QUATERNARY GEOLOGIC MAP OF THE PLATTE RIVER 4° X 6° QUADRANGLE, UNITED STATES

State compilations by
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This map was prepared by the U.S. Geological Survey in cooperation with the University of Nebraska conservation and survey division, South Dakota Geological Survey, Iowa Geological Survey, and Minnesota Geological Survey. Digital cartography was by Charles A. Bush, U.S. Geological Survey.

NOTE 1: 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 the parts of States included in the quadrangle were prepared by the State compilers. Secondly, these maps were integrated and locally supplemented by the editor. Map unit symbols were revised to a uniform system of classification; map unit descriptions were prepared by the editor from information received from the State compilers and from additional sources. Diagrams of the drainage evolution of the Platte River were prepared by V.L. Souders, J.B. Swinehart, and V.L. Dreeszen. Index map of loess distribution and thickness was prepared by Ann Coe Christiansen. Other diagrams were prepared by the editor.

Some differences in mapping or interpretation in different areas were resolved by correspondence; most simply reflect differences in available information or in philosophies of mapping and should encourage further investigation.

Surficial deposits have been mapped and described in less than 40 percent of the conterminous United States. Traditionally, mapping of surficial deposits has been focused on glacial, alluvial, eolian, lacustrine, marine, and landslide deposits. Slope and upland deposits have been mapped in detail only in restricted areas. However, 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). These materials commonly differ in their physical characteristics. Therefore, an effort has been made to classify, map, and describe them on the basis of published and unpublished subsoil data and the distribution and characteristics of bedrock parent materials.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. It provides a base from which a variety of maps relating to Quaternary geologic history can be derived. Nebraska includes the largest and most varied deposits of eolian sand in the United States, and an attempt to map their thicknesses and varieties is made. Widespread loess deposits also are mapped. End moraines of glacial deposits are distinguished in the northeastern part of the quadrangle and slope deposits representing different colluvial and disintegration residual deposits are present in the southern and western parts. Both the colluvium and the disintegration residuum 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. Erosional landforms, such as stream terraces, are not distinguished, but alluvial deposits distinguished as map units may be terraced. Differentiation of sequences of alluvial deposits is not possible at this map scale. Individual landslide deposits also are too small to be shown, but areas in which landslide deposits are abundant are mapped.

For practical purposes, this map is a surficial materials map. Materials are distinguished on the basis of lithology or composition, texture or particle size, 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 soils are 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.

NOTE 2: All of the states represented on this map employ extensive test drilling to obtain subsurface data in the loess. In Iowa where loess has been most intensively investigated, major stratigraphic subdivisions separated by intervening paleosols are shown on the map by patterns on the underlying pre-Illinoian till. The patterns are the same as those used in the adjacent Des Moines quadrangle, (Hallberg and others, 1991). Total loess thickness is shown by isopachs; the range in thickness of individual loess units is given in the description of the overlay patterns.

The loess patterns and isopachs in Iowa have been extended northward into Minnesota but are less controlled by drilling records. Loess similar to that in Iowa is present west of the Big Sioux River southeast of the limit of Wisconsin glaciation in South Dakota. However, loess isopach data are not available.

In Nebraska, more than 1,200 test holes provide the basis for determining loess thickness. However only the thickness of late Wisconsin Peoria Loess and overlying Bignell Loess, commonly only 3 m thick have been determined. Older loesses are known both from drilling and outcrops, but occur at different altitudes on a highly irregular underlying relief. Isopachs on the Peoria Loess display a great variation in thickness and intricacy of landform. Peoria Loess is overlapped to the west by Holocene dune sand.

Isopachs for loess in Iowa were compiled from abundant published and unpublished records of test holes and exposures in the files of the Iowa Geological Survey under the direction of G.R. Hallberg. Those for loess in Nebraska were compiled from unpublished maps of the Conservation and Survey Division by Herbert Kollmorgen and E.C. Reed, and on data from Guthrie (1990). Additional data were compiled by J.B. Swinehart, with the assistance of V.H. Dreeszen, J.A. Elder, F.A. Smith, D.A. Eversoll, R.F. Diffendal, and James Goeke.

DESCRIPTION OF MAP SYMBOLS ON PRINTED MAP

CONTACT

WESTERN EXTENT OF BROADWATER FORMATION IN SUBSURFACE

OUTER LIMIT OF GLACIAL ADVANCE OR STILLSTAND—Dashed where inferred; dotted where concealed. Ticks on side of advance

DIRECTION OF ICE MOVEMENT INDICATED BY STRIATIONS; SUCCESSIVE MOVEMENTS BY CROSSED STRIATIONS

OUTWASH CHANNEL

LOESS ISOPACH—In meters

LIMIT OF AREA IN WHICH THICKNESS OF PEORIA LOESS HAS BEEN MEASURED

DEFLATION BASIN

VOLCANIC ASH BED LOCALITY

Lava Creek B (Pearlette O) volcanic ash bed
Mesa Falls (Pearlette S) volcanic ash bed
Huckleberry Ridge (Pearlette B) volcanic ash bed
Pearlette family volcanic ash bed—Not individually identified
Bishop volcanic ash bed

LOCATION OF SIGNIFICANT STRATIGRAPHIC SECTION-May be combined with volcanic ash bed symbol. Described from youngest to oldest

1 Hartford section, S. Dak.—Located about 4 km southeast of Hartford in Minnehaha County. Peoria Loess, 2–7 m; A1 till (Hartington till, equivalent to Kansan till of Bain, 1896, Chamberlin, 1896, and Kay and Apfel, 1929) (normal magnetic polarity), 4.4–8.2 m; "Sappa Formation", 4–5 m; Lava Creek (Pearlette 0) volcanic ash bed (0.61 Ma), 0.3–0.9 m; "Sappa Formation", 0.8–0.9 m; A2 till (equivalent to Cedar Bluffs Till in its type area) (normal magnetic polarity), 5.18–11.27 m; local gravel, 3–3.7 m; silt 1–3.9 m; A3 till (equivalent to Nickerson Till in its type area) (normal magnetic polarity), 3.6–7.9 m. Composite section reinterpreted from Flint (1955), Steece and others (1960), Tipton and Steece (1965), and Boellstorff (1973a)

2 Clark Mills damsite section, Nebr.—Pre-Illinoian till, 6 m; pre-Illinoian outwash sand and gravel, 2.4 m; Huckleberry Ridge(?) volcanic ash bed, 1.0 m; late Pliocene lacustrine silt and clay (reversed magnetic polarity) containing near-glacial-climate late Blancan fauna, 3.6 m; late Pliocene sand, 1.5 m (Voorhies and others, 1989; Pierce, 1990)

