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**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7962**

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The New Quebec Orogen and its relationship with the Core
Zone in the Kuujjuaq area**

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2015

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doi:10.4095/297404

This publication is available for free download through GEOSCAN (<http://geoscan.nrcan.gc.ca/>).

Recommended citation

Corrigan, D., Van Rooyen, D., Morin, A., Houlé, M.G., and McNicoll, V.J., 2015. 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

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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 2015, 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.

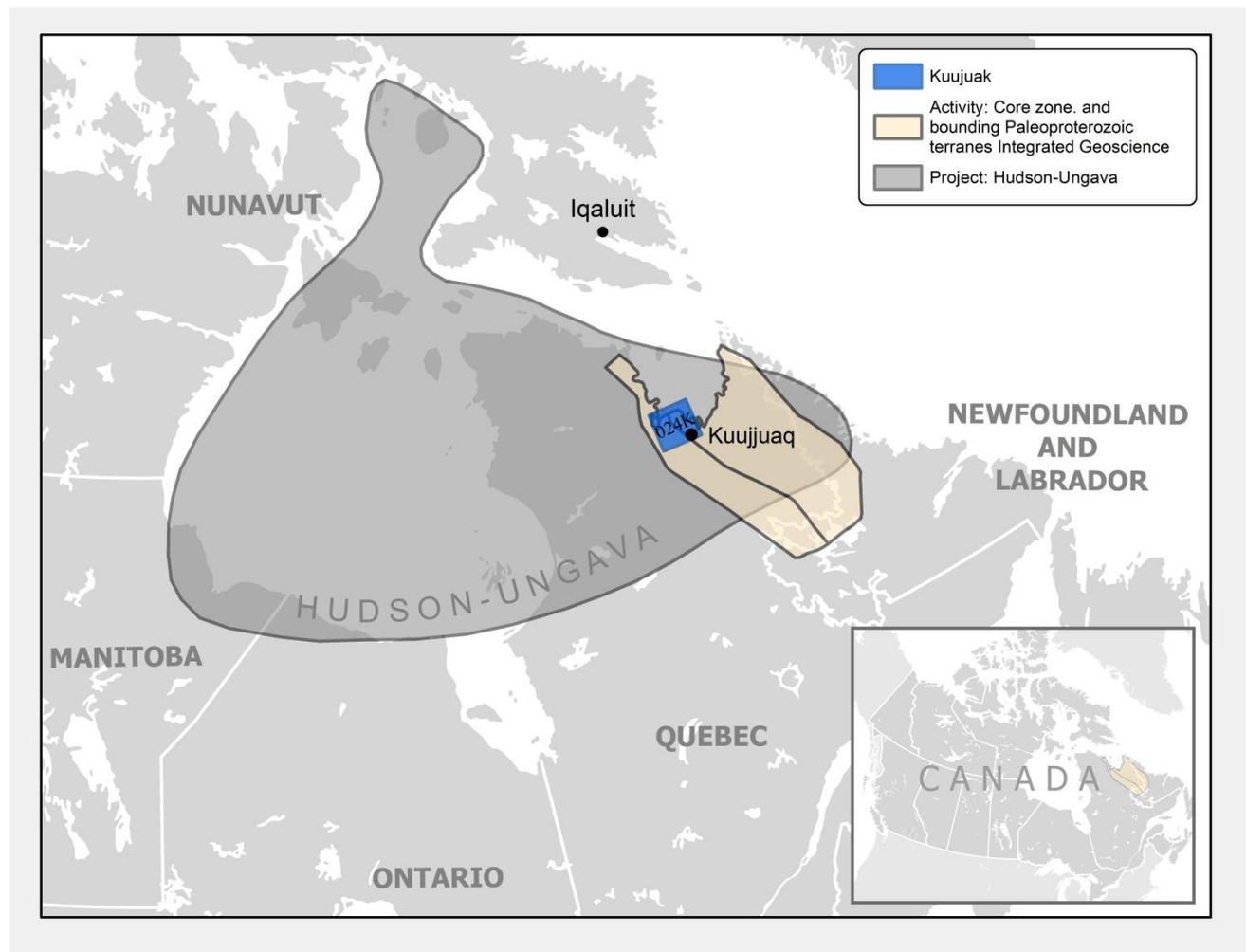


Figure 1: Approximate location of the Hudson-Ungava project (grey overlay) and the Core Zone and bounding orogens activities. The location of the current activity is shown in blue.

