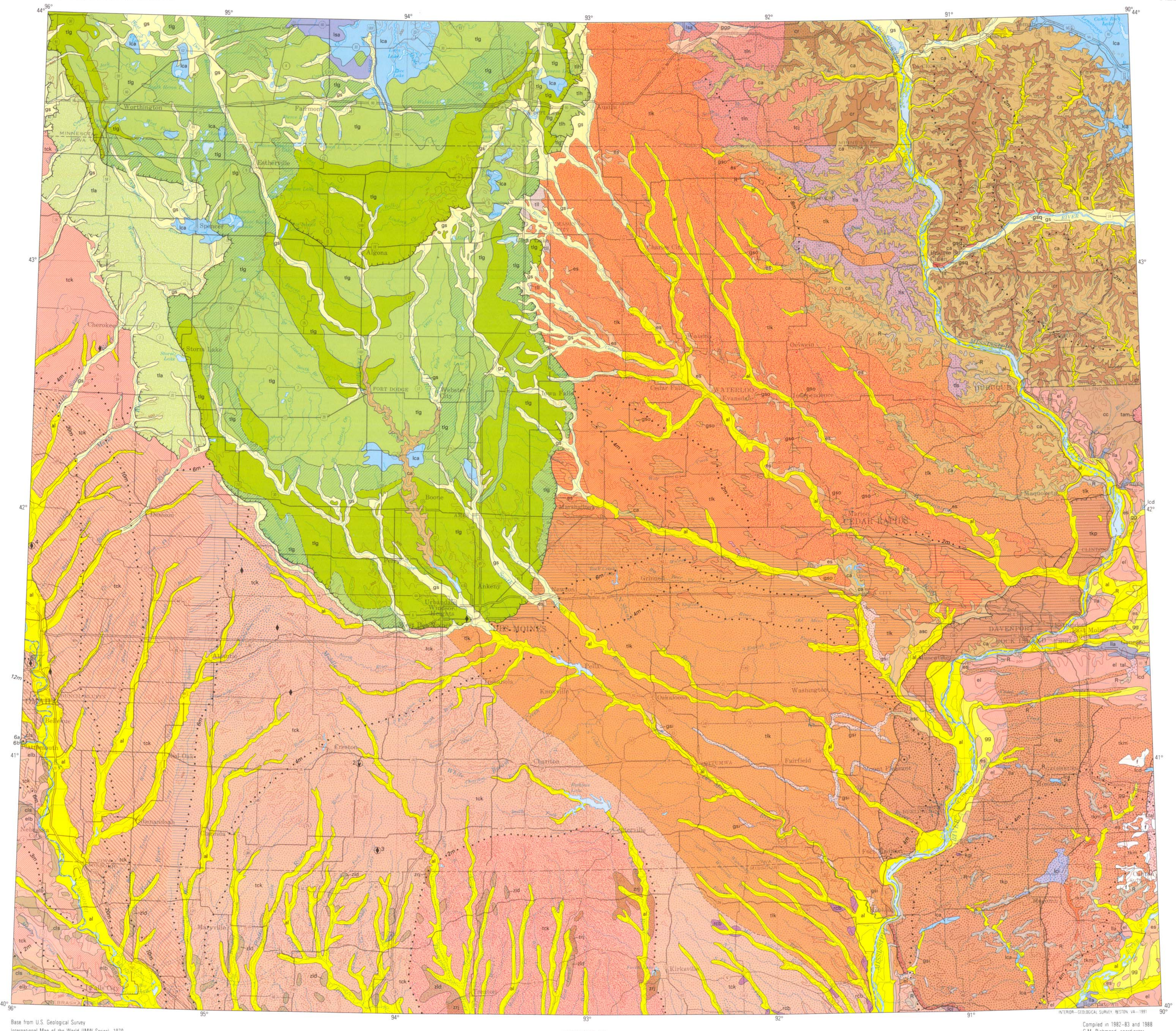
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
IOWA GEOLOGICAL SURVEY,
ILLINOIS STATE GEOLOGICAL SURVEY,
UNIVERSITY OF WISCONSIN DEPARTMENT OF GEOLOGY AND GEOPHYSICS,
UNIVERSITY OF WISCONSIN DEPARTMENT OF GEOGRAPHY,
MINNESOTA GEOLOGICAL SURVEY,
MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY, AND
NEBRASKA CONSERVATION AND SURVEY DIVISION

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
DES MOINES 4° × 6° QUADRANGLE
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1420 (NK–15)



Base from U.S. Geological Survey
International Map of the World (IMW Series), 1970
Lambert Conformal Conic Projection

SCALE 1:1 000 000
25 0 25 50 75 100 125 150 KILOMETERS
25 0 25 50 MILES
CONTOURS IN METERS ABOVE MEAN SEA LEVEL
NATIONAL GEODETIC VERTICAL DATUM OF 1929

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1991

Compiled in 1982–83 and 1988
G.M. Richmond, coordinator
Manuscript approved for publication,
October 18, 1989

LIST OF MAP UNITS

HOLOCENE AND LATE WISCONSIN

al ALLUVIUM
asc ALLUVIAL SILT AND SAND
es EOLIAN SHEET SAND
el LOESS
ca COLLUVIUM AND SHEETWASH ALLUVIUM
cls CHERT-CLAST CLAYEY SILT TO SILTY CLAY LOAM COLLUVIUM

HOLOCENE TO MIDDLE PLEISTOCENE

cc COLLUVIUM

WISCONSIN

lsa LAKE SAND
lca LAKE SILT AND CLAY
lla SLACKWATER LAKE SILT, CLAY, SAND, AND GRAVEL
gg OUTWASH SAND AND GRAVEL
gs OUTWASH SAND
LOAMY TILL
tlg Ground moraine
tlg Stagnation moraine
tlg End moraine
tlh LOAMY TILL
tla LOAMY TILL

EARLY WISCONSIN

lcd LAKE SILT AND CLAY

EARLY WISCONSIN OR ILLINOIAN

tll LOAMY TILL

WISCONSIN AND ILLINOIAN

cr COLLUVIUM
elb LOESS

ILLINOIAN

lci LAKE SILT AND CLAY
gsi OUTWASH SILT, SAND, AND GRAVEL
kgi ICE-CONTACT SAND AND GRAVEL
tal CLAYEY TILL
LOAMY TILL
tkm Ground moraine
tkm End moraine
tam CLAYEY TILL
LOAMY TILL
tkp Ground moraine
tkp End moraine

PRE-ILLINOIAN

ggp OUTWASH SAND AND GRAVEL
tlk LOAMY TILL
gso SAND AND GRAVEL
tck CLAY LOAM TILL
tln DISCONTINUOUS LOAMY TILL
tls DISCONTINUOUS LOAMY AND CLAYEY TILL
gsq OUTWASH SAND AND GRAVEL
tlt LOAMY TILL
tcj DISCONTINUOUS CLAYEY TILL

QUATERNARY AND TERTIARY

zld CLAYEY SILT TO SILTY CLAY DECOMPOSITION RESIDUUM
zrj SANDY TO SILTY CLAY DECOMPOSITION RESIDUUM AND CLAY SOLUTION RESIDUUM
rcb THIN CHERTY CLAY SOLUTION RESIDUUM

