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**GEOLOGICAL SURVEY OF CANADA
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Atlantic Craton (Nain province), Newfoundland and Labrador**

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Foreword

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for sustainable economic development in the North (Fig. 1). 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 2018, the GEM program successfully carried out a number of 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.

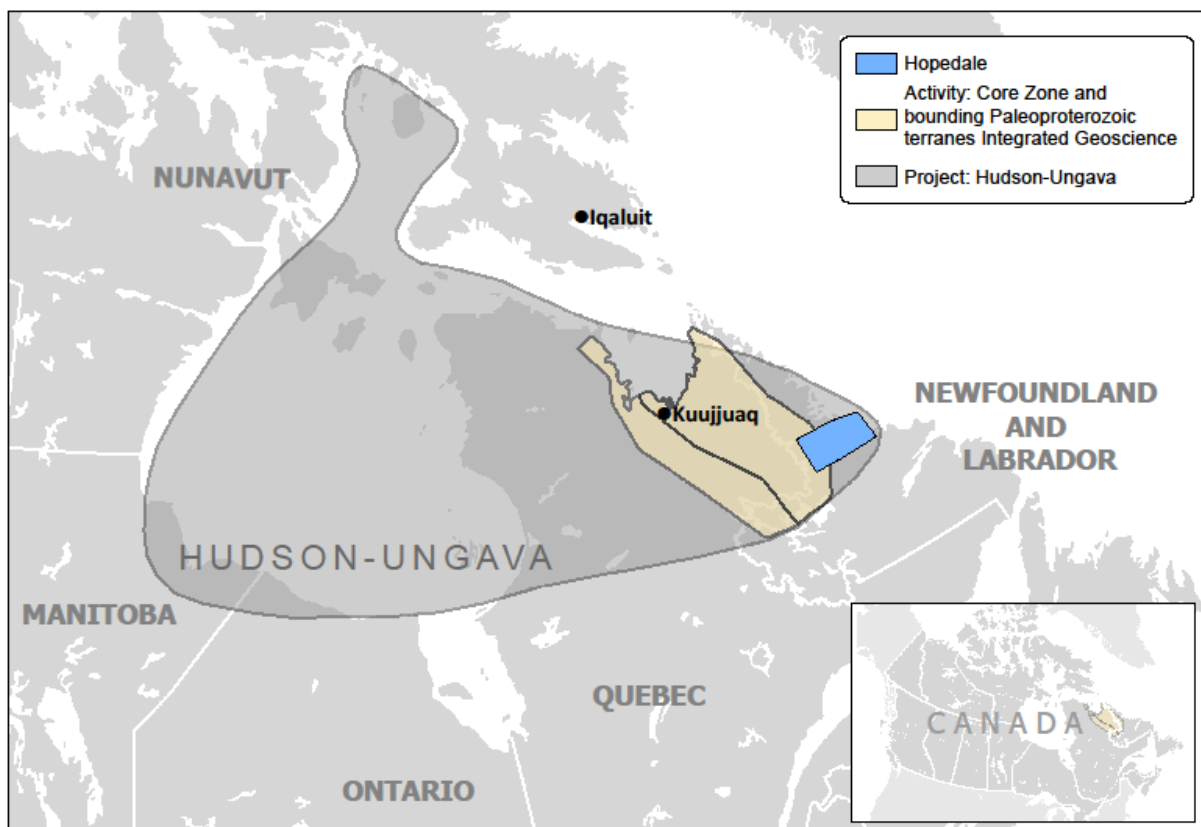


Figure 1: Approximate location of the Hudson-Ungava project (grey overlay) and the Core Zone and bounding orogens activities. The location of the current activity is shown in blue.

