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Age and geological setting of the Rankin Inlet greenstone belt and its relationship to the gold endowment of the Meliadine gold district, Nunavut, Canada

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ABSTRACT

Archean greenstone belts host a significant proportion of the world's gold, typically in deposits that formed late during greenstone belt formation and cratonization. However, this is not always the case and, in the multiply reworked western Churchill Province (wCP), orogenic lode gold deposition post-dates greenstone belt formation by nearly one billion years. The spatial link between Proterozoic gold and Archean greenstone belts in the wCP is thus particularly striking although its significance is still not fully understood. The Meliadine gold district (2.8 Moz contained Au in reserves, plus an indicated and inferred resources of 5.8 Moz Au) represents an important example of this deposit style and is hosted within the Rankin Inlet greenstone belt (RIGB), which occupies a critical, but controversial position along the largely inferred boundary between the Hearne craton and the Chesterfield block.

RIGB felsic volcanic rocks (ca. 2.66 Ga) are structurally intercalated, and broadly coeval, with mafic volcanic and volcaniclastic rocks (2.66–2.64 Ga), turbidite (≤2.66–2.64 Ga), argillite, auriferous banded iron formation successions and syn-volcanic granodioritic to tonalitic intrusions (2.67–2.64 Ga). Neoarchean basaltic to andesitic volcanic rocks possess calc-alkaline to primitive arc-like tholeiitic magmatic affinities along with lesser MORB-like basaltic compositions. Geochemically evolved lavas yield depleted $^{144}Nd/^{143}Nd$ ratios ($\varepsilon Nd_{2.66}$ Ga = −1.1 to +1.6) that reflect variable interaction with an evolved and hitherto undocumented Meso- to Neoarchean basement underlying the RIGB, whereas transitional, arc-like primitive tholeiitic and MORB-like basaltic samples overlap with the Nd isotopic composition of depleted mantle at ca. 2.66 Ga ($\varepsilon Nd_{2.66}$ Ga = +1.6 to +2.7). These Neoarchean volcano-sedimentary panels represent the main auriferous rock package within the Meliadine gold district and are intercalated with deformed Paleoproterozoic conglomerate (≤2.50 and ≤2.155 Ga). The latter are, in turn, unconformably overlain by a geochemically distinct pillowed-basalt sequence and a unique carbonate-siliciclastic package that presumably represent the remnants of Paleoproterozoic basins and are not known to host gold. The geological setting of gold deposits thus likely reflects this favourable Neoarchean lithostratigraphy in addition to metamorphism and fluid focusing along the reactivated faults during the collision of the Hearne and combined Chesterfield block-Rae craton at 1.90–1.85 Ga.

1. Introduction

The western Churchill Province (wCP) represents a vast and gold-rich region of Canada's North (Fig. 1). The largest gold deposits, including the world-class Meadowbank mine (e.g., Sherlock et al., 2004; Janvier et al., 2015), are hosted by Archean greenstone belts and associated meta-sedimentary successions that include turbidite and banded iron formation (BIF; Fig. 1). Deposit host rocks are metamorphosed from greenschist (e.g., Meadowbank; e.g., Pehrsson et al., 2013a) to upper amphibolite facies (e.g., Three Bluffs; Davies et al., 2010) and deformed during at least four temporally-distinct Paleoproterozoic orogenic episodes (e.g.,

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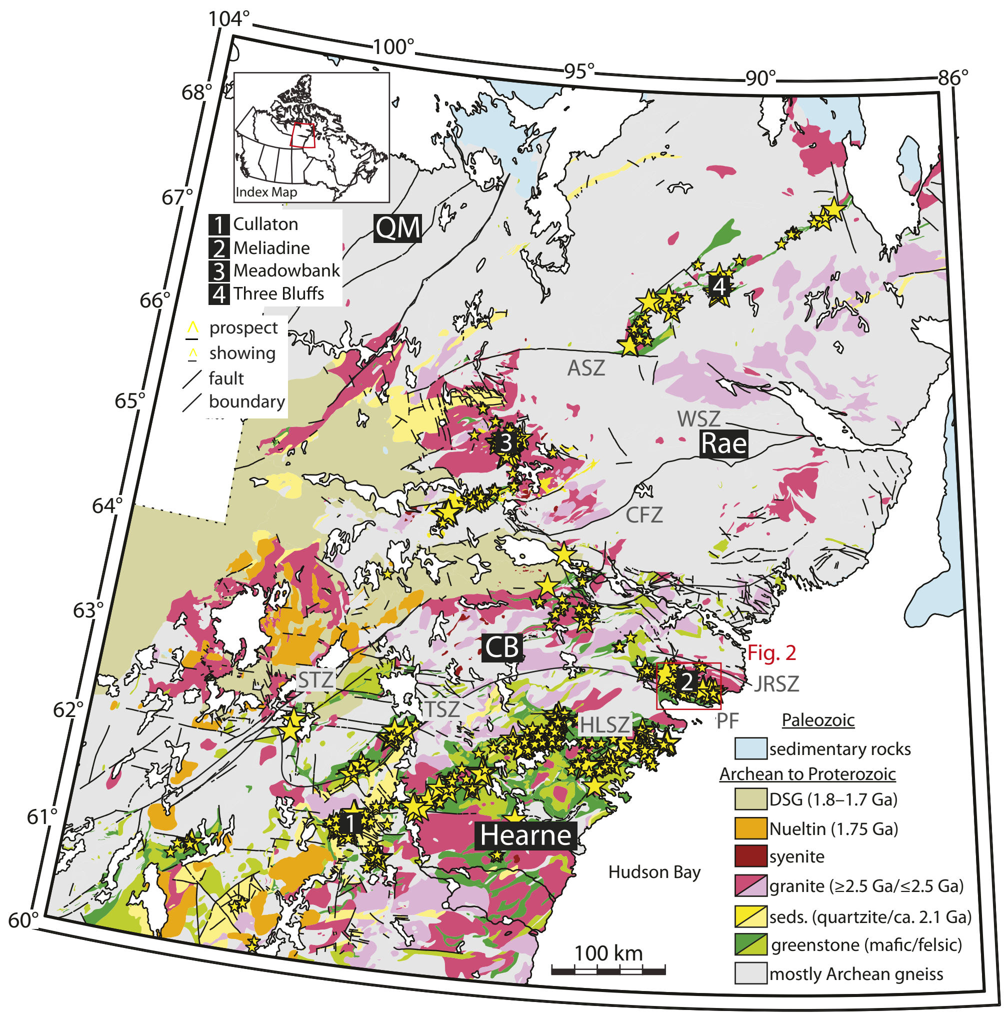

