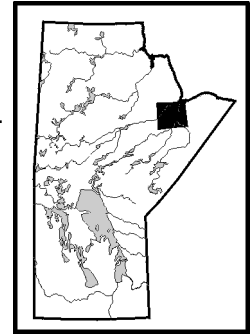


GS-24 QUATERNARY STRATIGRAPHY AND ICE-FLOW HISTORY ALONG THE LOWER NELSON, HAYES, GODS AND PENNYCUTAWAY RIVERS AND IMPLICATIONS FOR DIAMOND EXPLORATION IN NORTHEASTERN MANITOBA
by E. Nielsen



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SUMMARY

During the 2002 field season, 144 till and 3 alluvial sand and gravel samples were collected from 17 sections exposed in river cuts in the Hudson Bay Lowland of northeastern Manitoba. The 2002 survey was undertaken to outline the Quaternary stratigraphy and determine the ice-flow history and till provenance in the Hudson Bay Lowland of Manitoba in support of diamond exploration. Specifically, the 2002 survey was undertaken as a follow up to the 2001 survey immediately to the south of this area. The 2001 survey suggested that kimberlite indicator minerals were concentrated in Long Spruce till of northern provenance. The objectives of the 2002 survey will be met using a combination of pebble analysis, carbonate analysis, matrix geochemistry, textural analysis, kimberlite indicator-mineral analysis and pebble-fabric analysis.

Preliminary interpretation of the till fabric data suggests the lower part of the Long Spruce till was deposited by ice flow towards the southwest whereas the upper part of the Long Spruce till was deposited by south-southeasterly ice flow. The overlying Sky Pilot till, which forms the surface till throughout northeastern Manitoba, was deposited by southwesterly ice flow.

INTRODUCTION

Quaternary sections in the Hudson Bay Lowland of northeastern Manitoba expose multiple tills, interglacial sediments and a variety of postglacial sediments, including glaciofluvial sand and gravel, glaciolacustrine silt and clay, marine silt and clay, and Holocene fluvial sand and gravel. The oldest till in the Hudson Bay Lowland of Manitoba, the Sundance till, was deposited by ice flow towards the southeast. The next oldest till, the Amery till, is attributed variously to southeasterly and southwesterly ice flow, based on pebble-fabric measurements (Nielsen et al., 1986; Nielsen and Fedikow, 2002). Amery till is overlain by interglacial Nelson River sediments. Nelson River sediments and Amery till are stratigraphically overlain by Long Spruce till deposited by south-southwesterly ice flow. Sky Pilot till, the youngest till in the area, outcrops at the surface throughout northeastern Manitoba. Pebble fabrics of Sky Pilot till indicate southwesterly ice flow.

In the 2001 kimberlite indicator-mineral survey of seven Quaternary sections in the northern Superior Province and adjacent Hudson Bay Lowland, 21 kimberlite indicator minerals (KIM) were recovered from the 69 till and 2 gravel samples (Nielsen and Fedikow, 2002). The 18 Amery till samples from that survey produced no KIM. The 17 Long Spruce till samples contained 14 KIM, whereas the 34 Sky Pilot till samples contained only 2 KIM. The two Holocene gravel samples contained 5 KIM. KIM were concentrated in Long Spruce till and were probably derived from unknown source(s) to the north or north-northeast. The source(s) of KIM may be an unknown bedrock source or an older buried glacial dispersion or preglacial alluvial dispersion train. The KIM in the Sky Pilot till and Holocene gravel samples have been reworked from the underlying Long Spruce till (Nielsen and Fedikow, 2002).

OBJECTIVES

Fieldwork in the summer of 2002 was undertaken to the north of the 2001 survey area (Fig. GS-24-1) to

- 1) test the conclusion that KIM are concentrated in the Long Spruce till;
- 2) more precisely determine the provenance of the Long Spruce till;
- 3) determine the source(s) of KIM detected in the 2001 survey; and
- 4) obtain additional information on the Quaternary stratigraphy and kimberlite indicator mineral distribution in the Hudson Bay Lowland and adjacent areas of northeastern Manitoba.

The objectives of the survey will be met using a combination of pebble analysis, carbonate analysis, matrix geochemistry, textural analysis, kimberlite indicator-mineral analysis and pebble-fabric analysis.

