Precambrian geology of the surroundings of Steensby Inlet and western Barnes Ice Cap (parts of NTS 37E, 37F, 37G), Baffin Island, Nunavut

B.M. Saumur¹, ³, D.R. Skipton², M.R. St-Onge², E.R. Bros², ⁴, P. Acosta-Gongora³, C.J. Kelly², A. Morin⁵, M.E. O’Brien², ⁶, S.T. Johnston⁴ and O.M. Weller⁷

¹Natural Resources Canada, Geological Survey of Canada, Ottawa, Ontario, saumur.benoit-michel@uqam.ca
²Natural Resources Canada, Geological Survey of Canada, Ottawa, Ontario
³Département des Sciences de la Terre et de l’Atmosphère, Université du Québec à Montréal, Montreal, Quebec
⁴Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta
⁵Natural Resources Canada, Geological Survey of Canada, Quebec, Quebec
⁶Department of Earth Sciences, University of Ottawa, Ottawa, Ontario
⁷Department of Earth Sciences, University of Cambridge, Cambridge, United Kingdom

This work is part of the Geo-mapping for Energy and Minerals (GEM-2) Program on Baffin Island and is being led by the Geological Survey of Canada in collaboration with the University of Alberta, the University of Ottawa, the University of Cambridge and l’Université du Québec à Montréal. The study area comprises four 1:250 000 scale National Topographic System map areas south of Pond Inlet (NTS 38B, 37E, F, G). The objective of this work is to complete the regional bedrock mapping of northern Baffin Island and develop a new, modern, geoscience knowledge base for the region.


Abstract

The Geological Survey of Canada conducted two seasons of 1:100 000 scale bedrock mapping on northern Baffin Island, as part of the Geo-Mapping for Energy and Minerals (GEM-2) Program. The new mapping will contribute to modernizing the geoscience knowledge base of this part of Nunavut, as well as further characterizing poorly understood Archean and Paleoproterozoic units. Mapping in the Pond Inlet area was completed in 2017, resulting in three new bedrock geology maps. Summarized herein are the principal tectonostratigraphic units encountered during the second field season, which involved four weeks of mapping in July and August 2018, in the Steensby Inlet and Barnes Ice Cap areas (NTS area 37F, western half of 37E and southern half of 37G).

The geology of the Steensby Inlet and Barnes Ice Cap areas is dominated by a variety of Archean to Paleoproterozoic units of plutonic origin, ranging from dioritic to monzogranitic in composition, that vary from exhibiting a strong gneissosity, to forming S>L- to L-tectonite, to remaining massive to weakly foliated. The 2018 field area locally includes orthopyroxene-bearing monzogranitic gneiss, indicative of granulite-facies conditions. The area also contains numerous iron ore deposits hosted by the polydeformed and metamorphosed Archean Mary River Group, including Deposit No. 1 which is currently in production, as well as pelitic to psammitic gneiss, marble and calcsilicate interpreted as belonging to the Paleoproterozoic Piling Group.

Data from the 2018 field mapping campaign, integrated with results from the 2017 season, will refine the understanding of the metamorphic, structural and tectonic evolution of northern Baffin Island, as well as constrain correlations with other terranes on mainland Nunavut and Greenland that are prospective for several mineral commodities.

Résumé

Dans le cadre du programme de Géocartographie de l’énergie et des minéraux (GEM-2), la Commission géologique du Canada a mené deux saisons de cartographie du socle rocheux à l’échelle du 1/100 000, au nord de l’île de Baffin. Cette nouvelle cartographie va contribuer à la modernisation de la base de connaissances géoscientifiques de cette partie du Nunavut,

This publication is also available, free of charge, as colour digital files in Adobe Acrobat® PDF format from the Canada-Nunavut Geoscience Office website: http://cngo.ca/summary-of-activities/2018/.
Introduction

During the summer of 2018, the Geological Survey of Canada (GSC), under the Geo-Mapping for Energy and Minerals (GEM-2) Program, conducted 1:100 000 scale bedrock mapping in the Steensby Inlet–Barnes Ice Cap area of northern Baffin Island (Figure 1). The field area consists of the entirety of NTS area 37F, the western half of NTS 37E and southern portion of NTS 37G, including the environs of the Mary River iron ore deposits. This work represents the second and final phase of the two-year bedrock-mapping project, the first phase of which focused on the area around Pond Inlet south to Paquet Bay (Bros and Johnston, 2017; Saumur et al., 2017; Skipton et al., 2017). Phase 1 led to the release of three 1:100 000 scale bedrock maps (Saumur et al., 2018a, b; Skipton et al., 2018), which are compiled and summarized in Figure 2.

