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J.E. Campbell[1], I. McMartin[1], P.X. Normandeau[2], and P.-M. Godbout[1]

[1] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8
[2] Northwest Territories Geological Survey, C.S. Lord Building, 4601-B 52 Ave., Yellowknife, Northwest Territories X1A 2L9

2019

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Report of 2018 activities for the GEM-2 Rae project glacial history activity in the eastern Northwest Territories and the Kitikmeot and Kivalliq Regions, Nunavut

Janet Campbell, Isabelle McMartin, Philippe Normandeau and Pierre-Marc Godbout

Foreword

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for sustainable economic development in the North. The Program provides modern public geoscience that will set the stage for long-term decision making related to responsible land-use and resource development. Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and enables northern communities to make informed decisions about their land, economy and society. Building upon the success of its first five-years, GEM has been renewed until 2020 to continue producing new, publically available, regional-scale geoscience knowledge in Canada's North.

During the 2018 field season, research scientists from the GEM program successfully carried out 18 research activities, 16 of which will produce an activity report and 14 of which included fieldwork. Activities applied a variety of geological, geochemical, and geophysical methods. These activities have been undertaken in collaboration with provincial and territorial governments, Northerners and their institutions, academia and the private sector. GEM will continue to work with these key partners as the program advances.

Project Summary

The GEM-2 Rae Synthesis of Glacial History and Dynamics Activity centers on the interior region of the Keewatin Sector of the Laurentide Ice Sheet (LIS) and is divided into sectors, 1 (east) and 2 (west) for research management purposes. This publication summarizes the 2018 fieldwork completed in Sector 2 centered on the Aylmer-Healey lakes area of eastern Northwest Territories and mainland Kitikmeot region of Nunavut, as well as data compilation progress in Sector 1 over the Kivalliq and Kitikmeot regions.

The 2018 summer's fieldwork focused on targeted mapping of glacial flow indicators to provide insight into the ice-flow chronology west of the Keewatin Ice Divide (KID), documenting the nature and composition of the glacial sediments in various glacial terrains, and sampling material for age dating to help reconstruct the regional glacial and deglacial histories. This work will provide new geological knowledge of the glacial landscapes to address specific scientific questions with respect to the paleo-glacial dynamics of the Keewatin Sector of the LIS. This work is relevant to the mineral exploration industry, communities and government by supporting informed decision making for resource exploration and land use management.

Introduction

Goals and objectives

The 2018 summer's research is part of the GEM-2 Synthesis of Glacial History and Dynamics Activity (under Rae Project) which began in April 2017 (McMartin et al. 2017) (Fig. 1). It is a 3-year collaborative project between the Geological Survey of Canada (GSC) , the Canada-Nunavut Geoscience Office (CNGO) and the Northwest Territories Geological Survey (NTGS). Much of the Rae Province is heavily drift covered and has a complex glacial history involving multiple glaciations and dynamic glacial systems which impede both bedrock mapping and mineral exploration. The lack of a sufficient geological framework is contributing to this predominantly drift-covered region to remain underexplored for mineral resources. Therefore, the main objective of this activity is to compile and understand the distribution of glacial landforms and associated sediments, and to reconstruct glacial transport paths in the interior of the Keewatin Sector of the Laurentide Ice Sheet (LIS). This improved glaciological framework will support informed decisions-making for mineral exploration and land-resource management.

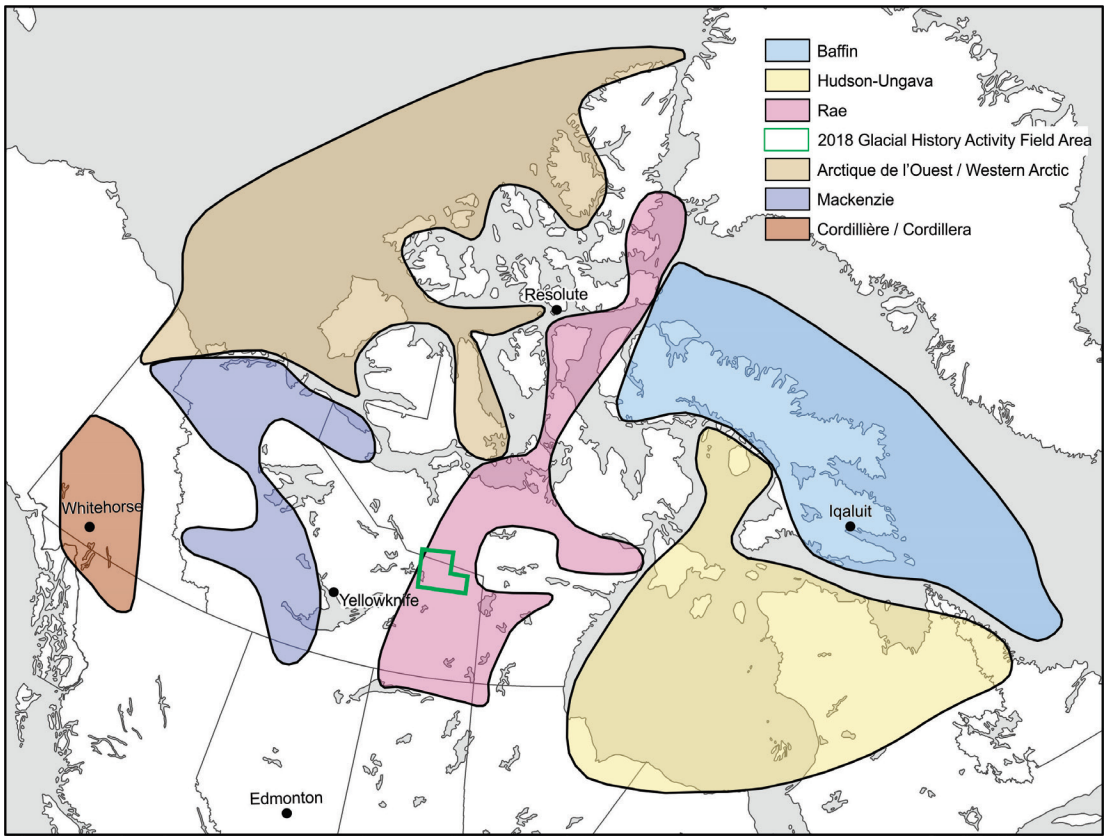

Figure 1. *Overview map of GEM-2 projects in northern Canada. The location of the 2018 Rae Glacial History Activity field area is outlined (green) within the west-central Rae project.*

The overall Rae Glacial Synthesis Activity involves a compilation of glacial landforms in a two-stage approach: first in Nunavut, south of latitude 68° and east of longitude 100° (Sector 1), and followed by compilation of data in NWT and Nunavut, south of latitude 68° and between longitudes 100° and 108° (Sector 2) (Fig. 2). The compilation will integrate published maps based on both field work and expert air photo interpretation, new mapping as part of Tri-T surficial compilation project, GEM-1, GEM-2 and CNGO projects, and new interpretation based on targeted field work, satellite imageries and digital elevation models (McMartin

et al. 2017). In 2017, McMartin et al. (2017), completed targeted fieldwork for Sector 1. The digital compilation of glacial features and interpretation of glacial landscapes is on-going in Sector 1 (McMartin et al., 2018).

