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2015 Report of Activities for Completing the Regional Bedrock Mapping of the southern half of Baffin Island: GEM 2 Baffin Project

Nicole Rayner, Marc St-Onge, Owen Weller, Victoria Tschirhart

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 2015, GEM program has successfully carried out 14 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 report serves as an update on the 2015 community engagement, training, and field activities undertaken as part of the GEM2 South Baffin bedrock mapping project (Fig. 1).

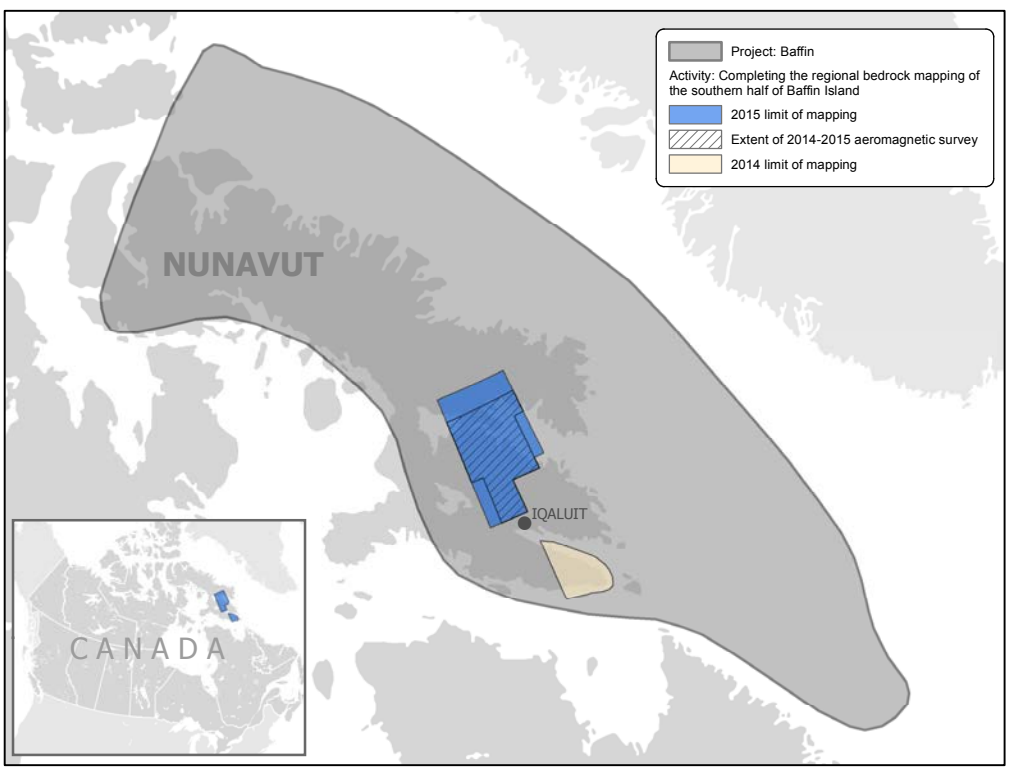

Figure 1: Sketch map illustrating the area encompassed by the GEM Baffin region of interest (grey outline/fill) and the bedrock geological mapping activity (blue and yellow outline/fill).

Modern geological maps inform industry, government, and community stakeholders of potential economic resources. During the past two decades, systematic and targeted mapping of Precambrian and Phanerozoic bedrock geology has been completed for large tracts of Nunavut. At the start of 2015, only one gap remained to finalize the coverage of Baffin Island south of latitude 70˚N: the Clearwater Fiord-Sylvia Grinnell Lake area. This region, directly north of Iqaluit, had little modern geologic information available. Prior to this summer's work it was limited to a reconnaissance study completed in the 1960s.

The current project undertook targeted, modern geological mapping to increase the geoscience knowledge of eastern Nunavut. Improved geological maps help determine the potential for precious metals, base metals, and carving stone in this region. The proximity of Nunavut's largest settlement, Iqaluit, makes exploration work in these areas easily accessible.

Effective and meaningful partnerships, including the City of Iqaluit and the Hamlet of Pangnirtung, the Qikiqtani Inuit Association, Hunters and Trappers Organizations, and most importantly Nunavut Arctic College, were key to the success of the field component of this project.

Introduction

Goals & Objectives

During the past two decades modern, systematic and targeted mapping of bedrock geology has been completed for large tracks of Baffin Island including: southern Baffin Island (1995-97; NTS sheets 25K, L, M, N on Fig. 2), central Baffin Island (2000-2002; not shown on Fig. 2), SW Baffin (2006; not shown), Cumberland Peninsula (2009-2011; NTS sheets 16E, L, 26H, I), Hall Peninsula (2012-13; NTS sheets 25O, P, 26A, B) and most recently eastern Meta Incognita Peninsula (2014; NTS sheets 25J, G, Fig. 2, blue outline). Only one gap remained to finalize the updated coverage of the whole of Baffin Island south of latitude 70˚N: the Sylvia Grinnell Lake-Clearwater Fiord area (Fig. 2, green outline). Available geological information for the project area was limited to low-resolution helicopter reconnaissance work completed in the 1960s. Targeted, precise bedrock mapping was needed to help define the lateral extent of various sedimentary strata, identify layered mafic/ultramafic sills as documented on both the Hall and Meta Incognita peninsulas, evaluate the carving stone potential in the vicinity of Iqaluit and Pangnirtung, and assist in constraining potential vectors to mineralization for a number of mineral commodities including diamonds, Ni, Cu, PGEs, Pb, and Zn. Integration of surface bedrock observations with new geochronological, geochemical, geophysical, and detailed tectonostratigraphic and petrological data will lead to an improved understanding of the geological history and Precambrian architecture of the whole of the southern half of Baffin Island, its relationship to western Greenland rocks, and result in a new modern compilation map and geodatabase for the southern half of Baffin Island including the territorial capital region.

Scientific questions to be addressed

- What is the extent and tectonic affiliation (Lake Harbour Group, Piling Group, Hoare Bay Group) of the extensive sedimentary packages shown in previous compilations and what are the implications for the present architecture and past assembly of Baffin Island?
- What is the western extent of the Hall Peninsula Gneiss Complex (host to the Chidliak diamond district)?
- How does the geology of western Hall Peninsula match that of the central Baffin Island and Cumberland Peninsula and does a Paleoproterozoic tectonic suture separate these areas?

