GS-17 Preliminary Quaternary geology in the Gillam area, northeastern Manitoba (parts of NTS 54D5–11, 54C12) – Year Two

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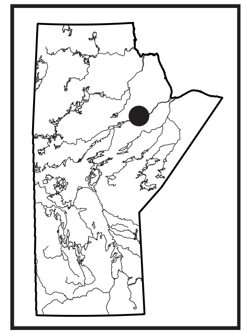

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Summary

This report presents a summary of activities related to four weeks of fieldwork undertaken in the Gillam area of northeastern Manitoba, in the summer of 2014. This is the second of a multiyear collaboration between the Manitoba Geological Survey, the Geological Survey of Canada and the University of Waterloo. Field sites were accessed by truck, boat and a helicopter with floats. Quaternary geology investigations included site characterization (sedimentology, geomorphology, type and thickness of glacial sediments), collection of representative till samples for compositional analysis of provenance, and till fabric analyses. Where possible, mainly within NTS 54D6, ice-flow indicators were collected to augment the current understanding of the regional ice-flow history. Geological observations, sampling of till, and/or measurements of ice-flow indicators were recorded at 270 stations within a 7380 km^2 area. Thirty-two stratigraphic sections were documented along the Nelson, Limestone, Kettle, Angling and Weir rivers, and at Stephens and Gull lakes. Road accessible field sites were mainly documented in 2013.

Introduction

In July and August 2014, Quaternary geology studies were conducted in northeastern Manitoba by use of a truck, a boat on Stephens Lake, and a Bell 206 helicopter with floats. The work focussed primarily on 1:50 000 scale mapping of NTS 54D6, 7 and 8 (Figure GS-17-1). Additionally, sites outside of that area were visited because they answered specific questions or they were made accessible by new roads. This report presents a summary of fieldwork activities, which included mapping of surficial materials, ice-flow indicators and stratigraphic sections, till fabric analyses, collection of shell material for radiocarbon dating, and regional till sampling surveys.

Surficial geology in the Gillam area was mapped from 1971 to 1974 at a 1:250 000 scale by Klassen and Netterville (1980). Though released as a Geological Survey of Canada "A" series colour map, this map is considered to be reconnaissance-scale because the region was subjected only to limited ground-truthing. Stratigraphy along the Nelson River, prior to building of the Long Spruce and Limestone generating stations, was investigated in greater detail and was the subject of two M.Sc. theses and a field trip guidebook (Klassen, 1972; Klassen and Netterville, 1973; Nielsen and Dredge, 1982; Dredge and Nielsen, 1985; Klassen, 1986; Nielsen et al., 1986; Roy, 1998). This work builds on a reconnaissance field study undertaken in 2013 (Trommelen, 2013a) and supports the M.Sc. project of the second author.

Physiography

The study area is located in the northeastern part of Manitoba. Elevation varies from 21 to 291 m asl with local relief reaching up to 40 m (Figure GS-17-1).

The Nelson River, with Gull and Stephens lakes as widened expanses, is the major northeast-flowing drainage channel that eventually drains into Hudson Bay. The study area is dominated by poorly to moderately drained topography. Stunted spruce bogs and spruce-tamarack/Labrador tea forests drape most of the region. Moderately drained areas, where sediment is at or near surface, may contain aspen, poplar, willow and alder, in addition to spruce. Well to very well drained areas, where sediments are at surface, are vegetated by jack pine. Surface permafrost is common beneath a cover of more than 0.2 m of organic deposits.

Bedrock is deeply buried throughout most of the road-accessible area, with the exception of limestone outcrops at the Limestone hydroelectric dam and two inaccessible gneissic islands just north of the Long Spruce hydroelectric dam. Bedrock can be found along the highway at, and west of, the northwesternmost tip of Stephens Lake, where ditch excavations have removed the overlying glaciolacustrine clays. Regionally, low-lying bedrock outcrops within NTS 54D6 were visible from air due to the massive 2013 forest fire.

Methods

Fieldwork was undertaken during a four-week period in the summer of 2014, to follow up on reconnaissance road-accessible fieldwork completed in 2013. Road work permitted the collection of till fabric data at six stratigraphic sections. Boat work was completed along the shores and islands of Stephens Lake. Float-equipped, helicopter work was based out of Landing Lake at Gillam and completed in the surrounding (<45 km) region. The thick vegetation cover made access difficult, and