METHODS

Helicopter-supported fieldwork was undertaken during a four-week period in July using Gillam as the central

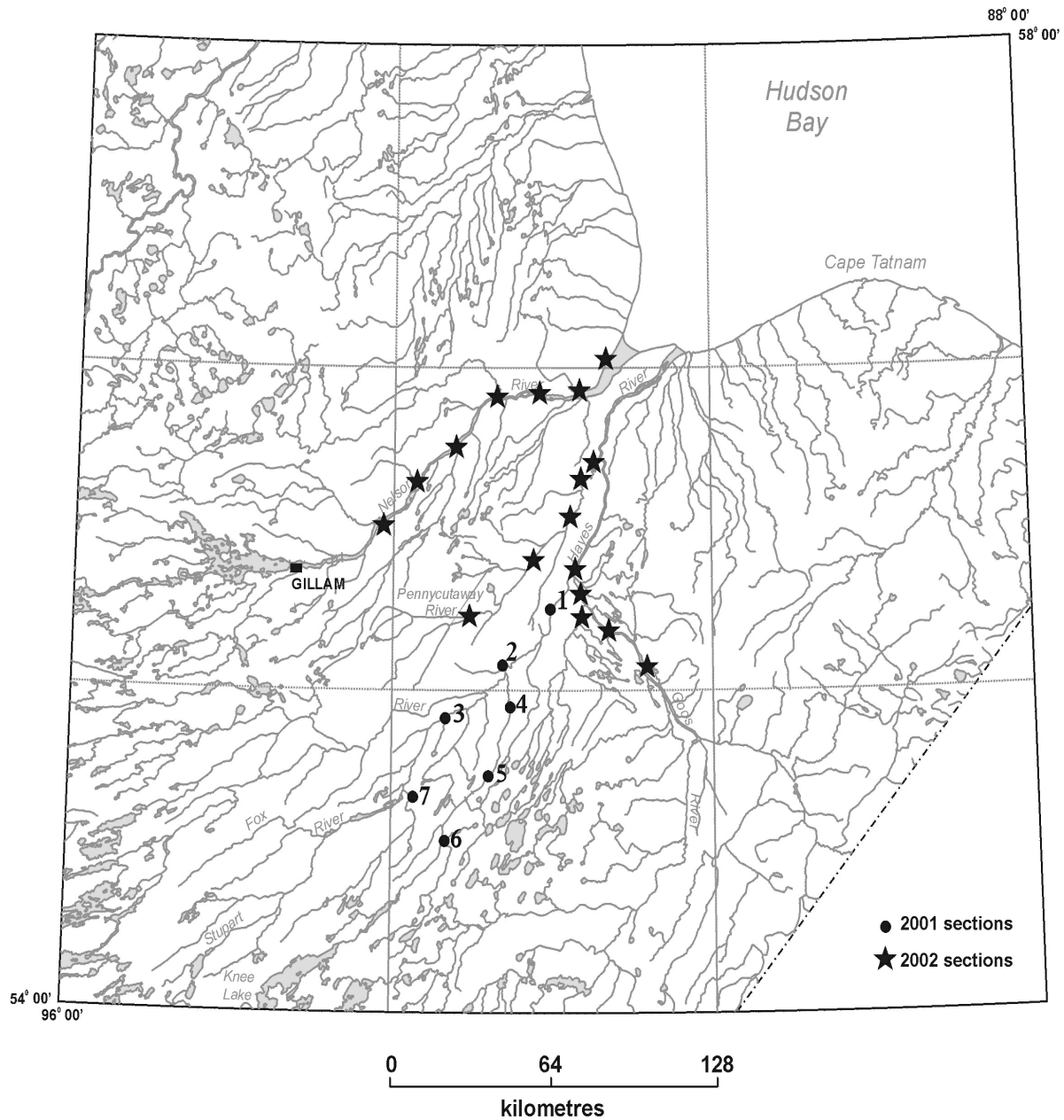


Figure GS-24-1: Location of sections investigated in the 2001 and 2002 surveys.

