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Report of 2016 Activities for the Geologic and Metallogenic Framework of the South Rae Craton, Southeast NWT: GEM 2 South Rae Quaternary and Bedrock Project

J.A. Percival, E. Martel, S.J. Pehrsson, P. Acosta-Gongora, D. Regis, E. Thiessen, D. Jamison, B. Neil and B. Knox

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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.

Introduction

This report builds on the geological framework for the South Rae region established over the past 5 years through extensive new data collection and analysis. Previously a ca. 400 km-wide knowledge gap between better known regions of Saskatchewan and Nunavut, the geology of the southeastern corner of the Northwest Territories is being brought up to modern standards by a partnership between the Geological Survey of Canada, Northwest Territories Geological Survey and Saskatchewan Geological Survey. Work under the Geo-mapping Frontiers project of GEM 1 contributed data mining of archival collections stemming from the GSC's helicopter reconnaissance of 1955-1958 (Pehrsson et al., 2013, Harris et al., 2013; Davis et al., 2015) as well as new geophysical (Kiss and Coyle, 2012), geochemical data acquisition (McCurdy et al., 2015), and field reconnaissance (Pehrsson et al., 2014; Campbell and Eagles, 2014). A field campaign in 2015 commenced systematic bedrock and surficial mapping in the southeastern part of the map area (Pehrsson et al., 2015) and this year's work extended coverage to the northwest. An accompanying report (Campbell et al. 2016) describes results of this year's surficial geological mapping activity.

The main goal of the South Rae activity is to advance geologic understanding and identify mineral potential in this underexplored, frontier region by addressing the following questions:

1. What is the orogenic architecture of the Rae Province and the nature, extent and temporal evolution of its Neoarchean crust and how do they determine the distribution of its mineral resources?
2. What is the nature, composition and distribution of the Quaternary sediments and how do they impact drift prospecting in this region?
3. What geochemical anomalies can be identified in lake sediments and surface waters, till, and bedrock, and how can they impact exploration initiatives in the region?

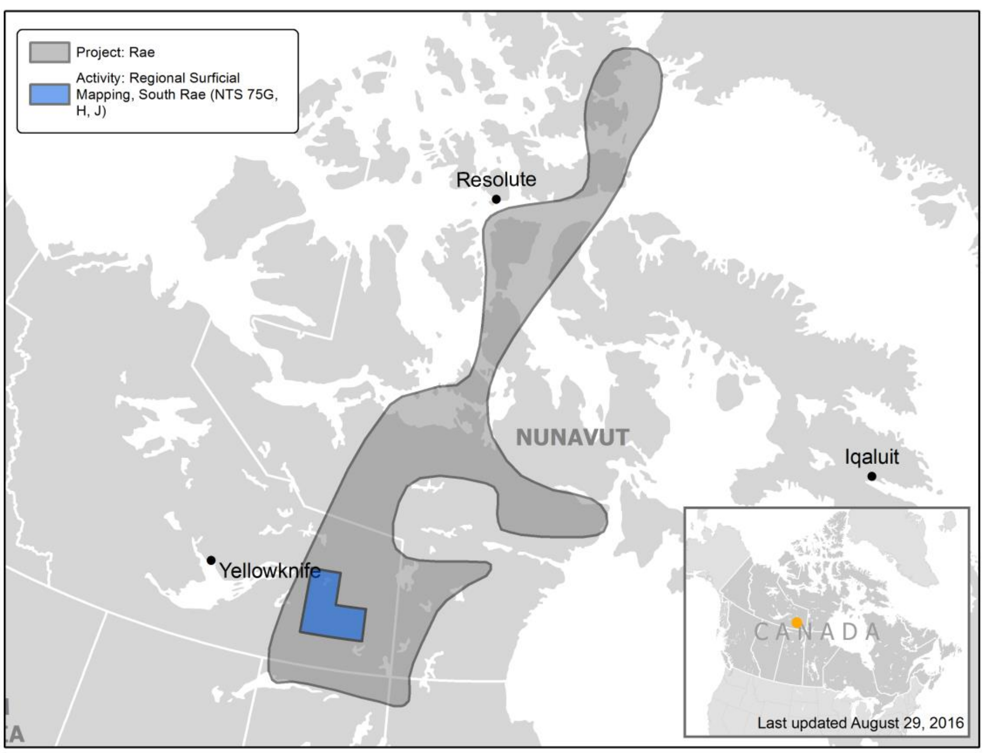

Figure 1: Location of 2016 field work in the GEM 2 South Rae Activity of the Rae project.

