



**GEOLOGICAL SURVEY OF CANADA**

**OPEN FILE 8142**

**Report of 2016 Bedrock 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**

**2016**



**Canada**



**GEOLOGICAL SURVEY OF CANADA  
OPEN FILE 8142**

**Report of 2016 Bedrock 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<sup>1</sup>, E. Martel<sup>2</sup>, S.J. Pehrsson<sup>1</sup>, P. Acosta-Gongora<sup>1</sup>, D. Regis<sup>1</sup>, E.  
Thiessen<sup>3</sup>, D. Jamison<sup>4</sup>, B. Neil<sup>3</sup>, and B. Knox<sup>2</sup>**

1. Geological Survey of Canada, 601 Booth Street, Ottawa, ON K1A 0E8;

2 Northwest Territories Geological Survey, Yellowknife, Northwest Territories

3 Department of Earth Sciences, Simon Fraser University, Burnaby, British Columbia

4 Department of Earth Sciences, University of Waterloo, Waterloo, Ontario

**2016**

©Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, Canada, 2016

doi:10.4095/299469

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

**Recommended citation**

Percival, J.A., Martel, E., Pehrsson, S.J., Acosta-Gongora, P., Regis, D., Thiessen, E., Jamison, D., Neil, B., and Knox, B., 2016. Report of 2016 Bedrock Activities for the Geologic and Metallogenic Framework of the South Rae Craton, Southeast NWT: GEM 2 South Rae Quaternary and Bedrock Project; Geological Survey of Canada, Open File 8142. 17 p. doi:10.4095/299469

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

## Table of Contents

Foreword .....	4
Introduction .....	4
Methodology .....	6
Results .....	7
Future work .....	16
Acknowledgments.....	16
References .....	16

## 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 (Fig. 1) established over the past 5 years through extensive new data collection and analysis. Previously regarded as 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 surveys of 1955-1958 (Pehrsson et al., 2013; Harris et al., 2013; Davis et al., 2015) as well as new geophysical (Kiss and Coyle, 2012) and geochemical data acquisition (McCurdy et al., 2015), and field reconnaissance (Pehrsson et al., 2014a; Campbell and Eagles, 2014). As part of GEM2, 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 as a whole is to advance geological 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 Neoproterozoic 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?

