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SURFICIAL GEOLOGY

By

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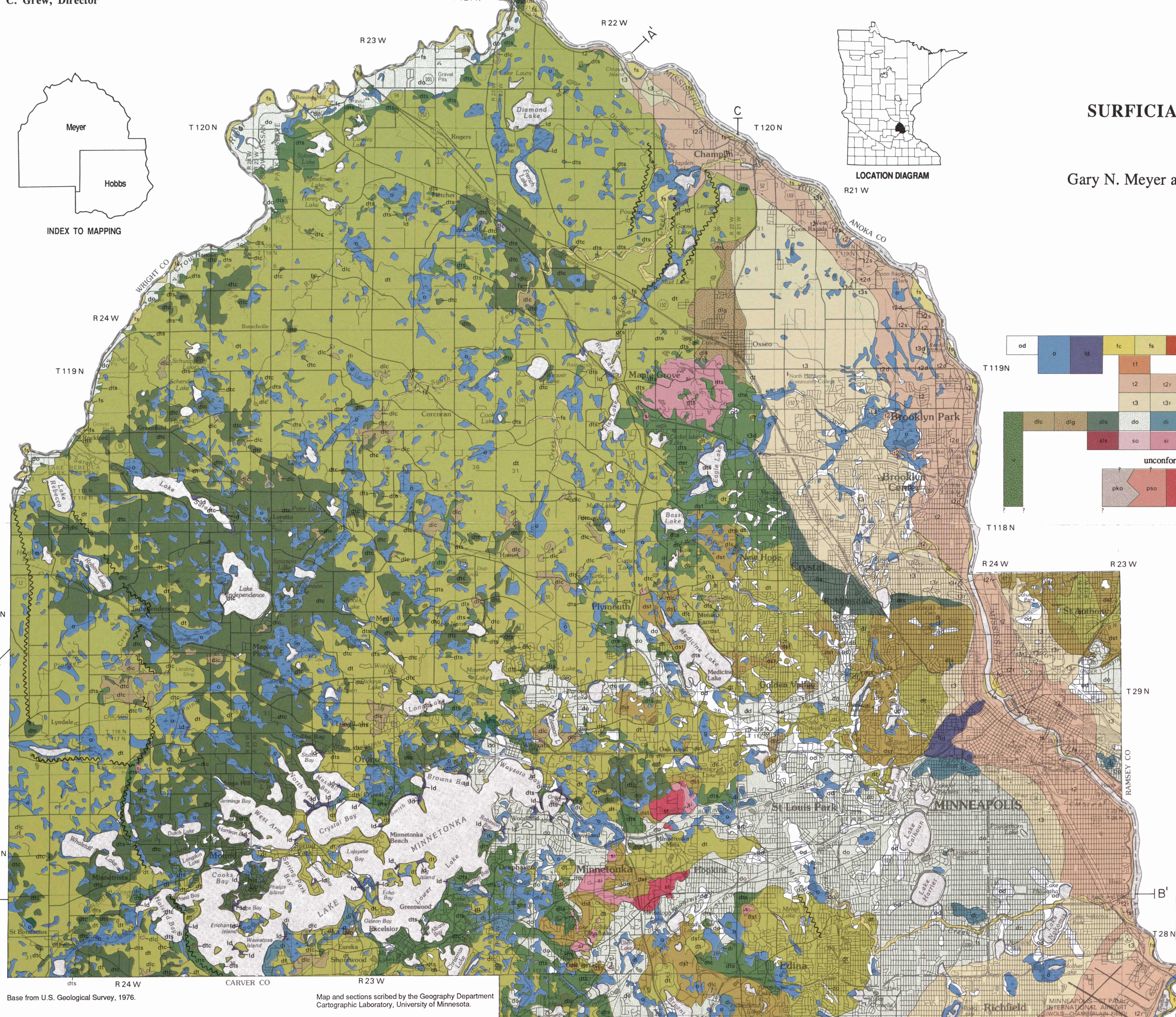
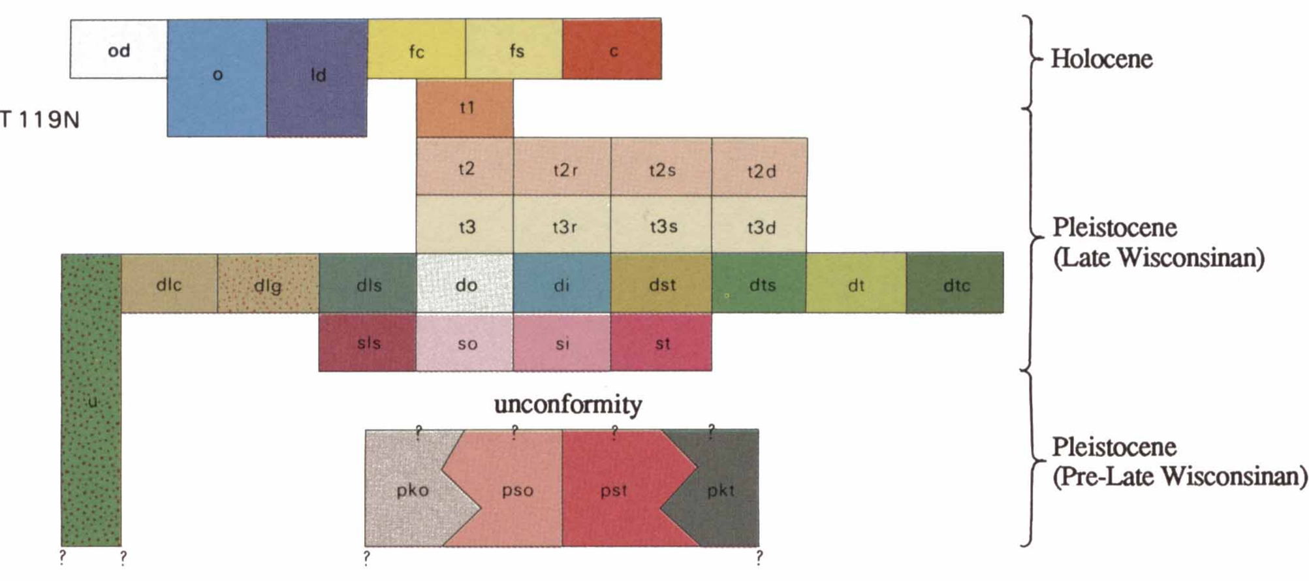
1989