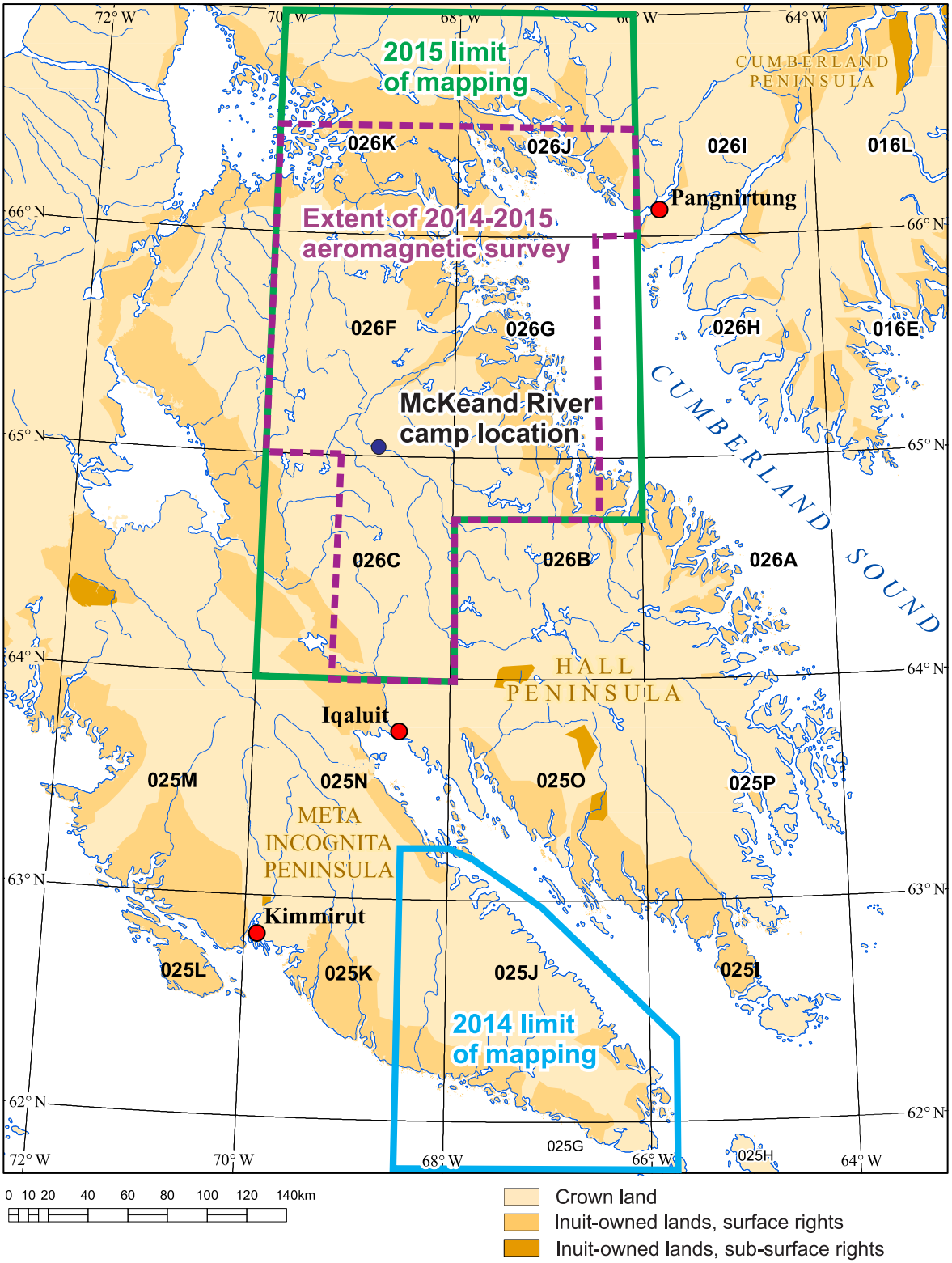

Figure 2: Overview of the area of interest for GEM activity "Completing the Regional Bedrock Mapping of the southern half of Baffin Island". Completed regional bedrock mapping areas are outlined in green (Clearwater Fiord-Sylvia Grinnell Lake, summer 2015) and blue (Meta Incognita Peninsula, summer 2014). The aeromagnetic survey area is outlined by a dashed purple box.

Portions of SE Baffin Island represent some of the last major missing tectonic pieces in our understanding of Nunavut geology and the current targeted bedrock tectonostratigraphic, geochronological, and structural studies will largely resolve this uncertainty.

Community Engagement

Community engagement is a vital aspect of conducting geoscience work in Canada's North. A successful engagement trip was undertaken in March 2015 prior to GEM field work on southern Baffin Island during the subsequent summer. Stakeholders from the communities of Pangnirtung and Iqaluit were thus engaged to discuss all aspects of the planned 2015 field season.

With the facilitation of Ajungi Group consultants, formal meetings with the Hamlet Councils, Community Lands and Resources Committees (CLARC), and Hunters and Trappers Organizations (HTO) were conducted (Fig. 3a). Community members were informed through public assemblies, as well as through a broadcast on the local radio station in Pangnirtung, an Open House with maps and rock samples on display in the local hotel, and presentations to the local high school (Fig. 3b). All of these activities were supported by consecutive or simultaneous translation into Inuktitut. By using different venues and times of day a broad cross-section of the community was able to ask questions and provide valuable feedback, thus providing the project leaders with more opportunities to explain the planned field activities and alleviate any potential concerns.

Figure 3: a) Nicole Rayner and Marc St-Onge presenting the proposed Sylvia Grinnell Lake – Clearwater Fiord mapping project to the Iqaluit Qikiqtani Inuit Association/Community Lands and Resources Committee in March 2015. b) Discussing geological maps and samples with students and teachers at the Attagoyuk Ilisavik High School in Pangnirtung, Nunavut.

A particular highlight of the engagement trip was the unveiling of printed maps resulting from fieldwork on Meta Incognita Peninsula the previous summer (Fig. 3b). The maps were received enthusiastically, in particular because they are among the first geological maps to be translated in full into Inuktitut. Providing research products in a form that is both respectful of the Inuit culture and accessible to the population for years to come ensures that the science is effectively returned to the communities. The six maps were subsequently formally released at the Nunavut Mining Symposium in Iqaluit on April 14, 2015 (St-Onge et al., 2015a-f).

Methodology

A number of research activities were planned to address the scientific questions posed above, including regional bedrock mapping, an airborne geophysical survey, geochemical analyses, geochronology, and quantitative petrology.

Regional and targeted bedrock mapping to upgrade the existing geological map coverage was carried out over eight weeks between June 21th and August 18th 2015 (all or parts of six 1:250 000 NTS map sheets: 26 B, C, F, G, K and J, Fig. 2) by a project team led by the authors and including scientists and students from the Geological Survey of Canada, Canada–Nunavut Geoscience Office (C-NGO), the Government of Nunavut, Oxford University, Carleton University, and the Nunavut Arctic College (Fig. 4a).

