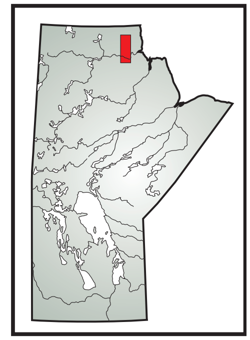
GS-14 Manitoba Far North Geomapping Initiative: field reconnaissance of surficial sediments, glacial landforms and ice-flow indicators, Great Island and Kellas Lake areas, Manitoba (NTS 54L, 64I, P)

by M.T. Trommelen[1] and M. Ross[1]



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Summary

In 2009, the Manitoba Geological Survey initiated collaboration with the University of Waterloo to investigate the surficial geology in northern Manitoba, as part of the Manitoba Far North Geomapping Initiative. This multi-year surficial geology study aims to elucidate the glacial geology and geomorphology of Manitoba's far north (north of 58°) – an objective that, in conjunction with detailed bedrock mapping by MGS, will provide a modern geoscience knowledgebase tailored towards current and future mineral exploration and development. This report presents a summary of fieldwork activities related to a two-week reconnaissance survey in the summer 2009. Geological observations, sampling of glacial sediments and/or measurements of ice-flow indicators were recorded at 83 stations within a 1400 km^2 area surrounding Sosnowski Lake, and at 12 additional sites north of Caribou Lake, mainly near Kellas Lake, in northeastern Manitoba. The surficial geology reconnaissance survey focused on the characterization and sampling of a terrain type that consists of swaths of ribbed moraine alternating with streamlined terrain. In addition, one section of drift cover was studied along the Seal River, and revealed an ice advance to the southeast. Ice-flow indicators measured across the study area suggests an early ice-flow phase to the southwest, followed by a southeast-trending phase, and then by a clockwise shift to south- and southwest-trending ice flows. These observations, although more complex than previously published ice-flow direction data for this area, are consistent with published reconstructions involving significant shifts in the position of the Keewatin ice divide located to the north.

Introduction

As part of the Manitoba Far North Geomapping Initiative (Anderson et al., GS-13, this volume), a reconnaissance survey of the surficial geology of the Great Island and Kellas Lake areas in northeastern Manitoba was completed during a two-week period in July and August, 2009 (Figure GS-14-1). This report presents a summary of fieldwork activities related to this reconnaissance survey.

Objectives

The main objective of the surficial geology component of the Manitoba Far North Geomapping Initiative is to better understand the glacial geology and geomorphology of the study area and to generate geoscience data and maps that aid mineral exploration. The specific goals of the reconnaissance survey were to

- document micro- and meso-scale ice-flow indicators (e.g., glacial striae, roches moutonnées) in a study area surrounding Sosnowski Lake,
- improve understanding of regional ice-flow phases,
- sample glacial sediments (mainly till) to investigate compositional patterns (dispersal trains) and
- examine field evidence for sediment-landform relationships, with particular emphasis on establishing potential links between subglacial processes, including glacial transport, and the unusual landscape areas characterized by extensive swaths of ribbed (ridged) moraine alternating with streamlined terrain.

Physiography

The study area is located in the far northeastern part of Manitoba. The Seal River is the major drainage channel, flowing east from Tadoule Lake into Hudson Bay. Sixty kilometres downstream of Tadoule Lake, the Seal River splits into north and south channels and the land between these channels is named Great Island. Eventually the channels connect into one river again. Numerous small streams flow across the drift plains from one lake to another, in a very immature drainage network, or flow through the muskeg. The area is characterized by extensive swaths of bouldery ribbed moraine alternating with swaths of streamlined terrain and areas of bedrock outcrop. Long eskers are present throughout the area. Elevation varies mainly from 100 to 250 m asl. Local relief is up to 30 m high.

