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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. 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 2016, the GEM program successfully carried out 17 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.

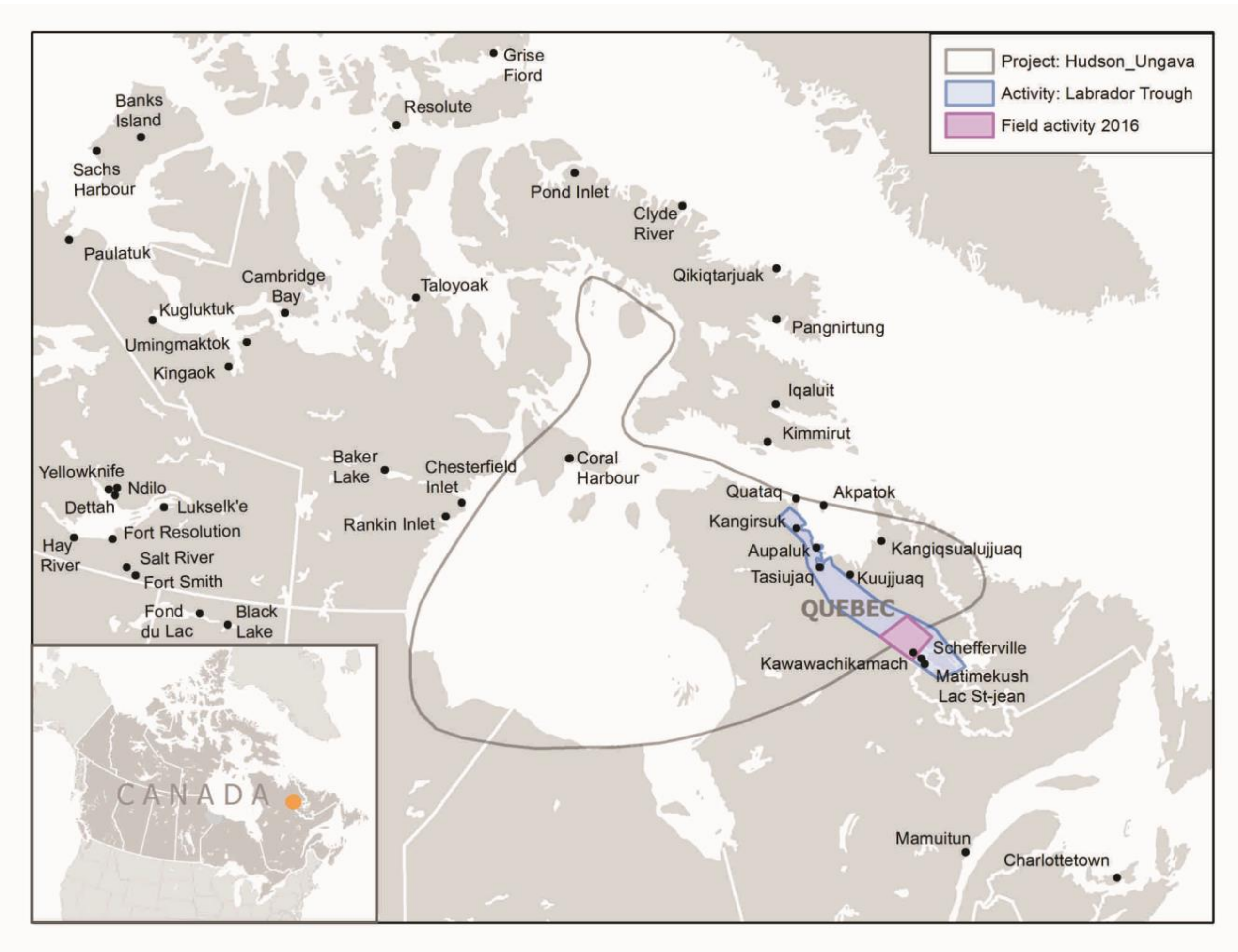


Figure 1: Approximate location of the Hudson-Ungava project (grey line) and the current area of focus for the Core Zone and bounding orogens activities (blue overlay, Labrador Trough). The location of the current activity is shown in pink.

Introduction

The Core Zone and bounding orogens activity (Figs. 1, 2) aims at providing a better understanding of the crustal growth, tectonic evolution and mineral potential of the Core Zone, as well as the orogens that border it to the west (New Quebec Orogen) and east (Torngat Orogen). Despite its relative accessibility, the Core Zone remained, prior to initiation of this activity, a relatively poorly known area of the Canadian Shield, lacking the basic and integrated lithologic, structural and metamorphic data that allow the formulation of robust crustal evolution models and inform potential correlations with crustal blocks elsewhere in the Churchill Province. In contrast, knowledge on the New Quebec Orogen is more advanced and has been synthesized recently by Clark and Wares (2005). However, the data sources are 1:50,000 scale maps produced decades ago, which are fairly accurate from a rock composition perspective but lack orogeny-scale constraints stemming from modern datasets (e.g., geochronology, basin analysis, structural analysis, metamorphic evolution) that would enhance knowledge on its tectonic evolution and provide further context for mineral deposits. This paper reports on the third and final field season of the “Core Zone and Bounding Orogens” project, specifically targeted on detailed investigations along a transect that crosses the southern extents of the New Quebec Orogen in the Schefferville area. This transect adds to a similar transect completed in the northern part of the New Quebec Orogen in the Kuujjuaq area, during the summer 2015 (Corrigan et al., 2015b; Houlé et al., 2015) and east of Schefferville in the adjacent 23-I and 23-P map sheets (Sanborn-Barrie et al., 2015).