staging area. Of the numerous sections exposed along the Nelson, Hayes, Gods and Pennycutaway rivers, 17 sections were selected for detailed investigation (Fig. GS-24-1). The 17 sections were selected based on the availability of a suitable helicopter landing site, nature of the geology and distance and relative spacing from other sites (Nielsen and Fedikow, 2002). Four tills, the Sundance, Amery, Long Spruce and Sky Pilot tills, were identified in the field based on colour, fracture habit, texture and stratigraphic position. Preference was given to sections that exposed thick sequences of Long Spruce till. Till samples were collected at 2 or 3 m intervals in each of the 17 sections and each sample was tentatively assigned to one of the four till units. Parts of some sections were not sampled because they were too steep to be sampled safely or they were badly slumped. Two samples were taken at each sampling interval; an 11 L (40–45 lb) sample was taken for kimberlite indicator-mineral and gravel analysis, and a 2 kg sample was collected for geochemistry. A total of 144 till and 3 gravel samples were collected for analyses from the 17 sites. Pebble fabrics, consisting of 30 clasts each, were measured at 42 sites. Time did not permit fabrics to be measured in section J.

De Beers Exploration Canada Inc. has again extended their offer to concentrate, pick and analyze by electron microprobe the diamond indicator minerals free of charge. In keeping with our usual confidentiality practice, the sample numbers and site locations are not shown in the accompanying figures. The sections have been randomly

labelled A through Q for the purpose of the present discussion. Calcite and dolomite content will be determined at the laboratories of the Geological Survey of Canada in Ottawa. Pebble counts, textural analysis and geochemical analysis will be contracted out.

RESULTS

The 17 stratigraphic logs measured in the field are shown in Figure GS-24-2. In places, the sections are capped by a variety of nonglacial sediments including fluvial sand and gravel, Lake Agassiz silt and clay, fine-textured, fossiliferous, Tyrrell Sea marine sediments or Holocene fluvial sediments. These interesting, and in places, complex late glacial and Holocene sediments are not relevant to the present discussion of kimberlite indicator minerals and will not be discussed further. Four tills, Sundance, Amery, Long Spruce and Sky Pilot tills, were identified in the field based on colour, fracture habit, texture and stratigraphic position.

Organic-rich, Nelson River sediments attributed to the Sangamonian interglacial were encountered in sections B, J and O (Fig. GS-24-2). The till below the Nelson River sediments was assigned to the Amery till and the overlying till was assigned to the Long Spruce till. Sections without exposed Nelson River sediments probably comprise only the upper part of the till stratigraphy, namely Long Spruce and/or Sky Pilot tills. This assumption is probably correct if the tills consist of yellowish brown till (Sky Pilot till) overlying dark greyish brown to olive-grey till (Long Spruce till). The presence of subglacial sand and gravel interbeds in sections D, I, M and O is open to interpretation. Paleocurrent directions towards 35° in the sand and gravel at the base of section P indicates these sediments were deposited under non-glacial conditions when Hudson Bay was free of glacial ice. For this reason the sand and gravel unit at the base of this section is assigned to the Nelson River sediments. This interpretation is consistent with the assignment of the overlying tills to Long Spruce and Sky Pilot tills. As paleocurrent directions are not always obtainable and because sand and gravel beds are known to be deposited subglacially, the interpretation of the origin of these beds can be problematic. For this reason the presence of sandy interbeds often adds little to the assignment of age to the tills.

Striations

Striated boulders and striated bedrock surfaces were encountered at only three sites. Striae trending 140° on the Paleozoic bedrock at the base of section J confirm the assignment of the sandy overlying till as Sundance till of north-western provenance. Striae trending 225° on a boulder pavement at the base of the upper till in section N confirm the overlying brown to dark brown till at this site is Sky Pilot till (Fig. GS-24-3A). A poorly exposed bedrock surface at the base of section M show striae oriented towards 160° or possibly 340° (Fig. GS-24-3B). This orientation is consistent with the pebble fabric of the overlying Long Spruce till though the contact is not exposed.

