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COUNTY ATLAS SERIES
ATLAS C-10, PART A
Plate 4—Quaternary Stratigraphy

QUATERNARY STRATIGRAPHY

By

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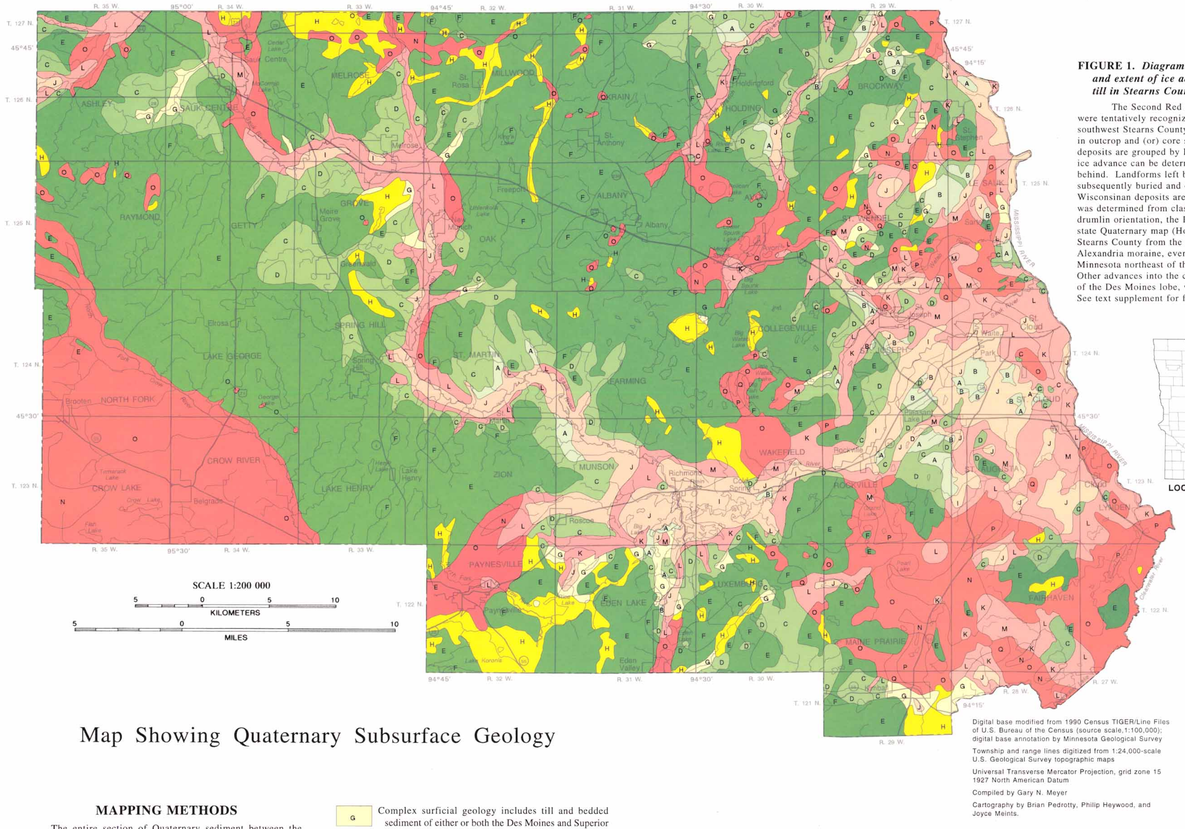
1995



Map Showing Quaternary Subsurface Geology

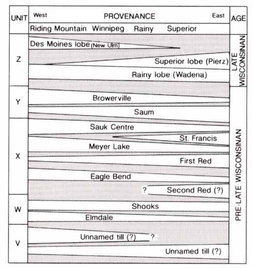


FIGURE 1. ***Diagram showing the relative timing and extent of ice advances that deposited each till in Stearns County.***