3 Winslow Hill section, Nebr.—Modern soil, 1.2 m; Peoria Loess, 6.7 m; Gilman Canyon Formation, paleosol, lower part ^{14}C age 31,400±1,500 B.P. (I–2192), upper part ^{14}C age 23,000±1,600 B.P. (I–2191); Illinoian and (or) Wisconsin deposits include Loveland Formation of Nebraska, reddish-brown silty clay, pre-Illinoian Cedar Bluffs Till (A2 till) (boulder clay), 6.7 m; paleosol; older pre-Illinoian till, >3 m (Dreeszen, 1970; Souders and others, 1971)

4 Fontanelle site, Nebr.—Peoria Loess, 2.4 m; late Pleistocene Gilman Canyon Formation, 0.5 m; Loveland Formation, 2 m; pre-Illinoian Cedar Bluffs Till (A2 till), 2.3–6 m; type Fontanelle paleosol; 0.8 m; type Nickerson Till (A3 till), 3.6 m exposed (Reed and Dreeszen, 1965; Dreeszen, 1965a)

5 Fremont Bluffs section, Nebr. (also known as Gas Pipeline Bridge section)—Wisconsin, Peoria Loess (eolian silt), >12 m; paleosol in Gilman Canyon Formation, 0.3 m; Illinoian and Wisconsin, Loveland Formation (reddish-brown silt and sand), 0.03–2 m; pre-Illinoian, Cedar Bluffs Till, oxidized boulder clay, 0.03–3 m (as thick as 10.6 m several hundred meters east of stratigraphic sec. 5, where zone of carbonate concretions is developed in upper 2.4 m) (type section of Cedar Bluffs Till is in bluff of Platte River 5.2 km to northwest); pre-Illinoian Nickerson Till, unoxidized gray boulder clay, 3.6 m; light-gray to yellowish-gray boulder clay containing secondary carbonate, 11 m (entire sequence contains blocks of sand and gravel, some more than 6 m across, that are inferred to have been frozen at time of incorporation in till); Fontanelle soil, 0.3–0.6 m (Lugn, 1935; Lueninghoener, 1947; Reed and Dreeszen, 1965; Wayne, 1987)

6 Elk Creek Till section, Nebr.—Type section, late Pliocene Elk Creek Till; middle Pleistocene sand of Atchison Formation containing till bodies, 4.5 m; silty clay and silty sand, 2.4 m; silt 19.8 m; Elk Creek Till, clay till commonly containing limestone and shale pebbles (Reed and Dreeszen, 1965; Dreeszen, 1965b; Boellstorff, 1978). Age based on paleomagnetic measurements (Easterbrook and Boellstorff, 1981)

7 Coopers Canyon section, Nebr.—Valley fill of the Elba terrace. The fill and terrace are stratigraphic and geomorphic references for the Holocene of central Nebraska. Holocene deposits include modern soil, 0.5 m; alluvial silt 1.5 m; Turtle Creek paleosol, 0.18 m; alluvial silt and silty sand, 1.3 m; Elba paleosol, 0.3 m; brown silt 0.55 m; Ord paleosol, 0.3 M; alluvial silt, 2 m; Brady paleosol, 0.3 m. Wisconsin deposits include Coopers Canyon gley soil, 0.3 m; alluvial silt with sand at base. Radiocarbon ages (corrected for isotopic fractionation, except for those on molluscs) include Turtle Creek paleosol, 4,670±730 B.P. (Tx–6643); Elba paleosol, 7,040±200 B.P. (Tx–6642); Ord paleosol, 8,300±220 B.P. (Tx–6641); and Brady paleosol, 9,250±110 B.P. (Tx–6656) (Souders and Kuzila, 1990); Coopers Canyon gley paleosol, 10,850±330 B.P. (W–919) and 10,500±250 B.P. (W–752) (Miller and Scott 1961)

8 Naponee site, Nebr.—Loess-mantled terrace fill of middle Wisconsin age includes modern soil, 0.27 m; unnamed Holocene loess, 0.7 m; unnamed paleosol, 0.7 m; Bignell Loess (eolian silt), 3.0 m; Brady paleosol, 0.3 m; Wisconsin Peoria Loess, 9 m; Gilman Canyon Formation, including paleosol, 1.4 m; alluvial sand, 4.3 m (Miller and others, 1964). Radiocarbon ages include unnamed paleosol in Bignell Loess, 1,210±90 B.P. (Beta–33578); charcoal (spruce?) 0.45 m above base of Peoria Loess, 17,880±170 B.P. (Beta–33579); paleosol in upper part

of Gilman Canyon Formation, 19,770± 590 B.P. (Beta–33940); lower part of paleosol in Gilman Canyon Formation, 29,870±1,650 B.P. (Beta–33941) (Souders and Kuzila, 1990)

9 Sappa Formation site, Nebr.—Type section of pre-Illinoian Sappa Formation. Peoria Loess, 6–7.6 m; Gilman Canyon Formation (silt), 0.6–7.9 m; Loveland Formation, eolian silt and clayey silt, 2.4–3.6 m; Illinoian Crete Formation, alluvial sand and gravelly sand, 0.5–1.2 m; early Illinoian Grafton(?) formation or part of Sappa(?) Formation, alluvial silty sand and sandy silt containing gastropods and volcanic ash shards, 5.2–6.0 m; Sappa Formation, alluvial and lacustrine silty sand and clay, 5.2–6.0 m thick, containing Mesa Falls (Pearlette S) volcanic ash bed, 1.2–2.1 m thick in lower part. Age of volcanic ash 1.2 m.y. (Boellstorff, 1973a) and 1.27 m.y. (Izett and others, 1970; Izett and Wilcox, 1982); gravelly sand, 1.2–3.7 m (Reed, 1948; Condra and others, 1950; Reed and Schultz, 1951; Izett and others, 1970; Boellstorff, 1973a; Izett and Wilcox, 1982)

10 Johnson Lake roadcut section, Nebr.—Late to middle Wisconsin Gilman Canyon Formation and Peoria Loess, a complex sequence of eolian deposits overlying alluvial sand. Peoria Loess with modern soil at top, 4.3 m; Gilman Canyon Formation, upper part, bedded sandy silt, 2.1 m, eolian sand, 3.3 m, eolian sandy silt 1 m, humic silt (weak paleosol), 1.2 m; Gilman Canyon Formation, lower part, alluvial sand, >3 m, eolian silt and sand, 3–12 m, with three superposed, discontinuous paleosols. Sequence flat at top but displays primary dip on slopes. Radiocarbon ages of paleosols in Gilman Canyon Formation include basal third of paleosol at top of formation, 24,310±530 B.P. (Beta–23343); upper of three superposed paleosols, 31,210±1,420 B.P. (Beta–25770); middle of three paleosols, 34,800±1,060 B.P. (Beta–23495); lower of three paleosols, 29,400±150 B.P. (Beta–21298) and 29,790±520 B.P. (Beta–25769) (May and Souders, 1988a, b)