Methodology

Fieldwork between June 26 and July 28, 2016 was based from a low-impact tent camp (Fig. 2) at MacArthur Lake, NWT in the central part of NTS 75F (Fig. 3). The field camp was set up by staging fuel and camp gear on Twin Otter flights from Stoney Rapids, Saskatchewan. A Bell 206L4 helicopter provided air support for bedrock studies during a 20-day period. Regional bedrock observations and sampling (Fig. 2) were accomplished by a team of 5 senior geologists of the GSC and Northwest Territories Geological Survey, 4 university researchers (students and supervisors) and 2 junior geological assistants supported by a GIS specialist, helicopter pilots, a cook, camp manager and camp assistant.

Figure 2: MacArthur Lake camp, base of the 2016 field work.

Planned research over the project lifetime will tackle the aforementioned questions with the following approaches:

a) remote predictive mapping (RPM) incorporating geophysical and archival sample information (cf. Harris et al. 2013);
b) bedrock mapping and targeted metallogenic assessments combining a variety of scales and approaches depending on exposure and access along multiple transects and targeting areas of
potential terrane boundaries;

c) assays, geochemistry, geochronology and sediment and/or rock property data on all field samples to strengthen framework geoscience knowledge

d) lake and till sediment survey over key transect areas to aid in regional map unit interpretation and understanding regional metallogenic potential;

e) thermobarometric and pressure-temperature-time studies to assess the architecture of the Rae craton

A synthesis of new information and correlation of bedrock features with those of Saskatchewan to the south, and other areas of the Rae project to the north, will conclude the project.

While the general region of interest for the bedrock study is defined by 60 to 62˚ latitude and 104 to 110˚ longitude (covering 7 NTS map sheets, 65E, 75 A to C, and 75F to H), the field component of the project will focus on 5 map sheets (65E, 75A, B, G and H), where little to no field-based bedrock or surficial geological maps are available. Field work in 2016 focused on the 75F and G map sheets.

Results

Bedrock geology:

Systematic bedrock mapping in 2016 focussed on NTS map sheets 75F and G (Fig. 3), augmented by targeted studies of structural boundaries. In total, bedrock data were collected from 695 sites (Fig. 3), completing a broad transect of the south Rae region, from the boundary with the Hearne Province in the southeast, to the Porter domain in the northwest. Highlights of the work include, from southeast to northwest:

Snowbird tectonic zone, Hearne-Rae boundary in the Kasba Lake area: Mafic schists previously correlated with the Ennadai greenstone belt have mylonitic fabrics in the amphibolite facies, with relict garnet-clinopyroxene assemblages. These rocks resemble those of the Chipman domain and likely form part of the Snowbird tectonic zone.

Wholdaia Lake shear zone: This km-wide ductile high-strain zone defined by ultramylonite and mylonite separates the Snowbird and Firedrake domains (Pehrsson et al. 2015). This crustal-scale structure has a complex kinematic and metamorphic history dominated by ca. 1.9 Ga high-pressure metamorphism and ca. 1. 89 Ga dextral oblique transcurrent movement.