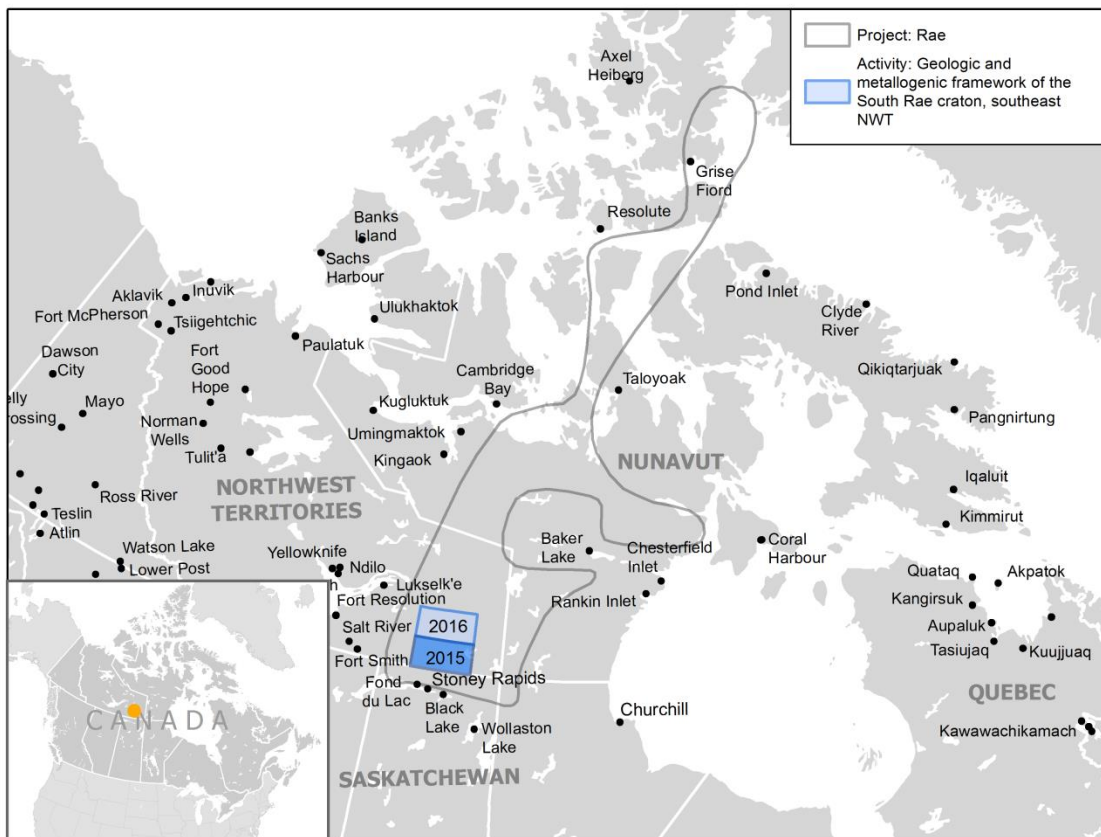


Figure 1: Location of 2016 field work in the GEM 2 South Rae Activity of the Rae project.

## Methodology

Fieldwork between June 26 and July 28, 2016 was based from a low-impact tent camp (Fig. 2) at McArthur Lake, NWT, in the central part of National Topographic System (NTS) 75G (Fig. 3). The field camp was set up by staging fuel and camp gear on Twin Otter flights from Stoney Rapids, Saskatchewan (Fig. 1). A Bell 206L4 helicopter provided air support for bedrock studies during a 20-day period. Regional bedrock observations and sampling (Fig. 4) 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: McArthur 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, litho- and isotope geochemistry, geochronology and sediment and/or rock property data on all field samples to strengthen framework geoscience knowledge
- d) a lake sediment geochemical survey over key transect areas to aid in regional map unit interpretation and understanding regional metallogenic potential (McCurdy et al., 2016);
- 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 focused on 5 map sheets (65E, 75A, B, G and H), where little to no field-based bedrock or surficial geological maps existed prior to this study.

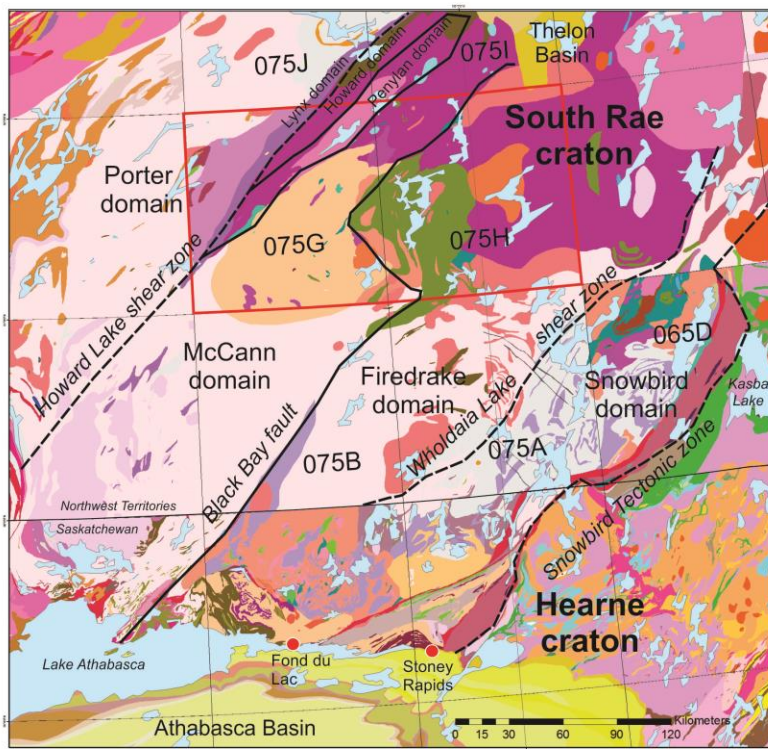


Figure 3: Geological compilation (Pehrsson et al., 2014b) showing location of features described in the text. Red box outlines the extent of 2016 field work.