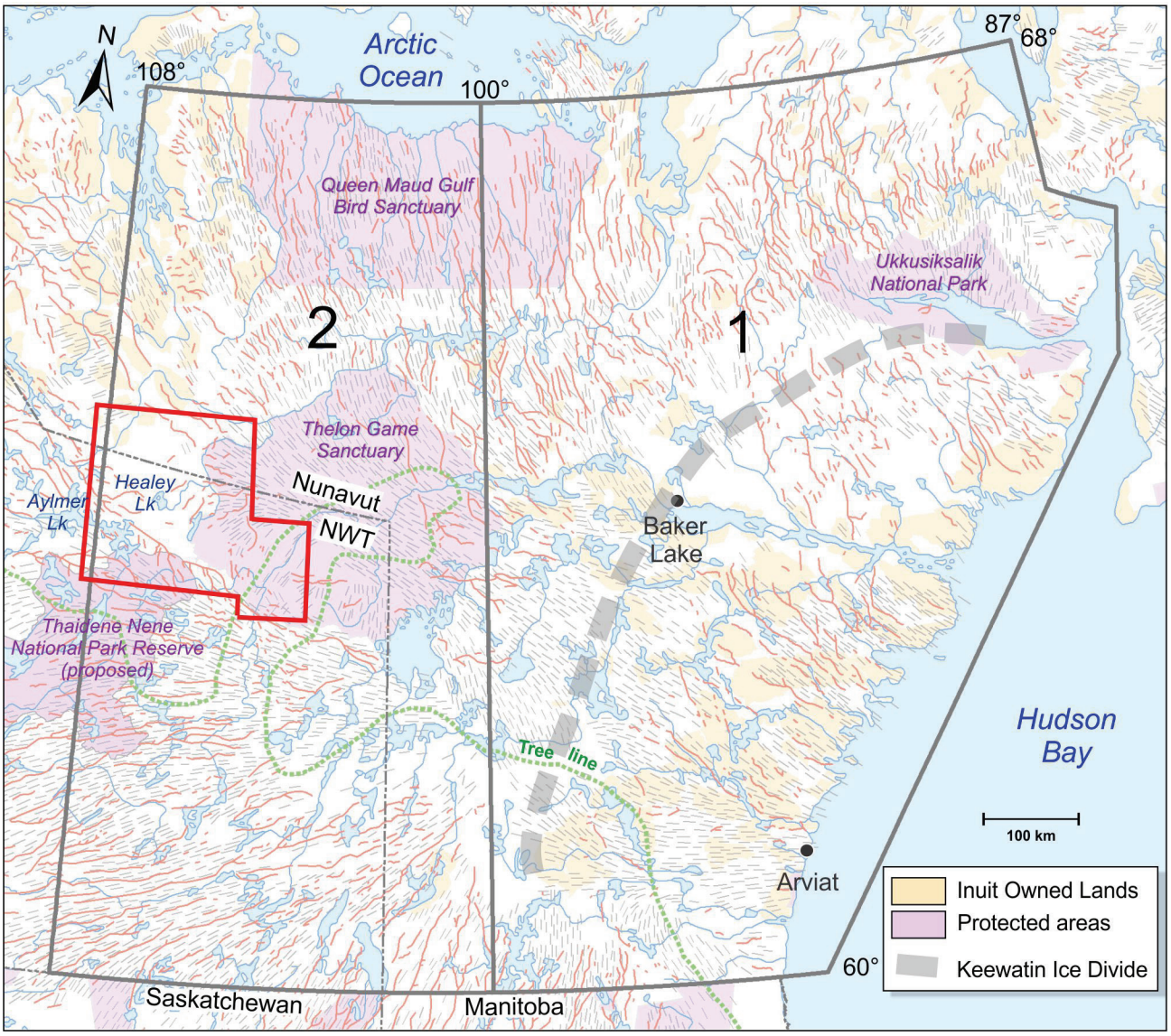

***Figure 2**. Region covered by the glacial history compilation in central Nunavut and NWT divided in Sector 1 and Sector 2 (grey outline). The 2018 field area is located in Sector 2 (red outline). Esker trends (red) and glacial lineations (grey) are from Prest et al. (1968). Last and approximate position of the Keewatin Ice Divide is also shown.*

This year's field component focused on surficial geological studies of the sediments and landforms in the region between Aylmer Lake, NWT and the western edge of the Thelon Wildlife Sanctuary and over the Northwest Territories and Nunavut border. The centre of the study area (Healey Lake, NWT) is approximately 370 km northeast of Yellowknife (Figs 1 and 2). The glacial geology in this region is poorly understood as there has been little field-based mapping since the reconnaisance-scale mapping in the late 1950's of the study area (Craig, 1964). With the exception of NTS mapsheet 76C (Dredge et al., 1995), the 1:250,000 scale surficial maps for the perimeter of the study area are based primarily on air-photo intepretation with little or no ground observations (e.g. Dyke and Kerr, 2013; Kerr et al 2013; Kerr et al 2014). The existing maps of the glacial

landscape and history are primarily at the national scale ≥ 1:1 000 000 (e.g. Prest et al., 1968; Aylsworth and Shilts, 1989; Fulton, 1995; Dyke et al., 2003).

Scientific question(s) addressed

The overall key scientific questions addressed in this Activity are outlined by McMartin et al. (2017) and are as follows: 1) what is the flow direction, sequence and degree of overprinting of shifting glacial and deglacial events in a poorly mapped core region of the LIS in Nunavut and NWT; 2) what is the extent and nature of early glacial landscapes that may have escaped younger glaciation(s) under non-erosive ice regimes (ice divides and/or cold-based) and, 3) what is the net effect of the glacial history on the nature of glacial dispersal patterns, i.e. palimpsest, recycled and/or inherited surface sediment composition.

Several specific questions for Sector 2 were identified to inform the activity's overall scientific questions. This summer's fieldwork focused on: 1) what is the recorded ice flow history; 2) are there unmapped relict or palimpsest terrains, and what is the nature and sediment composition of these landscapes; 3) what is the western extent of the Dubawnt Lake Ice Stream (DLIS); 4) is there evidence of the McClintock Ice Divide; and 5) what geomorphic evidence records the retreating ice margin in this region. This report provides a brief outline of the 2018 fieldwork methods and a summary the key field observations in the Healey Lake area, as well as an update on the ongoing compilation in Sector 1 area.

Methodology

Target fieldwork

The locations of the field sites were chosen in selected areas of interest based on glacial landforms and flow features from existing glacial history models (e.g. Boulton and Clark, 1990; Kleman et al., 2010; Dyke et al. 2003) and national-scale compilations (e.g. Prest et al , 1968; Aylsworth and Shilts, 1989) (Figure 3). The actual sites were selected using aerial photographs, digital elevation models (DEMs) and satellite imagery (LANDSAT 8), as well as integrating previous work mentioned above. The high-resolution (5 m) DEM of the Arctic north of 60°N latitude ("ArcticDEM"; PGC 2017) was used for site planning, initial landscape interpretation and field verification of glacial landforms.

