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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, Warner Miles

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 of 2014, GEM's new research program was launched with 14 field activities across 6 broad project areas (Figure 1) 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.

The activity entitled "Completing the regional bedrock mapping of the southern half of Baffin Island" is being led by the Geological Survey of Canada in collaboration with Canada-Nunavut Geoscience Office to provide regional syntheses and cross-sectional profiles that encapsulate new knowledge of the bedrock geology and sedimentary basins, including potential zones of mineralization (diamonds, Ni, Cu, Fe, PGEs, Pb and Zn) and carving stone.

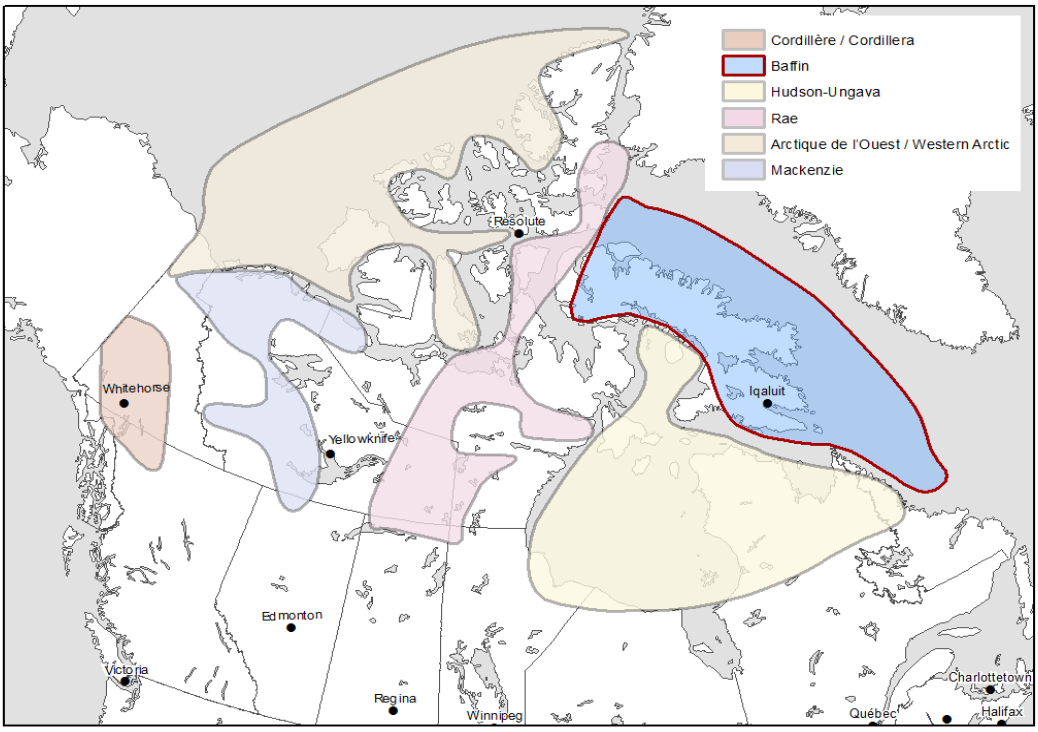

Figure 1: The six broad GEM2 Project Areas. The Baffin project area (outlined in red) is the focus of this activity report.

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 Figure 2), central Baffin Island (2000-2002; not shown on Figure 2), SW Baffin (2006 not shown), Cumberland Peninsula (2009-2011; NTS sheets 16E, L, 26H, I), and Hall Peninsula (2012-13; NTS sheets 25O, P, 26A, B). Only two gaps remain to finalize the updated coverage of the whole of Baffin Island south of latitude 70˚N; Meta Incognita Peninsula east of 68°W longitude, and south-central Baffin Island in the Clearwater Fiord-Sylvia Grinnell Lake area (Figure 2, green outline). Available geological information for both areas is presently limited to low-resolution helicopter reconnaissance work completed in the 1960's. Targeted, precise bedrock mapping was needed to help define the lateral extent of prospective Lake Harbour Group sedimentary strata and associated layered mafic/ultramafic sills as documented on both the Hall and western Meta Incognita peninsulas, the carving stone potential in the vicinity of Iqaluit, Kimmirut 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 addressed

- Does the Lake Harbour Group previously mapped on western Meta Incognita Peninsula extend east of 68° latitude and northward onto Hall Peninsula and what are the implications for the present architecture and past assembly of Baffin Island?

