Analysis of the Merden Lake Esker, Stearns County, Minnesota: A New Interpretation

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ABSTRACT

A gravel pit in south central Stearns County, Minnesota exposes sand and gravel of the Merden Lake esker which is thought to have been deposited by a subglacial stream associated with the Wisconsinan-aged Superior Lobe of the Laurentide ice sheet. An analysis of these sediments was conducted from samples collected through a vertical trench on an east-facing exposure of the gravel pit. A total of 12 distinct stratigraphic horizons were recognized. Each horizon was described in terms of overall color, grain size, and lithology, carbonate content, and sedimentary structures. A total of 436 clasts (>3 cm) were collected for lithology studies. Trench samples were collected across each horizon for grain size sieve analysis. Clasts were dominated by basalt (37.6%), granite (28.2%), gabbro (14.5%), quartzite (6.2%), diorite (3.5%), mica schist (3%), and andesite (1%). Minor components consisted of pisolitic claystone, shale, sandstone, limestone, dolostone, ironstone, bauxite, quartz, agate, and amethyst. The sedimentology provides an overall color of yellowish-orange to brown. Many of the large clasts (>5 cm) contained a rind of calcareous-cemented course sand. Several large (18-35 cm) armored clay balls were collected from the basal horizon. Grain size ranged from boulders (up to 37 cm in diameter) to clays. Average cobble size was 10.48 cm. The dominant grain size through the trench was 1-2 mm. Sedimentary structures included graded beds, minor cross bedding, and imbrication. Superior Lobe lithologies are dominated by red volcanics and sedimentary rocks from the Middle Proterozoic Keeweenawan Superior Group and have an overall brown to reddish-gray appearance. Rainy (Wadena) Lobe lithologies are dominated by Precambrian igneous and metamorphic rocks from southwest Ontario and northwest Minnesota and have an overall yellowish to yellow-brown appearance. Sedimentological analysis of the Merden Lake esker indicates its characteristics are more consistent with subglacial stream deposition within the Pierz Sublobe of the Rainy Lobe of the Laurentide ice sheet.

I. INTRODUCTION

Minnesota is well known for its many lakes, most of them formed as a result of Pleistocene glaciation. Many other glacial and fluvioglacial features can be found across the Minnesota landscape, including moraines, drumlins, kames, and eskers. Several well-formed eskers can be observed in south central Minnesota. Eskers are classic linear, fluvioglacial features and generally show a close correspondence with the most recent direction of regional ice movement [1]. Eskers can form beneath ice which is still active, but esker preservation is most likely when formed beneath dying or inactive ice. The presence of eskers indicates free melt water drainage toward the glacier margin, and deposition occurs as flow velocities are falling. Several well-formed eskers can be observed in south central Minnesota. The Merden Lake esker is a ~1.5 km long, sinuous ridge that begins in the very SW 1/4 of Section 19, T124N, R29W and trends southwest through the NW 1/4 of Section 30, T124N, R29W and terminates in the NE 1/4 of Section 25, T124N, R30W, Avon, Minnesota 7.5 minute-quadrangle (Stearns County, Minnesota) where it wraps around the southern