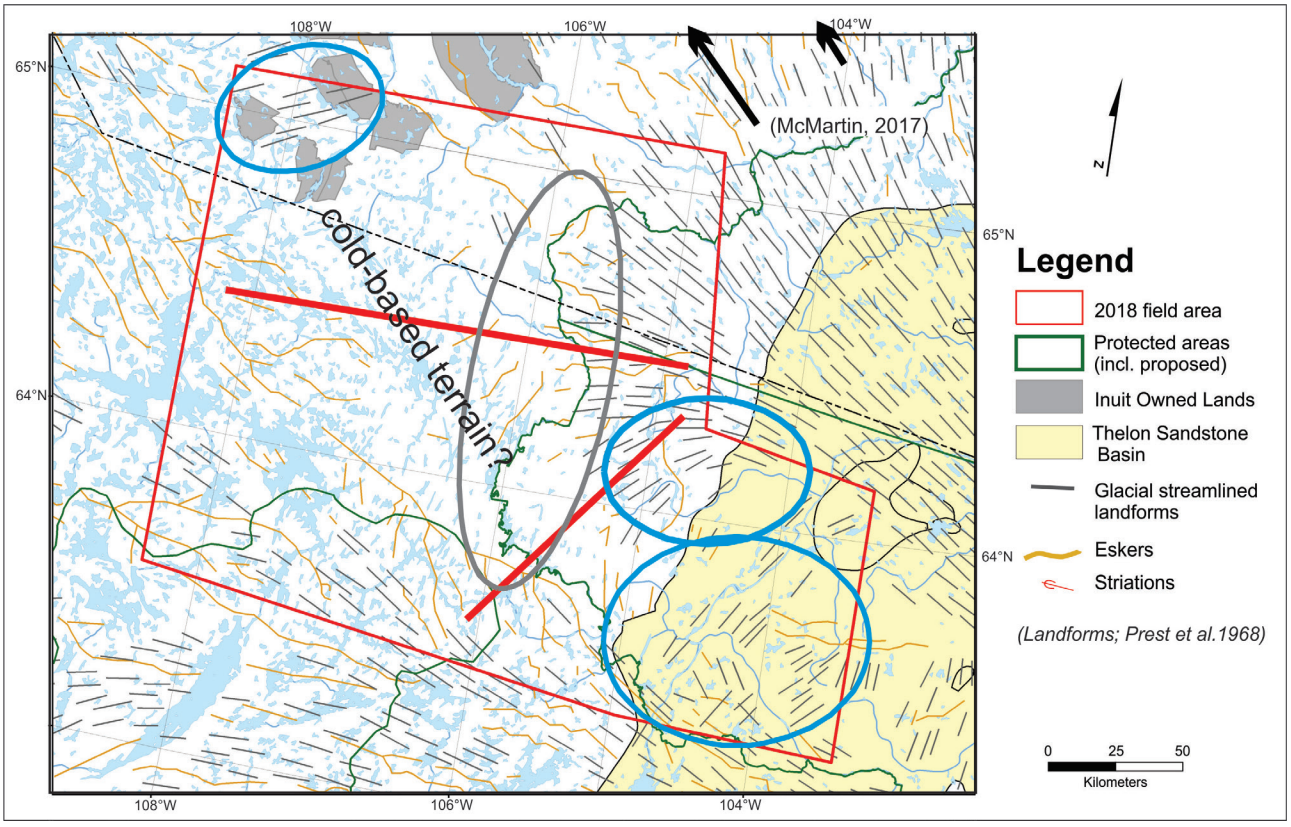

Figure 3. *Targeted areas for field investigations based on existing maps and models; areas of contracting ice flow sets (blue circles); the western terminus of the Dubawnt Lake Ice Stream (grey circle); glacial transport directions and distances across various glacial terrains (red lines) and region of drift-poor, featureless terrain (noted as possible "cold based terrain?"). Generalised extent of the Thelon Sandstone Basin (Barrenlands Group, Dubawnt Supergroup) after Harrison et al. (2011.)*

Two transects were selected to test for west and southwest regional glacial transport of debris from the Thelon sandstone basin and to complement other transects completed around the Keewatin Ice Divide (Kjarsgaard et al. 2014; McMartin et al., 2015, 2016, 2017; Campbell et al 2017; McMartin 2017). At each site, the surficial geology and ice flow indicators were recorded in addition to the collection of till samples for compositional analyses.

Surficial geology field data

Seventy ground sites were visited and 2 remote observations made (Fig. 4). Ground sites were accessed by helicopter. Aerial (remote) observation sites were made from the helicopter by a combination of notes on maps, air-photos and/or digital data capture, and accompanied by GPS-referenced photographs. The work involved collecting information on the terrain, surface sediments, landforms, and small scale erosional features on bedrock (e.g. striations, chattermarks, crescentic gouges, roches moutonnées) (Fig. 5a). Till samples were collected for compositional analyses at 40 sites. For age dating, boulder or bedrock samples were collected at 8 locations and sand samples at 2 sites. The terrain, ice-flow indicators, dughole or sample media and sample were photographed at each field site. Site data was digitally captured in GANFELD field forms on tablets.

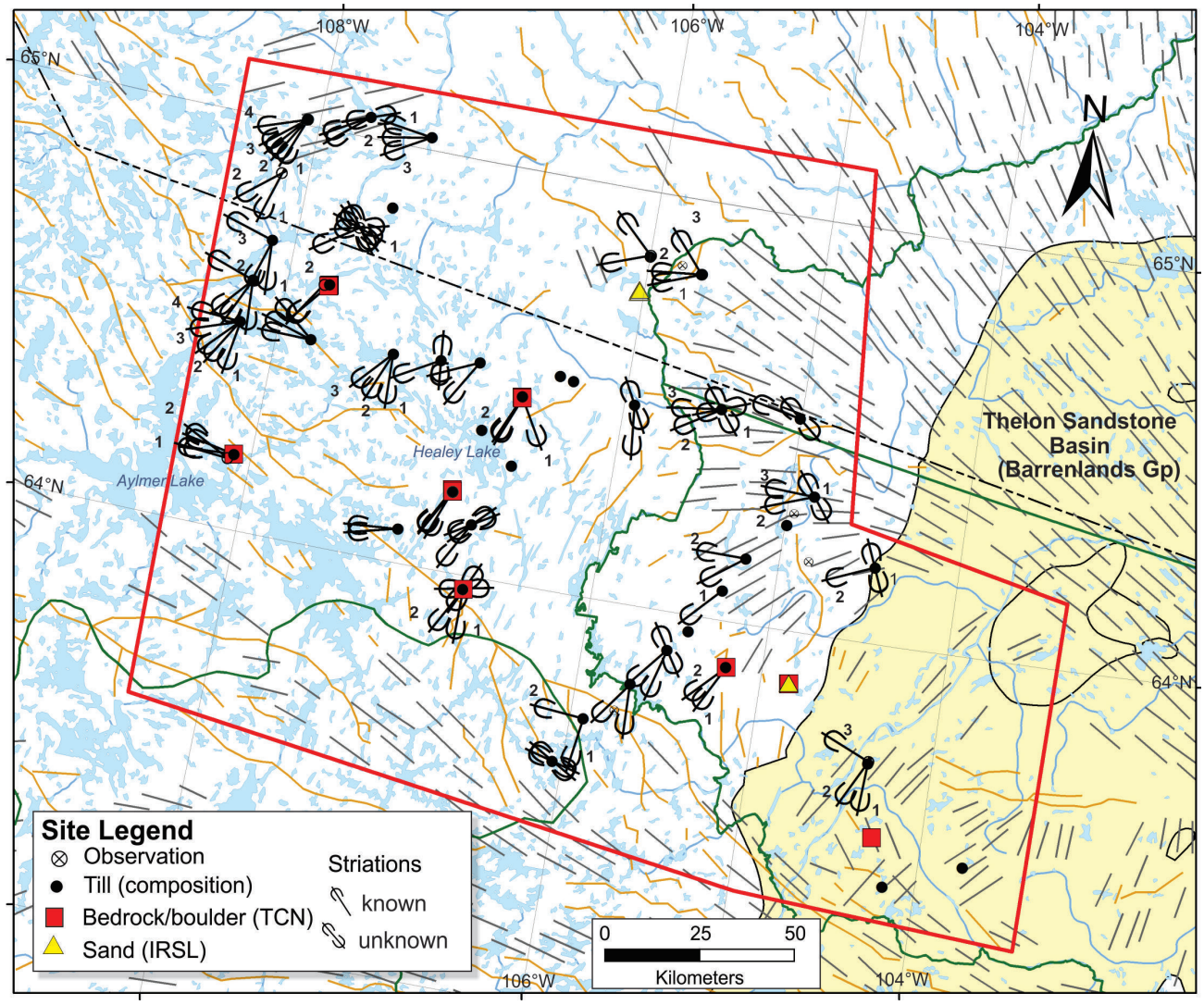

Figure 4. *Location of field stations, samples and striations collected in 2018. The relative ages of striations are shown. Eskers (orange) and glacial lineations (grey) are from Prest et al., (1968).*

Till sampling

Till samples were collected on a variety of glacial terrains to characterise the sediments associated with these terrains (i.e. relict, ice streams, veneers, plains and modified), and to determine their composition and provenance to support regional transport-dispersal studies. The sample sites were located on flat till surfaces on high ground with a few exceptions due to sampling conditions. At each site, a small (~3kg) and a large (~12kg) sample were carefully taken at an average depth of 60 cm, mainly from the C-Cy soil horizon material, in hand dug holes (Fig. 5b). Oxidation depth was highly variable. Often the sample holes were dug in inactive and active frost boils (fresh). The samples were submitted for compositional (textural, geochemical and clast lithology), indicator mineral and gold grain analyses. Sample collection and analyses were conducted following GSC Protocols (Spirito et al., 2011).