The aim of the mapping project is to bring the level and resolution of the geological knowledge base of northern Baffin Island to that of recent GEM campaigns elsewhere on Baffin Island (e.g., Weller et al., 2015; St-Onge et al., 2016), as well as to ascertain the area’s geological evolution and economic potential. Of particular interest is the Archean Mary River Group (MRG), which includes banded iron formation (BIF) that locally hosts iron ore deposits, most notably the high-grade, high-tonnage Deposit No. 1, and the Mary River mine, currently owned and mined by Baffinland Iron Mines Corporation (Figure 3). Despite the current mining activity, the regional distribution, age and geological history of the MRG remain uncertain, as well as relationships with spatially associated felsic to intermediate plutons and basement gneiss. Felsic to intermediate units are also poorly understood with respect to their petrology, geochemistry, age and relevance within the Archean to Paleoproterozoic tectonic framework of Baffin Island, mainland Nunavut (e.g., Sanborn-Barrie et al., 2018) and Greenland (e.g., Dawes, 2006).

This paper summarizes the regional geology of the Steensby Inlet and Barnes Ice Cap areas, describing the principal tectonostratigraphic units encountered during four weeks of mapping in July and August 2018. The structural and metamorphic history, and implications for the economic potential of the study area stemming from the 2018 field observations are also discussed.

Previous work

Bedrock mapping and mineral exploration

Skipton et al. (2017) comprehensively reviewed previous geological work in northern Baffin Island; a brief summary is provided here. The GSC conducted reconnaissance geological mapping in NTS map areas 37E, 37F and 37G in 1965–1968 as part of a larger scale regional mapping project on north-central Baffin Island. This work was summarized by Jackson (1969, 2000) and compiled as a set of 1:250 000 scale bedrock maps (Jackson and Morgan, 1978; Jackson et al., 1978; Davidson et al., 1979). Federally commissioned aeromagnetic surveys were carried out between 1973 and 1974 (Natural Resources Canada, 2017). Targeted studies by the GSC were also undertaken in the mid 1990s south of NTS 37F at Eqe Bay, an area that contains rocks correlatable with those underlying the 2018 field area (e.g., Bethune and Scammell, 1997, 2003a, b).

The Canada-Nunavut Geoscience Office (CNGO) completed targeted bedrock mapping in the Mary River area...
(Young et al., 2004; Johns and Young, 2006), leading to the compilation of 1:50 000 scale maps, the development of an interpreted stratigraphic and structural framework for the MRG, as well as the discovery of new economic mineral prospects, including Algoma-type iron formation in NTS map areas 37E and 37G, and local showings of gold- and molybdenum-bearing quartz veins.

Jackson (2000) and Iannelli et al. (2013b) provided a summary of past exploration efforts. Mining exploration activities in the area have been sporadic since the discovery of iron ore Deposit No. 1 at Mary River by M. Watts and R. Sheardown in 1962 (Guimond, 1963), leading to initial exploration efforts by Watts, Griffis and McOuat Limited. Baffinland Iron Mines Corporation was formed in 2004 and carried out drilling and exploration programs in the Mary River area. Assessment reports by Baffinland (Iannelli et al., 2010; 2013a–c) have recently become publicly available; these include geological maps and magnetic surveys that are being incorporated into the current GSC mapping compilation effort. Also of relevance are diamond exploration efforts by De Beers Group of Companies that produced airborne aeromagnetic surveys in the western portion of NTS 37F (Hundt, 2004; Wiznar and McKenzie, 2005; McMonnies et al., 2007).

**Geological framework**

Skipton et al. (2017) presented a full summary of available geochronology in the immediate vicinity of the 2018 field area, although virtually no published U-Pb ages exist for NTS map areas 37F and 37E. A crystallization age of 2726 ±3 Ma was determined on volcanic quartz-feldspar porphyry intercalated with mafic volcanic rocks in the southeastern corner of NTS 37F (Bethune and Scammell, 2003a).

Archean felsic plutonic rocks and greenstone belts in the Steensby Inlet–Barnes Ice Cap area, as well as those in the...
Pond Inlet–Mary River area (Skipton et al., 2017), are considered to belong to the Repulse Bay block (or north Rae domain) of the Rae craton, which extends southwestward toward central Churchill Province (e.g., Pehrsson et al., 2013; Snyder et al., 2013; cf., Jackson and Berman, 2000). Cratonic basement of Eo- to Mesoarchean age and ca. 2.97–2.60 Ga granite-greenstone belts, including the Mary River Group, characterize the Repulse Bay block (e.g., Snyder et al., 2013; LaFlamme et al., 2014; Spratt et al., 2014).

To the southeast, Archean crust on northern Baffin Island is bounded by the Isortoq Fault Zone (Figure 3) and the Paleoproterozoic Foxe fold belt (Figure 1), which represents the northern margin of the ca. 1920–1800 Ma Himalayan-scale accretionary/collisional Trans-Hudson Orogen (St-Onge et al., 2006; Corrigan et al., 2009; Weller and St-Onge, 2017). The Isortoq Fault Zone is considered to record northwest-directed thrusting of the Foxe fold belt and underlying basement over Archean crust of northern Baffin Island at ca. 1850–1820 Ma (Jackson, 2000; Jackson and Berman, 2000; Bethune and Scammell, 2003b).