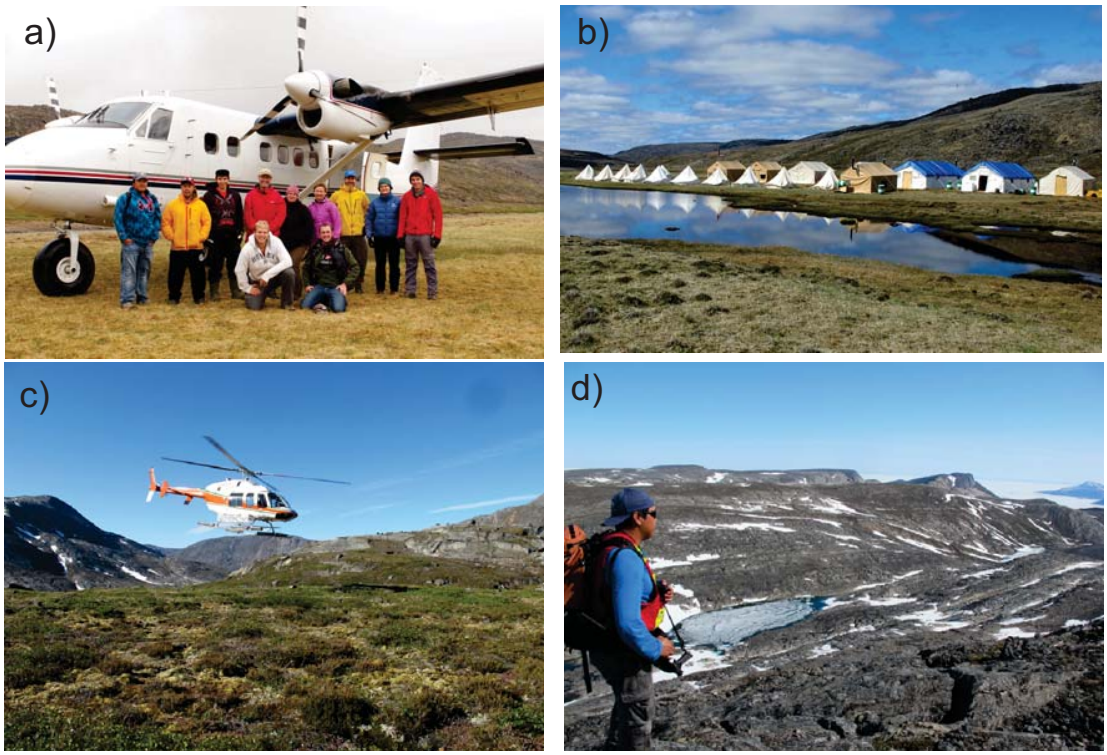

Figure 4: a) The Southern Baffin 2015 bedrock mapping team, ready to depart camp by Twin Otter; b) McKeand River base camp; c) Bell 407 helicopter after dropping off traversing pair; d) Terry Milton, Nunavut Arctic College student on traverse.

Geoscience activities in the Sylvia Grinnell Lake -Clearwater Fiord area were based in Iqaluit for the first three weeks of the project. While in Iqaluit the bedrock mapping team of 10 geologists, a cook, helicopter pilot, and engineer were accommodated in staff houses rented from PWGSC, private housing, and hotels. On July 12th, the entire team moved to a temporary camp on the McKeand River for the remaining five weeks of the field season (Fig. 4b). The camp was constructed by Discovery Mining Services, prior to arrival of the project team. The use of a professional logistics and camp construction contractor to build a "turn-key" remote field camp optimized the time the scientific staff had to complete the mapping of almost 50,000 km^2 in a single field season.

Field work was supported by one helicopter (Fig. 4c). Four mapping pairs were set out each day on 10-15 km foot traverses to document in detail areas of excellent bedrock exposure and/or areas where previous mapping and geophysical observations indicated geological complexity (Fig. 4d). A fifth pair of mappers would remain with the helicopter throughout the day making spot observations every 2-3 km along preplanned traverse lines. This spot-checking work was targeted to areas of limited bedrock exposure, or to ground-truth features highlighted by the aeromagnetic survey. This combination of foot traverses and helicopter spot-checks was critical in achieving observational coverage across the entire map area. Detailed station coordinates, geological field observations, samples, and photo records were logged using the Ganfeld system on small, handheld computers (HP ipac) and downloaded nightly to the master GIS project database by the project data manager. Observations included rock type, mineral assemblages, structural measurements, and extrapolated geological contacts. Point data collected via Ganfeld will serve to build the 10 new GEM maps for southern Baffin Island using ArcGIS 10.1. Samples were collected where it was deemed necessary for subsequent laboratory analysis and shipped by air freight back to Ottawa.

Training of Highly Qualified Personnel

The GEM Program supports the development of highly-qualified personnel by providing students from southern and northern educational institutions the opportunity to gain research and work experience in the Canadian Arctic.

As part of the South Baffin bedrock mapping project, two MSc theses are underway and the required field work completed. One MSc thesis, by Dustin Liikane of Carleton University, focusses on a suite of layered mafic/ultramafic sills (Frobisher suite) intrusive into the Lake Harbour Group across the whole of southern Baffin Island. Dustin is finishing the first year of a petrological study of the layered mafic/ultramafic suite and associated mineralization. Whether this suite is correlative or a different age from the 1886 Ma suite of similar layered intrusions in northern Quebec and associated Raglan Ni-Cu deposit will be one of the questions tackled by the thesis.

A second MSc thesis, by Tim Chadwick of Carleton University, focusses on an impressive area of folded thrust imbricates of Archean basement and Paleoproterozoic cover in the Ptarmigan Fiord region of western Hall Peninsula. Tim mapped this area in detail this summer and will focus on the structural framework for this part of the internal zone of the Trans-Hudson Orogen and model its 3D crustal structure. Three students from the Environmental Technology Program (ETP) at Nunavut Arctic College in Iqaluit were hired as field assistants for the duration of the project field activities. While the students had completed an introductory Earth Science module in their first year of the ETP program and had participated in a geological field school in the south-west US through Dalhousie University, this was their first experience mapping geology in a high-grade metamorphic terrane. The students were an integral part of the team, contributing to all aspects of the science and camp life, including: making observations on the outcrop, recording those results in the handheld computer, taking samples, participating in group discussions of the day's observations (geo-wrap), and assisting in the necessary daily chores around camp (Fig. 5). This work was both physically and intellectually demanding and these three young men excelled in all aspects. Through their commitment they have taken a large step towards ensuring that future geological work in Nunavut is done by Nunavummiut.