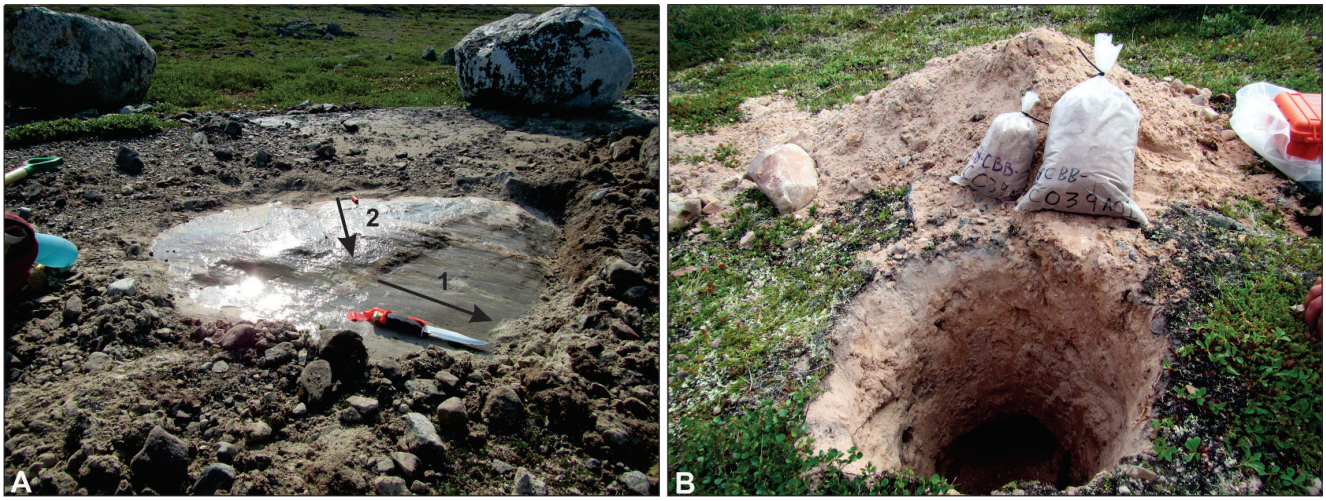

Figure 5. *A: Multiple sets of striations at 18CBB-C034 indicate relative age of 2 ice flow phases. Striae preserved on a protected lee surface (1) records older flow to the SW (~232 °). Striations on top of the outcrop (2) record the younger, main ice flow to the WNW (285°). B: Large (~12kg) and small (~3kg) till samples are collected from the C soil horizon in hand dug pits* (*18CBB-C039A01).*

Age dating material sampling

Geochronological samples were collected for two purposes: 1) to constrain ice margin retreat history with absolute ice-free dates and 2) to test for inheritance/degree of glacial erosion indicating preservation of relict terrains under non-erosive basal ice regimes (e.g., cold based) using relative age dates. Two samples were collected for Infrared Stimulated Luminescence (IRSL) dating (Bateman, 2015; Lamothe, 2016) from well-sorted fine to medium grained sands in raised beaches developed on glaciolacustrine ice-contact deltas (Fig. 6a.) Optical luminescence methods determine when quartz or feldspar grains in sediment were last exposed to sunlight (Huntley and Lian, 1999; Lamothe, 2016). Samples were collected using opaque plastic tubes that were inserted in freshly cleaned exposures at approximately 30-60 cm depth (Fig. 6b) in accordance with sampling methods developed by Aitken (1998) and outlined by Duller (2008). The IRSL exposure ages will help constrain the timing of the pro-glacial lake(s) stands at ice margins as well as minimum dates for the ice margin retreat.

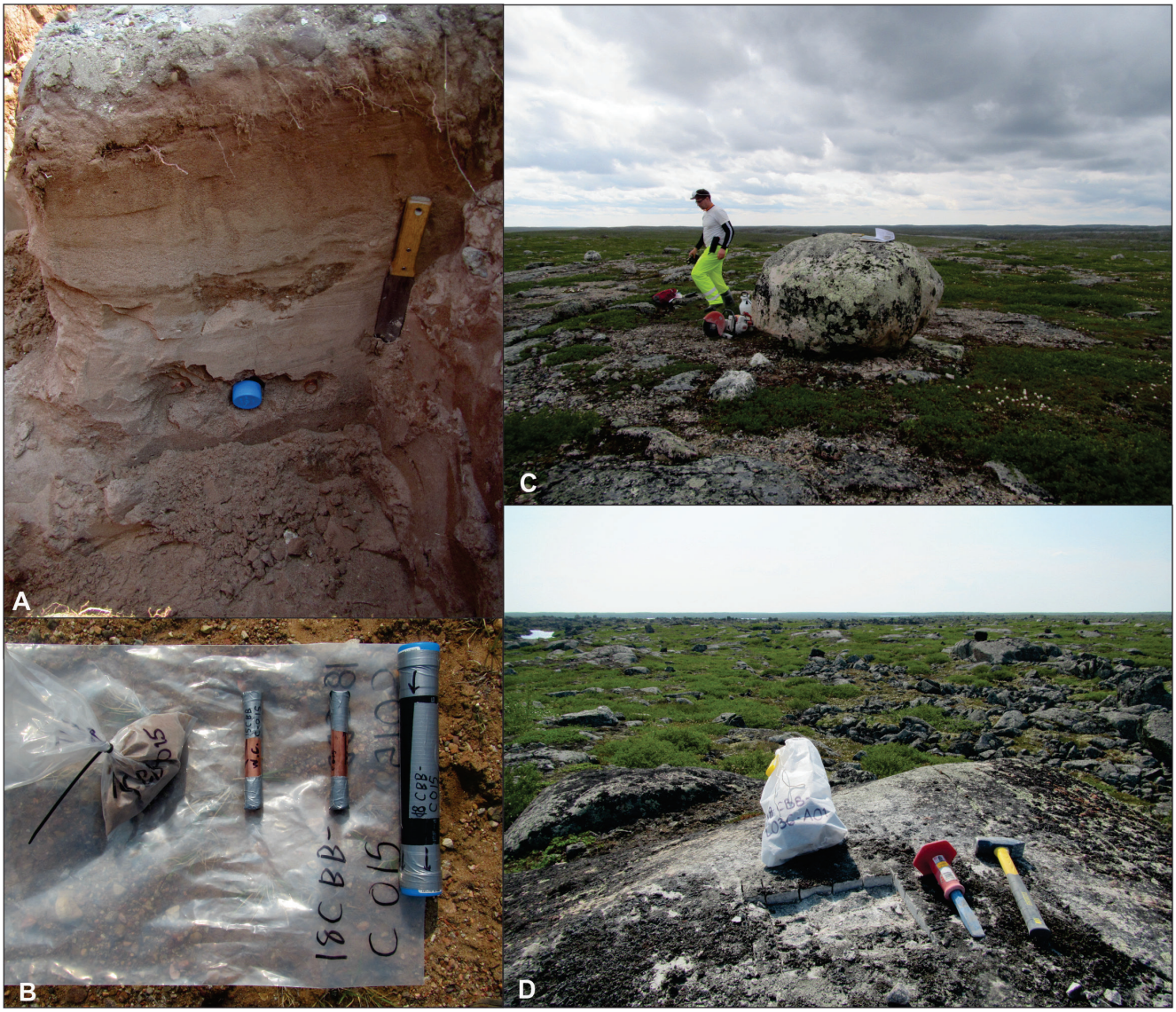

Figure 6. *Geochronology sample collection. A) In-situ IRSL sample tubes prior to removal from ice-contact deltaic sands (18CBB-C015); B) Sample consists of IRSL sample (large tube), two small tubes for average water content and a bag for texture analysis; C) Granitoid boulder for TCN exposure dating (18CBB-C005) to determine ice free age; and D) TCN sample (18CBB-L036) collected from granitoid bedrock surface for relative degree of glacial erosion/inheritance.*