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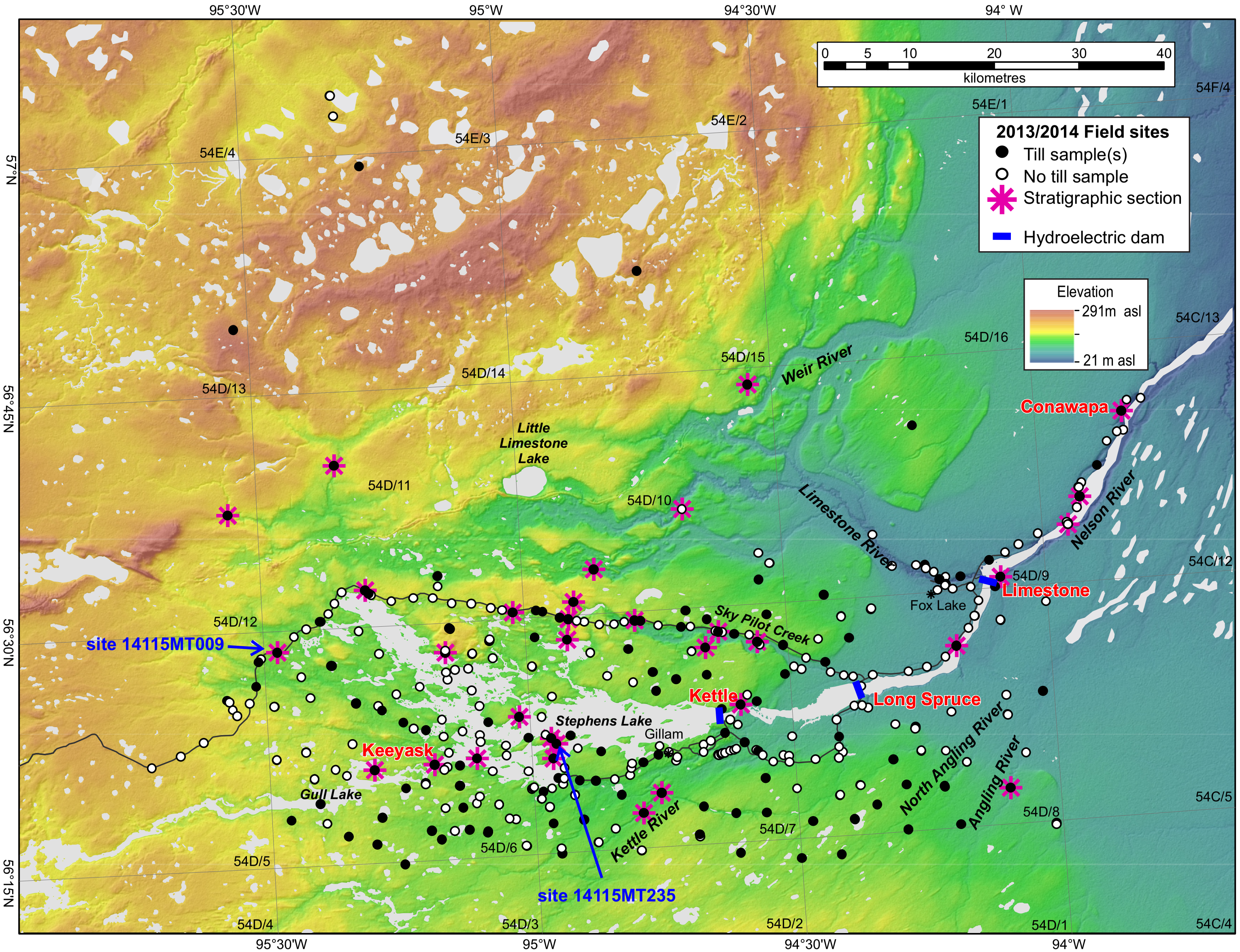

Figure GS-17-1: *Location of field sites, till-sample sites and stratigraphic sections visited in the 2013 and 2014 field seasons, northeastern Manitoba. Background hillshade image was generated using a Shuttle Radar Topography Mission (United States Geological Survey, 2002) digital elevation model.*

helicopter landings were largely restricted to areas with open untreed fens or open bogs, which heavily influenced where field stations could be situated. Shutdown areas for a helicopter without floats are rare, and floats are recommended for any similar future work. The three-person crew was based out of Manitoba Hydro accommodations in Gillam.

A total of 270 field sites (Figure GS-17-1) were visited, within a 7380 km^2 area, to ground truth surficial geology mapping, collect till samples and identify ice-flow indicators. Thirty-two stratigraphic sections were documented along the Nelson, Limestone, Kettle, Angling and Weir rivers, and at Stephens and Gull lakes. Sites were investigated using a shovel and/or an extendable auger (maximum depth of 2.3 m). One hundred and three surface-till samples, each weighing around 2 kg, were collected from C-horizon till throughout the area for geochemical analysis. An additional 38 till samples were collected from subsurface tills found in roadcuts, aggregate quarries or natural sections.