PRE-TERTIARY

R BEDROCK

CONTACT—Dashed where inferred
LOESS ISOPACH—In meters
STRIATIONS—Showing direction of glacier movement
OUTER LIMIT OF SIGNIFICANT GLACIAL ADVANCE—Marked by distal edge of end moraine or outer limit of till; ticks on side of advance
BURIED PLEISTOCENE RIVER CHANNEL—Mapped only in Missouri
f MANMADE FILL—Chiefly open pit coal mine waste. Mapped only in Illinois
VOLCANIC ASH BEDS
Lava Creek B (Pearlette O) volcanic ash bed
Huckleberry Ridge (Pearlette B) volcanic ash bed

LOCATION OF SIGNIFICANT STRATIGRAPHIC SECTION—May be combined with volcanic ash bed symbol. Sections described in descending order

1 Yarmouth subsurface section, Des Moines County, Iowa—From core hole along south line sec. 16, T. 72 N., R. 4 W. (modified from Hallberg, Fenton, and others, 1980). "Wisconsin" loess, 3.1 m; Sangamon paleosol, 0.8 m; Illinoian Kellerville Till Member of Glasford Formation, 24.3 m; undifferentiated peat and organic silt loam containing *Picea* pollen zone and comprising upper part of early Illinoian-late "Yarmouth" paleosol, 0.7 m; "Yarmouth" paleosol in till-derived sediments and uppermost Hickory Hills Till Member of pre-Illinoian Wolf Creek Formation, 2.1 m; Hickory Hills Till Member of Wolf Creek Formation, 5.9 m; undifferentiated sediments of Wolf Creek Formation, 1.5 m; Aurora Till Member of Wolf Creek Formation, 6.1 m; undifferentiated till of Alburnett Formation, 2.8 m; Lower Mississippian Burlington Limestone bedrock

2 Afton section, Union County, Iowa—Nebraska Geological Survey core hole 5–A–75, NE1/4NW1/4 sec. 33, T. 72 N., R. 29 W. (modified from Boellstorff, 1978a). Section is in type area of "Kansan" till, "Afton soil", and "pre-Kansan" till of Bain (1896) and Chamberlin (1896), and of "Nebraskan" till of Kay and Apfel (1929). "Wisconsin" loess, 2 m; late Sangamon paleosol, 1 m; pre-Illinoian "A1" till, equivalent to "Kansan" till of Bain (1896) and Chamberlin (1896), 7.8 m; Afton paleosol, 3.1 m; "A2" till, equivalent to "Nebraskan" till of Kay and Apfel (1929), 15.5 m; "B" till, 17.5 m; paleosol in undifferentiated nonglacial sediments of unnamed unit that includes thin silt containing Huckleberry Ridge (Pearlette B) volcanic ash (2.01 Ma), 3.1 m; late Pliocene "C" till containing reversed to normal magnetic polarity transition in upper part, 1.8 m; Pennsylvanian shale and limestone bedrock. See also Boellstorff (1973, 1978a, b, c), Hallberg and Boellstorff (1978), Easterbrook and Boellstorff (1981), and Izett and Wilcox (1982)

3 Mt. Ayr composite section, Ringgold County, Iowa—Modified from Nebraska Geological Survey records of test holes 4–A–75 and 19–A–75, SE1/4 sec. 18, T. 68 N., R. 28 W. Section is in type area of Afton paleosol. "Wisconsin" loess; late Sangamon paleosol; pre-Illinoian "A1" till, equivalent to "Kansan" till of Kay and Apfel (1929); paleosol in sediments containing Lava Creek B (Pearlette O) volcanic ash bed (0.6 Ma), stratigraphically equivalent to "Aftonian soil" of Kay and Apfel (1929); "A2" till, equivalent to "pre-Kansan" or "Nebraskan" till of Kay and Apfel (1929); paleosol correlated with Fontanelle paleosol in Nebraska; "A3"(?) till; unnamed alluvial sediments; "A4"(?) till. See also Boellstorff (1973, 1978b) and Hallberg and Boellstorff (1978)

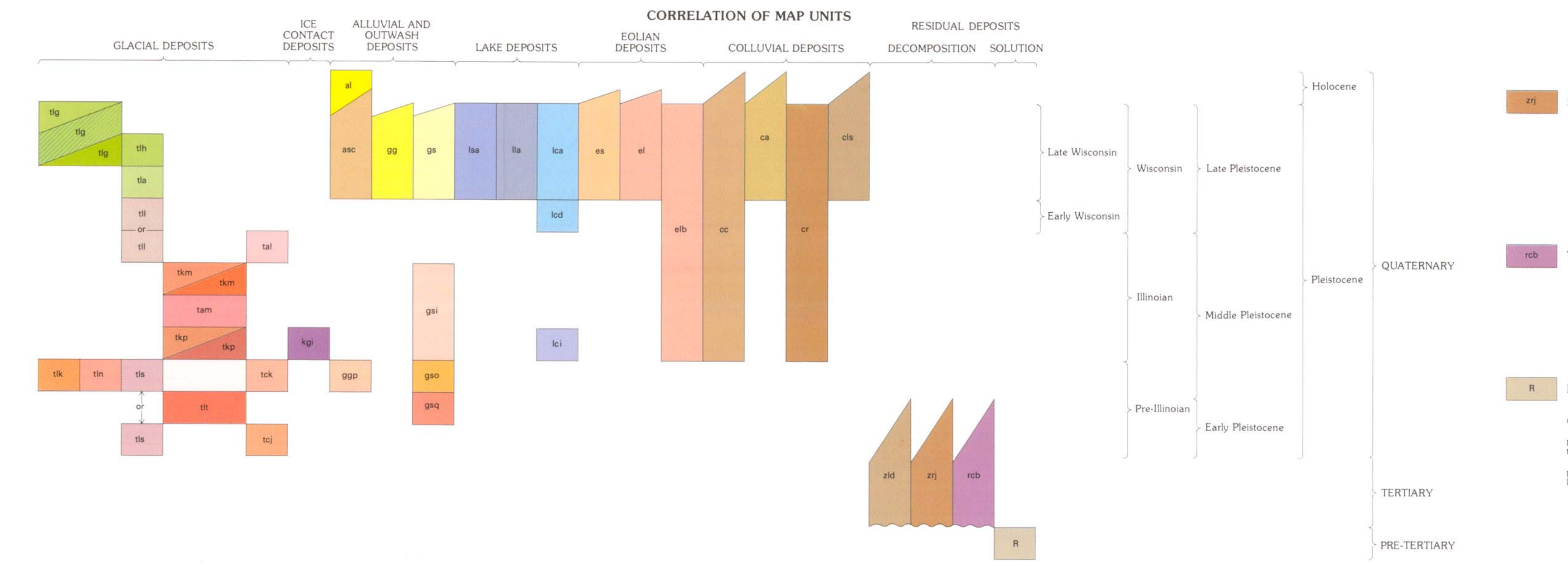
4 County Line section, Harrison County, Iowa—Outcrop and Nebraska Geological Survey test hole 9–4–76, NW1/4NE1/4 sec. 5, T. 81 N., R. 44 W. (modified from Boellstorff, 1973, 1978c; Easterbrook and Boellstorff, 1981, 1982, 1984; Shimek, 1909, 1910). Peoria Loess, 2.1 m; Loveland Loess, 4.6 m; silt, normal magnetic polarity, 4.6 m; Lava Creek B volcanic ash bed, 0.5 m; silt, normal magnetic polarity, 1.9 m; gravel and sand, 2.1 m; "A" till, 3 m; sand, thin; till, thin; sand. Paulson (1983) described Little Sioux local fauna (cool, moist boreal) from silt loam below volcanic ash, and Wright local fauna (warmer and less moist than Little Sioux local fauna (l.f.) from silt 36 cm above ash. Biota indicate ash deposited early in an interglacial. Shimek (1909, 1910) discussed and photographed a till about 3.6 m thick, which he called "Kansan", between the Loveland Loess and the underlying silt containing the volcanic ash. Subsequent work has not re-exposed that till

