UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
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COUNTY ATLAS SERIES
ATLAS C-24, PART A
Sibley County
Plate 4—Quaternary Stratigraphy

INTRODUCTION

This Quaternary Stratigraphy plate shows the unconsolidated materials expected to be encountered between the land surface and bedrock surface in Sibley County (cross sections A through E). Outcrops, auger samples, split spoon samples, drill core, drill cuttings, water-well drillers' logs, and bridge boring logs (Sibley County Public Works, 2008) were used to interpret the stratigraphy as shown on the cross sections. The surficial units that appear in the cross sections are similar, but not identical to those mapped and described on the surficial geologic map on Plate 3, *Surficial Geology*. Peat (unit Qp), the silty cap (unit Qz), and colluvium (unit Qco) are too thin to show in cross section. Sandy units including alluvium (units Qa and Qhb), alluvial fan deposits (unit Qf), terrace deposits (unit Qat), and outwash (units Qs, Qsc, Qsb) are combined into one unit (ss) for the purpose of modeling. Finer-grained lake sediments (units Qhl and Qll) are combined with the surface till for the purpose of the sand-distribution models (Plate 5) and are shown as unit sc on the printed cross sections. Glacial units that are mapped based on their geomorphic expression (for example hummocky, moraine, washed) are combined by geologic formation and represented as a single unit on the cross sections (see unit descriptions for a list of map labels). Deeper units appear only on the cross sections.

Key stratigraphic control points, such as rotary-sonic drill holes completed by the Minnesota Geological Survey and analyzed cuttings sets collected by the Minnesota Department of Natural Resources (Berg and Pearson, 2011), are differentiated on the cross sections and have an associated unique number on file at the Minnesota Geological Survey. Interpreted logs of the three rotary-sonic cores are shown in Figures 1 through 3. Their locations are shown on Figure 4. Some water-well drillers' logs and cuttings samples collected from sites outside the county were used for interpretation because they were near the county border and provided significant detailed stratigraphic control. These drill sites are not shown on the cross sections, but are included in the digital file data. Drill holes, represented by vertical lines, may start above or below the land surface because the data are projected onto the cross section from a distance of up to 0.3 mile (0.5 kilometer). Vertical exaggeration is 50x for all cross sections.

DESCRIPTION OF CROSS SECTION UNITS

ss **Sand and gravel**—Includes modern and Pleistocene stream sediment. Extremely small surficial deposits are not differentiated from unit sc *(units* Qhb, Qf, Qa, Qs, Qsc, Qsb, *and* Qat *from Plate 3)*.

sc **Silt and clay**—Includes modern and Pleistocene lake sediment. Extremely small surficial deposits are not differentiated from unit ss (*units* Qhl *and* Qll).

New Ulm Formation—Yellow-brown to dark gray, sandy loam to clay loam tills and bedded sediments of northwestern (Riding Mountain) provenance associated with the Des Moines lobe.

uht ***Heiberg Member*** *(includes mapped units* Qt, Qth, Qtc, Qtm, Qts, *and* Qtw*)*—Loam to clay loam till. Shale clasts generally compose from 35 to 45 percent of the very coarse-grained (1-2 millimeters) sand fraction (Table 1, Fig. 5). In places, the Heiberg Member is split into an upper (uht) and lower (*ht*) unit that may be separated by a thin silt or sand layer. This discontinuity is interpreted to represent the retreat of the ice depositing Villard Member till and expansion of the ice bearing Heiberg Member till into that area (Fig. 6). The till above and below the discontinuity is not noticeably different in texture or lithology.

sh ***Sand and gravel above unit ht.***

ht ***Heiberg Member***—Till as above; this lowermost Heiberg Member unit is interpreted to have been deposited by ice advancing at the same time as the ice that deposited the Villard Member of the New Ulm Formation (Fig. 6; see Plate 3, Fig. 2). The separate ice lobes advanced from slightly different source areas and the resulting glacial deposits, although very similar, may be distinguished by their matrix texture and rock fragments contained in the 1-2 millimeter very coarse-grained sand fraction (Table 1, Fig. 5). The contact between the Heiberg Member and the underlying Villard Member is variable and may include layers of sand and gravel or silt, as well as mixed or alternating layers of the two tills.

sv ***Sand and gravel above unit* vt.**

vt ***Villard Member*** *(includes mapped units* Qvh, Qvc, Qvm, *and* Qvw*)*—Loam to sandy loam till; shale clasts generally compose from 15 to 25 percent of the very coarse-grained (1-2 millimeter) sand fraction (Table 1, Fig. 5).

