Geology, geochemistry and petrogenesis of the Expo-Ungava–Raglan dike, sill and lava-channel system in the Paleoproterozoic Cape Smith Belt, Northern Nunavik, Quebec

D.J. McKevitt[1], C.M. Lesher[1] and M.G. Houlé[2]

[1]Mineral Exploration Research Centre, Harquail School of Earth Sciences, Laurentian University, Sudbury, Ontario P3E 2C6

[2]Geological Survey of Canada, Québec, Quebec G1K 9A9

INTRODUCTION

This report summarizes work completed thus far on a research project carried out in the east-central part of the Paleoproterozoic Cape Smith Belt (Ungava Orogen), northern Nunavik, Quebec. Work began in September 2016 as part of a M.Sc. project that was subsequently expanded to a Ph.D. project in 2018, with completion expected by summer 2021.

Geological Setting

Three distinct styles of magmatic sulphide mineralization occur in the volcano-sedimentary sequence within the southern domain of the east-central Cape Smith fold and thrust belt: 1) differentiated olivine pyroxenite±melagabbro blade-shaped dikes within the middle and upper parts of the Povungnituk group contain Cu-Ni-(platinum group elements [PGE]) mineralization along their sides and keels (e.g., Expo-Ungava–Méquillon deposits; Mungall, 2007); 2) differentiated gabbro±olivine pyroxenite sills intrude all parts of the Povungnituk group, some of which locally contain stratiform PGE-(Cu)-(Ni) mineralization (e.g., Delta deposit; Giovenazzo, 1991); 3) poorly differentiated peridotite–pyroxenite lava channels and the peridotitic channelized parts of differentiated olivine pyroxenite–gabbro sheet flows at the base of the Chukotat group contain Ni-Cu-(PGE) mineralization at or near their lower contacts (e.g., Raglan deposits; Lesher, 2007). Previous work by other researchers has focused only on individual parts of this system. The purpose of this project is to better understand the geological, temporal and petrogenetic relationships between various parts of this magmatic plumbing system through the use of field mapping, geochronology and geochemistry. Due to excellent exposure and low-grade metamorphism, this region of the Cape Smith Belt provides an ideal setting in which to understand the evolution of a mineralized Paleoproterozoic subvolcanic–volcanic plumbing system.

Research Objectives

The initial M.Sc. project aimed to establish the connection between well-studied mafic–ultramafic units located along the Raglan trend (a volcano-sedimentary sequence at the base of the Chukotat group that contains numerous magmatic Ni-Cu-PGE sulphide mines and/or deposits, including Cross Lake, Katinniq and Donaldson) and a northern thrust-repeated sequence of lithologically-similar units within the Northern Permits area of the Raglan mine property owned by Glencore, with the goal of determining the prospectivity of the Northern Permits for Raglan-style Ni-Cu-(PGE) mineralization. In the course of the present Ph.D. project, these objectives have been expanded to include the establishment of the geology, mineralogy, geochemistry and petrogenesis of poorly-understood or unstudied mafic–ultramafic units throughout the Povungnituk and Chukotat groups in the east-central Cape Smith Belt. Their geochemistry and petrology will be compared to previously studied units (listed above) and, where possible, geochronology will be utilized to temporally constrain different parts of the system. As a result, key factors controlling mineralization will be determined, along with the prospectivity of different parts of the system (both stratigraphically and laterally).

Research Methods

Published and unpublished current and legacy geological data for the Povungnituk–Chukotat volcano-sedimentary sequence was reviewed to establish a comprehensive database of geochemical data and geologic maps, and to help target areas of interest and guide fieldwork. Fieldwork was completed to characterize and sample mafic–ultramafic units from the lower part of the Povungnituk to the upper part of the Chukotat, to assess the accuracy of currently available geological mapping and to fill gaps in those areas where information was deficient. In addition, more detailed field investigations and sampling were conducted across units representative of different stratigraphic levels and mineralization styles along north–south geological transects (perpendicular to regional strike).

WORK DONE

Compilation of a regional geochemical database started in October 2016 and a first comprehensive version was completed in July 2018 (Figure 1). Publicly-available data were collected from M.Sc. theses and Ph.D. dissertations, academic journals, provincial assessment and company mineral exploration reports filed with the Quebec Ministère de l’Énergie et des Ressources naturelles, and other open sources. A large, private dataset was also contributed by Glencore. Repetition of records within multiple sources facilitated validation of data accuracy; preliminary plotting with ioGAS software aided in the identification of incorrectly-recorded data or poor analyses, most of which could be corrected by referencing original sources or identifying common mistakes (e.g., Pd swapped with Pb). In general, records containing only assay results (Ni, Cu, PGEs and S) have been removed, leaving sample records with lithogeochemical analyses of major±trace elements.

