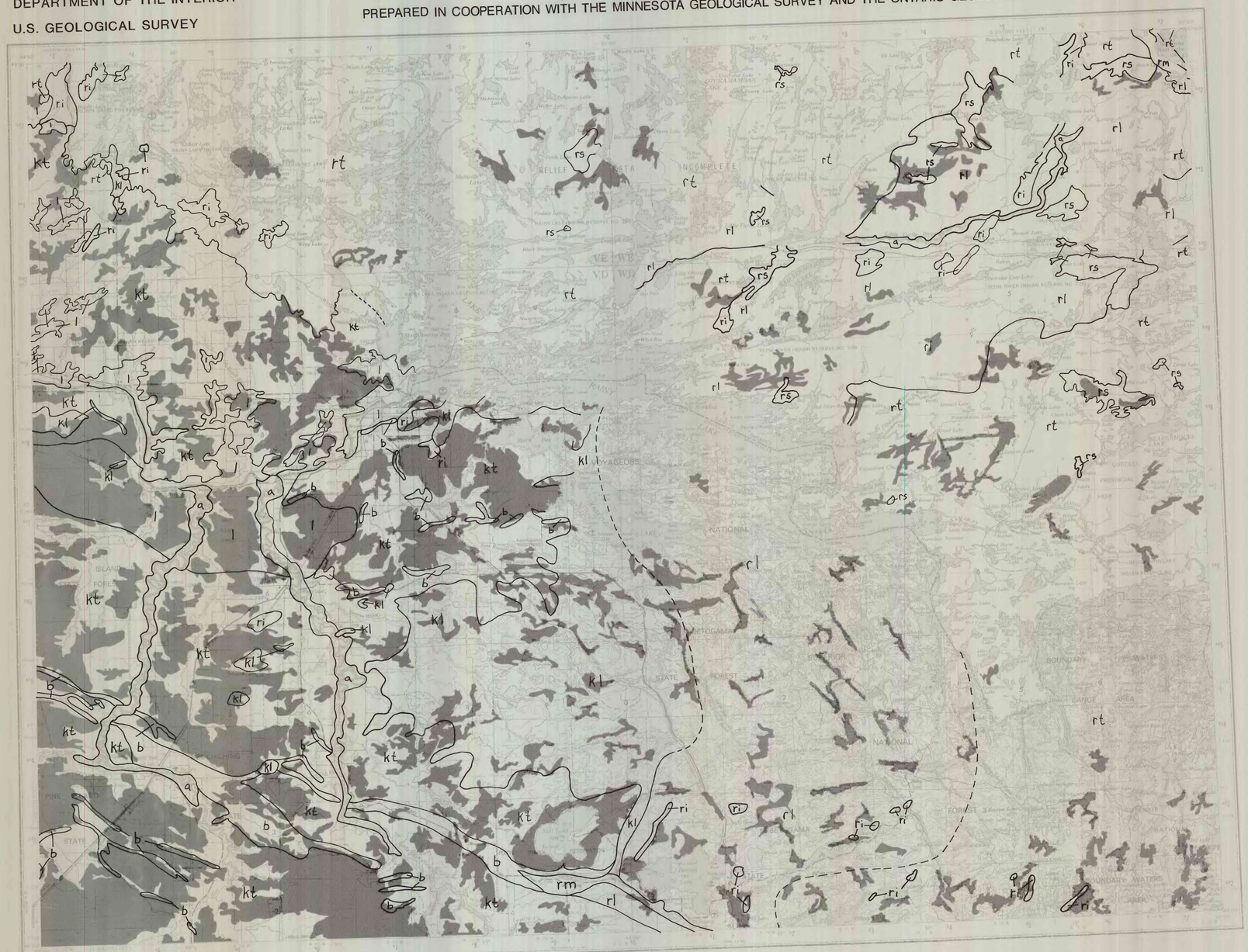
DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE MINNESOTA GEOLOGICAL SURVEY AND THE ONTARIO GEOLOGICAL SURVEY



Base from U.S. Geological Survey, 1954

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

5 0 5 10 15 Nautical Miles

TRANSVERSE MERCATOR PROJECTION

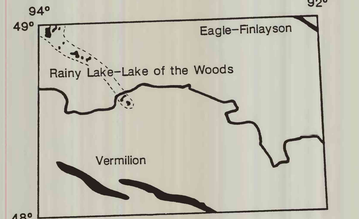
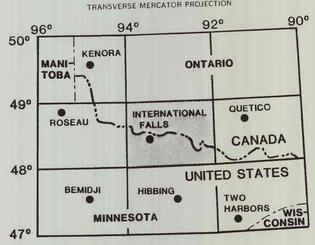


Figure 1. Glacial moraine deposits produced by the Rainy lobe. The Vermilion moraine was buried by Koochiching lobe deposits, then re-exposed by Lake Agassiz. The Rainy Lake–Lake of the Woods moraine, represented by ice-contact deposits, was deposited during the final advance of the Rainy lobe. The Eagle-Finlayson moraine was deposited during the final retreat of the Rainy lobe.