## Results

Systematic bedrock mapping in 2016 focussed on NTS map sheets 75G and H (Fig. 3), augmented by targeted studies of structural boundaries in 65D, 75I and J. In total, bedrock data were collected from 695



sites (Fig. 4), 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 schist previously correlated with the Ennadai greenstone belt (Taylor, 1963) has mylonitic fabrics in the amphibolite facies, with relict garnet-clinopyroxene assemblages. These rocks resemble those of the Chipman domain (Martel et al., 2008) and likely form part of the Snowbird tectonic zone. The retrograde rocks are juxtaposed against greenschist-facies pillow basalts of the Ennadai belt, transposed into the shear zone orientation.

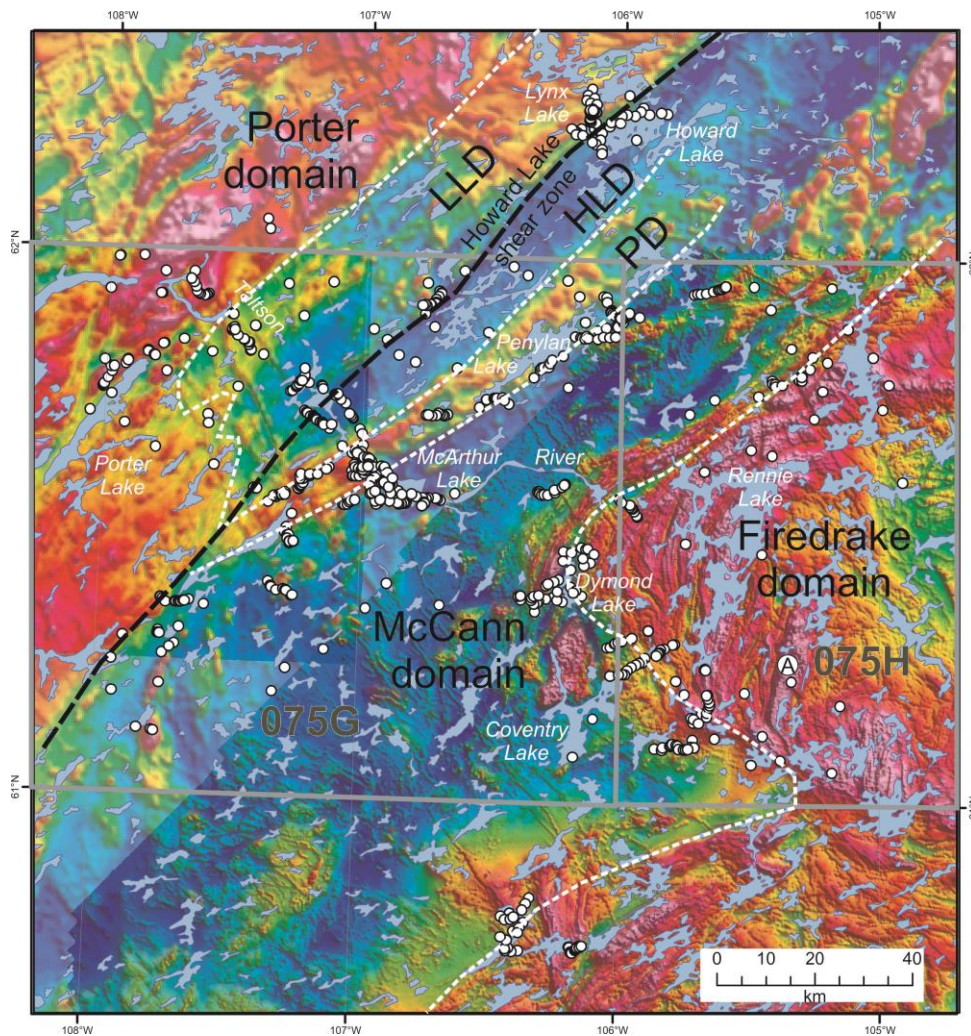
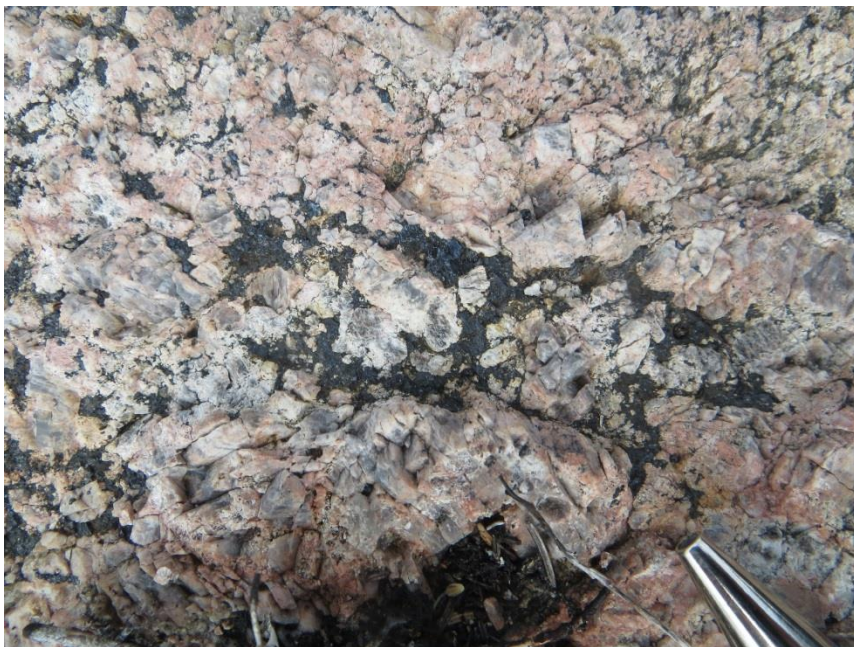