Thirty-six days of fieldwork during the July–August 2017 field season resulted in visits to 200 localities and the collection of 167 samples (Figure 2). A total of 162 polished thin sections was prepared from these, digitally scanned and reviewed; 165 representative samples (including duplicates and standards) were analyzed for whole-rock geochemistry, the process of quality assurance and quality control completed, and resulting geochemistry preliminarily reviewed.

Thirty-five days of fieldwork during the July–August 2018 field season yielded 181 samples (including two for geochronology) collected from 337 visited localities (*see* Figure 2).

RESULTS

The current northern Nunavik lithogeochemical database contains nearly 9650 analyzed samples (85% from within the southern domain of the Cape Smith Belt, 10% from within the northern domain and 5% as yet undetermined or sampled outside the Cape Smith Belt; *see* Figure 1). An additional database of nearly 15 000 sample analyses spanning across Nunavik above latitude 60°N has been obtained from the Système d’information géominière (SIGÉOM, 2018) of the Quebec Ministère de l’Énergie et des Ressources naturelles. Upon preliminary review, questionable data from multiple datasets have been compared to original reports and found to be incorrect (likely copy errors); thus, original data is being extracted from primary sources to correct and validate parts of the SIGÉOM database before it can be used.

Previous researchers suggested that the mineralized mafic–ultramafic units of the Expo-Ungava South trend area within the Povungnituk group are related to the mineralized Raglan trend units at the base of the Chukotat group and that they (along with the unmineralized sills throughout the Povungnituk) comprise the magmatic feeder system for overlying Chukotat group volcanic rocks. Numerous possibilities exist for the actual relationships between these units; two simplified models (and evidence that would support them) are presented in Figure 3. In general, Expo-Ungava trend magmatism may be part of the same system as the Raglan trend (Expo-Ungava feeds Raglan), or they may be separate, although possibly petrogenetically and/or temporally related, systems. Additional complexities result if the units within each stratigraphic level are not part of the same system; for example, part of the Expo-Ungava trend within the lower Povungnituk group may have fed Raglan trend magmatism, whereas another part of the Expo-Ungava trend may be unrelated to Raglan trend mineralization and may have only fed upper Chukotat group volcanism. Thus, this project will necessarily progress from defining relationships between stratigraphic levels as stratigraphic groups, to distinguishing between units and/or deposits within specific levels.

Recent work suggests that various components of the magmatic plumbing system are temporally and petrogenetically related. Mungall (2007) suggested that the Raglan trend, Chukotat group and Expo-Ungava trend units are all of similar age and might be considered a single magmatic suite. Indeed, radiometric dating of gabbroic units at the Expo-Ungava (1882.7 ±1.3 Ma; Randall, 2005), Katinniq (‘hanging wall’ gabbro 1883.0 ±1.7 Ma and ‘footwall’ gabbro 1882.1 ±2.0 Ma; Bleeker and Kamo, 2018) and Cross Lake (1881.5 ±0.9 Ma; Bleeker and Kamo, 2018) deposits temporally links these units (*see* Figure 3). However, based upon public geochemical data and new field observations, bladed dikes and differentiated sills in the Expo-Ungava part of the system are derived from less magnesian magmas (maximum MgO <35 w. %; melagabbroic chilled margins) than the Raglan formation (maximum MgO >40 w. %; pyroxenitic chilled margins) and may not represent feeders to lava channels and channelized sheet flows in the Raglan parts of the system.

Preliminary results related to this study have been recently presented at the Geological Society of America 2018 Annual Scientific Meeting in Indianapolis (McKevitt, Lesher and Houlé, 2018), Québec Mines 2018 conference in Québec City and in the Targeted Geoscience Initiative 2018 report of activities (McKevitt, Lesher and Houlé, in press) to be released by the Geological Survey of Canada (GSC).

Remaining Work

Lithogeochemical data compilation and validation is ongoing to yield a cohesive, comprehensive database spanning across northern Nunavik but focused on the Cape Smith Belt. The non-private part of this dataset will be released publicly as part of a GSC Open File report.

Current geological maps are being improved based upon recent field analyses, satellite imagery and historic maps that are being digitized.

Petrographic, geochemical and geochronological analyses resulting from the 2018 field season will hopefully aid in developing and refining an accurate, cohesive model for the Expo-Ungava–Raglan magmatic plumbing system. Another field season is being planned for summer 2019.