11 Buzzards Roost section, Nebr.—Late to middle Pleistocene loesses and paleosols. Type section of Gilman Canyon Formation includes late Wisconsin Peoria Loess, 25 m; middle Wisconsin Gilman Canyon Formation, 1.7 m which includes a lower paleosol, 1.06 m, loess, 0.3 m, and an upper paleosol, 0.3 m; Illinoian loess consisting of the Grafton Loess, Beaver Creek Loess, and loess of Loveland Formation, 18.4 m, including a paleosol at the top of each; pre-Illinoian loess formerly assigned to Sappa Formation but now recognized as post-Sappa in age because of nearby stratigraphic relation to Lava Creek B volcanic ash bed (0.61 Ma), 5.8 m, with a paleosol at its top (Schultz and Tanner, 1959; Schultz and Stout, 1961; Reed and Dreeszen, 1965; Dreeszen, 1970)

12 Bignell Hill section, Nebr.—Type section of Holocene Brady soil and Bignell Loess on high upland. Modern soil, 0.45–0.6 m; Bignell Loess (eolian silt), approx. 2.4 m; Brady soil, 0.45 m; Wisconsin Peoria Loess (eolian unit), >30 m. Radiocarbon age of Brady soil 9,750±300 B.P. (W–1676) (Schultz and Stout 1945, 1948; Reed and Dreeszen, 1965; Dreeszen, 1970)

13 Sand Draw area, Nebr. (includes two type sections)—Type section for Keim Formation of Pliocene (Blancan) age consists of Long Pine Formation, fluvial gravel and sand, 13.7 m; Keim Formation, alluvial sand and silt interlayered with carbonaceous lacustrine silt and clay, 14–28 m. Type section for Long Pine Formation of Pliocene (Blancan) age consists of Long Pine Formation, alluvial sand and gravel, 7.6 m; Keim Formation, alluvial sand and lacustrine clay, 13–19.8 m (Skinner and Hibbard, 1972; Stanley and Wayne, 1972; Swinehart and Diffendal, 1989)

14 Natick section, Nebr.—Late Holocene eolian sand, fine to very fine, large-scale crossbedding, 12.8 m; late Holocene interdune(?) silty sand, 7.6 m; late Holocene medium to coarse, crossbedded fluvial sand, 2 m; middle Holocene fluvial sandy to clayey silt including organic-rich and peaty horizons, 2.1–3 m. Radiocarbon dates from middle Holocene unit, 3,110±80 B.P. (W–4923) 1.6 m below top and 5,040±80 B.P. (DIC–2075) 2.9 m below top (Ahlbrandt and others, 1983)

15 Gudmundsen Ranch test hole 12–5H–88, Nebr.—Test hole located near top and center of barchan dune 52 m high. Stratigraphic units (youngest to oldest) include modern soil, 1 m; early(?) Holocene, brown, oxidized, very fine to fine sand, 1–48 m; late Wisconsin sand containing herbaceous woody fragments, ^{14}C age 13,160±450 B.P. (Beta–27758), 48–48.7 m; late Wisconsin fluvial(?) bluish-gray sand and silt 48.7–5.6 m (Swinehart, 1990)

DESCRIPTION OF MAP UNITS

HOLOCENE AND LATE WISCONSIN

al ALLUVIUM—Reddish- to yellowish-brown, brown, brownish-gray, black, or mottled mixture of clay, silt, sand, and gravel. Calcareous, commonly oxidized. Clasts angular to well rounded. Lithology varies, commonly reflects composition of till or other surficial material and bedrock in drainage basin. Deposit sandy to silty in upper part; becomes increasingly gravelly with depth. Poorly to well sorted, poorly to well stratified. Planar or channel-and-fill cross-bedded. Mapped areas include small alluvial-fan deposits, alluvium in low terrace remnants, and organic clay and silt in sloughs and marshes on flood plains. Mapped mostly in flood plains of the Missouri River and of the White, Niobrara, Keya Paya, and Platte Rivers in South Dakota and Nebraska. Thickness typically 1–9 m, locally more than 20 m

ala ALLUVIAL SILT, CLAY, SAND, AND GRAVEL—Pale-yellow, yellowish-brown, grayish-brown, brown, reddish-brown, or black, loamy, silty to sandy alluvium overlying coarser sand and gravel at depth. Poorly to well sorted, poorly to well stratified, planar to channel-and-fill crossbedded, and locally calcareous; contains local lenses of silt and clay. Deposit mapped only in Nebraska in flood plains of Platte, Loup, and Elkhorn Rivers and their tributaries. Silt and clay derived primarily from loess. Sand is arkosic and derived chiefly from local Pleistocene and Pliocene deposits (**asz**) and from sand dunes (**ed**) of Holocene and late Pleistocene age. Clasts are sparse, mostly well rounded pebble gravel. However, many deposits in flood plain of Platte River are derived from glacial deposits in its headwater areas and include granitic and metamorphic clasts. Mapped areas include small deposits of laterally derived colluvium, sheetwash alluvium, and eolian sand. Thickness 3–30 m

asa ALLUVIAL SAND, SILT, CLAY, AND GRAVEL—Light-brown, gray, or grayish-brown sand, silt, clay, and gravel, intermixed and interbedded. Along Republican River and its tributaries, chiefly arkosic sand with lenses of gravel. Commonly gravel increases in volume with depth. Clasts subrounded to rounded, mostly granitic rock types. Deposit poorly to well sorted, poorly to well bedded; planar to channel crossbedded; locally calcareous. Mapped areas include small deposits of colluvium derived from valley slopes. Thickness 3–20 m, mostly 5–6 m

ed DUNE SAND—Pale-yellow, yellowish- to reddish-brown, brown, brownish-gray, gray, or mottled, fine to medium quartz sand, locally arkosic; well sorted; obscure bedding or crossbedding; generally noncalcareous; grains clear or frosted; moderately to well rounded; locally stained by iron oxide. Typically oxidized to depths greater than 3 m. In places contains buried thin humic zones. Most dunes stabilized and grass covered. Thickness commonly 7 m; may be as thick as 25 m. Dune sand may overlie as much as 100 m of alluvial sand, gravel, silt, and caliche (Broadwater Formation (**asz**)) of early Pleistocene and Pliocene age. Dune types, mapped only in Nebraska, include linear, barchan, barchanoid-ridge, parabolic, and domelike dunes, most are Holocene in age but oldest deposits may be late Pleistocene

edl Linear dunes—Symmetrical ridges average 1.5 km in length, 5 m in width, and 15 m in height

edb Compound and complex barchan dunes—Crescentic dunes average 900 m in length, 1,200 m in width, and 45 m in height

edr Compound and complex barchanoid ridge dunes—Row of connected crescentic dunes; generally range from 3 to 8 km in length and average 50 m in height