Regional glacial history

The landscape of the study area mainly records the processes and events that took place at the base of the

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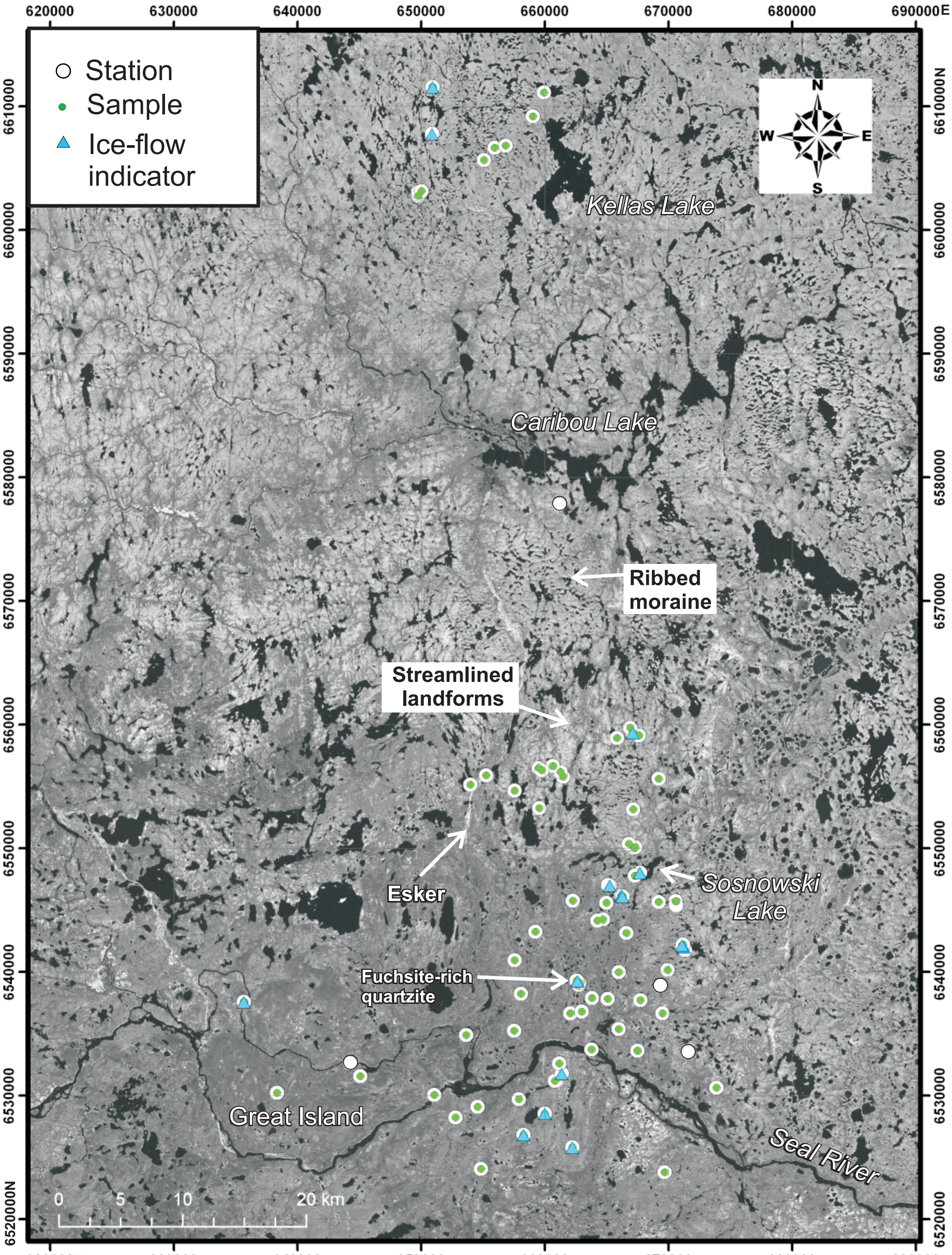

***Figure GS-14-1**: Location of field stations, samples and ice-flow indicator measurements in the Great Island and Kellas Lake study area, northeastern Manitoba. Background image was generated using Landsat ETM + images #033019_0100_010917_l7_08 and #033018_0100_010715_l7_08.*