Figure 4: Total field aeromagnetic map (Kiss and Coyle 2012) showing location of 2016 bedrock observations, domains and boundaries referred to in the text. HD: Howard domain; LD: Lynx domain; PD: Penylan domain.

*Wholdaia Lake shear zone:* This 10-20 km-wide ductile high-strain zone, defined by ultramylonite and mylonite, separates the Snowbird and Firedrake domains (Fig. 3; Pehrsson et al. 2015). The crustal-scale structure extends for 200-300 km and 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 (E. Thiessen, unpublished data).

*Firedrake domain:* The Firedrake domain (Figs 3, 4) 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 bodies (Fig. 5) are Paleoproterozoic (1.89-1.82 Ga). Retrograde amphibolite facies assemblages dominate but relict high-temperature, high-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 5: Outcrop photograph of massive, equigranular magnetite-bearing monzonite corresponding to a positive magnetic anomaly in the southern Firedrake domain (“A” in figure 4). 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 sporadic 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 (e.g.,



Pandur et al., 2014); 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 75G and H varies in orientation and character. In the Coventry Lake area, the northwest-trending undulating aeromagnetic boundary consists of variably refolded high-strain zones (Figs. 6, 7), 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. 8), with sparse enclaves of pelite, psammite and iron formation. Pyroxene and garnet-bearing assemblages in the plutonic rocks 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 6: Outcrop photograph of brittle-ductile shear zone at the Firedrake-McCann domain boundary in the northwest-trending segment. Field of view is 10.2 cm.*





*Figure 7: Outcrop photograph of low-dipping, high-strain fabric at the Firedrake-McCann boundary in the northwest-trending segment. Field of view is 60 cm.*



*Figure 8: 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 18 cm.*





*Figure 9: 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. 9). Stretching lineations vary from steep to subhorizontal, with predominantly dextral transcurrent kinematic indicators.

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

*Howard 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. 10), whereas the southwestern portion of the domain consists mainly of granodioritic rocks with schlieren and rafts of amphibolite, pelitic rocks and biotite schist.



*Figure 10: Outcrop photograph of bedding in calc-silicate rocks of the Howard domain. Axial planar cleavage is at a high angle to bedding. Field of view is 19 cm.*

