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Report of activities for the geology and mineral potential of the Chantrey-Thelon area: GEM-2 Rae project

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Forward

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 (GEM-2) to continue producing new, publically available, regional-scale geoscience knowledge in Canada's North.

During the summer of 2016, GEM-2 successfully carried out 17 research activities that included geological, geochemical and geophysical surveying. Many of these were 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.

Introduction

The Thelon tectonic zone is one of the most poorly known geological features of the Canadian shield in terms of modern geological maps, scientific understanding and mineral potential. Following a 550 km-long reconnaissance-scale geological transect across the western Rae craton and Thelon tectonic zone (Berman et al., 2015a), studies in the Bathurst Inlet - Chantrey Inlet region were initiated to understand the geological evolution and mineral potential of three areas (Fig. 1): (a) Montresor belt, (b) Elu basin, and (c) Thelon tectonic zone (Ttz). Investigations of the Montressor region led to a new bedrock map of the belt (Percival et al., 2016), reconciled lithological and metamorphic contrasts to reflect early thrust and late extensional faulting (Tschirhart et al., 2015; Percival and Tschirhart, 2017), and highlighted IOCG-type mineral potential (Percival et al., 2015). Fieldwork in the Elu and northeastern margin of the adjacent Kilohigok basin has upgraded understanding of the evolution of Paleoproterozoic sedimentation (Ielpi et al., 2016) and revealed potential for unconformity-related uranium mineralization (Ielpi and Rainbird, 2015). This report describes 2016 field activities and observations within the Ttz that advance initial work undertaken in 2014 (Berman et al., 2015b; McMartin and Berman, 2015; McCurdy et al., 2016).

The Ttz comprises a series of pronounced, N- to NNE-striking magnetic highs that extend >500 km from the MacDonald fault to north of Queen Maud Gulf. The Ttz has been postulated to represent a ca. 2.0 Ga continental arc built on the western flank of the Rae craton and subsequently intensely deformed during ca. 1.97 Ga collision with, and subsequent indentation by, the Slave craton (Hoffman, 1988; Culshaw et al., 1991). Alternative models propose that the Ttz formed in an intracontinental setting either after crustal thinning (Thompson et al., 1989), or within an interior mountain belt far removed from an active plate boundary (Chacko et al., 2000; Schultz et al., 2007). Distinguishing between these models is one of the key goals of the bedrock component of this project in order to derive a comprehensive understanding of the evolution, architecture and economic potential of this major feature of the Canadian shield.

The Ttz is covered by variable thicknesses of Quaternary sediments, including thick till deposits, often streamlined within the terminal zone of the Dubawnt Lake Ice Stream, and a series of eskers terminating at coalescing outwash plains and terraces, part of the MacAlpine Moraine System (McMartin and