All till samples have been submitted for trace-element geochemistry (>63 µm fraction) and clast lithology (2–80 mm fraction) analyses. Shell material from 15 sites was submitted to Paleotec Services (Ottawa, Ontario) to obtain radiocarbon ages. The orientation of striations, grooves, chattermarks and roches moutonnées were measured at 18 sites (Trommelen, 2014[2]). Striae data from 2013 were released in Trommelen (2013b).

Preliminary results

Stratigraphy

Stratigraphic sections are numerous in the field area; they can be found along the river valleys, as well as along the scarps of the deeply incised meltwater corridors. Some sections along the Nelson River valley have previously been described by Nielsen and Dredge (1982), Nielsen et al. (1986), Roy (1998) and Nielsen (2002). Most previous work has focused on characterization of pre–Late Wisconsinan stratigraphy. Due to fluctuations in water levels, infrastructure development (dams and generating stations) and accessibility, undocumented sections are present in many areas. Most previously studied sections were flooded after construction of Long Spruce and Limestone dams, and only the tops of these sections are now accessible.

Figure GS-17-1 shows the location of stratigraphic sections visited in 2013 and 2014. These sections range from 3 to 40 m in height, and expose a variety of surficial material types (see the example presented in Trommelen, 2013b). Future work will focus on correlating the different till types exposed in these sections.

Radiocarbon ages

Shell material collected in 2014 includes whole and single marine valves, single lacustrine pelecypod valves, lacustrine gastropods and abraded shell fragments, from a total of 15 field sites (Figure GS-17-2). These have been submitted to Paleotec Services for identification and preparation for radiocarbon dating at the W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory (Irvine, California). Previous radiocarbon ages in the same region were obtained from shell material by Blake (1982), Klassen (1986), Nielsen et al. (1986) and Trommelen (2013c).

Surficial geology

A general description of surficial geology in the region is provided by Trommelen (2013b) and Nielsen and Dredge (1982). A brief update follows below.

Marine limit

Efforts were made to confirm the marine limit within NTS 54D7 and 8 (Figure GS-17-1). Numerous beach ridges (Figure GS-17-3a) and trimlines (wave-cut escarpments, Figure GS-17-3b) are present at around 122 m asl, and marine silty fine sand deposition was generally restricted to below this same elevation. The maximum elevation of beach gravels (Nielsen and Dredge, 1982), sand and gravel derived from washing of till, and marine silty fine sand deposition is 135 m asl (Figure GS-17-4). Thus the authors consider the maximum marine limit, in the Gillam area, to have been around 135 m asl.

Shell fragments can be found above this elevation, within till and buried gravels, as noted by previous researchers. These shell fragments are generally interpreted as reworked organic material, transported above marine limit by ice/water that pre-dates the Late Wisconsinan.

Further work to determine marine limit needs to be completed within NTS 54D10 (Figure GS-17-1). It was noted that the meltwater corridors/spillways in this area are at, or very close to, the same elevation as marine limit. Nielsen and Dredge (1982) suggested that the drainage of glacial Lake Agassiz began through these large meltwater corridors, possibly subglacially. Stratigraphic data is needed to support this interpretation, as glaciolacustrine sediment was found to cap sections at a few sites visited within these corridors in 2014.

Water-laid or ice-marginal till deposition

At several sections documented along the shores of Stephens Lake, there is transgression from sandy diamict to water-laid, stratified, sandy diamict to glaciolacustrine rhythmites to massive glaciolacustrine silty clay. At site

[2] MGS Data Repository Item DRI2014003, containing the data or other information sources used to compile this report, is available online to download free of charge at http://www2.gov.mb.ca/itm-cal/web/freedownloads.html, or on request from minesinfo@gov.mb.ca or Mineral Resources Library, Manitoba Mineral Resources, 360-1395 Ellice Avenue, Winnipeg, MB R3G 3P2, Canada.

