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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 2014, GEM’s new research program has been launched with 14 field 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.

Introduction

Following a 550 km-long reconnaissance-scale geological transect in 2012 (Berman et al., 2013, 2014; McCurdy et al., 2013; McMartin et al., 2013; Davis et al., 2014), the Thelon tectonic zone project was initiated to address a number of scientific questions relevant to the mineral exploration industry in a region broadly referred to as the Thelon tectonic zone (Ttz). The area of study (Fig. 1) includes parts of NTS map sheets 76H and 76I, which have not seen systematic field investigations since the mid-1980’s in the western half, while geological knowledge for the eastern half derives from 1955-1962 GSC helicopter reconnaissance mapping. The main goal of this activity is to advance geologic understanding and attract mineral exploration to this underexplored, frontier region of Nunavut by addressing the following questions:

- What is the architecture of the Thelon tectonic zone, including the pedigree of crust within it (e.g. Slave vs. Rae affinity)?
- What is the extent and tectonic setting of Paleoproterozoic magmatism and sedimentation in the Ttz, how does this history in the Ttz compare to that of Taltson magmatic zone to the south, and what are the implications for the evolution of the Rae craton margin?
- What is the metamorphic and structural history of the Ttz, and what constraints does it provide for understanding successive orogenic events in the northwestern Canadian shield?
- What insight does understanding the history and architecture of the Ttz provide on the mineral potential of the region?
- What is the glacial history of the area and its influence on drift prospecting strategies?

- What geochemical anomalies can be identified in stream sediments, till, and bedrock, and how can they impact exploration targets in the region?

Methodology

Fieldwork between June 23 and July 16, 2014 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, 3). The field camp (Fig. 4) was set up by staging fuel and camp gear on DASH-7 flights from Yellowknife to Sabina Gold & Silver Corporation's Goose Lake exploration camp (~525 km), with Twin Otter flights (using tundra tires) between Goose Lake and the Ellice River camp (~60 km). The length of the 2014 field season was in large part dictated by Sabina's planned mid-July departure from the Goose Lake camp.

A Bell 206L4 helicopter provided air support for bedrock and magnetotelluric (MT) studies over the entire 22 day period (Fig. 3). In addition, a Bell 206LR helicopter was used for 10 days to support a stream sediment geochemical survey in the northern part of NTS 76I (Fig. 2). Targeted surficial observations and sampling (Fig. 2) were accomplished over a ten day period in conjunction with the other bedrock, MT and geochemical activities. In total, the field operation involved 7 senior geologists and 3 junior geologists supported by a GIS specialist, 2 geochemists, 1 geophysicist, 2 helicopter pilots, 1 engineer, a cook and a bear monitor.

Results

Bedrock geology:

Bedrock mapping was focussed along two transects across NTS map sheet 76H, with additional mapping the southern part of 76I along the northern MT transect (Fig. 3). In total, bedrock data were collected from more than 400 sites (Fig. 3). Highlights of this work include:

a) Recognition of the lithologic and structural continuity of nine, roughly N-striking, crustal domains with distinct aeromagnetic characteristics (Fig. 3), including (from west to east):
    1) a metaplutonic domain dominated by K-feldspar augen monzogranite (Fig. 5), previously dated at ca. 1994 Ma at two localities (Frith and van Breemen, 1990; Davis et al., 2014),
    2) a supracrustal package (of uncertain age) comprising mafic (Fig. 6) and lesser intermediate volcanic rocks, and semipelitic to psammitic (Fig. 7) rocks at lower- to middle-amphibolite facies (i.e. lower metamorphic grade than other domains),
    3) a metaplutonic domain dominated by monzogranite-granodiorite with lesser diorite to quartz diorite,

4) a 6-10 km wide, > 100 km long magnetic low, dominated by moderately to strongly deformed garnet-bearing leucogranite and lesser monzogranite,
5) a metaplutonic domain composed of orthopyroxene-bearing monzogranite – tonalite and less abundant diorite,
6) a moderate magnetic low consisting predominantly of monzogranite – granodiorite metaplutonic rocks, bounded to the east by a 2-4 km wide, dextral high strain zone
7) a distinctive, highly magnetic belt comprising diatexite and migmatitic Fe-rich metasedimentary rocks ± cpx-opx dioritic plutonic rocks (Fig. 8), in places cut by deformed monzogranite
8) a prominent, but discontinuous magnetic low characterized by leucogranite which is commonly garnet-bearing and strongly deformed (Fig. 9)
9) an eastern metaplutonic domain (Queen Maud block) with orthopyroxene tonalite (magnetic high, dated nearby at ca 3160 Ma; Davis et al., 2014) and granodiorite (magnetic low) which are relatively weakly deformed except near the western domain boundary