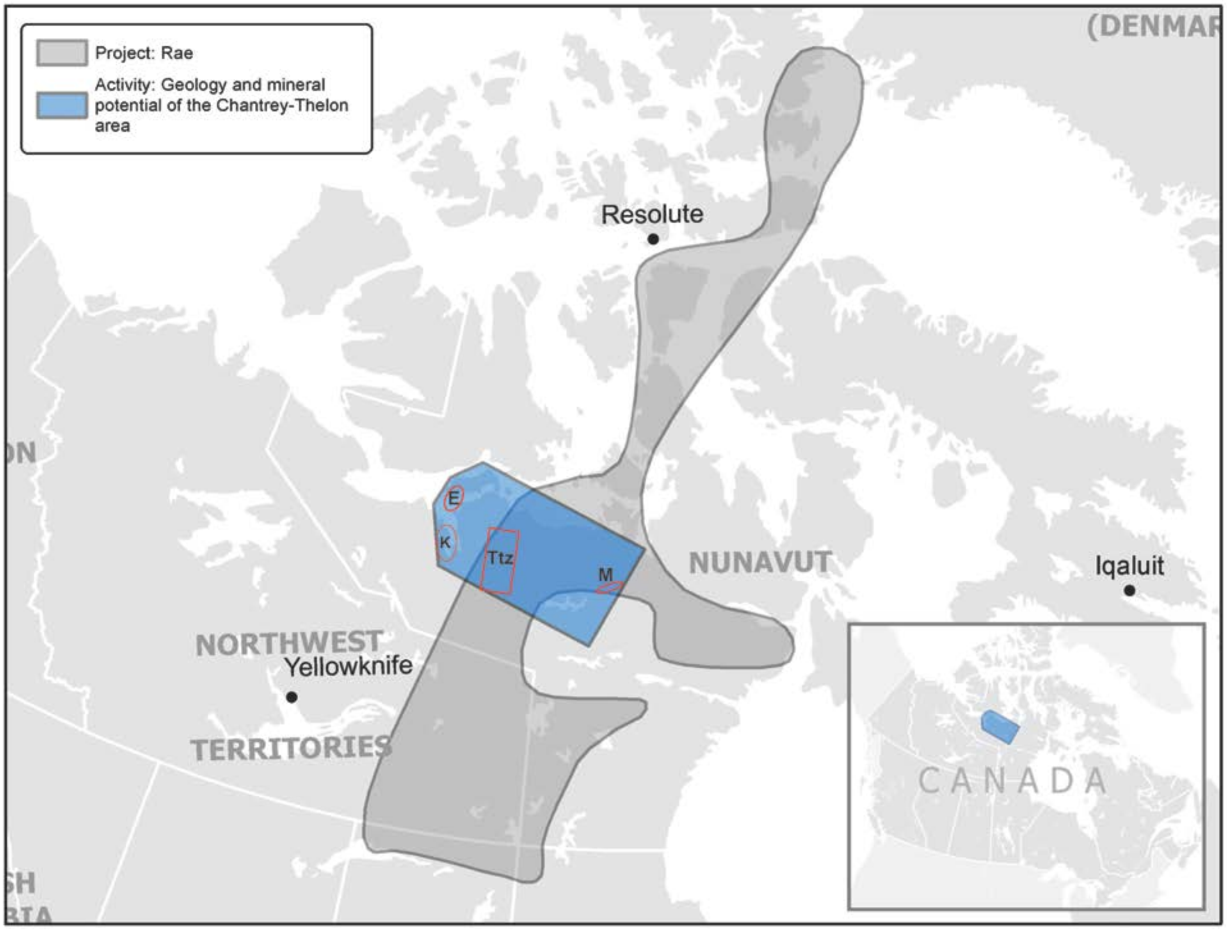

Figure 1. Location map showing the GEM-2 Rae region of interest (grey polygon) and the area encompassing Chantrey-Thelon activities (blue polygon). Project area abbreviations: E = Elu basin; K = Kilohigok basin; M = Montresor belt; Ttz = Thelon tectonic zone

Berman, 2015). The main objectives of the surficial geology component of the GEM-2 Thelon tectonic zone project are to provide a Quaternary geological framework required for interpreting the transport history of surficial sediments, and to collect targeted till samples for mineral potential evaluation and provenance studies. Surficial studies complement a stream sediment survey (McCurdy et al., 2013) aimed at locating areas with elevated mineral potential.

Methods

Multidisciplinary geoscience studies are focused within NTS map sheets 76I and 76H, situated between and adjacent to the protected Queen Maud Migratory Bird sanctuary and Thelon Wildlife sanctuary (Figure 2). The first season of fieldwork (2014) comprised bedrock and surficial mapping transects mostly in the southern sheet (76H; Berman et al., 2015b; McMartin and Berman, 2015), a magnetotelluric transect across both map sheets (Craven et al., 2015), and a stream geochemical survey in the northern sheet (76I; McCurdy et al., 2016). Fieldwork in 2016 involved targeted, thematic