The following sections provide a brief report on the result of field work conducted in the Schefferville area in June 2016. The rationale for this field campaign was to complete a tectonostratigraphic cross-section in the southern part of the New Quebec Orogen in order to add important data and observations there, which will enable comparisons with a similar transect completed in the northern part in of the orogen in the summer 2015, in the Kuujjuaq area. Field work was helicopter-supported and based out of Schefferville between June 7^{th} to 21^{st}. During that period about 120 observation points were made along a rough transect extending from the Archean basement contact eastwards to the undivided Core Zone (Figure 2). The two main targets of scientific focus were *i)* regional tectonostratigraphy and *ii)* nature and age of volcanism as well as mafic and ultramafic magmatism. The transect crossed the entire Kaniapiskau Supergroup including geological units forming Cycles 1, 2 and 3 of Clark and Wares (2005), as well as the Laporte Domain, generally interpreted to represent higher-grade metamorphic equivalents of the Kaniapiskau Supergroup. The area had been the focus of both regional and detailed bedrock geological mapping in the past (Taylor, 1979; Dimroth, 1970, 1972, 1978, 1981; Harrison et al., 1972; Dimroth and Dressler, 1978; Wardle and Bailey, 1981). This early body of work permitted more recent and thematic work by Le Gallais and Lavoie (1982), Clark and Thorpe (1990), Wardle et al. (1990), Wares and Skulski (1992), James and Dunning (2000), Skulski et al. (1993);

Rohon et al. (1993), Findley et al.(1995), and Clark and Wares (2005), for example, who have published stratigraphic and/or lithotectonic models based on limited geochemical and radiometric data. However, due to the paucity of robust radiometric ages, most stratigraphic and magmatic models in the region rely heavily on lithological correlations and perceived similarities in rock types and associations. Our work aims at revisiting and potentially revising existing stratigraphic and tectonic models by combining new databases such as high-resolution aeromagnetic maps and digital elevation models recently published by the Ministère des Ressources Naturelles du Québec and Geological Survey of Canada (D'Amours and Intissar, 2012), combined with systematic zircon provenance studies of major sedimentary units, regional and micro-structural analysis, as well as lithogeochemistry and precise U-Pb dating of igneous rocks.