5 Hummel Park section, Douglas County, Nebraska—Nebraska Geological Survey core hole 4–A–76, NW1/4SW1/4 sec. 9, T. 16 N., R. 13 E.; section is near type locality of "Nebraskan" till of Shimek (1909) (modified from Boellstorff, 1978c; Easterbrook and Boellstorff, 1981, 1982). Thicknesses approximate. Latest Wisconsin Bignell Loess, 12.8 m; late Wisconsin Peoria Loess, 16.2 m; Gilman Canyon Formation and Loveland Loess, 18.2 m; silt, with normal magnetic polarity, 12.2 m; Lava Creek B (Pearlette O) volcanic ash bed (Hartford ash in Nebraska), 0.3 m; silt, 3.4 m; "A4" till, reversed magnetic polarity, correlated with nearby type "Nebraskan" till of Shimek (1909), 9.7 m

6a City Wide Rock Quarry section, Sarpy County, Nebraska—NE1/4NW1/4 sec. 29, T. 13 N., R. 13 E. (modified from City Wide Quarry section 2 of Boellstorff, 1973, 1978c). Peoria Loess, 2.1 m; Loveland Loess, 5.5 m; "A" till, 3.0 m; "B" till, 4.9 m; "C" till, 3.7 m; sand and silt, 2.4 m; "C" till 4.9 m; striations on limestone bedrock trend S. 25° W.

6b City Wide Rock and Excavation Company Quarry section, Sarpy County, Nebraska—SE1/4SW1/4 sec. 20, T. 13 N., R. 13 E. (modified from Burchett, 1971, fig. 14). Yarmouth paleosol; Cedar Bluff Till, 4.9 m; Fontanelle paleosol; Nickerson Till, 7.3 m; Afton paleosol complex, 0.9 m; Fullerton Formation, 4.9 m; sand and silt, 2.1 m; Elk Creek Till, 5.8 m; limestone bedrock. Nickerson Till at type locality is classed as an "A2" till (Boellstorff, 1973) and has normal magnetic polarity (Easterbrook and Boellstorff, 1981). Till at City Wide Rock Quarry called Nickerson by Burchett (1971) was classed as an "A4" till by Boellstorff (1978c). "A4" tills have reversed magnetic polarity. No magnetic polarity measurements are available from City Wide Rock Quarry

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

HOLOCENE AND LATE WISCONSIN

al ALLUVIUM (Cahokia Alluvium in Illinois; unnamed elsewhere)—Light-brown, gray, grayish-brown, or black, loamy silty sand and sandy silt locally containing organic matter ^{14}C dated from 10,500 years B.P. to present. Includes underlying sand and gravel or small terrace alluvial deposits of late Wisconsin age in major valleys. Noncalcareous to calcareous, moderately to well sorted, stratified. Clasts chiefly limestone, chert, and erratic igneous and metamorphic rock types derived from glacial deposits. Mapped areas include local lenses of colluvium and loess. Thickness 3–35 m

asc ALLUVIAL SILT AND SAND—Light-brown to gray or black, silty, coarse to fine, feldspathic quartz sand; moderately well sorted; poorly to well stratified; channel-and-fill crossbedded. Includes local lenses of clay and layers of colluvium derived from valley slopes. Underlies broad terrace remnants locally mantled with eolian sand along ancestral drainage of Wapsipinicon, Cedar, and Iowa Rivers northwest, west, and southwest of Davenport in southeastern Iowa. Thickness 4–10 m

es EOLIAN SHEET SAND (included in Parkland Sand in Illinois)—Pale-brown, weakly calcareous, well-sorted, medium to fine sand, locally silty. Generally downwind from areas of outwash sand and gravel (gg). Commonly forms blanketlike deposit, but in Iowa locally includes dunes. Locally overlies lake deposits (lla, lca). Mapped only in Illinois and Iowa. Thickness 1–3 m; as thick as 6 m in dunes

el LOESS (Peoria Loess in Illinois)—Gray to yellowish-brown windblown silt and silt loam. Calcareous where thick; weakly compact and jointed. Occurs chiefly on uplands adjacent to major outwash deposits. Peoria Loess is distinguished as a map unit only in Illinois. Commonly overlies Farmdale paleosol developed on more compact, leached, brown or reddish-brown to dark-gray Roxana Silt. Mapped only where total thickness of all loess is more than 6 m; thinner unmapped deposits of Peoria Loess (late Wisconsin) and younger loess are shown by overprint patterns. In Iowa, Missouri, and Minnesota, "Wisconsin" loess deposits and paleosols also are shown by overprint patterns. In Wisconsin, "Wisconsin" loess is not mapped, but is discussed in description of map units on which it is present

ca COLLUVIUM[1] AND SHEETWASH ALLUVIUM—Colluvium and sheetwash alluvium cannot be distinguished separately at the scale of this map. Mapped as one unit in Wisconsin, Minnesota, and along valley of Des Moines River in Iowa. Commonly covered by 2–4 m of unmapped loess or windblown sand. Colluvium is brown or reddish-brown, noncalcareous to weakly calcareous, nonsorted, nonstratified to faintly stratified, sandy to silty clay containing angular to subangular clasts of sandstone, dolomite, limestone, and chert; chiefly on valley sides; separated by scattered, numerous, or extensive outcrops of sandstone, dolomite, and limestone. Sheetwash alluvium is brown to reddish-brown, noncalcareous to weakly calcareous, poorly sorted to well-sorted sand, silt, and clay; contains local layers of subangular, subrounded, or slabby boulders to pebbles of sandstone, dolomite, limestone, and chert; chiefly on lower slopes of valley sides and valley floors. Thickness of combined unit 1–3 m

cls CHERT-CLAST CLAYEY SILT TO SILTY CLAY LOAM COLLUVIUM[1]—Reddish- to grayish-brown or gray, fine sandy silt, silty clay, or clay; contains abundant angular to subround fragments, mostly chert, but also some limestone, sandstone, and shale. Mapped only in Nebraska in southwesternmost part of quadrangle. Mapped areas include unmapped eroded remnants of decomposition residuum (zld), till (tck), and bedrock outcrops, from all of which the colluvium is derived, and small deposits of alluvium. Thickness 0.25–2 m

HOLOCENE TO MIDDLE PLEISTOCENE

cc COLLUVIUM[1]—Includes colluvium (cr) of uplands and colluvium and sheetwash alluvium (ca) of lower slopes. Occurs as thin, discontinuous patches; mapped only in Illinois. Brown or reddish-brown to gray, noncalcareous to weakly calcareous clay, sandy clay, or clayey sand; sand mostly quartz. Contains angular to subangular clasts of dolomite and chert, and minor limestone and sandstone; also well-rounded pebbles of chert and quartz in places. Nonsorted to well sorted, nonstratified to well stratified. Overlies bedrock or, in places, reddish-brown cherty clay as thick as 1.5 m reworked from older residuum. Overlain by unmapped Roxana Silt and Peoria Loess as much as 5 m thick. Mapped areas include numerous and extensive unmapped bedrock outcrops both on uplands and as cliffs and ledges along valley walls. Thickness 0.5–2 m