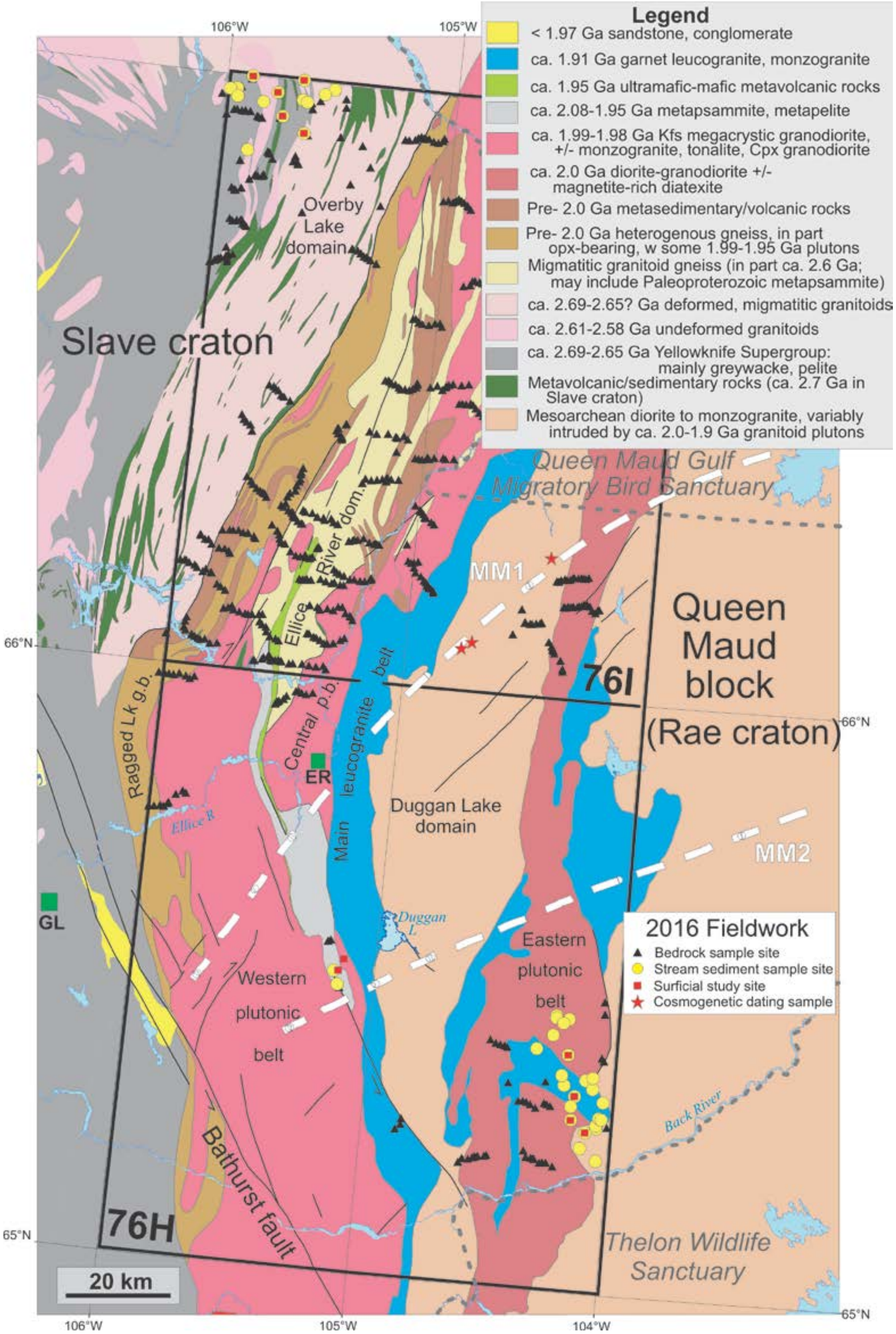

Figure 2. 2016 fieldwork stations plotted on simplified geologic map of the Thelon tectonic zone in NTS map sheets 76H and 76I (Berman et al., 2015b, d), based on interpretation of aeromagnetic data integrated with previous work (Thompson et al., 1986; Frith, 1982; 2014 mapping observations, 2015 geochronology and geochemistry), and revised extent of 1.95 Ga volcanic belt based on 2016 mapping. Abbreviations: p.b. = plutonic belt; g.b. = gneiss belt; GL = Goose Lake camp; ER = Ellice River camp. Dashed white lines show two moraines of the MacAlpine Moraine System (MM1, MM2).

bedrock mapping concentrated in 76I, with stream sediment sampling and surficial studies focused on previously identified geochemical anomalies in 76H and 76I.

