain the Williams l.f. Based on stratigraphic position and comparison with other faunas, both Duck Creek l.f. and Williams l.f. are considered Illinoian in age and interpreted as recording cool, moist summers but not full glacial conditions. Thickness 5-10 m

ILLINOIAN TO PRE-ILLINOIAN

alj ALLUVIAL SILTY CLAY, SAND, AND GRAVEL—Reddish-brown to brown or dark-gray silty clay. Sand and pebble- to granule-gravel occur in basal layer and local lenses. Sand chiefly quartz and feldspar; gravel chiefly chert and limestone. Underlies terraces 10-16 m above the streams in valleys draining the Flint Hills (underlain by map unit **zri**) in eastern part of quadrangle. Deposits in drainages to east of Flint Hills contain much more chert than those in drainages to west; they also contain angular clasts of shale and limonite-cemented sandstone near base. The Lava Creek (Pearlette 0) volcanic ash bed (age 0.61 Ma) is present above the basal gravel in a prominent terrace 10 m above Cottonwood River at Emporia. Mapped areas locally include small deposits of map unit **agh** (for example, in valley of Cottonwood River near Emporia), small deposits of locally derived colluvium, and a thin mantle of loess. Thickness 5-20 m

SANGAMON, ILLINOIAN, AND PRE-ILLINOIAN PLEISTOCENE, AND LATE PLIOCENE

agl GRAVEL, SAND, SILT, AND CLAY (alluvium along Arkansas and Cimarron Rivers, Crooked Creek, and tributaries)

Alluvium along Arkansas River (Kingsdown Formation and older unnamed deposits in Kansas) —Reddish- to yellowish-brown, tan, gray, bluish-gray, or black, poorly sorted, massive to wellbedded sand, silt, and clay, including a few beds of hard limestone and local lenses of sandy gravel. Silt and clay thickest and most persistent near top; gravel increases in abundance downwards. Sand is fine to coarse, angular to subangular, mostly quartz and feldspar; contains a few scattered pebbles. Gravel is sandy; clasts mostly pebbles and cobbles of granitic rock, feldspar, quartz, and waterworn calcrete derived from Miocene Ogallala Formation. Rare pebbles of sandstone, limestone, chert, and shale. In a few places, includes lenses of crossbedded Pearlette family volcanic ash, not more specifically identified. Loose to tightly cemented; includes nodules, stringers, and irregular masses of soft to hard caliche; fills channels cut in Ogallala Formation and older rocks. Maximum thickness more than 100 m in channels; about 30 m on uplands. Gravel decreases in size and abundance, and sand and silt increase in abundance eastward and southeastward

Alluvium along Cimarron River and Crooked Creek (Kingsdown Formation, entrenched in valleys)—Tan, yellow, pink, pale-reddish-brown, or gray massive to thin-bedded silt, silty fine sand, and clay containing thin layers of crossbedded pebble gravel. Clasts chiefly Precambrian igneous rocks and waterworn calcrete clasts from the Ogallala Formation; thick caliche at top. Underlies Vanhem Formation in low terraces or forms separate, slightly higher terraces. Contains the Jinglebob l.f. and the Cragin Quarry l.f.; latter also present in sand and silt deposits in sinkholes. Both faunas inferred to represent a warm, humid interval of the Sangamon preceding a dry interval recorded by the overlying caliche. Older part of Kingsdown Formation includes greenish-brown to gray silty to sandy clay, limonite-stained, crossbedded, medium to coarse sand, and basal sandy gravel; deposits contain the successively older Mt. Scott l.f., Butler Spring l.f., Adams l.f., and, in northwestern Oklahoma, the Doby Springs l.f. and the Berends l.f., all inferred to record late Illinoian climates. Thickness 5-40 m

Unnamed pre-Illinoian Pleistocene alluvial deposits and Pliocene Crooked Creek and Ballard Formations on uplands.