Till Fabrics

Amery till

Pebble fabrics were measured in the Amery till in sections B and O (Fig. GS-24-2). In section B the fabric was measured 1.5 m below the contact with the overlying Nelson River sediments and shows a strong pebble alignment towards the southeast (137°). Two fabrics, 0.5 m and 3.0 m below the overlying Nelson River sediments, were measured in section O. The upper fabric, being too close to the surface and possibly affected by frost and other near-surface processes, is inconclusive and was disregarded. The fabric at the 3.0 m level should be deep enough so as not to have been affected by near-surface processes during the Sangamonian. This fabric shows ice flow towards approximately 195°. The variable fabrics of the Amery till is consistent with the findings in the 2001 survey (Nielsen and Fedikow, 2002), but clearly more sections must be investigated to get a clear understanding of the changing ice-flow trajectory and provenance of the Amery till.

Long Spruce till

The Long Spruce till, as interpreted in the field, is exposed in every section except section Q (Fig. GS-24-2). Fabrics were measured at 30 sites in the Long Spruce till and a duplicate fabric was measured at the base of section P to test the reproducibility of the technique.

Long Spruce till fabrics measured near the base of sections A, B, C, H, M, N and P in the 2002 survey and from two sites in the 2001 survey are oriented towards the southwest (Fig. GS-24-4a). Fabrics at higher levels in sections A, B, C, D, E, F, G, I, K, L, O and P from the 2002 survey and three sites from the 2001 survey are oriented more towards the southeast (Fig. GS-24-4b). Sections E, F, G, I, K, L, M and O show a southeasterly or a southerly and southeasterly