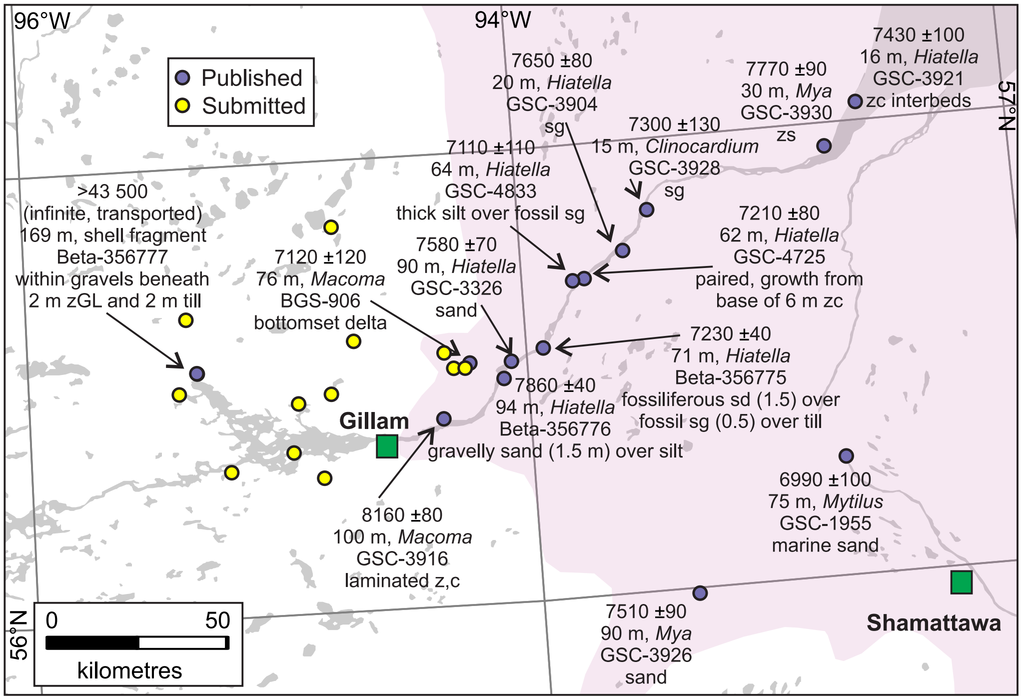

***Figure GS-17-2**: Conventional yr ¹⁴C BP ages on marine shells in the study area, and the location of newly sampled shell material. Information provided at each site includes age, elevation, species submitted, laboratory number and brief description of the enclosing sediments. The pink shading delimits the maximum extent of the Tyrrell Sea. Abbreviations: Beta, Beta Analytical (Miami, Florida); BGS, Brock University (St. Catharines, Ontario); c, clay; GL, glaciolacustrine; GSC, Geological Survey of Canada; sd, sandy diamict; sg, sand and gravel; z, silt; zc, silty clay; zs, silty sand.*

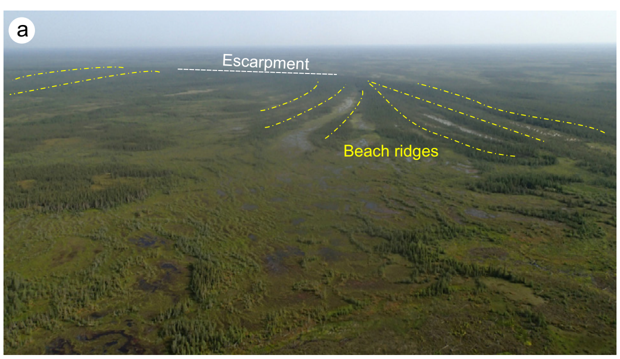

***Figure GS-17-3: a)** Sand and gravel beach ridges at 122 m asl and **b)** an oceanic wave-cut escarpment, 124 m asl at the base to 132 m asl at the top. Photos are of features situated in the southern half of NTS 54D8.*

14115MT235, the overlying glaciolacustrine rhythmites are contorted (Figure GS-17-5), which suggests deposition and subsequent deformation onto melting ice.

Similar contorted glaciolacustrine rhythmites, 1.2 m thick, were documented overlying a sandy diamict at site 14115MT009 (Figure GS-17-6). At that particular site, 1.8 m of beige loose diamict, with a sandy silt matrix and rare shell fragments, overlies diorite that is striated toward 306°. This stratigraphy indicates that the ice-flow phase here (Phase IV, see below) was strong and erosive, as no evidence for older, commonly preserved Hudson Bay Lowland sediment remains.

Ice flow

The study area was repeatedly glaciated by the Laurentide Ice Sheet (LIS) during the Quaternary (Dredge and Thorleifson, 1987; Dyke and Dredge, 1989; Dredge et al., 1990; Dredge and Nixon, 1992). New ice-flow measurements were obtained at 18 field sites (Figure GS-17-7; Trommelen, 2014). Interpretation of these ice-flow measurements as phases is presented in Figure GS-17-8.