Unnamed deposits—Tan, grayish-brown, and gray, massive clay and silt, reddish-buff, sandy silt, and basal sandy, coarse gravel. Clasts chiefly granitic rocks, quartzite, calcrete nodules, and minor amounts of basaltic scoria. Includes Lava Creek (Pearlette 0) volcanic ash bed (0.61 Ma) in upper part. Silt beneath ash includes Cudahy l.f. from which glacial climate inferred. Thickness 4-11 m. Disconformably underlying sediments contain the Cerro Toledo B volcanic ash bed (1.2 Ma), identified as an air-fall unit of Cerro Toledo Rhyolite in the Jemez Mountains, New Mexico, where an associated upper pumice is dated 1.23 Ma and a lower pumice 1.50 Ma. The disconformity therefore may represent a hiatus of as much as 0.6 Ma. Sandy silt and clay beneath Cerro Toledo B (?) ash at one locality contains the Nash l.f. (Irvingtonian), from which a cool, dry climate is inferred, and, at another locality, the Aries l.f. (Irvingtonian). A disconformity at the base of the sandy silt and clay also may represent a hiatus of as much as 0.6 Ma, and may include the time of Pliocene-Pleistocene boundary (1.64 Ma). Thickness 2 -10 m

Crooked Creek Formation- Consists of two members

Atwater Member—Grayish-brown to gray, sandy silt and clay; includes minor sand and caliche layers; contains the Borchers l.f. (late Blancan), interpreted as recording a warm climate, and underlying Huckleberry Ridge (Pearlette B) volcanic ash bed (2.01 Ma). Along the Cimarron River, the Huckleberry Ridge volcanic ash bed locally overlies clay lenses containing the Arkalon l.f. Lower sediments include rust-colored, poorly sorted, medium sand and basal, well-sorted, coarse sand; thickness 10-11 m

Stump Arroyo Member—Reddish-tan to light-buff, coarse sand containing white quartz pebbles. Upper part poorly sorted, medium sand with caliche nodules at top and sandy gravel at base; contains the Seger l.f. (late Blancan); thickness' about 4 m. Crooked Creek Formation disconformably underlain by Ballard Formation

Ballard Formation-Consists of two members

Missler Member—Calcrete, grading down through reddish-tan silt into pale-reddish-brown, caliche-mottled, sandy silt with scattered pebbles; contains the Sanders l.f., Deer Park l.f., and Spring Creek l.f. (each late Blancan); inferred thickness about 7 m

Angell Member-Gray to buff clay with carbonate nodules, sandy gravel, and sandy silt locally including lenses of blue clay; contains the Hart Draw l.f. (late Blancan); basal sand and fine to coarse gravel; thickness about 5 m

asg SAND AND GRAVEL, SILT, AND CLAY (paleovalley and high terrace alluvium of Smoky Hill River, Saline River, and other rivers heading in High Plains)

Some high terrace alluvial deposits consist of compact fine silt, fine to coarse arkosic sand, and a basal gravel composed of granitic rocks and waterworn calcrete clasts. Contain the Kanopolis l.f. and the Rezabek l.f., both interpreted as interglacial but here inferred to be separated in time, probably a time of glaciation in eastern Nebraska and western Iowa on the basis of muskrat evolutionary development. Neither local fauna is associated with volcanic ash, but on the basis of faunal differences, the Kanopolis l.f. is inferred to be younger than the Cudahy l.f., which immediately underlies the Lava Creek B (Pearlette 0) volcanic ash bed (0.61 Ma), in southwest Kansas. Both the Kanopolis l.f. and the Rezabek l.f. therefore are considered pre-Illinoian post 0.61 Ma in age