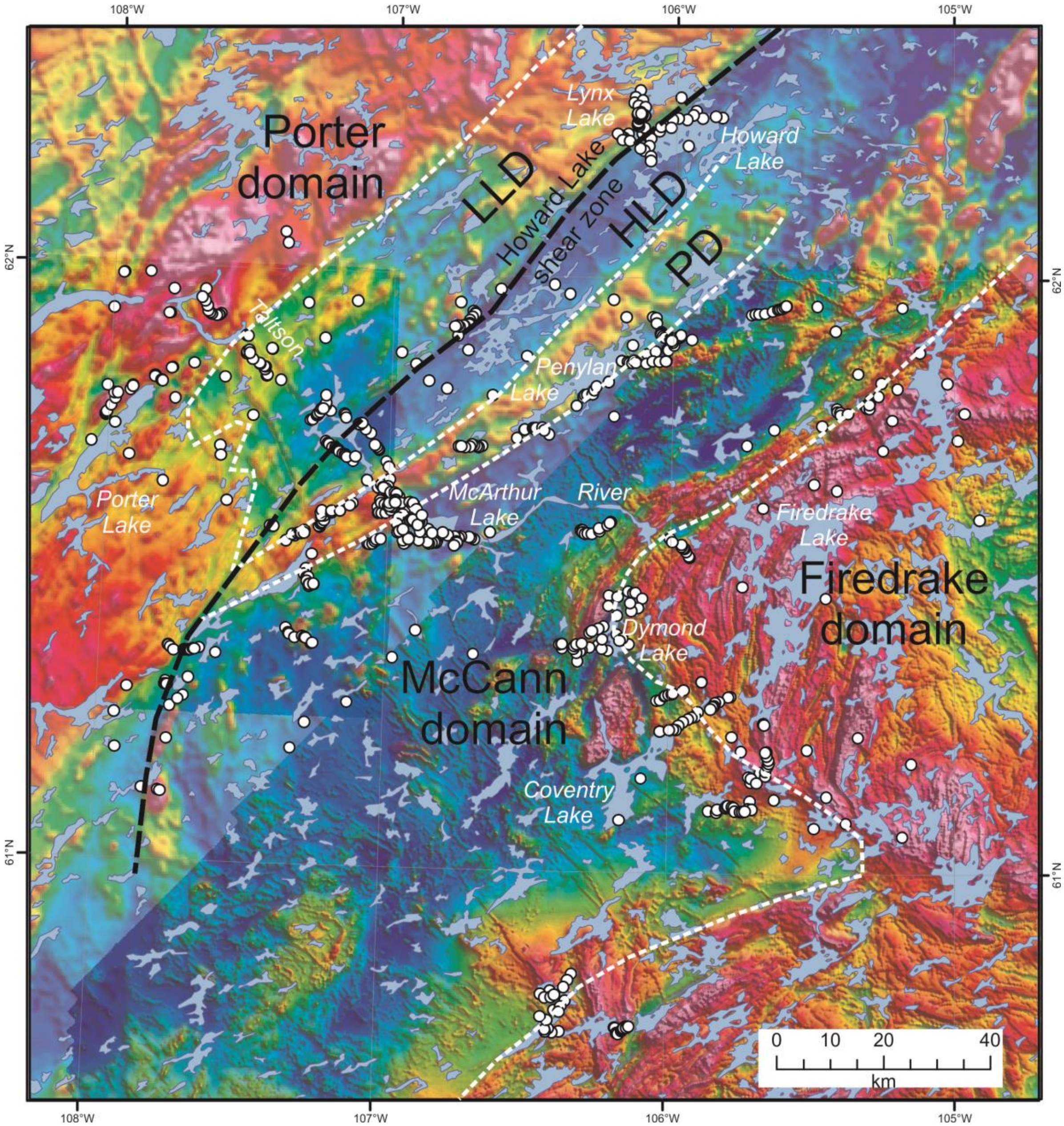

Figure 3: Total field aeromagnetic map (Kiss and Coyle 2012) showing location of 2016 bedrock observations, domains and boundaries referred to in the text. HLD: Howard Lake domain; LLD: Lynx Lake domain; PD: Penylan domain.

Firedrake domain: The Firedrake domain (Fig. 3) consists dominantly of foliated, gneissic and migmatitic metaplutonic rocks of Archean (2.7-2.59 Ga) age (Davis et al., 2015) including tonalite, granodiorite and granite, with minor metasedimentary enclaves. Some gabbro, diorite, quartz diorite, monzonite and syenite (Fig. 4) is Paleoproterozoic (1.89-1.82 Ga). Retrograde amphibolite facies assemblages dominate but relict high temperature, pressure assemblages are sporadically preserved.

Map-scale folds of the dominant foliation/gneissic layering have amplitudes of 10's of km and are cut by ductile high-strain zones.