LOCATION DIAGRAM

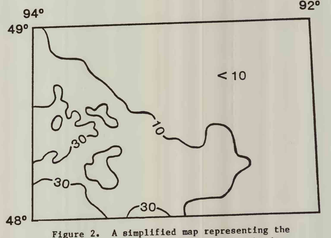


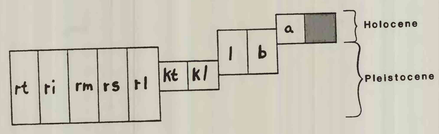
Figure 2. A simplified map representing the regional distribution of average overburden thickness. Contour intervals are 10, 30, and 60 meters. It is not uncommon to find bedrock outcrops in areas having an average overburden thickness of 30 meters or less.

Reconnaissance Quaternary Geology Map of the International Falls 1° X 2° Quadrangle

By

R.J. Horton, G.N. Meyer, and A.J. Bajc

CORRELATION OF MAP UNITS



UNIT DESCRIPTION

rt (Late Pleistocene) Till deposited as ground moraine by the Rainy Lobe. This till is composed of loose, unsorted stony material in a sandy matrix. The matrix portion of the till, generally 50% of the volume, is predominately sand with some silt and clay. The stony portion of the till is composed of angular, subangular and subrounded material ranging in size from pebbles to boulders. The composition of the stony portion was derived almost entirely from Precambrian rocks of local origin. Occasional Paleozoic pebbles are thought to originate from the Hudson Bay area (Zoltai, 1961). Within the quadrangle, this unit ranges in thickness from a thin veneer to over 20 meters.

ri (Late Pleistocene) Glaciofluvial ice-contact deposits, deposited against the Rainy lobe ice. These deposits, composed of stratified poorly sorted sand and gravel, were formed in direct contact with the melting glacier. The ice-contact deposits located between International Falls, Minnesota and the northwest corner of the map are part of the Rainy Lake–Lake of the Woods terminal moraine complex (figure 1), deposited during the final advance of the Rainy lobe (Bajc, 1987). Many other ice-contact deposits exist within units mapped as **rt**, **rl**, and **kl**, however, it is not possible to delineate these deposits due to insufficient information.

rm (Late Pleistocene) Glacial moraine deposits, produced during standstills of the Rainy lobe. Two prominent moraine features are located within the mapped area (figure 1). These moraines form long, relatively narrow ridges composed of poorly stratified Rainy lobe till. The Vermilion moraine, located in the south central portion of the map, was partially overridden by the Koochiching lobe then reexposed by Glacial Lake Agassiz (Norvitch, 1962). The Eagle-Finlayson moraine, located in the northeast corner of the map, formed during the final retreat of the Rainy lobe.

rs (Late Pleistocene) Undifferentiated sand and gravel deposits. These glaciolacustrine and glaciofluvial deposits are composed of stratified, well sorted sand and gravel, that was transported by meltwater streams flowing from the Rainy lobe. Depending on the local depositional environment, this outwash material was deposited as glacial lake sediment, underflow fan deposits, ice-contact deposits, or gently sloping outwash plains. These deposits are generally located in areas dominated by bedrock outcrops, where the overburden thickness is relatively thin and discontinuous.

rl (Late Pleistocene) Glaciolacustrine sediment overlying Rainy lobe till or bedrock, deposited in the proglacial lakes which fronted the Rainy lobe. Discontinuous clayey sediment covers about one third of the mapped units; the remaining area, particularly at the higher elevations, are characterized by thin patches of Rainy lobe till. Unit thickness varies from less than 1 to over 30 meters thick.

kt (Late Pleistocene) Till deposited by the Koochiching lobe. This grey, fine grained calcareous till is predominately composed of silt and clay containing small amounts of stony material. The silt and clay portions of the till were derived from glaciolacustrine sediments deposited in front of the advancing ice-sheet then reincorporated into the till as the glacier overrode them. The stony portion of the till, usually less than 15%, consists of angular, subangular, and subrounded material ranging in size from pebbles to boulders. Stony composition ranges from Precambrian rocks of local origin to sedimentary rocks of Paleozoic and Mesozoic age derived from the northeastern flank of the Williston Basin. Deposited as ground moraine, this unit is generally more than 15 meters thick but thins to less than 3 meters at its eastern boundary where it overlies Rainy lobe till or bedrock. This unit is commonly overlain by lacustrine sediment less than 2 meters thick. A drill hole in the vicinity of Lindford, Minnesota, indicates the unit can obtain a thickness of up to 50 meters.