Introduction

During the summer of 2018, we conducted field activities consisting of a four-weeks targeted field mapping and sampling campaign in the area surrounding and west of Hopedale, Labrador, in NTS map sheet 013N and the eastern half of 013M (Fig. 2). This formed the fifth and last field season of the “minerals” component of the GEM-II Hudson-Ungava project (Corrigan et al., 2015a; 2015b; 2016; 2018; Houlé et al., 2015; McClenaghan et al., 2014; 2015; 2016; Sanborn-Barrie et al., 2015, 2016; McCurdy et al., 2018), and completed a targeted bedrock mapping transect spanning from the western edge of the Labrador Trough to the coast of Labrador. Prior to this field season, a high-resolution aeromagnetic survey was acquired, covering NTS map sheets 013M (eastern half) and the onshore portion of 013N. This airborne survey joins a previously published high-resolution survey acquired over the western half of NTS map sheet 013M. Together with aeromagnetic maps published by the Ministère de l’énergie et des ressources naturelles du Québec (MERNQ), they provide a nearly seamless coverage from the Labrador Trough to the Labrador coast. The overall objective of this summer’s campaign was to provide improved constraints on crustal and tectonothermal evolution of the Core Zone and southern North Atlantic Craton, including the intervening Torngat Orogen. Much of the fieldwork focused on areas that showed obvious discrepancies between observed aeromagnetic patterns and geological map patterns. We also collected about 20 bedrock samples that will be processed and analyzed for U-Pb zircon dating as well as Sm-Nd tracer isotope studies. Together, these new observations and data will be used to produce new 1:250,000 scale maps of NTS map sheets 013M and 013N. Some of our work also focused on providing better constraints on the nature of the boundary between the Hopedale and Saglek blocks of the North Atlantic Craton. These new field observations, together with surficial (till) data collected by the Newfoundland and Labrador Department of Natural Resources, will provide enhanced knowledge on the geological framework and mineral potential of the area.

Core Zone – Hopedale Block transect

The area investigated this summer (Fig. 3) has been previously mapped at various scales since the reconnaissance work of Taylor (1979), including 1:100,000 scale maps of the Hopedale block (Ermanovics, 1979; 1981a; 1993; Ermanovics and Korsgard, 1981; Ermanovics and Raudsepp, 1979; Ermanovics et al., 1982), and detailed maps of the Paleoproterozoic-age Ingrid Lake supracrustal belt (Ermanovics, 1981b) and the Archean Florence Lake and Hunt River belts (James et al., 1996; 2002). Bedrock geology maps of the Flowers River Complex (Hill, 1991; Miller, 1994) and of a Core Zone to Hopedale transect (Thomas and Morrison, 1991) were also published.

Overall, this area is tectonically complex, located at the junction of four tectonic ‘blocks’ or paleo-plates that are bound by Archean to Paleoproterozoic orogens. These are the 2.8-3.3 Ga Hopedale block, the 3.2-4.0 Ga Saglek block, the 2.3-2.8 Ga Core Zone, and the 1.88-1.74 Ga Makkovik Province (James et al., 2002; Ketchum et al., 2002; Corrigan et al., 2018). The Hopedale and Saglek blocks together form the Nain Province, as defined by Stockwell (1963), which is part of the larger North Atlantic Craton, portions of which occurs in Greenland as well as northwest Scotland. In this

report we use the term North Atlantic Craton rather than Nain Province. The boundary between the Hopedale and Saglek blocks is assumed to be tectonic and of Neoarchean age, although its exact nature and location is uncertain (James et al., 2002). The Core Zone is separated from the North Atlantic Craton by the ca. 1.87-1.85 Ga Torngat orogen, a zone of intense transpression and high-grade metamorphism that affected mainly the Tasiuyak Gneiss, the Lac Lomier complex, and the eastern edge of the Core Zone (Wardle et al., 2002). To the south, the Core Zone and North Atlantic Craton are bounded by the Makkovik Orogen, a zone of crustal reactivation and terrane accretion that formed during the Paleoproterozoic (Ketchum et al., 2002). The area under investigation has also been the locus of voluminous anorthosite-mangerite-charnockite-granite (AMCG) type magmatism during the Mesoproterozoic, with intrusion of the Harp Lake anorthosite, the Mistastin pluton, the Flowers River Complex, as well as the Nain Plutonic suite (Emslie, 1978).