Laurentide Ice Sheet (LIS) during the Late Wisconsinan. Late phase ice deposited long esker systems and alternating belts of ribbed moraine, flutings and conjugate ridges (crevasse fill?) in the eastern part of the study area. According to Dredge et al. (1986), the juxtaposition of ribbed moraine and flutings may indicate contemporaneous zones of active ice within a generally less mobile ice mass. The study area has, in part, been washed by the Tyrrell Sea, and the marine limit in the study area is between 165 and 180 m asl (Dredge and Nixon, 1992). A radiocarbon date of 7770 ±140 BP (sample GSC-3070) for emergence from the LIS was obtained from paired valves just south of the study area along the North Knife River (Dredge and Nixon, 1992).

Methods

Helicopter-supported fieldwork was undertaken out of a base camp at Sosnowski Lake. Ribbed and streamlined terrain field sites were identified from Landsat imagery and pre-existing 1:500 000 scale maps (e.g., Dredge et al., 1986). A total of 35 samples, each weighing approximately 2 kg, were collected on the crest and lee-slopes of chosen landforms in two separate areas of ribbed and streamlined terrain (Figure GS-14-1). An additional 41 till samples were obtained from wave-washed terrain in and surrounding a known outcrop area of fuchsite-rich brecciated quartzite (Figure GS-14-1). Striae and other ice-flow indicators were measured at several sites (Figure GS-14-1).

Results

Ribbed and streamlined terrain

Two areas, north and south-southeast of Sosnowski Lake, contain swaths of ribbed moraine alternating with streamlined terrain (Figures GS-14-1 and -2). These swaths