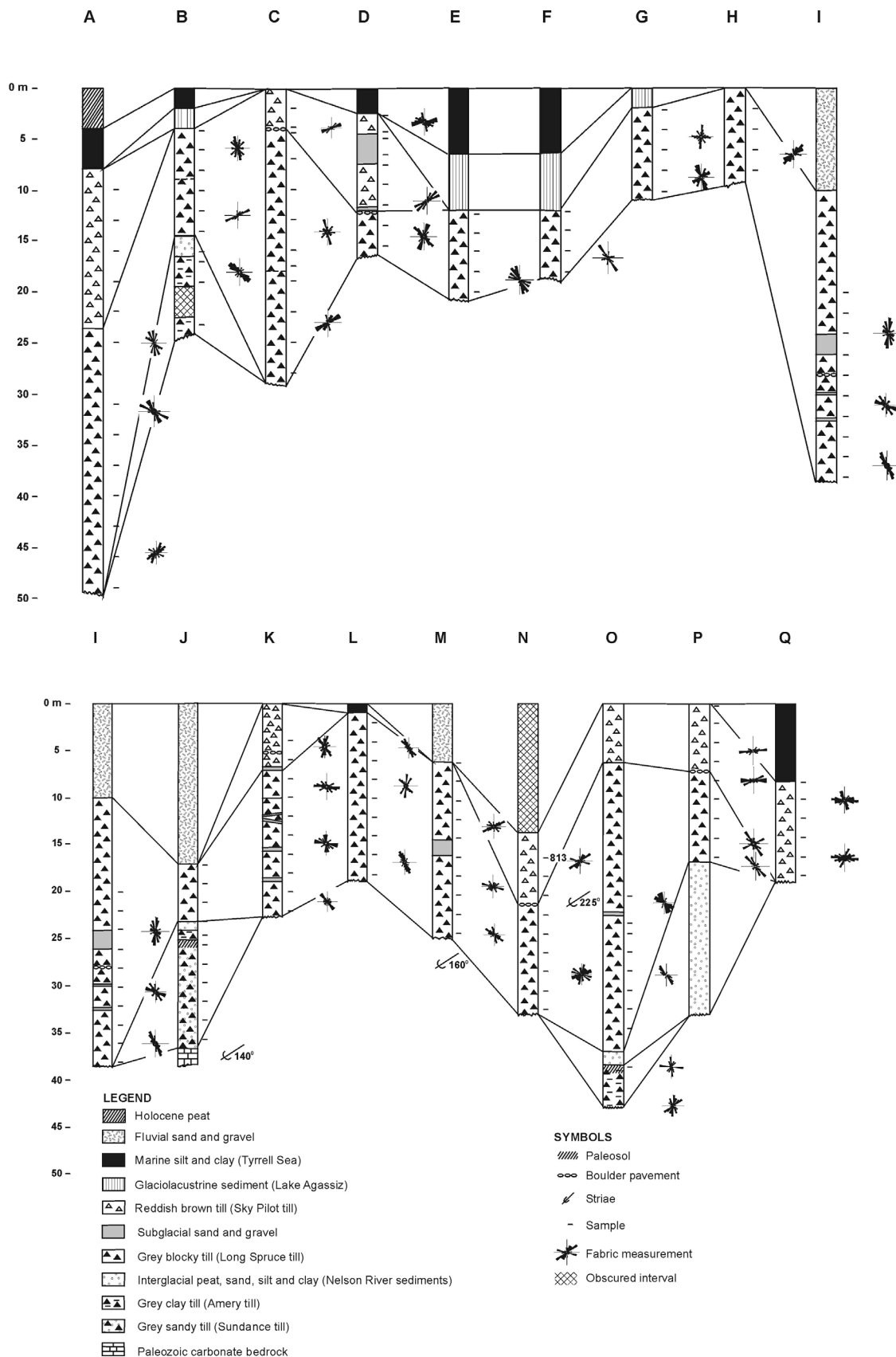


Figure GS-24-2: Stratigraphic logs measured along the Nelson, Pennycutaway, Gods and Hayes rivers.



Figure GS-24-3A: Striated boulder pavement at the base of the Sky Pilot till in section N.



Figure GS-24-3B: Striated bedrock at the base of section M.

pebble fabric and are interpreted to represent only the upper part of the Long Spruce till sequence (Fig. GS-24-4b). The westerly oriented fabric near the top of the Long Spruce till in section P is probably the result of reorientation of the pebbles by overriding ice, which deposited the Sky Pilot till. Care should be taken so as not to measure till fabrics too close to major stratigraphic boundaries as has happened in this case. The fabric near the base of section N appears random and was disregarded. Other fabrics such as the Long Spruce fabric at the base of sections D and G are bimodal and must be interpreted with care.

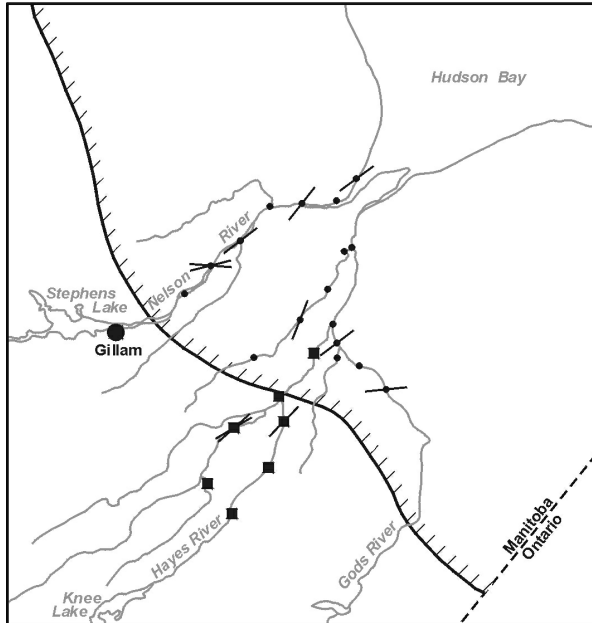
The change in the fabrics from southwesterly near the base of the Long Spruce till to more southeasterly towards the top of the sequence indicate the ice-flow trajectory changed from southwest to southeast during deposition of the till (Fig. GS-24-4a, GS-24-4b). This conclusion highlights the need for measuring multiple till fabrics from numerous sections before a clear understanding of the ice-flow history can be obtained.