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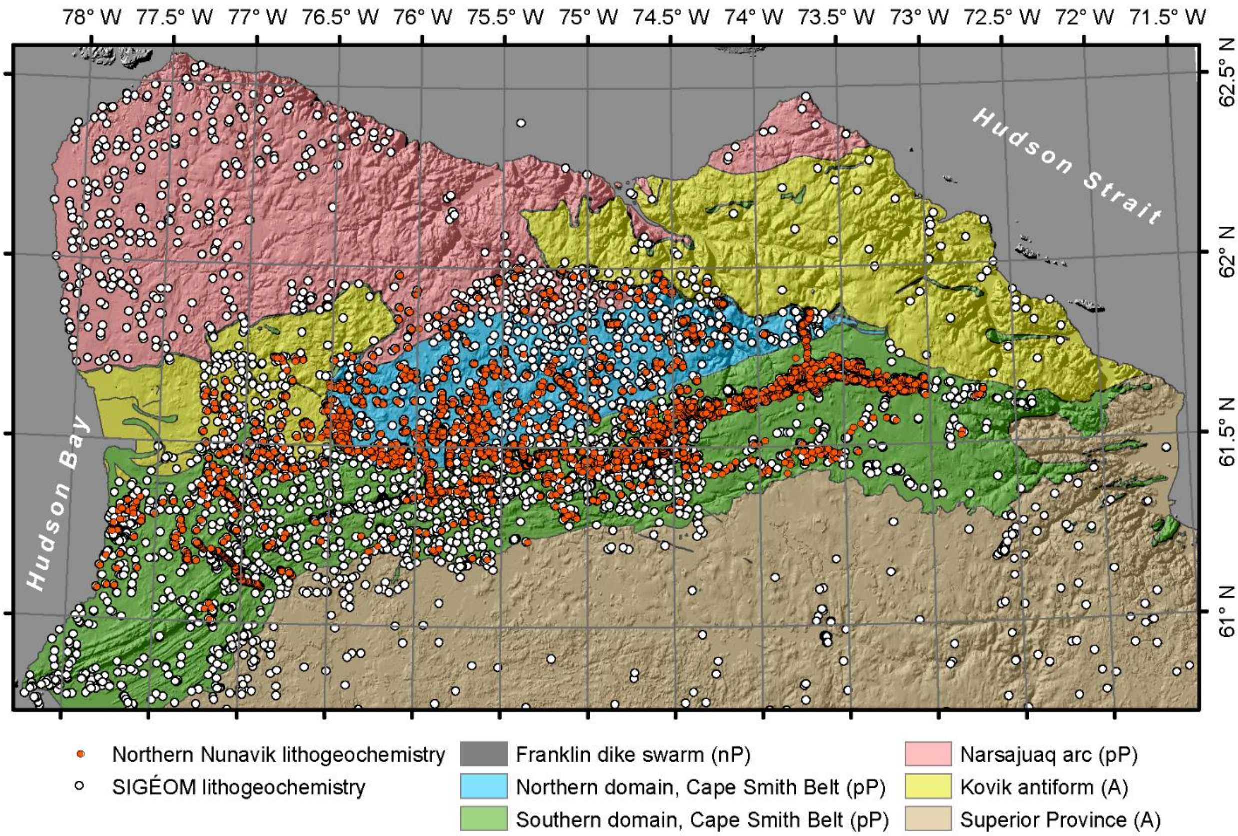

Figure 1. Map showing coverage of whole rock geochemical analyses across northern Nunavik and the Cape Smith Belt (Ungava Orogen). Two datasets are shown: red dots represent locations of approximately 9650 samples comprising an organized, 'clean' database compiled from private and public sources; white dots represent a subset of the SIGÉOM regional public dataset (SIGÉOM, 2018) comprising lithogeochemical analyses of nearly 15 000 samples across northern Nunavik above latitude 60°N. Some SIGÉOM data have been identified as incorrect, so validation and referencing of original reports is ongoing before this dataset can be used. Geology and underlying shaded relief after St-Onge et al. (2007). Abbreviations: A, Archean; nP, Neoproterozoic; pP, Paleoproterozoic.