Prior to initiating field operations, the communities of Umingmaktok and Bathurst Inlet, as well as the Kitikmeot Inuit Association were informed of planned activities. Fieldwork between June 26 and July 19, 2016 was based from a low-impact tent camp situated on a sandy plateau flanking the Ellice River in the northern part of NTS map sheet 76H (Figs. 2). The 22 day length of the field season was dictated by budget limitations. Camp setup was greatly facilitated by use of an airstrip at Sabina Gold & Silver Corporation's Goose Lake exploration camp to stage required equipment via a DASH-7 flight from Yellowknife (~525 km). A Twin Otter on tundra tires shuttled the gear ~65 km east to the Ellice River site along with three staff from Discovery Mining Services who constructed much of the camp. Twin Otter flights were used to supply fuel to Ellice River camp and to several small caches from TMAC's Hope Bay camp, where the fuel had been positioned by sea lift in 2014. In addition, a Caravan aircraft fitted with floats from Yellowknife was used to position a fly camp on the east side of Bathurst Inlet to support mapping and sampling of sedimentary rocks of the Kilohigok basin (K in Fig. 1).

A Bell 206L4 helicopter provided air support for bedrock mapping, stream sediment geochemical sampling and surficial studies (Fig. 2). In total, the field operation involved seven senior and three junior bedrock geologists, one GIS specialist, one senior surficial geologist, one geochemist, a helicopter pilot, engineer, cook and wildlife monitor.

Prior to the fieldwork, traverses were planned using air photos, satellite imagery, geophysical maps and archival data. Traverses were then digitized and stored into the Project Bedrock Geodatabase; start and end points were automatically calculated using the GanFeld Data Management toolkit and given to the helicopter pilot at the start of each day. Daily traverses were carried out with the support of handheld devices (Getac PS336) or small tablet computers (Mobile Demand XT8500P) equipped with GanFeld, GSC's portable digital data acquisition system customized for use with ArcPad™ (Shimamura et al., 2008). With these portable devices, geologists digitally captured field observations, structural measurements and sample information, and were able to access multiple datasets (e.g. traverse path, topographic base maps, legacy geological maps, geophysical maps). All gathered data were downloaded on a daily basis to the Project Bedrock Geodatabase and made available for display and queries in ArcMap™. Once available in ArcMap™, the observed lithologies and structural data were symbolized so that they could be efficiently used to guide geological interpretations and further traverse planning.

Results

Bedrock work

Previous work in 2014-2015 defined seven dominantly metaplutonic, strongly deformed, crustal domains (Fig. 2) on the basis of aeromagnetic signature, supplemented by geochemistry and geochronology of samples collected during 2014 fieldwork in 76H and a digital compilation (Buller et al., in prep) of the GSC archival collection of the GSC's 1983-1985 Tinney Hills – Overby Lake project (Thompson et al., 1986). The 55 foot traverses (with 585 bedrock stations) undertaken in 2016 (Fig. 2) allowed further characterization of these domains, assessment of their lithologic continuity to the north, and investigation of boundaries between them.

Highlights of 2016 mapping, from west to east, include:

- a representative sample suite was collected from the Goulburn Supergroup, Kilihigok basin (Fig. 1), from which a detrital zircon geochronological study will evaluate the changing source of sedimentary material delivered to the proposed foreland basin (Grotzinger and McCormick, 1988); comparison with plutonic rock ages in the adjacent Ttz will provide insight into the tectonic history of the region;

- a potentially significant tectonic boundary is manifest in several steeply dipping mylonite zones (e.g. Fig. 3) within the boundary zone between Yellowknife supergroup metasedimentary rocks and metaplutonic dominated rocks (diorite-tonalite-granodiorite) in the eastern part of the Slave craton (Fig. 2); a distinct heritage for the latter, referred to here as the Overby Lake domain (Fig. 2), is suggested by preliminary Nd model ages of archival samples from this domain that are older than typical ca. 2.6 Ga Slave granitoids;