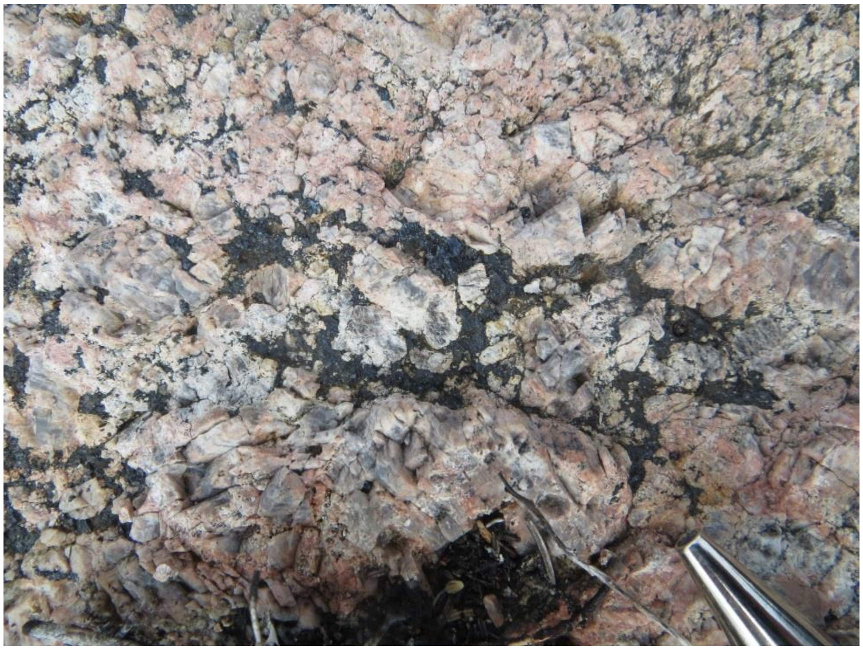

Figure 4: Outcrop photograph of massive, equigranular magnetite-bearing monzonite corresponding to a positive magnetic anomaly in the southern Firedrake domain. Field of view is 10 cm.

Black Bay fault zone: This northeast-trending ductile-brittle fault zone has a complex kinematic history involving dominantly dextral movement, with relict early sinistral and spoaradic late sinistral components, and may have acted as a conduit for syenite dykes and plutons. The alkaline rocks appear to be less fractionated than those associated with the Hoidas deposit in Saskatchewan; work continues on their petrology, geochemistry and U-REE potential (Pehrsson et al., 2015).

Firedrake domain - McCann domain boundary zone: Defined by the Black Bay fault zone in the south (75B), the Firedrake-McCann domain boundary in 75H varies in orientation and character. In the Coventry Lake area, the northwest-trending undulating aeromagnetic boundary consists of variably refolded high-strain zones (Figs. 5, 6), whereas northeast of Dymond Lake, the northeast-trending boundary is relatively linear, and defined by a steeply-dipping, ductile, dextral high-strain zone that overprints and folds the gneissic layering in both the Firedrake and McCann domains.

McCann domain: This broad region comprises plutonic and metaplutonic granite, granodiorite, tonalite and quartz diorite (Fig. 7), with sparse enclaves of pelite, psammite and iron formation.

Figure 5: Outcrop photograph of brittle-1ductile shear zone at the Firedrake-McCann domain boundary in the northwest-trending segment. Field of view is 10.2 cm.

Figure 6: Outcrop photograph of folded, high-strain fabric at the Firedrake-McCann boundary in the northwest-trending segment. Field of view is 60 cm.

Pyroxene and garnet-bearing assemblages indicate high-temperature and medium to high-pressure conditions of crystallization, corroborated by the characteristic blue hue of quartz indicating high Ti content. Geochronology reveals a complex history of metamorphic and plutonic events at ca. 2.5, 2.4-2.27, and 1.9-1.8 Ga (Davis et al., 2015).

Figure 7: Outcrop photograph of orthopyroxene-clinopyroxene quartz diorite layer in the McCann domain. These medium-grained, equigranular rocks have coarse-grained, pyroxene-rich segregations on the 1-5 cm scale. Field of view is 8 cm.