Introduction

The Core Zone and bounding orogens activity (Figs. 1, 2) aims at gaining 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, one of the least known regions 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 in southern Baffin Island. Similarly, the knowledge on the New Quebec Orogen, has been synthesized more recently by Clark and Wares (2004), but the data sources are 1:50 000 maps produced decades ago, which lack fundamental modern datasets (e.g., geochronology, basin analysis, structural analysis, metamorphic evolution) that would enable a better understanding of its tectonic evolution (e.g., Wardle et al., 2002) and potential for commodities such as magmatic- and VMS-type base metals and orogenic gold.

During the summer of 2014, a reconnaissance field campaign in the central part of the Core Zone covered parts of four 1:250,000 map sheet (Fig. 2) and yielded 40 new samples for radiogenic dating (U-Pb) and tracer isotope analyses (Corrigan et al., 2015). Results and interpretations from that survey are being completed and form the basis of a synthesis map to be published over the Fall/Winter 2015-16. Those preliminary results suggest that the central part of the Core Zone is composed of three tectonically amalgamated terranes including, from west to east, *i*) remnants of a ca. 2.70 Ga greenstone belt and associated plutons *ii*) an earliest-Paleoproterozoic terrane composed of volcanic, sedimentary and plutonic rocks, and *iii*) a ca. 2.8 – 3.2 Ga domain composed mainly of high-grade orthogneiss and migmatites. The Core Zone appears to have been tectonically extruded southwards during terminal collision at ca. 1.80 Ga. The report herein reviews the main highlights of the 2015 field season in the Kuujuaq area of northern Quebec, where a transect was completed across the New Quebec Orogen from exposed Superior Craton crust, to the eastern margin of the Core Zone, across variably deformed and metamorphosed supracrustal sequences of the Labrador Trough, including the Kaniapiscou Supergroup and its apparently correlative, higher metamorphic grade equivalent, the Rachel-Laporte zone (Fig. 2). Helicopter-supported field work was conducted in collaboration with the Ministère de l'Énergie et des Ressources naturelles du Québec (MERN) and was based in a camp located approximately 70 km NW of the town of Kuujuaq, on Lac Lizotte. The scale of mapping varied substantially depending on the scientific question being addressed. In addition to regional and targeted mapping, four specific themes are being investigated: *i*) tectonostratigraphy of the Labrador Trough, *ii*) extent and nature of Archean basement beneath – and east of – the Labrador Trough (Core Zone), *iii*) the nature, age and economic potential of mafic and ultramafic suites emplaced in the Labrador Trough, and *iv*) the tectonometamorphic evolution of the region and its potential to host orogenic gold mineralization.

The region chosen for the study, Kuujuaq map sheet 24K and surrounding sheets, offers a relatively well-exposed section across the Labrador Trough and western Core Zone. According to present lithotectonic subdivisions, it exposes the upper part of the 1st, as well as the 2nd and 3rd cycles of the Labrador Trough succession (Clark and Wares, 2004) from little-deformed and metamorphosed sequences lying unconformably on the Superior Craton (Kaniapiscou Supergroup), to their structural and metamorphic equivalents (Rachel-Laporte zone). The latter has been the subject of targeted M.Sc. theses completed at McGill University, parts of which were published in short article format in

Geoscience Canada (Perreault and Hynes, 1990; Moorhead and Hynes, 1990). More recently, the eastern half of the Kuujuaq map sheet was the focus of a regional mapping program by the MERN (1: 250 000 scale), with efforts being concentrated in the high-grade gneiss sequences of the Core Zone, and the Rachel-Laporte Zone (Simard et al., 2013).