The Paleoproterozoic Piling Group on central Baffin Island (Figure 1) comprises shallow-water siliciclastic-carbonate strata, mafic to ultramafic volcanic rocks and deep-water basinal strata (e.g., Morgan et al., 1976; Henderson et al., 1979; Henderson and Tippett, 1980; Tippett, 1985; Jackson, 2000; Corrigan et al., 2001; Scott et al., 2002, 2003; St-Onge et al., 2005; Partin et al., 2014; Wodicka et al., 2014). The supracrustal succession is generally interpreted as the result of regional crustal extension along the southeastern margin of the Archean Rae craton (e.g., Rainbird et al., 2010), followed by development of a foreland or proto-ocean basin (Partin et al., 2014; Wodicka et al., 2014), and subsequent deformation and metamorphism at ca. 1880–1765 Ma during the Trans-Hudson Orogen (Gagné et al., 2009). It forms part of an extensive cover sequence on the Rae craton, with stratigraphic correlatives extending from the western Churchill Province on mainland Nunavut (e.g., Penrhyn, Amer and Ketyet River groups; Jackson and Taylor, 1972; Taylor, 1982; Rainbird et al., 2010), across Baffin Island (Hoare Bay Group; St-Onge et al., 2009), to western Greenland (Karrat and Anap nunâ groups; Escher and Pulvertaft, 1976; Henderson and Pulvertaft, 1987; Garde and Steenfelt, 1999).

Paleozoic (Cambrian to Ordovician) strata lie unconformably upon Archean and Paleoproterozoic felsic plutonic rocks in the western portion of the field area. An updated stratigraphic framework for these units is the subject of another paper in this volume (Zhang, 2018) and the mapping...
resulting from this work will be incorporated in a future 1:100,000 scale map covering the western half of NTS 37F.

A Tertiary unit, documented by Andrews et al. (1971) on a hill 25 km northwest of the Barnes Ice Cap, is included in the reconnaissance-scale map published for NTS 37E (Jackson and Morgan, 1978). Andrews et al. (1971) indicated that the outcrop is of limited spatial extent, amounting to a few square metres. Fieldwork in this locality during 2018 did not document the putative Tertiary unit and therefore it is not considered further.

8Tertiary is a historical term. In this paper, the authors use the term to reflect its original usage in Andrews et al. (1971). Upon recommendations of the International Commission on Stratigraphy (e.g., Cohen et al., 2013), the term has been superseded in favour of the Paleogene and Neogene periods.

Lithological units: 2018 field observations

Felsic plutonic rocks

The field area is dominated by plutonic to gneissic felsic rocks similar to those observed in NTS map areas 37G and 38B, and which are described in detail by Skipton et al. (2017). New U-Pb dating will elucidate the timing of emplacement of each unit and help determine the age of the Archean basement in the area.

The main types of felsic rocks are summarized below, in order of most to least extensive.

Dioritic to monzogranitic gneiss

This rock unit is foliated and medium grained. It commonly exhibits a well-developed gneissosity (Figure 4a) and generally has S>L fabric (Figure 4b, c) although it locally forms L-tectonite. Felsic bands within the gneiss consist of...
Figure 4: Field photographs of felsic gneiss and felsic plutonic rocks from the Steensby Inlet–Barnes Ice Cap area, showing a) biotite-bearing monzogranitic gneiss with bands of syenogranite and bands/enclaves of biotite-hornblende-magnetite quartz diorite; b) a sharp contact between strongly foliated dioritic gneiss (right) and weakly foliated biotite monzogranite (left); c) foliated biotite-magnetite granodiorite containing K-feldspar megacrysts; d) a folded mafic enclave within biotite monzogranite; e) weakly foliated to massive biotite-garnet-orthopyroxene monzogranite; f) a tourmaline (black crystals)-bearing pegmatitic dyke in contact with felsic orthogneiss (left); g) a metre-scale pegmatitic K-feldspar crystal in quartz syenite west of Nina Bang Lake. Abbreviation: Kfs, K-feldspar.
plagioclase+quartz+K-feldspar and mafic bands are enriched in biotite+hornblende+magnetite. Locally, decimetre- to metre-scale enclaves of diorite to quartz diorite occur within the gneiss and these are transposed parallel to foliation or gneissosity.