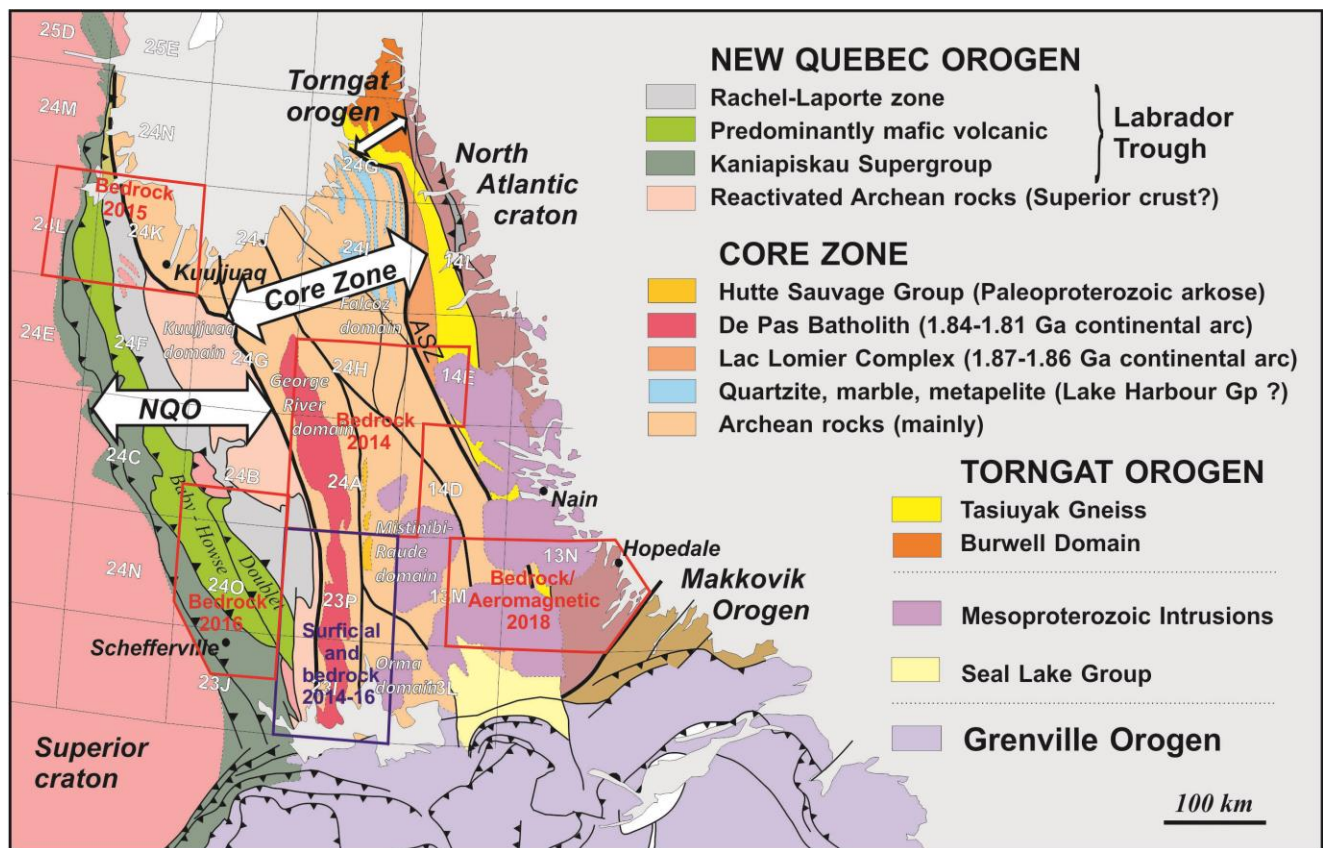


Figure 2: Simplified geological map of the Precambrian Shield east of the Superior Craton in Québec and Labrador. The box outlined in blue represents the area targeted for surficial and bedrock studies (see McClenaghan et al., 2014, 2015; 2016; Sanborn-Barrie et al., 2015; 2016). The red boxes delimit areas investigated by Corrigan et al. (2015a; 2015b, 2016) and this publication (Bedrock/Aeromagnetic 2018). Modified after James et al. (2003).

