Preliminary Results of Summer 2019 Fieldwork in the Northwestern Pontiac Subprovince, Rouyn-Noranda Area, Quebec

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INTRODUCTION

In this report, partial results from fieldwork of a Ph.D. project conducted by the lead author in summer 2019 are presented. The study area (Figure 1) is located approximately 9 km south of the city of Rouyn-Noranda, Québec. The aims of the project were to constrain the extent to which the fluids released during Barrovian metamorphism (from the biotite to the sillimanite zone) of the northwestern Pontiac Subprovince contributed to the significant endowment in gold of the Cadillac–Larder Lake fault zone (CLLFZ)—a world-renowned gold district in the Abitibi greenstone belt. Further constraining the metamorphic evolution of the Pontiac Subprovince will also provide an opportunity to better understand its geodynamic significance.

The fieldwork involved the description of approximately 110 outcrops (Figures 1, 2); examination of oriented and nonoriented thin sections from systematically sampled metapelitic rocks (biotite–sillimanite zone); and the recognition of their spatial distribution, stratigraphic stacking and lithological relationships. The structural analysis involved standard procedures for the description of geometric and kinematic relationships among tectonic structures in the field; the collection with compass of structural data such as foliations, lineations, folds and faults; and the determination of their hierarchy, based on superposition criteria (e.g., Ramsay and Huber, 1983; McClay, 1987; Ragan, 2009).

GEOLOGICAL SETTING

The Pontiac Subprovince is an Archean clastic metasedimentary-granitoid gneiss terrane located along the southeastern margin of the Superior Province (Camiré and Burg, 1993; Benn et al. 1994). Its northern limit is bounded by mafic and ultramafic flows of the Piché group (Pilote et al., 2015) within the CLLFZ. Its southeastern boundary is the Grenville Province (Rivers, 1997), whereas the western portion is covered by Proterozoic sequences of the Huronian Supergroup (Fedo et al., 1997).

Results from detrital zircon analyses (e.g., Gariépy et al., 1984; Davis, 2002; Frieman et al., 2017) indicated two major sources for the Pontiac metasediments. The first is attributed to the Abitibi greenstone belt based on the Neoarchean ages (ca. 2682 Ma) of the youngest detrital zircon populations (80–95% of the total) and the 2682 ±1 Ma zircon crystallization age of the crosscutting Lac Fournière pluton (e.g., Mortensen and Card, 1993; Davis, 2002; Frieman et al, 2017). Frieman et al. (2017) argued that the second source involves the Winnipeg River, Marmion and Opatica subprovinces, which contributed Mesoarchean detrital zircon populations to the Pontiac Subprovince. The Archean evolution of the Pontiac Subprovince has been attributed to three different tectonic models: 1) a fore-arc accretionary wedge (e.g., Dimroth et al., 1983; Daigneault et al., 2002; Frieman et al., 2017); 2) a syn-orogenic foreland basin or exotic terrane that collided with the Abitibi greenstone belt (e.g., Feng and Kerrich, 1992; Camiré and Burg, 1993; Davis, 2002); or 3) a rift-fill basin between ribbon continents that were later deformed and metamorphosed during underplating (Bédard, 2018; Piette-Lauziére et al., 2019).

The northwestern Pontiac Subprovince is mostly composed of a monotonous turbiditic greywacke and mudstone succession (Pontiac group) interbedded with a few minor mafic and ultramafic bodies (Figure 1). The metasedimentary rocks underwent Neoarchean (2657 ±4.4 Ma; Lu-Hf age from garnet) clockwise looping P-T-t path metamorphism, with conditions ranging from greenschist to amphibolite facies (Figure 2; Piette-Lauzière et al., 2019). Felsic to intermediate rocks from the Réservoir Decelles batholith and Lac Fréchette pluton intruded both the basement and supracrustal rocks (Figure 1; Ghassemi, 1996). Several north-northeast-oriented Proterozoic dyke swarms (Matachewan, Abitibi and Sudbury) crosscut the other lithotypes (Figure 1).