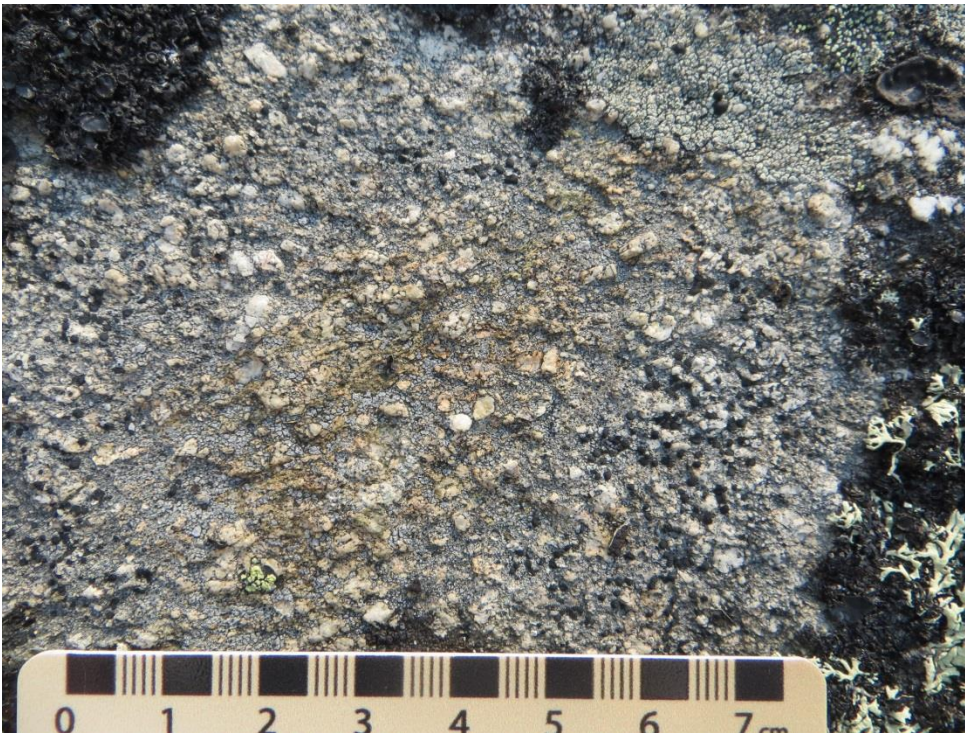
*Howard Lake shear zone (Howard -Lynx /Porter domain boundary):* This northeast-striking shear zone is a prominent aeromagnetic feature over at least 300 km of strike length. At Howard Lake the ca. 5-km-wide zone comprises steeply dipping, protomylonitic through ultramylonitic, amphibolite-facies fabrics with generally subhorizontal stretching lineations and dextral kinematic sense (Fig. 11). The zone maintains its macroscopic characteristics as it narrows to the southwest through 75G.

*Lynx domain (new):* A ca. 20-km-wide corridor of variable magnetic signature northwest of the Howard Lake shear zone, extending from Lynx Lake to Porter Lake, is herein named the Lynx domain. It is made up of granodiorite and tonalite with sparse enclaves in the southwest and metavolcanic and associated units in the northeast. The composite metavolcanic unit near Lynx Lake includes fine-grained metabasaltic schist, plagioclase-phyric meta-andesite (Fig. 12), and medium-to coarse-grained metagabbro (cf. Wright, 1967; Gandhi, 1986; Davidson and Gandhi 1989). To the southwest, magnetic intensity decreases abruptly and only sparse mafic enclaves and schlieren occur within foliated to gneissic granitoid units.