Base from U.S. Geological Survey, 1976.

Map and sections scribed by the Geography Department Cartographic Laboratory, University of Minnesota.



DESCRIPTION OF MAP UNITS

POSTGLACIAL DEPOSITS

o ORGANIC DEPOSITS—Peat and organic-rich sediment; includes small bodies of open water. Many bogs are too small to show, especially within units dt and dtc

od ORGANIC DEPOSITS, DRAINED AND FILLED—Organic deposits largely removed prior to filling; includes small undrained areas. In places, too thin to show on the cross sections

ld LACUSTRINE DEPOSITS—Sand, loamy sand, and loam with local organic-rich layers; includes manmade beaches. In places overlies muck or peat. Large deposit in T. 29 N., R. 24 W. is chiefly thick clay, but is overlain by areas of thick artificial fill over peat that cannot be shown at the scale of this map. Many deposits along lakes and bogs also are too narrow to be shown. Occurs as fine-grained sediment beneath lakes but is too thin to show on cross sections

fc FLOODPLAIN ALLUVIUM (CLAYEY)—Chiefly clay and silt, commonly mixed with variable amounts of very fine sand and organic matter; overlain by thick artificial fill in developed areas. Much thicker in the Minnesota River valley than elsewhere

fs FLOODPLAIN ALLUVIUM (SANDY)—Chiefly loamy sand, sand, and gravelly sand interbedded with and overlain by thin beds of finer sediment and organic matter. Artificially filled where developed