There were six main phases of ice flow in the area. The oldest flow (Phase I, ~145°) includes rare striae that trend southeastward. On the basis of rarely preserved ice-flow indicators, this southeast flow phase was followed

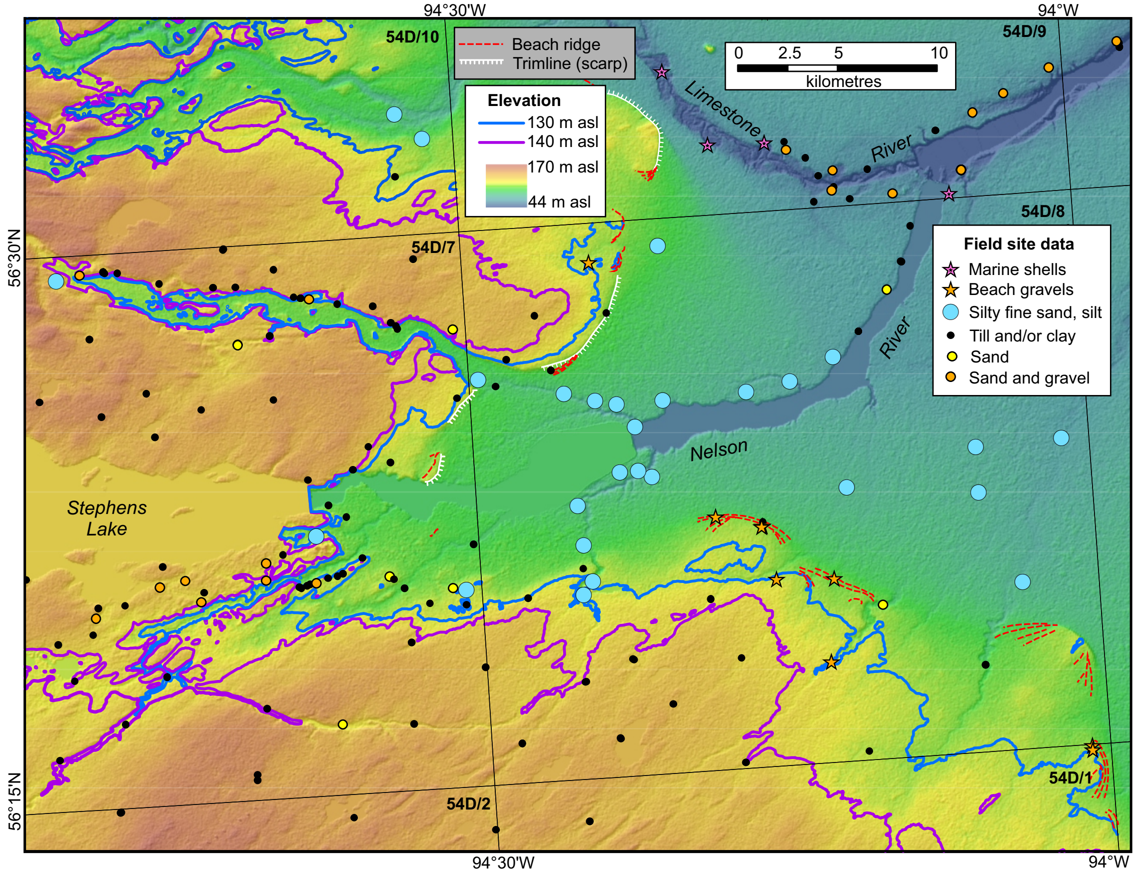

Figure GS-17-4: The presence of beach ridges and trimlines (interpreted from aerial photographs), and marine sediments (silty fine sand or beach gravels encountered during fieldwork) were used as proxies to determine the marine limit in the Gillam area of northeastern Manitoba. Background hillshade image was generated using a Shuttle Radar Topography Mission (United States Geological Survey, 2002) digital elevation model.

by southerly ice flow (Phase II, between 180 and 205°). Phase II striae are crosscut by southwest-trending striae (Phase III, between 222 and 230° and Phase IV, between 240 and 250°), which likely formed as part of the Hayes lobe. Streamlined landforms and eskers (Figure GS-17-7) generated during the Hayes lobe event are depicted on Figure GS-17-8 by the green flowset(s). During deglaciation, ice was thought to have flowed to the west (Phase V, ~265° to 275°) and northwest (Phase VI, between 280 and 320°), as part of the Stephens Lake sublobe or readvance. Streamlined landforms (Figure GS-17-7) generated during this phase crosscut the Hayes lobe landforms in a few areas, and are depicted on Figure GS-17-8 by the blue-purple flowset. These interpretations are preliminary. Results will be integrated with till clast-fabric analyses, boulder pavement striations and other stratigraphic data, in order to provide a new reconstruction of the glacial history in this area of Manitoba.

Future work

Ongoing surficial geological analysis focuses on tracing lithological indicators from known bedrock source areas, using clast counts and the major- and trace-element geochemical composition of the collected till samples; in combination with information interpreted from till-clast fabrics and stratigraphic relationships. Results of these analyses will

- establish compositional till characteristics, to determine how the till samples collected in 2013 and 2014 correlate to each other, and to the established stratigraphic record for the Hudson Bay Lowland of Manitoba (Nielsen and Dredge, 1982; Klassen, 1986; Nielsen et al., 1986; Nielsen, 2001, 2002; E. Nielsen, unpublished data, 2002; Dredge and McMartin, 2011); and
- provide information that can further delimit which phases of the complex ice-flow record affected sediment erosion/transportation/deposition in the area; knowledge of which is pertinent for mineral exploration using till.