The structural framework of the Pontiac Subprovince is highly debated, but most workers agree on the existence of at least two deformational regimes (e.g., Camiré and Burg, 1993; Benn et al., 1994; Ghassemi, 1996; Bedeaux et al., 2017; Perrouty et al., 2017; de Souza et al., 2019; Piette-Lauziére et al., 2019). The first deformational regime is attributed to the north–south shortening event represented by a regional penetrative east-trending schistosity (S_p), which is axial planar to the regional folds ($F_{p;}$ Bedeaux et al., 2017). The second regime corresponds to an extensional movement recorded along major fault zones and encompasses sigmoid-shaped fragments, bookshelf structures along the acquired S_p schistosity and the presence of an S_{p+1} crenulation cleavage with associated open folds (Bedeaux et al., 2017). In the northwestern Pontiac Subprovince (Figures 1, 2), Camiré and Burg (1993) identified a nappe system divided into an upper nappe, which recorded two deformation events, and a lower nappe, which showed evidence of only one deformation event. Alternatively, Benn et al. (1994) and Ghassemi (1996) suggested that the two deformation events could be observed in the whole metasedimentary package of the Pontiac group.

FIELD RELATIONSHIPS

The Pontiac group comprises mainly a sequence of metawacke and metapelitic rocks intercalated with minor thin lenses of mafic to ultramafic bodies (Figure 3). They form a series of discontinuous outcrops based on systematic field mapping supported by aeromagnetic data (SIGÉOM, 2019). The metasediments display a regional penetrative schistosity (S_p) usually parallel to a millimetre- to centimetre-thick compositional layering ($S_{0;}$ Figure 3a). Both schistosity (S_p) and layering (S_0) exhibit a subvertical northeast-trending orientation. Minor bodies of mafic and ultramafic rocks occur wrapped in the S_p foliation as centimetre- to metre-sized deformed boudins (Figure 3b), while hydrothermal haloes around veinlets contain plagioclase and nonoriented actinolite crystals (Figure 3c), and crosscut the earlier S_p schistosity. Five metamorphic zones striking parallel to the regional foliation (S_p) were observed to the south of Rouyn-Noranda. These are shown, from north to south, on Figure 2: a biotite zone (biotite+chlorite±muscovite), a garnet zone (biotite+garnet±chlorite±muscovite), a staurolite zone (biotite+garnet+staurolite±chlorite±muscovite), a kyanite zone (biotite+garnet+staurolite+kyanite±chlorite±muscovite) and a sillimanite zone (biotite+garnet+staurolite+kyanite+sillimanite±chlorite±muscovite). These observations are consistent with those noted in previous work done in the Rouyn-Noranda area (Camiré and Burg, 1993; Ghassemi, 1996).

The Réservoir Decelles batholith is mainly composed of greyish, medium- to fine-grained, leucocratic two-mica monzogranite. Locally, these rocks were overprinted by the same S_p regional schistosity as the metasediments in the northern part of the intrusion (Figure 1). In some outcrops, centimetre- to metre-sized enclavess of metapelite were observed (Figure 3d). A subordinate rock type is characterized as a pinkish, coarse-grained to pegmatitic phase that intrudes the metasediments along abrupt contacts.

FUTURE WORK

This project involves a multitechnique approach, including petrographic, microstructural and scanning electron microscope-based mineral liberation analyses of samples from the biotite- to sillimanite-zone rocks, to identify the mineral assemblages, textural relationships and microstructures, as well as to measure the modal mineralogy. In addition, micro X-ray fluorescence and electron microprobe analysis will provide qualitative and quantitative results on the mineral chemistry of representative thin sections of each metamorphic zone. These analyses will be carried out during the winter season (2019–2020). Isochemical phase diagrams (phase-equilibria modeling) will be constructed to constrain the regional metamorphic P-T paths. The composition of the Pontiac Subprovince-derived fluids in terms of C-O-H-S isotopes and trace elements will be characterized through multiple sulphur isotope analysis (secondary-ion mass spectrometry), C-O-H stable isotope analysis (isotope-ratio mass spectrometry), and trace-element analysis (laser-ablation inductively coupled plasma–mass spectrometry) of sulphides (i.e., pyrite, pyrrhotite), carbonates and hydrous phases. Whole-rock and mineral major, trace and isotopic geochemical data will be integrated with phase-equilibria modeling to infer the volume and composition of fluids released during Barrovian metamorphism. Multimethod geochronology will be used to date specific fluid-producing metamorphic reactions, including Lu-Hf geochronology of garnet and U-Pb geochronology of zircon, monazite and titanite. The timing of these fluid pulses and their modeled composition and volume will be compared to inferences from the gold deposits of the CLLFZ to test how metamorphism of the Pontiac Subprovince contributed to the regional endowment in gold. The results will 1) provide a deeper understanding of the controls on the development of orogenic gold mineralization during Barrovian metamorphism and 2) be tested against the current tectonic models proposed for the Archean geodynamic evolution of the Pontiac Subprovince.