c COLLUVIUM AND SMALL ALLUVIAL FANS—Chiefly loamy sand

TERRACE DEPOSITS

t1 LOWER TERRACE—Sand and gravel; contains zones of cobbles

t2 MIDDLE TERRACE—Sand, gravelly sand, and loamy sand; overlain by thin deposits of silt, loam, or organic sediment. Covered by thick artificial fill where heavily developed. Where terrace sand is less than 10 feet thick, modifiers d, s, and r denote underlying Des Moines lobe till, Superior lobe till, and bedrock. Boulder lags are common at contact with Superior lobe till, and where t2r is very thin, it consists mostly of boulder lag or artificial fill

t3 UPPER TERRACE—Sediment same as middle terrace but at higher elevation

DES MOINES LOBE AND GRANTSBURG SUBLOBE DEPOSITS (Twin Cities Formation)

dlc LACUSTRINE CLAY AND SILT—Laminated clay to silt generally less than 10 feet thick. Commonly overlies dt, dtc, dts, and locally dst in the eastern part of the county. Thin beds of fine silty sand to gravelly sand occur at boundaries and at or near the base in places

dls LACUSTRINE SAND AND SILT—Silt to medium sand; contains interbeds and lenses of silty clay to gravelly sand. Coarse, gravelly sand occurs locally along boundaries. Where it is thick, can include beds of loamy to sandy mudflow sediments

dlg LACUSTRINE SAND AND GRAVEL—Medium to coarse sand to fine gravel; may overlie coarser outwash sediment

do OUTWASH—Sand, loamy sand, and gravel; overlain by loess less than 4 feet thick

di ICE-CONTACT STRATIFIED DEPOSITS—Sand, loamy sand, and gravel; locally interbedded with units dts and dls, and with dst in the eastern part of the county. Cobbles and boulders commonly present

GLACIAL TILL—Unsorted sediment ranging from clay to boulders. Calcareous except for a leached zone extending a few feet below the surface. Oxidized yellowish to olive brown above unoxidized gray

dt LOAMY TILL—Chiefly loam in texture; few beds and lenses of stratified sediment. Underlain by Superior lobe stratified sediment or till generally at a depth of more than 20 feet in the eastern part of the county, and more than 50 feet in the western part. Includes small areas of thick, fine, loamy colluvium

dtc CLAYEY TILL—Loam to clay loam, with small areas of silt loam. Thin beds and lenses of shale-rich, generally fine, stratified sediment are fairly common both overlying and within the till. Shale clasts more abundant than in units dt, dts or dst. Broadly gradational with unit dt. Includes small areas of thick, fine loamy to clayey colluvium. Included in unit dt on cross sections

dts SANDY TILL—Loam to sandy loam, commonly capped by and interbedded with thin deposits of silty to gravelly stratified sediment. Commonly gradational between unit dt or dst and unit di, do, or dls. Locally patchy over thick deposits of sand and gravel. Commonly less than 20 feet thick over unit dst or st in the eastern part of the county. Includes small areas of thick loamy to sandy colluvium. Included in unit dt on cross sections

dst TILL OF MIXED COMPOSITION—Complexly intermixed yellowish-brown to gray and reddish-brown to reddish-gray, loam to sandy loam. Reddish till or stratified sediment commonly within 20 feet of the surface. Locally includes small areas of thick reddish-brown till and thick loamy to sandy colluvium. Lenses of stratified sediment, primarily sand and gravel, are common. Included in unit dt on cross sections