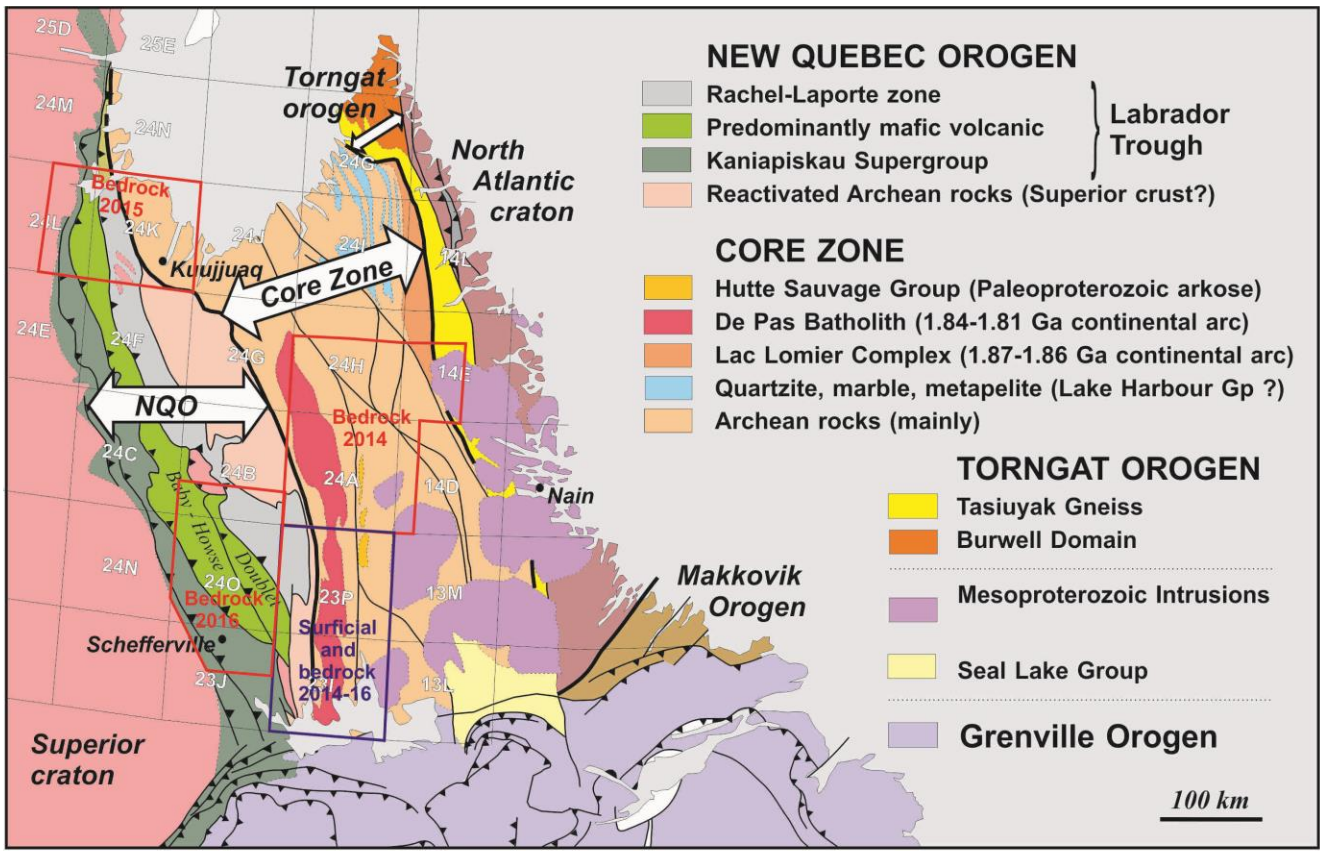


Figure 2: Simplified geological map of the Precambrian Shield east of the Superior Craton in Québec and Labrador. The box outlined in blue represents the area targeted for surficial and bedrock studies (see McClenaghan et al., 2014, 2015; Sanborn Barrie et al., 2015). The red boxes delimit areas investigated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

Methodology

Fieldwork was helicopter-supported and based out of Schefferville, Quebec, for a period of 14 consecutive days, from June 7^{th} to 20^{th}, with daily set-outs. Prior to field work, a GIS-based multi-layer database was assembled and included a digital elevation model image, various satellite imagery

(Spot, Landsat, GoogleEarth, RapidEye), radiometric maps, aeromagnetic maps, geological compilation maps (SIGEOM and a Newfoundland and Labrador geological compilation map), topography, 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, approximately 120 new observation points were made and rocks systematically sampled for petrographic and structural analysis. Over 30 samples were collected either for zircon provenance studies, 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 age-dating will be analyzed by either 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.

Results

Preliminary results from field observations are focused on four fronts including: *i)* the age of major lithological domains, *ii)* tectonics and basin evolution, *iii)* structural and metamorphic evolution, and *iv)* age and nature of mafic and ultramafic sills. All the above will contribute to enhancing basic geological knowledge and provide more rigorous constraints for the elaboration of tectonic evolution and metallogenic models.

i) Lithological Domains:

The geology of the New Quebec orogen in the Schefferville area provides a complete section from Archean basement in the foreland (Superior Craton), through variably metamorphosed and deformed cover sequences (Labrador Trough including the Laporte zone), and more deeply exhumed hinterland consisting predominantly of medium- to high-grade metamorphosed plutonic rocks of Archean and Proterozoic age (Fig. 4). The latter includes the Wheeler Dome, a likely uplifted block of Superior Craton basement, as well other mostly meta-plutonic domains interpreted as “undivided Core Zone” and whose association with the Superior craton is more obscure. The Labrador Trough, or more specifically the Kaniapiskau Supergroup, was the result of at least three episodes of basin formation accompanied by volcanism and magmatism on the eastern edge of the rifted Superior Craton margin, referred to in the literature as Cycles 1, 2 and 3 and each separated by unconformities (see Clark and Wares (2005) for a literature review and newly proposed stratigraphy, reproduced here in Figure 3). Cycle 1 (Seaward, Pistolet, Swampy Bay and Attikamagen groups, in bottom-to-top stratigraphic order), consist of clastic and chemical sedimentary sequences, with the Seaward Group intruded by a 2169 ±4 Ma Ga gabbro (Rohon et al., 1993) and Swampy Bay Group including mafic and minor felsic volcanism with the latter dated at 2142 +4/-2 Ma (B. Dressler and T. Krogh, cited in Clark, 1984). They are interpreted to represent rift to drift supracrustal sequences deposited on the Superior margin between ca. 2.2 and 2.0 Ga ago. Cycle 2 units lie unconformably on these supracrustal rocks and include a broad variety of pene-contemporaneous clastic and chemical sedimentary formations (Wishart, Ruth, Sokoman, Menihek) as well as mafic to felsic volcanic sequences (ca. 1.88 Ga Nimish

Formation; Findlay et al. 1995). Models of provenance and tectonic environment of emplacement for this group range from foredeep basin (Hoffman, 1988), to marginal pull-apart rift basins (Skulski et al., 1993), to back-arc basin (Rohon et al., 1993). Cycle 3 (Tamarak River formation) lies unconformably on Cycle 1 and 2 rocks and consists of conglomerate and arkose interpreted as a syn-orogenic molasse deposit (Clark and Wares, 2005).