Figure 5: a) Reviewing rock and mineral identification and familiarization with the Ganfeld system at the Canada-Nunavut Geoscience Office; b) Ordovician fossil identification near Sylvia Grinnell Lake; c) Sean Noble-Nowdluk from Nunavut Arctic College, recording field observations into the Ganfeld system; d) Each day concludes by reviewing the days observations with a group "geo-wrap".

Geophysical Results

Given the large aerial extent to be mapped in 2015 (covering all or part of six NTS 1:250000 sheets, Fig. 2) field work needed to be targeted to the areas of greatest significance. To this end two modern, high-resolution aeromagnetic surveys were conducted over the Clearwater Fiord-Sylvia Grinnell Lake area to measure the magnetic properties of underlying bedrock (Figs. 2 and 6, dashed purple lines). The surveys were designed to support bedrock geological mapping in an area with no existing coverage. They comprised 105, 447 line km of surveying and flying, funded jointly by the C-NGO ($1.0M) and GEM ($680K). The surveys began in early August 2014 and were completed by early April 2015. Processing of the results was completed in April 2015, and publication of Open File maps, as well as digital profile and gridded data followed on April 30 2015 (McKeand River survey, Geological Survey of Canada, 2015a), and June 9 2015 (Amittok Lake survey, Geological Survey of Canada, 2015b). The surveys further support calibration of the bedrock magnetic properties with the observed aeromagnetic response for rapid, remote resource assessment.

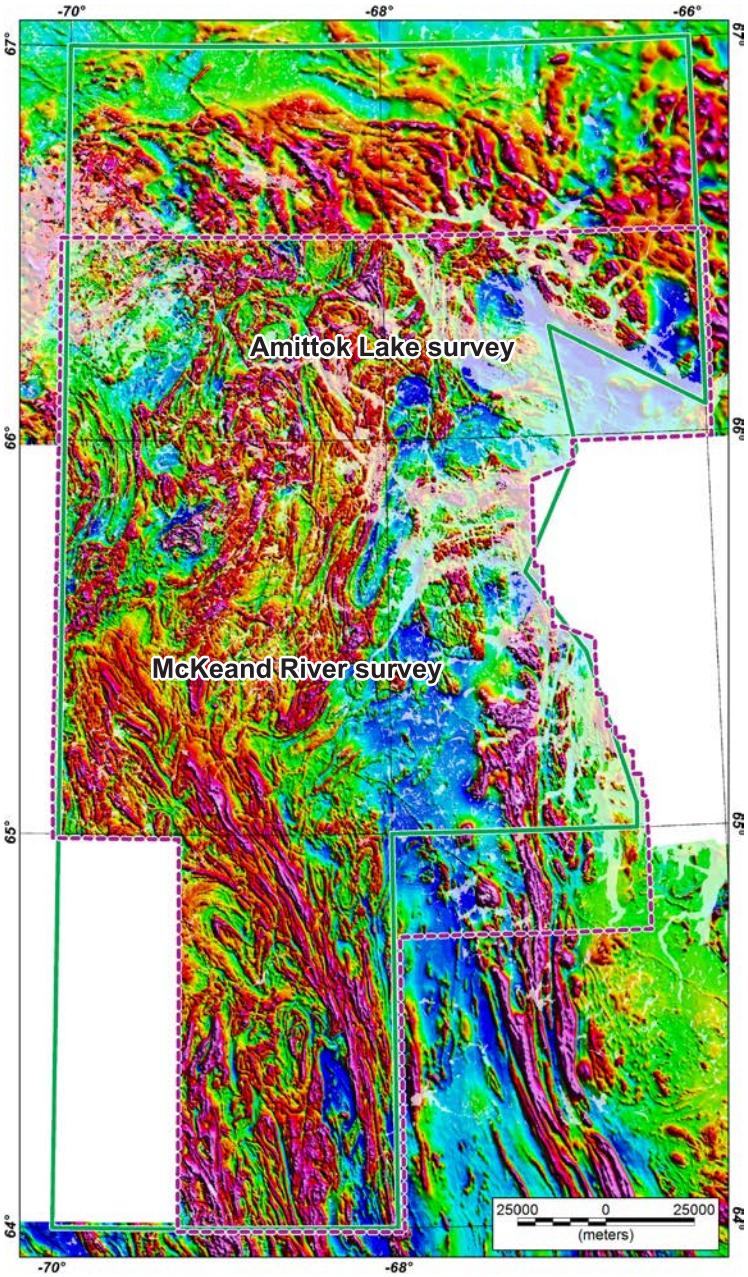

Figure 6: Aeromagnetic data over southern Baffin Island. Completed regional bedrock mapping areas are outlined in green (Clearwater Fiord-Sylvia Grinnell Lake, summer 2015). The high-resolution McKeand River (64°N - 66°N) and Amittok Lake (66°N – 66.5°N) aeromagnetic survey areas are outlined by a dashed purple box.

Bedrock Mapping Results

The bedrock mapping of the Sylvia Grinnell Lake-Clearwater Fiord area was completed as planned after eight weeks of field work and will result in a substantial improvement to the accuracy and significance of the upcoming bedrock map products.

The bedrock in the map area is dominated by a plutonic suite ranging in composition from gabbro/quartz diorite to syenogranite (Fig. 7a-f). Cross-cutting relationships observed across many outcrops define a relative chronology of the various phases (Fig. 7a, b) which can be broadly summarized as a transition from mafic (Fig. 7a), through intermediate/calk-alkaline compositions (Fig. 7b-d) to more silicic compositions (Fig. 7e,f). A series of samples were collected in order to test the field hypotheses and cross-cutting relationships pertaining to this plutonic "stratigraphy".