- Does the Hall Peninsula Gneiss complex (host to the Chidliak diamond district) extend onto eastern Meta Incognita?

- How does the geology of Hall Peninsula match that of the Cumberland Peninsula and does a Paleoproterozoic tectonic suture separate these two areas?

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.

Methodology

A number of activities have been planned to address each of the three scientific questions posed above, including regional bedrock mapping, an airborne geophysical survey, geochemical analyses, geochronology, and quantitative petrology in both the Meta Incognita Peninsula (2014) and Clearwater Fiord (2015) areas. This report serves as an update on the field activities undertaken to date.

Regional and targeted bedrock mapping to upgrade the existing geologic map coverage was carried out between July 15th and August 15th 2014 (NTS sheet 25J, Figure 2) by a project team led by the authors and including scientists from the Canada–Nunavut Geoscience Office (C-NGO), Aboriginal Affairs and Northern Development Canada, students from Canadian universities and the Nunavut Arctic College.

Field work was based out of Iqaluit and supported by one helicopter. Two staff houses, one serving as office and the other as kitchen/dining room, were rented from PWGSC to accommodate the team. Iqaluit-based field work proved to be exceedingly convenient, smooth and efficient. A camp cook provided nutritious and delicious meals daily and a rented 7-passenger van made for straightforward transport, procurement and logistics within Iqaluit. The average helicopter commute from Iqaluit to the field area with the Bell 407 helicopter (6 passengers) was roughly 45 minutes. Depending on the nature of the work (traversing, sampling, covering areas too difficult to reach by foot), 1 or 2 helicopter loads of field personnel were set out each day. Meta Incognita Peninsula, particularly the eastern portion is probably one of the most scenic in the Canadian Arctic with a dramatic northern coast character-