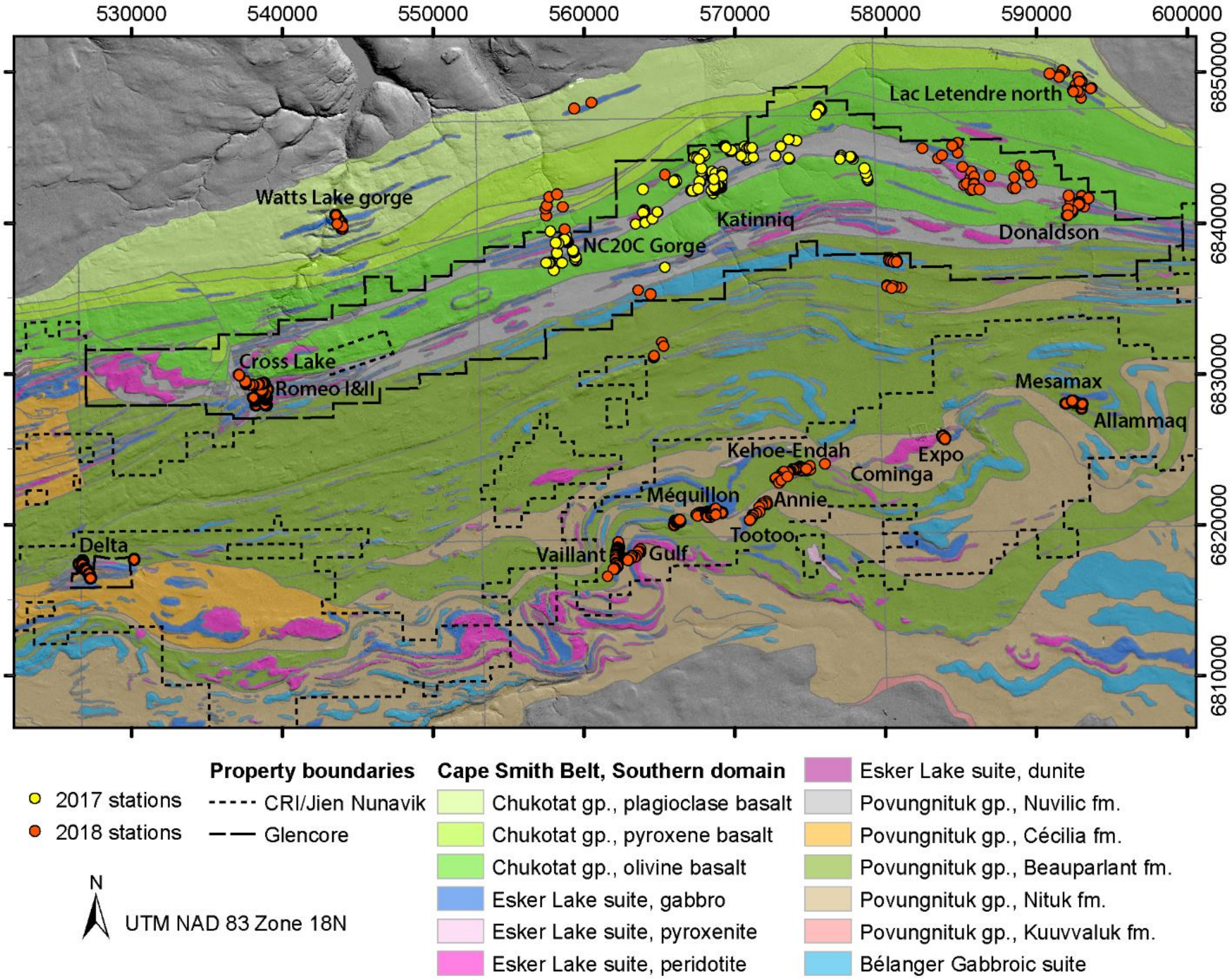

Figure 2. Map of the 2017–2018 field areas showing station locations and mafic–ultramafic units of interest (*see* Figure 3). Geology after Lamothe (2007) and St-Onge et al. (2007); overlying digital elevation model *from* Porter et al. (2018). Abbreviations: CRI, Canadian Royalties Inc.; Fm., formation; Gp., group.