edp Parabolic dunes—U-shaped in plan view; average about 400 m in length and 20 m in height

edd Domelike dunes—Compound and complex dunes with no apparent slip faces; probably originally barchan dunes modified by later winds of different force or direction. Average 25 m in height, 1 km in length

es EOLIAN SHEET SAND—Similar to unit **ed**, but occurs chiefly as a blanketlike deposit. Includes some low dunes. Thickness 1–3 m

el LOESS (Peoria Loess in Nebraska; "Wisconsin" loess in Iowa, Minnesota, and southeastern South Dakota. Included in unit **elb** elsewhere)—Pale-yellow, yellowish-brown, brownish-gray, gray, or mottled silt and silt loam; locally very fine sandy loam. Calcareous; generally oxidized throughout. Silt and sand grains chiefly quartz. Nonstratified to very faintly bedded; well sorted but, in places, includes scattered granules or pebbles. Generally massive, blocky, friable. weakly compact; stands in vertical exposures; columnar jointing where dry. Occurs as mantle over older deposits, including older loesses. Basal part commonly mixed with uppermost part of those deposits. Modified by creep or solifluction in places. Thickness 1 to >20 m

Peoria Loess in Nebraska and southeastern South Dakota; "Wisconsin" and older loess in Iowa

"Wisconsin" loess 6 to >20 m thick over Sangamon or late Sangamon paleosol developed in Loveland Loess over Yarmouth paleosol developed in pre-Illinoian clay loam till (**tck**)

“Wisconsin” loess 6 to 10 m thick over Yarmouth-Sangamon paleosol developed in pre-Illinoian clay loam till (**tck**)

"Wisconsin" loess 2 to 6 m thick over extensive erosion surface cut on pre-Illinoian till (**tck**). Intervening paleosol locally present

jca LANDSLIDE DEPOSITS, CLAYEY DISINTEGRATION RESIDUUM[1], AND SHEETWASH ALLUVIUM[2]—Characterized by abundant landslide deposits consisting of slump blocks of shale and earthflow deposits of heterogenous mixtures of clay,silt, sand, and scattered clasts. Mapped areas also include deposits of clayey disintegration residuum and sheetwash alluvium (**xce**). Landslide deposits commonly retain original bedding, but have rotated and slid downslope below steep escarpment heads as much as 45 m long; commonly 5–10 m wide and 30 m long; typically mantled with unmapped thin loess. Thickness of landslide deposits generally 1–20 m; thickness of disintegration residuum generally less than 1 m; thickness of sheetwash alluvium generally 0.5–2 m, locally more than 4 m

jcb LANDSLIDE DEPOSITS, CLAYEY DISINTEGRATION RESIDUUM[1], SHEETWASH ALLUVIUM[2], AND GLACIAL DEPOSITS—Complex unit similar to unit **jca**; distinguished by presence of discontinuous till of late Wisconsin age (**tlx**),generally less than 2 m thick, and glacial erratics. Mapped along Missouri River, mostly in South Dakota

wlb LOAMY TO CLAYEY SHEETWASH ALLUVIUM[2] AND ASSOCIATED BADLAND TERRAIN—Pale-yellow, yellowish-brown, olive-brown, brownish-gray, or mottled alluvium. Typically either (1) clay, silty clay, silty clay loam, and clay loam, (2) clay loam, silt, silt loam, and sandy loam, or (3) sand and silty sand. Generally calcareous and alkaline; saline in many areas. Disseminated organic matter abundant in many areas; local buried soils (humic horizons). Includes scattered granules and small pebbles, or stringers, pods, and lenses of granule or pebble gravel. Nonstratified to moderately well stratified; poorly to moderately well sorted. Massive, thinly laminated, or with weak horizontal bedding. Commonly interbedded with well-sorted, pebbly, coarse silt and very fine sand. Forms aprons extending from abrupt base of steep badland slopes. Thickness 0.5–8 m

xla LOAMY DISINTEGRATION RESIDUUM[1] AND SHEETWASH ALLUVIUM[2]—Yellowish to olive-brown or brownish-gray clay loam to silty loam clay; locally silty clay or clay. Weakly to highly calcareous; mildly to strongly alkaline. Clasts dominantly angular or subangular, soft shale, platy shale, siltstone, sandstone, or limestone. Includes bedrock outcrops and locally a mantle of loess (**elb**). Mapped only in South Dakota in northwest corner of quadrangle

Disintegration residuum—Nonstratified; nonsorted; massive or with faint relict stratification. Loosely consolidated or compact. Grades down through zone of rock fragments in lower part into bedrock. Thickness commonly less than 1 m

Sheetwash alluvium—Nonstratified to moderately well stratified; poorly to moderately well sorted. Calcareous, alkaline, locally saline. Thickness commonly 0.5–2 m

xlt SILTY CLAY DISINTEGRATION RESIDUUM[1] AND SHEETWASH ALLUVIUM[2]—Yellowish- to olive-brown, grayish-brown, or gray silty clay loam. Sand fraction very fine. Locally includes clasts of calcrete, carbonate-cemented sandstone and, in places, fine gravel. Weakly to highly calcareous; mildly to strongly alkaline. Mapped only in northwestern part of quadrangle in South Dakota. Mapped areas include some bedrock outcrops on ridge crests and steep slopes. Upland locally mantled with loess (**elb**)

Disintegration residuum—Nonstratified; nonsorted, massive; loosely consolidated. Grades down through zone of rock fragments in lower part into bedrock. Thickness commonly less than 1 m

Sheetwash alluvium—Nonstratified to weakly stratified; poorly to moderately well sorted. Thickness commonly about 0.52 m

xce CLAYEY DISINTEGRATION RESIDUUM[1] AND SHEETWASH ALLUVIUM[2]—Yellowish- to olive-brown or grayish-brown silty clay, clay loam, or loam. Slightly to highly calcareous; mildly to strongly alkaline. Selenite crystals, ironstone concretions, and redeposited pyrite, marcasite, or siderite crystals common. Hard and blocky where dry or plastic, sticky and slippery where damp. Clasts dominantly angular or subangular fragments of micaceous and bentonitic shale or soft clayey shale; local fragments of siltstone or sandstone. Locally includes bedrock outcrops, loess (**elb**), and areas of shale "breaks" in highly dissected terrain. Commonly mantled with eolian silt on uplands. Mapped in northwest quarter of quadrangle

Disintegration residuum—Nonstratified; nonsorted; massive; loosely consolidated or compact. Iron oxide stains common. Shale fragments common to abundant, particularly in lower part and grades down through thin layer of platy shale fragments into bedrock. In many areas, overlain by thin or discontinuous loess (**elb**). Thickness commonly less than 1 m