kl (Late Pleistocene) Clayey calcareous till and/or lacustrine sediment derived from the Koochiching lobe. Generally less than 3 meters thick, this unit was deposited over Rainy lobe till or bedrock in the proglacial lake which fronted the Koochiching lobe.

l (Late Pleistocene to Holocene) Lacustrine sediment deposited in the deeper parts of Glacial Lake Agassiz. These deposits consist of massive to laminated, calcareous clay and very fine sand and silt. The clay is the dominant component. These sediments are generally less than 2 meters thick, but can range up to 6 meters in thickness.

b (Late Pleistocene to Holocene) Beach and nearshore sand and gravel deposits marking the shorelines of Glacial Lake Agassiz. These long, relatively narrow deposits range from less than 3 to more than 15 meters thick. Composed of sand or sand and gravel, these deposits were primarily derived from reworked Koochiching lobe till. However, the extensive southeast trending deposits that extend from Big Falls to Nett Lake, Minnesota, appear to be a reworked extension of the Vermilion moraine (figure 1) which was buried by Koochiching lobe till. Beach deposits may extend below peat lands in areas mapped as Koochiching lobe till.

a (Holocene) Alluvium located along recent flood-plains bordering rivers and streams. This unit usually consists of a basal sand or sand and gravel layer overlain by silt loam to silty clay loam, however, either member may be absent. Thickness ranges from less than 1 to 8 meters. Only major alluvium deposits are shown on the map, minor deposits occur along many rivers and streams.

Peat (Holocene) Peatlands composed of partially decomposed plant matter in shallow, poorly drained basins. Deposits are commonly less than 2 meters thick, ranging from less than 1 to 10 meters.

INTRODUCTION

This map was produced by the U.S. Geological Survey in cooperation with the Minnesota Geological Survey and the Ontario Geological Survey, as part of the International Falls Conterminous United States Mineral Assessment Program (CUSMAP). The map was compiled from existing soil, engineering, and surficial geology maps, supplemented with additional data collected by the authors. This map is designed to be used as a reconnaissance guide to the distribution of Quaternary deposits within the quadrangle.

Quaternary surficial deposits, composed of glacial till, glaciofluvial and glaciolacustrine sediments, flood-plain alluvium, and peat, unconformably overlie Precambrian bedrock within the mapped area. Throughout the Pleistocene this area was extensively glaciated by numerous glacial advances. The surficial deposits observed represent only the area's last glacial events.

GLACIAL HISTORY

Within the International Falls quadrangle, Quaternary deposits of late Wisconsin and Holocene age are the product of the advances of two lobes of the Laurentide ice sheet. At most times and places, within the mapped area, these lobes were fronted by proglacial lakes. The areas oldest glacial deposits were produced by an advance of the Rainy lobe. Glacial striations indicate this lobe advanced from the northeast, spreading out from the Labradorian ice center located in Quebec and Labrador (Johnson, 1915). Noncalcareous till and glaciofluvial deposits are associated with this advance.

The next advance was by the Koochiching lobe (Martin and others, 1989), spreading out from the Keewatin ice center located northwest of Hudson Bay (Johnson, 1915). Calcareous till was deposited by this advance, which came from the west and north as shown by glacial striations. During the advance and subsequent retreat of the Koochiching lobe, glaciolacustrine sediments were deposited in a proglacial lake which fronted the ice sheet.

The final glacial advance was a readvance of the Rainy lobe from the northeast. The terminal moraine of this advance is marked by several ice-contact deposits in the northwest quarter of the mapped area. Locally, deglaciation began with a retreat of the Rainy lobe to the northeast corner of the mapped area where it stopped for a considerable length of time forming the Eagle-Finlayson moraine (Zoltai, 1961). Meltwater, dammed by the Koochiching lobe to the northwest and the Rainy lobe to the northeast, formed Glacial Lake Agassiz. Lacustrine sediments were deposited over much of the mapped area.

The lake level dropped in stages, creating numerous shoreline and beach deposits, as successively lower outlets were created by melting ice and erosion by lakewater discharge. As the water level receded, wave action passed across the lake plain, eroding large areas down to bedrock, leaving isolated pockets of sediment and till. Peat bogs formed in shallow, undrained depressions and over large flat-lying portions of the lake plain with insufficient grade to efficiently drain precipitation.

Glacial overburden ranges in thickness from less than 1 to greater than 60 meters (figure 2). The northeast half of the quadrangle is dominated by bedrock outcrops. Here, overburden consists of a thin discontinuous veneer of till; however, it is not uncommon to find 30 meters or more of sediment filling narrow valleys between bedrock exposures. The overburden is thinnest in the northeast part of the quadrangle, increasing in thickness to the southwest. This distribution is attributed to the regional northeast-to-southwest slope of the bedrock surface, which exposed the higher northeast portion to more erosion and less deposition.

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