SUPERIOR LOBE DEPOSITS (Cromwell Formation)

si ICE-CONTACT STRATIFIED DEPOSITS—Sand, loamy sand, and gravel; locally interbedded with units st and sls. Cobbles and boulders common

st GLACIAL TILL—Reddish-brown (oxidized) to reddish-gray, sandy loam, with minor loam to silt loam. Lenses of stratified sediment, primarily sand and gravel, are commonly present

sls LACUSTRINE SAND AND SILT—Silt to medium sand; contains interbeds and lenses of silty clay to gravelly sand, including sandy mudflow sediment. Shown only on cross sections

so OUTWASH—Sand, loamy sand, and gravel. Shown only on cross sections

PRE-LATE WISCONSINAN KEEWATIN DEPOSITS

pko OUTWASH—Sand, loamy sand, and gravel. Minor lacustrine silt and clay. Includes sediment from several separate ice advances. Shown only on cross sections

pkt GLACIAL TILL—Yellowish to olive brown (oxidized) to gray; loam to clay loam; uncommon lenses of stratified sediment. Includes sediment from several separate ice advances. Shown only on cross sections

PRE-LATE WISCONSINAN LABRADOREAN DEPOSITS

pso OUTWASH—Sand, loamy sand, and gravel. Minor lacustrine silt and clay. Includes sediment from at least two separate ice advances. Shown only on cross sections

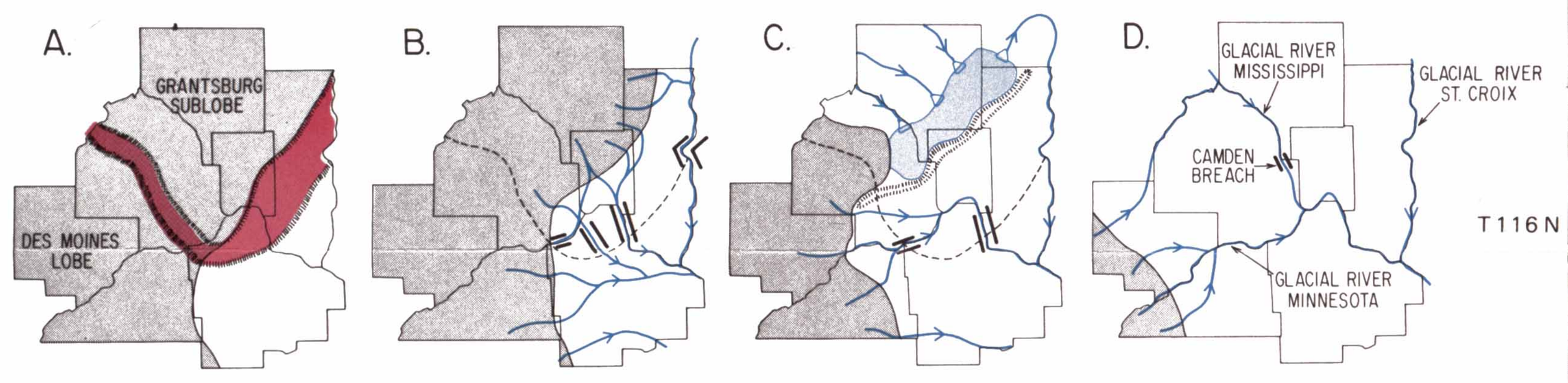
pst GLACIAL TILL—Reddish-brown to brown, sandy loam; common lenses and beds of sandy stratified sediment. Includes sediment from at least two separate ice advances. Shown only on cross sections

UNDIFFERENTIATED SEDIMENT

u DEPOSITS OF UNKNOWN AGE—Glacial till, outwash, ice-contact, and lacustrine deposits, as well as minor interglacial and preglacial deposits. Shown only on cross sections

MAP SYMBOL

Eskers—Long ridges of sand, gravel, cobbles, and boulders deposited in ice-walled channels of glacial streams. Length shown to scale; width exaggerated