WISCONSIN

lsa LAKE SAND—Pale-yellowish-brown to brown, well-sorted to poorly sorted, fine to medium sand containing local lenses of pebbly or gravelly sand or silt and clay. Mapped only in Minnesota. Sand chiefly quartz, feldspar, and mica from glacial sources; clasts dominantly limestone and dolomite. Represents beach, near-shore, and off-shore sediment. Locally, includes foreset-bedded delta sand deposited where a stream entered a former lake. In places covered by less than 1 m of unmapped windblown sand. Thickness 1 m to more than 3 m

lca LAKE SILT AND CLAY (part of Carmi Member of Equality Formation in Illinois; unnamed elsewhere)—Yellowish-brown to brown, bluish- or greenish-gray to gray clay and silt. Well bedded; soft; plastic; commonly thinly laminated; locally varved; contorted in places. In places, it underlies extensive, flat, low-lying areas formerly occupied by glacial lakes; elsewhere it occurs in small, separate lake basins. Thin and discontinuous in some areas. Includes local areas of undifferentiated lake sand (lsa) and wave-washed or current-scoured till. Commonly covered by unmapped loess, thin eolian sand, swamp deposits, or alluvium. Thickness 1–10 m

lla SLACKWATER LAKE SILT, CLAY, SAND, AND GRAVEL (part of Carmi Member of Equality Formation in Illinois)—Yellowish-brown to brown, becoming dark gray downward, massive to thinly laminated silty clay and silt, texturally similar to loess. Locally calcareous; may include calcareous concretions. Contains interstratified layers of near-shore sand and pebble gravel. Formed in lakes impounded in tributary valleys by aggrading outwash along rivers flowing from glacier margins in late Wisconsin time. Mapped only in Illinois. Commonly covered by loess, thin eolian sand, swamp deposits, or alluvium. Thickness 1–10 m

gg OUTWASH SAND AND GRAVEL (Mackinaw Member of Henry Formation in Illinois)—Pale- to yellowish-brown, or gray pebble to cobble gravel in fine to coarse sand or silty sand matrix; bouldery in places; local lenses or thin beds of silt. Mapped only in Illinois. Poorly to well sorted; poorly to well stratified; beds chiefly planar, but channel-and-fill crossbedding in beds common. Gravel as much as 5 cm in diameter; boulders as large as 75 cm common. Clasts chiefly limestone or dolomite, locally shale; include minor amounts of granite, gneiss, ironstone, basalt, and other Precambrian rock types. Leached 0.5–1 m; secondary carbonate concretions at depth. Iron oxide or manganese oxide locally appears as streaks parallel to bedding and coatings on clasts. Underlies terraces; in places, covered by less than 2 m of unmapped loess. Mapped areas commonly include small unmapped deposits of Holocene alluvium and colluvium. Thickness commonly 4–8 m; locally as much as 15 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; beds chiefly planar, but channel-and-fill structure and local delta foreset bedding common. Gravel mostly finer than 32 mm; some cobbles as large as 20 cm in diameter; clasts rounded to subangular; locally platy. As much as 50 percent limestone or dolomite clasts; as much as 20 percent each granitic rocks and gabbro; shale locally abundant. Minor constituents include other crystalline rocks, diabase, basalt, ironstone, schist, quartzite, sandstone, chert, and quartz. Coarse crystalline rocks commonly crumble easily. Leached 0.5–1 m; secondary carbonate concretions, chiefly derived from overlying loess, form at depth and locally cement deposit. Iron oxide and manganese oxide form streaks along bedding planes and coatings on gravel, and locally cement masses. Underlies terraces whose surfaces may be smooth, pitted, or extensively collapsed. In places, covered by less than 2 m of unmapped loess or eolian sand. Mapped areas commonly include small deposits of alluvium and colluvium. Thickness commonly 4–8 m; locally as much as 20 m

LOAMY TILL (Dows Formation in Iowa; included in New Ulm Formation in Minnesota)—Light-brown, gray, or grayish-brown silt loam and loam. Very calcareous; nonsorted to poorly sorted; sand fraction about 8 percent carbonate; calcite to dolomite ratio 3.78. Clay minerals dominantly expandable (smectite); lesser illite, kaolinite, and chlorite. Clasts chiefly shale, limestone, and dolomite; minor amounts of basalt, diabase, granite, chert, and sandstone. Thin, patchy cover of loess in places. Radiocarbon age of successive deposits in Iowa ranges from about 14,000 to 12,650 years B.P. (Hallberg and Kemmis, 1986)

tlg Ground moraine—Thickness 4–25 m

tlg Stagnation moraine—Broad, irregular area of hummocky topography without distinct morainal ridges. Till more sandy than ground moraine and interbedded with stratified gravel and sand. Thickness generally less than 15 m

tlg End moraine—Broad ridges, locally with hummocky topography. Thickness 2–30 m

tlh LOAMY TILL (included in New Ulm Formation in Minnesota)—Yellowish-brown silt loam and loam. Calcareous; nonsorted to poorly sorted. Sand fraction derived chiefly from crystalline rocks. Pebbles and cobbles common to rare, mostly shale and limestone, a few of basalt, diabase, granite, schist, and chert. Forms ground moraine. Mapped only in Minnesota. Locally covered by less than 2 m of unmapped loess. Thickness 5–15 m

tla LOAMY TILL (Tazewell Till in Iowa)—Light-brown, gray, or grayish-brown loam to clay loam; very calcareous; high content of carbonate and crystalline rocks in sand- to pebble-size fraction. Numerous pebbles and cobbles, mostly shale. Few boulders, mostly dolomite and granite. Matrix calcareous; high content of expandable clays (smectite); illite more abundant than kaolinite. Considerably dissected and lacks significant constructional topography. Radiocarbon age of wood from till ranges from 25,500 to 20,000 years B.P. (Ruhe, 1969). Covered by as much as 2 m of Wisconsin loess (shown by overprint pattern). Thickness 2–5 m

EARLY WISCONSIN

lcd LAKE SILT AND CLAY (part of Carmi Member of Equality Formation in Illinois)—Yellowish-brown to brown or bluish-gray to gray silt and clay. Mapped only in Illinois. Well bedded; locally includes laminae of fine sand. Commonly thinly laminated; locally varved. Occurs in basins formerly occupied by glacial lakes. Generally covered by unmapped thin eolian sand, loess, swamp deposits, or alluvium. Thickness 1–6 m

EARLY WISCONSIN OR ILLINOIAN

tll LOAMY TILL—Light-brown, gray, or grayish-brown silt loam and loam. Mapped only in Iowa. Calcareous; high in expandable clay (smectite); unsorted to poorly sorted. Depth of leaching greater than on map units tlg, tlh, or tla. Scattered pebbles and cobbles, mostly limestone, dolomite, and shale, some of basalt and granite. No constructional topography. Radiocarbon age greater than 39,900 years B.P. from organic material in stratified sediment in uppermost part of till (G.R. Hallberg, oral commun., 1988). Commonly covered by as much as 2 m of loess (shown by overprint pattern). Thickness 2–10 m