Economic considerations

As bedrock outcrops are rare, a thorough understanding of surficial geology is essential for drift prospecting

***Figure GS-17-5: a)** Stratigraphy at site 14115MT235, a section on an island in central Stephens Lake (see Figure GS-17-1 for site location). This section exposes **b)** 1.0 m of contorted glaciolacustrine rhythmites that overlies **c)** 0.4 m interbedded fine sand and pea gravel, **d)** 1.0 m of water-laid stratified sandy diamict with rare abraded shell fragments, **e)** 1.0 m of dirty poorly sorted gravelly sand, and 2.0 m of gravelly sand to sandy diamicton which transitions to diamicton with depth.*

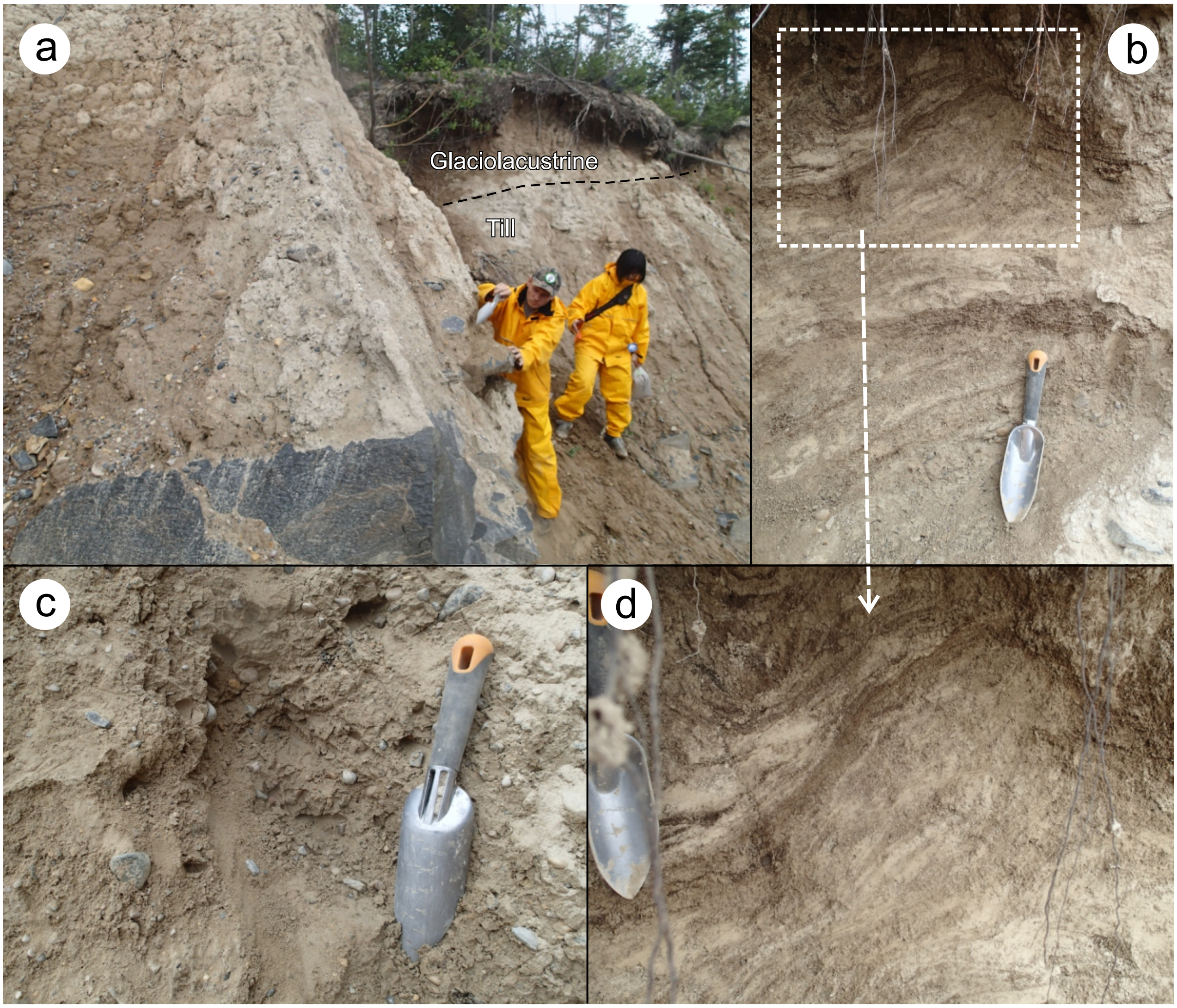

***Figure GS-17-6**: **a)** Stratigraphy at site 14115MT009, a bedrock quarry excavated by Manitoba Hydro (see Figure GS-17-1 for site location). This section exposes **b, d)** 1.2 m of contorted glaciolacustrine rhythmites that sharply overlie **c)** 1.8 m of loose sandy diamict, which overlies diorite bedrock that is well-striated toward 306°.*