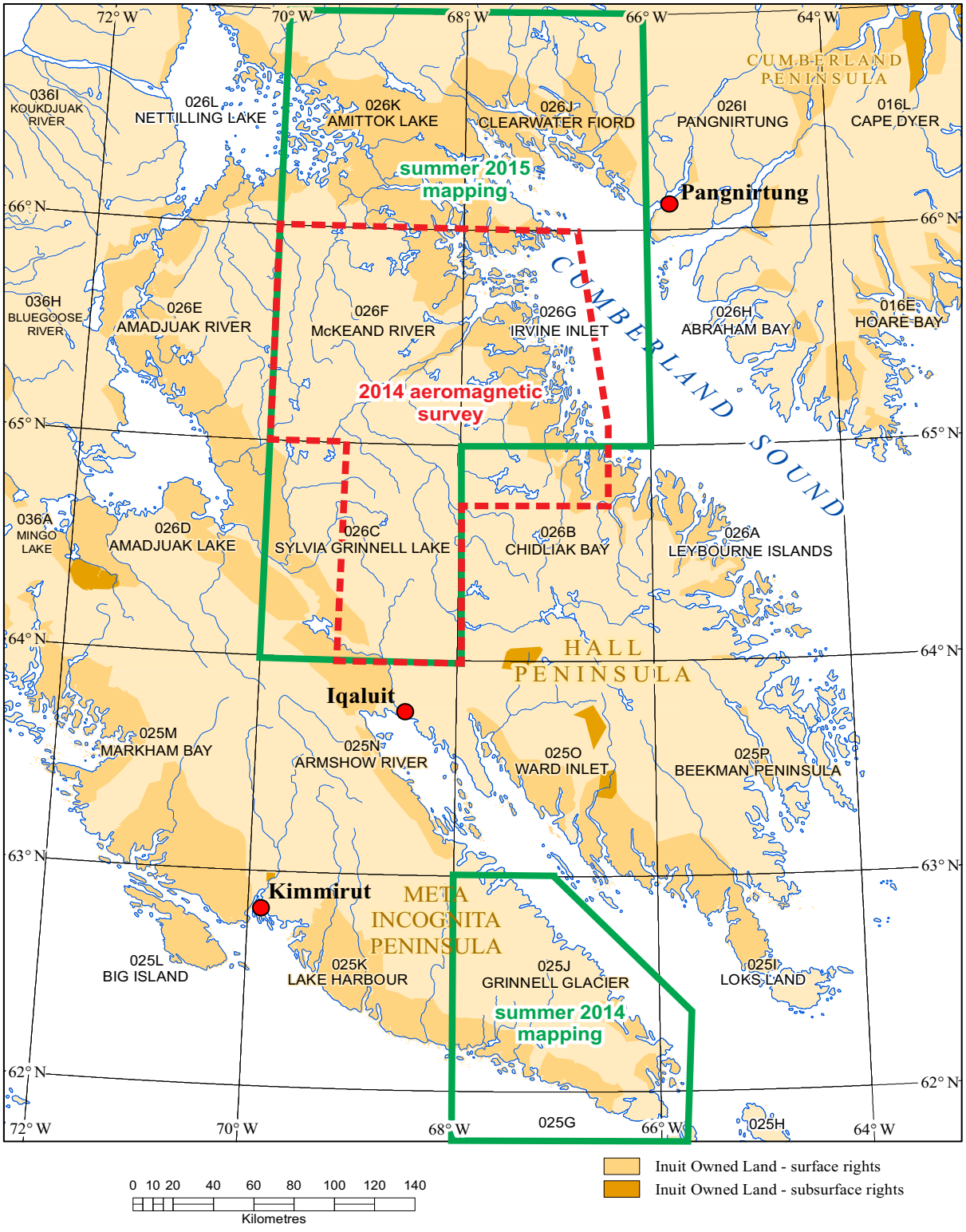

Figure 2: Overview of the area of interest for GEM activity "Completing the Regional Bedrock Mapping of the southern half of Baffin Island". Regional bedrock mapping areas are outlined in green. Mapping was completed on Meta Incognita Peninsula during the summer of 2014 and is planned for the Clearwater Fiord-Sylvia Grinnell Lake area in the summer of 2015. The ongoing aeromagnetic survey area is outlined in red.

ized by ice caps, fiords, and towering rocky spires (Figure 3). While bedrock exposure is excellent, the extreme topography and general roughness of the terrain required adjusting the length of paired foot traverses to ca. 10-14 km per day.

Figure 3: Rugged northern coastline of Meta Incognita Peninsula.

Observations including rock type, mineral assemblages, structural measurements and extrapolated geological contacts were drafted on printed airphotos which were also used for navigation. In addition, detailed station coordinates and geological field observations, sample and photo records were logged using the Ganfeld system on small, handheld computers (HP ipac, Figure 4) and downloaded nightly to the master GIS project database by the project data manager.

Figure 4: Field assistant and MSc candidate Tim Chadwick recording field observations from a mineralized gossan into Ganfeld.

The compilation of line work was done directly on airphotos (e.g., Figure 5) which were then scanned, orthorectified (georeferenced) and the line work digitized. This, along with the point data collected via Ganfeld, will serve to build the 2014 GEM maps for Southern Baffin mapping in ArcGIS 10.1. Samples were collected where it was deemed necessary for subsequent laboratory analysis and shipped by air freight back to Ottawa.

