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# Report of 2016 Activities for the Regional Surficial Geological Mapping of the South Rae Craton, Southeast NWT: GEM 2 South Rae Quaternary and Bedrock Project

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## 2016



doi:10.4095/299391

This publication is available for free download through GEOSCAN (http://geoscan.nrcan.gc.ca/).

**Recommended citation**
Campbell, J.E., Lauzon, G., Dyke, A.S., Haiblen, A.M., and Roy, M. 2016. Report of 2016 activities for the regional surficial geological mapping of the south Rae Craton, southeast NWT: GEM 2 South Rae Quaternary and Bedrock Project; Geological Survey of Canada, Open File 8143. 13p. doi:10.4095/299391

Publications in this series have not been edited; they are released as submitted by the author.

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## 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 investment in responsible 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 summer 2016, GEM program has successfully carried out 17 research activities that include geological, geochemical and geophysical surveying. 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 collaborators as the program advances.

## Project Summary

This publication summarizes the 2016 field work completed in NTS map sheets 75G and H as part of the surficial geological mapping component of the GEM 2 South Rae activity within the Rae Project. This report outlines field methods and highlights preliminary findings regarding the regional surficial geology and Quaternary history of the study area. This work was undertaken to provide new knowledge concerning the nature and distribution of surficial materials deposits and to address specific scientific questions relevant to the mineral exploration industry, communities and government with respect to informed decision making for resource exploration and land use management.

## Introduction

The area referred to as the South Rae craton in southeastern Northwest Territories, has not seen field investigation since the GSC's helicopter reconnaissance mapping of 1955-1958. The lack of a sufficient geological framework contributed to this predominantly drift-covered region of the South Rae Craton remaining underexplored. GEM 1 reconnaissance bedrock mapping exercise in 2012 demonstrated that the region has unrecognized mineral potential and dramatically more complex geology than had previously been appreciated (Pehrsson et al., 2014; Davis et al., 2015). As follow-up, the South Rae project of GEM 2 (Fig. 1) was initiated to address a number of scientific questions relevant to the mineral exploration industry in this underexplored, frontier region of Northwest Territories.