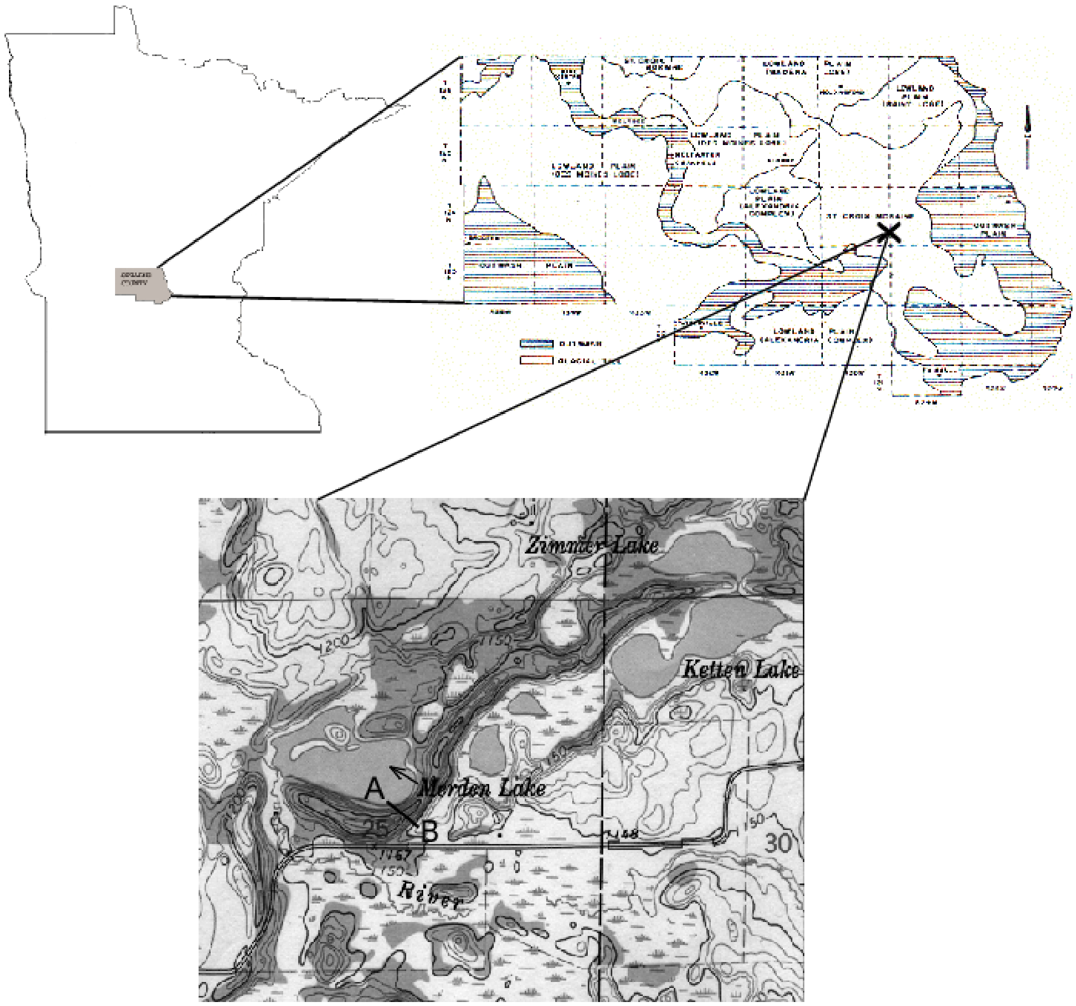

Figure 1. Maps showing the location of the Merden Lake esker in Stearns County, Minnesota, USA. The county map (top right) shows general glaciation. The topographic map (bottom) shows relief of the esker and the cross-sectioned region that was used for excavation.

shore of Merden Lake (Figure 1). The esker is approximately 24 m high at its maximum elevation above the surrounding terrain, with till capping the sand and gravels of the esker; it is 121 m wide at its maximum width near the terminus. The terminus of the esker is being excavated for sand and gravel and provides access for the present study.

II. METHODS

A 1.5 m wide, and 5.7 m deep vertical trench was hand excavated down a cross-sectional face of the esker in an inactive portion of the quarry (Figure 2). Due to safety concerns the vertical trench was excavated near the margin of the esker (side B). Consequently, every stratigraphic horizon was likely not sampled. Each horizon in the trench was described in the field and sampled for lithologic and grain-size analysis. Each horizon was shoveled into a single sample bag and individual clasts were sampled from each horizon. The color of each horizon was determined using a Geological Society of America Rock-Color chart. A total of 436 clasts greater than 3 cm in diameter were collected for lithologic description. Grain-size analysis was conducted by dry sieving sediment using (-2.0Ø, -1.0Ø, 0.0Ø) standard brass sieves.

Figure 2. Photograph of the esker as viewed from the southwest. A-B corresponds to the label on the topographic map in Figure 1. The trench marker corresponds to a trench depth of ~5 m. For scale, author Aaron Hirsch is standing on a graveled slope midway up the esker face.