**Biotite-bearing monzogranite to granodiorite**

Plutons are homogeneous, medium to coarse grained, massive to moderately foliated and/or lineated, and contain variable amounts of magnetite and hornblende. Metre-scale enclaves of dioritic to mafic rocks are common (Figure 4d). Consistent with observations farther north from the 2017 field season, this unit locally crosscuts tonalitic to monzogranitic orthogneiss, either as dykes or tabular intrusions subparallel to gneissosity (Figure 4b).

**Monzogranite to granodiorite containing orthopyroxene, biotite and magnetite (±garnet)**

This unit is massive to weakly foliated and/or lineated (Figure 4e); it tends to have distinctive orange weathered surfaces and greenish brown or orange fresh surfaces and occurs in the southern part of the area mapped in 2018.

**Feldspar-megacrystic granodiorite**

Plutons occur in several places in NTS 37G, and locally in map areas 37F and 37E. The granodiorite is characterized by euhedral megacrysts (2–5 cm in diameter) of moderately to weakly zoned K-feldspar within a medium-grained granodioritic (locally monzogranitic) groundmass. It is locally strongly foliated to gneissic in NTS 37E, forming augen gneiss with K-feldspar porphyroclasts (Figure 4c).

**Pegmatitic syenogranite**

Field relationships indicate that this unit represents the youngest magmatic phase in the study area and occurs mostly as dykes. It is massive, coarse grained to pegmatitic, contains biotite and, locally, magnetite, amphibole, phlogopite, apatite and/or tourmaline (Figure 4f). Ten kilometres west of Nina Bang Lake (Figure 3), a previously undocumented syenogranitic to quartz syenitic pluton occurs, which contains decimetre- and even metre-scale K-feldspar crystals (Figure 4g).

**Archean Mary River Group (MRG)**

Previous reconnaissance-scale mapping identified extensive tracts of MRG in the northwestern and southeastern corners of NTS area 37F and north of the Barnes Ice Cap in NTS 37E, as well as numerous smaller (1–10 km scale) MRG exposures throughout both map areas (Jackson and Morgan, 1978; Jackson et al., 1978). Targeted mapping has shown that the MRG is less extensive than previous mapping efforts suggest, and that these areas are dominantly underlain by tonalitic to monzogranitic gneiss and/or monzogranite to granodiorite plutons. Nonetheless, several exposures of MRG strata were documented (Figures 5, 6), such as at Maino Lake, Freshney Lake and a previously un-mapped 5 km scale panel of psammitic rock located 45 km north of the Barnes Ice Cap (BN, Figure 3). Further examples of MRG with exposed iron formation occur in the Magnetite Hill (Figure 5a), Nivalis Lake (Figure 5b), Rowley River (Figure 5c) and Cockburn River areas (Figure 3).

The MRG comprises mafic–intermediate metavolcanic rocks (Figure 6a–c), with lesser psammitic to pelite (Figure 6d, e), iron formation and ultramafic rocks (Figure 6f). Iron formation is typically oxide-facies type, ~5–20 m thick, and composed of banded magnetite and quartz (Figure 5a–c). Outcrop is sparse in several areas, including near the edges of the Barnes Ice Cap (Figure 3), where MRG strata are exposed as isolated outcrops or as several outcrops across areas of 1–2 km that are separated by till and, locally, subcrops or boulders of MRG (Figure 5d). This results in some uncertainty regarding the spatial extent of the MRG and its contact relationships with the surrounding felsic plutonic and felsic–intermediate gneissic rocks.

In areas with good outcrop exposure, MRG strata form more extensive (~1–4 km) panels surrounded by felsic gneiss and plutonic rocks. These panels are oriented parallel to the regional structural grain but are discontinuous along strike. As noted in the 2017 mapping area, this relationship may be due to a combination of the MRG having been intruded by monzogranite–granodiorite plutons and surviving as rafts, and of subsequent deformation, including boudinage (Bros and Johnston, 2017; Skipton et al., 2017). For example, in the Rowley River area, the MRG forms a north-northwest-dipping panel of supracrustal rocks occupying an area of ~1 km², surrounded by foliated to gneissic monzogranite and diorite. The Rowley River package consists of layers of BIF, pelite and intermediate metavolcanic rocks 3–10 m thick. Contact relationships with surrounding plutonic rocks are unexposed, but similarities between deformation fabrics suggest that the MRG and surrounding plutonic rocks underwent a similar deformation history. Repeated stratigraphy in the MRG suggests that the sequence at Rowley River represents a north- to northwest-dipping isoclinal fold.

The 2018 field area includes numerous Mary River iron ore deposits (Figure 3) that have been extensively mapped at the deposit scale (e.g., Young et al., 2004; Jackson, 2006; Iannelli et al., 2013b, c). Iron ore, such as that currently mined at Deposit No. 1, consists of high-grade hematite, magnetite and specularite iron formation. These high-grade zones commonly comprise oxide- to silicate-facies iron formation grading into or interlayered with quartzite, quartz-mica schist or chlorite schist (Iannelli et al., 2013a–c). The MRG in the area is strongly polydeformed (e.g., Young et al., 2004). Upgrading of iron orebodies is attributed to pervasive metasomatism causing desilicification of oxide- and silicate-facies BIF, which has been linked to the Trans-Hudson Orogen (MacLeod, 2012). New (2018) field
observations from gneiss outcrops surrounding the Mary River deposits, made at separate localities from where previous mapping was conducted, are consistent with a complex polydeformational history, as interpreted by previous workers.