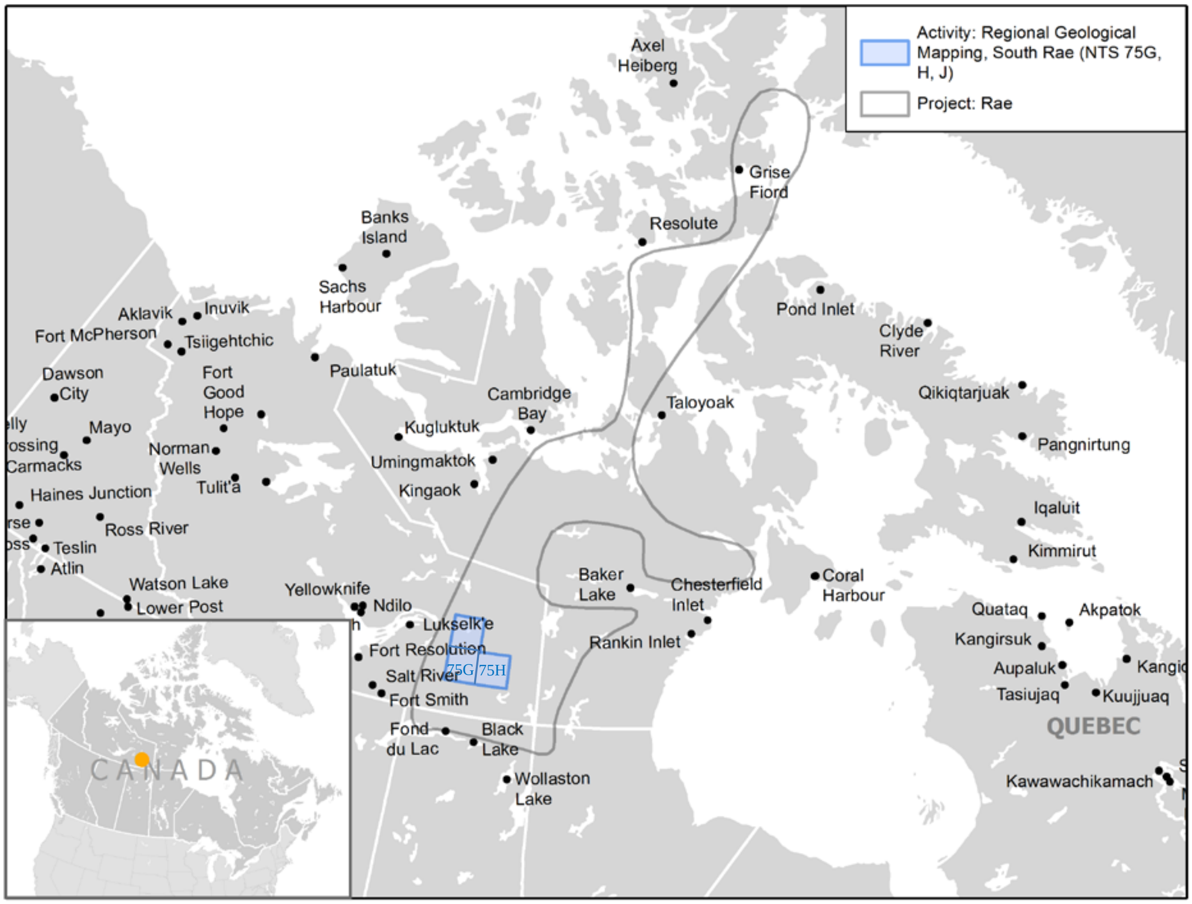


*Figure 1. Location of 2016 GEM 2 South Rae bedrock and Quaternary mapping activity area within the Rae project area. Surficial mapping and sampling was carried out in NTS map sheets 75G and H.*

The main objective of the Quaternary component of this project is to fill in a major knowledge gap in Quaternary geological framework for the South Rae region. The key scientific questions include: 1) what is the nature, composition and distribution of the Quaternary sediments, and how can they be used for drift prospecting in this region; 2) what is the glacial transport history and resultant dispersal patterns; and 3) what was the rate and influence of deglaciation in this region? Apart from the limited field work in the east half of Rennie Lake map sheet (NTS 75H) by Craig (1964), the surficial geology of the South Rae study area has only been mapped remotely at a reconnaissance scale (e.g. Prest et al, 1968; Aylsworth and Shilts, 1989; Fulton, 1995). Building on previous years field activities primarily in NTS 75A and B, (Campbell and Eagles, 2014; Campbell et al., 2015; Pehrsson et al., 2015), this summer's fieldwork continued surficial geological mapping at 1:100 000 scale and reconnaissance-scale till sampling survey covering NTS map sheets 75G and H (Fig. 2). The surficial geological field investigations were carried out in conjunction with the bedrock mapping component of the South Rae Activity (Percival et al., 2016). The Quaternary framework investigations comprises surficial map coverage, documenting glacial transport characteristics, determine regional surficial till composition for provenance studies and mineral potential evaluation, and gathering data concerning the glacial and post-glacial histories of this area. This report briefly outlines the 2016 field work methods and highlights preliminary findings.