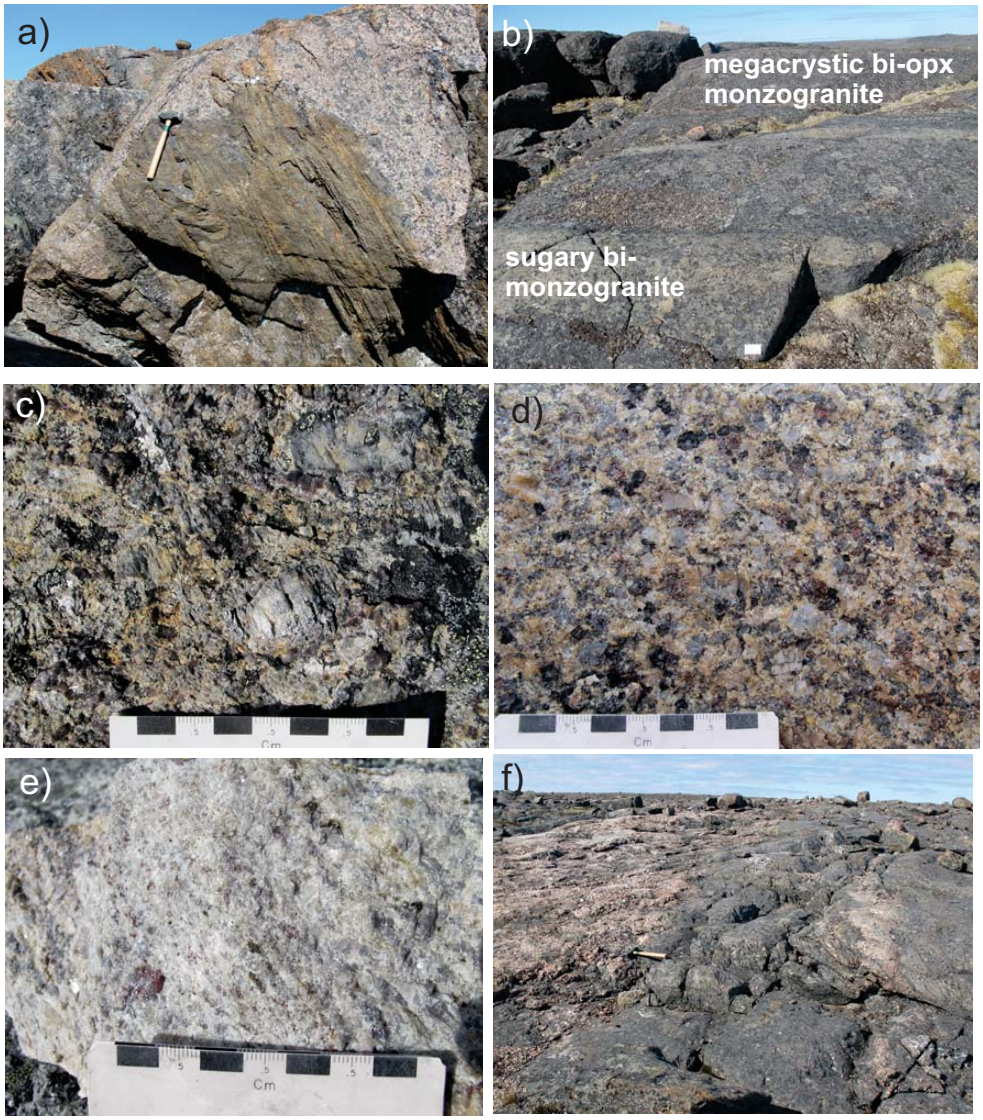

Figure 7: Bedrock summary photos – Granitoids. a) 15SAB-R152: Enclave of foliated and folded diorite in massive, coarse-grained bi-opx syenogranite; b) 15SAB-D283: megacrystic bi-opx monzogranite cut by fine grained, sugary bi-monzogranite; c) 15SAB-D283: detail of zoned feldspar megacrysts in bi-opx monzogranite; d) 15SAB-D77: coarse grained garnet k-feldspar megacrystic monzogranite; e) 15SAB-D106: detail of gt-sil-bi leucogranite; f) 15SAB-R141: fine to medium grained bi monzogranite (lichen covered in photo) cut by dykes of coarse grained to pegmatitic syenogranite.

The plutonic rocks in the map area have previously been correlated with the Cumberland Batholith, which has emplacement ages between 1865 -1848 Ma (Whalen et al. 2010 and references therein). The Cumberland Batholith has been variably interpreted as an Andean margin-type batholith (St-Onge et al, 2009), or as the result of post-collisional lithospheric delamination and mantle upwelling (Whalen et al. 2010). An older (ca. 1880-1910 Ma) suite of granitoids, referred to as Qikiqtarjuaq Plutonic suite, has been recognized to the west on Cumberland Peninsula. Through upcoming geochronological studies of plutonic samples from the Sylvia Grinnell Lake-Clearwater Fiord area, we will evaluate the various possible correlations with the plutonic suites on Baffin Island and the associated tectonic models.

Enclaves, screens and panels of metasedimentary rock are engulfed by the extensive plutonic suite. The metasedimentary strata dominantly comprise quartzite, psammite and semi-pelite (Fig. 8a) with minor marble and calc-silicate components (Fig. 8b). These units are notably overrepresented on the existing maps. The composition, association, and context of the metasedimentary rocks in the Sylvia Grinnell Lake - Clearwater Fiord area are identical to those recorded on the adjacent western Hall Peninsula and to the south across Frobisher Bay on Meta Incognita Peninsula, both of which have been correlated with the type Lake Harbour Group assemblage. However, in the north-eastern corner of the map area, an enclave of greywacke, distinct from the assemblage listed above, was identified (Fig. 8c). This might represent the transition from Lake Harbour Group rocks to a different basin assemblage.