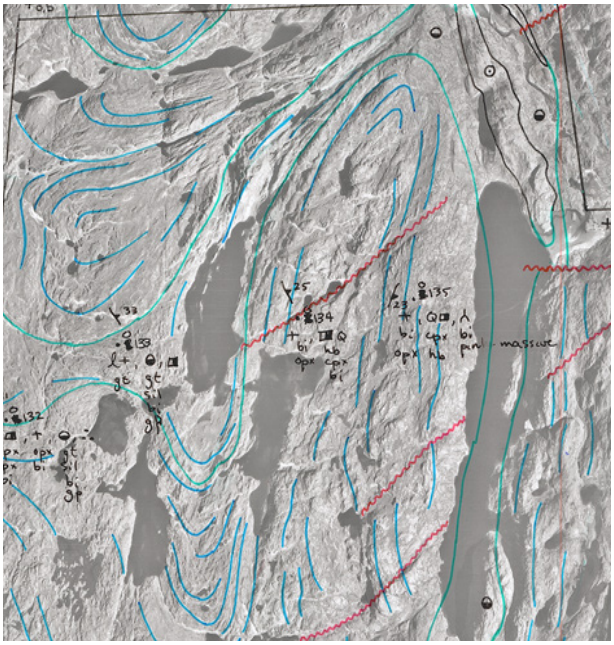

Figure 5: Scanned airphoto with traverse observations and annotated linework. Various colours distinguish geological contacts (defined and inferred), faults, and form lines. Scanned airphotos are georeferenced and the digitized linework is used with the Ganfeld geodatabase as the basis for 2 new 1:100 000 scale CGM maps.

Results

The bedrock mapping of Meta Incognita was completed as planned after 5 weeks of field work. First-order observations include the 3D spatial distribution (based on abundant structural and topographic relief) and field characteristics of an extensive metasedimentary sequence comprising quartzite, marble, and psammite, pelite and semi-pelite (Figure 6). This sequence is correlated with the contiguous middle Paleoproterozoic Lake Harbour Group strata as observed in the type area to the west. The Lake Harbour Group is interpreted as comprising shelf to slope-rise facies clastic and carbonate units deposited on Meta Incognita microcontinent and deformed and metamorphosed during the ca. 1.8 Ga Trans-Hudson Orogen. Emplaced in the Lake Harbour Group strata is a suite of layered mafic/ultramafic intrusions and sills (Figure 7), each several hundred meters in thickness and many of which are

Figure 6: Typical exposure of the Lake Harbour Group on Meta Incognita Peninsula, comprising alternating bands of rusty sillimanite-garnet psammite and white quartzite.

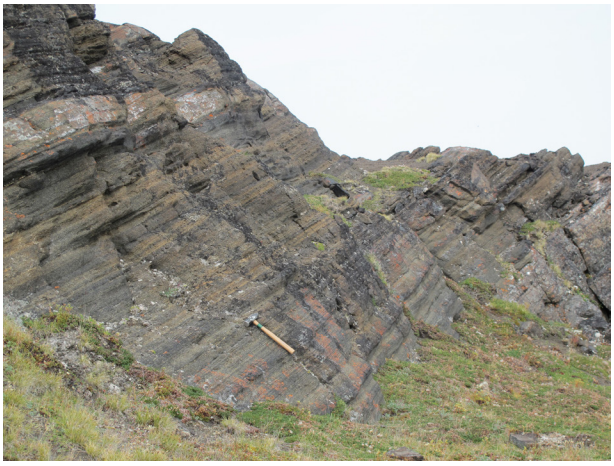

Figure 7: An example of the extensive layered mafic-ultramafic plutonic suite that intrudes Lake Harbour Group sedimentary strata across southern Baffin Island.

Figure 8: A well-developed gossan and ferricrete (iron-oxide cemented weathering horizon, beneath hammer) adjacent to a layered mafic intrusion (vertical face in background).

characterized by the presence of sulphides, some with well-developed gossans (Figure 8). Orthopyroxene-bearing felsic to intermediate plutonic rocks (Figure 9) intrude the Lake Harbour Group and contain enclaves of the mafic/ultramafic suite. These plutonic rocks may be correlated with the 1865-1850 Ma Cumberland batholith.