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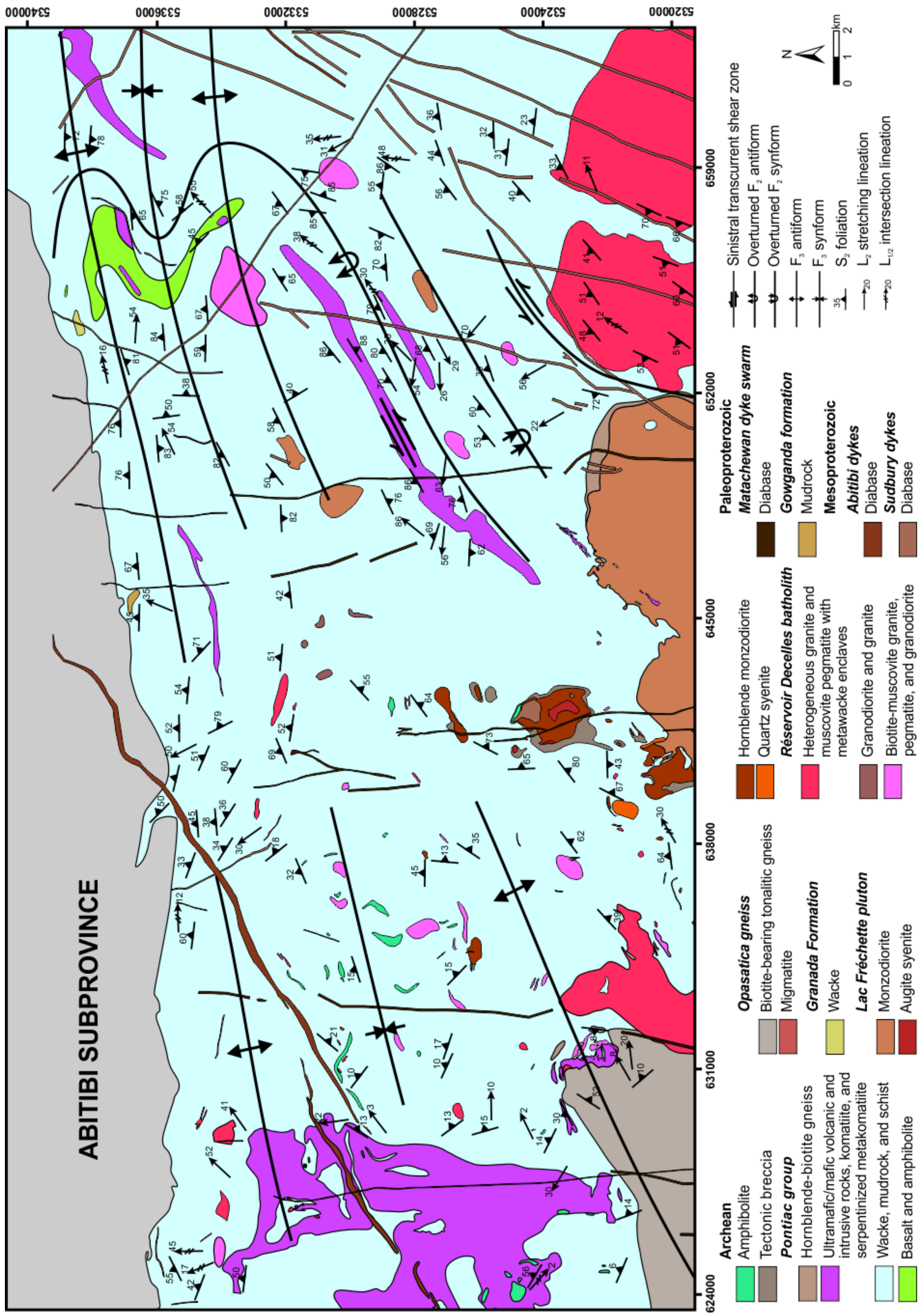

Figure 1. Geology of the northwestern Pontiac Subprovince (*modified from* Ghassemi, 1996 and SIGÉOM, 2019).