Methodology

Fieldwork was helicopter-supported and based out of Hopedale, Labrador, for a period of four weeks in July 2018. Prior to field work, a GIS-based multi-layer database was assembled, including satellite imagery (Spot), radiometric maps, aeromagnetic maps, geological compilation maps (Geological Survey of Canada, Newfoundland and Labrador Department of Energy and Mines, MERNQ), as well as a multi-element lake sediment chemical analysis data layer. This collection of data and images was utilized to evaluate the accuracy of existing maps, to develop structural models, and to identify specific targets for field investigations. Overall, more than 250 new observation points were made and rocks systematically sampled for petrographic and structural analysis. Over 30 samples were collected to determine zircon provenance, age of crystallization or age of tectonothermal overprint, depending on rock type targeted. Samples with potential mineralization were also collected for assay. Rocks collected for dating will be analyzed by either the SHRIMP or TIMS U-Pb method at the Geochronological laboratory, Geological Survey of Canada. Lithogeochemical analyses will be done in commercial laboratories by XRF for major elements and LA-CP-MS for trace and rare-earth elements. Results will be published in subsequent papers. A surficial geology project including glacial dynamics studies and till sampling, led by Heather Campbell of the Newfoundland and Labrador Department of Natural Resources, was done simultaneously with our work.

Results

The Hopedale block (Fig. 3) was formed between ca. 3.3 and 2.8 Ga (Ermanovics, 1993). It hosts two distinct supracrustal belts dominated by mafic volcanic rocks. These are the 3.1 Ga Hunt River volcanic belt (Fig 4a) and the 3.0 – 2.98 Ga Florence Lake volcanic belt (James et al., 2002). The Maggo Gneiss (Fig 4b) has been interpreted to be basement to the Florence Lake and Hunt River belts, but James et al., (*ibid.*) found that some of the Archean rocks interpreted to be part of Maggo Gneiss are actually intruding the Florence Lake Belt, which would make them younger, not older. This suggests some degree of complexity in correlation of Archean metaplutonic units and assessing what constitutes basement versus post-depositional intrusive rocks. In order to try to resolve some of these issues, we have sampled approximately ten outcrops mapped as either Maggo Gneiss or ca. 2.83-2.89 Ga Kanairiktok Plutonic Suite. Results will help in assessing the overall crustal evolution of the Hopedale Block. With the same general objective, a M.Sc. thesis was initiated in the Hunt River Belt to assess *i)* the age and source of detritus in clastic metasedimentary rocks, and *ii)* the age of deformation and metamorphism using in-situ U-Pb analysis of accessory minerals. A second M.Sc. study concentrated on more detailed geochemistry, geochronology and petrography of the Flowers River Igneous Complex (FRIC), which comprises a more alkaline, younger phase of the Nain Plutonic suite (Hill, 1990). Part of that study will test, with precise U-Pb dating, whether or not lobe-shaped intrusions surrounding the FRIC belong to that suite.

Another feature that is apparent from the high-resolution aeromagnetic survey is the potential partitioning of the Hopedale Block into a northwestern gneissic domain and a more highly transposed