Sheetwash alluvium—Similar to that in unit **xla**. Thickness commonly 1–2 m, locally more than 6 m

xcf CLAYEY DISINTEGRATION RESIDUUM[1], SHEETWASH ALLUVIUM[2], AND GLACIAL DEPOSITS—Complex map unit similar to unit **xce**; distinguished by presence of discontinuous till of late Wisconsin age (**tlx**), generally less than 2 m thick, and glacial erratics. Mapped only on upland slopes above White River near its confluence with Missouri River in South Dakota

HOLOCENE TO ILLINOIAN

cga CALCRETE- AND GRANITIC-CLAST LOAMY TO GRAVELLY COLLUVIUM[3]—Reddish- to yellowish-brown, brown, or gray mixture of gravel, sand, silt, and clay. Clasts mostly pebble size; chiefly granitic and dark metamorphic rock types, and fragments of calcrete; in headwater areas some clasts are shale, chalk, and limestone. Sand is arkosic. Mapped areas include bedrock outcrops and small areas of locally derived alluvium. Thickness commonly less than 1 m, locally 2–4 m at base of slopes

csl SANDSTONE-CLAST FINE SANDY COLLUVIUM[3]—Reddish-brown to pink, pale-orange-brown, or pale-gray mixture of gravel, fine sand, and silty sand, locally clayey. Clasts angular, pebble- to cobble-size blocks of weakly to well-cemented sandstone derived from volcaniclastic Arikaree Group and locally from arkosic White River Group. Sand is chiefly quartz. Deposit mantles valley walls, commonly beneath cliffs or ledges. Overlain locally by dune sand. Mapped only in west-central Nebraska in headwaters of North Loup River. Thickness 1–3 m at base of slopes

csg SANDSTONE- AND SHALE-CLAST LOAMY COLLUVIUM[3]—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. Abrupt contact with underlying rock. Locally mantled with thin loess. Mapped areas include bedrock outcrops and local alluvium. In places, preserved on gently sloping uplands, but commonly has been 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[3]—Reddish- to dark-brown or brownish-gray silt loam to clay loam containing scattered subangular to angular fragments of shale, limestone, and chert. Included in glaciated area in southeast corner of quadrangle are clasts of igneous and metamorphic rocks derived from till. Abrupt contact with underlying bedrock. Commonly mantled with thin loess. Mapped areas include small deposits of till (**tck**), locally derived 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 COLLUVIUM[3]—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 and 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 0.55 m; thickness of residuum 1 m (over chalk) to less than 3 m (over shale)

cls CHERT-CLAST CLAYEY SILT TO SILTY CLAY LOAM COLLUVIUM[3]—Reddish-, dark-, and grayish-brown or gray fine sandy silt, silty clay, or clay; contains abundant angular fragments of chert and sparse limestone, sandstone, and shale. Derived from older disintegration residuum or bedrock upslope. Also contains erratics of igneous and metamorphic rocks derived from till (**tck**) upslope. Mapped only in southeasternmost part of quadrangle where till is deeply dissected by steep slopes. Mapped areas include minor local alluvium and bedrock outcrops. Thickness 0.25–2 m

clu CALCRETE- AND FINE SANDSTONE-CLAST SILTY CLAY COLLUVIUM[3]—Yellowish-brown to pale brownish-gray or light-olive-gray, fine sandy silt loam to clay loam. Includes chips and slabs of calcrete, fine-grained sandstone, and pebble conglomerate cemented with calcium carbonate, and locally with chalcedony or opaline silica. Pebbles chiefly of Precambrian igneous and metamorphic rocks, but include some of porphyry derived from the Black Hills of South Dakota. When wet becomes dark gray and slippery but not expansive. Mapped only in Nebraska in headwaters of Keya Paya River in northwestern part of quadrangle. Thickness 0.5–2 m

elb LOESS (Bignell Loess, Peoria Loess, Gilman Canyon Formation, Loveland Formation, Beaver Creek Loess, and Grafton Loess in Nebraska; "Wisconsin" loess and Loveland Loess in Iowa, unnamed loess equivalent to Bignell, Peoria, and Loveland Loess in South Dakota)—Pale-yellow, yellowish-brown, reddish-brown, brown, brownish-gray, gray or mottled windblown silt, silt loam, and fine sandy silt loam. Calcareous; local white or pale-gray filaments, powdery interstitial fillings, or nodules of secondary calcium carbonate. Generally oxidized. Silt and sand grains dominantly quartz. Typically nonstratified, massive, well sorted; faintly bedded locally; contains scattered granules and pebbles in places. Unconsolidated or weakly compact; exposures stand in vertical faces. Columnar joints common. Friable; block structure. Preserved chiefly on uplands. Underlies dune sand (**ed**) in central Nebraska. Brady soil locally present in uppermost part of Peoria Loess. Gilman Canyon Formation very locally present; consists of dark-gray to grayish brown, humic silt. Sangamon soil locally preserved in uppermost part of Loveland Formation. Molluscan fauna common in Peoria Loess and "Wisconsin" loess, sparse in Loveland Formation. Mapped areas include intercalated deposits of sheetwash, colluvium, creep, solifluction, and other masswasting deposits, mostly derived from loess but also from other deposits. Mapped areas also include small deposits of locally derived alluvium, landslide deposits, and bedrock outcrops. In southern part of quadrangle in Nebraska and in northwestern part of quadrangle in South Dakota mapped as unit **elb**, but in northeastern part of quadrangle in Iowa, shown by overprint pattern. Bignell Loess commonly 2–3 m thick; Peoria Loess and "Wisconsin" loess about 3–5 m thick, locally as much as 25 m; Gilman Canyon Formation commonly 1–5 m thick; Loveland Formation 5–13 m thick; Beaver Creek Loess 1–3 m thick; Grafton Loess 2–16 m thick. Total thickness in quadrangle 5–30 m

WISCONSIN

lca LAKE SILT AND CLAY—Pale-yellow, yellowish- to olive-brown, brownish- to bluish-gray, or mottled, calcareous silt and clay. Includes thin lenses or stringers of sand or fine gravel. Clay is hard where dry, sticky and plastic where wet. Clay minerals dominantly illite and smectite. Well bedded to massive; commonly laminated, locally varved; penecontemporaneously folded or contorted in some areas. Commonly clast free but locally contains some ice-rafted pebbles and cobbles. Present only in northeast part of quadrangle in Minnesota. Overlain by less than 2 m of eolian sand and loess. Thickness 2–10 m

nld LOAMY SOLIFLUCTION DEPOSIT—Yellowish-brown to brownish-gray, gray, or mottled sandy loam, silt loam, or clay loam. Generally calcareous. Faintly stratified to non-stratified, poorly sorted to nonsorted. Contains scattered granules and pebbles, locally cobbles and boulders. In places massive; includes few or no rock fragments. Mostly reworked till (**tlx**); includes areas of unmapped till. Mapped only northeast of Yankton, S. Dakota. Thickness 2–6 m