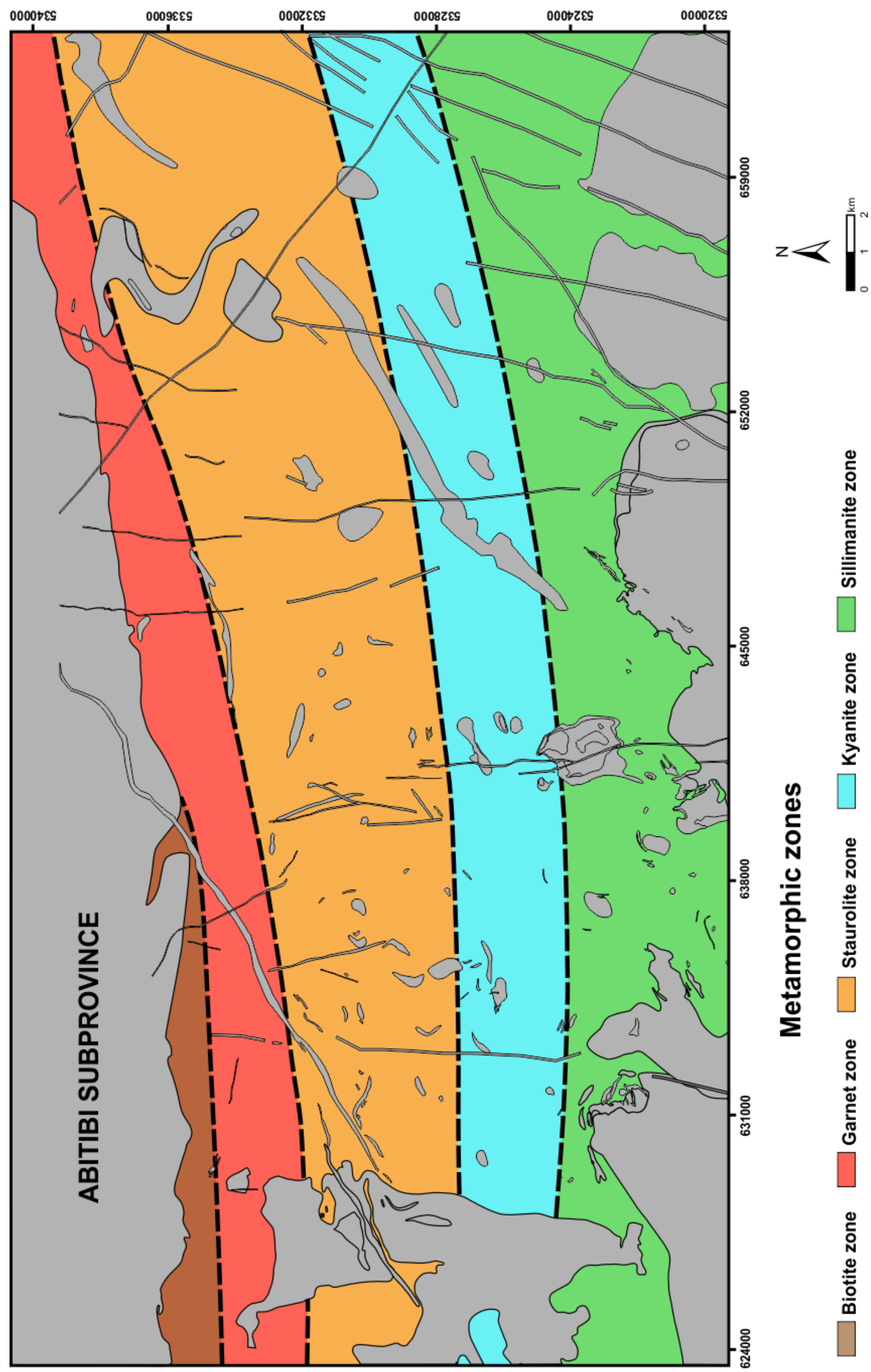

Figure 2. Metamorphic mineral zones in the northwestern Pontiac Subprovince (*modified from* Ghassemi, 1996).