Other high terrace and paleovalley alluvium is reddish brown to yellowish brown, buff, or gray, and, locally, comprises an upper sand and gravel, an upper silt that locally contains the Lava Creek B volcanic ash bed, a lower sand and gravel, and a lower silt and clay; disconformities common at base of sand and gravel units. Sand and gravel poorly sorted, planar bedded and crossbedded pebble to cobble gravel in a sandy matrix. Clasts chiefly granitic rocks and waterworn calcrete fragments; locally, some are limestone and shale. Sands are medium to fine and arkosic. Silts and clays are massive to well bedded, poorly sorted, and contain thin lenses of pebble gravel. Deposits include the Wilson Valley l.f., Tobin l.f., Holzinger l.f., and Cedar Bluff Canal l.f., all characterized by more than 40 percent northern taxa and an almost complete absence of southern taxa. The Wilson Valley l.f., Tobin l.f., and Holzinger l.f. all underlie the Lava Creek B volcanic ash bed, but may not be precisely the same age. The Cedar Bluff Canal l.f. appears to be stratigraphically slightly lower than the Holzinger l.f. and is not associated with volcanic ash. All the local faunas are inferred to record a cool climate; the Holzinger l.f. has the highest percentage of southern taxa. The paleovalley and high terrace alluvial deposits are overlain by loess of Loveland and younger formations. Thickness commonly 5-8 m; maximum 13 m

Paleovalley and older deposits north and south of McPherson, Kansas include the McPherson Formation and alluvial sand and waterworn pebbles. The McPherson Formation fills a paleovalley that is cut in older Pleistocene and Pliocene deposits. Upper part includes yellow, coarse to fine arkosic sand, beds of waterworn calcrete rubble, and dark-brown clay. Sand contains the Sandahl l.f. inferred to record a cool,

proglacial or glacial, climate. Basal gravelly sand is fine to coarse, crossbedded, chiefly quartz and feldspar; contains pebbles of quartz, chert, limestone, calcrete, granite, volcanic rock, basic igneous rock, and, near the base, boulders derived from local shale bedrock and lenses of clay as thick as 1 m. McPherson Formation fills broad channels cut in alluvium of Meade Group, which contains the Lava Creek B volcanic ash bed (0.61 Ma). The Sandahl l.f. therefore is younger than 0.61 Ma and older than overlying Loveland Formation. Thickness about 5 m. Alluvial sand and waterworn pebbles of caliche containing the Kentuck l.f. fill narrow channels cut in pre-Meade deposits that contain the Huckleberry Ridge (Pearlette B) volcanic ash bed (2.01 Ma) and overlie thick, blue-gray clay from which a Blancan horse has been obtained. The Kentuck l.f., formerly inferred to be a mixed fauna, is now thought to record a cool climate. The fauna is classed as early Irvingtonian and considered equivalent in general to the Nash l.f. and Aries l.f. in southwestern Kansas, which are older than the Cerro Toledo B volcanic ash bed (1.2-1.5 Ma) and younger than Huckleberry Ridge volcanic ash bed (2.01 Ma). The Kentuck l.f. also is considered equivalent to the Wathena l.f., which underlies a pre-Illinoian till in northeastern Kansas beyond limits of this map

PRE-ILLINOIAN

ggk ALLUVIAL SILTY CLAY, SAND, AND GRAVEL—Reddish-brown to dark-gray silty clay locally containing lenses of sand and gravel at base. Occurs in terraces. Clasts mostly locally derived chert and limestone but includes erratics of igneous and metamorphic rocks reworked from older glacial deposits. Mapped only in drainage of Kansas River and its tributaries in glaciated northeast part of quadrangle. Mapped areas may include some terrace deposits that are Illinoian in age. Thickness 3-20 m

gtk OUTWASH SANDY GRAVEL AND TILL—Reddish-, yellowish-, or grayish-brown clayey to loamy till containing pebble- to boulder-size clasts of chert, limestone, and erratics of igneous and metamorphic rock types; may include deposits of more than one glaciation. Occurs on uplands and in terrace deposits along Kansas River and tributaries in northeast part of quadrangle. Till 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 lacustrine varved silt and fine sand. Thickness commonly 9-16 m; locally as thick as 33 m