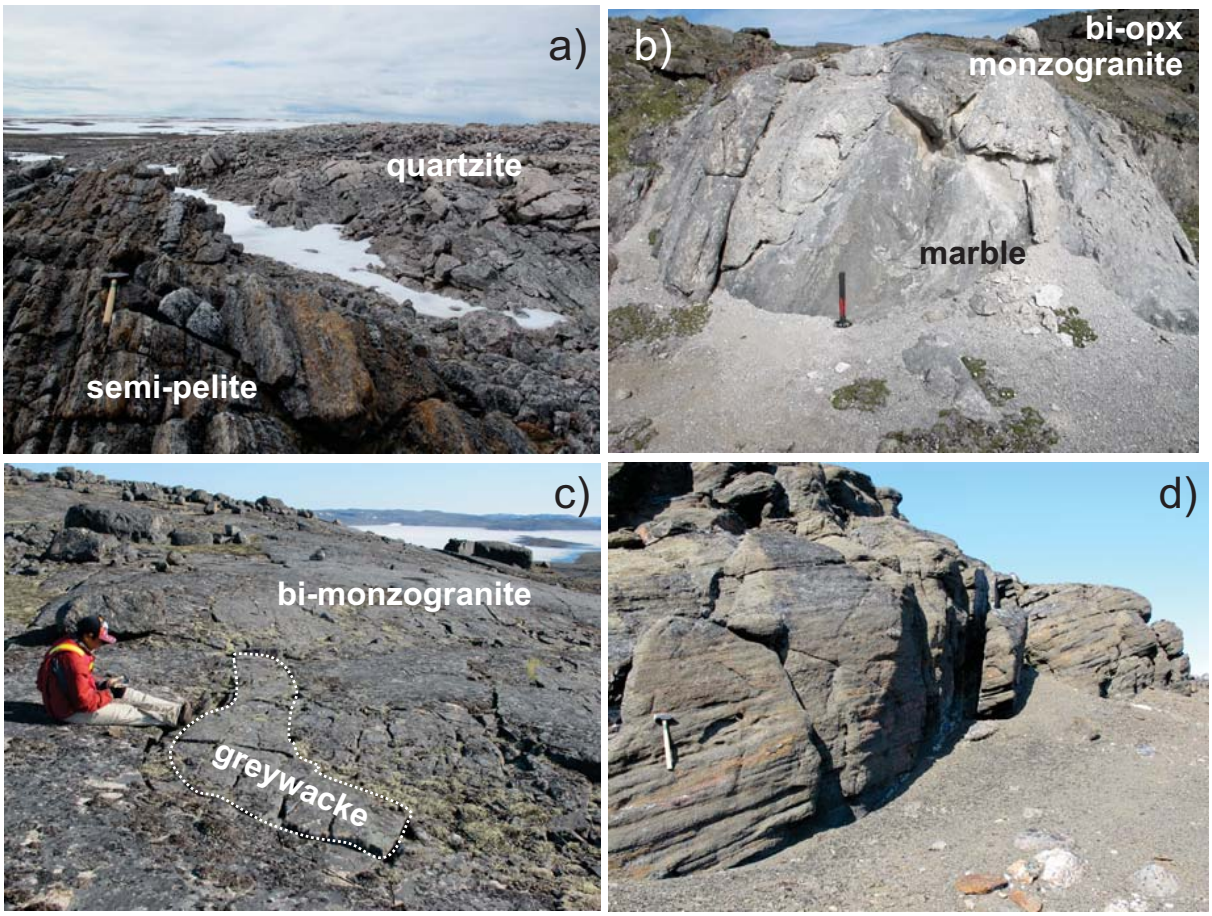

Figure 8: Bedrock summary photos – Metasedimentary units and mafic-ultramafic rocks. a) 15SAB-R32: Extensive quartzite, interbedded with psammite/semi-pelite; b) 15SAB-W53: Enclave of marble within bi-opx monzogranite; c) 15SAB-C84: Enclave of greywacke in bi-monzogranite; d) 15SAB-R174: Central portion of layered gabbro body.

Associated with the metasedimentary rocks is a suite of mafic to ultramafic intrusions, informally referred to as the Frobisher suite. These bodies, which have been documented to the west (Hall Peninsula) and to the south and southwest (Meta Incognita Peninsula and Foxe Peninsula) on Baffin Island, are also exposed across the map area (Fig. 8d). In some locales, the Frobisher suite can be shown to clearly intrude metasedimentary rocks of inferred Lake Harbour Group affinity. Elsewhere the mafic-ultramafic bodies are present as enclaves in the plutonic suite and their relative age relationship to the metasedimentary rocks is unconstrained. Planned geochemical and petrological investigations as part of Dustin Liikane's MSc thesis will shed light on the mineral deposit potential of this widespread mafic intrusive suite. Importantly, when hydrated and serpentinized, this lithology is modified into a suitable carving stone.

Fabrics and various structural domains across the map area are characterized by a strong foliation preserved in the early phases of the plutonic suite (Fig. 9a). In places this foliation was observed to be axial planar to isoclinal folding (Fig. 9b), indicating widespread shortening across the region. However, the youngest magmatic phases (sillimanite-bearing leucogranite and syenogranite) were generally undeformed (e.g. Fig. 9a), suggesting that they were emplaced following the main deformation. Furthermore, the presence of sillimanite in leucogranite indicates that it is likely derived from partial melting of metasedimentary rocks. Understanding the relative timing of magmatism, deformation, and metamorphism across the region will be the focus of post-doctoral research.

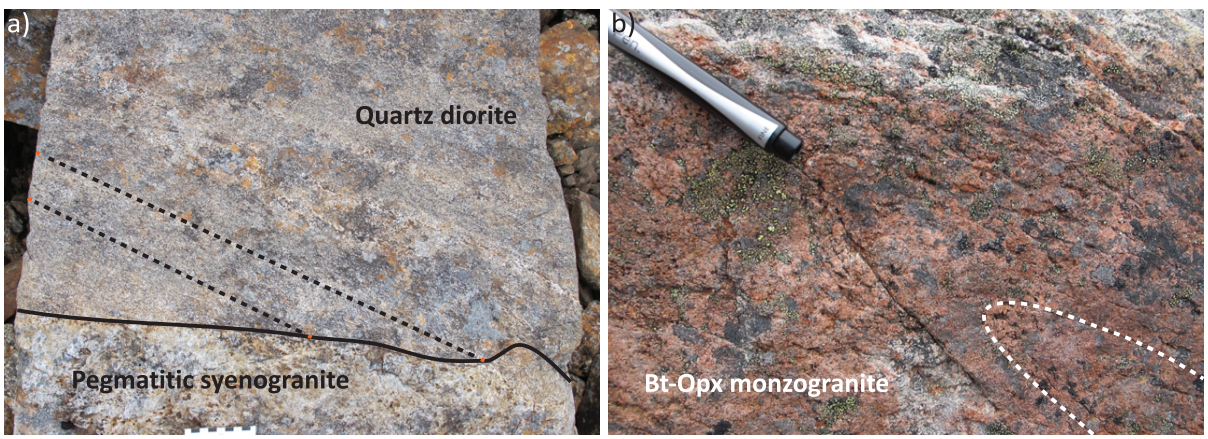

Figure 9: Bedrock summary photos – Structure. a) 15SAB-S016: fine-grained foliated diorite crosscut by coarse-grained syenogranite; b) 15SAB-W003 Isoclinal folding in bi-mt-gt monzogranite, view to the west.

Conclusions

All the planned objectives of the 2015 field season were accomplished on time. The observations and proposed tectonostratigraphic and plutonic correlations will be tested through thesis research, geochronology, and pressure-temperature-time-deformation (P-T-t-d) studies across the project area in order to develop a tectonic model that addresses the scientific questions posed at the beginning of this report.

Planned laboratory work in the Fall/Winter 2015-2016 includes bedrock geochronology to establish the age of the major plutonic and metasedimentary rock packages. The primary focus is on a representative suite of plutonic units and detrital samples to contribute to the calibration of the legend for the new bedrock maps.

Post-doctoral research has begun documenting the P-T-t-d conditions of metamorphism for samples collected from Meta Incognita Peninsula in 2014 by integrating advanced quantitative phase diagram modeling with petrographic observations and attendant geochronology. This study will be supplemented by samples collected from the 2015 field campaign, in order to characterise the tectonic evolution of the entire southern Baffin region.