Fourteen samples were collected from either bedrock or boulder surfaces at 8 sites for 10Be, 26Al and/or 14C terrestrial cosmogenic nuclides (TCN) dating methods. Boulder samples were collected at 4 sites to help establish a minimum age for ice-free conditions in this region (Fig. 6c). One site is located on the same ice contact delta as an IRSL sample (Fig. 4). Another site is a poorly defined end moraine segment (Dyke and Kerr, 2014). The remaining two boulder sites are located on high, exposed till ridges in the western part of the study area (Fig. 2). Bedrock TCN samples (2 per site) were collected from 4 sites to test for relative inheritance or degree of glacial erosion (Fig 6d). Two sites in the central region are believed to be weathered relict terrains preserved under cold-based ice during deglaciation. For comparison, bedrock samples were collected at two other sites in warm-based glacial terrains where outcrops are glacially moulded, polished and striated indicating a higher degree of removal of surface material by glacial erosion. These later sites will also provide a minimum age date for deglaciation. All sites are open, flat and are predominantly well exposed (< 5° shielding) to ensure optimum

exposure to the cosmic rays. Samples were collected using a portable rock saw. A ~20 x 20 cm grid surface was cut and ~1.5-2 cm thick cuttings were removed (~3kg) with a chisel (Fig. 6d; inset) The lithologies collected included granitoids and quartz-rich metasediments to ensure sufficient quartz grains for 10Be and/or 14C exposure age dating (Gosse and Phillips, 2001).

Results

Ice-flow patterns

Landforms and small-scale erosional indicators (e.g., striations, roches moutonnées) record multiple ice-flow directions and phases that vary across the study area. When possible, the sense and relative ages of the ice-flow indicators were determined for each record site (Fig.4). A preliminary interpretation of the relative regional ice-flow chronology is presented in Figure 7. The oldest direction recorded through the study area trends SE-NW with sense unknown. Well-defined indicators record an early regional ice flow to the south followed by a south-southwest ice flow, which is the dominant direction in the central and far southeast regions. The ice flow shifts to the west; flowing from the KID located to the east (McMartin and Henderson, 2004). This flow dominates the west central portion of the 2018 field area. The westward ice flow shifts to northwest as expressed in the landforms and striae recorded in the south. A late localised lobe flowing from the northeast to the southwest occupied the NW corner (Dredge et al. 1995). The late deglacial Dubawnt Lake Ice stream (DLIS) terminates in the western part of the study area (e.g. Stokes and Clark, 2003). Ice flow in the terminus of the DLIS shifts from northwest in the north, to west in the central part and southwest in the south.

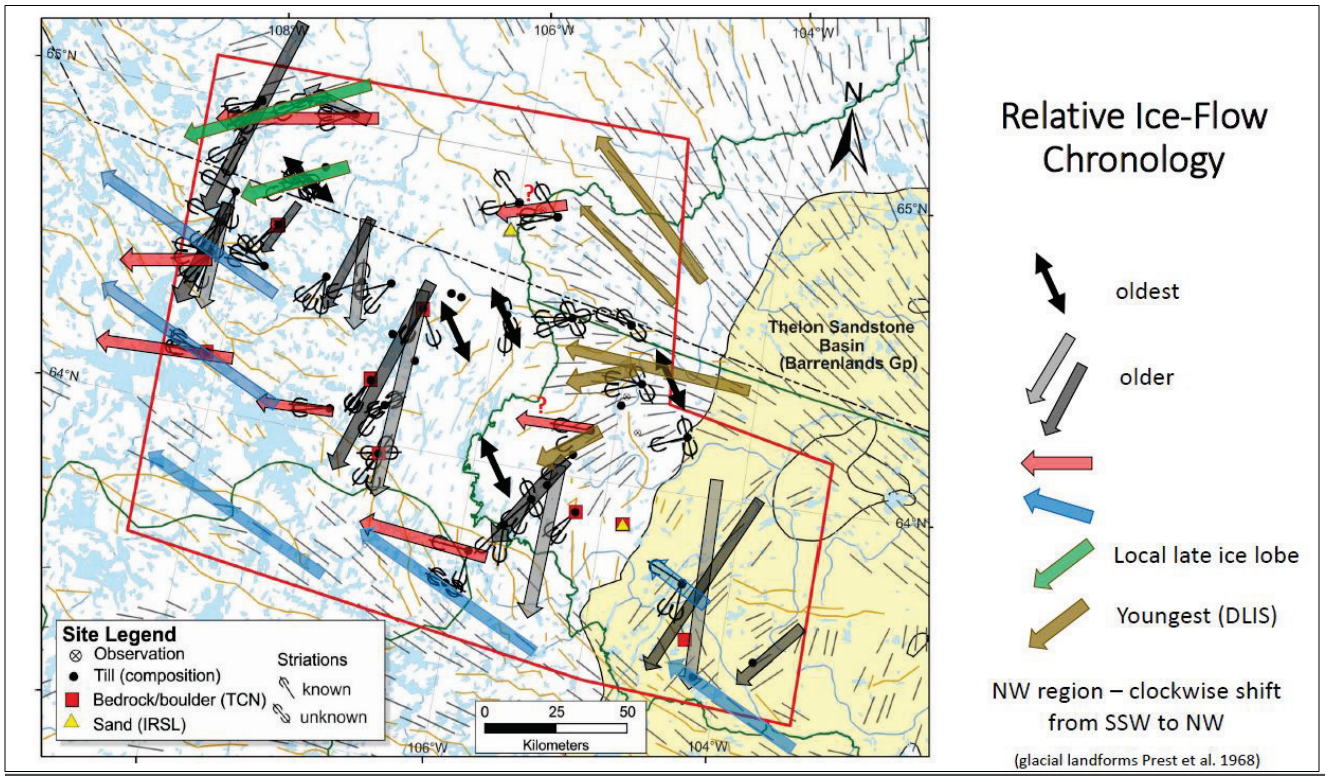

Figure 7. *Preliminary regional relative ice-flow chronology for the Sector 2 study area.*

Immediately west of the study area in NTS 76C, Dredge et al. (1995) related the west flow to ice flow from an ice divide situated immediately to the east in the present study area (McClintock Ice Divide - MID); Dyke

and Prest, 1987). Although the south end of the MID as portrayed by Dyke and Prest (1987) roughly correlates with the central featureless region, no evidence of eastward flow indicators were found to suggest the presence of the MID in the study area. Immediately north of the study area between 65° to 67° N and 104˚ to 106˚W (NTS 76H and I), McMartin and Berman (2015) also found no evidence of an early westward or eastward flow of ice that would originate from a north-south trending ice divide. The west flow is the regional flow found primarily west of Healey Lake that postdates the south and southwest flows.

Glacial landscapes

Field observations and striations mapping indicate the glacial landscapes mirror the complex nature of the glacial history. The spatial variability in geomorphology, surface material composition, thickness and degree of weathering/erosion results from changes in substrate lithology, basal thermal conditions (warm-based to cold-based) and paleo-ice flow dynamics (Figs. 7 and 8). There is a general correlation between the dominant ice flow direction and degree of preservation of older phases with the glacial terrains (Figs. 7 and 8). The landscape of the NW-SE trending region centred around Healey Lake (dark grey, Fig. 8) is bedrock-controlled; dominated by low relief, weathered and frost-shattered outcrops, block fields, with thin veneers of till and boulders reminiscent of relict terrains preserved under non-erosive, intermediate cold-based ice conditions (Figs. 8 and 9a, b) (c.f. Kleman and Hättestrand, 1999; Tremblay et al. 2016). Small patches of warm-based ice terrains are interspersed throughout this area. These patches are of glacially moulded and polished outcrops that record the older south and southwest flow (Fig. 9c) and thicker till deposits.