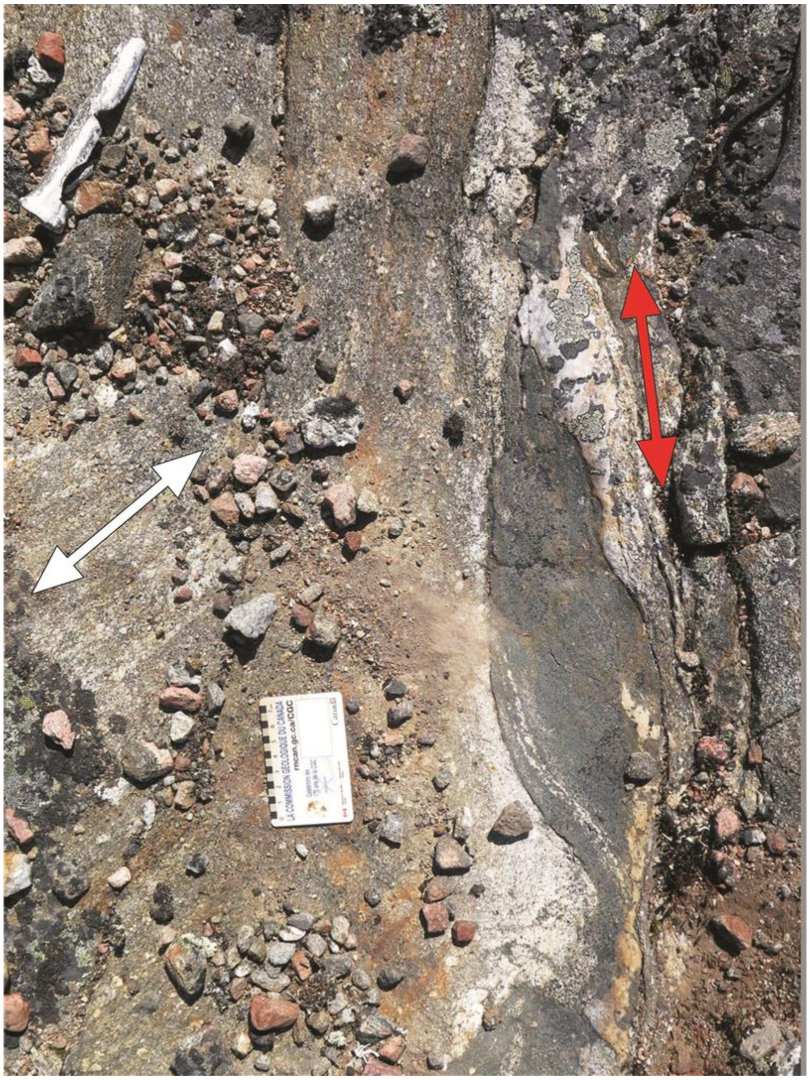

Figure 3. Garnet-bearing amphibolite boudin in NW-striking shear zone (red arrow) overprinting ~E-W fabric of Yellowknife supergroup migmatite (white arrow); western boundary zone of the Overby Lake domain.

- the Slave – Rae boundary has previously been defined by the occurrence of orthopyroxene on the Rae side (e.g. Hoffman, 1988; Culshaw et al., 1991); traverses across this boundary zone revealed similar lithologies (quartz diorite, granodiorite, monzogranite) with less abundant supracrustal rocks than previously interpreted, no consistent change in metamorphic grade and no obvious structural break; geochemical and isotopic data will be used to further investigate this boundary zone;

- most domains (Fig. 2) have broadly similar plutonic histories, characterized by early mafic (diorite – quartz diorite) followed by felsic (monzogranite – granodiorite) plutonism (Fig. 4); 24 geochronology samples and 44 geochemistry samples were collected to gain insight into this plutonic history;

- a volcanic belt, which in the south (76H) is dominated by basaltic rocks with a minor dacitic component dated at 1.95 Ga (Berman et al., 2015c, d) and associated with a number of geochemical anomalies (e.g. Au, Ag, Ni, Cu, U; McCurdy et al., 2013), was extended >20 km to the north in map sheet 76I (Fig. 2) where andesitic to dacitic metavolcanic rocks (Fig. 5) form a 2 km wide strand;

Figure 4. Diorite cut by monzogranite, central plutonic belt (76I).