tck CLAY LOAM TILL (Cedar Bluffs Till, Nickerson Till, and Atchison Formation in Kansas; correlation with type deposits of Cedar Bluffs and Nickerson Tills in Nebraska uncertain) —Reddish- to yellowish-brown or dark-gray clay loam till; poorly sorted, unstratified, locally jointed. Contains pebble- to boulder-size clasts of limestone, chert, sandstone, shale, and erratics of quartzite, granite, and other igneous and metamorphic rocks. Oldest till tends to be most clayey and to contain the fewest erratics. Locally includes poorly sorted glaciofluvial deposits (Atchison Formation) of sand and silt, lenses of erratic-bearing gravel, and glaciolacustrine medium to fine sand, silt, and clay. A Yarmouth paleosol developed on the till commonly is overlain successively by loesses of Loveland Formation, Peoria Formation, and Bignell Formation and their associated paleosols (**elb**). Unnamed pre-Illinoian loesses are locally present between till and Loveland Loess. Occurs only in northeast part of quadrangle in Kansas. Thickness 3-33 m; locally as thick as 110 m where filling buried valleys in bedrock

PRE-ILLINOIAN AND LATE PLIOCENE

agp SANDY SILT, SAND, AND SANDY CLAY (paleochannel and high terrace alluvium of Republican River)—Unnamed deposits and Belleville Formation

Unnamed deposits—Sandy silt, coarse limonitic sand, an organic paleosol, and mottled reddish-buff sandy clay and clayey sand; contains the Lava Creek B (Pearlette 0) volcanic ash bed (age 0.61 Ma), beneath which the silt contains the middle late Irvingtonian Hall Ash l.f. and the middle Irvingtonian Courtland Canal l.f., here considered separated by a time of glaciation in eastern Nebraska and western Iowa. Thickness as much as 70 m

Belleville Formation—Disconformably underlies previously described unnamed deposits; consists of an upper gravelly sand and a lower silt and clay that interfinger locally. Upper gravelly sand is coarse, arkosic, planar bedded, crossbedded, poorly sorted, and oxidized. Sand contains the late Blancan White Rock l.f., interpreted as recording an early phase of climatic deterioration prior to the oldest glaciation in eastern Nebraska and western Iowa. Formation includes thick beds and lenses of pebble- to cobble-gravel in a sandy matrix. Clasts mostly pink granite; a few of anorthosite from the Laramie Mountains, Wyoming. Becomes finer downward to sandy silt at base. Lower silt and clay unit consists of poorly sorted, massive silty clay and minor sandy silt; contains layers of caliche nodules 2-10 cm in diameter, and, near its base, lenses of laminated fine limestone gravel. Scarce vertebrate fossils suggest a

slightly earlier late Blancan evolutionary stage than the White Rock l.f. Thickness of upper gravelly sand as much as 170 m; of lower silt and clay as much as 125 m

EARLY PLEISTOCENE OR LATE PLIOCENE

agh UPLAND CHERT AND QUARTZITE GRAVEL—Gravel on isolated hilltops and remnants of high terraces below drainage divide of Flint Hills (area of map unit **zri**) and 10-30 m above terrace deposits containing lenses of a Pearlette family volcanic ash not specifically identified. Gravel consists chiefly of pebbles, mostly chert from limestone formations in the Flint Hills; also includes rare polished pebbles of non-Flint Hills chert and quartzite. A single granite pebble suggests possible glacial drainage relationship to west or north. Quartzite pebbles thought to be derived from Cretaceous, Pliocene, or early Pleistocene deposits of central Kansas west of Flint Hills. Thickness is chiefly a veneer

PRE-WISCONSIN PLEISTOCENE AND TERTIARY

zsd SANDY DECOMPOSITION RESIDUUM[3]—Brown to dark-grayish-brown or olive-brown, medium to fine sandy loam, very locally silty clay loam. Grades through a zone of angular fragments into underlying source rock of sandstone or limestone, or chips of shale; source rock is mostly sandstone. Occurs principally on flat to gently sloping uplands; locally covered with thin loess. Mapped only in Oklahoma in southeast part of quadrangle. Mapped areas include some locally derived colluvium and alluvium. Thickness 0.5-2 m