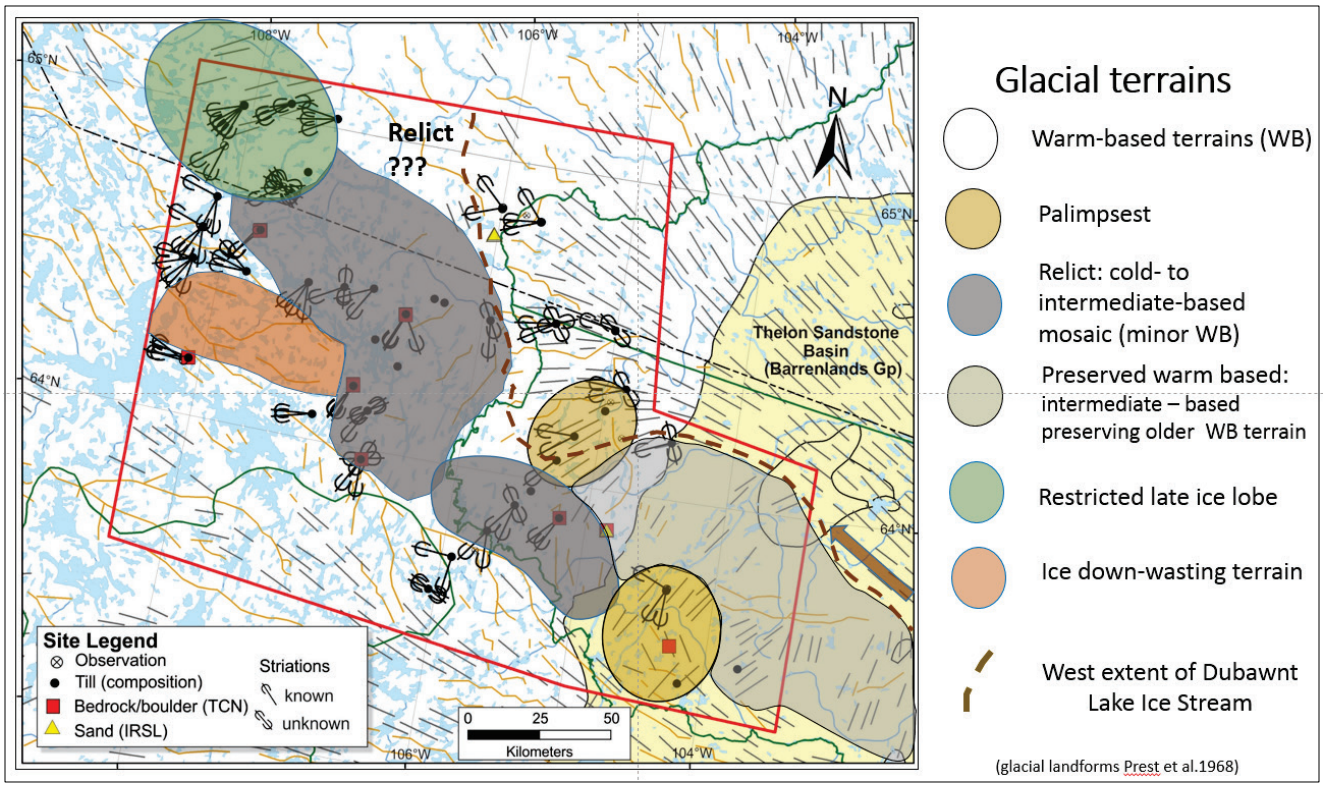

Figure 8. *Preliminary terrain classifications of the glacial landscape in Sector 2 study area.*

Surrounding the central region, warm based terrains of molded, glacially polished bedrock, streamlined landforms, esker systems and/or thicker drift dominate (Fig. 8 white areas with glacial features; Figs. 9d and e).

The warm-based regions record the late deglaciation ice-flow directions as the main event phase, namely the northwest flow and the DLIS. In the southeast, both crosscutting streamlined landforms (Fig. 8: palimpsest terrain; Fig. 9f) and landforms with diverging orientations (Fig. 8: preserved warm-based terrain) indicate preserved terrains related to older ice-flow directions that have escaped overprinting by deglacial ice flows.

Figure 9. *Glacial Terrains. Relict terrain comprised of intermediate to cold-based, frost-shattered and weathered bedrock viewed from the ground (A) and from the air (B). (C) There are enclaves of warm-based terrains within the relict terrains as evidenced by molded outcrop preserved in the older S-SW ice flow direction and patches of till at 18CBB-C036. Warm based terrains: D) Streamlined drift such as the crag-and-tail landforms in the northwest (arrow indicted direction of flow) and E) till veneer and plains interspersed with glacially molded outcrop ridges in the west and southwest regions. F) Palimpsest terrain: smaller, younger WSW trending drumlins cross-cut south trending streamlined features.*

Glaciofluvial deposits and ice-marginal positions

On existing surficial maps for the study area (Craig, 1964; Prest et al., 1968; Aylsworth and Shilts, 1989; Kerr et al., 2013; Storrar, 2013; Dyke and Kerr, 2014), eskers trend in two main orientations (e.g. Fig. 4) and are noticeably absent to rare in the central region. Shorter, less frequent northwest-southeast trending eskers observed mainly in the east central region are re-interpreted primarily as deglacial ice-marginal features (Fig 10a). Alternatively some of the esker segments may be preserved features related to the south-southwest flow. Larger, more continuous eskers, which are aligned with the late deglacial northwest ice flow, occur in the south and west regions and within the DLIS in the northeast. Many of the eskers are flat topped (Fig. 10a) indicating they formed in open channels, or in other instances, due to wave washing as evidenced by the presence of glaciolacustrine shoreline features. It is interesting to note the morphology of the large, continuous northwest trending esker that crosses the southern part of the study area. Tributary branches only occur on the south side of this esker. The north side abuts the relict terrain which suggests the esker formed at the margin between the cold-based ice to the north and the adjacent warm-based ice flowing to the northwest (A. Dyke, pers. comm.).

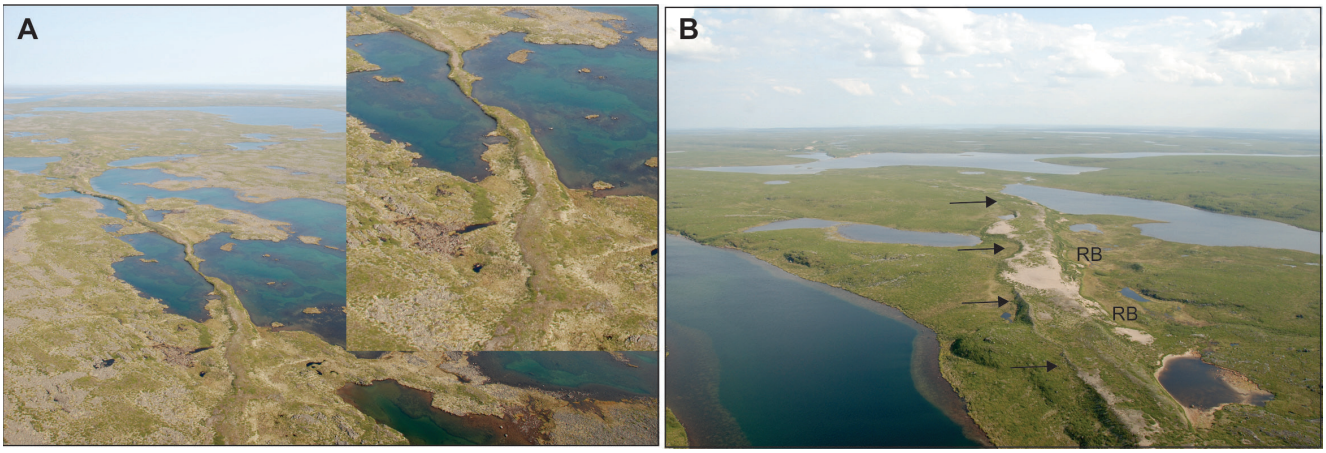

Figure 10. *A) Many of the NW trending eskers are flat topped. B) Features previously mapped as NNE-SSW eskers are interpreted here as ice marginal eskers and/or coalesced subaqueous outwash fans marking former ice margin positions during deglaciation. Arrows indicate former ice position. North is roughly towards the photographer. Note the raised beaches (RB) on the right side of the landform.*

A series of ice marginal glacial lakes, ice-contact glaciofluvial deposits (e.g. ice-contact deltas and subaqueous fans; Figure 10b) and minor moraines record the retreat of the ice margin across the study area (Fig.11a). The most prominent ice marginal feature is a large N-S trending hummocky ice-contact glaciofluvial complex along the western border of the Thelon Game Sanctuary (Fig. 11b). This major ice retreat still-stand position is interpreted as a southwestern extension of the MacAlpine Moraine System.