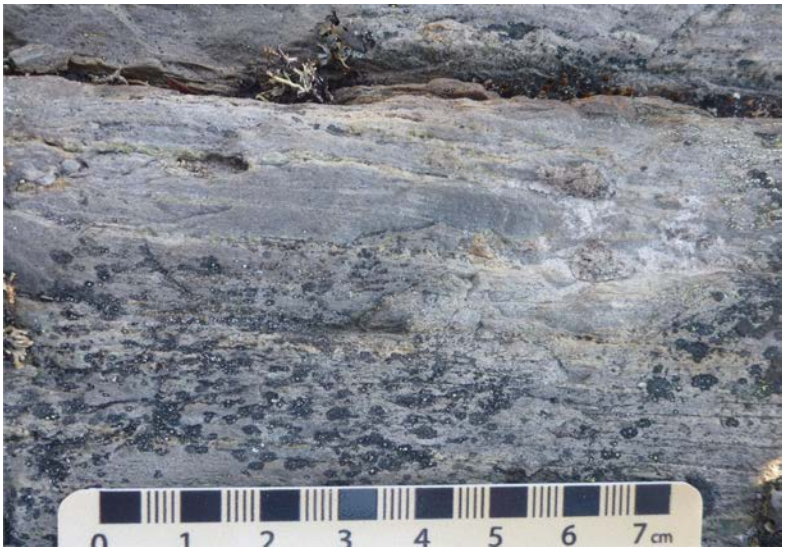

Figure 5. Foliated metadacitic volcanic rock sampled for geochronology; Ellice River domain (76I).

- orthogneiss of the Ellice River domain, dated at 2591±27 Ma at one locality from a 2012 transect (Davis et al. 2014), extends both south (Fig. 6a) and north (Fig. 6b) where exposures of granodiorite ± diorite gneiss record polydeformational histories; these observations suggest that Neoarchean rocks may represent a significant component of the Ellice River (magnetic low) domain in 76I (Fig. 2);

- the central plutonic belt, which is defined by a magnetic high that is far more extensive in 76I than in the southern sheet, mainly comprises magnetite±clinopyroxene-bearing monzogranite-granodiorite±monzonite with subordinate diorite; long, narrow (<1 km) magnetic lows are commonly monzogranite ± metasedimentary panels (psammite, semipelite, metatexite) or garnet-bearing monzogranite;

- the eastern plutonic belt (Fig. 2) appears somewhat more mafic than the western and central plutonic belts, with magnetite-bearing dioritic rocks being almost as abundant as monzogranitic rocks ± garnet-bearing leucogranite and migmatite; no outcrops were found that exposed the boundary of this belt with Mesoarchean gneiss of the western Rae craton;

- metasedimentary rocks (e.g. Fig. 7; psammite, semi-pelite, metatexite) occur within each of the plutonic domains although it is not possible to distinguish different packages by domain based on field occurrence; their detrital zircon populations will allow insight into the sedimentary provenance of each domain, which may help to differentiate them;

- six gossan zones (e.g. Figs. 7,8), including one associated with the volcanic belt, were identified and sampled for assay analysis.