**Paleoproterozoic Piling Group**

Sequences of pelite, psammite and calcisilicate (Figure 7) located in the southeastern part of NTS 37F (Figure 3) have been previously mapped as part of the Paleoproterozoic Piling Group (Jackson, 2000). New mapping has updated their spatial distribution, stratigraphy and composition. The strata form packages of dominantly pelite and psammite ~0.5–2 km thick, locally with calcisilicate units (Figure 7a) and minor marble (Figure 7b). The metasedimentary strata form discontinuous panels surrounded by monzogranite. Pelite contains garnet (Figure 7c), biotite and sillimanite, and calcisilicate and marble contain phlogopite and diopside.

A large outcrop of quartzite (at least ~30 m thick) underlies Beacon Hill in the Nivalis Lake area (Figure 7d). The quartzite, mapped as MRG in previous maps (Jackson and
Morgan, 1978), comprises gently south-dipping beds 10–50 cm thick; here it is tentatively correlated with the middle member of the Dewar Lakes Formation, lower Piling Group (Scott et al., 2003). South of the map area, this unit comprises medium- to thick-bedded, sillimanite-rich quartzite characterized by crossbedding indicating sedimentary transport toward the south. The field correlation will be tested with geochronological studies.

**Metamorphism and structure: 2018 field observations**

**Metamorphism**

As in the 2017 field area to the north (Skipton et al., 2017), metamorphic mineral assemblages observed in plutonic/gneissic rocks during the 2018 field season are, in large part, consistent with medium-pressure and medium- to high-temperature metamorphic conditions. Archean quartzofeldspathic units mostly exhibit biotite-hornblende+magnetite+clino.pyroxene assemblages, consistent with broadly amphibolite-facies conditions. This is consistent with widespread hornblende+clino.pyroxene+biotite assemblages in mafic–intermediate enclaves within felsic gneiss and plutonic rocks.

Variations in metamorphic grade are recorded in supracrustal sequences, which suggest a minor increase in peak metamorphic conditions toward the south in the 2018 map area. In the northeastern corner of NTS area 37F, mafic metavolcanic rocks of the MRG contain hornblende+clino.pyroxene, whereas some intermediate volcanic rocks contain garnet, cordierite and grunerite (e.g., at Rowley River; Figure 6c). Associated pelite is characterized by assemblages of biotite-muscovite+sillimanite, biotite-garnet+sillimanite or biotite-sillimanite-magnetite, with little to no partial melt. These mineral assemblages suggest that middle- to upper-amphibolite–facies conditions were attained during peak metamorphism. To the southeast, pelite in the MRG at Magnetite Hill (Figure 6d, e) contains biotite, garnet and abundant sillimanite that is typically coarse grained, in addition to a higher proportion of melt, implying higher temperature metamorphism. Similarly, in the Freshney River area, 40 km west of Magnetite Hill, mafic volcanic rocks in the MRG contain orthopyroxene, clinopyroxene and garnet (Figure 6a), an assemblage that is characteristic of granulite-facies conditions. In the southeastern corner of NTS 37F, metasedimentary rocks of the Piling Group include biotite-garnet-sillimanite pelite (Figure 7c) and diopside-phlogopite calc-silicate. In summary, metamorphic mineral assemblages in supracrustal rocks in the southern parts of NTS map areas 37F and 37E suggest thermal-peak upper-amphibolite– to granulite-facies metamorphism.

The southward increase in metamorphic grade is corroborated by occurrences of orthopyroxene=garnet in monzo-
granite and granodiorite in several localities in the southern portion of the 2018 study area. Orthopyroxene-bearing felsic rocks are characteristic of granulite terranes (Frost and Frost, 2008). In previous studies, the orthopyroxene-in isograd in felsic plutonic rocks was used to delimit the northern extent of the Dexterity granulite belt (Figure 3), a discontinuous belt of granulite-facies rocks ~50–80 km wide trending northeast along the northwestern side of the Isortoq Fault Zone (Jackson and Morgan, 1978; Jackson et al., 1978; Jackson, 2000; Jackson and Berman, 2000). Orthopyroxene was generally absent southeast of the fault and mineral assemblages are consistent with amphibolite-facies metamorphism.