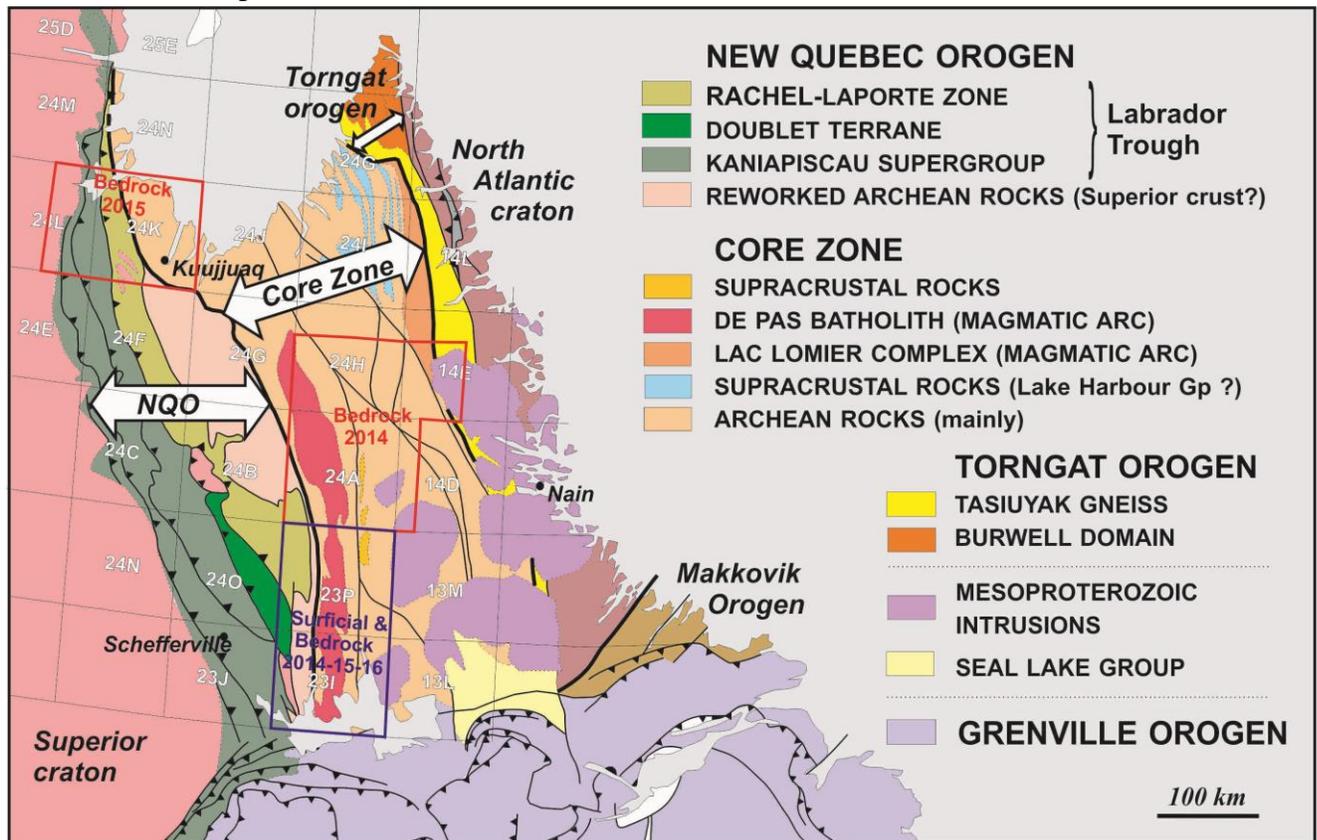


Figure 2: Simplified geological map of the Precambrian Shield east of the Superior Craton in Québec and Labrador. The box outlined in blue represents the area targeted for surficial and bedrock studies (see McClenaghan et al., 2014, 2015; Sanborn Barrie et al., 2015). The red boxes delimit areas investigated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

Methodology

Field mapping was a collaborative effort between the MERN and Geological Survey of Canada with the former's focus being mainly in the Labrador Trough supracrustal sequences complementing the latter's more regional work throughout both Paleoproterozoic cover and Archean basement rocks. Field work included detailed and regional mapping, stratigraphy, structural analysis, as well as detailed work in magmatic suites that have high economic potential including mafic and ultramafic suites intruding the Labrador Trough (Montagnais Suite), as well as the Kaslac plutonic complex, a layered mafic to intermediate intrusion emplaced in Archean crust of the Core Zone (Simard et al., 2013). Field work and traverse planning were facilitated by a new, high-resolution aeromagnetic survey acquired by the MERN in 2012 (D'Amours and Intissar, 2012). Overall, approximately 400 samples were collected for lithogeochemical analyses and a smaller number for assays. About 40 samples were collected for high-precision U-Pb radiogenic isotope dating for protolith age determination, as well as timing of metamorphism and deformation. The field research program included support for a post-doctoral study (see below; basin analysis and zircon provenance study),

three M.Sc. theses (*i*- mineralization in mafic-ultramafic sills; *ii*- history of deformation and metamorphism in the Rachel-Laporte Zone; *iii*- nature, age and mineral potential of the Kaslac layered intrusive complex), and one B.Sc. honours project (age and nature of a plagioclase megacrystic mafic intrusion).