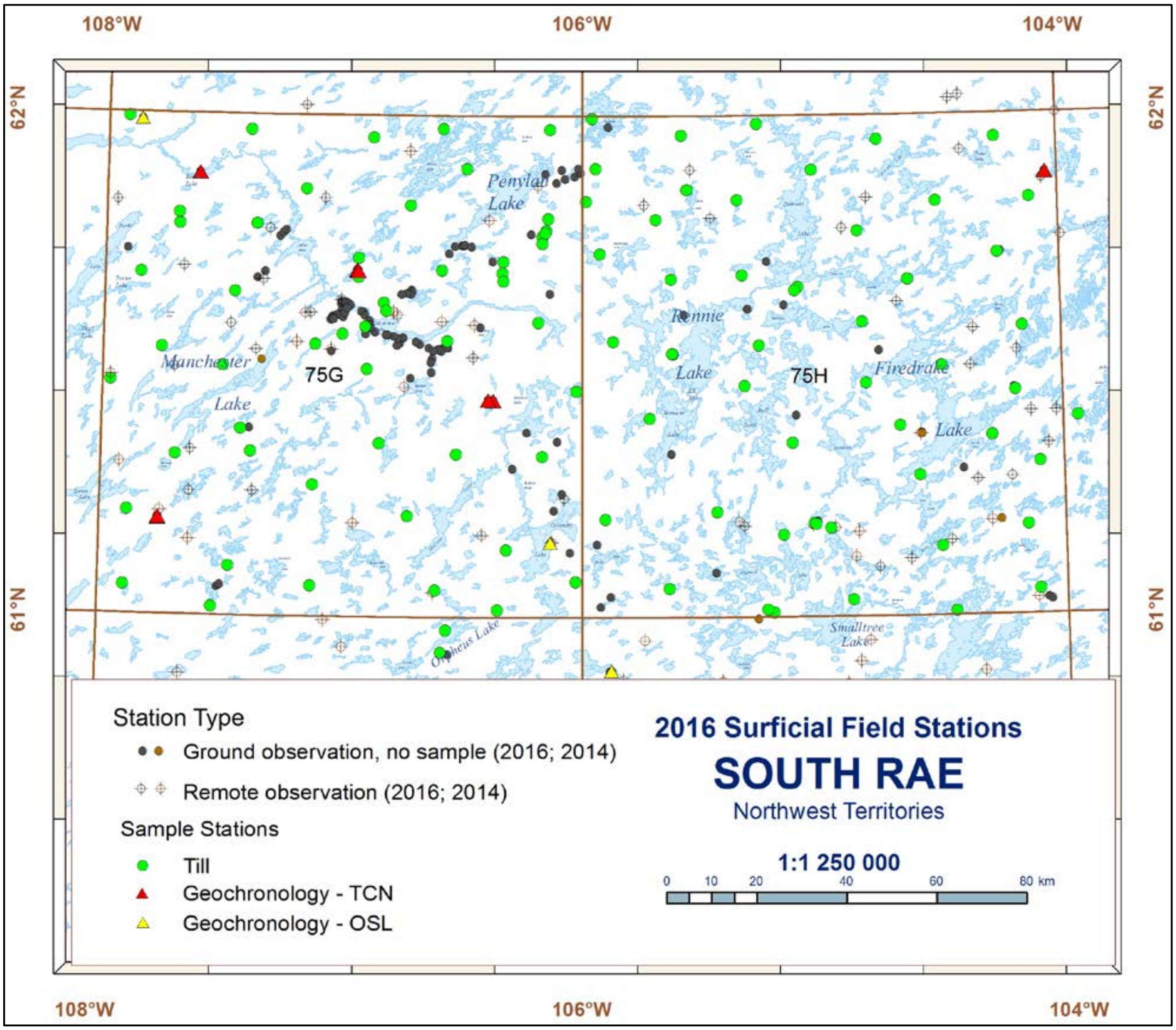


*Figure 2. Location of 2016 surficial field stations (ground and remote) and samples in NTS 75G and 75H. 2014 site locations are indicated by brown symbols.*

# Methods

## *Surficial geology observations*

Ground and/or remote observations were recorded at 295 sites (249 ground observations) in map sheets NTS 75G and H (Fig. 2). Ground sites were accessed by helicopter or foot traverse. Remote or aerial 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 surface sediments, landforms, small scale erosional features on bedrock and determining the limit of glacial lake(s) inundation. Sites were chosen based on ground-truthing A. Dyke's manuscript surficial geology map for NTS75G (Fig. 3), key features as noted on air photos and satellite imagery, targeted bedrock units, as well as locations for till samples.


*Figure 3. Surficial geological map for NTS 75G based on airphoto interpretation. This summer's mapping in 75G focused on ground-truthing the map and key questions that arose from the preliminary interpretation.*

## *Till samples*

One hundred and nine till samples were collected at 103 sites (Fig. 2). At each site, a small (~2kg) and large (~10kg) sample was taken at an average depth of 75 cm, mainly from the C soil horizon, in hand dug holes (Fig. 4a). The samples will be submitted for compositional (textural, geochemical and clast lithology), indicator mineral and gold grain analyses. Sample collection and analyses were conducted as per GSC Protocols (Spirito et al., 2011). These samples will provide information on sediment provenance to support dispersal studies and bedrock mapping, background metal concentrations and may identify geochemical/mineral anomalies in this drift covered region.