b) Collection of 82 bedrock samples to fully characterize geochemical differences between domains and constrain the tectonic setting of plutonic and volcanic rocks
c) Collection of 32 samples suitable for geochronology in order to unravel key age relationships and place timing constraints on the geologic evolution
d) Identification of a number of previously unknown, kinematically diverse, high strain zones which provide insight into the structural evolution of the region (e.g. Figs. 5, 8, 9)
e) Discovery of 7 new gossans with samples collected for multiple-metal geochemical analysis (Fig. 10)

Magnetotelluric transects:

Successful overnight MT recordings were made at 20 locations along 2 east-west transects crossing major boundaries inferred from aeromagnetic data (Fig. 3). The MT data provide information dominantly from the crust, but signals from the upper mantle may also be present. Preliminary analysis of the variations in MT response suggests that the generally steep structures observed in bedrock outcrops also characterize crustal domain boundaries to mid-crustal depths.

Surficial geology:

Reconnaissance surficial geology maps derived from air photograph interpretation (St-Onge and Kerr, 2013 & Dredge and Kerr, 2013) were verified and refined, both by ground-truthing and aerial observations by helicopter over parts of NTS 76H and 76I. The elevation of the post-glacial marine limit was determined from geomorpholocial features at approximately 210 m a.s.l. for the region, 15 m higher than that shown on the Glacial Map of Canada (Prest et al., 1968), but closer to the ones interpreted on recent map compilations. Cross-cutting striae (Fig. 11) and glacially-molded bedrock surfaces indicate that regional ice flow toward the north shifted to the northwest, consistent with superimposed streamlined landforms (Fig. 12) found in the Back River Basin in the southern part of NTS 76H (Fig. 2). Two short traverses along prominent MacAlpine Moraine segments resulted in the identification of appropriate sites for radiocarbon dating of organic lake-bottom sediments from kettle lakes (e.g. Fig. 13). One valley and a marine delta near the marine limit skirting the moraine were explored for radiocarbon dating of ancient shells.

Follow-up till sampling, boulder prospecting and ice-flow indicator mapping were completed at three stream and till geochemical anomalies identified in 2012 as part of the Geo-mapping Frontiers' Chantrey project (locations D, N26, N27 in Fig. 2; McMartin et al., 2013; McCurdy et al., 2013). At the Cu-Ag till geochemistry anomaly in NTS 76I (location N26; Fig. 2), sulphide-rich boulders were discovered and traced up-ice, which helped bedrock geologists locate gossanous outcrops. Surficial geology observations and till samples were also collected along two 80-km long transects (Fig. 2) parallel to the Dubawnt ice stream flow and perpendicular to the MacAlpine Moraines to document glacial dispersal characteristics in the area. Far-travelled Thelon sandstone clasts in till were observed along the transects as far as the distal end of the ice stream terrain. All till samples (n=29) were submitted for heavy mineral preparation and analysis, pebble lithology analysis and geochemical determinations.

Geochemical survey:

Over nine days, 85 sites on streams and rivers in northern NTS 76I were sampled for stream silt and water (Fig. 2). An additional 7 sites (Fig. 2) were sampled to follow up on results from a similar 2012 survey carried out to the south (NTS 76H and 76I south). By employing the same methods of sample preparation and analysis as samples collected in 2012, a layer of baseline geochemical data will be provided for a contiguous area of 15, 900 km^2, a region where geochemical data were not previously available. Field observations and measurements (e.g. pH, conductivity) were recorded at each site. At 36 sites, additional samples were collected for indicator mineral recovery and pebble identification. Preliminary plots of pH and conductivity data outline several areas of relatively high conductivity and low pH that are of high interest to further investigate with geochemical analyses.

Silt samples were dried and sieved at the GSC Sedimentology Laboratory in Ottawa and geochemical analysis of 65 elements will be carried out at commercial laboratories. Water samples are being analyzed for 62 elements at the GSC Inorganic Geochemistry Research Laboratory in Ottawa. Bulk sediment samples are being processed for indicator mineral recovery and identification at a commercial facility in Ottawa. Analytical data and field observations will be published in a GSC open file.