Future works/next steps

The results of the GEM Southern Baffin Mapping activity will be disseminated in an efficient and timely manner through the annual release of preliminary CGM maps, SOA field reports and presentations at the Nunavut Mining Symposium. The following are the anticipated publication outputs for the 2015 GEM Southern Baffin Bedrock Mapping project this coming Fall/Winter:

1- Canadian Geoscience Maps (CGM) bedrock maps: 1:100K scale, set of 10. Lead: M. St-Onge

2- Summary of Activities (SOA) report: Plutonic suites and regional tectonostratigraphy. Lead: O. Weller

3- SOA report: Frobisher suite mafic/ultramafic sills and geochemistry. Lead: D. Liikane

4- SOA report: Ptarmigan Fiord basement/cover thrust imbricates and mylonite development. Lead: T. Chadwick

5- SOA report: Aeromagnetic maps and field investigations. Lead: V. Tschirhart

6- SOA report: Geochronology of Meta Incognita Peninsula. Lead: N. Rayner

It is anticipated that SOA reports will be publically released online in December 2015 and in hard-copy form at the Mineral Exploration Roundup (January 2016), and the CGM maps at the Nunavut Mining Symposium in April 2016.

By the end of the project lifetime, results will be synthesized and made available in the public domain with two MSc theses, peer-reviewed papers, and, most significantly, a signature modern bedrock compilation of all of southern Baffin Island.

Acknowledgments

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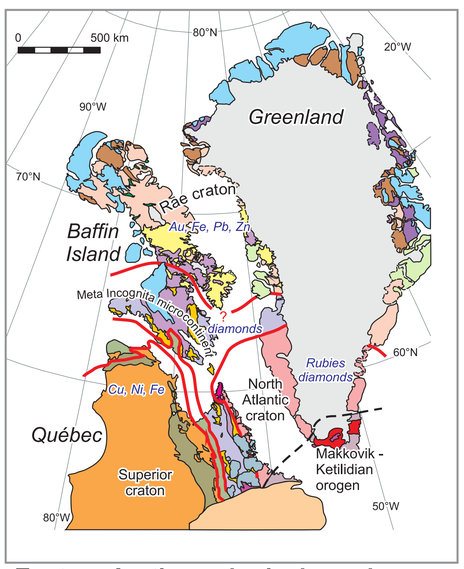
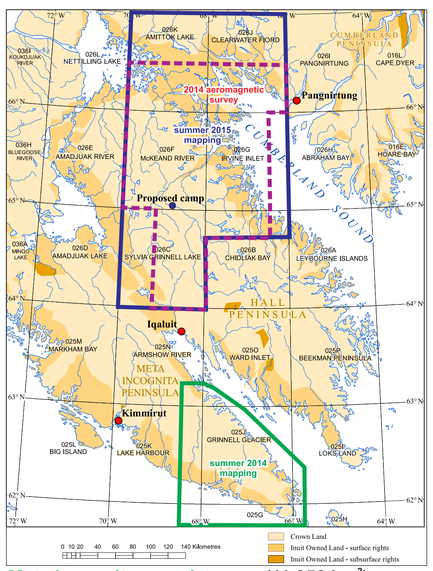
GEM Southern Baffin Mapping 2014 – 2016

The Project



Eastern Arctic geological puzzle

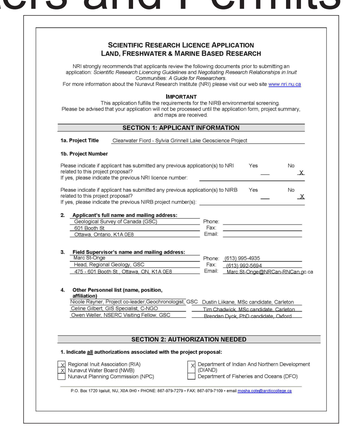


Meta Incognita mapping area (11,852 km^2); Sylvia Grinnell Lake – Clearwater Fiord mapping area (49,855 km^2); McKeand River airborne aeromagnetic survey area

Community Involvement

Introductory Letters and Permits

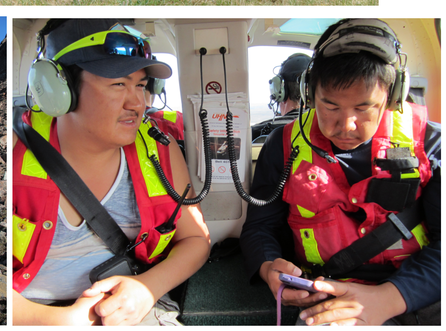
Community engagement letter to Taukie Qappik, Chairperson, Innamariit Piqusingit in English and Inuktitut

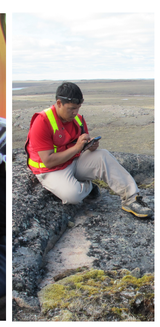


Application to the Nunavut Research Institute (NRI)

Training and Field Visits

Local carver, Jerry Ell, visits camp as part of the Government of Nunavut carvingstone assessment program, to explain the ideal properties of this artistic medium.





Nunavut Arctic College students from the Environmental Technology Program learning geological mapping skills on the job.

Community consultations

Community engagement visits in March 2015 facilitated by Ajungi Arctic Associates

AJUNGI GROUP
Professional Aboriginal Consulting Services

Camp Life

Temporary 16-person McKeand River field base camp

Temporary field base camp – sleeping tents

Turk-key camp - kitchen facility

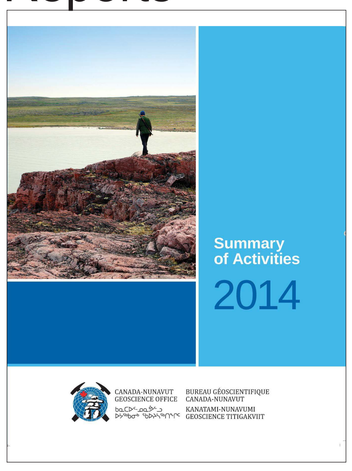
Transport of field personnel with Bell 407 helicopter