Sky Pilot till

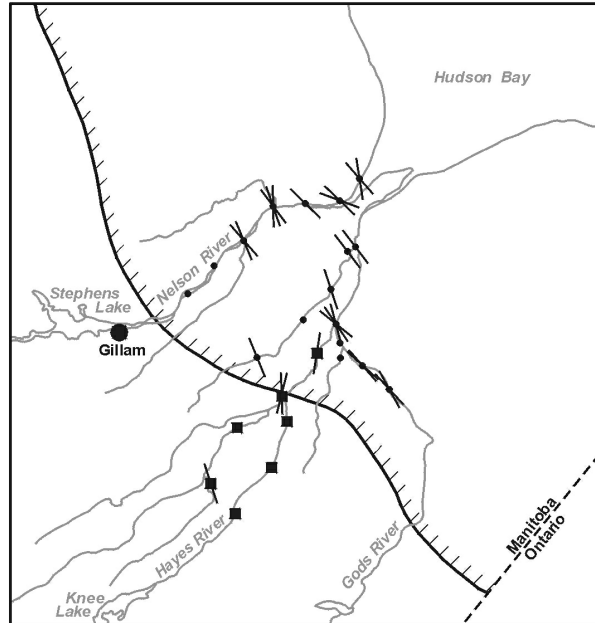
Till fabrics measured in Sky Pilot till in sections C, D, K, N, P and Q from the 2002 survey (Fig. GS-24-2) and one site from the 2001 survey trend west-southwest and west (Fig. GS-24-4c), and are subparallel to the orientation of drumlins, eskers and striations in the Hudson Bay Lowland and adjacent parts of the northern Superior Province (Nielsen et al., 1986; Fedikow et al., 2002).

The fabric in section K is bimodal and the orientation is unlike that of the other Sky Pilot fabrics. This fabric is

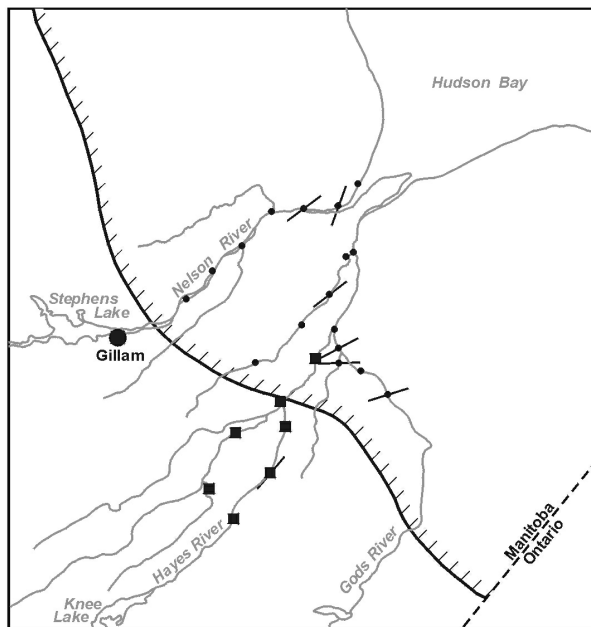
a) Lower Long Spruce till



b) Upper Long Spruce till



c) Sky Pilot till



0 50 100
kilometres

- 2001 sections
- 2002 sections
- ↙ ↘ Till fabric orientation
- Paleozoic carbonate bedrock

Figure GS-24-4: a) Southwesterly oriented till fabrics in the lower part of the Long Spruce till. b) Southeasterly oriented till fabrics in the upper part of the Long Spruce till. c) Southwesterly oriented till fabrics in the Sky Pilot till.

similar to the upper till fabric in section B, which was tentatively assigned to the Long Spruce till based on the colour and similarity of the fabric to the top fabric in section A. The sandy texture and brown colour of the upper till in section K may indicate a more locally derived facies not representative of Sky Pilot till.

CONCLUSION

Two till fabrics, measured in two sections, indicate Amery till was deposited by ice flowing first towards the south-east and then the southwest.

Based on the analysis of 30 till fabrics measured in 16 sections, Long Spruce till was deposited by ice flowing towards the southwest and then changing trajectory to the south and southeast.

Sky Pilot till was deposited by southwesterly and westerly ice flow as recorded by 8 fabrics measured in 6 sections.

Clearly the ice-flow trajectory during the deposition of each till was variable in both time and space and many till fabric sites are necessary to obtain a clear understanding of the provenance of the resultant till(s). In addition to field relations, till fabric and colour determinations, compositional data such as pebble counts and trace-element geochemistry may help determine the provenance of tills in areas with complex glacial stratigraphies and few ice-flow directional indicators. Only when the sequences of ice-flow events, ice-flow directions and approximate glacial transport distances are known, can the source(s) of KIM in the Hudson Bay Lowland of Manitoba be located.

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