*Figure 4. Till compositional and geochronology sample collection. A) Both large (~10kg) and small (~3kg) till samples are collected from C soil horizon in hand dug hole (16CB-C264). B) In-situ OSL sample tubes prior to removal from deltaic sands (16CBB-L202). C) Sampling of a granitoid boulder for TCN exposure dating (16CBB-L222).*

### *Geochronology samples*

Eight samples were collected for geochronological dating by either optically stimulated luminescence (OSL) or terrestrial cosmogenic nuclides (TCN) methods. Three OSL samples were collected from well sorted fine-med grained sands in a glaciolacustrine ice-contact delta and 2 high elevation paleo-shorelines (Fig. 4b.) Optical luminescence methods determine when quartz or feldspar grains in sediment were last exposed to sunlight (Huntley and Lian, 1999). Samples were collected using opaque plastic tubes that were inserted in freshly cleaned exposures at approximately 30-60 cm depth (Fig. 4b; inset). The OLS exposure ages will help constrain the timing of the glacial lake(s) stands at these elevations as well as well as a minimum date for deglaciation. Boulder samples were collected at 5 sites (Fig. 2) for TCN to help establish a minimum age for ice-free conditions in this region (Fig. 4c). Three sites are located on ice-marginal glaciofluvial deposits and adjacent till plains along an interpreted ice margin in 75G. The other two sites are located on high, exposed till ridges in the SW and NE of the study area (Fig. 2). All sites are open, flat and well exposed (< 5° shielding) to ensure full optimum exposure to the cosmic rays. An ~ 20 x 20 cm grid surface was cut and ~2 cm thick cuttings were removed (~3kg) by chisel (Fig. 4c; inset) The lithologies collected included granitoids and quartz-rich metasediments to ensure sufficient quartz grains for $^{10}$Be and/or $^{14}$C exposure age dating (Gosse and Phillips, 2001).

## Results

Regional surficial mapping indicates bedrock exposure varies from 0 to 40 percent but is generally less than 10 percent. The region is characterized by swaths of streamlined, till veneers and blankets, ribbed moraine, and minor hummocky moraine, interspersed with a system of subglacial meltwater corridors (Fig.5). Ribbed moraine is predominantly found in the eastern edge of 75H and north of Penylan Lake. Ice margins are primarily identified by the presence of ice-contact fans, deltas and nodes associated with esker systems and subglacial corridors and patches of hummocky moraine. Scattered patches of sandy glaciolacustrine deposits are present over much of NTS 75 H, eastern 75G and along the Taltson River valley.