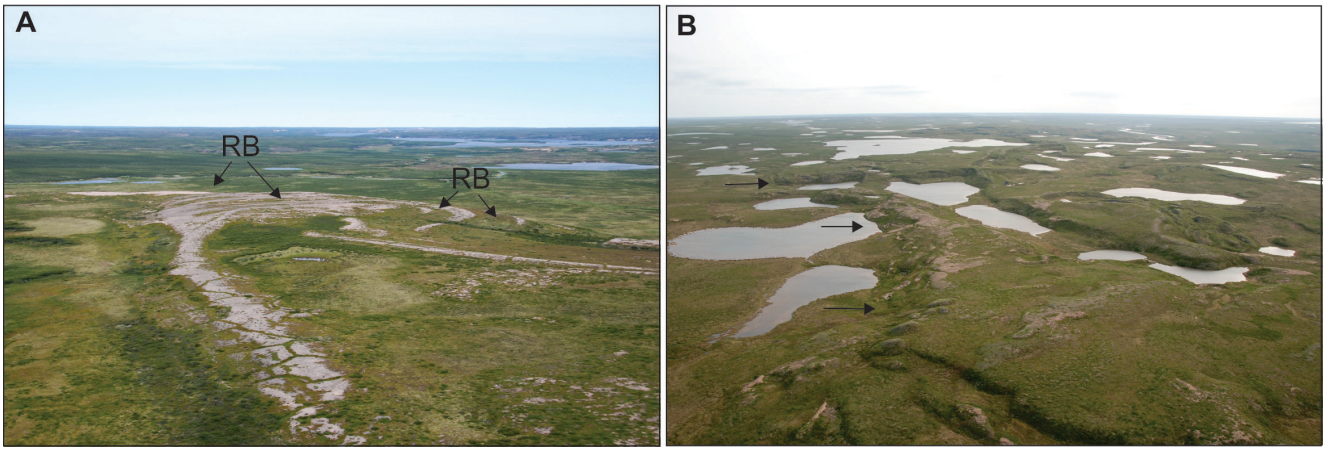

Figure 11. *Ice marginal features: A) ice contact delta with a series of raised beaches (RB); flow was away from the photographer. B) southwestern extension of the MacAlpine Moraine System comprised of a broad belt of hummocky ice-contact sandy deposits. The moraine marks the main terminus stillstand of the DLIS in the study area. Ice contact slope is indicated by black arrows. North is roughly towards the photographer.*

Dubawnt Lake Ice stream

The western and northwestern extents of the Dubawnt Lake Ice stream (e.g. Stokes and Clark, 2003; Margold et al., 2015; McMartin and Berman, 2015; McMartin, 2017) are well defined in the study area as evidenced by ice-contact marginal deposits, young western and northwestern streamlined landforms and/or striations. There is a clear shift in till provenance reflected in the clast and matrix fractions of the till as observed in the field. Within the ice stream terrain, Dubawnt Supergroup lithologies (Rainbird et al., 2003) dominate the clast fraction. At one site within the DLIS approximately 70 km east-southeast of Healey Lake, a high percentage of slightly calcareous siltstone and chert was encountered. The presence of these clasts suggests the occurrence of an unmapped Paleozoic outlier in the up-ice direction. West of the ice stream terminus local bedrock lithologies dominate; however, rare Dubawnt Supergroup clasts were observed on field site surfaces, and beaches as far as the western edge of the study area. This suggests long westward dispersal by earlier ice flow(s). To the north of the study area, McMartin (2017) also reported major changes in clast content, texture, and geochemical composition in till collected over and beyond the ice-stream footprint. The till composition over the Dubawnt Lake ice stream was found to reflect a significant distal component, high in Dubawnt debris, relatively clay-rich, SiO2-rich, and depleted in most trace and major elements (except SiO2); these changes coincide with an ice-front position at the MacAlpine Moraine System. In the southeast part of the study area the identification of the DLIS terminus is less clear.

Glacial compilation in Sector 1

The compilation of glacial features and interpreted glacial landscapes is in progress for an area covering ~400,000 km2 in the Kivalliq and Kitikmeot regions of Nunavut (Sector 1; Fig. 2). The map comprises 43 complete/partial 1:250K scale NTS map sheets. Selected polygons, lines and point features are grouped into simplified shapefiles by theme. Information (metadata) is stored in attribute tables for each feature observation type regarding timing, mapper and nature of interpretation (e.g., error, duplication, shift, addition), and original data source. In addition, the compilation will reconcile a number of archived field observations and surface sample compositional databases from years of government mapping. In total, 126,606 line features, 5,835 point features and 13,335 polygons are now included in the database, in addition to 5,753 ground and remote stations with field observations, ice-flow measurements and/or glacial sediment samples. The new compilation will

permit the identification and grouping of various glacial features into coherent glacial landscapes, including ice streams, ice divides, ice retreat positions, flow sets, palimpsest flows, relict and retreat cold- to warm-based landscapes, and subglacial meltwater corridors. The field-based observations as well as the samples for age dating and composition collected in targeted areas in 2017 and 2018 will provide constraints on the glacial history, and help evaluate glacial transport in areas of complex ice-flow dynamics and changing basal ice thermal regimes. The final product will consist of a scalable map with accompanying database of glacial features and landforms (individually identified); a field database including ground and remote stations with field observations, ice-flow measurements and/or glacial sediment samples; an interpretation of glacial landscapes (georeferenced overlays); a bibliography of all published sources; and a nomenclature of the map features.

Conclusions

Field observations, till sampling and striation mapping indicate the landscape reflects a complex glacial history. The variability in till composition is related to provenance as well as net glacial erosion and transport. Future till geochemical, indicator mineral and lithological analytical results will be used to evaluate glacial transport characteristics under shifting glacial dynamics and basal ice conditions over time. This information will help define and interpret net dispersal patterns. Geochronological samples were collected to constrain ice margin retreat history (absolute ice-free dates), and to test for degree of inheritance/glacial erosion (relative age dates). This work is intended to improve the geoscience framework for mineral exploration.

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References

Aitken, M. J., 1998, An Introduction to Optical Dating: The Dating of Quaternary Sediments by the Use of Photon-Stimulated Luminescence. , Oxford, Oxford University Press, v. 1, 267 p.

Aylsworth, J.M. and Shilts, W.W., 1989. Glacial features around the Keewatin Ice divide: Districts of MacKenzie and Keewatin; Geological Survey of Canada, Paper 88-24, 21 p., 2 maps.

Bateman, M.D., 2015. The Application of luminescence dating in sea-level studies; In: Shennan I, Long, A.L. and Horton, B.P. (Eds), Handbook of Sea-Level Research, Wiley-Blackwell, Chapter 27.

Boulton, G. S. and Clark, C. D., 1990. A highly mobile Laurentide ice sheet revealed by satellite images of glacial lineations: Nature, v. 346, no. 6287, p. 813-817.