*Figure 11: 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.*

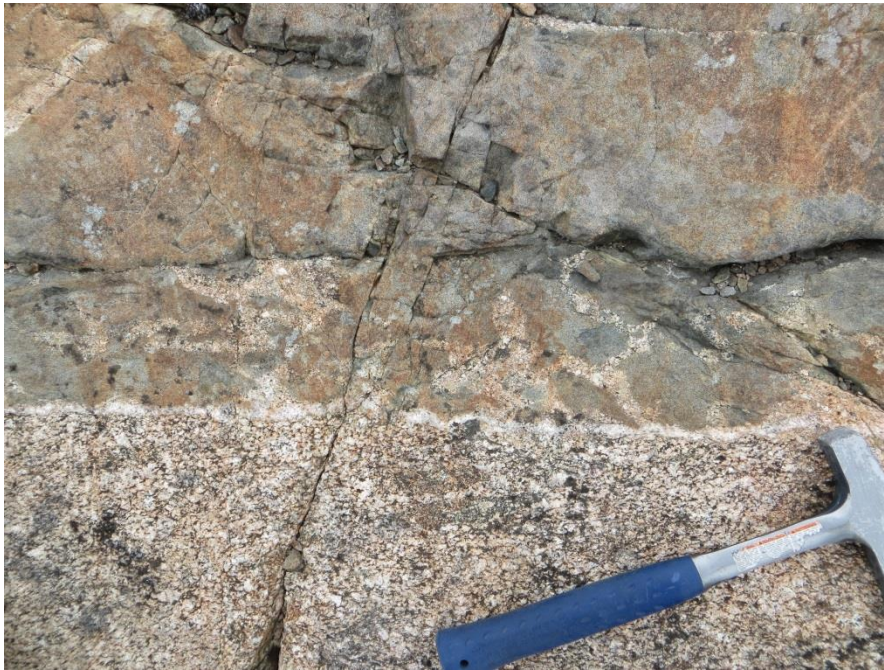


*Figure 12: Outcrop photograph of plagioclase-phyric meta-andesite, Lynx Lake supracrustal belt. Meta-andesite comprises a fine-grained matrix, with plagioclase phenocrysts up to 8 mm, and is interlayered on a 10-50 cm scale with fine-grained, metabasaltic schist. Field of view is 10 cm.*



*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. 13). 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 domains. Pale pink and purple quartz arenite of the Lynx domain resembles ca. 2.2 Ga Assemblage 1 of the Amer Group to the northeast (Rainbird et al., 2010); unmetamorphosed pebbly sandstone around Porter Lake has 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. 14) may also be equivalent.



*Figure 13: Outcrop photograph of hornblende-biotite granodiorite (lower 1/3 of photo) and mafic dyke (upper 2/3 of photo). Textures suggest that the granodiorite re-melted during dyke emplacement and flowed back into fractures in the dyke margin. Field of view is 55 cm.*



*Figure 14: Outcrop photograph of massive, conglomeratic arkose on Porter domain basement. Isolated rounded clasts of red, trydimite-phyric rhyolite occur within pink arkosic arenite. Field of view is 15 cm.*

### **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.
- 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.

### **Acknowledgments**

The writers wish to thank Discovery Mining Services and in particular Peter McLachlan and Mike Shamborski for their help in camp set-up, maintenance and expediting, Adam and Julie of Scotts' General Store, Stoney Rapids for their help with groceries, supplies and fuel, and Heather and Pete Thomson of WhiteWater Inn for their hospitality. Helicopter support was provided by Helicopter Transport Services of La Ronge, Saskatchewan. The hard work and unfailing skill of pilots Jim Watson and Pierre Fiset are much appreciated. Transwest Air of Stoney Rapids provided Twin Otter support. Angela Ford provided

timely GIS and field assistance support. The manuscript was improved through a critical review by Natasha Wodicka.

## References

- Campbell, J.E., and Eagles, S., 2014. Report of 2014 Activities for the Geologic and Metallogenic Framework of the South Rae Craton, Southeast NWT: Reconnaissance Surficial and Bedrock Fieldwork in the GEM 2 South Rae Project Area; Geological Survey of Canada, Open File 7701. 6 p. doi:10.4095/295463
- Campbell, J.E., Lauzon, G., Dyke, A. and Haiblen, A. 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, 12p. doi:10.4095/299391
- Davidson, G.I., and Gandhi, S.S., 1989. Unconformity-related U-Au mineralization in the middle Proterozoic Thelon Sandstone, Boomerang Lake Prospect, Northwest Territories, Canada. *Economic Geology* 84, 143-157.
- Davis, W.J., Pehrsson, S.J. and Percival, J.A., 2015. Results of a U-Pb zircon geochronology transect across the southern Rae craton, NWT, Canada: 2009-2014 Geological Survey of Canada, Open File Open File 7655, 74 p.
- Gandhi, S.S., 1986, Garnetiferous gneisses and a quartz syenite intrusive sheet at Lynx Lake, Northwest Territories: Canada. *Geol. Survey Paper* 86-1B, p. 853-857.
- Harris, J.R., Hillary, E.M., Percival, J.A., Buller, G., Buenviaje, R., Bazor, D., Baer, S., Kiessling, G.M., Pehrsson, S. J., Davis, W., Berman, R.G., Wodicka, N., Beauchemin, M., Coyne, M. and Therriault, A.M. 2013. Geo-mapping Frontiers: Updated information on the regions covered by Operations Baker, Bathurst, Keewatin, Northern Keewatin, Thelon and Wager; Nunavut and Northwest Territories. Geological Survey of Canada, Open Files 7434-7448.
- Kiss, F. and Coyle, M., 2012. Aeromagnetic survey of the South Rae Craton, Northwest Territories; Geological Survey of Canada, Open File 7120-7136, scale 1:100 000.
- Martel, E., van Breemen, O., Berman, R.G., and Pehrsson, S. 2008. Geochronology and tectonometamorphic history of the Snowbird Lake area, Northwest Territories, Canada: new insights into the architecture and significance of the Snowbird tectonic zone. *Precambrian Research*, 161: 201-230.
- McCurdy, M.W., Pehrsson, S.J., Campbell, J.E., and Adcock, S.W., 2015. Regional lake sediment and water geochemical data, northern Saskatchewan (NTS 64-L, 64-P, 74-N, 74-O and 74-P). Geological Survey of Canada, Open File 7746, 2015; 23 pages, doi:10.4095/295977
- McCurdy, M.W., Pehrsson, S.J., Falck, H., Day, S.J.A., and Campbell, J.E., 2016. Geochemical Data for Lake Sediments and Surface Waters, Abitau Lake Area, Northwest Territories (NTS 75-B); Geological Survey of Canada, Open File 8082, 1 .zip file. doi:10.4095/xxxxxx
- Pandur, K., Kontak, D.J., and Ansdell, K.M., 2014. Hydrothermal evolution in the Hoidas Lake vein-type REE deposit, Saskatchewan, Canada: Constraints from fluid inclusion microthermometry and evaporate mound analysis. *Canadian Mineralogist*, 52: 717-744.
- Pehrsson, S.J., Currie, M., Ashton, K.E., Harper, C.T., Paul, D., Pana, D., Berman, R.G., Bostock, H., Corkery, T., Jefferson, C.W. and Tella, S. 2013. Compilation (1:550,000) - South Rae and parts of