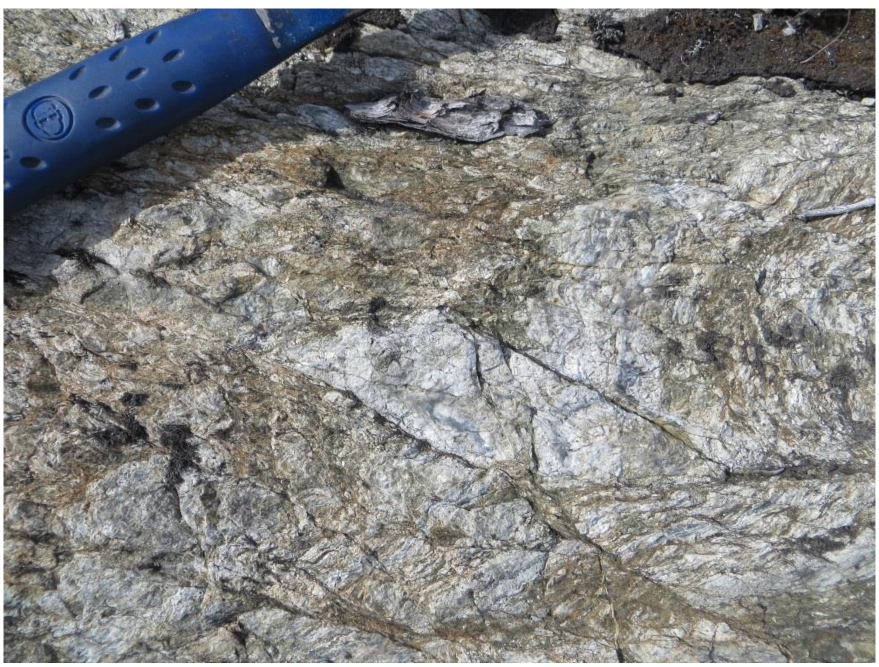

Figure 8: Outcrop photograph of brittle-ductile shear zone at the Penylan-McCann boundary. In this segment of the boundary, earlier ductile fabrics are not apparent. Field of view is 26 cm.

McCann- Penylan domain boundary: A sharp aeromagnetic lineament characterizes this narrow (10-50 m), northeast-trending, steeply southeast-dipping zone consisting of variably folded and mylonitic orthogneiss, gabbroic anorthosite and sparse paragneiss, locally overprinted by brittle-ductile shear zones and cataclasite (Fig. 8). Stretching lineations vary from steep to subhorizontal, with predominantly dextral transcurrent kinematic indicators.

Penylan domain: This lozenge-shaped domain of massive and variably foliated monzogranite, quartz diorite and anorthositic gabbro has yielded crystallization ages in the 2.03-2.05 Ga range (Davis et al., 2015).

Howard Lake domain (new): This southwest-tapering wedge of consistently low aeromagnetic expression and poor exposure consists of metasedimentary rocks, foliated to gneissic granodiorite, anorthositic orthopyroxene gabbro and granite. In eastern Howard Lake (75I), sedimentary compositions include wacke, andalusite-bearing pelite, muscovite schist and calc-silicate (Fig. 9) whereas the southwestern portion consists mainly of granodioritic rocks with schlieren and rafts of biotite schist.

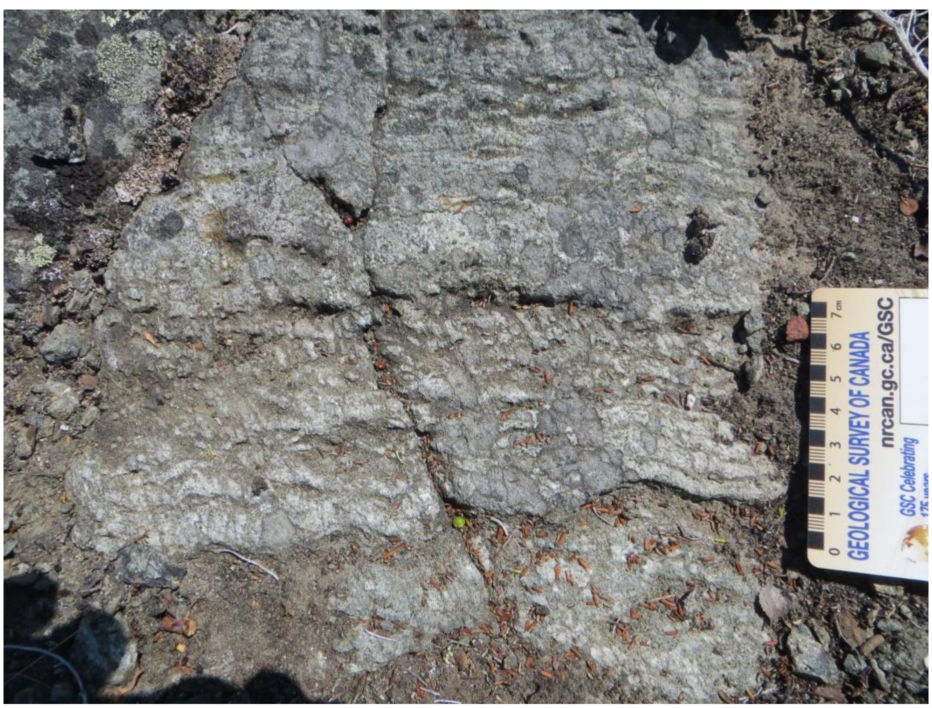

Figure 9: Outcrop photograph of bedding in calc-silicate rocks of the Howard Lake domain. Axial planar cleavage is at a high angle to bedding. Field of view is 19 cm.