in Manitoba's northern region. Till geochemistry is commonly used in drift-covered regions to help determine the source area for boulder trains, but is more difficult to interpret in palimpsest terrains such as the Gillam area in northwestern Manitoba, which have been modified by more than one ice advance and transport direction. Forthcoming results will provide new constraints to drift exploration in this area. Ongoing surficial geological studies aim to provide a detailed framework for the directions, timing and nature (e.g., erosive or depositional) of major and minor ice-flow events in the region. The outcomes of these studies are geared toward providing mineral exploration geologists with an up-to-date surficial geology knowledge base and the adequate tools to more accurately locate exploration targets in Manitoba's drift-covered areas.

Acknowledgments

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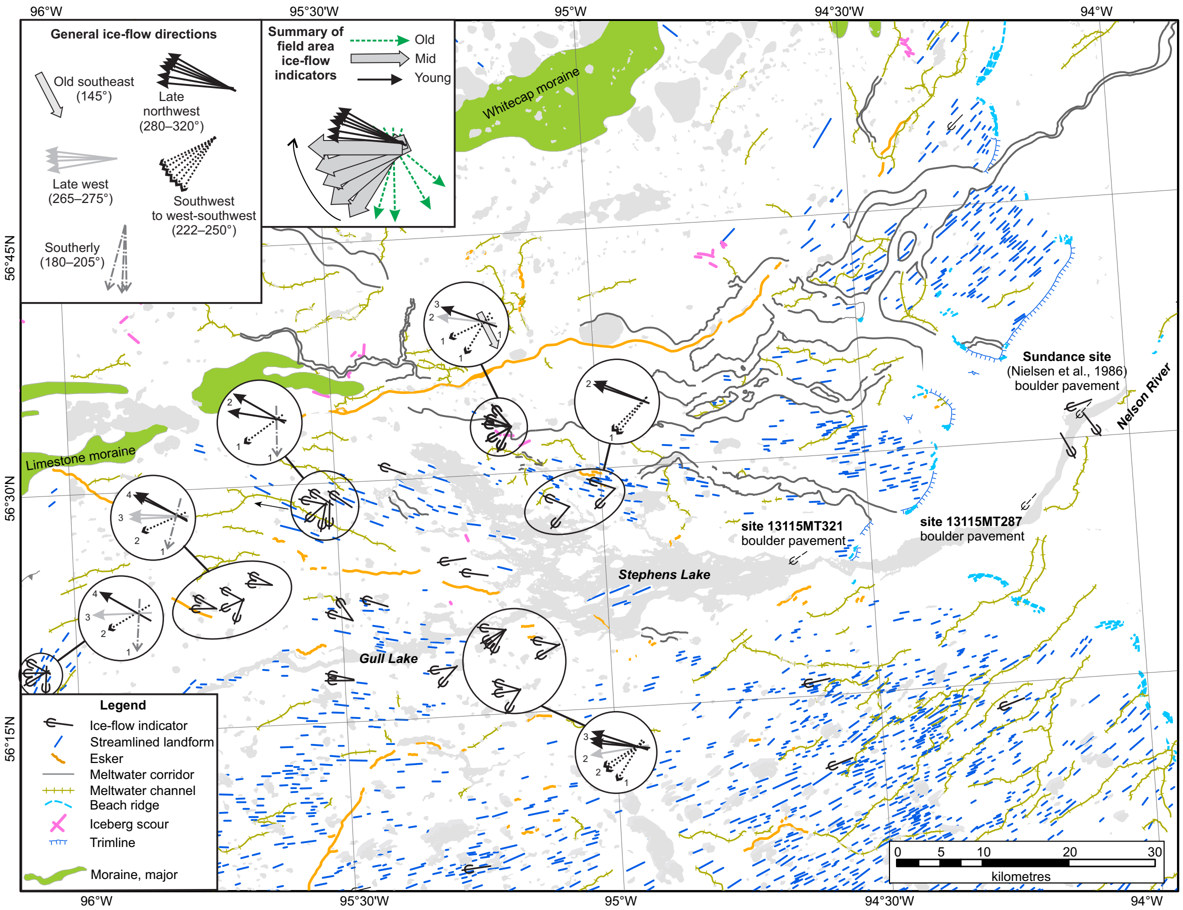