Sand and gravel above unit mt.

sm **mt** ***Moland Member*** *(included in mapped unit* Qc*)*—Sandy loam till; may be dense. Shale clasts generally compose from 2 to 12 percent of the very coarse-grained (1-2 millimeter) sand fraction (Table 1, Fig. 5). Without laboratory analyses this unit is difficult to distinguish from the older Traverse des Sioux Formation. In cross sections, the Moland Member of the New Ulm Formation and the Traverse des Sioux Formation may be combined.

Traverse des Sioux Formation *(included in mapped unit* Qc*)*—Yellow-brown to gray, dense, sandy loam till of north/northeastern (Winnipeg/Rainy) provenance. This unit was sampled in outcrop and in rotary-sonic drill cores SC-1 (Fig. 1) and SC-3 (Fig. 3). Without laboratory analyses this unit may be difficult to distinguish from the overlying Moland Member of the New Ulm Formation. In cross sections, these units may be combined. Exposed in places at the surface along the Minnesota River valley bluffs and along larger tributaries to the Minnesota River.

st **tt** ***Sand and gravel above unit tt.***

Sandy loam till—Shale clasts are rare or absent in the very coarse-grained (1-2 millimeter) sand fraction (Table 1, Fig. 5).

Henderson Formation and other Superior-source tills *(included in mapped unit* Qc*)*—Red-brown to red-gray sandy loam till of northeastern (Superior) provenance. This unit was interpreted from drillers' descriptions of color in a few water wells and sampled in rotary-sonic drill core SC-1 (Fig. 1). It is also exposed and was sampled in gullies along the Minnesota River valley and its tributaries. The full extent of the Henderson Formation is unknown because the exposures are thin and discontinuous and commonly too small to be shown in cross section. Evidence suggests that there may be multiple Superior-source red tills that occur above or below the Browerville, Good Thunder, and older formations (Plate 5, Fig. 1). Where multiple red units are exposed or sampled, the texture and lithologic character is similar (Table 1) even though they are separated by a completely different till (for example SC-3; Fig. 3). In well logs, red units may be identified by the driller's description of red sediment. However, it is impossible to determine which of the many red units might be present. For the purpose of sand modeling, red till units are numbered 1 through 3 from the top down as they are encountered. Where additional information is available, red units may be assigned a number based on the interpretation of the surrounding stratigraphy.

sr **rt** ***Sand and gravel above unit rt.***

Sandy loam till—Red, volcanic rocks and sandstones are common; few to common amounts of carbonate rock fragments are present (Table 1).

Browerville Formation *(included in mapped unit* Qc*)*—Yellow-brown to gray, dense, loamy till of northern (Winnipeg) provenance. This unit was encountered and sampled in only one outcrop and recognized in cuttings in a few water wells. Till of the Browerville Formation is extensively preserved in central Minnesota (Knaeble and Meyer, 2007; Meyer and Gowan, 2010), but in Sibley County it is thin and discontinuous. It is unclear whether the Browerville Formation is older or younger than the Henderson Formation because these units have not been found in stratigraphic contact.

sb **bt** ***Sand and gravel above unit bt.***

Loam till—Carbonate is common along with some Cretaceous shale, dark, tabular limestone, and fossil fragments, as well as abundant monomineralic quartz grains (Table 1).

Good Thunder formation tills *(included in mapped unit* Qc*)*—Yellow-brown to gray, dense, loam-textured till of northern (Winnipeg) provenance; may be interbedded with some Rainy provenance tills. These tills generally have high carbonate and small amounts of gray shale (Table 1). There are at least four tills identified as part of the informal Good Thunder formation (SC-2; Fig. 2). For the purpose of sand modeling, these tills are numbered 1 through 4 from the top down as they are encountered. Even though all four identified units are similar in texture and grain content, distinctions can be made. Unit *gt1* has some gray shale fragments, and the others have trace amounts. Unit *gt3* is finer-grained. These units likely correlate at least in part with the Lake Henry and Eagle Bend formations of central Minnesota (Johnson and others, in press). In places, the Good Thunder formation tills are separated by red, Superior-source tills described above (Table 1; Plate 5, Fig. 1).

sg1 ***Sand and gravel above unit gt1.***

gt1 ***Loam till***—Abundant carbonate rock fragments; some gray shale.

sg2 ***Sand and gravel above unit gt2.***

gt2 ***Loam till***—Abundant carbonate rock fragments.

sg3 ***Sand and gravel above unit gt3 (and below unit gt2).***

gt3 ***Loam to silt loam till***—Abundant carbonate rock fragments.

sg4 ***Sand and gravel above unit gt4 (and below unit gt3).***

gt4 ***Loam till***—Abundant carbonate rock fragments.

suu **Unknown units**—Subsurface units separated by sands on water well records.

ups ***Sand and gravel***—Encountered in isolated water wells within undifferentiated sediment.