Previous workers documented a localized greenschist-facies retrograde overprint of Archean and Paleoproterozoic units (e.g., Jackson, 2000). Chloritization of biotite and/or hornblende was observed in parts of the areas mapped in 2017 and 2018, consistent with minor retrograde alteration. Although such an overprint was observed locally in the north, such as in the Tuktuliavik area (Bros and Johnston, 2017), this overprint seems to be more extensive around Steensby Inlet and in the southeastern portion of the study area.

Deformation

The structural history recorded by Archean–Paleoproterozoic rocks is attributed to at least four deformation events, broadly consistent with observations made further north, specifically in NTS area 37G (Skipton et al., 2017), and the general structural framework of units in the Mary River area (e.g., Young et al., 2004). However, the nomenclature used here is independent to that used in previous works (i.e., D_1 here may not be equivalent to D_1 in other published reports). Future compilation efforts will focus on a consolidated and comprehensive structural model for the entirety of northern Baffin Island.

Early fabrics (D_1) are provisionally subdivided into D_1a in the orthogneissic basement (S_1a, locally L_1a; Figure 4a) and
D_{1b} in the supracrustal strata (dominant S_{1b} and associated L_{1b}; Figures 5, 6). Peak-metamorphic mineral assemblages define both sets of structures. As in NTS 37G (Skipton et al., 2017), basement gneiss may have recorded deformation events that predate the MRG. Although D_{1b} and D_{1b} may indeed represent distinct deformation events, further work and age constraints are necessary to determine the relationship between D_{1b} fabrics in granitic rocks and those in the supracrustal rocks. The expression of these events varies at the regional scale: in many cases, the S_{1a/b} foliation occurs as well-developed centimetre- to decimetre-scale gneissosity, whereas in other places rocks exhibit a weak S_{1a/b} fabric and a strong L_{1a/b} lineation (L>S or L-tecstonite). In supracrustal units, S_{1b} is parallel to primary sedimentary or gneissosity, producing a fabric parallel to S_{1}, which is coincident with the inferred fault zone; a pronounced magnetic low to the southeast contrasts with magnetic highs to the northwest (Figure 8a). The tectonic significance of the zone remains ambiguous: Jackson (2000) suggested that it represents the southern extent of the late Archean/Paleoproterozoic Committee Orogen; alternatively, a link to the Trans-Hudson Orogen has been proposed (Bethune and Scammell, 2003b), with the zone marking the northwesternmost extent of Trans-Hudson deformation.

**Isortoq Fault Zone**

The Isortoq Fault Zone (Figures 3, 7) has been postulated to be a discrete southeast-dipping, east-northeast-striking zone of brittle and/or ductile shear (e.g., Jackson, 2000; Bethune and Scammell, 2003b). In previous studies, the fault zone trends east-northeast across the southeastern portion of NTS map area 37F and the southwestern corner of NTS 37E, between the Barnes Ice Cap and the southwestern coast of Baffin Island. It is considered to separate orthopyroxene-bearing felsic plutonic rocks and granulite-facies assemblages to the northwest (Dexterity granulite belt) from lower grade, upper-amphibolite–facies rocks in the southeast. A sharp break observed in aeromagnetic data is coincident with the inferred fault zone; a pronounced magnetic low to the southeast contrasts with magnetic highs to the northwest (Figure 8a). The tectonic significance of the zone remains ambiguous: Jackson (2000) suggested that it represents the southern extent of the late Archean/Paleoproterozoic Committee Orogen; alternatively, a link to the Trans-Hudson Orogen has been proposed (Bethune and Scammell, 2003b), with the zone marking the northwesternmost extent of Trans-Hudson deformation.

The best exposures of the Isortoq Fault Zone appear to occur at Eqe Bay, south of 70°N and therefore outside of the study area. Nevertheless, Jackson (2000) gave the following description of exposures of the Isortoq Fault Zone north of 70°N:

In 1992, R. Berman and the author identified mylonites along a 10 km stretch of the Isortoq Fault Zone that extends northeast from the south side of the Steensby Inlet map sheet [...]. This mylonite zone dips about 50 degrees southeast and is about 50 m wide. It is mostly blastomylonite that contains rounded and rotated fragments of quartz, antiperthitic plagioclase, minor microcline, and rare myrmekite in a finely sheared and recrystallized matrix composed mostly of quartz, plagioclase, and green to brown biotite. [...]

Elsewhere, only one mylonitic foliation is shown on the bedrock maps for the Eqe Bay area (Bethune and Scammell, 2003b), along the trace of the aeromagnetic break upon which the continuation of the Isortoq Fault Zone is inferred.