WISCONSIN AND ILLINOIAN

cr COLLUVIUM[1]—Red, reddish-brown, or brown, noncalcareous to weakly calcareous clay, sandy clay, or clayey sand. Restricted to high uplands and interfluves. Mapped areas include abundant bedrock outcrops. Sand mostly quartz. Material poorly to well sorted, massive to well stratified, clast-free to bouldery rubble. Clasts mostly peanut sized polished pebbles of well-rounded quartz and subangular chert, but commonly also include angular to subangular pebble- to boulder-sized fragments of limonite, limonite-cemented chert breccia, and limonite-cemented sandstone. Quartz and chert pebbles derived from East Bluff (upper) Member of Windrow Formation of Cretaceous or possible Tertiary age; limonite derived from remnant outcrops of Cretaceous Iron Hill (lower) Member. Windrow Formation is locally preserved on uplands in northeastern part of quadrangle. To south, where Windrow Formation is lacking, the colluvium overlies a residual red clay developed from cherty limestone, and dolomite bedrock. Clay is fissile, blocky, or structureless, and contains abundant chert fragments. Colluvium commonly overlain by 2 m to as much as 8 m of "Wisconsin" loess. Thickness 0.5–2 m

elb LOESS (Bignell Loess, Peoria Loess, and Loveland Loess in Nebraska; "Wisconsin" loess and Loveland Loess in Iowa; Peoria and Loveland Loess in Missouri)—Grayish-, yellowish-, or reddish-brown silt loam; calcareous; mapped only in Nebraska; locally includes deposits of dark-gray silty clay (Gilman Canyon Formation) in low-lying areas. Sangamon paleosol commonly developed in uppermost Loveland Loess beneath Peoria Loess. Loess is thickest near Missouri River and thins rapidly away from it. Loveland Loess, and Peoria Loess (Missouri) or "Wisconsin" loess (Iowa) (shown by overprint patterns) are widespread on pre-Illinoian till in Iowa and northern Missouri. In places, thin, patchy loess is intermixed and (or) interbedded with locally derived colluvial or alluvial deposits. Loess thickness 2–10 m, locally as much as 40 m along Missouri River in Nebraska

ILLINOIAN

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

gsi OUTWASH SILT, SAND, AND GRAVEL (Pearl Formation in Illinois; unnamed in Iowa and Missouri)—Yellowish- or reddish-brown to gray silt and pebbly sand in Iowa and Illinois. In Missouri consists of poorly stratified sand, gravel, cobbles, and boulders, probably eroded from pre-Illinoian till (tlk) on adjacent uplands. Weakly to well bedded. Similar in composition to younger outwash sand and gravel (gg) in some areas, but more oxidized and better cemented. Age imprecisely known in Iowa and Missouri. Sangamon paleosol developed in uppermost part. Covered by 2–6 m of loess (Peoria Loess and Roxana Silt, shown by overprint pattern). Thickness about 12 m; locally thicker

kgi ICE-CONTACT SAND AND GRAVEL (Hagarstown Member of Glasford Formation in Illinois)—Well-sorted, bedded sand and gravel; includes some gravelly till. Mapped only in Illinois at one locality southwest of Galesburg, but other deposits too small to map occur throughout area of map unit tkp; forms kames. Overlies Kellerville Till Member of Glasford Formation (tkp). Sangamon paleosol developed in uppermost part. Covered by 3–4 m of loess (Peoria Loess and Roxana Silt, shown by overprint pattern). Thickness 5–15 m

Till members of Glasford Formation in Illinois and unnamed units in Iowa

All till units of Glasford Formation locally covered by small, unmapped deposits of outwash silt, sand, and gravel (gsi, gg), lake silt and clay (lci, lcd, lca), eolian sand (es), alluvium (al), or younger till.

tal CLAYEY TILL (Radnor Till Member of Glasford Formation in Illinois)—Yellowish-brown or brown to dark-gray clay loam, silty clay loam, and loam. Illitic and dolomitic; commonly interbedded with sand and silt. Compact; locally massive and jointed. Clasts mostly limestone and dolomite. Mapped only in Illinois. Sangamon paleosol locally developed in upper part. Covered by as much as 4 m of unmapped loess (Peoria Loess and Roxana Silt). Thickness commonly less than 6 m

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

tkm Ground moraine—Thickness 2–10 m

tkm End moraine—Thickness 5–15 m

tam CLAYEY TILL (Winslow Till Member of Glasford Formation in Illinois)—Yellowish-brown to gray or dark-gray clay loam, silty clay loam, and silty clay. Moderately illitic; sand fraction dolomitic; nonsorted to very poorly sorted; pebbles and cobbles uncommon. Clasts chiefly dolomite and limestone. Mapped in only one area in northwesternmost Illinois. Mapped area includes bedrock outcrops. Till commonly overlain by as much as 2 m of unmapped loess (el). Thickness 2–5 m

LOAMY TILL (Kellerville Till Member of Glasford Formation in Illinois)—Reddish- to yellowish-brown, brownish-yellow, bluish-gray, or gray, calcareous clay loam and loam. Generally leached more than 1 m; maximum 7 m. Texture highly variable; ranges from sandy loam to clay loam. Nonsorted to poorly sorted; locally exhibits faint pseudostratification. Commonly contains intercalated or interstratified pods or zones of silt, sand, or gravel; locally very sandy or gravelly in lower part. Generally massive and compact; jointed; oxidized along joints; crude horizontal partings. Carbonate or iron oxide concretions present in places. Till commonly contains few pebbles, but locally is very pebbly. Clasts chiefly limestone and dolomite, many of granite and other crystalline rocks, a few of shale and sandstone; coal fragments abundant locally. In Iowa, average depth of leaching is 1 m, maximum depth 2.2 m. In Illinois, average depth is 0.3–0.4 m. Sangamon paleosol commonly developed in upper part. Overlain by less than 6 m of unmapped loess (Peoria Loess and Roxana Silt, shown by overprint pattern)

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

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

PRE-ILLINOIAN

ggp OUTWASH SAND AND GRAVEL—Yellowish-brown, fine to coarse sand and pebbly sand, commonly interbedded with pebble or cobble gravel. Derived from and interfingers with loamy till (tlk). Mapped only in eastern Minnesota along north boundary of quadrangle. Calcareous; poorly sorted to well sorted; weakly to well stratified. Textures vary laterally and vertically. Rounded pebbles and cobbles are chiefly granite, greenstone, schist, limestone, and sandstone. Shale clasts are lacking. Locally covered by "Wisconsin" loess. Distribution of loess cover 2 m or more thick shown by overprint pattern. Thickness of sand and gravel 2–20 m