Figure 10: Outcrop photograph of straight gneiss of the Howard Lake shear zone. Note dismembered pegmatite dykes and quartz veins. Field of view (foreground) is 3.5 m.

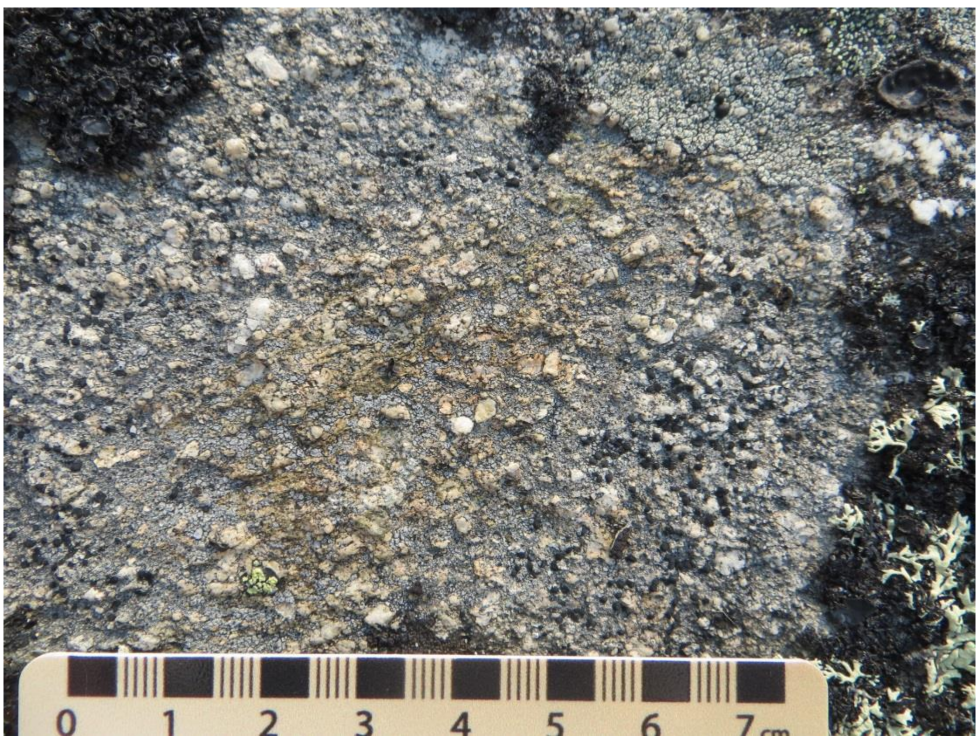

Figure 11: Outcrop photograph of plagioclase-phyric andesite, Lynx Lake supracrustal belt. Andesites comprise fine-grained matrix, with plagioclase phenocrysts to 8 mm, and are interlayered on a 10-50 cm scale with fine-grained, metabasaltic mafic schist. Field of view is 10 cm.

Howard Lake shear zone (Howard Lake-Porter domain boundary): This northeast-striking zone is a prominent aeromagnetic feature over at least 300 km of strike length. At Howard Lake the ca. 5-km-wide zone comprises steeply dipping, protomylonitic through ultramylonitic, amphibolite-facies fabrics with generally subhorizontal stretching lineations and dextral kinematic sense (Fig. 10). The zone maintains its macroscopic characteristics as it narrows to the southwest through 75G.

Lynx Lake domain (new): A ca. 20-km-wide corridor of variable magnetic signature northwest of the Howard Lake shear zone extends from Lynx Lake to Porter Lake is herein named the Lynx Lake domain. It is made up of granodiorite and tonalite with abundant enclaves of supracrustal origin, including a mafic to intermediate metavolcanic package and wacke-pelite metasedimentary component. The composite metavolcanic unit includes fine-grained metabasaltic schist, plagioclase-phyric meta-andesite (Fig. 11), and medium-to coarse-grained metagabbro (cf. Wright, 1967; Gandhi, 1986; Davidson and Gandhi 1989). To the southwest, enclaves include sillimanite-garnet-biotite paragneiss, mafic-ultramafic intrusive rocks and local iron formation.