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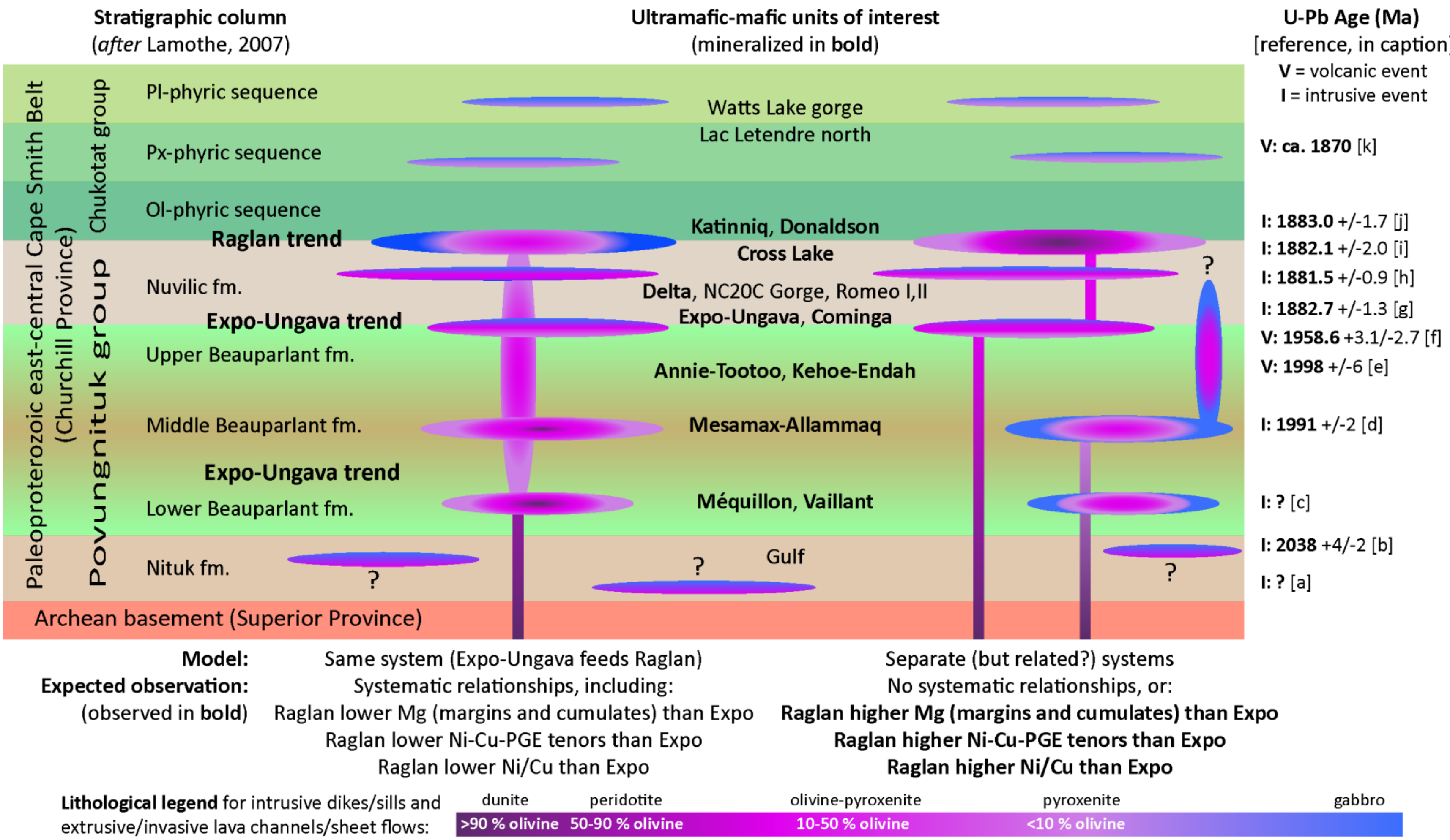

Figure 3. Diagram showing two generalized potential models for the Expo-Ungava–Raglan magmatic plumbing system in the east-central Cape Smith Belt. Select, representative units are placed in their approximate stratigraphic positions based upon field observations and current geological maps (e.g., St-Onge et al, 2007). Location of units is shown in Figure 2. Radiometric U-Pb zircon/baddeleyite ages are shown in their approximate stratigraphic positions and represent the most recent, lowest-error radiometric dates available for particular stratigraphic levels. Descriptions include: [a] Gulf differentiated sill (this study, analysis pending); [b] Korak gabbro sill (Machado et al., 1993); [c] Méquillon dike (this study, analysis pending); [d] granodiorite intrusion in pillowed basalt (Machado et al., 1993); [e] subvolcanic gabbroic unit (Kastek et al., 2016); [f] rhyolite near top of basalt sequence (Parrish, 1989); [g] varitextured melagabbro from Expo-Ungava intrusion (Randall, 2005); [h] gabbro sill near Cross Lake (Bleeker and Kamo, 2018); [i] Katinniq

‘footwall’ gabbro sill and [j] Katinniq ‘hanging wall’ gabbro (Bleeker and Kamo, 2018); [k] subvolcanic gabbroic unit (St-Onge, Lucas and Parrish, 1992). Abbreviations: Cu, copper; Fm., formation; Mg, magnesium; Ni, nickel; Ol, olivine; PGE, platinum group element; Pl, plagioclase; Px, pyroxene (group).