gs OUTWASH SAND—Pale- to dark-brown, brownish-red, yellowish- to grayish-brown, or gray fine to coarse sand or silty sand containing scattered pebbles and small cobbles, and local lenses or thin beds of silt. Poorly to well sorted; poorly to well stratified; bedding chiefly planar, but channel-and-fill structures common. Pebbles and cobbles mostly smaller than 32 mm in diameter; some cobbles as large as 20 cm in diameter; clasts rounded to subangular, locally platy. Limestone or dolomite comprise as much as 50 percent of clasts; granitic rocks and gabbro as much as 20 percent each; shale locally abundant. Coarse crystalline rocks commonly crumble easily. Deposit leached 0.5–1 m; secondary carbonate, chiefly derived from overlying loess, forms concretions at depth and locally cements deposit. Iron oxide and manganese oxide form streaks along bedding planes, coatings on gravel, and locally cement deposit. Underlies terraces, valley trains, and outwash plains whose surfaces are typically flat to undulating, locally pitted with ice-block depressions. In places, covered by less than 2 m of unmapped loess (**el**) or eolian sand (**es**). Mapped areas commonly include small deposits of alluvium and colluvium. Thickness commonly 4–8 m, locally as much as 20 m

gg OUTWASH SAND AND GRAVEL—Pale-yellow, yellowish-, reddish-, or olive-brown, brownish-gray, gray, black, or mottled pebble to cobble gravel in fine to coarse silty sand matrix. Commonly intercalated with sand and silt, locally with silt and clay. Poorly to weakly stratified; poorly to well sorted. Bedding chiefly planar, but channel-and-fill cross-bedding common within beds. Commonly stained and locally cemented by secondary calcium carbonate or iron oxide. Cobbles and boulders common to abundant near end moraines. Clasts subangular to rounded; as much as 50 percent are limestone or dolomite; 20 percent are granitic rock types; a few are of gabbro, dolomite, basalt, slate, and ironstone, derived from the northeast in Minnesota, and a few are locally derived sandstone, siltstone, claystone, and chert. Clasts of locally derived quartzite are present in northeast part of quadrangle. Deposit occurs in terrace remnants, valley trains, and meltwater-channel fills whose surfaces are typically flat to undulating. Commonly overlain by less than 2 m of eolian sheet sand (**es**) or loess (**el**). Thickness commonly 4–8 m, locally as much as 20 m

kg ICE-CONTACT SAND AND GRAVEL—Pale-yellow, yellowish-, reddish-, olive-, or grayish-brown, olive-gray, brownish-gray, gray, black, or mottled calcareous sand and gravel including minor silt. Textures vary laterally and vertically. Locally boulder or cobble gravel. Commonly interbedded with or contain lenses or masses of clay, silt, till, or flowtill. Poorly to well stratified; irregularly bedded to well bedded. Poorly to well sorted. Faults, folds, and slump or collapse structures common. Locally cemented by calcium carbonate or stained with iron oxide. Clasts subangular to well rounded. Pebbles, cobbles, and boulders dominantly erratic limestone, dolomite, and igneous and metamorphic rocks; minor sandstone, siltstone, claystone, shale, lignite, ironstone, and chert. Shale locally very abundant. Cobbles and boulders common on surface. Surface typically hummocky and locally pitted with ice-block depressions. Mapped areas include small deposits of locally derived alluvium and colluvium. Overlain in places by less than 2 m of eolian sheet sand (**es**) or loess (**el**). Mapped only in South Dakota, in north-central part of quadrangle, where it forms a large, long, sinuous, eskerlike deposit. Thickness 3–20 m

LOAMY TILL—Pale-yellow, yellowish-orange, yellowish-, reddish-, olive-, or grayish-brown, olive- or bluish-gray, bluish or olive-black, or mottled calcareous clay loam and loam; in some areas silty or sandy clay loam. Locally very gravelly; matrix consists of nearly pure sand, silt, or clay. Nonstratified; nonsorted or very poorly sorted. Compact; commonly massive; cohesive to friable; soft and sticky where damp, hard and blocky where dry. Clay minerals dominantly montmorillonite. Joints weakly developed, locally coated with calcium carbonate or iron oxide. In places, selenite crystals, less than 0.3 cm long, are oriented parallel to joint surfaces. Small secondary calcium carbonate nodules locally present in upper part of deposit. Ranges from very pebbly to nearly pebble free; cobbles and boulders rare to abundant. Pebbles chiefly subangular to rounded erratic limestone, dolomite, and granite in regions of thick till; angular to subrounded shale, siltstone, sandstone, and lignite in regions of thin till. Cobbles and boulders chiefly subangular to well-rounded erratic granite, limestone, and dolomite. Some large boulders of chalk in Vermillion River area. Locally derived clasts of quartzite in northeast part of quadrangle. Mapped areas include landslide deposits, sheetwash alluvium, and local alluvium; outwash and ice-contact sand and gravel (**gg**, **kg**), and organic sediments in depressions, sloughs, and marshy areas. Locally covered by less than 2 m of eolian sheet sand (**es**) or loess (**el**)

tlx Ground moraine—Thickness generally 1–15 m, locally 30 m

tlx End moraine—Broad hummocky ridges or narrow sharply defined ridges, commonly with undrained depressions and lag cobbles and boulders on surface. Thickness commonly 6–40 m, locally 60 m

tlx Stagnation moraine—Broad areas of hummocky collapsed topography without distinct morainal ridges. Locally merges with gravelly kame-moraine deposits. Lakes, ponds, and marsh-filled depressions and sloughs common. Thickness commonly 6–30 m, locally 60 m

tla LOAMY TILL (Tazewell Till in Iowa)—Yellowish- or olive-brown, olive-, brownish-, or bluish-gray, gray, or mottled, very calcareous loam and clay loam; locally sandy loam. Pebbly to very pebbly; local lenses, pods, and stringers of sand and gravel. Surface concentrations of cobbles and boulders common. Matrix is nonstratified; nonsorted to poorly sorted; compact and firm;

commonly blocky, fissile. High content of expandable clay minerals (smectite); illite more abundant than kaolinite. Typically oxidized along joint surfaces and locally throughout but less intensely oxidized than unit **tll**, Pebbles chiefly subangular to well-rounded erratic limestone, dolomite, and igneous and metamorphic rocks; minor shale, sandstone, and ironstone. Boulders chiefly subangular to subrounded limestone, dolomite, and granite. Surface considerably dissected and lacks significant constructional topography. Till generally thin. Small unmapped outcrops of an underlying older till (**tll**) are exposed in some areas. Wood from base of till in South Dakota yielded ^{14}C ages of 22,900±1,000 B.P. (GX–3439) and 26,150+3,000 to -2,000 B.P. (GX–2864) (Beissel and Gilbertson, 1987; Lehr and Gilbertson, 1988). Locally overlain by less than 2 m of loess (**el**). Mapped areas include small deposits of alluvium (**al**) and colluvium. Thickness generally 2–5 m, locally 18 m