zld CLAYEY SILT TO SILTY CLAY DECOMPOSITION RESIDUUM[3]—Reddish-brown to dark-grayish-brown or dark-gray fine clayey silt to silty clay; locally calcareous. Contains small chips of shale, fragments of limestone and chert, or sandstone; local iron-manganese concretions in Oklahoma. Grades down through fragmented zone into bedrock, mostly shale and limestone, locally minor sandstone. Mapped areas include bedrock exposures on steep slopes, locally derived colluvium, and, on uplands in Kansas, small areas of residual chert clasts. Thickness commonly 0.25-2 m; locally as much as 5 m where developed from shale on gentle slopes in Kansas

zlq FINE SANDY LOAM DECOMPOSITION RESIDUUM[3]—Reddish-brown to brown, fine sandy loam, locally clayey loam; slightly acid to moderately alkaline. Grades down through weathered and fractured rock into bedrock, mostly red, fine-grained sandstone interbedded with minor siltstone, and shale. Commonly thinned by slope erosion and deflation. Mapped areas include rock outcrops, minor local alluvium, and locally extensive colluvium on steep slopes. Thickness less than 3 m

zlr CLAY LOAM AND FINE SANDY LOAM DECOMPOSITION RESIDUUM[3]—Reddish- to dark-brown or brown clay loam and silty to fine sandy loam. Sand mostly quartz and feldspar. Clay loam grades down into soft, red shale. Silty to sandy loam grades down through weathered, fractured rock into red or pink, fine-grained sandstone with interbeds of siltstone. Residuum commonly thinned by slope erosion and deflation. Mapped areas include bedrock outcrops, local alluvium, and locally overlying colluvium (**clr**) on steep slopes. Mapped only in Oklahoma Thickness as much as 3 m

zlt RED CLAY LOAM DECOMPOSITION RESIDUUM[3] WITH LOCAL GYPSUM RUBBLE—Reddish- to dark-brown, brownish-gray clay loam, locally silt loam; grades down through, zone of broken rock into hard shale or minor limestone, dolomite, or siltstone. Contact with limestone and dolomite is abrupt and shows evidence of solution. Sinkholes and areas of partly dissolved gypsum rubble in places. Mantled with thin loess. Mapped areas include unmapped local alluvium and colluvium (**clt**) on steep slopes. Thickness less than 3 m over shale; less than 2 m over limestone

zcj CLAY AND SILTY CLAY DECOMPOSITION RESIDUUM[3]—Grayish- to yellowish-brown or brown clay to silty loam, locally mottled; fine sandy loam in places; grades down into soft shale or fractured fine-grained sandstone or siltstone. Occurs only in Oklahoma in southeastern corner of quadrangle. Mapped areas include bedrock outcrops, minor alluvium, and local colluvium. Colluvium contains as much as 15 percent sandstone and shale fragments less than 25 cm long, and may be as thick as 2 m on lower slopes. Thickness 0.5-1.5m

zri SILTY CLAY DECOMPOSITION RESIDUUM[3] AND CHERTY CLAY SOLUTION RESIDUUM[4]—Reddish- or dark-grayish-brown to light-brown, silty to clayey, locally loamy, slightly acid residuum derived from alternating beds of shale and locally cherty limestone. Grades down through fragmented zone into bedrock. Decomposition residuum commonly contains shale fragments; solution residuum, abundant chert and partly dissolved limestone fragments. In Flint Hills area of Kansas, which is underlain by this unit, divide crests are extensively veneered with angular residual chert in a matrix of

reddish-brown clay 1-2 m thick. On steep slopes, mapped areas include bedrock outcrops and locally derived colluvium. Thickness 0.5-5 m

[1]COLLUVIUM is a general term applied, for purposes of this map, to material transported and deposited by mass-wasting processes.
[2]DISINTEGRATION RESIDUUM, for purposes of this map, is defined as material derived primarily by the in-place mechanical breaking up of rock with no appreciable subsequent lateral transport.
[3]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.
[4]SOLUTION RESIDUUM, for purposes of this map, is defined as material derived by in-place solution of carbonate rock or carbonate-cemented rock, with no appreciable subsequent lateral transport,

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