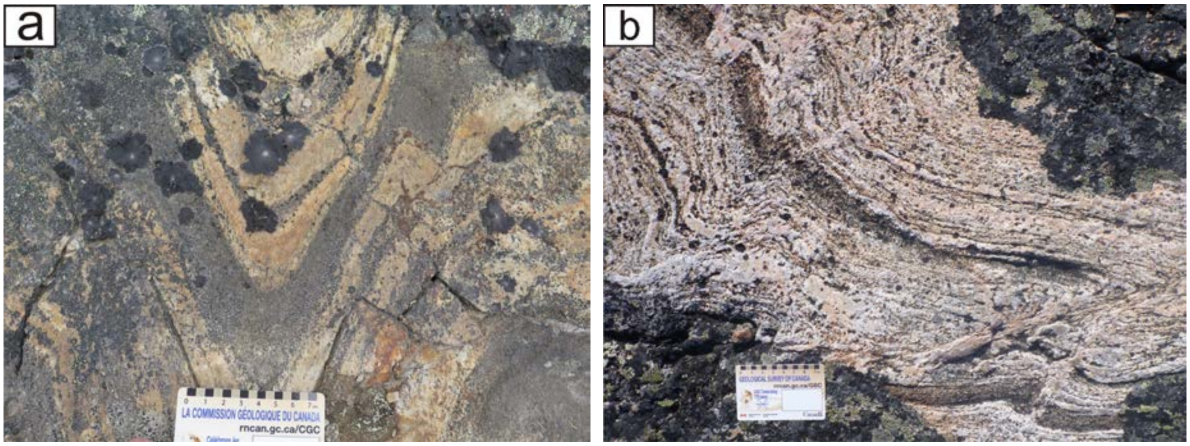

Figure 6. Polydeformed orthogneiss of the Ellice River domain (76I). (a) Tight folding (F2) of gneissic layering (S1) in Archean? diorite-tonalite; (b) gneissic quartz monzodiorite provisionally interpreted as Neoarchean in age; note buckled S_2 tansposition fabric and drag folds related to dextral shear zone (lower right).

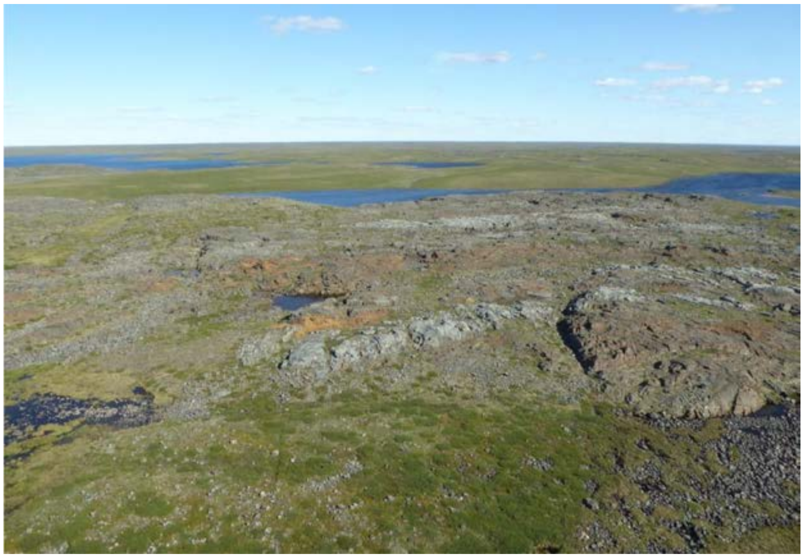

Figure 7. Km-scale, N- striking gossan zone associated with semipelite-marble±calc-silicate, Ellice River domain (76I).

Figure 8. Sulphide-rich gossan zone with malachite (inset) in metadiorite, Central plutonic belt (76I).

Stream sediment survey & surficial studies

Targeted stream sediment and surface till sampling focused on following up three geochemically anomalous areas (Fig. 2): 1) a Cu-Pb-Ni-Zn-Ag (including heavy mineral separates with chalcopyrite, molybdenite, pyrite, and gahnite) stream sediment anomaly in northwestern NTS 76I associated with Slave supracrustal rocks (McCurdy et al., 2016); 2) a Au anomaly in the silt and heavy mineral fractions of stream sediments within a single watershed draining into the Back River in southeastern NTS 76H (McCurdy et al., 2013); and 3) a Cu-Pb-Zn-As-sulphide till and stream sediment anomalous area in central NTS 76H southwest of Duggan Lake (McCurdy et al., 2013, 2016; McMartin and Berman, 2015). Geochemical sampling involved collection of eight bulk stream sediment samples for heavy minerals and 14 stream silt samples for geochemistry in area 1, seven bulk sediment samples for heavy mineral concentrates and an additional 23 samples of stream silt for geochemistry in area 2, and two bulk samples for heavy minerals in area 3. Surficial field observations were recorded at 45 stations; till samples were collected at 11 of these sites adjacent to stream sediment samples (Figs. 2,9a), and will be processed for geochemistry and heavy minerals.