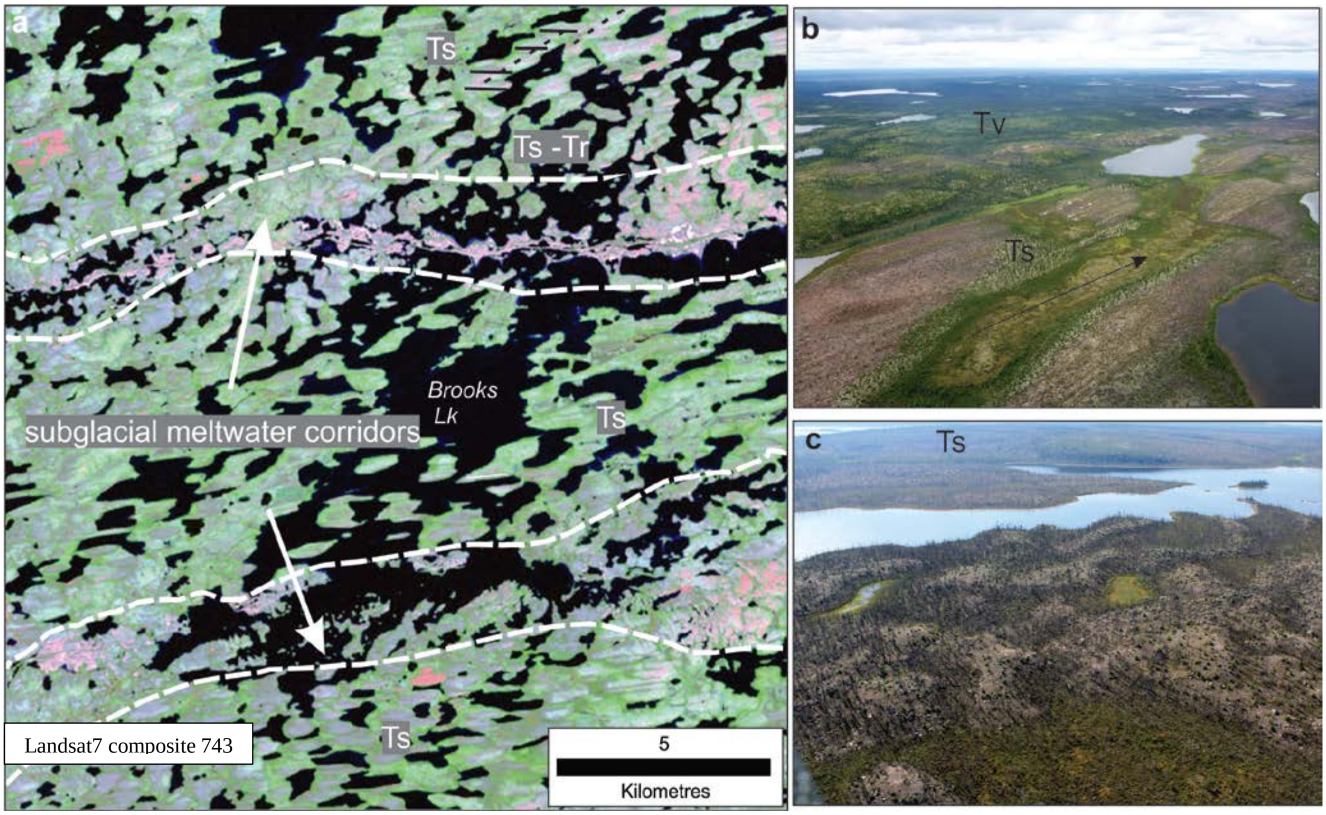


*Figure 5. A) The landscape is dominated by large swatches of streamlined terrain (Ts), till veneer and blankets, and minor ribbed moraine (Tr) interspersed with a complex system of subglacial meltwater corridors. Brooks Lake is in northeast 75G. B) Fluted terrain and drumlinoid till ridges (Ts) adjacent to till veneer deposits (Tv). Ice flow is from left to right. C) Till hummocks and ridges within a subglacial meltwater corridor west of MacArthur Lake (75G). Streamlined terrain (Ts) is in the background..*

Till composition varies from silty sand to sandy diamictons however, it is predominantly a matrix-supported sandy diamicton. Variability in composition is related to the provenance rock composition (s), thickness and facies. The till becomes sandier towards the north, likely reflecting an increase content of sandstone detritus derived from the Thelon Basin. Much of the surface tills in NTS 75H below 410 m elevation, have been extensively reworked by glacial lake wave action to produce till ridges and cores with gravelly/sandy aprons, veneers, beaches and berms (Fig.6a; Fig.7d).

The glacial landscape records complex ice flow dynamics and history as reflected in the juxtaposed regions of fast (streamlined landforms) and slow (non-streamlined) flow or sticky spots (Fig. 5a), as well as in the cross-cutting relationship of streamlined landforms (e.g. Fig. 5a; Fig. 6a), and small-scale erosional features (Fig. 6b). Multiple small scale erosional ice-flow indicators (e.g. striations, grooves, crescentic gouges, roches moutonnées) were measured at 109 ground locations.

Similar to last year's mapping to the south (Pehrsson et al., 2015), 4 phases of ice flow were documented in the northern map sheets. An old flow of unknown sense (SSE/NNW) and temporal relationship was recorded at a few sites. Rare E to SE measurements have been reported in adjacent map sheets (e.g. Hardy et al., 2005; Campbell et al., 2007). Well defined indicators in cross-cutting relationships reveal a regional clockwise rotation in ice-flow directions evolving from a southward to a westward flow (Fig. 6b). The dominant regional flow directions were to the SW followed by a late, overprinting westward flow. The southwest to west regional flowsets are attributed to ice flow during deglaciation. The late westward flow (Fig. 6a) is more dominant in the northern map sheets (Pehrsson et al., 2015).