III. GLACIAL HISTORY OF STEARNS COUNTY

During the Pleistocene, the Laurentide ice sheet covered all of Canada and most of the northern U.S. including Minnesota (Figure 3). The ice sheets that advanced into Minnesota from Canada came from two distinct areas of Canada: the Keewatin, to the northwest and the Labrador, to the northeast. During the late stages of the Pleistocene, two lobes advanced into Minnesota from the Labrador sector. These were the Rainy (Wadena) Lobe and the Superior Lobe [2]. Ice from the Rainy Lobe advanced from the north – northeast, but more specifically it came from the area around Rainy Lake in southern Ontario. The Superior Lobe advanced from the east – northeast, centering on the Superior basin now occupied by Lake Superior. The Rainy lobe was the first to advance into Stearns County in the late Wisconsinan, 25,000 years ago [2]. Advance of the Superior Lobe followed shortly thereafter and began to push westward into the retreating Rainy Lobe. According to Meyer and Knaeble [2], the Superior Lobe advanced into the eastern portions of Stearns County, Minnesota. Melting along the ice margin resulted in the formation of the Merden Lake esker at ground level. With the final retreat of the Superior Lobe, the newly formed esker laid out across the landscape as an approximately 1.5 km long, 24 m high sinuous ridge.

IV. DISCUSSION

Studies by Schneider [3] characterize the till of the Cromwell Formation (Pierz Till) in Stearns County as being browner and containing fewer Precambrian sandstone clasts than the tills of the Superior Lobe east of Stearns County. Hobbs and Goebel [4] and Meyer [5] assigned the sediments across the north central part of the county to the Pierz Till of

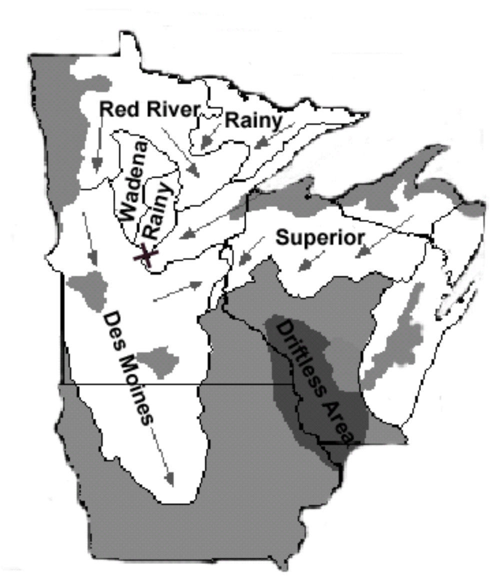

Figure 3. Glacial movement during the Wisconsinian in Minnesota. (Adapted from Anonymous, 1993, figure 2 [2]). “X” marks the area of study.

Hobbs and Goebel [4] and Meyer [5] assigned the sediments across the north central part of the county to the Pierz Till of the Rainy Lobe while Mooers [7, 8] suggests a closer affinity of the Pierz Till to the Superior Lobe because (1) the north side of the Superior lobe did not encounter as much of the red Precambrian rock that gives the lobe's deposits the typical reddish brown color, (2) the lobe's deposits were diluted by the incorporation of older, underlying Pleistocene deposits, and (3) the orientation of the Pierz drumlins along with lithologic similarities. More recent studies by Meyer and Knaeble [2] characterize the Rainy Lobe sediments as a yellow to yellowish-brown till with clasts of black Precambrian basalts and gabbros not associated with Superior basin volcanism and containing only minor Precambrian sandstones.

Anderson [9] points out that variation in clast lithology from place to place is real and cannot be erased and that clast counts greater than 100 do not increase accuracy beyond a few percent. In spite of Anderson's findings, for this study a total of 436 clasts were collected and separated according to lithology (see Table 1). Basalt (37.62%), granites (28.21%), and gabbro (14.45%) dominated the clast lithologies, with metamorphics (9%), sandstone (1%), and iron formation (1%) making up a lesser percentage. A widely mixed lithology, including diorite, limestone, andesite, shale, and dolostone, makes up about 9.1% of the clasts. Clasts counts for the Pierz till of the Rainy Lobe in Morrison County northeast of the study area were made by Arneman and Wright [10] and their data show the following percentages: basalt-gabbro-diabase (41%), granites (19%), metamorphic (13%), sandstone (3%), and iron formation (3%). Stone counts as reported by Arneman and Wright [10] from the Superior till in Morrison County have the following average percentages: basalt-