Three glacially transported boulders were sampled for cosmogenic nuclide exposure dating along the northern splay of the MacAlpine Moraine System in NTS 76I to constrain the age of this major ice retreat position (MM1; Fig. 2). The boulders selected are large, flat-topped and lay at the surface of the morainic ridges in a stable position (Fig. 9b,c). These results will provide a minimum deglaciation age and will be compared with a single radiocarbon date on marine shells collected on the distal side of the moraine about 50 km to the NW in NTS 66L (GSC-110: corrected ^{14}C age of 7750±140 years (Blake, 1963).

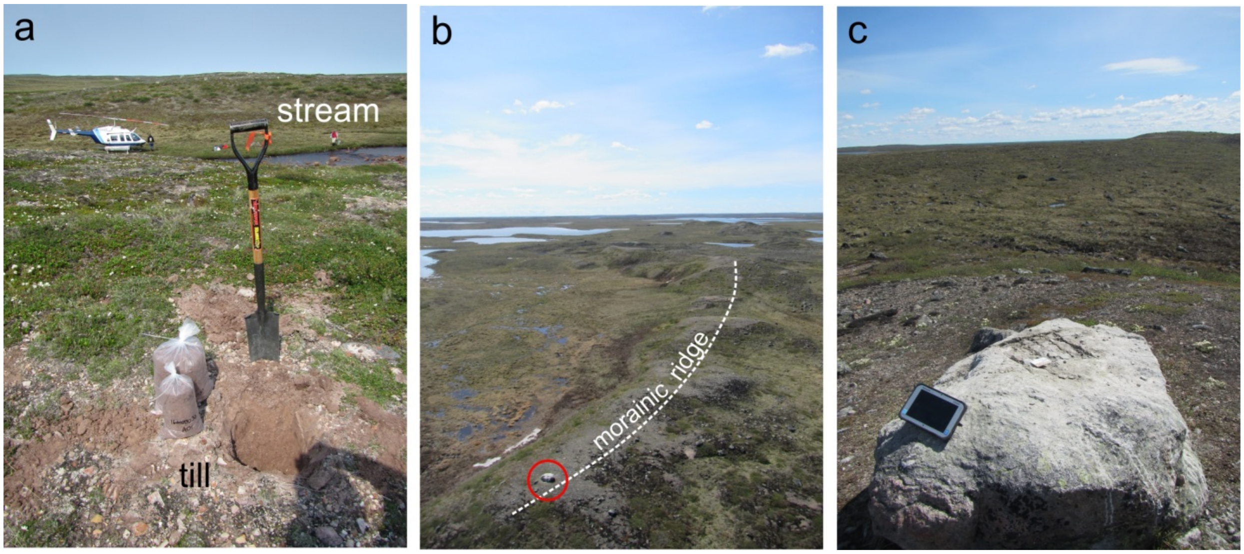

Figure 9. Stream sediment survey and surficial studies. a) Paired till and stream sediment sampling, about 20 m apart along an unnamed stream in NTS 76H; b) Large boulder (circled in red) sampled for cosmogenic nuclide exposure dating over a morainic ridge of the MacAlpine Moraine System in NTS 76I; c) Close-up of boulder showing flat-top surface sampled using a rock saw and chisel.

Future work

- Geochemical, neodymium and oxygen isotopic, geochronological and petrological analyses of bedrock samples will be used to characterize the origin and age of crustal domains and their metamorphic histories, and provide important constraints on the evolution of the area.
- Comparison of till, stream sediment and gossan analyses will be used to assess mineral potential in the region.
- GSC open files and journal papers documenting fieldwork, analytical results and interpretations are in preparation.
- Bedrock geology maps for NTS 76H and 76I will be released as CGM-series maps.

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