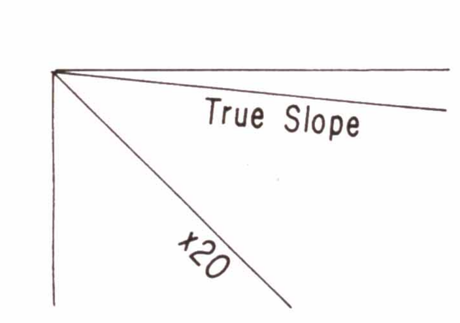
Geomorphology of the Des Moines Lobe

A. St. Croix moraine (red) and extent of Des Moines-Grantsburg ice (stippled) in the Twin Cities Metropolitan Area.

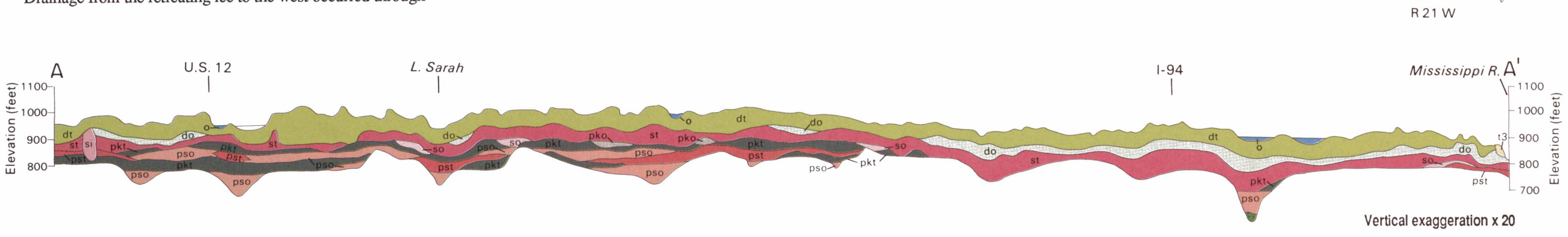
B. An early position of the retreating ice. Heavy bars show breaches cut through the St. Croix moraine.

C. Bounded to the south by a topographic highland, Glacial Lake Fridley (Stone, 1966) was fed by streams from ice fields to the north, the Crow River valley, and the Plymouth area. Its first outlet was the St. Croix valley. Drainage from the retreating ice to the west occurred through breaches in the moraine; two of these are now occupied by the Minnesota and Mississippi Rivers.

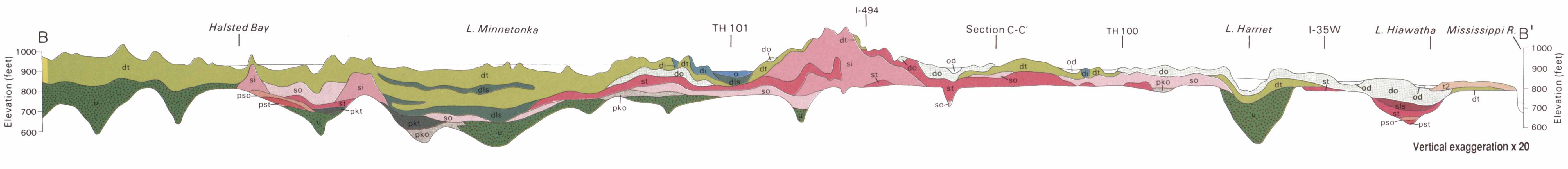
D. Stagnant ice lodged in a bedrock valley near Camden melted enough to lower the till highland, and thus opened a new outlet for Glacial Lake Fridley. This outlet drained the lake and established the Mississippi River in its present position. The upper terrace was then cut into most of the Lake Fridley plain in Hennepin County, and below the lake's outlet, into the Minneapolis outwash plain.



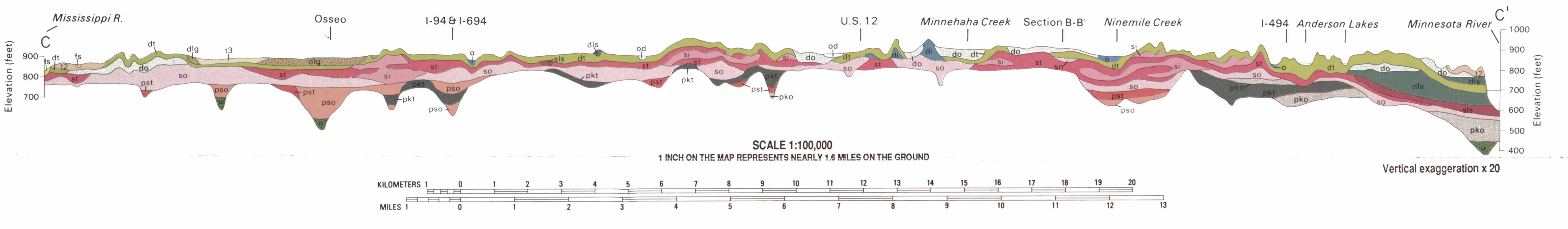
Slope exaggeration for 10 - percent slope