Porter domain: The Porter domain is defined by a relatively high aeromagnetic signature and consists mainly of granodiorite, both hornblende-biotite and orthopyroxene-clinopyroxene bearing, with local gabbroic enclaves and dykes, cut by granitic dykes and plutons (Fig. 12). Broad zones of cataclastic deformation and associated chlorite-hematite-epidote alteration and fracture filling are widespread. Small sedimentary outliers overlie basement rocks of both the Porter and Lynx Lake domains. Pale pink and purple quartz arenite of the Lynx Lake domain resembles ca. 2.2 Ga Assemblage 1 of the Amer Group to the northeast (Rainbird et al., 2010); unmetamorphosed purple siltstone and conglomerate around Porter Lake have been correlated with the ca. 1.9 Ga Nonacho Group (Taylor, 1959), and a sandstone-conglomerate assemblage ca. 20 km northeast of Porter Lake Fig. 13) may be equivalent to the Amarook formation of the ca. 1.75 Ga Wharton Group (Rainbird et al., 2003).

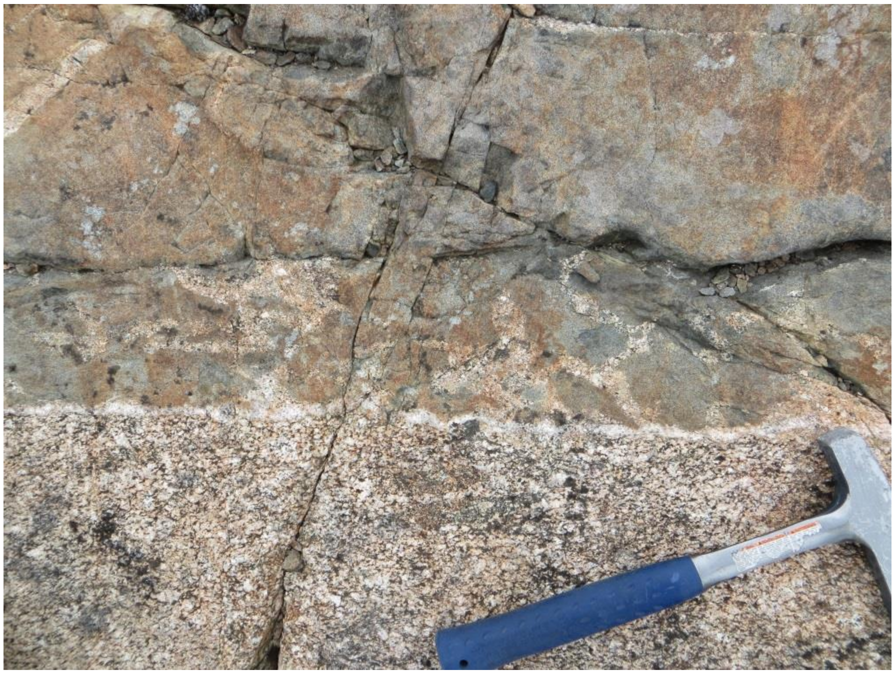

Figure 12: Outcrop photograph of hornblende-biotite granodiorite (lower 1/3 of photo) and mafic dyke (upper 2/3 of photo). Textures suggest that that the granodiorite re-melted during dyke emplacement and flowed back into fractures in the dyke margin. Field of view is 55 cm.

Figure 13: Outcrop photograph of massive, conglomeratic arkose on Porter domian basement. Isolated rounded clasts of red, trydimite-phyric rhyolite occur within pink arkosic arenite, possibly equivalent to the Wharton Group. Field of view is 15 cm.

Lake sediment geochemistry

Lake sediment and surface water samples were collected in 2015 at 407 sites within priority areas of 75-B to characterize surrounding rocks and identify geochemical anomalies. Results are presented in McCurdy et al. (2016).

Future work

- Geochemical, Nd isotopic and geochronological analyses of bedrock samples will help characterize the age and origin of the proposed crustal domains and their geological components.
- Structural and tectonometamorphic studies will aid in evaluating the tectonic evolution of the area and its role in the evolution and assembly of the Canadian shield.
- Gossan analyses and targeted studies of new occurrences and the Thye Lake nickel deposit will aid in understanding the area's regional metallogenic potential.
- Till compositional analyses will help to identify potential targets and define cumulative glacial transport and dispersal patterns to guide mineral exploration in the area.
- Final bedrock and surficial maps of 75A, 75B, 75G and 75H, as well as open files and reports for the area will be released in 2016, 2017 and 2018.

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