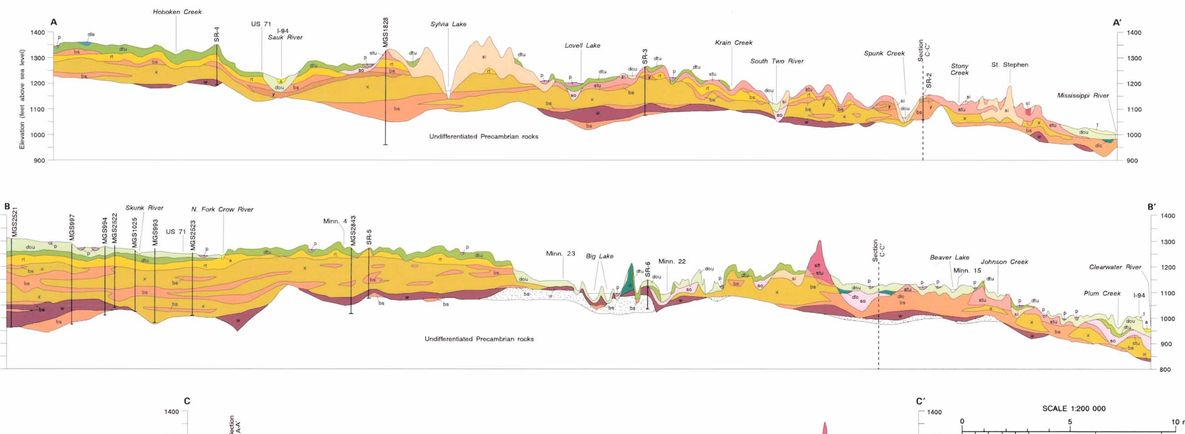
The Second Red as well as the unnamed unit **v** tills were tentatively recognized in a few cuttings sets from southwest Stearns County. All other tills were recognized in outcrop and (or) core samples. Late Wisconsinan deposits are grouped by lobe, as the general shape of each ice advance can be determined by the landforms left behind. Landforms left by earlier advances were subsequently buried and obliterated, so pre–late Wisconsinan deposits are grouped by provenance, which was determined from clast lithology. As indicated by drumlin orientation, the Rainy lobe—Wadena lobe on the state Quaternary map (Hobbs and Goebel, 1982)—entered Stearns County from the northwest, and advanced to the Alexandria moraine, even though Rainy ice entered Minnesota northeast of the county (see Fig. 1, Plate 3). Other advances into the county from the west, prior to that of the Des Moines lobe, were of Winnipeg provenance. See text supplement for further discussion.

PLEISTOCENE STRATIGRAPHY OF STEARNS COUNTY

Interpretation of outcrops, drill cuttings, and, in particular, core led to the general understanding of the Pleistocene stratigraphy of Stearns County presented in **Figure 1** and the **cross sections**. This stratigraphic classification, which has as its basis the recognition of individual glacial tills, was originally developed for the adjoining Todd County area (Meyer, 1986); it has been expanded here to include Stearns County. Stratigraphic data were not sufficient to map subsurface deposits in the county by provenance as in the surficial map (Plate 3), or to show the areal extent of individual tills. However, the general subsurface distribution of Quaternary sediment is portrayed in the Quaternary subsurface map on this plate. Special attention is given to the sand and gravel deposits of southwestern Stearns County, which have been extensively studied as aquifer systems.

In accordance with recent work in north-central Minnesota (G.N. Meyer, report in prep.), the Pleistocene section is divided into five major units. Unit **z** (**Figure 1**) encompasses deposits laid down during the last glaciation, the late Wisconsinan. Des Moines lobe deposits were the very last to be laid down, and their extent is well delineated on the surficial map (Plate 3). Superior lobe till apparently was not deposited more than a few miles beyond the Greenwald ice margin (**Figure 2**). Rainy lobe deposits once covered most if not all of the county prior to extensive erosion by the advancing Superior lobe.

Tills and related deposits of unit **y** (**Figure 1**) have been positively identified only in the northern quarter of the county (**cross sections A–A'** and **C–C'**). These deposits were probably stripped away from southern Stearns County by subsequent erosion, as they are believed to be present in the subsurface south (down-ice) of Stearns County (Meyer, 1986). The dominant subsurface Quaternary deposit across the western half of the county is the northwest-source (Winnipeg provenance) tills of unit **x** (**Figure 1**). Unit **x** tills also underlie most of those areas where till thickness generally exceeds 50 feet in the eastern half of the county. Unit **w** deposits (**Figure 1**), though not as thick or pervasive as unit **x** deposits, also underlie a significant portion of the county. Unit **v** tills (**Figure 1**) are poorly understood, as their distribution is apparently very spotty.