tlk LOAMY TILL (loam facies of Hickory Hills Till Member of Wolf Creek Formation in eastern Iowa; "eastern old gray drift" of Goebel and Walton (1979) or thick drift zone of "St. Charles till" of Hobbs (1987) in Minnesota)—Fresh till in light- to dark-gray sandy to silty loam; nonsorted to poorly sorted; compact, calcareous; however, wide-spread erosion surface developed on till is underlain by dark-yellow to yellowish-brown oxidized and leached zone about 1 m thick. Fresh till beneath contains carbonate concretions and, near base, dark iron or manganese oxide coatings along joints and sandy partings. In northern part of mapped area, till clasts are chiefly pebble and gravel size; a few are cobbles and small boulders. Most are granite and fine-grained igneous and metamorphic rocks. Where concentrated along stone lines, clasts include gabbro, basalt, quartzite, rhyolite, diorite, slate, greenstone, ironstone, and well-rounded quartz and chert. All carbonate clasts have been dissolved. The few large boulders on the till surface are mostly granite and pegmatite. In Iowa, igneous, metamorphic, and volcanic rocks become less abundant southward and limestone, dolomite, and chert more abundant. Igneous rocks tend to be decomposed. Till is chiefly ground moraine. In Minnesota, the "St. Charles till" locally overlies an older oxidized and leached till, and Hobbs (1987) suggests that the thick drift zone of that till may include older tills comparable to the till members of Wolf Creek Formation in Iowa. Mapped areas locally include deposits of colluvium (ca, cr). A "Yarmouth-Sangamon" paleosol in the upper part of the till is overlain by 2–4 m of loess (distribution shown by overprint pattern). Thickness commonly 3–30 m; as much as 150 m in some buried valleys

gso SAND AND GRAVEL (Buchanan Gravel in Iowa)—Light-brown, brownish-red, or grayish-brown, coarse to fine arkosic sand and gravel, locally containing scattered cobbles and boulders. Poorly sorted; well stratified; mostly horizontally bedded; some lenticular beds crossbedded. Includes clay balls and masses of till in places. Pebbles chiefly basalt, diabase, greenstone, granite, chert, sandstone, and siltstone; some are gabbro, syenite, quartz, quartzite, schist, shale, ironstone, and jasper. Most clasts less than 1.5 cm in diameter; some 1.5–5 cm. Scattered cobbles and boulders, predominantly greenstone and granite; boulders are mostly 45–60 cm in diameter; a few are 1 m in diameter. Clasts and grains are coated with iron oxide, which locally cements deposit to form sandstone or conglomerate. All limestone and dolomite clasts and all primary matrix carbonate leached from outcrops; depth of leaching typically about 6 m, locally as much as 16 m. Granite clasts crumble to arkosic sand. Boulders commonly coated with secondary carbonate. Occurs at ground surface or at base of a till. In places fills buried valleys cut in bedrock. Locally folded and sheared or thrust into overlying till. Most deposits considered to have been initially pre-Illinoian outwash of one or more glaciations. Those at the surface overlie extensive stepped erosion surfaces and are interpreted either as exhumed from beneath a till during formation of an erosion surface or of subsequent alluvial or glaciofluvial origin. Thickness 2–10 m; typically 5–6 m

tck CLAY LOAM TILL ("A1" tills in central western Iowa; clay loam facies of Hickory Hills and Aurora Till Members of Wolf Creek Formation in south-central Iowa)—Reddish-, yellowish-, or grayish-brown, bluish- or greenish-gray clay loam. Poorly sorted; nonstratified; compact, hard. Commonly oxidized 5–6 m, locally 12 m; joints coated with iron or manganese oxide; average depth of leaching 1.75 m; beneath the oxidized zone, till matrix calcareous; secondary calcium carbonate nodules and joint fracture fillings common. Contains rounded pebbles and scattered cobbles and boulders. Clasts dominantly granite and other igneous rocks, quartzite, and limestone in northwest part of quadrangle; mostly shale and limestone in southwestern part; mostly granite, basalt, greenstone, limestone, dolomite, chert, quartz, sandstone, and ironstone in south-central part. Till locally includes layers and lenses of sand and silt, medium to fine sand, or fine gravel. In Iowa, Wolf Creek Formation tills of at least three pre-Illinoian glaciations which have normal magnetic polarity and locally are separated by paleosols (see chart). In central-western Iowa, "A1" tills and "A2" tills, both with normal magnetic polarity, are separated by normally magnetized interglacial deposits containing the Lava Creek B (Pearlette O) volcanic ash bed (age 610,000 years). A "Yarmouth-Sangamon" paleosol in upper part of the surface till is overlain by 2–6 m of "Wisconsin" loess (Iowa) or Peoria Loess (Missouri) (shown by overprint pattern). Thickness 2–15 m; as thick as 150 m in some buried valleys eroded in bedrock

tln DISCONTINUOUS LOAMY TILL (thin drift zone of "St. Charles till" of Hobbs (1987) in Minnesota)—Thin, discontinuous, patchy deposits separated by numerous and extensive areas of bedrock plateau uplands, escarpments, and valley walls. Mapped only in Minnesota. Yellowish-brown to light-gray, calcareous pebbly loam to clay loam; secondary carbonate in underlying fresh till; limonite or manganese oxide stained at base. Clasts mostly pebbles and granules of locally derived sandstone, dolomite, and limestone, but include scattered erratics of ironstone, limonite-cemented sandstone, quartz, basalt, greenstone, and sparse granite. Granite common in granule fraction. No constructional topography. Where overlain by thick loess, a pre-loess, reddish-brown, deeply oxidized and leached zone is preserved in the uppermost part of the till. Where overlain by thin loess, oxidation and leached zone thins to about 1 m owing to erosion prior to loess deposition. Mapped areas include local talus, other colluvium, and alluvium. Both the till and associated areas of upland bedrock (not separately mapped) commonly covered by 1–3 m of "Wisconsin" loess (shown by overprint pattern). Thickness 0.1–4 m

tls DISCONTINUOUS LOAMY AND CLAYEY TILL—Dark-brown, yellowish-brown to brown, pebbly sandy to clayey loam containing sparse erratics of quartzite, sandstone, quartz, basalt, greenstone, and rare granite, commonly disintegrated. Mapped only in Iowa; equivalent to "residual" till (tcj) and thin drift zone of "St. Charles till" (tln) in Minnesota. Occurs as thin, discontinuous patches separated by numerous and extensive areas of bedrock uplands, escarpments, and valley walls in Minnesota, Wisconsin, and northeastern Iowa. No constructional topography. Depth of leaching 2–4 m; secondary carbonate concretions and joint fillings in underlying oxidized till. Commonly present in sink-hole depressions, locally in caves. In southeastern part of deposit in Iowa and across Mississippi River in Illinois where it is not mapped, includes lenses and surface accumulations of outwash gravel. Both the till and associated bedrock surfaces of upland plateaus commonly mantled by 2–4 m of "Wisconsin" loess (shown by overprint pattern). Thickness 0.1–5 m

gsq OUTWASH SAND AND GRAVEL—Reddish brown to brown where deeply weathered and oxidized, becoming yellowish brown to brownish gray at depth, gravelly sand with local silt interbeds. Pebbles and cobbles mostly limestone and dolomite; some granite and quartzite; a few are striated. Recognized only in high terrace along Wisconsin River in Wisconsin. Poorly to well sorted; poorly to well stratified; locally crossbedded. In places contains angular boulders of local bedrock, transported by colluvial processes from valley walls; grades into or interfingers with loamy till (tls) at west end of Wisconsin River valley. Terrace in which deposit occurs slopes east in contrast to west-sloping late Wisconsin terraces and present flood plain. Silt bed in sand and gravel has reversed magnetic polarity, suggesting that deposit is older than Matuyama-Brunhes magnetic polarity reversal (about 750 ka). In western part of valley, weathered surface overlain by two loesses separated by well-developed Sangamon paleosol. In eastern part, loess mantle has been stripped by late Wisconsin floods. Thickness about 10 m