Campbell, J.E., Lauzon, G., Dyke, A.S., and Roy, M. 2017. Regional glacial history, paleo-dynamics and dispersal patterns, South Rae craton, Northwest Territories; Kingston 2017; Geological Association of Canada-Mineralogical Association of Canada, Kingston, Ontario, Program with abstracts, v. 40, p. 48

Craig, B.G., 1964. Surficial geology of the east-central district of Mackenzie; Geological Survey of Canada Bulletin 99, 41 p. 2 maps.

Dredge, L. A., Ward, B. C., and Kerr, D. E., 1995. Surficial Geology, Aylmer Lake, District of Mackenzie, Northwest Territories; Geological Survey of Canada, "A" Series Map 1867A, 1995, 2 sheets, scale 1:250,000 https://doi.org/10.4095/207631

Duller, G. A. T., 2008, Luminescence dating: Guidelines on using luminescence dating in archaeology. English Heritage, Swindon, England, 43p.

Dyke, A.S. and Kerr, D E., 2014. Reconnaissance surficial geology, Hanbury River, Northwest Territories, NTS 75-P; Geological Survey of Canada, Canadian Geoscience Map 186, (ed. prelim.) 2014, 1 sheet, scale 1:250,000 https://doi.org/10.4095/293991

Dyke, A.S., Moore, A., and Robertson, L., 2003. Deglaciation of North America; Geological Survey of Canada, Open File 1574.
.
Dyke, A. S. and Prest, V.S., 1987. Paleogeography of northern North America, 18 000 - 5 000 years ago, 3 sheets, scale 1:12,500,000.

Fulton, R.J., 1995. Surficial materials of Canada; Geological Survey of Canada, "A" Series Map 1880A; 1 sheet, scale 1:5,000,000.

Gosse, J.C. and Phillips, F.M., 2001. Terrestrial in suite cosmogenic nuclides: theory and application; Quaternary Science Reviews, v.20., p.1475-1560.

Harrison, J.C., St-Onge, M.R., Petrov, O.V., Strelnikov, S.I., Lopatin, B.G., Wilson, F.H., Tella, S., Paul, D., Lynds, T., Shokalsky, S.P., Hults, C.K., Bergman, S., Jepsen, H.F., and Solli, A., 2011. Geological map of the Arctic / Carte géologique de l'Arctique; Geological Survey of Canada, Map 2159A, scale 1:5,000,000.

Huntley, D.J. and Lian, O.B. 1999. Using optical dating to determine when a sediment was last exposed to sunlight. In Holocene climate and environmental change in the Palliser Triangle: a geoscientific context for evaluation the impacts of climate change on the southern Canadian prairies; edited by D.S. Lemmen and R.E.Vance. Geological Survey of Canada, Bulletin 534, pp. 211–222.

Kjarsgaard, B. A., Plourde, A.P., Knight, R. D., Sharpe, D. R., 2014. Geochemistry of regional surficial sediment samples from the Thelon River to the East Arm of Great Slave Lake, Northwest Territories, Canada; Geological Survey of Canada, Open File 7649; 17 pages, doi:10.4095/295195.

Kerr, D. E,. Knight, R.D., Sharpe, D. R., and Cummings, D. I., 2013. Surficial geology, Artillery Lake, Northwest Territories, NTS 75-O; Geological Survey of Canada, Canadian Geoscience Map 110, (ed. prelim.); 1 sheet, scale 1:250,000 https://doi.org/10.4095/292268

Kerr, D .E., Knight, R.D., Sharpe, D. R., and Cummings, D. I., 2014. Surficial geology, Walmsley Lake, Northwest Territories, NTS 75-N; Geological Survey of Canada, Canadian Geoscience Map 140, (ed. prelim.); 1 sheet, scale 1:250,000 https://doi.org/10.4095/293773

Kleman, J. and Hättestrand, C., 1999. Frozen-bed Fennoscandian and Laurentide ice sheets during the Last Glacial Maximum: Nature, v. 402, p. 63.

Kleman, J., Jansson, K., De Angelis, H., Stroeven, A.P., Hättestrand, C., Alm, G., and Glasser, N., 2010, North American Ice Sheet build-up during the last glacial cycle, 115–21 kyr: Quaternary Science Reviews, v. 29, no. 17–18, p. 2036-2051

Lamothe, M., 2016. Luminescence dating of interglacial coastal depositional systems: Recent developments and future avenues of research; Quaternary Science Reviews, 146(Supplement C), p. 1-27.

Margold, M., Stokes, C.R., and Clark, C.D., 2015. Ice streams in the Laurentide Ice Sheet: Identification, characteristics and comparison to modern ice sheets; Earth-Science Reviews, v. 143, p. 117–146.

McMartin, I., 2017. Till provenance across the terminus of the Dubawnt Lake Ice Stream, central Nunavut; Geological Survey of Canada, Current Research 2017-1, 13 p.

McMartin, I. and Berman, R.G., 2015. Till composition across the MacAlpine Moraine System: results from the GEM-2 Thelon tectonic zone project, Nunavut (NTS 76-H and NTS 76-I); Geological Survey of Canada, Open File 7910, 1 .zip file. doi:10.4095/296833

McMartin, I., Campbell, J.E., Kerr, D., Tremblay, T., and Normandeau, P.X., 2018. New glacial landscape map database for the interior of the Laurentide Ice Sheet, Central Nunavut and Northwest Territories; CANQUA-AMQUA 2018, Joint Meeting of the Canadian and American Quaternary Associations, Program, Ottawa, Ontario, August 2018, p. 133.

McMartin, I., Day, S.J.A., Randour, I., Roy, M., Byatt, J., LaRocque, A., and Leblon, B., 2016. Report of 2016 activities for surficial mapping and sampling surveys in the Tehery-Wager GEM-2 Rae Project area; Geological Survey of Canada, Open File 8134, 13 p.

McMartin, I. and Henderson, P., 2004. Evidence from Keewatin (Central Nunavut) for Paleo-Ice Divide Migration: Géographie physique et Quaternaire, v. 58, no. 2-3, p. 163-186.

McMartin, I., Tremblay, T., and Godbout, P.-M., 2017. Report of 2017 field activities for the GEM-2 Rae glacial history activity in the Kivalliq region, Nunavut; Geological Survey of Canada, Open File 8320, 14 p. https://doi.org/10.4095/306006

PGC, 2017. Arctic DEM, 5-meters mosaic tiles. Dataset created from DigitalGlobe, Inc. images by the Polar Geospatial Center (NSF), Minnesota. https://www.pgc.umn.edu/data/arcticdem/.

Prest, V.K., Grant, D.R., and Rampton, V.N., 1968. Glacial Map of Canada; Geological Survey of Canada, Map 1253A, Scale 1:5 000 000.

Rainbird, R.H., Hadlari, T., Aspler, L.B., Donaldson, J.A., Lecheminant, A.N., and Peterson, T.D., 2003. Sequence stratigraphy and evolution of the Paleoproterozoic intracontinental Baker Lake and Thelon Basins, western Churchill Province, Nunavut; Precambrian Research, v. 125, p. 21-53.

Spirito, W.A., McClenaghan, M.B., Plouffe, A., McMartin. I., Campbell, J.E., Paulen, R.C., Garrett, R.G., and Hall, G.E.M., 2011. Till Sampling and Analytical Protocols for GEM Projects: from field to archive; Geological Survey of Canada Open File 6850, 73 p.

Stokes, C.R. and Clark, C.D., 2003. The Dubawnt Lake palaeo-ice stream: evidence for dynamic ice sheet behavior on the Canadian Shield and insights regarding the controls on ice-stream location and vigour; Boreas, v. 32, p. 263-279.

Storrar, R.D. and Livingstone, S.J., 2017. Glacial geomorphology of the northern Kivalliq region, Nunavut, Canada, with an emphasis on meltwater drainage systems; Journal of Maps, v. 13, No. 2, p. 153-164

Tremblay, T., Lamothe, M., and Paulen. R.C., 2016. Glacial geomorphology and till geochemistry and mineralogy of southern Melville Peninsula, Nunavut; Geological Survey of Canada, Open File 7494, 50 p.