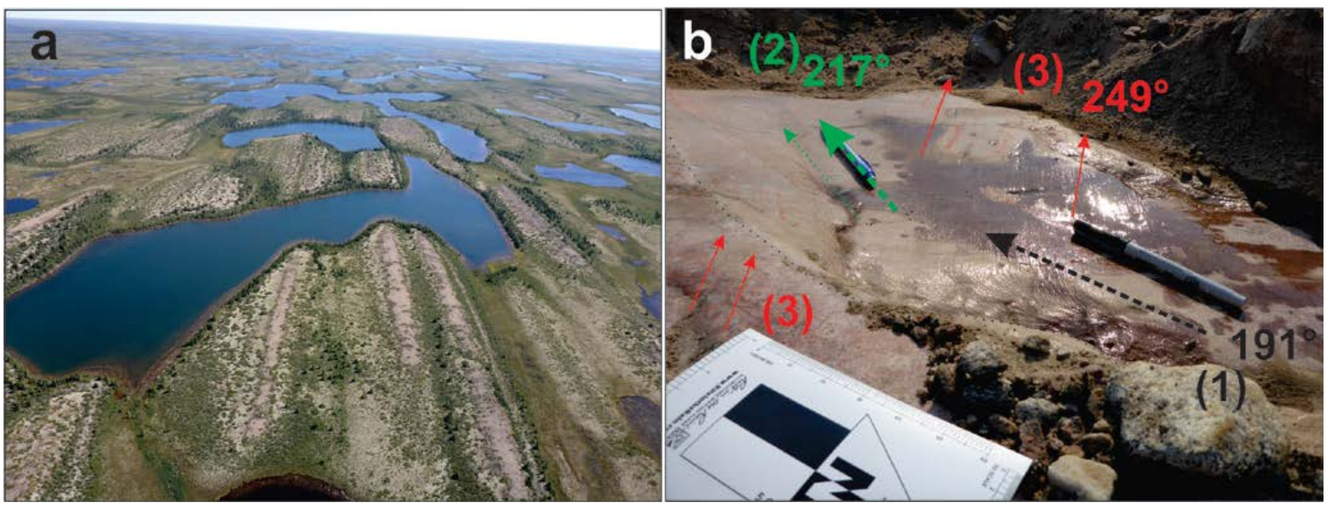


*Figure 6. Ice flow history is recorded in both landforms and small-scale erosional features. A) Streamlined terrain records the late deglacial west-southwest flow in NW 75H (front to back). Glacial lake wave action has resulted in reworked and winnowed till with thin sandy, gravelly glaciolacustrine deposits surrounding the drumlinloid ridges. B) Relative position of striations and grooves on outcrop indicate their relative age relationship between the south (1-oldest) and southwest (2) on protected lee surface and later southwest-west (3) (on top and on west edge of protected lee) ice flows. The youngest flow to the west (265°) is recorded on the top of the outcrop but not shown in this photo.*

Record of a distinct SW (older) flow and an overprinting SWW flow were reported in the southern part of the study area (Campbell et al., 2015; Pehrsson et al, 2015). The older regional SW flow is less defined in the 2016 map area and is difficult to separate from the later deglacial flow overprint.

Erratics of known source locations assist with delineation of glacial transport distance and dispersal patterns. As reported in NTS75A and B map areas ( Pehrsson et al., 2015), distinctive pebble- to boulder-size erratics, of the Dubawnt Supergroup units, such as Thelon sandstones and conglomerates, were found in higher concentrations throughout the 2016 map area. The increased concentrations of these erratics northward are consistent with the interpretation of sustained transport and dispersal of glacial debris by the old southward flow. Erratics of conglomerate, quartzite, and rare metamorphosed supercrustrals of unknown origin were noted in the northeast part of NTS 75G and the northern half of 75H.

Numerous subglacial meltwater corridors trend WSW to SW across the map area (>200km), many originating and ending outside of the study area. The corridors are typically 1-4 km wide, spaced 5-10 km apart and generally trend sub-parallel – parallel to adjacent streamlined landforms (Fig. 5a). Two types of signature landform-sediment assemblages of the corridors as described by Pehrsson et al. (2015) are present in the map area. While large esker systems with associated glaciofluvial ice-contact deposits cross the map area, the dominant landform/ sediment assemblages within the subglacial meltwater corridors consists of hummocky till (hills and ridges), short streamlined landforms, till remnants, boulder lags, exposed bedrock with small discontinuous eskers and related ice contact deposits. The hummocky landforms (Fig. 5c) are most common where the corridors are cut into thicker till deposits. Transects were carried out across several corridors to investigate the morphology and composition of the hummocks and ridges. The variability in morphology and composition indicates that the hummocks are products of either or both depositional and erosional processes. The majority of hummocks and ridges were composed of till which resembled the surrounding regional till. A veneer of sandy diamicton sometimes capped these mounds and ridges which may be related to wave-reworking of sediments subsequently inundated by the glacial lakes. Noted along several corridors was a continuum of landforms reflective of increase erosion - progressing from eroded till surfaces with boulder lags into short, flat topped till ridges to hummocks in the down-flow direction. This continuum of landforms supports the interpretation that majority of hummocks in this areas are primarily products of subglacial meltwater erosion of the pre-exiting till.