agt SAND AND GRAVEL OF WHITE AND LITTLE WHITE RIVER TERRACES—Pale- or yellowish- to grayish-brown, pale red, or gray, poorly to well-sorted, channel-and-fill crossbedded gravel, sand, silt, and clay. Sand chiefly quartz and feldspar; silt and clay minor. Clasts angular to rounded, composed of sandstone, siltstone, claystone, limestone, quartz, chalcedony, limonite, flint, chert, and feldspar, also schist, granitic rocks, and pegmatitic rocks of foreign derivation. Deposit underlies terraces, probably ice-contact in origin, 18–26 m, 61 m, 66–96 m, 91–123 m, 165–168 m above stream level. A few erratics present locally in glacially distorted, varved lacustrine deposits in drainage of White River. Terrace surfaces commonly mantled with eolian sand, loess, or colluvium. Mapped areas include some bedrock exposures. Thickness 1–16 m, commonly about 7 m

agv SAND AND GRAVEL OF NIOBRARA RIVER TERRACES—Pale-yellow to yellowish-brown or gray, poorly to well-sorted, poorly to well-stratified, channel-and-fill crossbedded sand and gravel. Abundant calcareous, medium to fine sand. Clasts angular to well rounded, chiefly of local derivation; composed of sandstone, siltstone, limestone, chert, shale, chalcedony, and tuffaceous sandstone. Locally covered with eolian sand or colluvium. Similar deposits, too small to show at scale of map, are locally present along Loup and Keya Paya Rivers and their major tributaries. Thickness 3–12 m

asg SAND AND GRAVEL OF REPUBLICAN RIVER TRIBUTARY TERRACES—Light-brown, gray, grayish-brown or pinkish-brown sand, silt, and pebble gravel, chiefly derived from underlying Broadwater Formation (**asz**). Clasts mostly well rounded Precambrian igneous and metamorphic rock types, but includes sparse well-rounded pebbles of anorthosite from the Laramie Range and pale-gray quartzite from the Medicine Bow Range, both in Wyoming. Sand is arkosic and commonly silty. Channel-and-fill crossbeds in places. Locally covered with thick loess. Thickness 3–8 m

asv GRAVELLY SAND OF PLATTE, NORTH PLATTE, AND SOUTH PLATTE RIVER TERRACES—Pale- or pale-yellowish- to grayish-brown, or gray, poorly sorted to well-sorted, planar bedded and channel-and-fill crossbedded, fine to coarse sand and pebble gravel. Sand is arkosic, chiefly quartz and feldspar, in large part derived from Broadwater Formation (**asz**); pebbles chiefly pink to gray granite, gneiss, and biotite and hornblende schist. A few are anorthosite from Laramie Mountains, and a few are pale-gray quartzite from Medicine Bow Mountains to west. Pebbles of limestone, shale, sandstone, chert, and calcrete are locally derived. Coarser and increasingly gravelly downward. Many pebbles reworked from Ogallala Formation and older Cretaceous rocks. Deposits mantled with eolian dune sand (**ed**) or loess (**elb**). Thickness 5–30 m

ILLINOIAN

lci LAKE SILT AND CLAY—Reddish-brown, brownish-gray to gray, or light-olive silt loam and clay; plastic, smectitic. Includes local fine sand laminae and a few scattered ice-rafted pebbles. Grades shoreward into poorly sorted to well-sorted, stratified fine sand. Commonly overlain by 0.5–1 m of loess. Thickness 1–5 m

tll LOAMY TILL—Pale-yellow, yellowish- or olive-brown, brownish- or bluish-gray, gray, or mottled silt loam and loam. Clay minerals chiefly expandable (smectite). In places contains lenses, pods, and stringers of stratified silt, sand, and gravel. Commonly calcareous; locally leached to depth of more than 1 m where not covered by loess. Intensely oxidized throughout in most exposures. Nonstratified; nonsorted to very poorly sorted. Generally compact; locally friable or crumbly.

Where compact, till is weakly to strongly jointed. Joints coated with iron or magnesium oxide and filled with calcium carbonate. Pebble surfaces coated with calcium carbonate in some areas. Scattered pebbles, cobbles, and boulders. Pebbles mostly subangular to rounded limestone and dolomite less than 1 cm in diameter; remainder are of granite, gneiss, schist, diorite, basalt, quartzite, slate, sandstone, shale, ironstone, and chert. Cobbles and boulders mostly subrounded limestone, dolomite, and granite. Relief is smooth and gently undulating, but markedly more dissected than units **tla** and **tlx.** Includes subdued, eroded remnants of end moraines. Locally, pre-Illinoian clay loam till (**tck**) is exposed beneath the surface till. Mapped areas include small unmapped deposits of Holocene and (or) late Wisconsin alluvium (**al**), sheetwash alluvium, and outwash and ice-contact sand and gravel (**gg**, **kg**). Commonly covered by loess (**el**) 0.5–1 m thick. Although inferred to be early Wisconsin or Illinoian in age in the adjacent Des Moines quadrangle (Hallberg and others, 1991), currently is interpreted to be Illinoian in age (Lehr and Gilbertson, 1988). Thickness commonly 2–12 m, locally more than 30 m

ILLINOIAN AND PRE-ILLINOIAN

ast ALLUVIAL GRAVELLY SAND AND LOCALLY UNDERLYING LACUSTRINE SAND—Yellowish- to reddish-brown, pale- to dark-gray, coarse to fine, calcareous arkosic alluvial gravelly sand with interbeds of silt. South of the Platte River, is an alluvial-fan deposit of probable Illinoian age derived from drainage of the Platte River. The sand is unusually arkosic, and the gravel includes a high proportion of granite, metamorphic rocks, and anorthosite from the Laramie Range, and a few clasts of white quartzite from the Snowy Range, both in Wyoming. East of the pre-Illinoian glacial limit, underlain by pre-Illinoian clay loam till (**tck**). West of the glacial limit, underlain by very locally exposed laminated to massive lacustrine sand, silt, and minor clay deposited in a lake dammed by the pre-Illinoian till and possibly also by ice at the pre-Illinoian moraine limit. Thickness of the alluvial gravelly sand 4–6 m; thickness of underlying pre-Illinoian lacustrine sand commonly 5–20 m, greater at Illinoian glacial limit.