	Fs[a]	Rr[b]	Mafics	Ss[c]	Gr[d]	Meta[e]	If[f]	Ls/Ds[g]	Chert
Superior Till									
Average[1]	12	4	34	15	14	16	4		1
Rainy Till									
Average[1]	17	8	51	1	9	13	1		
Pierz Till									
Average[1]	17	3	41	3	19	13	3		1
Brainerd Till									
Average[1]	18		31	4	26	16	3		2
17 Pierz and Brainerd Till									
Average[2]	12		27	1	27	27	6		
Merden Lake Esker									
Average	1	1	56	1	28	9	1	1	

Table 1. Average cobble counts from different tills from Stearns County. Cobble counts of the Merden Lake esker (this study) are included for comparison. [a]Fs=Felsics, [b]Rr=redrock, [c]Ss=Sandstones, [d]Gr=Granites, [e]Meta=Metamorphics, [f]IF=Iron formation, and [g]Ls/Ds=Limestone/Dolostone. Data from: [1]Arneman and Wright [10] and [2]Schneider (as reported by Arneman and Wright [10]).

Horizon	Horizon Thickness	Color	Average Cobble Size	Sedimentology	Calcareous
Z1	55 cm	Dark Yellowish-Orange	6.8 cm	Clay -Fine Sand	Slight
Z2	42.5 cm	Moderate Yellowish-Brown	6.52 cm	Medium Sand	No
Z3	30 cm	Medium Yellowish-Orange	X	Clay	Yes
Z4	70 cm	Medium Yellowish-Orange	7.8 cm	Sandy Cobble	Yes
Z5/Z6	60 cm	Moderate Yellowish-Brown	7.67 cm	Gravelly Sand	Yes
Z7	15cm	Light Yellowish-Brown	X	Sand	Yes
Z8	35 cm	Pale Yellowish-Brown	9.9 cm	Sandy Cobble	Yes
Z9	64 cm	Medium Yellowish-Brown	11 cm	Sandy w/ Cobbles	Yes
Z10	11.5 cm	Medium Orange-Red Brown	5.48 cm	Cobble	Yes
Z11	30 cm	Light Yellowish-Brown	4.933 cm	Gravelly Sand	Yes
Z12	42 cm	Grayish Orange-Brown	8.16 cm	Gravelly Sand	Yes
Z13	X	Moderate Yellowish-Brown	15.38 cm	Cobble/Boulder	Yes

Table 2. Description of each recognized horizon in the trenched portion of the Merden Lake esker. X = no data. See associated Figure 5 for a visual reference.

gabbro-diabase (34%), sandstone (15%), granite (14%), metamorphic (16%), and iron formation (4%). A sedimentological analysis of the esker found 12 lithologically different layers based on the sedimentology and grain size. The overall color of the esker sediment was yellow to yellow-brown (Table 2). This till color more closely resembles the Rainy Lobe than the Superior Lobe, which has an overall brown to reddish-gray color. The sedimentology also revealed a unique grain-size distribution.

The lower layers have a much larger overall grain and cobble size than the layers that are towards the top. This correlates well with what is known about subglacial esker formation. Large grain sizes (coarse sand) and cobbles are found “upstream” in the glacier while small grain sizes (fine sands and clays) are found “downstream” in the glacier. Since eskers are relatively stable structures under the glacier this pattern of the grain sizes shows a retreat of