Results

Preliminary results from field observations suggest that major advances will likely be made along three fronts including: *i*) the distribution of major lithological domains, *ii*) tectonostratigraphic evolution, *iii*) structural and metamorphic evolution, and *iv*) emplacement of mafic and ultramafic sills.

i) Lithological Domains:

The geology of the New Quebec orogen in the Kuujuaq area provides a complete section from Archean basement in the foreland (Superior Craton), through variably metamorphosed and deformed cover sequences (Labrador Trough including the Rachel-Laporte Zone), and deeply exhumed hinterland consisting predominantly of high-grade metamorphosed plutonic rocks of the Core Zone, which also contains supracrustal assemblages of Paleoproterozoic and possibly Archean age as well. Preliminary observations from this summer suggest that major improvements can be made in the definition of the Western part of the Core Zone, particularly on its age and relationship with the Rachel-Laporte Zone. In their report, Simard et al. (2013) defined a new lithotectonic domain forming the westernmost extent of the Core Zone, the Gabriel domain, which they interpreted as a Paleoproterozoic age crustal block composed predominantly metasedimentary rocks. It is overthrust onto the Rachel-Laporte Zone on its western side, along the Turcotte Lake shear zone, and is itself overthrust by the Archean-age Baie aux Feuilles domain on its eastern edge, along the Gabriel Lake shear zone. Our observations from this summer suggest that the Gabriel domain is predominantly composed felsic to intermediate orthogneiss and migmatite that are likely of Archean age and probably reworked Superior crust, corroborated by U-Pb ages obtained by Machado et al. (1989). These orthogneisses are locally interlayered with metasedimentary and metavolcanic rocks that could be either Archean or Paleoproterozoic age, but the former is more likely. However, rare marble and psammite units within the Gabriel domain do likely represent infolded Paleoproterozoic cover, adding complexity to the area and suggesting that both Proterozoic and Archean supracrustal rocks are present.

Our detailed work also confirmed the presence of meta-tonalite of likely Archean age within the eastern margin of the Rachel-Laporte Zone, identified as the Ballantyne suite in Simard et al. (2013). This suite is compositionally and texturally similar to the Archean-age orthogneissic suites in the Gabriel domain, and may be related to the latter. If so, it would require that the present boundary between the Labrador Trough and Core Zone be relocated up to 5 km further west, bringing into question the significance of the Turcotte Lake fault as a major suture or terrane boundary.

The current U-Pb sampling program will help resolve some of these first-order questions, which have major implications for the interpretation of the evolution of the New Quebec Orogen as well as

correlations with rock units along strike to the north and as far south as the Schefferville area. This correlation will be tested in the summer of 2016.

ii) Tectonostratigraphic Evolution:

The prevalent thought for the region is that the Rachel-Laporte Zone represents a more highly deformed and metamorphosed equivalent of the relatively low-grade and lesser deformed Kaniapiscou Supergroup sequence, both forming the Labrador Trough (Clark and Wares, 2004). That appears to be a correct assessment for the most part. However, some of the rock sequences mapped this summer in the Rachel-Laporte Zone are sufficiently different in composition and association to warrant revisiting older paradigms and stratigraphic nomenclature. For example, supracrustal rocks that stratigraphically overlie thick transitional MORB-type basalts (Hellencourt Formation) include abundant metasediments of probable mafic to felsic volcanogenic origin as well as staurolite-garnet schists, polymictic conglomerate with mainly fine-grained metasedimentary clasts, as well as isolated basaltic flows (identified as the Klein suite by Simard et al., 2013). This contrasts sharply with the continental margin sequences of the Kaniapiscou Supergroup, which include mainly continent-derived clastic sequences and dolomites hosting oxide- and carbonate-facies BIFs and their metamorphosed equivalents, with minor basalt of tholeiitic composition. Within the supracrustal package stratigraphically overlying the Hellencourt basalt, all clastic sediments were attributed to the Freneuse suite by Simard et al., 2013). However, observations suggest that there may be even more complexities, suggesting the presence of a number of unconformities representing different facies and tectonic environments of deposition. To address questions surrounding sedimentary provenance and tectonic setting, ten clastic rock units were sampled for detrital zircon studies and will form the basis of a post-doctoral study undertaken at Université Laval, in collaboration with the MERN and the geochronology laboratory at the Geological Survey in Ottawa. Neodymium isotopes will also be utilized to determine whether some of the mafic volcanic units in the Gabriel domain are of Proterozoic or Archean age. All the above will allow the reassessment of current tectonostratigraphic models and development of new ones based on precise geochronological data and tectonic evolution models.