From a geological map perspective, Wardle et al. (2002) subdivide the Kaniapiscau Supergroup in four different 'terranes" (see Figure 2), namely i) the autochthonous Chioak/Tamarak River formations (equivalent to Cycle 3); ii) the Schefferville Zone, which represents folded and metamorphosed rocks of Cycle 2 that are overthrust on Cycle 3 rocks; iii) The Baby-Howse Zone, which is underlain mostly by voluminous gabbro sills, with lesser mafic volcanic rocks and inter-flow sediments, and

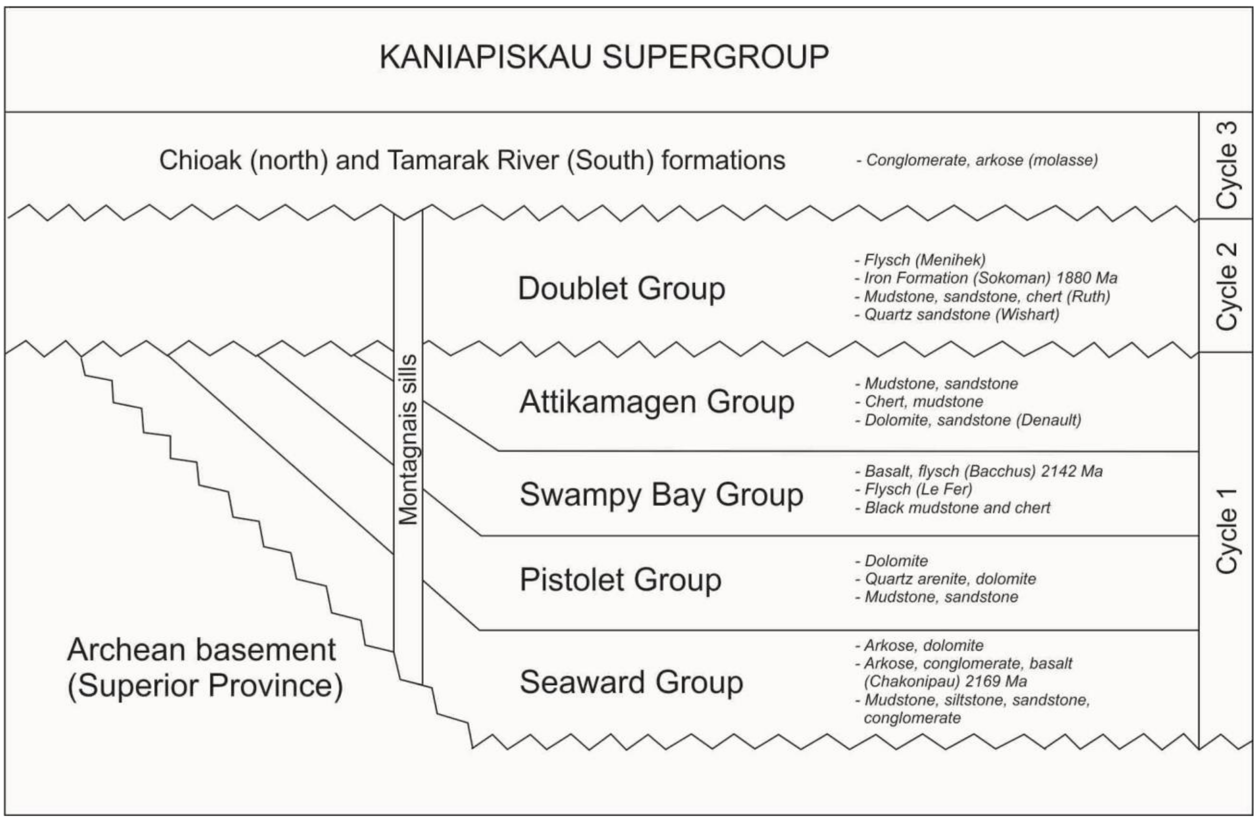


Figure 3: Simplified stratigraphy of the Kaniapiskau Supergroup, modified after Clark and Wares (2005).

iv), The Doublet zone, represented by large volume of mafic flows, deep-water metasediments, and intruded by mafic and ultramafic sills. The Baby-Howse zone contains a mixture of Cycle 1 and 2 rocks, whereas the Doublet zone contains exclusively Cycle 2 rocks.