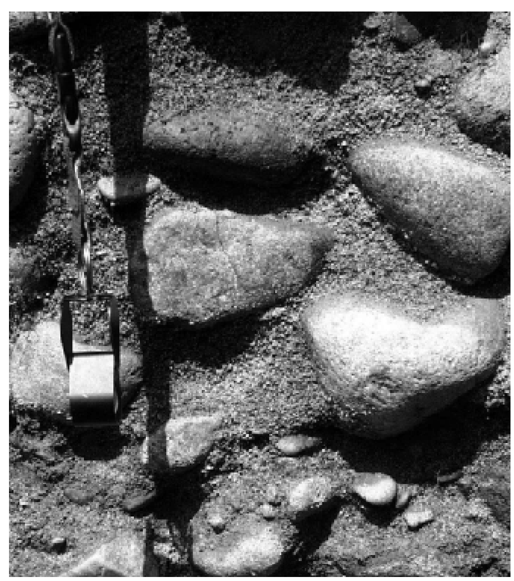

Figure 4. View of matrix supported cobbles, typical of the middle to lower portions of the Merden Lake esker. Note the cobble imbrication. A hand lens is used for scale.

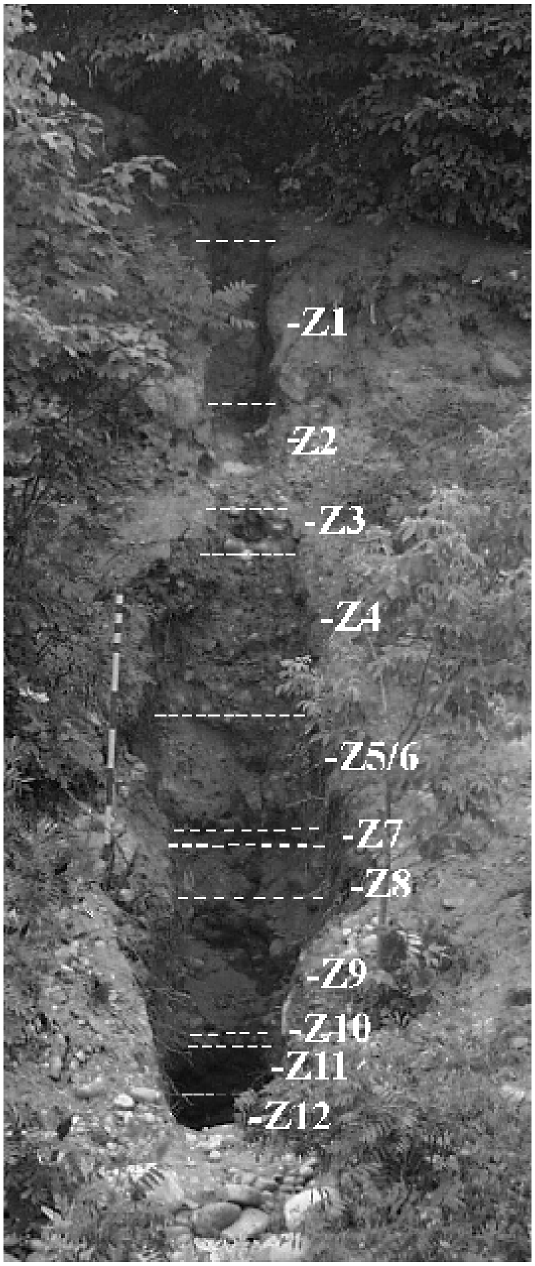

Figure 5. View of the trenched portion of the esker, showing the recognized horizons.

the glacier relative to the esker. Other aspects of the esker that show fluid motion include imbricated cobbles (Figure 4), poorly cross-bedded sands, and matrix-supported gravels.

V. CONCLUSIONS

Overall, the sediments examined in this investigation are distinctly yellow to yellowish-brown in color, similar to the color of the Rainy Lobe sediments. Darker colored basalts and gabbros dominate clasts in the Merden Lake esker, with only a minor occurrence of sandstones. Analysis of clasts in this study correspond well with the percentages outlined by Arneman and Wright [10] and Schneider [3] and are dissimilar to the clasts of the Superior till as reported by Arneman and Wright [10]. According to Embleton and Sissons (in Sugden and John, 1976 pg. 329 [1]) eskers are features which generally show a close correspondence with the most recent direction of the regional ice movement. Therefore it is concluded that ice movement was in a southwestward direction, and that the Merden Lake esker has a closer affinity with the Rainy Lobe than the Superior Till. However, whether or not it is Pierz Sublobe Till or not is debatable. The esker's formation was associated with the melting along the ice margin of the northeast retreating Rainy Lobe.

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