Future work

- Geochemical, Nd isotopic, and geochronological analyses of bedrock samples will help characterize the origin and age of the proposed crustal domains and their geologic components, and provide important constraints on the evolution of the area.
- Modeling and interpretation of MT data along two east-west transects will provide crustal-scale cross-sections providing valuable insights into the 3D architecture of the Ttz.
- Till, stream sediment and gossan analyses will help to identify potential targets for economic mineral exploration in the area.
- Current Research papers and GSC open files documenting fieldwork and analytical results will be prepared prior to March 31, 2015.
- Surficial and bedrock geology maps for NTS 76H and 76I will be revised and released as GEM2 publications.

Acknowledgments

We are most grateful to Sabina Gold and Silver Corporation, and in particular to J. Laitin, D. Jackaman, R. Peters, and R. Darling, whose logistical support via the Goose Lake exploration camp made it possible to establish a base camp for fieldwork in this remote region. We also thank Air Tindi (especially B. Schnoor) and Great Slave Helicopters for their safe and reliable fixed and rotary wing support In addition we gratefully acknowledge Discovery Mining Services for their expediting and assistance with camp setup, T. Chadwick, M. English, and D. Liikane for their excellent and enthusiastic assistance with fieldwork, Sarah Harper for her steady stream of delectable dishes, Bobby Klengenberg for his wildlife monitoring and assistance with the field camp, and Polar Continental Shelf Program for logistical support. J. Percival provided a constructive review of this report.

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Figures

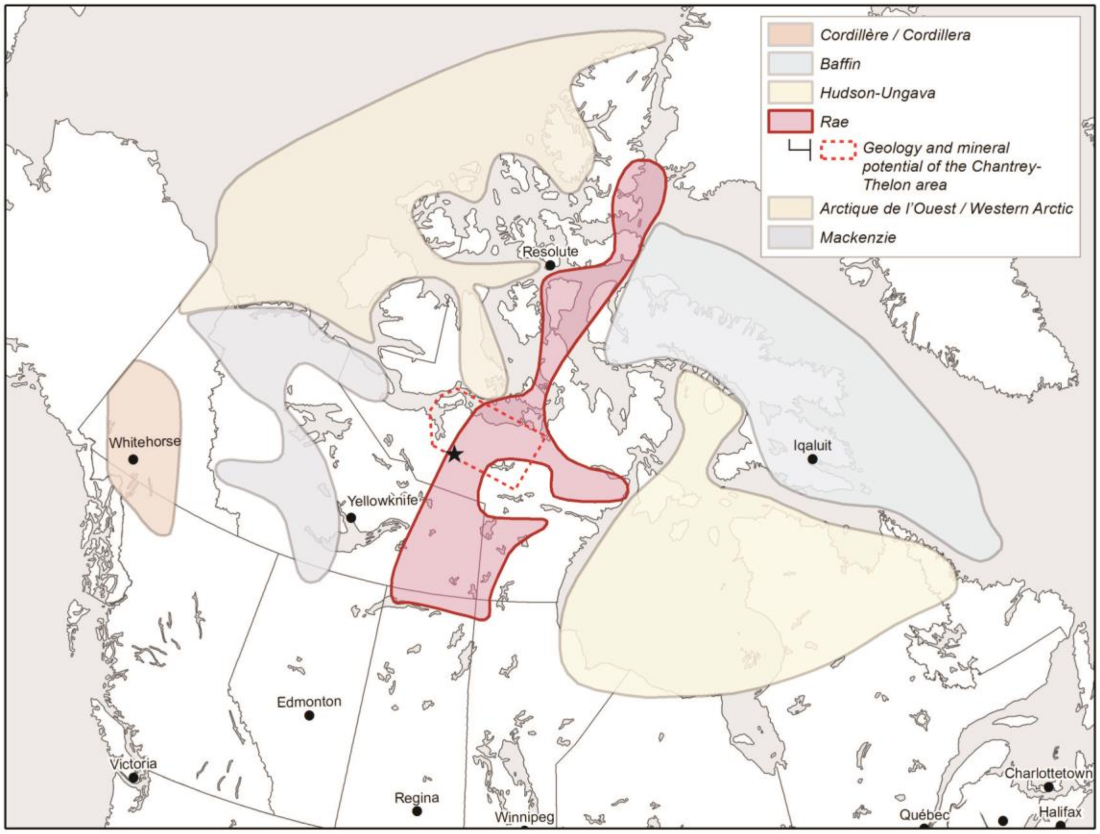

Figure 1. Location map showing region of Chantrey-Thelon activity and Thelon tectonic zone project (star).

