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Regional and local controls on mineralization and pluton emplacement in the Bondy gneiss complex, Grenville Province, Canada interpreted from aeromagnetic and gravity data

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ABSTRACT

The Bondy gneiss complex in the Grenville Province of Southwest Quebec hosts a mineralized iron oxide- and copper-rich hydrothermal system. The northern part of the complex overlies the lithospheric-scale Mont-Laurier lineament and is cut by the regional Mont-Laurier South shear zone interpreted from Bouguer gravity. A sinistral 6 km wide strike–slip corridor defined by several second-order shears (the Mont-Laurier South shear zone) in the complex was identified from geophysical data, including a new high-resolution airborne magnetic survey, and field observations. The spatial association of a metamorphosed alteration system, several pre- to post-metamorphic mineralized zones and mafic intrusions within the Mont-Laurier South shear zone suggests that (i) underlying basement structures controlled hydrothermal fluid migration during the formation of epithermal-IOCG mineralization and associated alteration system before ca. 1.2 Ga high-grade metamorphism and penetrative ductile deformation in the complex; (ii) post-metamorphic reactivation allowed magma ascent and pluton emplacement in the complex and adjacent supracrustal rocks within dilatational sites; and (iii) brittle–ductile shears that postdate high-grade metamorphism provided channel ways for fluid migration associated with magnetite-related mineralization. Although the complex does not host an economic mineral deposit, the role between structures at different levels and the combination of gravity and aeromagnetics at different scales provides an example of an approach for mineral exploration in similar high grade gneiss terrains.

1. Introduction

Structural controls are fundamental elements in the genesis, remobilization, and worldwide distribution of many mineral deposits including porphyry Cu–Au, Carlin-type Au, epithermal sulphide, SEDEX, VHMS and iron oxide copper–gold ± REE ± U (IOCG) deposits. Identification of crustal to lithospheric scale structures is of particular interest in regional exploration targeting as they provide channel ways for fluid migration, facilitating fluid–host rock interaction, and can focus economic mineralization (e.g., Drummond et al., 1998; F. Bierlein et al., 2006; F.P. Bierlein et al., 2006; Groves and Bierlein, 2007; Ge et al., 2009; Austin and Blenkinsop, 2010) in various geodynamics settings (Chernicoff et al., 2002; Groves and Bierlein, 2007). Paradoxically, large scale, deeply penetrative structures, which play a major role in formation of mineralized systems, may not be apparent from mapping of isolated surface exposures (Austin and Blenkinsop, 2008). This study provides an example of the surface expression of a long-lived lithospheric-scale structure and its relationship to mineralization and pluton emplacement at different stages in regional deformation.

The Grenville Province in North America is a Mesoproterozoic orogen displaying a complex tectonic history (Rivers, 1997; Dickin and McNutt, 2007; Davidson, 2008; Hynes and Rivers, 2010; McLelland et al., 2010) with favourable geodynamic environments for mineral deposit formation (Blein et al., 2003; Gauthier and Chartrand, 2005; Corriveau et al., 2007). From regional potential field data, Dufréchou et al. (2014) interpret the Mont-Laurier shear corridor, a new transverse sinistral shear corridor in the Central Metasedimentary Belt of Quebec (CMB-Q, also termed the Mont-Laurier terrane by Martignole et al., 2000; Fig. 1a) which is dominated by amphibolite-facies quartzite and marble (the Sourd group; Wynne-Edwards, 1972; Nantel, 2008; Corriveau, 2013). The Mont-Laurier shear corridor is bounded to the south by the Mont-Laurier South shear zone that cross cuts the Bondy gneiss complex (BGC; Fig. 1b). This complex is one of several high-grade basement gneiss domes in the CMB-Q (Corriveau et al., 1998; Corriveau, 2013) and hosts a Cu–Au–Fe hydrothermal system (Corriveau et al., 1997; Blein et al., 2004). Previous field studies in the BGC and the adjacent metasedimentary rocks (e.g., Corriveau et al., 1997; Corriveau and Jourdain, 2000; Harris et al., 2001; Blein et al., 2003; Boggs and Corriveau, 2004; Wodicka et al., 2004;