Other plutonic rocks ranging from diorite to syenogranite mapped on Meta Incognita peninsula have elsewhere on Baffin Island yielded ages as young as 1830 Ma. Garnet-bearing leucogranite, inferred to be derived from melting of metasedimentary rocks (Figure 10) during crustal thickening related to Trans-Hudson Orogen are among the youngest recognized lithologies. The above correlations and hypotheses will be tested with a comprehensive integrated geochronological and petrological program prior to the 2015 field season.

The layered mafic/ultramafic sills intrusive into the Lake Harbour Group define a magmatic suite that characterizes the whole of southern Baffin Island. A mantle-derived magmatic province of this size undoubtedly represents a major Large Igneous Province (LIP) event and warrants further study. A senior undergraduate student field assistant is initiating an MSc thesis on the petrology and geochemistry 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.

The regional structural grain observed on Meta Incognita Peninsula is dominantly NW (north to northeast dips) with SW-verging folds (Figure 11), consistent with observations along the southern peninsulas of Baffin Island (extending west to Foxe Peninsula). These are in contrast to a distinct set of east-verging folds and thrust imbricates of Archean basement and Paleoproterozoic cover units immediately to the north on Hall Peninsula. Further to the north on Cumberland Peninsula and to the northwest in the central Baffin Island area, folds and thrusts are south-verging and north-verging respectively. These structural changes are a reflection of the tectonic interaction of a number of crustal blocks during the Paleoproterozoic assembly of the Nuna supercontinent, including the Rae craton, Meta Incognita microcontinent, the Superior craton

Figure 9: Potassium-feldspar megacrystic monzogranite part of an extensive and highly variable plutonic suite that intrudes Lake Harbour group metasedimentary rocks across Meta Incognita peninsula.

Figure 10: Lake Harbour Group psammite pervasively invaded along foliation by garnet-bearing leucogranite. Both psammite and leucogranite are cut by late, pegmatitic monzogranite dykes.

and possibly the North Atlantic craton. A second MSc thesis using published tectonic/structural data and the new observations from the 2014 and 2015 field seasons will aim to integrate the various datasets into a regional 3D tectonostructural model of northeastern segment of Trans-Hudson Orogen.

Compilation and digitization of the geology and line work for new CGM field maps of the eastern portion of Meta Incognita Peninsula has begun with the able contribution of Celine Gilbert from C-NGO as data manager. Coordination with Holly Steenkamp (C-NGO) on map unit definitions and portrayal is underway to ensure consistency with upcoming Hall Peninsula maps. Two field reports are in preparation for inclusion in the CNGO's annual Summary of Activities volume. Anticipated publication of the new field maps and reports is January/February 2015.

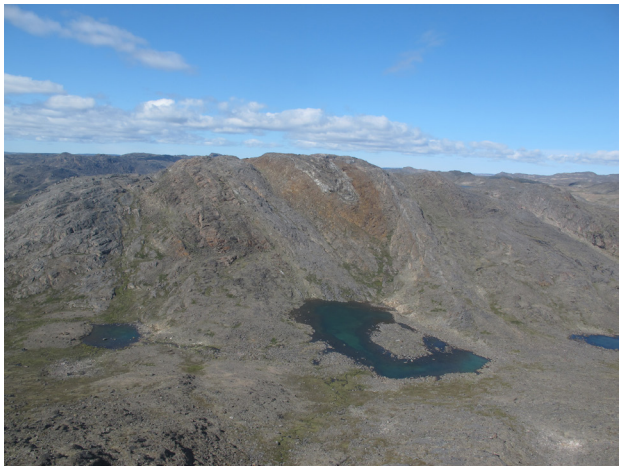

Figure 11: Typical structures observed include tight, upright folds of psammite (in fold limbs in this example), quartz diorite and leucogranite (in core of fold). View to north.