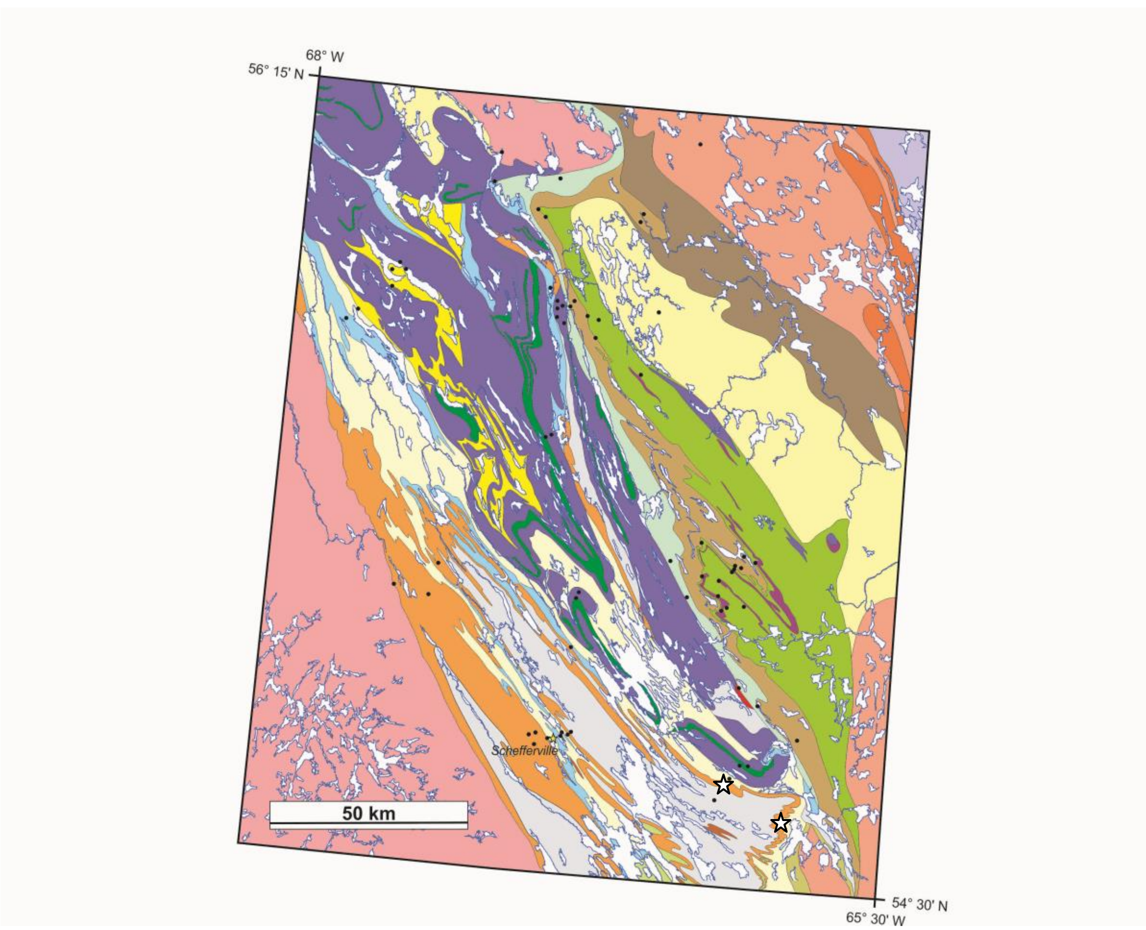
In order to test the above tectonostratigraphic models, we have collected ten samples of clastic sedimentary rocks from each of the main formations of Cycles 1 and 2. U-Pb dating of detrital zircons from each of these samples should provide a robust dataset on sediment maximum age and provenance and provide constraints on basin evolution. These data will be compared to a similar study undertaken within the northern Kuujjuaq transect (Corrigan et al., 2015b), and the southeastern part of the New Quebec Orogen (Sanborn-Barrie et al., 2015) and provide a belt-wide constraint on basin evolution of the Labrador Trough (Kaniapiskau Supergroup). A rhyolite spatially associated with the Menihek Formation in Cycle 2 was also sampled, with the aim of finding datable zircon.

i) Tectonics and basin evolution:

One of the main conclusions drawn from the 2015 field season in the Kuujjuaq area was that rocks of the Rachel-Laporte Zone comprised significantly different lithologies from the Kaniapiskau Supergroup to warrant reconsideration of previous correlations. In fact, the association of deep-water sediments deposited in an anoxic environment, mafic, ultramafic and minor felsic volcanism, the common occurrence of barren sulphides, and the presence of thick greywacke and psammitic sequences overlying these rocks suggested that they could potentially represent remnants of a continental back-arc basin. This model is currently being tested by geochemistry and U-Pb study of detrital zircons, and is supported by the presence of a ca. 1870 Ma continental arc suite east of the Rachel-Laporte Zone (V. McNicoll, in progress). The working model of Corrigan et al., (2015b) proposed that; i) the eastern half of the Rachel-Laporte zone actually consists of Archean gneiss which we assigned to the Kuujjuaq domain; and ii) Supracrustal rocks in the western half of the Rachel-Laporte zone represent different compositions and associations than those of the adjacent Baby-Howse zone, and more likely represent remnants of a continental back-arc basin, a hypothesis which we are continuing to test. One observation from this summer's work is that there appears to be an even greater diversity of preserved rock types and potential 'basins' in the southern part of the New Quebec Orogen. This is based on detailed sections through well-exposed areas, as well as interpretation of high-resolution aeromagnetic images. In order to test the hypothesis of multiple distinct basins, we have systematically collected mafic volcanic rock samples (see section below), which we will analyze for major, trace and REE elements and add to existing databases to see whether or not specific trends or associations can be observed.