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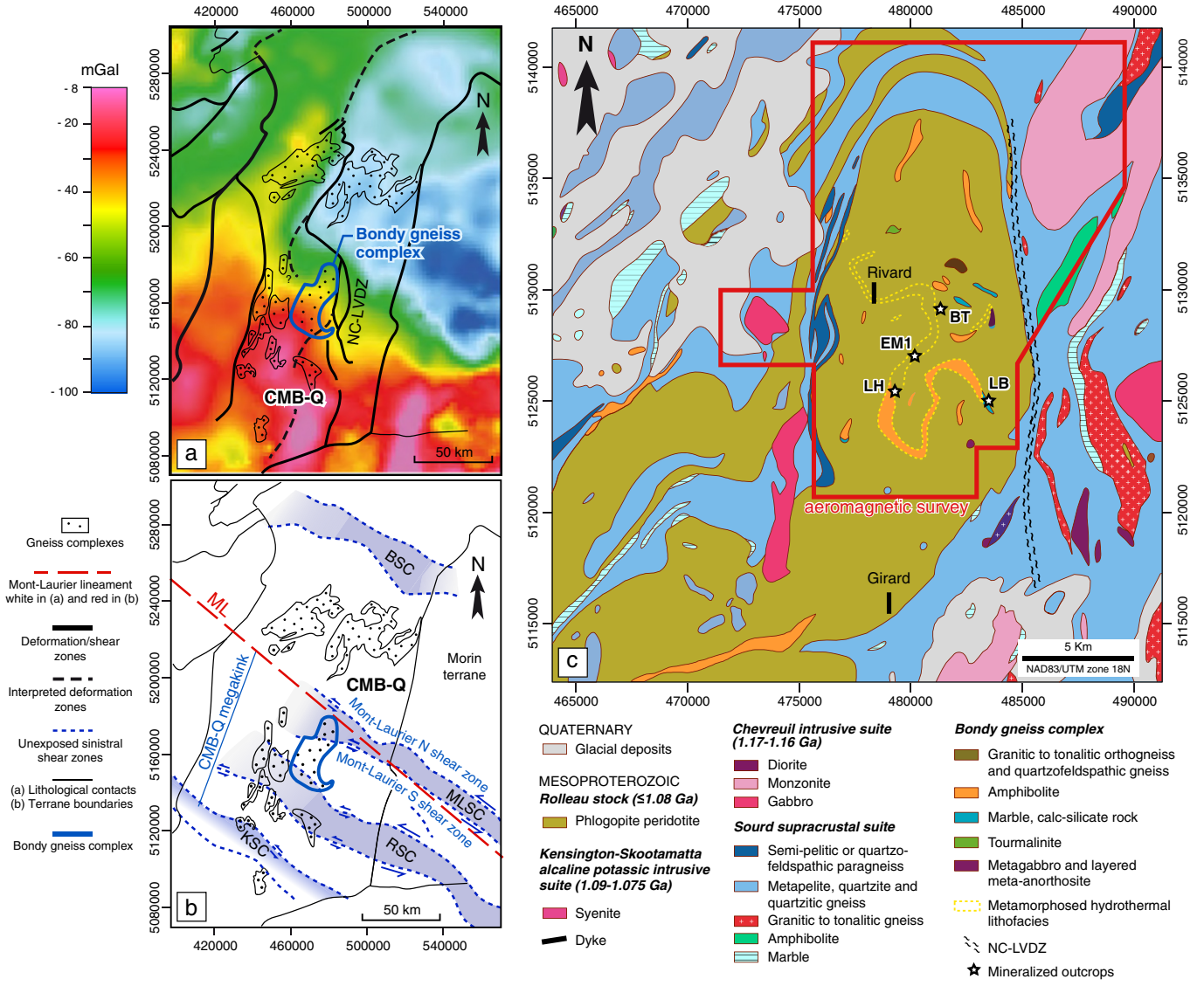

Fig. 1. (a) Bouguer gravity map with superposed outlines of the simplified tectonic map of the Central Metasedimentary Belt of Quebec modified from Dufréchou et al. (2014). The Bondy Gneiss complex is in blue. (b) Simplified tectonic map of the Central Metasedimentary Belt of Quebec modified from Dufréchou et al. (2014). (c) Simplified geological map of the northern part of the Bondy gneiss complex with the simplified form surface of the proposed metamorphosed hydrothermal system and adjacent Sourd metasedimentary sequence covered by the aeromagnetic survey (modified from Corriveau and Jourdain, 2000). BSC: Beauregard shear corridor; BT: Breccia Trail outcrop; CMB-Q: Central Metasedimentary Belt of Quebec; KSC: Kazabazua shear corridor; LB: Lac Bing outcrop; LH: Lac Harvey outcrop; MLSC: Mont-Laurier shear corridor; NC–LVDZ: Nominingue–Chénéville–La Lièvre deformation zone; RSC: Roddick shear corridor.

Dufréchou et al., 2011a; Corriveau, 2013 and references therein) did not identify the surface expression of a major shear zone (the Mont-Laurier South shear zone) interpreted from regional gravity data (Dufréchou et al., 2014) though many local shear zones including duplex-type structures were mapped. A major late, north northeast-trending structure active at 1.07 Ga has been inferred based on the distribution and the orientation of a series of xenolith-bearing minette dykes across the CMB-Q (Corriveau, 2013). The dense vegetation cover and the sporadic distribution and size of most outcrops complicate identification of the structures across the complex even if they crop out. To facilitate the identification and characterization of structures that may have affected the BGC and the local structural expression of a regional shear zone, a high resolution aeromagnetic survey was undertaken in its northern part by Fugro Airborne Surveys (2007). This article presents the structural interpretation of this aeromagnetic data, documenting structures produced during displacement along the sinistral Mont-Laurier South shear zone in the BGC, the controls on mineral occurrences and the recognition of structures at different structural levels and their reactivation history. Implication of the regional Mont-Laurier South shear zone in the formation and remobilization of mineralized zones and controls on magma emplacement in the BGC are described.

2. Crustal- to lithospheric-scale structures in the western Quebec Grenville Province

Northwest–southeast Palaeoproterozoic faults controlled by structures in Archaean sub-continental lithospheric mantle (SCLM) are interpreted from regional gravity data in Archaean basement of the western Quebec Grenville Province (Dufréchou and Harris, 2013). These faults are interpreted as having (i) initially formed at ca. 2.51–2.4 Ga during break-up of the Superior and Wyoming cratons (possibly controlled by Archaean SCLM structures; Harris and Bédard, 2014) and (ii) subsequently reactivated as transfer faults at ca. 2.17 Ga during break-up of the Superior and Baltic cratons. These faults may be still active and can explain the seismic activity of the Western Quebec Seismic