tlt LOAMY TILL—Reddish brown to dark brown, becoming yellowish brown at depth. Deeply weathered, intensely oxidized, deeply leached, compact, poorly sorted loam to sandy loam till and till-like material extending from Mississippi River eastward 5–10 km into lower end of Wisconsin River valley in Wisconsin. No constructional topography. Below weathered zone, includes abundant, rounded to subangular, pebble- to cobble-size clasts, mostly dolomite, limestone, and sandstone, and a few erratics, chiefly granite and quartzite. Some stones striated. Grades eastward into outwash sand and gravel (gsq), reversed polarity of which suggests that both the gravel and till are older than the Matuyama-Brunhes magnetic polarity reversal (about 750 ka). The till is therefore probably equivalent to the Alburnett Formation, oldest till in eastern Iowa, which also has reversed magnetic polarity and underlies the Hickory Hills Till Member (tlk) and other members of the Wolf Creek Formation

tcj DISCONTINUOUS CLAYEY TILL ("residual" till of Hobbs (1987) in Minnesota)—Reddish- to dark-brown, colluvially reworked clayey sand to clay. Includes erratic, angular to subrounded pebbles and granules, mostly of quartz derived from Precambrian igneous rocks. Occurs as patches separated by numerous and extensive areas of bedrock uplands, escarpments, and valley walls. Mapped only in Minnesota. Deeply weathered, intensely oxidized, completely leached. No constructional topography. Remnants commonly occur in sinkholes and other depressions, locally in caves. Mapped areas include talus, other colluvium, and local alluvium. Precise pre-Illinoian age uncertain. In Wisconsin, northwest of the Driftless Area in the adjacent Minneapolis 4° × 6° quadrangle (Goebel and others, 1983) the Hersey (till) Member of Pierce Formation interfingers with lacustrine silt (Kinnickinnic Member) of a lake ice-dammed at the Hersey glacial maximum. This interfingering was not recognized at the time the Minneapolis quadrangle was compiled. Paleomagnetic polarity measurements of the silt indicate a reverse-to-normal transition (Baker and others, 1983), probably the Matuyama-Reunion reversal, which also occurred during a glacial maximum, rather than the Matuyama-Brunhes reversal, which occurred during an interglacial interval (D.S. Fullerton, written commun., *in* Matsch and Schneider, 1986)

QUATERNARY AND TERTIARY

zld CLAYEY SILT TO SILTY CLAY DECOMPOSITION RESIDUUM[2]—Reddish-, dark-, or grayish-brown, fine sandy silt to silty clay or clay; contains small chips of shale and fragments of limestone, chert, and sandstone. Mapped only in Missouri and Iowa. Mapped areas include bedrock exposures and locally derived colluvium on steep slopes. Residuum is discontinuously mantled by unmapped thin pre-Illinoian till (tck) or sparse erratics, and thin to thick loess (shown by overprint pattern). Thickness commonly 0.25–2 m; locally as much as 5 m

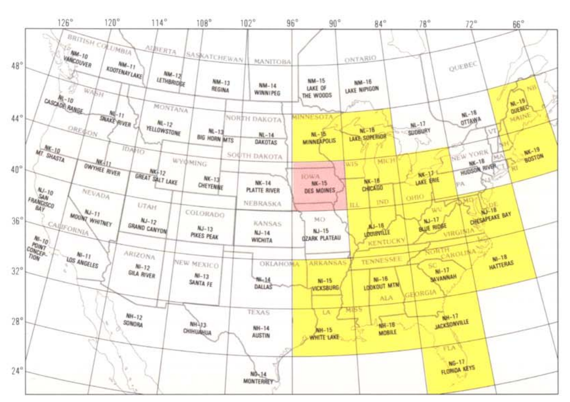
zrj SANDY TO SILTY CLAY DECOMPOSITION RESIDUUM[2] AND CLAY SOLUTION RESIDUUM[3]—Brownish yellow to dark gray. Two units not separately mappable at map scale. Sandy to silty clay decomposition residuum derived from widespread shale and lesser channel sandstone, clay, and coal; contains chips of shale and fragments of sandstone. Clay solution residuum derived from massive limestone; contains solution-surfaced limestone fragments; overlies abrupt solution surface on limestone bedrock into which it extends along fractures. Mapped only in Missouri. Locally mantled by unmapped pre-Illinoian till (tck) or erratics, and thin to thick loess (shown by overprint pattern). Thickness 0.5–3 m

rcb THIN CHERTY CLAY SOLUTION RESIDUUM[3]—Yellowish- to reddish-orange, reddish-brown to brown, or grayish-brown clay loam to silty clay loam, locally sandy clay loam containing scattered subangular to angular fragments of white, tan, black, green, or gray chert as much as 30 cm in diameter. Abrupt contact with underlying limestone bedrock. Mapped only in Missouri. Residuum locally overlain by unmapped pre-Illinoian till (tck, tlk) or outwash sand and gravel and loess (shown by overprint pattern). Thickness 0.5–10 m

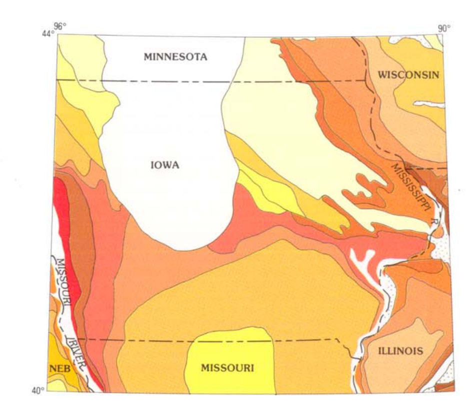
PRE-TERTIARY

R BEDROCK

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

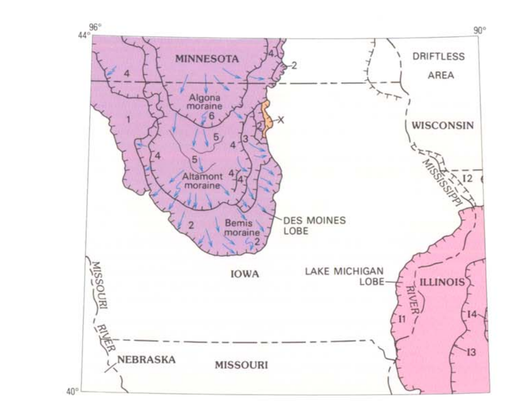


INDEX TO INTERNATIONAL MAP OF THE WORLD 1:1,000,000 TOPOGRAPHIC SERIES
Showing location of the Quaternary Geologic Map of the Des Moines 4° × 6° quadrangle in red [U.S. Geological Survey, Miscellaneous Investigations Series Map I–1420 (NK–15)] and other published maps in the Quaternary Geologic Atlas of the United States in yellow.