Conclusions

All the planned objectives of the 2014 field season were accomplished on time and within budget. Highlights include:

1. the identification and 3D spatial distribution of metasedimentary units comprising quartzite, marble, minor iron formation, psammite, pelite and semi-pelite all of which can be correlated with the contiguous middle Paleoproterozoic Lake Harbour Group. These units are notably underrepresented on existing helicopter reconnaissance maps and are present to the easternmost tip of Meta Incognita Peninsula.
2. the identification and spatial distribution of a suite of layered mafic to ultramafic sills intrusive into the sedimentary strata. Layering is cm- to m-scale, with many bodies containing disseminated sulphide, some associated with gossan or ferricrete. This assemblage and setting has an intriguing similarity with the host of the Ni-Cu Raglan deposit in northern Quebec.
3. the identification and spatial distribution of high-grade felsic to intermediate plutonic rocks tentatively interpreted as part of the Cumberland Batholith. The eastward limit of the plu-

tonic suite was delineated near the eastward extent of mapping.

4. a structural assessment of the map pattern on eastern Meta Incognita Peninsula which is controlled by tight to transposed folds trending north-northwest overprinted by east-northeast crossfolding of the assemblages described above. The completion of mapping now permits the development of a structural and metamorphic framework for comparison with existing models.

These observations and proposed correlations will be tested with further mapping, thesis research, geochronology, 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.

Future works/next steps

Planned laboratory work in the Fall/Winter 2014-2015 includes bedrock geochronology of the greater Meta Incognita area to establish the age of the major Archean and Paleoproterozoic 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.

A visiting post-doctoral fellow will be joining the project in early 2015. Upon arrival he will begin documenting the pressure and temperature conditions of samples collected from Meta Incognita Peninsula in 2014 (thermobarometry and quantitative phase diagram modeling), constraining mineral assemblages and growth history, and attendant geochronology.

With Meta Incognita Peninsula mapping successfully completed this summer, central Baffin in 2000-2002, Cumberland Peninsula in 2009-2010, and eastern Hall Peninsula in 2012-2013, the last unmapped region and likely tectonic keystone for the entire eastern Arctic segment of Trans-Hudson Orogen will be the Clearwater Fiord-Sylvia Grinnell Lake area (Figure 2). Engagement, planning and permitting activities are underway in preparation for an eight week mapping campaign between mid-June and mid-August 2015.

Given the large aerial extent to be mapped in 2015 (covering all or part of five NTS 1:250000 sheets, Figure 2) field work will be targeted to the areas of greatest significance. To this end a modern, a high-resolution aeromagnetic survey (Figure 2, dashed red line) is being conducted over the Clearwater Fiord-Sylvia Grinnel Lake area to measure the magnetic properties of underlying bedrock. The survey was designed to support bedrock geological mapping in an area with no existing coverage and was facilitated by community engagement and consultation carried out by C-NGO. It comprises 74,818 line km of surveying and flying, funded jointly by the C-NGO ($1.05M) and GEM ($150K). The survey began in early August, 2014 and is scheduled to be completed by October 31, 2014. Processing of the results will be completed in January 2015 and publication of Open File maps, as well as digital profile and gridded data is planned for February 2015. 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. 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 with a signature modern bedrock compilation of all of southern Baffin Island.

Acknowledgments

Able and enthusiastic co-leadership of the field program was provided by Holly Steenkamp with field assistance contributed by Diane Skipton, Tim Chadwick, Dustin Liikane, Alia Bigio, Andrea Markey, Randy Hinanik and Harry Iyerak. Celine Gilbert's knowledge, care and organization of the project data management proved invaluable. Debbi Guilfoyle's delicious meals fuelled the many and varied participants of the team and we are grateful for her contributions and flexibility. Universal Helicopters is thanked for safe and professional air support. Particular thanks to the management and administrative support of Sonya Dehler, David Mate, Marlene Francis, Rosemarie Khoun, and Thomas Schroeder. The Polar Continental Shelf Program provided logistical support. Finally, Annie Laviolette, Guy Buller and Rochelle Buenviaje are thanked for invaluable help with capturing the archival and new data for Meta Incognita Peninsula. Mary Sanborn-Barrie is thanked for her thorough review of this report.