During fieldwork in 2018, foot and helicopter-supported traverses conducted across the proposed hangingwall and immediate footwall of the Isortoq Fault Zone in the south-
Figure 8: a) Regional aeromagnetic data (Natural Resources Canada, 2017) focused on the Isortoq Fault Zone in the southern parts of NTS map areas 37F and 37E, with the northwestern side of the zone showing a pronounced magnetic high, whereas the southeastern side shows a pronounced low, except for a patch of high magnetic readings southeast of the main boundary (yellow circles highlight the position of traverses and helicopter-supported site visits). Field photographs from the southeastern corner of NTS 37F, at the IQ-A site (Figure 3), showing b) S-C-C’ fabrics in a mylonitic quartzofeldspathic rock on the southeastern side of the Isortoq Fault Zone (photo facing southeast), consistent with oblique-dextral shear (top-to-the-south); c) mylonitic fabric folded by decimetre-scale southeast-plunging crenulations in a biotite-bearing quartzofeldspathic rock.
eastern corner of NTS map area 37F and the southwestern corner of NTS 37E (Figure 8a) revealed no distinctly sheared or high-strain rocks. Instead, monzogranitic to granodioritic plutonic rocks exhibiting varying degrees of foliation and/or lineation development, and locally exhibiting a moderately developed gneissosity, were observed. No mylonite was documented at site IQ-B (Figure 8a); however, mylonitic quartz-plagioclase-biotite schist occurs at site IQ-A, defining a millimetre- to centimetre-scale schistosity, locally exhibiting S-C-C’ fabrics consistent with dextral-sense, top-to-the-south shearing (Figure 8b) that was locally refolded by decimetre-scale crenulations (Figure 8c). Therefore, and considering mylonites documented southwest of the study area at Eqe Bay (Bethune and Scammell, 2003b), mylonites sensu stricto occurred as 10–50 m thick intervals, are estimated to measure up to ~1 km in strike length and lack continuity at the regional scale.

The fieldwork conducted on either side of the proposed fault zone has yielded two further observations: 1) rocks toward the southeast have a much lower magnetic susceptibility (generally below 0.05 SI) than those toward the northwest (>0.1 SI and up to ~10 SI), consistent with regional aeromagnetic surveys (Figure 8a); and 2) planar fabrics in rocks toward the southeast are shallowly dipping to subhorizontal, whereas those to the northwest tend to be moderately to steeply dipping. The dip direction is generally toward the east-southeast within ~10 km northwest of the proposed fault zone. Therefore, despite the absence of continuous high-strain zones coinciding with the proposed trace of the Isortoq Fault Zone, the zone evidently represents a geological boundary: it separates moderately- to steeply-dipping, magnetic, granulite-facies rocks in the northwest from shallowly dipping, amphibolite-facies rocks with low magnetic susceptibility in the southeast. To confirm this hypothesis and establish the tectonic significance of the proposed Isortoq Fault Zone, the age and petrology of the rocks on either side of the zone need to be determined. Furthermore, structural data from the proposed fault zone must be interpreted within the context of the regional structural framework that is currently under compilation based on 2017–2018 field mapping.

**Regional tectonic considerations**

Observations from the 2017–2018 GEM-2 North Baffin Bedrock Mapping campaign have provided a tectonostratigraphic framework for research into regional tectonics. Ongoing geochronological and geochemical characterization of basement gneiss and plutons will help determine the Archean cratonic affinity of northern Baffin Island. Resolving the metamorphic and structural history of the study area will fill a gap in the understanding of Baffin Island geology, potentially leading to tectonic and stratigraphic links with other regions and a better understanding of constituent structural elements. Notably, the role and importance of the Isortoq Fault Zone with respect to the Archean tectonic framework and Paleoproterozoic plate reconstructions remains an open question.

**Economic considerations**

The fieldwork completed in 2017–2018 reveals that the MRG is not as extensive as portrayed in previous 1:250 000 reconnaissance-scale mapping (cf., Jackson and Morgan, 1978; Jackson et al., 1978). In many locations, there was indeed significant outcrop of MRG, such as at Maino Lake and Rowley River (Figure 3). However, in other localities, felsic plutonic rocks were noted where MRG had been previously mapped. It seems that the spatial footprint of MRG was overemphasized on the earlier reconnaissance-scale maps, as observed when comparing the spatial extent of MRG in new and earlier maps of the Kanajuqtuuq area (Saumur et al., 2018b; cf. Davidson et al., 1979). These results refine the understanding of the mineral prospectivity of the area, as greenstone belts are prospective for BIF-hosted iron ore deposits, orogenic gold, and magmatic nickel, copper and platinum-group elements.

Ironstone and BIF encountered during 2017–2018 mapping were dominantly of the oxide-facies type. The Magnetite Hill BIF showing also contains minor bornite and chalcopyrite. Some of the iron-ore–rich rocks at Rowley River may represent an extreme case of silicate-facies ironstone, metasomatized and metamorphosed to upper-amphibolite grade. Minor pyrite and arsenopyrite were observed at this locality.

The area remains, in theory, of interest for diamond exploration, as are other portions of the Archean Rae craton. Future geochronological and isotopic work will elucidate where the oldest, and potentially thickest (and thus most prospective), portions of Archean cratonic basement occur.