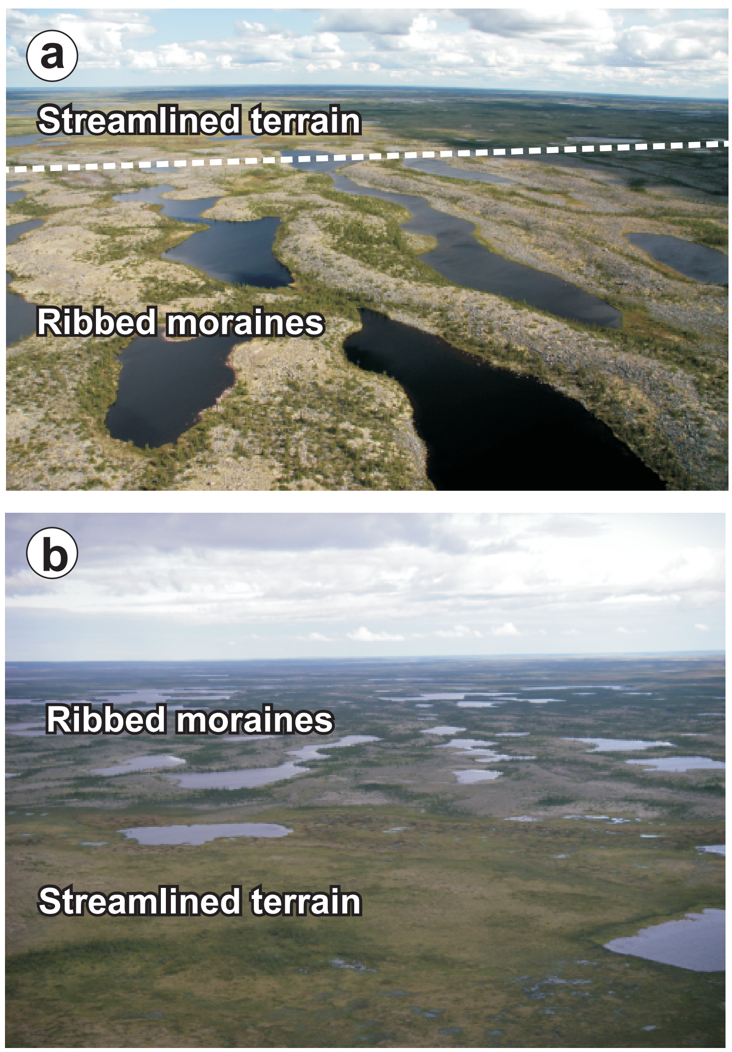

Figure GS-14-2: *Photographs of ribbed and streamlined terrain in the Sosnowski Lake area, northeastern Manitoba:* ***a)*** *field of ribbed moraine ridges with subdued streamlined ridges in the background; the dotted line is the approximate boundary between the two terrain types;* ***b)*** *a closer view of the sharp boundary separating ribbed moraine and streamlined terrain.*

are similarly unconfined by topography. The ribbed moraine ridges range from 2 to 5 m in height, 0.5 to 2 km in length, and trend east-northeast. Generally, the north side (stoss) of the ridges have a gentle slope (10–20°), while the south sides (lee) are steeper (30–40°). Streamlined landforms (drumlins and other fluted ridges) range from one half to a few metres in height, 0.3 to 2 km in length, and have a general southward orientation. Preliminary geomorphological analysis suggests that ribbed moraine in the study area formed first and most of the ridges were later reworked by an active ice-flow phase. The degree of reworking varies considerably and may have occurred over a long time span. At one end of the spectrum, there are unmodified ribbed moraine ridges with steep lee sides. Transition landforms consist of slightly to extensively altered ribbed moraine ridges, either overprinted by drumlins or smeared/reworked laterally into elongated or partially streamlined ridges. At the other end of the spectrum, streamlined landforms are dominant. This spectrum of landforms varies both down-ice and laterally (perpendicular to ice flow).

From a field observational point of view, the two landscape end members contain contrasting surficial sediments. The ribbed terrain is generally characterized at the surface by an extensive sediment layer (approximately 0.5–1 m thick) consisting of a loosely packed, clast-rich diamicton covered by medium-large boulders. This clast-rich diamicton layer is thinner over modified ribbed moraine that was overprinted by drumlins and is lacking in streamlined terrain regions. This clast-rich diamicton is interpreted as a meltout till consisting of subglacial, intraglacial and supraglacial material. A relatively dense, matrix-supported diamicton has been identified in both terrains. It was found (in hand-dug holes up to 1 m deep) below the clast-rich diamicton in many ribbed moraine ridges, generally at the top and sometimes on the lee side of ridges. The ribbed moraine ridges thus appear to have a core of finer diamictic material, although it was not possible to observe this at every site due to the thickness of the coarse diamicton. Stacked, imbricated (up-ice dip), cobble-sized clasts were also encountered in several holes dug into the lee side of the ribbed moraine ridges. In the streamlined terrain, a fine-grained, clast-poor diamicton, similar to the matrix-supported diamicton, was commonly found at the surface or underneath a thin sandy layer of marine littoral sediments. This diamicton is confidently interpreted as a subglacial traction till (Evans et al., 2006). It is unclear, however, whether this till has similar compositional characteristics in both terrain types. This will be further investigated by analyzing the collected samples. Ongoing work includes the analysis of published models on the origin of ribbed moraine, and to evaluate whether these models could explain all of the field observations.

Seal River section

In the summer of 2009, water levels in the Seal River were abnormally high. Additionally, several sedimentary sections were completely obscured, up to 6 m above observed river level, by ice push from a spring ice jam. Only one suitable Quaternary section was found, a 6 m high section along the north channel of the Seal River in the Great Island area (Figure GS-14-1). This section was described and samples were collected from the middle and lower units below the upper fluvial gravels.

The 2 m thick lowermost unit is predominately well-sorted, medium-grained sand. This unit contains a folded bed of medium- to coarse-grained sand and granules (Figure GS-14-3a), and several thin (2–4 cm) dark grey, silty diamicton beds, one of which is also folded. The fold axis of the sand and granule bed trends 233°, with a horizontal plunge (0° dip). A diamicton bed near the top of the unit strikes 280°, with a plunge of 17°. A sample of diamicton was taken for pollen analysis.