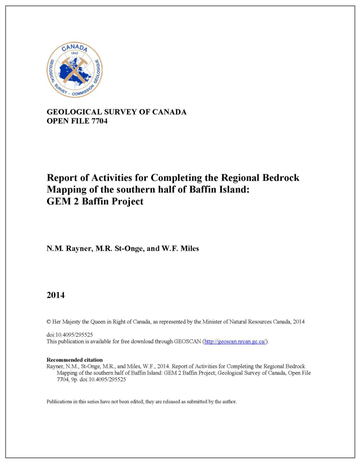
Low impact foot-traversing

Fist-size sample collection for laboratory analytical studies

Products

Reports





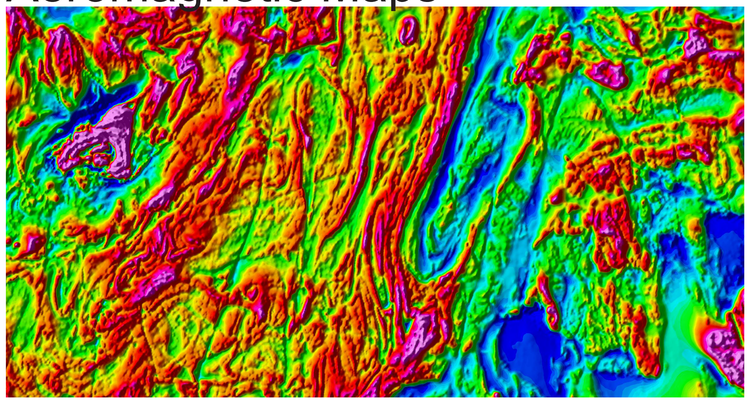
GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7704

Report of Activities for Completing the Regional Bedrock Mapping of the southern half of Baffin Island: GEM 2 Baffin Project

N.M. Rayner, M.R. St-Onge, and W.F. Miles

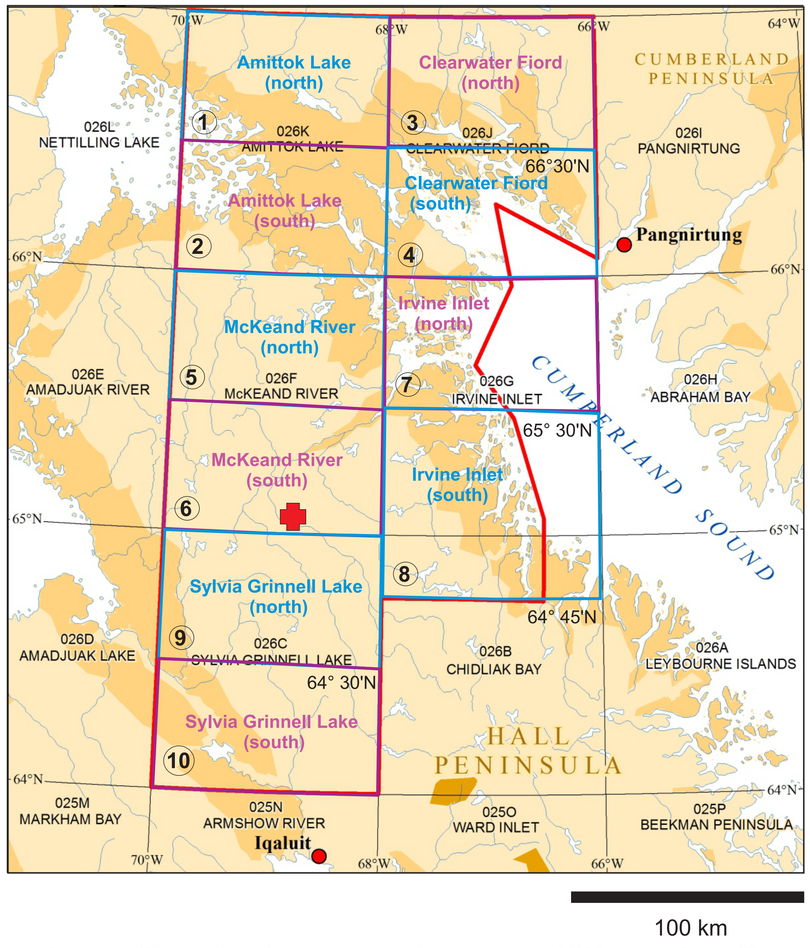
2014

Aeromagnetic Maps

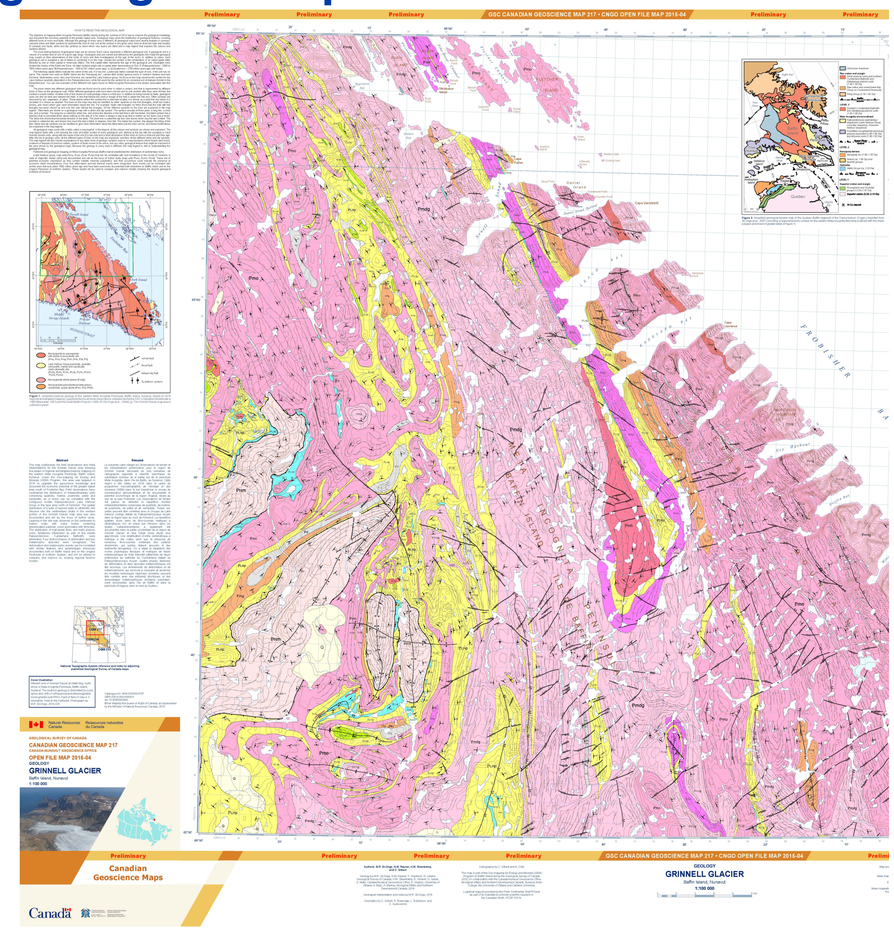


New McKeand River aeromagnetic survey results. Capture of parts of map sheets 26K and 26J.

COMING SOON: Ten new bedrock geological maps



Index map illustrating the coverage of the 10 new CGM maps that will result from the 2015 field season.



Clip of one of the six bedrock geology maps, produced after 2014 field season. Meta Incognita Peninsula, English version.

Canada

Natural Resources Canada | Ressources naturelles Canada