Undifferentiated Pleistocene sediment—This unit includes all sediment below the lowermost identified till unit. Although some water wells extend below this boundary, the data are too few and far between to make meaningful correlations.

CROSS SECTION SYMBOLS

Geologic contact—Approximate. Dots along the bottom of the cross section denote bedrock contacts where they touch surficial units. Unit labels appear as depicted on Plate 2, *Bedrock Geology*.

Drill hole—The top of the drill hole symbol may not coincide with the cross section surface elevation line because some drill holes are located near (within 0.3 mile [0.5 kilometer]) but not on the cross section line and therefore may have a slightly different surface elevation. Some Minnesota Geological Survey unique well numbers are given.

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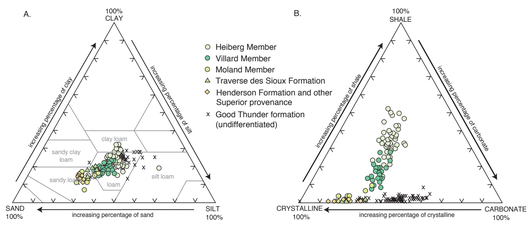

Figure 5. Ternary diagrams showing (A) matrix texture (less than 2 millimeter size fraction) and (B) composition of the very coarse-grained (1 to 2 millimeters) sand fraction in samples from the rotary-sonic cores in Sibley County (Figs. 1, 2, 3).

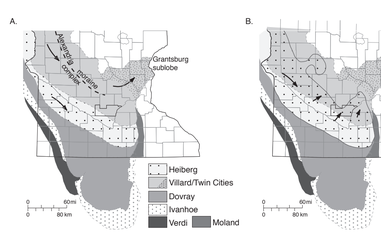

Figure 6. A. Early distribution of the Villard and Heiberg Member tills (from Lusardi and others, 2011). Not all units are present in Sibley County; older, buried units are not listed.

B. Subsequent distribution of the Villard and Heiberg Member tills as the Villard Member ice source diminished and the Heiberg Member ice spread into the area. The area where Heiberg Member till overlaps Villard Member till is both shaded and stippled (from Lusardi and others, 2011). Not all units are present in Sibley County; older, buried units are not listed.

QUATERNARY STRATIGRAPHY

By

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2012

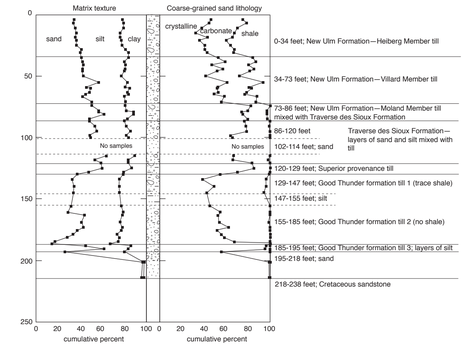

Figure 1. Sibley County rotary-sonic core SC-1 (shown on Fig. 4). Sampled at T. 114 N., R. 26 W., sec. 4, elevation 989 feet above sea level; Minnesota Geological Survey unique number 270326.

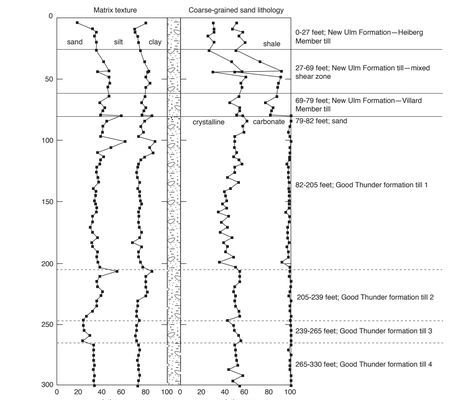

Figure 2. Sibley County rotary-sonic core SC-2 (shown on Fig. 4). Sampled at T. 114 N., R. 31 W., sec. 16, elevation 1,074 feet above sea level; Minnesota Geological Survey unique number 270327.