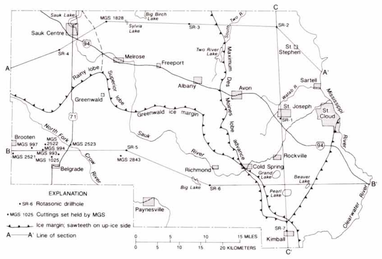


FIGURE 2. ***Map showing the lines of cross section, and the locations of test holes that yielded cuttings and core used in the construction of the sections. The locations of other subsurface data used in making the cross sections are shown on Plate 1.***

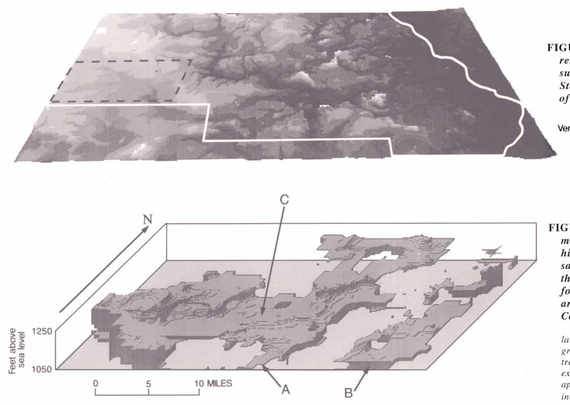


FIGURE 3. ***Oblique shaded-relief image of the land-surface topography in Stearns County. The area of Figure 4 is outlined.***

Vertical exaggeration x 5

FIGURE 4. ***Three-dimensional model showing areas with a high probability of having sand and gravel deposits in the subsurface. See Figure 3 for the location of the study area in southwestern Stearns County.***

Features A and B are largely discontinuous sand and gravel layers confined to south-trending valleys. Feature C is an extensive sand and gravel layer at approximately the 1100–1120 foot interval. See text for discussion.

MAPPING METHODS

The entire section of Quaternary sediment between the surface and bedrock is portrayed in the Quaternary subsurface geologic map. Color on the map (**Table 1**) is determined by surface sediment (Plate 3) and depth to bedrock (Plate 5). The Description of Map Units further differentiates the map units, describing the presence and position of sand and till beds in the subsurface. These descriptions are based primarily on water-well records and are supplemented with other subsurface data when available (Plate 1). The accuracy of the map in any particular area depends on the amount and quality of available subsurface data. Organic deposits and open water were ignored in constructing the map. Clayey lake sediment is not thought to constitute a significant part of the Quaternary sequence across most of Stearns County; for this reason, various "clays" described by well drillers were generally interpreted as different glacial tills. Therefore, some of the beds interpreted as tills may actually have a lacustrine origin.

TABLE 1. ***Classification of map units by color.***

		DEPTH TO BEDROCK		
		Less than 50 feet	50–100 feet	More than 100 feet
SURFACE SEDIMENT	Clayey to sandy till, lake clay			
	Till, sand-and-gravel complex	Not applicable		
	Sand to gravel			

DESCRIPTION OF MAP UNITS

A One to several tills over bedrock; generally at least one sand bed between the till and bedrock, or within the till. Sand beds exceed ten feet in thickness in places, generally where depth to bedrock is near 50 feet.

B Mostly subglacial till of the Superior lobe over bedrock; generally no intervening sand beds; unit includes bedrock outcrops and quarries. Older till may be present where depth to bedrock exceeds 20 feet.

C Upper part is mostly thick till of the Des Moines or Superior lobes; generally at least one or two tills are present below; these tills are interbedded with sand bodies that are commonly less than ten feet thick.

D Mostly till; one or two older tills below the uppermost till in most places. Sand beds are generally thin or absent.