i) Structural and metamorphic evolution:

The New Quebec orogen has been recognized as a zone of collision between the Superior Craton, its autochthonous and parautochthonous supracrustal cover, and the Core Zone (Wardle et al., 2002). Detailed studies of deformation and metamorphism, mainly done in the northern part of the orogen, suggest a relatively short-lived collisional event with a dextral strike-slip component between ca. 1.83 and 1.79 Ga (e.g., Perreault and Hynes, 1990). However, details of that complex collisional history, its structural evolution and its thermal response have yet to be fully understood or quantified using modern thermodynamic modelling and in-situ determination of metamorphic or cooling ages. To that end, we initiated a systematic re-evaluation of existing models in the northern Kuujjuaq transect during the 2015 field season. This work currently forms part of a M.Sc. thesis at the University of New Brunswick (Celine Porter), a M.Sc. thesis at university of Ottawa (Rebecca Montsion) and active research at University of Cape Breton by professor Deanne van Rooyen, in collaboration with professors Mike Williams (University of Massachussetts) and Chris McFarlane (University of New Brunswick). Our main observation from the 2016 field season is that the degree of orthogonal crustal shortening in the southern Schefferville transect appears to be substantially less than that observed in the northern section. Folds are in general more open and primary sedimentary and volcanic features better preserved. The metamorphic field gradient is also less abrupt in the south. This appears to corroborate the suggestion that a promontory may have existed along the ancient rifted Superior margin north of 57°N, prior to collision (Wares and Skulski, 1992). One common feature of the northern and southern transects, is evidence for pervasive transpressional tectonics (dextral-oblique) throughout the region, except perhaps areas nearest the edge of exposed Superior crust. For example, in the southern transect we have observed dextral thrust stacking of competent units, as well as a pervasive southern vergence of parasitic secondary folds developed on the orogen-parallel fold-thrust structures. Wherever possible, we have taken oriented samples which will be used for micro-analyses and where compositions permit, metamorphic temperature and pressure calculations and in-situ U-Pb dating of accessory minerals linked to fabric development. Results will be combined with those from the northern transect to provide orogen-scale tectono-metamorphic models. Such regional analysis may be useful in evaluation potential for orogenic gold and structural BIF enrichment, for example.



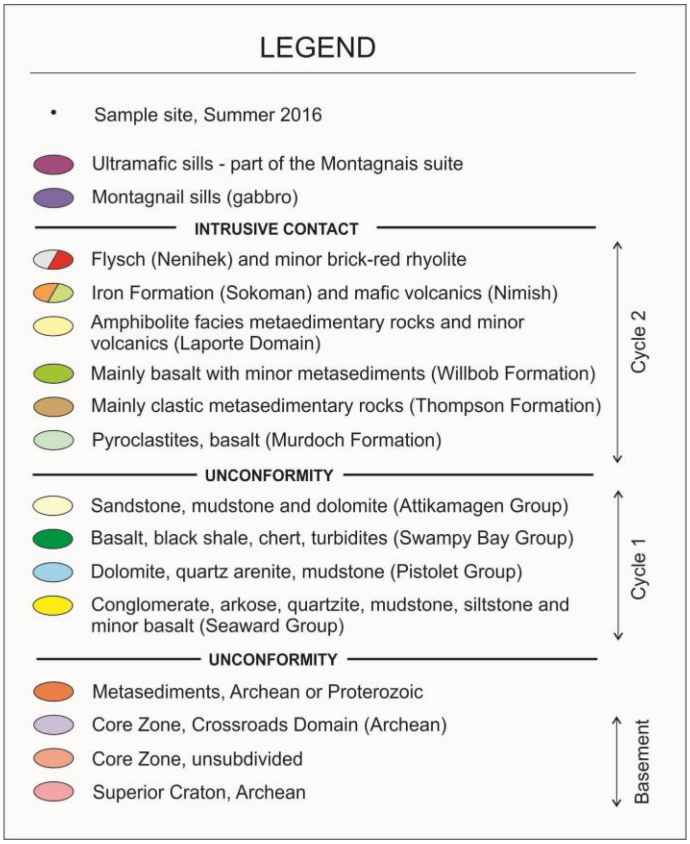


Figure 4: Simplified geological map and accompanying legend of the southern part of the New Quebec Orogen in the Schefferville area. (☆)= area of significant BIF enrichment (magnetite and possibly specularite) in fold hinges. Map modified after SIGEOM digital geological map database (http://sigeom.mines.gouv.qc.ca/SIGEOM_WMS/service.svc/get?) and the Geological Survey of Newfoundland and Labrador digital geoscience Atlas (http://geoatlas.gov.nl.ca/custom/help/Help_Layers.html)

ii) Mafic and ultramafic intrusions:

One of the targeted objectives of this project is to increase our knowledge of the history of emplacement of mafic and ultramafic suites with the goal of gaining insights on the prospectivity for magmatic-hosted Ni-Cu-PGE as well as Fe-Ti-V-P type deposits (e.g., Houlé et al., 2015). During the summer 2015, detailed sections across selected Montagnais sills (Clark and Wares, 2005) were completed and now form the basis of a M.Sc. thesis currently under way at Université Laval (Marie-Pier Bédard). A pegmatitic pocket in one of the sills yielded a preliminary U-Pb zircon age of 1884 ±1 Ma (V. McNicoll, personal communication), confirming the growing body of evidence suggesting the association of this gabbro suite with the widespread circum-Superior intrusive event (e.g., Heaman et al., 2009). This summer, we conducted a similar survey of representative mafic and ultramafic intrusions in the southern Schefferville transect to test for compositional and mineralogical variations. At least six different gabbro sills intruding both Cycle 1 and 2 sequences were sampled for U-Pb zircon and/or baddeleyite analysis. Results will be combined with those stemming from the northern transect and with previously published data, to provide constraints on the age and nature of this voluminous magmatic event, in particular to test whether there is more than one period of sill emplacement and whether sills from the different lithotectonic zones have common origins. A few mineralized samples from the mafic and ultramafic suites will be assayed for Ni-Cu and PGEs.

Conclusions

Despite the availability of relatively detailed maps and published stratigraphic correlations, few robust geochronological constraints exist for the Labrador Trough. In all, only about 6 or 7 reliable U-Pb ages are available for protoliths within the entire belt. This has made the testing of current models of crust formation and tectonic evolution somewhat challenging and opens the door for alternative models based on more robust geochronological and geological databases. The work initiated in 2015 and continued in 2016 will help to fill this knowledge gap by providing the first belt-scale set of constraints for basin evolution, tectonostratigraphic analysis, magmatism, deformation, metamorphism and tectonic evolution of the New Quebec orogen. The abovementioned research in the New Quebec Orogen will complete the work initiated in 2014 in the Core Zone (Corrigan et al., 2015a) and together will provide a significantly updated knowledge base for the tectonic evolution and mineral potential of the Core Zone and Bounding Orogen activity within the GEM-2 program. For the New Quebec orogen, this includes an assessment of prospectivity of magmatic suites for Ni-Cu-PGEs, as well as orogenic gold, among other commodities.

Acknowlegements

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References

Clark, T., 1984. Géologie de la région du lac Cambrien, Territoire du Nouveau-Québec. Ministère de l'Énergie et des Ressources, Québec, ET 83-02, 71 pages.

Clark, T., and Thorpe, R.I., 1990. Model lead ages from the Labrador Trough and their stratigraphic implications. *In*, The Early Proterozoic Trans-Hudson Orogen of North America. *Edited by* J.F. Lewry and M.R. Stauffer. Geological Association of Canada, Special Paper 37, pp. 413-432.

Clark, T., and Wares, R., 2005. Lithotectonic and metallogenic synthesis of the New Quebec Orogen (Labrador Trough), Minstère des Ressources naturelles, de la Faune et des Parcs, Québec ; MM 2005-01, 182 pages, 1 map.

Corrigan, D., Brouillette, P., Morin, A., Van Rooyen, D., Wodicka, N., Houlé, M.G., Douma, S.L., and Robillard, K., 2015a. Report of activities for the Core Zone and bounding orogens: Tectonic framework and mineral potential; Geological Survey of Canada, Open File 7706, 10 p.

Corrigan, D., Van Rooyen, D., Morin, A., Houlé, M.G., and McNicoll, V.J., 2015b. Report of activities for the Core Zone and Bounding Orogens: The New Quebec Orogen and its relationship with the Core Zone in the Kuujjuaq area; Geological Survey of Canada, Open File 7962, 11 p. doi:10.4095/297404

D'Amours, I., et Intissar, R., 2012. Levé magnétique et spectrométrique aéroporté de la rivière Koksoak, Province de Churchill, Ministère des Ressources naturelles et de la Faune, Québec, DP 2011-07, 8 pages, 180 plans.

Dimroth, E., 1970. Evolution of the Labrador Geosyncline. Geological Society of America Bulletin, vol. 81: 2717-2742.

Dimroth, E., 1972. The Labrador Geosyncline revisited. American Journal of Science, vol. 272: 487-506.

Dimroth, E., 1978. Région de la fosse du Labrador. Ministère des Richesses naturelles du Québec, Rapport géologique 193.

Dimroth, E., 1981. Labrador Geosyncline: type example of early Proterozoic cratonic reactivation. *In*, Precambrian Plate Tectonics (A. Kröner, editor). Developments in precambrian geology 4, Elsevier Scientific, Amsterdam, pp. 331-352.

Dimroth, E., and Dressler, 1978. Metamorphism of the Labrador Trough. *In*, Metamorphism in the Canadian Shield. Geological Survey of Canada, Paper 78-10, p: 215-236.

Findlay, J.M., Parrish, R.R., Birkett, T, and Watanabe, D.H., 1995. U-Pb ages from the Nimish Formation and Montagnais glomeroporphyritic gabbro, of the Central New Quebec Orogen, Canada. Canadian Journal of Earth Sciences, vol. 32: 1208-1220.