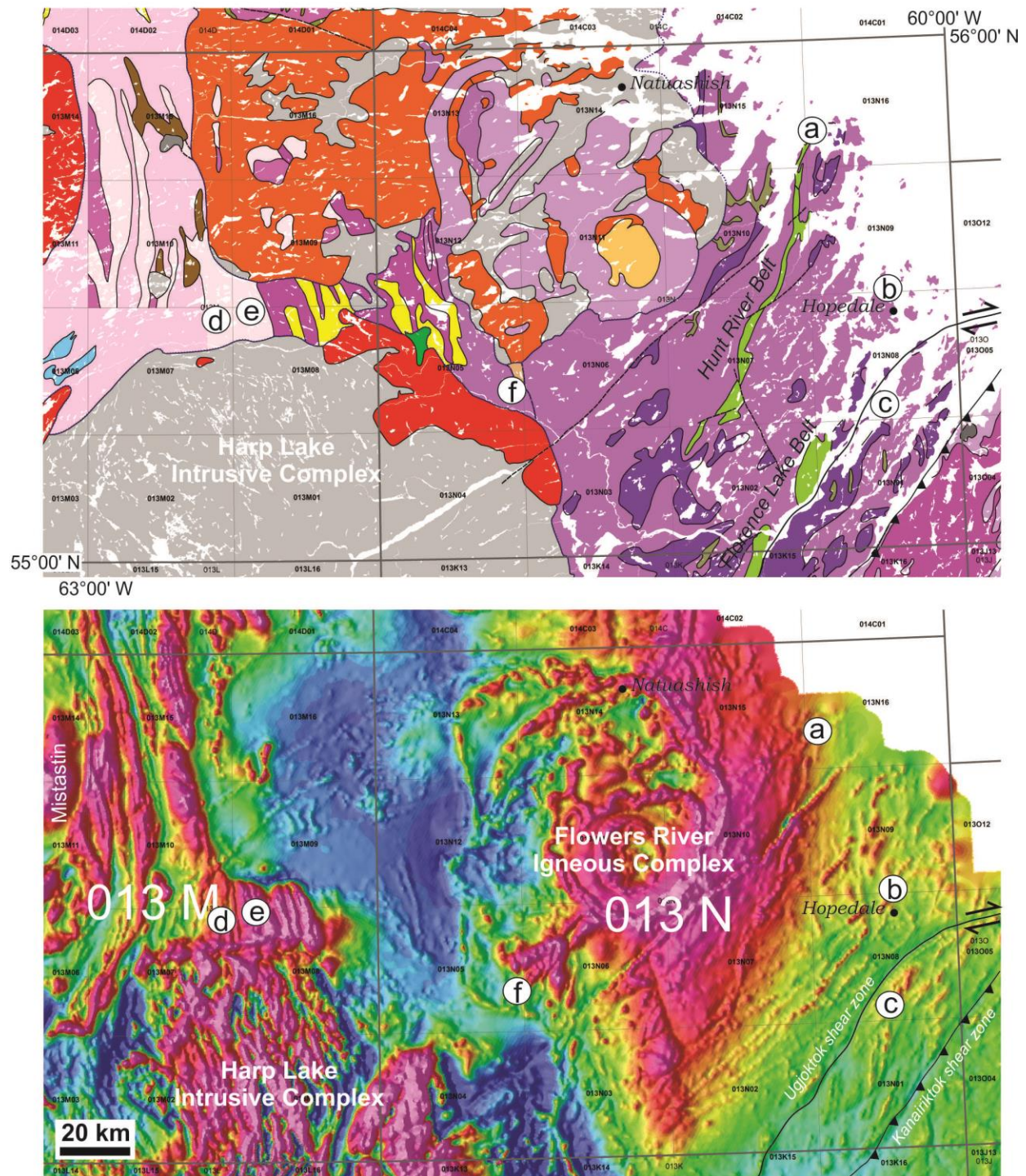


Figure 3: a) Simplified bedrock geological map for NTS map sheets 13M (eastern half) and 13N; b) Corresponding total field aeromagnetic map (GSC analogue data, Geophysical Data Repository). Photo locations from Figure 4 are marked 'a' to 'f'.