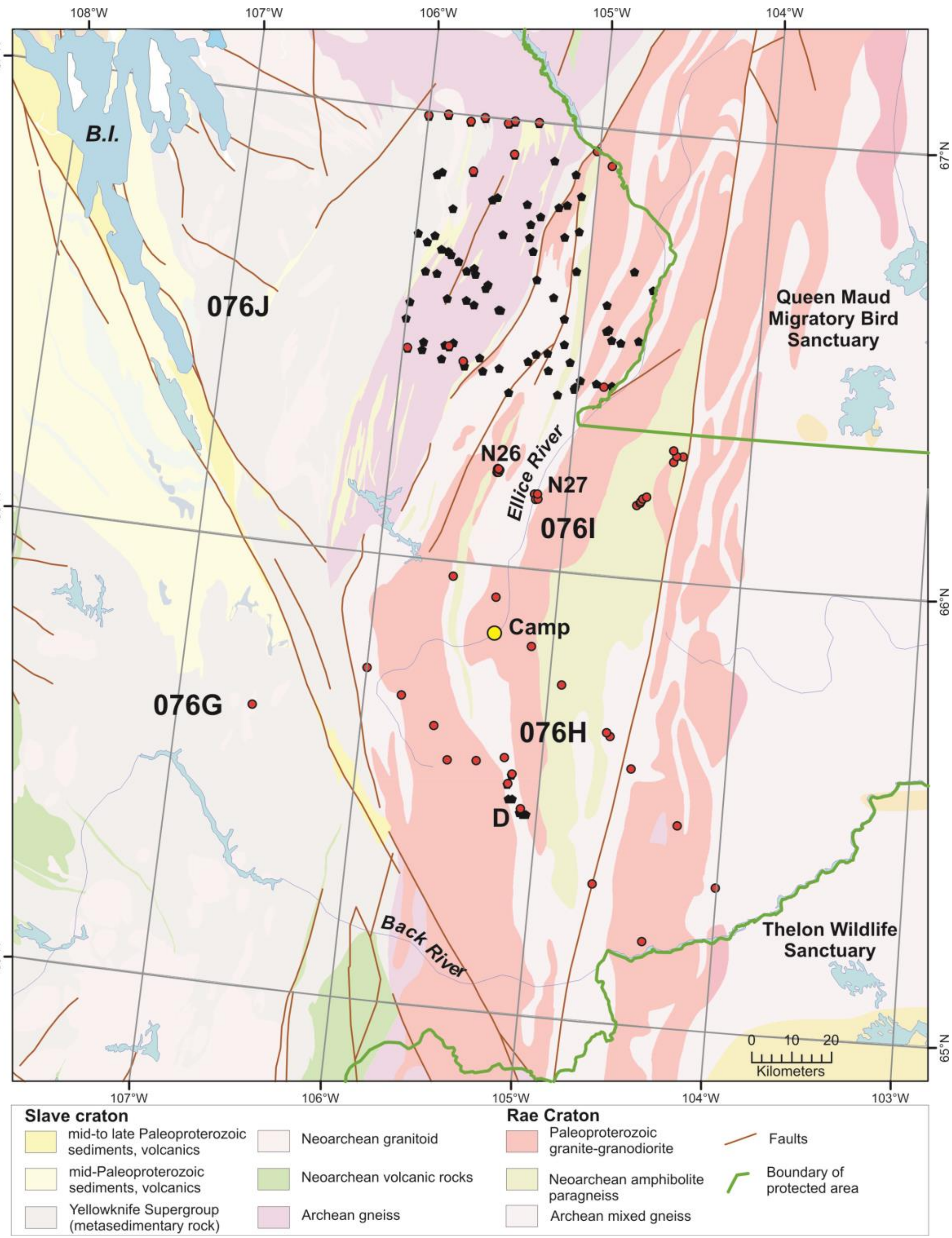

Figure 2: Bedrock compilation geology map (Harrison et al., 2011) of project area (parts of NTS 76H and 76I), showing location of 2014 surficial stations (red) and geochemical stream sediment and water sample sites (black). D, N26, N27 = reinvestigated 2012 locations (see text); B.I. = Bathurst Inlet.