Harrison, J.M., Howell, J.E., and Fahrig, W.F., 1972. A geological cross-section of the Labrador miogeosyncline near Schefferville, Quebec. Geological Survey of Canada, Paper 70-37, 34 pages.

Heaman, L.M., Peck, D., and Toope, K. 2009. Timing and geochemistry of 1.88 Ga Molson Igneous Events, Manitoba: Insights into the formation of craton-scale magmatism and metallogenic province. Precambrian Research, vol. 172: 143–162.

Hoffman, P.F. 1988. United plates of America, the birth of a craton: Early Proterozoic assembly and growth of Laurentia. Annual Review of Earth and Planetary Sciences, vol.16: 543–603.

Houlé, M.G., Bédard, M.-P., McNicoll, V.J., Corrigan, D., and. Huot, F, 2015. Investigations of the mafic and ultramafic intrusive rocks of the Montagnais sills, northern Labrador Trough, Nunavik, Québec; Geological Survey of Canada, Open File 7979.

James, D.T., Dunning, G.R., 2000. U-Pb geochronological constraints for Paleoproterozoic evolution of the Core Zone, southeastern Churchill Province, northeastern Laurentia. Precambrian Research; volume 103, pages 31-54.

James, D.T., Nunn, G.A.G., Kamo, S., and Kwok, K. 2003. The southeastern Churchill Province revisited: U-Pb geochronology, regional correlations, and the enigmatic Orma Domain. Current Research, Newfoundland Department of Mines and Energy, Geological Survey Report 03-1, pages 35-45.

Le Gallais, C.J., and Lavoie, S., 1982. Basin evolution of the lower Proterozoic Kaniapiskau Supergroup Central Labrador miogeocline (Trough), Quebec. Bulletin of Canadian Petroleum Geology, vol. 30, p. 150-166.

McClenaghan, M.B., Paulen, R.C., Rice, J.M., Sanborn-Barrie, M., McCurdy, M.W., Spirito, W.A., Adcock, S.W., Veillette, J.J., Garrett, R.G., Grunsky, E.C., Pickett, J., Layton-Matthews, D., and Corrigan, D., 2014. GEM 2 Hudson-Ungava Project: southern Core Zone surficial geology, geochemistry, and bedrock mapping activities in Northern Quebec and Labrador; Geological Survey of Canada, Open File 7705, 2014; 18 pages, doi:10.4095/295521

McClenaghan, M.B., Paulen, R.C., Rice, J.M., McCurdy, M.W., Fortin, R., Spirito, W.A., Adcock, S.W., Ross, M.,Pyne, M., Dubé-Loubert, H., and Lion, A.J. 2015. Report of activities for the Core Zone: 2015 surficial geology, geochemistry, and gamma-ray spectrometry studies in northern Quebec and Labrador, Open File 7946, doi:10.4095/297388.

Perreault, S., and Hynes, A., 1990. Tectonic evolution of the Kuujjuaq terrane, New Quebec Orogen: Geoscience Canada, vol. 17- 4, p. 238-240.

Rohon, M.-L., Vialette, Y., Clark, T., Roger, G., Ohnestetter, D., and Vidal, P., 1993. Aphebian mafic-ultramafic magmatism in the Labrador Trough (New Quebec Orogen): Its age and the nature of its mantle source. Canadian Journal of Earth Sciences, vol. 30: 1582-1593.

Sanborn-Barrie, M., Rayner, N.M. and Lion, A., 2015. Report of activities for the 2015 bedrock component of the GEM Southern Core Zone activity, northern Quebec and Labrador. Geological Survey of Canada, Open File Report 7952.

Skulski, T., Wares, R.P., and Smith, A.D., 1993. Early Proterozoic (1.88-1.87 Ga) tholeiitic magmatism in the New Quebec Orogen. Canadian Journal of Earth Sciences, vol. 30: 1505-1520.

Taylor, F.C., 1979. Reconnaissance geology of part of the Precambrian Shield, northeastern Québec, northern Labrador and Northwest Territories. Geological Survey of Canada, Memoir 393, 99 pages and 19 maps.

Wardle, R.J., and Bailey, D.G. 1981. Early Proterozoic sequences in Labrador. In: Proterozoic Basins in Canada, Edited by F.H.A. Campbell. Geological Survey of Canada, Paper 81-10, pp. 331-359.

Wardle, R.J., Ryan, B., Nunn, G.A.G., and Mengel, F.C., 1990. Labrador segment of the Trans-Labrador Orogen: crustal development through oblique convergence and collision. *In* The Early Proterozoic Trans-Hudson Orogen of North America. *Edited by* J.F. Lewry and M.R. Stauffer. Geological Association of Canada, Special Paper 37, pp. 353-369.

Wardle, R.J., James, D.T., Scott, D.J., and Hall, J., 2002. The southeastern Churchill Province: synthesis of a Paleoproterozoic transpressional orogen. Canadian Journal of Earth Sciences; vol. 39, p. 639-663.

Wares, R.P., and Skulski, T., 1992. Evolution of the 2.2-1.7 Ga New Quebec Orogen. EOS, vol. 73, p. 333.