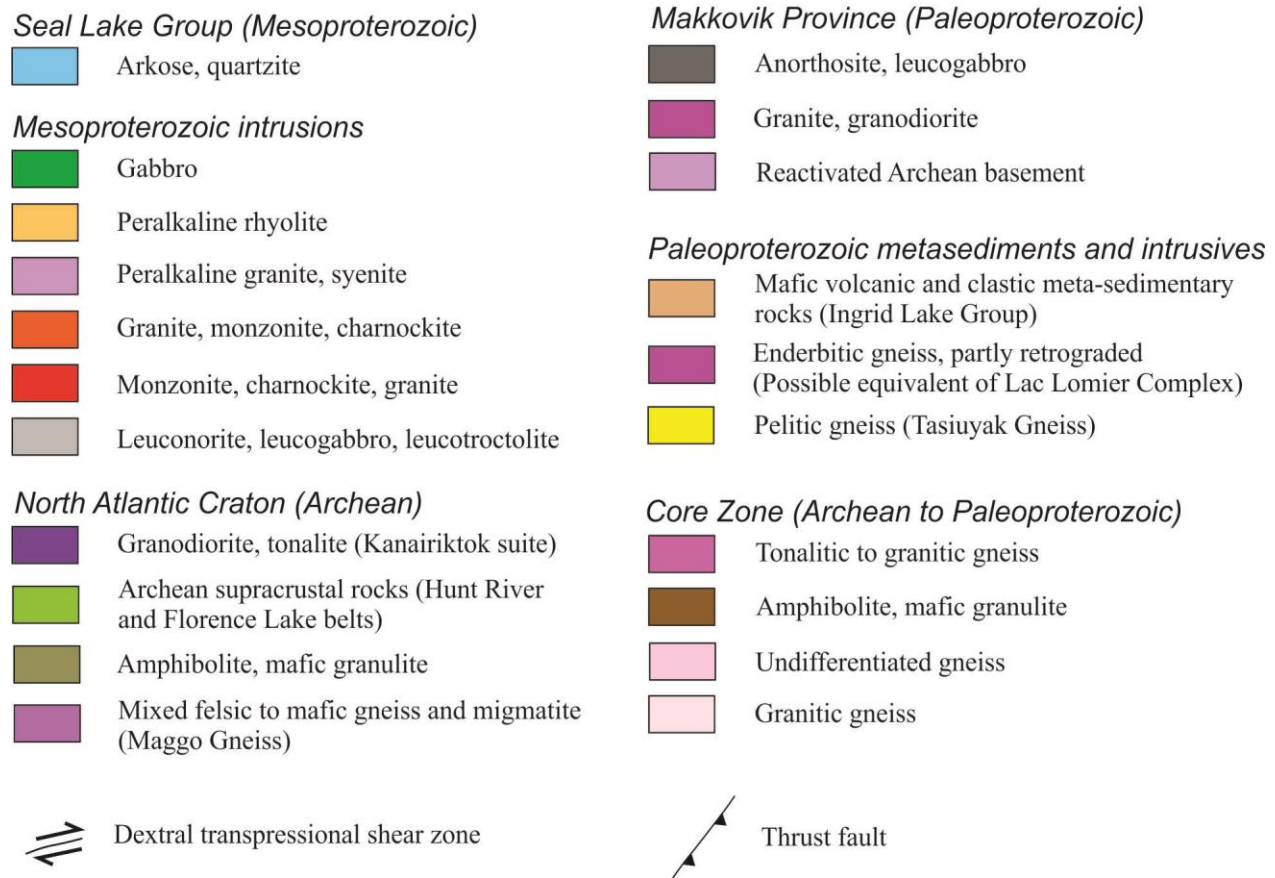


Figure 3 continued... Legend.

(perhaps during the Paleoproterozoic or late Archean?) southeastern domain. The two domains have slightly different structural orientations and are separated by a zone of ductile shear (“Ugjuktuk Shear Zone” in Figure 4c) corresponding to a magnetic low passing along Ugjuktok Bay. A separate study, initiated by I. Coutand, D. Van Rooyen and students (Dalhousie University and Cape Breton University, respectively) via a GEM Program Grant and Contribution, will use medium- to low-temperature thermochronology to test whether or not the shear zone and immediate footwall and hanging wall were affected by Paleoproterozoic (Makkovik) events. This may have implications for the thermotectonic evolution of the southern and central Hunt River Belt, which lies in the immediate footwall of that structure.