A 1.3 m thick unit of interstratified dense, dark grey, silty sand diamicton and moderate to well-sorted, medium-grained sand unconformably overlies the sand and granule unit (Figure GS-14-3b). The lower contact is erosive and undulating. The diamicton beds range from 6 to 15 cm thick, while the sand beds range from 2 to 15 cm thick. A sample of diamicton was taken for geochemical and pebble lithology analyses.

Crudely imbricated, clast-supported and moderately sorted, bouldery gravel and sand (2.5 m thick) cap the section (Figure GS-14-3c).

***Figure GS-14-3**: Units observed in a section along the Seal River (northeastern Manitoba) from bottom to top: **a)** folded sand and granule layers; **b)** interstratified diamicton and sand; **c)** crudely imbricated sand and bouldery gravel.*

This section records an ice advance into a sand unit, unconformably overlain by fluvial gravel. Glaciotectonic folds in the lower sand unit suggest ice advanced towards the southeast (~145°). An early southeast flow is present in the study area and this advance is tentatively correlated with that flow. The lower sand unit may have been deposited in a warmer climate (interstadial) or during ice advance into a proglacial lake, possibly impounded by Hudsonian ice. Pollen from the silty diamicton, if present, may yield constraints on the time of deposition.

Ice flow

Regional mapping suggests that ice from the Keewatin sector of the LIS covered the study area in the Late Wisconsinan, flowing south during the Last Glacial Maximum (LGM; Dredge et al., 1986; Dredge and Nixon, 1992). Most published ice-flow directions range from south-southwest to south-southeast. Dredge and Nixon (1992) also suggest that a penultimate Keewatin glaciation flowed southeast, based on a 130° striation at Churchill.

Striae, grooves and crescentic scours were identified on several outcrops in the study area (Figure GS-14-1). The earliest Keewatin ice flow formed 230° trending roche moutonnées near the Sosnowski Lake camp. These landforms appear to be remnant due to the plucked faces being polished and striated. The roche moutonnées are thus older than the erosional marks on their surface, which were in turn protected from a younger ice flow that re-abraded the stoss side of the roches moutonnées. One site with striae on a protected quartzite face also recorded the old southwest flow (238–245°). The old plucked face of the roche moutonnée near camp was polished and striated by a 130–145° trending ice flow. This younger southeast flow is also documented by the glaciotectonic fold axis at the above described Seal River section, and one other striae site (near the 2009 camp). In summary, ice-flow indicators document an early southwest flow (230–245°) that may have been from a penultimate glaciation. Younger indicators suggest two ice flows trending 130–145° and 155–178°, followed by a 184–195° trending ice flow, a subsequent major 200–214° trending ice-flow event that created regional-scale streamlined landforms, and possibly a late, 230–260° trending ice-flow phase. No one site was found that included all ice-flow directions, and these relationships were determined by cross-cutting relationships. Figure GS-14-4 is an example of one such site with multiple cross-cutting ice-flow indicators.

These ice flow indicators suggest a shifting in the position of the Keewatin ice divide, resulting in ice flow directions first to the southwest, then to the southeast, and followed by a clockwise shift to south and southwest. These observations are consistent with a published reconstruction suggesting major shifts of the Wisconsinan Keewatin ice divide north of the study area (e.g., McMartin and Henderson, 2004). The earliest, southwest-trending flow may be a record of a pre- to late Wisconsinan ice-flow phase. In addition, a crescentic scour on a protected rock face is trending 310°, which may be related to an even earlier ice-flow phase from the Quebec-Labrador sector of the LIS (e.g., Veillette et al., 1999). Fossiliferous carbonate cobbles found on gravel bars along the Seal River may have weathered out of till related to this flow. Ice flow from east of the study area could account for impounding of drainage along the ice margin, causing the formation of a lake where the interbedded lacustrine sands and diamicton beds found at the Seal River section could have been deposited.