Vertical exaggeration x 20



Vertical exaggeration x 20



Vertical exaggeration x 20

SCALE 1:100,000
1 INCH ON THE MAP REPRESENTS NEARLY 1.6 MILES ON THE GROUND

KILOMETERS 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
MILES 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13

QUATERNARY GEOLOGY OF HENNEPIN COUNTY

Essentially the entire surface of Hennepin County is underlain by sediments deposited during the Quaternary Period, which began about 2 million years ago, and extends to the present. The Quaternary is divided into two epochs, the Pleistocene (Ice Age) and the Holocene or Recent Epoch from 10,000 years ago to the present. The continental ice sheets, which advanced and receded in response to fluctuations in global climate, originated in two source areas in northern Canada—the Keewatin ice center to the northwest and the Labradorean to the northeast. Their flowpaths crossed different rock types, and the resulting difference in sediment is useful in reconstructing Quaternary history.

Comparison of Glacial Sediments in Hennepin County

Keewatin		Labradorean
	Till texture	
loamy to clayey		sandy
	Color (oxidized)	
yellow-brown to olive		brown to reddish-brown
	Color (unoxidized)	
gray		gray-brown
	Paleozoic carbonate content	
moderate to high		low to moderate
	Dark-gray to gray-green rocks	
less common		common
	Red felsite and sandstone	
rare to absent		fairly common
	Cretaceous shale	
absent to abundant		absent

The uppermost glacial sediments in Hennepin County were laid down during the last glaciation, the late Wisconsinan (about 25,000 to 10,000 years ago). Remnants of earlier glaciations are preserved in the subsurface, particularly in the western part of the county. Sediments from at least five distinct pre-late Wisconsinan ice advances have been identified in the county. Two advances from the Keewatin ice center left tills separated by stratified sediment and zones of oxidation and leaching. These tills overlie reddish sandy till and outwash from the northeast, which in turn overlie a third clayey Keewatin till, over yet older Labradorean sediment.

Late Wisconsinan Glacial Events

Hennepin County was completely covered by ice sheets of both domains during the last glaciation. Labradorean ice of the Superior lobe carried glacial sediment of the Cromwell Formation (Wright and others, 1970) into the county. The till (unit st) is slightly less sandy than older Labradorean till, but contains much more gravel. It is progressively finer grained and contains increasing carbonate from northeast to southwest across the county, because of incorporation of older Keewatin sediment and local bedrock. This incorporation changes the color of the till from reddish brown (5YR) to brown (7.5YR); an example is well exposed in cutbanks near the mouth of Ninemile Creek in Bloomington .

Although the Superior lobe once reached across Hennepin and into Carver County, it apparently did not remain at its maximum for long, but retreated to a more stable position where it constructed the hills of the St. Croix moraine. During formation of the moraine, a subglacial meltwater stream system in extreme western Hennepin County broadly paralleled the active ice front. The resulting eskers indicate that meltwater from all along the active ice front drained into outlets to the southeast. Areas mapped si in Minnetonka are kames that formed as alluvial fans at the mouths of subglacial streams. The highest point in the county is one of these kames. The large kame complex southwest of Osseo.formed later over stagnant ice.

Much of the area inside the St. Croix moraine was flooded as meltwater was trapped between it and the retreating glacier. Sediments laid down in one such lake are exposed along the bank of the Mississippi River from north Minneapolis to north Brooklyn Park. They overlie Superior lobe till and are overlain by Grantsburg sublobe till.