New mapping has continued to delineate the extent of glacial lakes (e.g. Craig, 1964; Prest et al. 1968; Maynard and Kerr, 2014; Stea and Kerr, 2014; Ferbey et al., 2015; Pehrsson et al., 2015) in this region. Beach ridges, littoral and nearshore sands, washing lines, deltas, ice contact deltas, subaqueous fans, spillways and the extensive reworking of till and glaciofluvial sediments indicate the presence of both smaller, short-lived, ice-marginal lakes and a large, relatively long-lived proglacial lake (Figs. 7a to d). In central NTS 75G map sheet, paleo-shorelines features (Fig.7a) ~ 430-440 m asl and spillways (Fig.7b) suggest short-lived ice marginal lakes were present along the receding ice margin when it was west or near the Mackenzie/Thelon-Dubawnt paleo-drainage divide. The spillways indicate drainage of the lakes into a lower glacial lake now occupied by the Taltson River. A large glacial lake occupied both the Dubawnt and Thelon drainage basins, inundating most of 75H and into the eastern part of NTS 75G. Waters reached as high as ~445 m asl before falling to a more stable lake levels around 410 - 400 m asl, as indicated by the preponderance of well-developed strandlines at and below this elevations (Fig. 7c). The reworking of the existing glacial and glaciofluvial deposits below 400 m elevation within the glacial lake basin has resulted in a widespread veneer of sands and sandy diamictons over the low relief terrain (Fig. 7d).