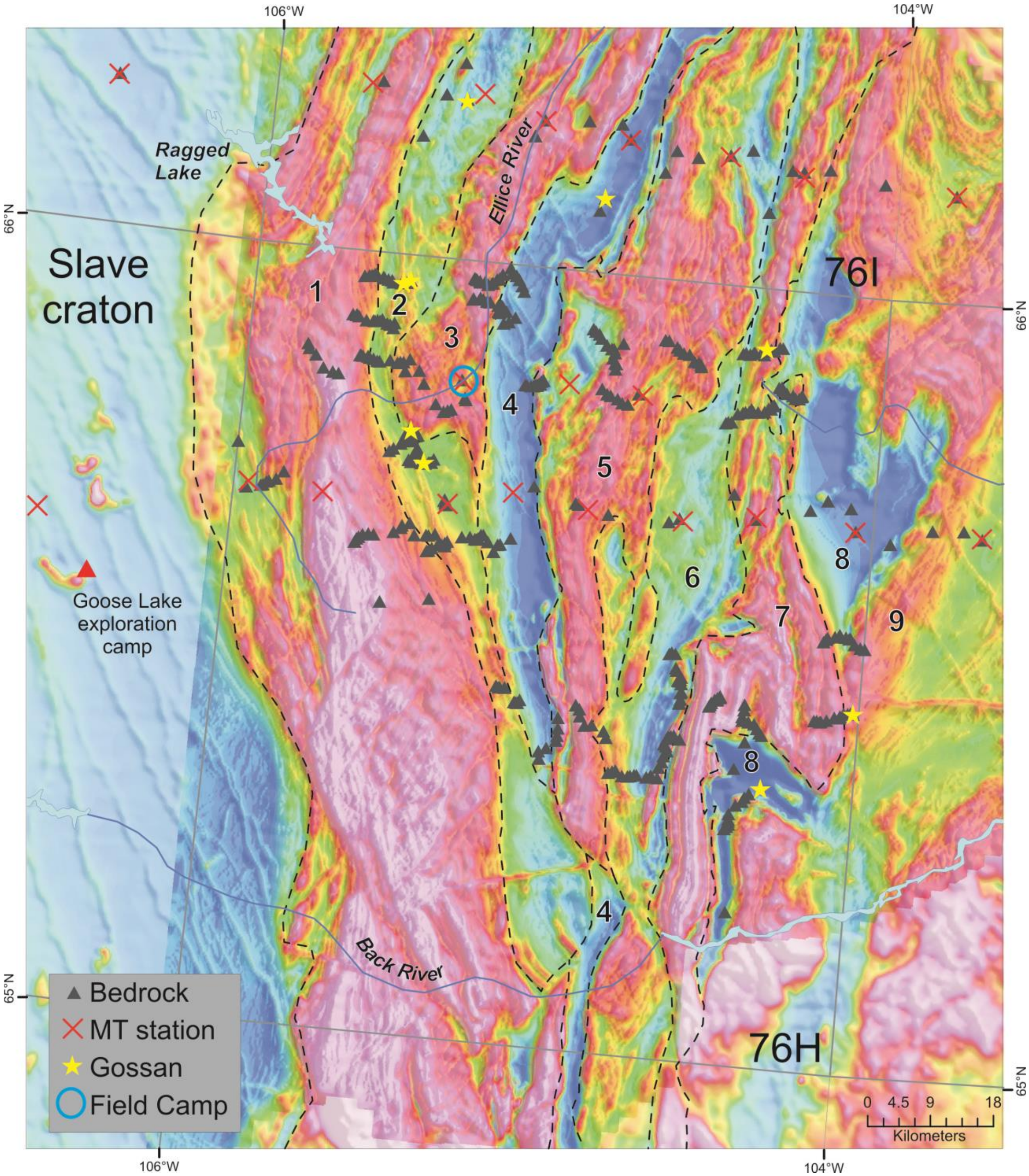

Figure 3: Aeromagnetic map of project area (parts of NTS 76H and 76I), showing location of bedrock stations, MT stations, and gossans. Dashed lines indicate interpreted boundaries of crustal domains (labelled 1-9).