One of the areas of focus where our input may have a significant impact is on the lithology and age of the Core Zone in the eastern half of map sheet 013M. There, abundant, variably deformed and recrystallized K-feldspar megacrystic granite was observed (Fig. 4d) where previous maps described “gneiss” or “granitic gneiss” only. They appear to form a set of large plutons emplaced in felsic orthogneiss. They have been metamorphosed at amphibolite facies and become progressively deformed towards the southern extents of the Ablovialq shear zone, where kinematic indicators show

sinistral movement (Fig. 4e). Map-scale, elongate lenses corresponding to magnetic highs were also visited and correspond in outcrop to compositionally heterogeneous, garnet-bearing amphibolite bodies of uncertain origin and age. Where observed, elongate zones of magnetic lows correspond to upper-amphibolite facies siliciclastic metasedimentary rocks, mainly of pelitic and psammitic composition. A large, isolated leucogabbro interpreted on compilation maps as a member of the Nain Plutonic Suite was also visited. The newly-acquired aeromagnetic map suggests that this magnetic-high intrusive body has been affected by regional-scale sinistral shear associated with the Torngat orogeny and is therefore likely older than 1.87-1.85 Ga. The apparent replacement of pyroxene by amphibole may confirm this hypothesis. This leucogabbro was sampled for U-Pb dating.

East of these aforementioned lithologies (which comprise the Core Zone) lies a roughly 20 km wide swath of steeply-dipping mafic to felsic granulites forming orthogneiss layered at the meter to decimeter scale. These rocks are very similar in all aspects to, and in structural continuity with, map units observed to the north in map sheets 014D and 014E, and associated with the ca. 1.87-1.85 Ga Lac Lomier Complex (Corrigan et al., 2018). This suggests that the Lac Lomier Complex, interpreted as the plutonic root of a continental arc (Wardle et al., 2002), is continuous for at least 500 km from the northern edge of the Harp Lake intrusion to the northeastern shore of Ungava Bay, and is continuously flanked to the east by the Tasiuyak Gneiss, a prominent unit of high-grade metasediments interpreted as an accretionary complex (Wardle et al., 2002).

Another feature highlighted by the high-resolution aeromagnetic survey is the potential expansion of units associated with the 2.57 Ga Aucoin pluton, which is host to Au-Ag-Te bearing quartz veins (Sandeman and McNicoll, 2015). This alkali monzodiorite – syenite body intrudes Archean gneisses of the Hopedale block near its interpreted boundary with the Saglek block, and is characterized by positive magnetic anomalies. Prominent magnetic highs that we visited adjacent to the known Aucoin intrusion revealed rock types similar to those of the Aucoin suite, with some bearing rutilated quartz crystals. These were sampled for U-Pb dating to test whether or not they are in fact part of the ca. 2.57 Ga Aucoin suite. A detrital zircon provenance study of the Ingrid Lake Group (Fig. 4f) is under way, with the objective of providing constraints on the age of deposition as well as source of the sediments.

Conclusions

The Hopedale Block and southeastern Core Zone include crust that has had a long and complex history of formation, including a wide range of tectonic, magmatic, structural and thermal processes favorable to the formation of various types of economic mineral deposits. These include greenschist to amphibolite facies Archean greenstone belts with multiple stages of tectonothermal overprint, numerous plate boundaries (paleo-sutures), “anorogenic” magmatic events, and sedimentary basin