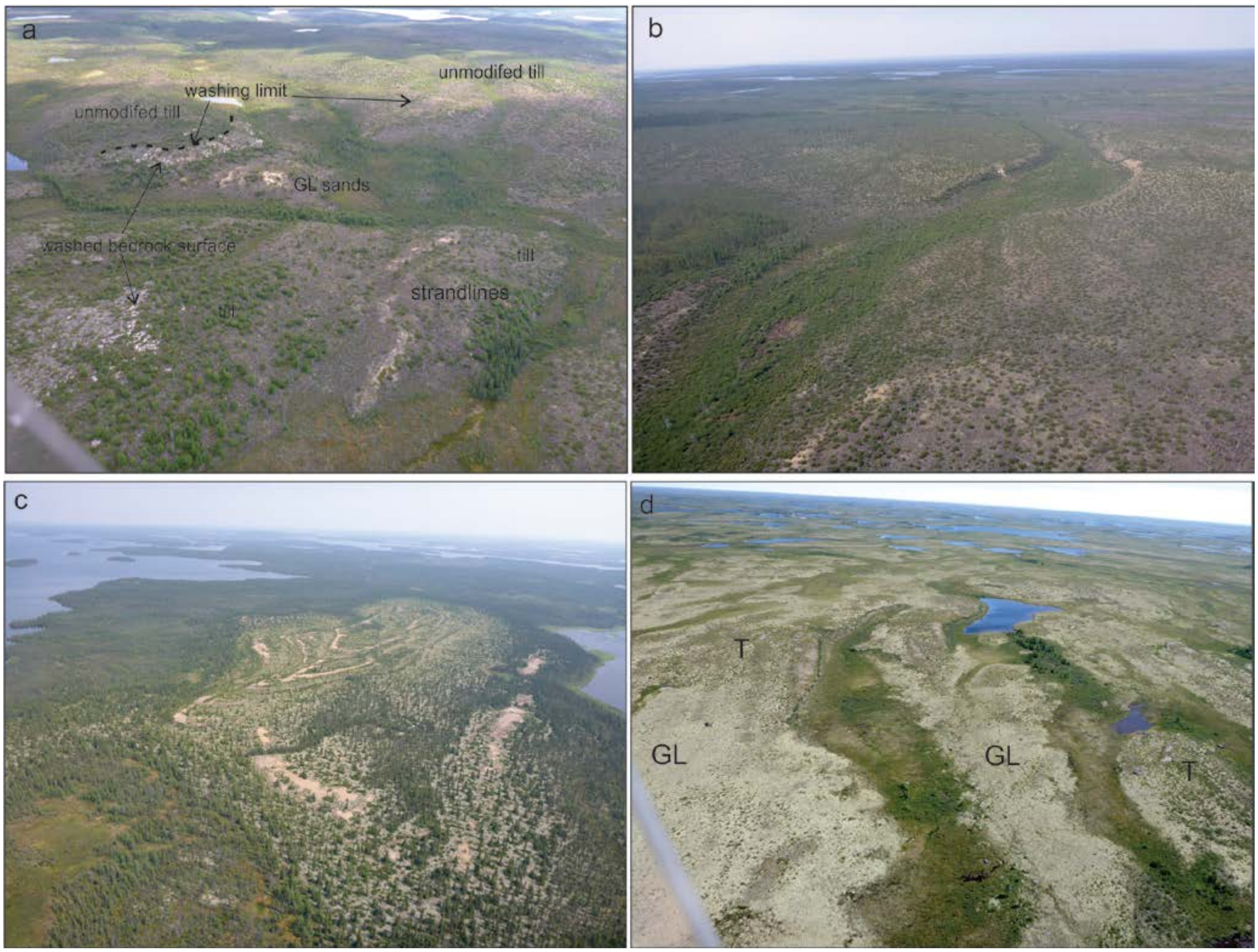


*Figure 7. Evidence of proglacial glacial lakes. A) Washing lines, exposed bedrock, strandlines and nearshore sand deposits indicate the presence of short-lived, small proglacial lakes in 75G (e.g. Burpee Lake area). B) A series of spillways drained these short-lived ice marginal lakes into the Taltson River valley. Much of 75H was inundated by a large and longer-lived lake as evidenced by; C) well-developed flights of raised beaches and D) extensive deposits of sandy/ gravelly littoral and nearshore deposits (GL) derived from reworking of till (T).*

## Conclusions

This summer's field work in the northern half of the South Rae activity area (NTS 75G and 75H) provided more data concerning the surficial geology of the south Rae craton. Information was gathered on the sediment types and distribution, landforms, delineation of glacial lakes and subglacial corridors, as well as the pattern and history of both ice flow and ice margin retreat. This new mapping has revealed a glacial landscape resulting from complex and changing paleo-ice dynamics through the Late Wisconsinan glaciation and early Holocene. Surficial mapping and field observation have determined the nature of the sand-rich areas: sand-rich tills, eskers and ice marginal deposits, and glacial lake sediments. Each terrain is approached differently with respect to the application of drift prospecting techniques. The till samples collected will expand the regional-scale framework for provenance and dispersal studies, mineral exploration and baseline environmental assessments.

Future work will include:

- Data and map compilations
- Till sample analyses and data interpretation to help identify potential mineral targets and define cumulative glacial transport and dispersal patterns.
- Release of 2015 till compositional and indicator mineral data for 75A and B map sheets,
- Surficial maps at 100 000 scale for all investigated NTS sheets (75A, 75B, 75G and 75H) will be released as GEM 2 publications.
- Analysis of geochronology samples to provide minimum ages for glacial retreat and presence of glacial lakes in the study area.

As part of his MSc. Thesis at UQAM Gabriel Lauzon, (Dr. Martin Roy, supervisor), will compile the surficial geology of the south half of Wholdaia Lake map sheet (NTS 75A). The thesis will also include delineation and reconstruction of regional dispersal patterns based on till composition and provenance (geochemical, mineralogical and clast lithology), geomorphology and ice flow indicators for NTS map sheets 75A and B.

## Acknowledgements

This work was conducted as part of the South Rae Activity within the Rae Project of the GEM 2 program. We are most grateful to Sally Pehrsson for project management, logistics and scientific leadership and to John Percival for looking after camp and field logistics at the McArthur Lake camp.

GIS support was expertly provided by Angela Ford. The authors thank Dr. Sam Kelly for his tutelage in TCN sampling methods. The assistance of Benjamin Neil (bedrock assistant) with geochronology sampling is gratefully appreciated. In addition, the authors would like to thank Discovery Mining Services and in particular Peter McLachlan and Mike Shamborski for their help in camp set-up, maintenance and expediting, Louise Levesque for the most enjoyable meals and Doris Catholique as camp helper. We greatly appreciated Adam and Julie Duff of Scott's General Store, Stony Rapids for their help with groceries, supplies and fuel, and Heather and Pete Tomson of White Water Inn for their hospitality. Helicopter support was provided by Helicopter Transport Services. The hard work and unfailing skill of pilots Jim Watson and Pierre Fiset are much appreciated. Transwest Air of Stony Rapids provided fixed wing support. This manuscript was improved through a critical review by Dan Kerr.

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