***Figure GS-17-7**: Field-based ice-flow indicator data in the study area. Larger circles are a compiled summary of the relative ages (1 = oldest) and trends of ice-flow indicators for a single site or sites in close proximity to each other. The general ice-flow directions provide a key for differentiating between old and young ice flows of similar orientation (upper-left inset).*

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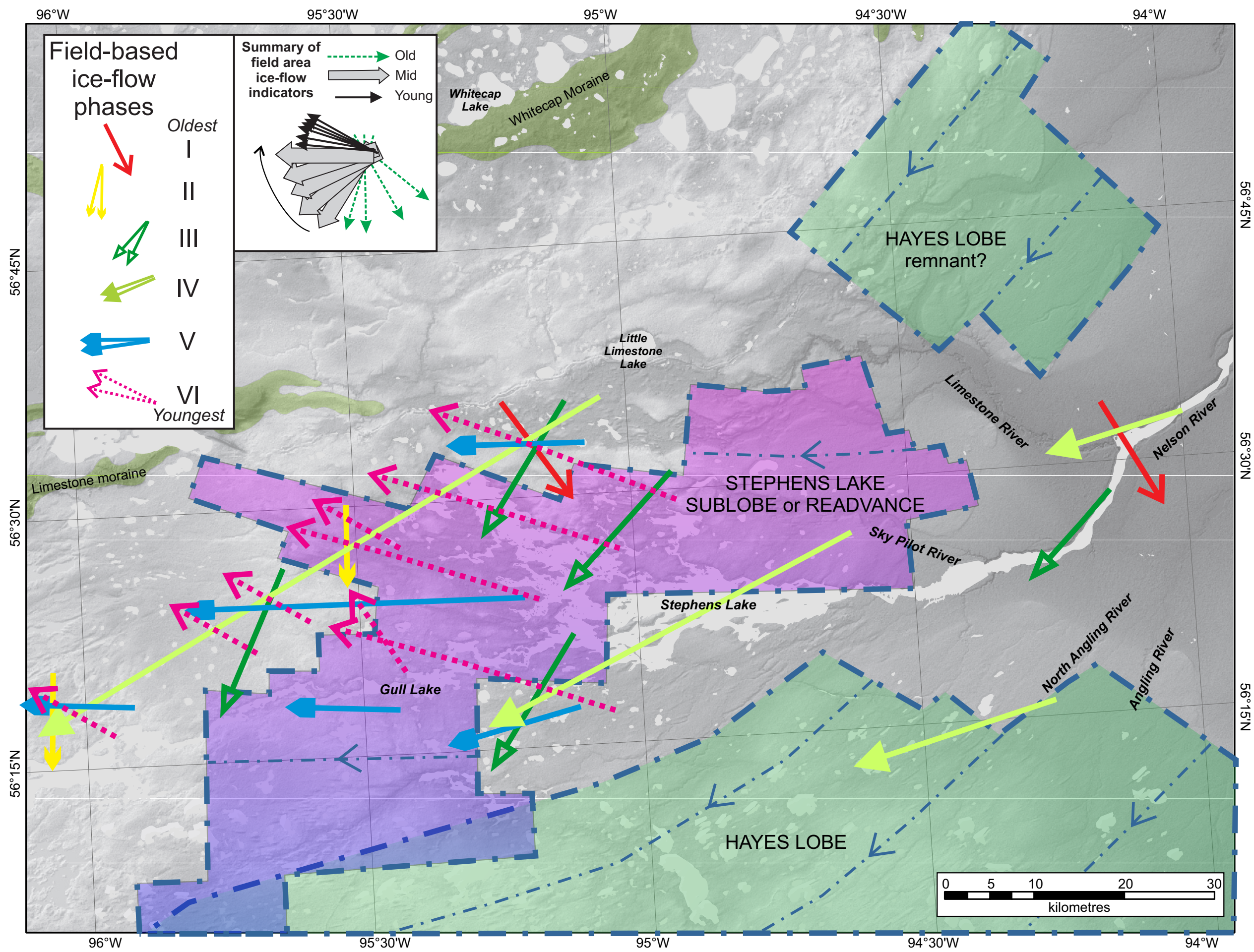

***Figure GS-17-8**: Compiled and interpreted ice-flow phases in the study area, summarized from the data presented in Figure GS-17-7. The summary of ice-flow indicators (upper-left inset) provides a depiction of possible dispersal-fan orientations for the area, which may be encountered during drift exploration. The blue-purple and green polygons outline streamlined-landform flowsets, termed the Stephens Lake sublobe or readvance, and Hayes lobe, respectively.*

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