- Hearne domains, Churchill Province Northwest Territories, Saskatchewan, Nunavut, Manitoba, and Alberta. Geological Survey of Canada, Open File 5744, 3 sheets.
- Pehrsson, S.J., Percival, J.A., Kjarsgaard, B.K., Davis, W.J, Berman, R.G. McCurdy, M., Hillary, E.M., Kiss, F. 2014a. Operation GEM South Rae: Reconnaissance geology of the most poorly known part of the Churchill Province, Northwest Territories and Nunavut. Geological Survey of Canada, Open File 7410.
- Pehrsson, S.J., Currie, M., Ashton, K.E., Harper, C.T., Paul, D., Pana, D., Berman, R.G., Bostock, H., Corkery, T., Jefferson, C.W., and Tella, S., 2014b. Bedrock geology compilation south Rae and western Hearne provinces, Churchill Province, Northwest Territories, Saskatchewan, Nunavut, Manitoba, and Alberta; Geological Survey of Canada, Open File 5744, scale 1:550 000. doi:10.4095/292232
- Pehrsson, S.J., Campbell, J.E., Martel, E., McCurdy, M.W., Agosta-Gongora, P., Theissen, E., Jamieson, D., Lauzon, G., Buller, G., Falck, H., and Dyke, A.S., 2015. Report of 2015 activities for the Geologic and Metallogenic Framework of the South Rae Craton, Southeast Northwest Territories: GEM 2 South Rae Quaternary and Bedrock Project; Geological Survey of Canada, Open File 7958, 24 p. doi:10.4095/297387
- Rainbird, R.H., Davis, W., Pehrsson, S.J., Wodicka, N., Rayner, N., and Skulski, T., 2010. Early Paleoproterozoic supracrustal assemblages of the Rae domain, Nunavut, Canada: Intracratonic basin development during supercontinent break-up and assembly. *Precambrian Research* 181: 167–186.
- Taylor, F C., 1959. Penylan Lake-Firedrake Lake, District of Mackenzie, Northwest Territories; Geological Survey of Canada, Preliminary Map 8-1959, 1 sheet, doi:10.4095/108528
- Taylor, F C., 1963. Snowbird Lake map-area, district of Mackenzie. Geological Survey of Canada, Memoir 333, 1963; 23 pages (1 sheet), doi:10.4095/100557
- Wright, G. M., 1967, Geology of the southeastern barrenground, parts of the Districts of Mackenzie and Keewatin (Operations Keewatin, Baker, Thelon). Geological Survey of Canada, Memoir 350, 91 p.