While stagnant blocks of Superior lobe ice were melting, glacial ice from the Keewatin center moved into Hennepin County. This ice sheet, named the Des Moines lobe, differed in its sediment load from earlier Keewatin ice advances, in that it contained siliceous shale. With buildup of Des Moines lobe ice and concurrent melting of ice blocks within the St. Croix moraine, an offshoot of the Des Moines lobe, called the Grantsburg sublobe, eventually overrode the moraine, reaching its maximum position at Grantsburg, Wisconsin, about 16,000 years ago (Wright, 1972).

Advancing ice and meltwater of the Des Moines lobe picked up and incorporated much Superior lobe sediment. Deposits of the Des Moines lobe that include or overlie Superior lobe sediment are defined as the Twin Cities Formation (Stone, 1966). Till of mixed composition (unit dst) is common at and near the surface in the eastern part of the county, and also in the subsurface elsewhere in the lower part of the Des Moines lobe section.

After the active ice retreated to downtown Minneapolis and west of the Calhoun chain of lakes, its meltwater laid down a broad outwash plain (unit do) fed by several large streams moving across and within the stagnating ice and draining through the St. Croix moraine. All of the Minneapolis water towers are built on kames (unit di) deposited by these streams at the edge of the outwash plain.

Meltwater streams feeding the Minneapolis outwash plain crossed stagnant ice in the area now occupied by Lake Minnetonka, and joined to flow through the breach in the St. Croix moraine now occupied by Minnehaha Creek. The Eden Prairie outwash plain also was laid down at this time, but over silty sediment from an earlier lake trapped between the moraine and retreating ice. A minor readvance of the Des Moines lobe laid down a thin layer of till over the western part of the Eden Prairie outwash. The pitted character of parts of both outwash plains reflects continued melting of ice after deposition ceased and collapse of the outwash already in place. Small ice-walled lakes (unit dlc) formed on drainage divides where no outlets were available to the major meltwater streams.

With the retreat of the Des Moines lobe north of the continental divide, Glacial Lake Agassiz formed in northern Minnesota and adjacent North Dakota and Canada. Its southern outlet followed the path of Glacial River Minnesota, but has been given a separate name—Glacial River Warren—to denote its much larger size and erosive capacity.

River Warren cut its valley in stages. The first stage was the cutting of the middle terrace (unit t2) into the surface of the upper terrace (unit t3). The cutting of the lower terrace (unit t1) into the middle terrace happened when the receding falls of River Warren (Plate 4), removed the last resistant Platteville bedrock from the valley just south of Fort Snelling, and the river then cut into soft glacial deposits farther upstream.

Recent Events

The lowest level cut by River Warren is not shown on the map, because it is everywhere covered by thick alluvium (units fc and fs). When Glacial Lake Agassiz found lower outlets into Lake Superior less than 10,000 years ago, the much smaller Minnesota River was unable to carry all the sediment supplied by its tributaries. The main valley has been gradually filling in ever since, as have the valleys of the Mississippi and Crow Rivers and the various tributary streams within Hennepin County.

Postglacial lake and bog deposits began to form before glacial ice had completely melted from the county. A spruce log at the base of lake sediment that collapsed by ice-block meltout yielded a radiocarbon date of about 12,000 years before present. Deeply buried ice blocks, especially those in bedrock valleys like that below Lake Minnetonka, were insulated by overlying sediment for hundreds of years after the active ice retreated. In fact, many of these ice blocks were laid down by the Superior lobe, and remained intact for thousands of years following stagnation of the Superior lobe ice sheet. Most of the lakes and bogs in Hennepin County are in depressions created by the eventual melting of buried remnants of the two last ice advances.

Slopewash and gully erosion have removed material from the steep walls of the Minnesota River valley and deposited it as colluvium and small alluvial fans (unit c) farther down slope. Lakes and bogs are filling with sediment and organic debris (units ld and o). Human activity in places has speeded up the process (unit od).

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