Figure 4: Ellice River base camp of 2014 fieldwork

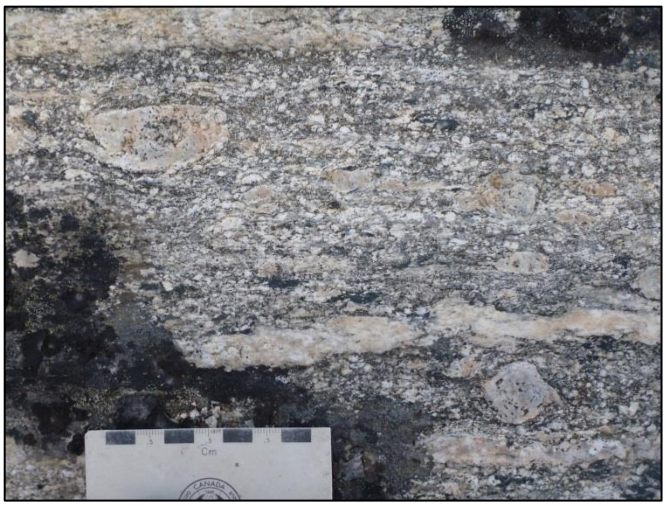

Figure 5: Sinistral shear zone on east side of K-feldspar monzogranite pluton (domain 1; station 14NK-M036).

Figure 6: Lower amphibolite-facies mafic volcanic rock (domain 2; station 14NK-M075)

Figure 7: Lower to middle amphibolite facies metapsammite cut by monzogranite (domain 2; station 14NK-S050).

Figure 8: Typical W-dipping fabrics in diorite gneiss (left) cut by E-dipping, extensional shear zone (domain 7; station 14NK-S009)

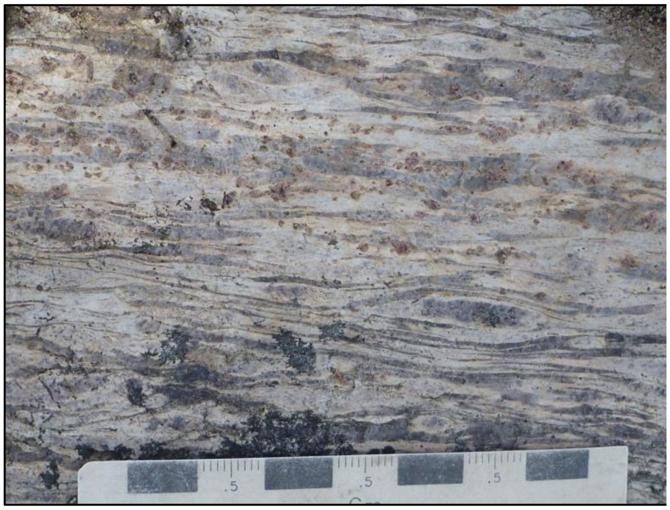

Figure 9: strongly deformed peraluminous leucogranite (domain 8; 14NK-M065)

Figure 10: ~5 m wide gossan zone in metavolcanic rocks (domain 2; station 14NK-S025)

Fig. 11. Cross-cutting striations showing relative age relationship between northward and northwestward ice flows

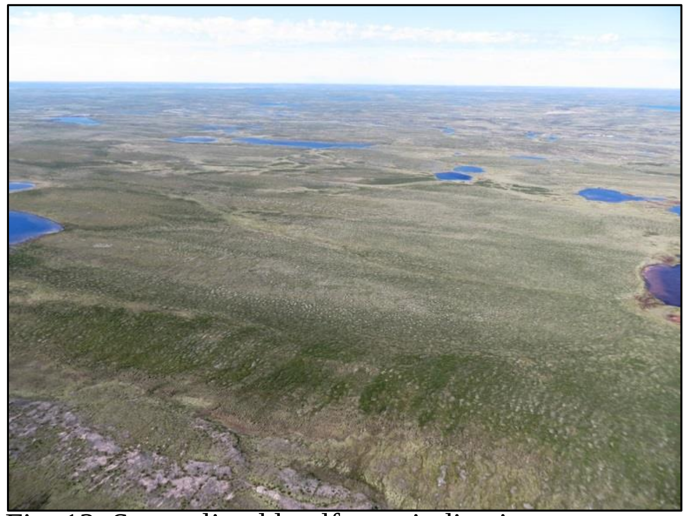

Fig. 12. Streamlined landforms indicating northwest ice flow, and exhibiting large mudboils developed in Thelon sandstone-rich till

Fig. 13. Kettle lake on top of large MacAlpine Moraine segment south of Queen Maud Gulf Migratory Bird Sanctuary.