E Upper part in most places is thick till of the Des Moines or Superior lobes; at least one sand bed thicker than ten feet at depth. Generally at least two to six, or more, tills are present below the surficial till. Multiple sand beds are common at depth, especially where depth to bedrock exceeds 200 feet. However, in some areas thick sand beds are found only at depths exceeding 100 feet.

F Three or more overlying tills; intervening sand beds are generally less than ten feet thick, and are absent in many places.

G Complex surficial geology includes till and bedded sediment of either or both the Des Moines and Superior lobes. Includes areas of thick surficial sand, thick sand below thin to thick till, and thick till(s) with thin to no sand beds. In a few places depth to bedrock is less than 50 feet.

H Complex surficial geology includes till and bedded sediment of either or both the Des Moines lobe and Superior or Rainy lobes. Includes areas of thick surficial sand, thick sand below thin to thick till(s), and, especially in areas where depth to bedrock is less than 150 feet, thick till(s) with thin to no sand beds.

I Primarily sand and gravel of Des Moines lobe outwash over bedrock; sand and gravel of Superior lobe outwash may be present in places at depth. Little or no glacial till or lake sediment is present at depth; bedrock is near the surface in a few places.

J Primarily sand and gravel of Des Moines lobe outwash over till over bedrock. The underlying till is commonly Des Moines lobe within the bounds of the advance (**Figure 2**), and is of the Superior lobe elsewhere. In places below the sand, Des Moines lobe till is thin over Superior lobe till. In the Richmond area and, possibly, elsewhere, pre–late Wisconsinan till (units **w** or **x** in the cross sections) is above the bedrock. In some areas the sand is separated from bedrock by clayey lake sediment. A thin sand bed may be present between till and bedrock, and, especially in areas where depth to bedrock approaches 50 feet, the sand bed may exceed ten feet in thickness.

K Greater than 50 feet of sand to gravel over mostly Superior lobe or older till, or lake sediment. Beds of sand generally less than ten feet thick are present between the till and bedrock in places; till is very thin to absent in some areas; includes small areas of map unit **J** in places.

L Less than 50 feet of sand to gravel over one or more beds of till or, in places, clayey lake sediment, over a sand bed that mostly exceeds ten feet in thickness.

M Less than 50 feet of sand to gravel over two or more beds of till or, in places, clayey lake sediment; generally thin to no intervening sand beds.

N Greater than 50 feet of sand to gravel over one or more beds of till or clayey lake sediment, over one or more sand beds that generally exceed ten feet in thickness.

O Less than 50 feet of sand to gravel over one or more beds of till or clayey lake sediment, over one or more sand beds that generally exceed ten feet in thickness.

P Greater than 50 feet of sand to gravel over two or more beds of till or, in places, clayey lake sediment; generally thin to no intervening sand beds.

Q Less than 50 feet of sand to gravel over multiple beds of till and, in places, clayey lake sediment; generally thin to no intervening sand beds.

SURFICIAL AND BURIED SAND AND GRAVEL DEPOSITS OF SOUTHWESTERN STEARNS COUNTY

The southwestern corner of Stearns County is covered by a broad outwash plain that was deposited by meltwater streams from the Des Moines lobe near the end of the late Wisconsinan glaciation (**Figure 3**). The plain extends into adjacent counties to the west and south and is bordered on the north and east by the North Fork of the Crow River. Surface drainage is toward the southeast. Surficial sand and gravel deposits in the area vary in thickness from 10 to 20 feet in the northeast, to 40 to 60 feet in the southwest. Two hundred to over 400 feet of Pleistocene sediment that was deposited during repeated glacial advances and retreats lies beneath the surface outwash. The underlying bedrock surface is incised by several south-sloping valleys. Each glaciation eroded some of the previously deposited glacial material and added new deposits. Glacial deposits consisting of till interlayered with sand and gravel beds eventually filled the bedrock valleys and the surrounding uplands. A few sand and gravel beds are as thick as 60 feet, but most are much thinner.