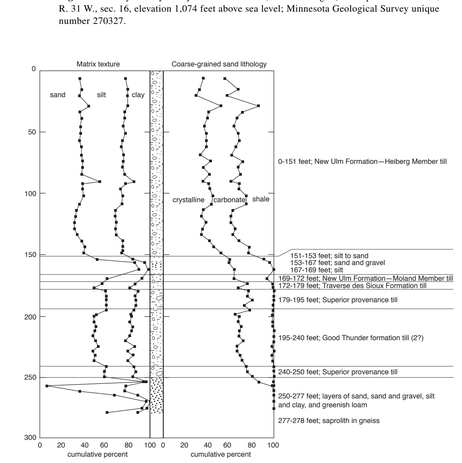

Figure 3. Sibley County rotary-sonic core SC-3 (shown on Fig. 4). Sampled at T. 112 N., R. 31 W., sec. 36, elevation 1,051 feet above sea level; Minnesota Geological Survey unique number 270331.

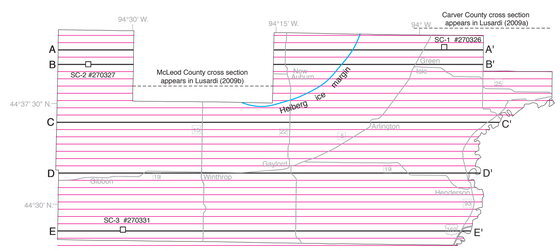

Figure 4. Location of the 30 cross sections, constructed at regular 0.6-mile (1-kilometer) intervals, used to create a three-dimensional model and sand layer model (Plate 5, *Sand Distribution Model*) of the Quaternary deposits of Sibley County. Cross sections A through E appear on the this plate. The blue line represents the unit boundary that corresponds to the interpreted margin of ice that deposited the Heiberg Member of the New Ulm Formation. Boxes denote the location of rotary-sonic cores. Cross section lines match those from both McLeod (Lusardi, 2009b) and Carver (Lusardi, 2009a) counties. Correlative sections are noted.

Table 1. Average values for the texture and composition of till units (listed in stratigraphic order) recognized in Sibley County. Matrix texture (less than 2 millimeter grain-size fraction) is expressed as relative proportions of sand, silt, and clay in percent. The lithologic composition of the very coarse-grained sand fraction (1 to 2 millimeters) is expressed in percent as relative proportions of crystalline rock, carbonate rock, and shale fragments. The crystalline fraction is further subdivided by rock type—light (granite and gneiss), monomineralic quartz, dark (mafic-rich igneous and metamorphic rocks), and red (rhyolite, agate), and the relative proportion of gray shale to total Cretaceous fragments.

		MATRIX TEXTURE				CLAST TYPE									
		Percentage of the less than 2 millimeter fraction				Percentage of total grains counted of the 1-2 millimeter fraction				Percentage of total crystalline grains counted					
Deposit description and geologic units	Total number of samples	Gravel (percentage of total sample weight)	Sand	Silt	Clay	Total number of samples	Precambrian crystalline rock fragments	Carbonate rock fragments	Cretaceous shale	Light	Dark	Red	Clear quartz	Gray shale/total Cretaceous (percent)	
New Ulm Formation deposits (Riding Mountain)															
Heiberg Member till	255	5	38	38	24	255	38	26	36	91	9	0	12	96	
Villard Member till	155	7	44	36	20	155	49	30	21	91	9	0	14	94	
Moland Member till	50	8	48	35	17	50	62	29	9	87	12	1	14	91	
Traverse des Sioux Formation till (Winnipeg/Rainy)	49	11	54	32	14	49	74	25	1	78	17	5	15	39	
Browerville Formation till (Winnipeg)	1	2	24	55	21	1	65	8	27	88	12	0	53	3	
Henderson Formation till (Superior)	20	10	59	25	16	19	81	19	0	64	22	14	19		
leached						1	100	0	0	49	27	14	13		
Good Thunder formation till 1 (Winnipeg)	76	5	37	40	23	76	47	48	5	88	11	1	14	52	
Red Superior-provenance till	6	9	60	27	13	6	77	22	1	68	19	13	10		
Good Thunder formation till 2 (Winnipeg)	59	5	38	40	22	59	57	42	1	88	11	1	16	47	
Red Superior-provenance till	2	11	59	27	14	2	78	22	0	58	25	17	13		
Good Thunder formation till 3 (Winnipeg)	9	4	29	45	26	9	50	49	1	89	11	0	11	41	
Good Thunder formation till 4 (Winnipeg)	17	6	32	41	27	17	52	47	1	85	15	0	10	44	

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