Fig. 1. Regional western Churchill Province lithologic map showing the location of gold deposits, prospects and showings discussed in the text (simplified from Paul et al., 2002; gold locations are from NUMIN; cratonic boundaries from Pehrsson et al., 2013a,b. *Abbreviations*: CB: Chesterfield block; QM: Queen Maud block; ASZ: Amer shear zone; WSZ: Wager shear zone; CFZ: Chesterfield Fault Zone; JRSZ: Josephine River shear zone; PF: Pyke Fault; HLSZ: Happy Lake shear zone; TSZ: Tyrrell shear zone; STZ: Snowbird Tectonic Zone, NWT: Northwest Territories; DSG: Dubawant Super Group).

Berman, 2010). Each episode was coupled with the development and/or reactivation of lithospheric-scale faults and smaller-scale, subsidiary structures (Jones et al., 2002; Spratt et al., 2014). Gold is linked to this Paleoproterozoic metamorphic and reworking history and, at the scale of the wCP, occurs where regional faults cut favourable Archean greenstone belts (Fig. 1).

The broad association between gold, greenstone belts, faults and metamorphism is typical of the orogenic gold deposit type and characterizes most Archean gold districts globally (Groves et al., 1998, 2003; Goldfarb et al., 2005; Robert et al., 2005; Dubé and Gosselin, 2007; Robert et al., 2007, references therein). However, gold deposits within the wCP are atypical as gold post-dates the timing of mafic volcanism and cratonization by up to one billion years (Miller et al., 1995; Sherlock et al., 2004; Carpenter et al., 2005; Davies et al., 2010; Lawley et al., 2015a). This age gap contrasts with classic Neoarchean orogenic gold districts, such as the Abitibi, which share a close spatial and temporal relationship between gold, basin development, basin inversion along basin-bounding faults and attendant metamorphism during orogenesis (e.g., Bleeker, 2012, 2015). The spatial link between Proterozoic gold and Archean greenstone belts may reflect an extremely effective gold depositional mechanism(s) that operates exclusively in these settings (e.g., Groves et al., 1998) and/or may suggest that greenstone belts and associated supracrustal successions represent the ultimate source for gold (e.g., Pitcairn et al., 2006; Large et al., 2009).

The Meliadine gold district (MGD) represents a large (2.8 Moz contained Au in reserves and total resources of 5.8 Moz Au, www.agniecoeagle.com) and important example of BIF- and greenstone-hosted mineralization within the wCP (Fig. 1; Miller et al., 1994, 1995; Carpenter et al., 2005; Lawley et al., 2015a,b). The largest deposits occur north and along the Pyke Fault, which cuts Neoarchean mafic to felsic volcanic rocks, turbidite and BIF successions comprising the Rankin Inlet greenstone belt (RIGB; Fig. 2). The Pyke Fault also represents the approximate surficial trace of one segment of a lithospheric-scale fault network that cuts the wCP and potentially demarcates the inferred cratonic boundary between the Hearne craton and combined Rae craton and Chesterfield block (Fig. 1; e.g., Jones et al., 2002; Berman et al., 2007; Spratt et al., 2014; Pehrsson et al., 2015). The RIGB thus occupies a critical position within the wCP, but its age and relationship to nearby greenstone belts are undocumented.

In this contribution we report new U–Pb detrital and igneous zircon ages that confirm Neoarchean RIGB volcanic and siliciclastic rocks (2.67–2.66 Ga) are structurally imbricated with multiple Paleoproterozoic (≤2.50 Ga, this study; ≤2.155 Ga, Davis et al., 2008) conglomerate units and dismembered volcano-sedimentary basins. New field data are also synthesized with lithogeochemistry