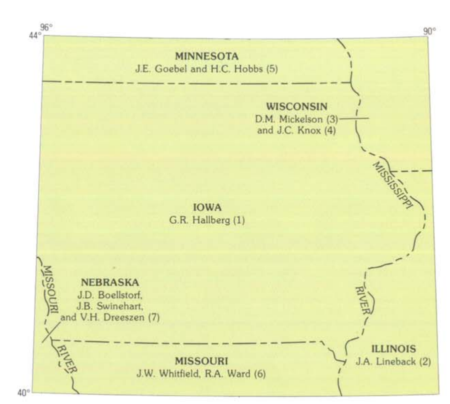


LOESS DISTRIBUTION AND THICKNESS

NEBRASKA: 0.5–1 m; 1–2 m; 2–3 m; 3–6 m; 6–9 m; More than 9 m
MINNESOTA, WESTERN AND SOUTHERN IOWA, AND MISSOURI: Less than 0.5 m; 0.5–1 m; Less than 1 m; 1–2 m; Less than 2 m; 2–4 m; 4–6 m; 6–10 m; 10–20 m; More than 20 m
WISCONSIN, ILLINOIS, AND NORTHEASTERNMOST IOWA: Less than 0.5 m; 0.5–1.5 m; 1.5–2.5 m; 2.5–5 m; 5–7.5 m; More than 7.5 m; 5–10 m; More than 10 m; Eolian sand



RELATIONSHIPS OF LATE WISCONSIN ADVANCES AND STILLSTANDS OF THE DES MOINES LOBE, AND OF ILLINOIAN SUBLOBES OF THE LAKE MICHIGAN LOBE
Letters and numbers indicate relative ages of surface tills (oldest to youngest). Des Moines lobe: x, Illinoian(?) or early Wisconsin(?); 1–6, late Wisconsin. Lake Michigan lobe: I1, I2, I3, I4, Illinoian. Hachured lines indicate limits of glacial advances and stillstands shown on Quaternary geologic map; dashed where approximately located. Arrows indicate inferred direction of late Wisconsin ice flow perpendicular to crests of washboard moraines (Gwynne, 1942).



RESPONSIBILITY FOR STATE COMPILATIONS
(1) Iowa Geological Survey
(2) Illinois State Geological Survey
(3) University of Wisconsin Department of Geology and Geophysics
(4) University of Wisconsin Department of Geography
(5) Minnesota Geological Survey
(6) Missouri Division of Geology and Land Survey
(7) Nebraska Conservation and Survey Division

NOTE: This map is the product of collaboration between State geological surveys, universities, and the U.S. Geological Survey, and is designed for both scientific and practical purposes. It was prepared in two stages. First, a separate map and map explanation of that part of each State included in the quadrangle was prepared by the State compiler. 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 edited, supplemented, and coordinated with those of other maps of this series. Diagrams accompanying the map were prepared by the editors.

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

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

For scientific purposes, the map differentiates Quaternary surficial deposits on the basis of a combination of criteria, such as lithology, texture, genesis, stratigraphic relationships, and age, as shown on the correlation diagram and indicated in the map unit descriptions. Some geomorphic features, such as end moraines, are distinguished as map units. Others, such as stream terraces, are not distinguished. Sequences of adjacent alluvial deposits of different ages commonly are too narrow to distinguish at a scale of 1:1,000,000, and most landslide deposits are too small to be shown at that scale.

For practical purposes, the map is a surficial materials map. Materials are distinguished on the basis of texture, composition, and local specific characteristics such as swelling clay. It is not a map of pedologic or agronomic soils. 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 engineering, land-use planning, or land-management maps can be derived.

LOESS STRATIGRAPHY AND THICKNESS ON WISCONSIN, ILLINOIAN, AND PRE-ILLINOIAN TILLS—Wisconsin loess is an informal stratigraphic name in Iowa

Late Wisconsin loess less than 2 m thick over older late Wisconsin and early Wisconsin(?) or Illinoian(?) till

"Wisconsin" loess and eolian sand over Sangamon or late Sangamon paleosol developed in Illinoian till or other Illinoian deposit
Loess and sand more than 6 m thick
Loess and sand 2–6 m thick
Loess and sand 2–6 m thick—Sangamon paleosol generally absent
Loess and sand less than 2 m thick

"Wisconsin" loess more than 6 m thick over Sangamon paleosol in 2–6 m of Loveland Loess (Illinoian) over Yarmouth paleosol developed in pre-Illinoian till

"Wisconsin" loess and eolian sand over "Yarmouth-Sangamon" to late Sangamon paleosol developed in pre-Illinoian till
Loess more than 6 m thick
Loess and sand 2–6 m thick
Loess 2–6 m thick
Loess 2–4 m thick, locally more than 6 m thick, with or without underlying paleosol

"Wisconsin" loess and eolian sand or loamy sediment over extensive erosion surface on pre-Illinoian till—Paleosol generally absent
Loess and minor sand more than 6 m thick
Loess 2–6 m thick
Loess or sand less than 2 m thick or loamy sediment less than 1 m thick

Correlation of surface and subsurface pre-Illinoian tills in eastern Nebraska and Iowa (modified from Hallberg, 1986) and possible equivalents in southeastern Minnesota and southwestern Wisconsin
[N, normal polarity; R, reverse polarity; R/N or N/R, transitional polarity]

NEBRASKA	NEBRASKA AND WESTERN IOWA	WESTERN IOWA	EASTERN IOWA	MINNESOTA AND WISCONSIN
		N "A1" tills: "Kansan" till of Bain (1896), Chamberlin (1896), and Kay and Apfel (1929).	N Hickory Hills Till Member of Wolf Creek Formation.	St. Charles till.
		Afton paleosol in its type area.	N Dysart paleosol.	
N Lava Creek (Pearlette O) volcanic ash bed (0.61 Ma).		N Lava Creek (Pearlette O) volcanic ash bed (0.61 Ma).		
N Cedar Bluffs Till and Clarkson Till in type areas.		N "A2" tills: "Nebraskan" till of Bain (1896), Chamberlin 1896), and Kay and Apfel (1929).	N Aurora Till Member of Wolf Creek Formation.	Unnamed till (oxidized/unoxidized).
Fontanelle paleosol.			Franklin paleosol.	
N Santee Till and Nickerson Till in type areas.		"A3" till.	N Winthrop Till Member of Wolf Creek Formation.	
			Westburg paleosol.	Unnamed paleosol.
R "Nebraskan" till of Shimek (1909).		R "A4" tills.	R Alburnett Formation (multiple unnamed tills).	R Unnamed till and associated sediments of Bridgeport Terrace.
	Unnamed paleosol.			
	R "B" tills.			
	Unnamed paleosol.			
	N Eolian and fluvial deposits.			N R Hersey (till) Member of Pierce Formation (not in quadrangle).
	R Mesa Falls (Pearlette S) volcanic ash bed (1.27 Ma).			
	N Eolian and fluvial deposits.			"Residual" till of Hobbs (1987) age unknown; probably pre-Alburnett.
	R/N Huckleberry Ridge (Pearlette B) volcanic ash bed (2.01 Ma).			
	Unnamed paleosol.			
Elk Creek Till in type area.	N/R "C" tills.			

QUATERNARY GEOLOGIC MAP OF THE DES MOINES 4° × 6° QUADRANGLE, UNITED STATES

State compilations by
George R. Hallberg, Jerry A. Lineback, David M. Mickelson, James C. Knox, Joseph E. Goebel, Howard C. Hobbs,
John W. Whitfield, Ronald A. Ward, John D. Boellstorf, James B. Swinehart, and Vincent H. Dreeszen
Edited and integrated by
Gerald M. Richmond, David S. Fullerton, and Ann Coe Christiansen
1991
QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

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