Carving stone has been documented near the Mary River mine (Steenkamp et al., 2017). At least two additional potential localities for carving stone were identified during 2018 fieldwork: calc-silicate and marble of the Piling Group, cropping out west of Steensby Inlet (Figure 7a, b); and a second locality occurring ~20 km north of Rowley River, consisting of a body of tremolite-bearing serpentinized clinopyroxenite (Figure 6f), presumably of the MRG, located near a 20 metre thick pegmatitic felsic dyke (FC, Figure 3).

**Future work**

The compilation of five 1:100 000 scale bedrock geology maps will synthesize the results of new bedrock mapping conducted in NTS area 37G in 2017 and 2018, and in NTS 37F and the western half of 37E in 2018. The integration of the work done in 2017 and 2018 with new mapping by the
CNGO in portions of NTS map areas 47E and 47H as part of the Fury and Hecla Geoscience Project (Bovingdon et al., 2018; Steenkamp et al., 2018; Zhang, 2018) will lead to an updated, modern geoscience framework for northern Baffin Island matching the level of that achieved for southern Baffin Island (Weller et al., 2015; St-Onge et al., 2016).

Several research studies are ongoing, including an M.Sc. thesis project (E. Bros, University of Alberta) focusing on the stratigraphy and structural history of the Mary River Group in the Tuktuliavik (informally known as Long lake) area (Figure 3). A new B.Sc. thesis project (M. O’Brien, University of Ottawa) will focus on the petrography, mineralogy and isotope geochemistry of felsic plutonic rocks of northern Baffin Island. An additional postdoctoral study (Université du Québec à Montréal) on the effects of prograde metamorphism on the geochemistry of magnetite and BIFs is also planned.

To determine the metamorphic evolution of northern Baffin Island, pressure-temperature-time (P-T-t) studies of samples from the 2017 study area are in progress, and additional studies are planned on selected samples collected in 2018. Specifically, P-T studies and in situ U-Pb monazite dating are underway to investigate the tectonometamorphic evolution of a basement-cover thrust imbricate in the Qimivvioq area (Figure 2), and of the Mary River Group in the Tuktuliavik (Figure 2) and ‘Felsenmeer flats’ (Figure 3) areas. Furthermore, P-T and in situ U-Pb monazite studies are planned for key exposures of the MRG in the 2018 fieldwork area (NTS 37E, 37F). Results from this work will be combined with geospatial analysis of the distribution of peak- (and, where applicable, retrograde-) metamorphic assemblages across the study area to investigate variations in regional metamorphic grade. Additionally, structural data from the 2017 and 2018 map areas will be compiled and interpreted to form a regional 3-D structural framework.

To determine igneous crystallization and depositional ages of the main rock units mapped in 2018, approximately 15 samples will be dated using U-Pb zircon geochronology. Results of U-Pb zircon dating from the main rock units mapped in 2017 are forthcoming; these will be released in the public domain in a government (Geological Survey of Canada) publication, with an estimated publication date of May 2019.

Acknowledgments

The Polar Continental Shelf Program co-ordinated logistical support for this project, and the Tununiq Sauniq Co-Op provided support on the ground in our staging locality of Pond Inlet. A pleasant summer at Isortoq camp was made possible thanks to the contributions of C. Seveik, first-aid attendant and cook extraordinaire. P. Ivalu (Igloolik, NU) and L.J. Apak (Clyde River, NU) diligently served as wild-life managers and camp aids. E. Polzin (Summit Helicopters) provided invaluable support and advice throughout the summer. Baffinland’s exploration team, notably T. Iannelli, M. Robatian and J. Hey, provided guidance and advice. S.T. Johnston was supported in part by a National Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant. The authors also acknowledge support from managers and administration staff at the GSC and the GEM co-ordination office, including M. Ville- neuve, C. Bjerkelund, N. Shea, M. Francis, K. Clark, M. MacKay and R. Murphy.

Natural Resources Canada, Lands and Minerals Sector contribution 20180281

References


Henderson, G. and Pulvertaft, T.C.R. 1987: The lithostratigraphy and structure of a Lower Proterozoic dome and nappe complex: Descriptive text to 1:100 000 sheets Mârmorilik 71 V. 2 Syd, Níqgítsiaq 71 V. 2 Nord and Pangnertôq 72 V. 2 Syd; Grønlands geologiske Undersøgelse (Geological Survey of Greenland), Copenhagen.


Jackson, G.D. 2006: Field data, NTS 37 G/5 and G/6, northern Baffin Island, Nunavut; Canada; Geological Survey of Canada, Open File 5317, 2 sheets.


Johns, S.M. and Young, M.D. 2006: Bedrock geology and economic potential of the Archean Mary River group, northern