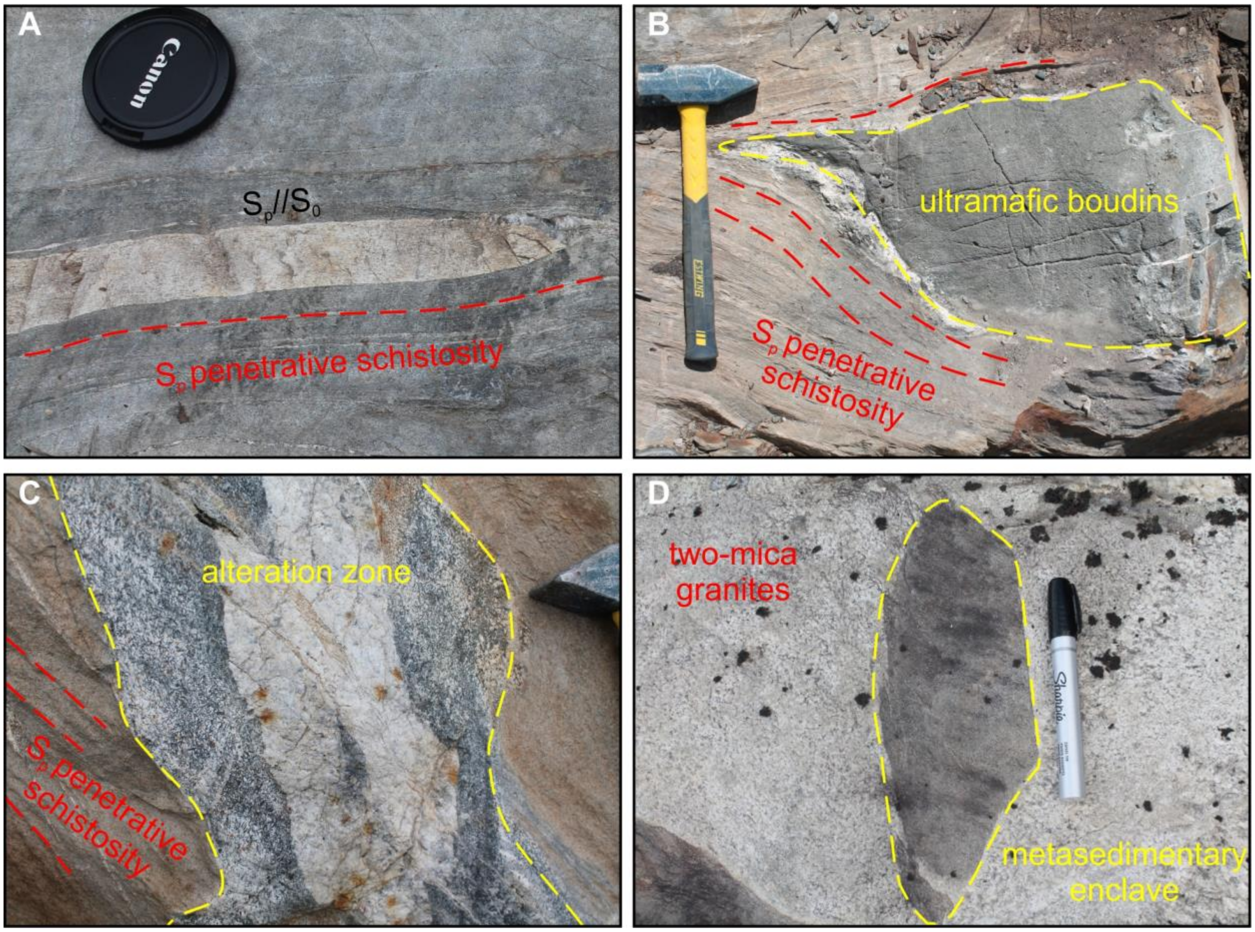

Figure 3. Photographs of the rock types from the Pontiac group and Réservoir Decelles batholith: **a)** metapelitic rock showing an S_p schistosity parallel to compositional layering (S_0); **b)** centimetre-sized ultramafic boudin wrapped in the S_p schistosity; **c)** alteration zone (plagioclase+actinolite) crosscutting the earlier S_p schistosity; **d)** greyish two-mica granite exhibiting an elongated metasedimentary enclave.