Future work

Ongoing surficial geological analysis focuses on tracing lithological indicators from known bedrock source areas, through pebble counts and major and trace element geochemical analysis of the collected till samples. Results of these analyses will

- establish the compositional characteristics of the subglacial traction till of ribbed and streamlined terrains

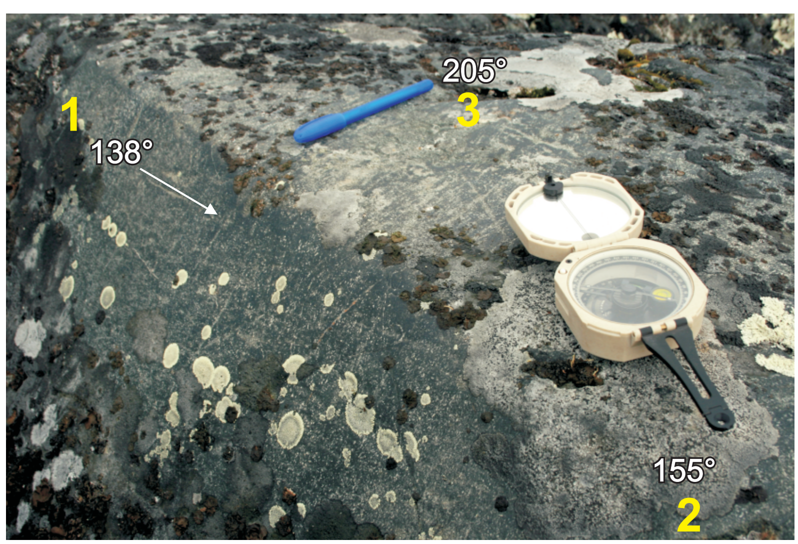

Figure GS-14-4: *An example of multiple meso-scale ice-flow indicators and their interpreted relative age relationship (3 = youngest flow). These striae occur on a greenstone volcanic outcrop formed into a roche moutonnée that indicates ice flow to 230° (oldest flow at this site; not shown on photo), Sosnowski Lake area, northeastern Manitoba.*

and aid in the investigation of subglacial transport processes and distances;

- confirm the known fuchsite-rich, pebbly and brecciated quartzite outcrops just northeast of Great Island (Anderson et al., GS-13, this volume) as the source for reported arsenic till geochemistry anomalies (Dredge and Pehrsson, 2006; Dredge and McMartin, 2007), and to map the glacial dispersal train; and
- detail the ice-flow history for the area and delimit the use and interpretation of till geochemistry for mineral exploration in the study area.

Economic considerations

As bedrock outcrop is rare in Manitoba's northern region, a thorough understanding of surficial geology is essential for drift prospecting. Till geochemistry is commonly used for mineral exploration in drift-covered regions but exploration is made more complex in this area due to a palimpsest terrain related to more than one ice advance and transport direction. A cover of glaciomarine sediments also limits the effectiveness of traditional exploration through grid sampling. Preliminary results described in this report provide new constraints to drift exploration in this area, applicable to exploration for a variety of commodity types including diamonds, precious metals and gold (Dredge and Nielsen, 1986; Nielsen, 1987; Syme et al., 2004; Dredge and Pehrsson, 2006; Anderson and Böhm, 2008). Ongoing surficial geological studies aim to provide

- a detailed framework for the directions, timing and nature (e.g., erosional or depositional) of major and minor ice-flow events in the region,
- dispersal train patterns as measures for ice transport distances and directions, and
- guidelines for the preferred sampling media for geochemical analysis, as a large portion of the area has been wave-washed and may not have retained its local geochemical signature indicative of the underlying bedrock.

These studies are geared toward providing mineral exploration geologists with an up-to-date surficial geology knowledgebase and the adequate tools to more accurately locate exploration targets in Manitoba's far north.

Acknowledgments

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