North of the Platte River, unmapped alluvial-fan deposits of sand containing pebbles and cobbles of angular to well-rounded clasts of limestone, chert, sandstone, and shale are present in drainages from the northwest. The preservation of their morphology suggests an Illinoian age. Eastward, along the pre-Illinoian drift limit, mapped deposits include clasts of red quartzite and igneous and metamorphic rocks derived from glaciated sources to the northeast in Minnesota. Thickness 5–30 m

alo ALLUVIAL SAND AND GRAVEL—Reddish- to yellowish-brown, yellowish- to brownish-gray, or gray, sand and granule or pebble gravel and minor silt and clay. Commonly calcareous. Poorly to well stratified; poorly to well sorted. Crossbedded, horizontal, or lenticular bedded. Loose to weakly compacted. Deposit mostly derived from present drainage basin; igneous and metamorphic rocks from Black Hills region to west rare or absent. Clasts angular to well-rounded granules, pebbles, cobbles, and small boulders; chiefly ironstone and limestone concretions, chert, chalcedony, and vein quartz; minor orthoquartzite, sandstone, siltstone, and shale. Occurs in upland terrace remnants in northwest corner of quadrangle. Mapped areas include local unmapped deposits of flood-plain alluvium, sheetwash alluvium, disintegration residuum, and landslide deposits. Commonly overlain by eolian sand or loess (**es**, **ed**, **elb**) 0.2–5 m thick. Thickness 2–9 m

PRE-ILLINOIAN

tck CLAY LOAM TILL (Cedar Bluffs Till)—Reddish- to yellowish-brown, olive- to dark-gray clay-loam till; poorly sorted, unstratified, locally jointed. Joints commonly filled with calcium carbonate; joint surfaces commonly oxidized. Contains pebble- to boulder-size clasts of limestone, chert, sandstone, shale, and erratics of red quartzite, granite, and other igneous and metamorphic rocks derived from glaciated sources to the north. Locally includes lenses of poorly sorted glaciofluvial deposits. The till overlies, and its associated outwash interfingers with, glaciolacustrine deposits (lower part of unit **ast**) in lower valley of Platte River. It also overlies older Pleistocene deposits (stratigraphic sec. 5) on south side of Platte River opposite town of Fremont Bluffs (misspelled Freemont Bluffs on base map), Nebr. In places, till is overlain by alluvial gravelly sand of probable Illinoian age which extends eastward and southward through saddles in the pre-Illinoian moraine. A Yarmouth paleosol developed on the till commonly is overlain by loess (**elb**). Thickness 3–33 m; locally as much as 110 m where filling buried valleys in bedrock

PRE-ILLINOIAN AND LATE PLIOCENE

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

Unnamed deposits—Include sandy silt, coarse limonitic sand, an organic paleosol, and mottled reddish-buff sandy clay and clayey sand; contains Lava Creek B (Pearlette 0) volcanic ash bed (age 0.61 Ma). Thickness as much as 70 m

Belleville Formation—Disconformably underlies the 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. Includes thick beds and lenses of pebble- to cobble-gravel in a sandy matrix. Clasts mostly pink granite, but some are anorthosite derived from Laramie Mountains to southwest in Wyoming. Lower silt and clay consists of massive, silty clay, minor sandy silt, and a few pebble-gravel lenses. Thickness upper gravelly sand 170 m; lower silt and clay as much as 125 m

EARLY PLEISTOCENE AND PLIOCENE

asz ALLUVIAL SAND, PEBBLE GRAVEL, AND LACUSTRINE SAND AND SILT (Broadwater Formation and locally differentiated Keim, Long Pine, Duffy, and Pettijohn Formations in Nebraska)—Pale-pinkish-orange to pale-brown, sandy gravel, sand, and silty sand interlensing and interbedded. Gravel well bedded to poorly bedded, channel-and-fill crossbedded. Pebbles commonly well rounded to subangular. Most are granite or anorthosite from Laramie Range, Wyo., but some are pale-gray quartzite from the Medicine Bow Mountains, Wyo.; a few are chert and quartz. Sand is arkosic, mostly poorly sorted, locally silty, massive to planar bedded. Silt and clay not abundant to west, but increase in abundance eastward. Local reworked pebble gravel at base. Broadwater Formation is mostly late Pliocene in age but in part early Pleistocene. The Keim, Long Pine, Duffy and Pettijohn Formations contain a late Blancan fauna and are older than 1.65 Ma, the age of the Pliocene-Pleistocene boundary; they therefore are late Pliocene in age. Mapped area includes some unmapped Illinoian and younger alluvial-fan deposits derived from drainages to the northwest (see postulated evolution of Platte River and related drainages, sketch map 3). Mostly covered with thick loess (**elb**) and eolian sand. Thickness 60–110 m

agw ALLUVIAL GRAVELLY SAND (Herrick Formation in South Dakota)—Pale-yellow, light-yellowish-brown, light-brownish-gray, or pale-gray very coarse to medium arkosic sand including thin, discontinuous lenses and layers of well-rounded pebbles of granite, quartz, gneiss, schist and petrified wood. Individual lenses are channel crossbedded, layers commonly planar bedded. Deposit well sorted in thin beds. Cobbles of greenish-gray siliceous arkose scattered throughout upper part of deposit. Vertebrate fauna indicate that most of deposit is late Blancan (late Pliocene) in age. However, presence of *Rangifer* in one deposit suggests that uppermost part locally may be Irvingtonian (early Pleistocene) in age (Green and Lillegraven, 1966). Deposit mantles an upland surface cut on Miocene rocks. Thickness commonly 11–12 m, locally as much as 16 m

PLIOCENE

agx ALLUVIAL GRAVEL AND SAND (Medicine Root Gravel in South Dakota)—Yellowish- to reddish-brown or brownish-gray to gray cobble to pebble gravel and some boulders in a silty, locally clayey, coarse to fine, angular to rounded sand matrix. Poorly to moderately bedded, poorly sorted, locally cemented with calcium carbonate, locally oxidized. Clasts well rounded to angular, composed of Precambrian metamorphic and granitic rocks, pegmatite, quartzite, quartz sandstone, limestone, chert, quartz porphyry, and rhyolite, mostly derived from Black Hills to west. In places, includes abundant fossils, many reworked from older Tertiary and Cretaceous formations. Inferred Pliocene-Pleistocene age (Harksen, 1966). Caps highest tableland in northwest part of quadrangle. Overlain by Red Dog Loess that locally rests on and in places also underlies channel gravel containing a volcanic ash bed (Harksen, 1968) identified as the Lava Creek B volcanic ash, age 610 ka (Izett and Wilcox, 1982). Maximum thickness 16 m

PLIOCENE AND OLDER

R BEDROCK

[1]DISINTEGRATION RESIDUUM, for purposes of this map, is defined as material derived primarily by the inplace mechanical breaking up of rock without appreciable lateral transport.

[2]SHEETWASH ALLUVIUM, for purposes of this map, is a general term for material transported and deposited by unconfined running water, chiefly sheetflow and rillwash.

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

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