iii) 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). A few local studies of deformation and metamorphism done in parts 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. In order to construct a robust tectonothermal framework, part of our work this summer was dedicated to the completion of a transect across the entire orogen, from foreland to deep hinterland, begun in the summer 2014. Structures were mapped at various scales and oriented samples with key metamorphic assemblages were systematically collected across all the different crustal blocks. Syn-deformation intrusions were collected to help pin the relationship between deformation and metamorphism. Together, these data will provide the first comprehensive dataset across the northern part of the orogen

and will establish constraints on the tectonic evolution of the region, from initial accretion and collision to the timing of transpressional convergence linked to far-field stresses, possibly related to oblique collision with the North Atlantic Craton. Part of this study will form the basis of a M.Sc. thesis at the University of New Brunswick, supported by a Research Affiliate Program bursary. This study will also help assess the role of peak-metamorphic, syn-collisional extension and release bends in the formation of potential structural traps for gold.

iv) 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 (see also Houlé et al., in press). For this purpose, a large number of mafic and ultramafic sills distributed across the entire Labrador Trough section were sampled, all historically grouped into the Montagnais suite despite different textures and compositions. Also, large isolated intrusions in the Core Zone were visited and sampled. Two distinct suites form part of new M.Sc. studies underway at Université Laval. One addresses the nature and mineral potential of ca. 1.88 Ga metagabbros of the Montagnais suite, and the other, the age and nature of the Kaslac plutonic complex, a large, layered intrusion with known Fe-Ti-V mineralization. These studies will be supported by the GSC, the first through a Research Affiliate Program bursary and analytical support, and the second by analytical support. We have also sampled a variety of other mafic and ultramafic sills of various composition and texture, for lithochemical analysis and U-Pb dating. The new information gathered on the mafic and ultramafic intrusions will help compare the magmatic history of the Labrador Trough with other areas along the Superior Craton margin, including world-class Ni-Cu-PGE districts in the Cape Smith (Raglan - QC) and Thompson (MB) nickel belts of similar age (e.g., Heaman et al., 2009).

Conclusions

Despite the availability of relatively detailed maps and published stratigraphic correlations, the Labrador Trough remains one of the least dated belts in Canada, with only about 12 reliable U-Pb ages available for the entire area. This has made the testing of current models for crust formation and tectonic evolution quite difficult and opens the door for alternative models based on more robust geochronological and geological databases. This activity will help to fill this knowledge gap by providing the first complete set of constraints for tectonostratigraphic analysis, magmatism, deformation, metamorphism and tectonic evolution across a key transect in the northern part of the New Quebec orogeny near Kuujuaq. This will be followed in the summer of 2016 by a similar transect in the southern part of the orogen in the Schefferville area, completing a transect already initiated by the GSC (Sanborn Barrie et al., 2015). The research done on the New Quebec orogen will complete the work initiated in 2014 in the Core Zone (Corrigan et al., 2015) 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 BIF-hosted and orogenic gold.

Acknowledgements

We wish to thank staff at Technical Field Support and Services and the Polar Continental Shelf Program for efficient logistical support. Nunavik Rotors, Air Inuit and Canadian Helicopters provided excellent fixed- and rotary-wing support. Carl Bilodeau of the MERN is thanked for facilitating a very fruitful federal-provincial collaboration and sharing numerous ideas in the field. Internal review by John Percival is appreciated.

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