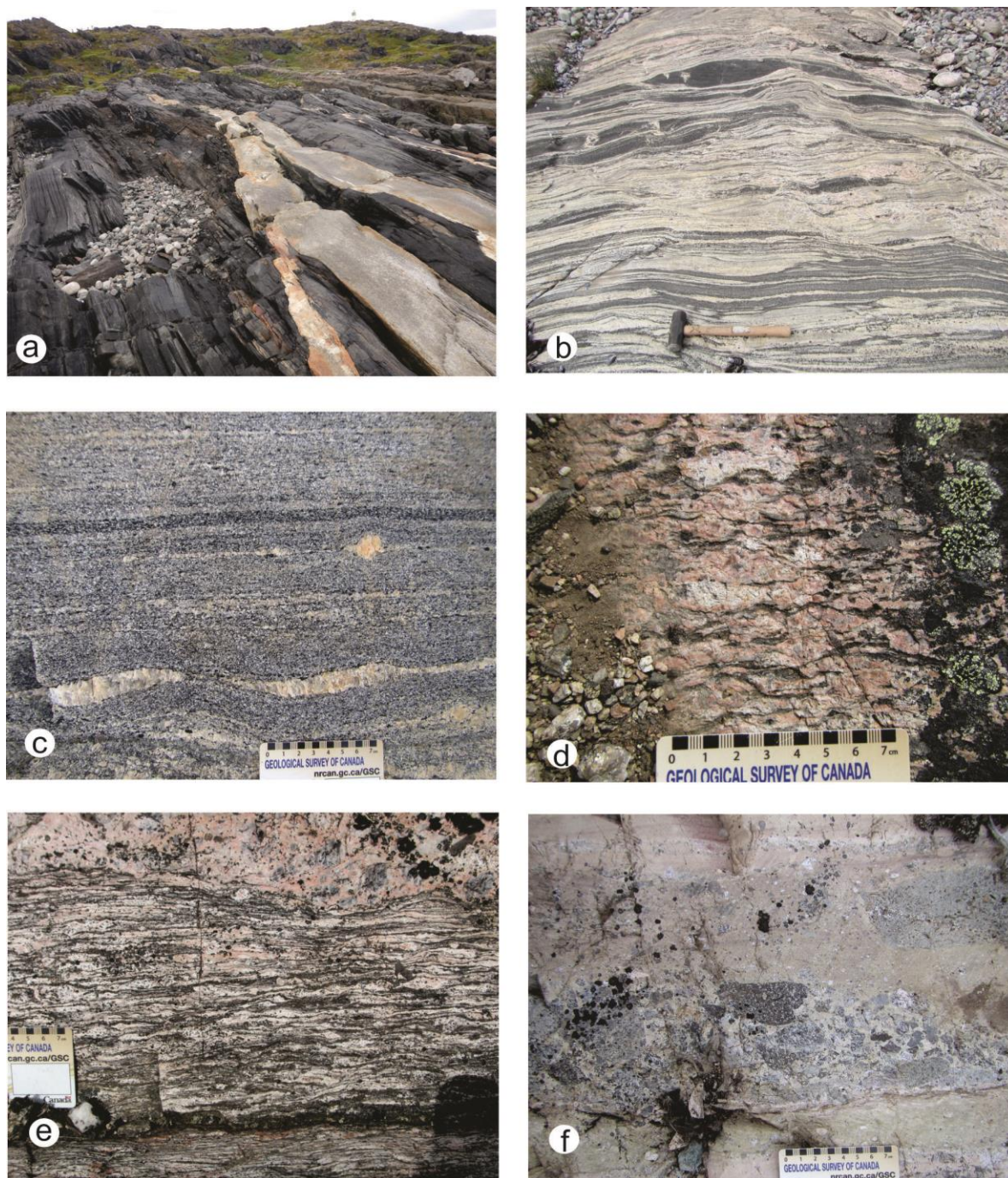


Figure 4: Outcrop photographs, with hammer or graduated card for scale (in centimeters). a) Syn-tectonic leucogranite cutting highly transposed supracrustal rocks of the Hunt River Belt; b) Migmatitic, banded Maggo Gneiss; c) Strongly transposed meta-diorite with δ -rotated (dextral) feldspar porphyroclast and back-rotated (dextral) quartz vein; d) Partly recrystallized and foliated K-feldspar megacrystic granite; e) Same rock unit as (d), affected by sinistral shear in the Abloviak shear zone; f) conglomerate layers in meta-arkose, Ingrid Lake Group. Photo locations are shown in Figure 3.

formation. We aim to produce new 1:250,000 scale bedrock geology maps for NTS map sheets 013-M and 013-N, based on more abundant and precise U-Pb zircon and monazite ages, as well as new ground observations supported by high-resolution aeromagnetic data (the latter are in final production stage at the time of this publication).

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