Geostatistical methods were used to analyze and display the two- and three-dimensional distribution of buried sand and gravel in southwestern Stearns County. The results were compared to those of an earlier hydrogeologic investigation of the same area by the U.S. Geological Survey (Delin, 1990). In the U.S. Geological Survey study a series of vertical cross sections that divided the sand and gravel deposits into identifiable layers was developed, but the study did not offer a depositional history of the study area. **Figure 4** presents the estimated three-dimensional distribution of buried sand and gravel and shows how the sand and gravel may have been deposited and eroded over time. It indicates more connections between sand and gravel deposits than actually exist. Water-well records and cuttings samples from various drilling projects (Wolf, 1976; Delin, 1990; Southwick and others, 1990) indicate that the subsurface sand and gravel layers are largely discontinuous and are confined in places to south-trending valleys (*features A and B*, **Figure 4**). However, a distinct sand and gravel layer around the 1100–1120 foot interval appears to be extensive in the northern half of the area (*feature C*, **Figure 4**; unit **bs** in **cross section B–B'**). Cuttings samples and stratigraphic position associate this layer with the Sauk Centre and Meyer Lake tills of cross section unit **x** (**Figure 1**), which underlie most of western Stearns County. The 1100-foot sand and gravel layer indicates that the southwestern corner of the county was the site of a broad outwash plain, not only during the late Wisconsinan, but also during at least one earlier glaciation.

This study area of southwestern Stearns County shows the significant influence that pre-glacial bedrock topography and drainage patterns had on subsequent glacial deposition and drainage, and the contribution of many glacial episodes to the complex depositional and erosional history of the area.

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EXPLANATION TO CROSS SECTIONS

UNITS FROM THE SURFICIAL MAP—See Plate 3 for a detailed description of units.

- **p** Peat.
- **a** Alluvium.
- **t** Terrace deposits.
- **dlc** Lake clay (Des Moines lobe).
- **dls** Lake sand (Des Moines lobe).
- **di** Ice-contact deposits (Des Moines lobe).
- **sl** Lake sand (Superior lobe).
- **so** Outwash (Superior lobe).
- **si** Ice-contact deposits (Superior lobe).
- **stl** Thrust complex (Superior lobe).

UNITS MODIFIED FROM THE SURFICIAL MAP.

- **dou** Outwash (Des Moines lobe)—Map units **do** and **dot** from Plate 3.
- **dtu** Till (Des Moines lobe)—Map units **dc, dtp, dt, dst, dsc,** and **drt** from Plate 3.
- **stu** Till (Superior lobe)—Map units **sc, stp,** and **st** from Plate 3.

UNITS ON THE CROSS SECTIONS ONLY.

- **rt** Rainy lobe till (**Figure 1**; Wadena till)—Chiefly sandy loam textured, unsorted sediment, with pebbles, cobbles, and boulders. Sand and gravel lenses are generally uncommon. This unit may be more widespread in eastern Stearns County than portrayed in the cross sections owing to the difficulty of distinguishing it in well logs from Superior lobe till (unit **stu**).
- **bs** Bedded sediment—Chiefly sand to gravel, but includes clay and silt beds in places, especially where the unit is thick. Where above pre–late Wisconsinan deposits (**Figure 1**), it commonly includes sediment laid down by meltwater issuing from the Superior and (or) Rainy lobes.
- **y** Winnipeg-provenance Browerville till (common carbonate, rare to uncommon shale clasts) over Rainy-provenance Saum till (rare red felsite and sandstone clasts)—Only the Saum till has been identified in the western portion of Stearns County.
- **x** Winnipeg-provenance Sauk Centre, Meyer Lake, and Eagle Bend tills (abundant carbonate, absent to rare shale clasts) interbedded with Superior-provenance St. Francis, and First and Second Red tills (common red felsite and sandstone clasts)—The Superior-provenance tills in general compose a minor part of the unit, except in the northeast and eastern parts of the county. Where the unit is thin it may include till of only one provenance.
- **w** Winnipeg-provenance Elmdale till (uncommon carbonate, rare to uncommon shale clasts) overlain in a few places by Rainy-provenance Shooks till (rare red felsite and sandstone clasts)—This unit may include in a few places at depth older "unit **v**" tills of both Winnipeg (abundant carbonate clasts) and Superior provenance (**Figure 1**).
- Cretaceous rocks—Described on Plate 2.
- Precambrian rocks, undifferentiated—Early Proterozoic and Archean rocks; described on Plate 2.

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