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Paleoproterozoic orogenesis during *Nuna* aggregation: A case study of reworking of the Rae craton, Woodburn Lake, Nunavut

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ABSTRACT

New insights into the assembly of the Nuna supercontinent are gained from detailed mapping, structural analysis, and geochronology which constrain the tectonometamorphic evolution of the Rae craton, Woodburn Lake area, Nunavut. The earliest Paleoproterozoic fabric, S_{P1}, is a subhorizontal to shallowly dipping schistosity that helps to define a regional fold and thrust belt bracketed in age between 1.95 and 1.83 Ga. The probable ca. 1.9 Ga age and southerly vergence of this belt are consistent with formation during the 1.9 Ga collision of the Rae and Hearne cratons.

The other dominant regional fabric, S_{P2}, is related to a northwest-vergent, thick-skinned, fold-thrust belt involving Paleoproterozoic cover and Archean basement. In situ SHRIMP monazite data for three amphibolite-facies metasedimentary samples yield statistically indistinguishable ages regardless of textural location, most precisely dated at 1834 ± 5 Ma from monazite inclusions in garnet that are aligned with the external S_{P2} foliation. The chemical and textural features suggest synchronous, syn-D_{P2} monazite and garnet growth at 540–560 °C on a clockwise *P*–*T* path constrained by thermobarometry and calculated phase relationships. The extent, orientation and vergence of the tectonic thickening event indicated by these observations is most consistent with the ca. 1870 Ma collision of Meta Incognita–Sugluk block with the southeastern flank of the Rae craton, during early stages of Manikewan ocean closure. Three subsequent phases of deformation are related to final stages of amalgamation of Nuna. The widespread extent, yet contrasting times, of mid-Paleoproterozoic interior orogenic reworking recognized within the western Churchill Province negates the use of its interior Trans-Hudson-related orogens as piercing points for Nuna reconstruction.

1. Introduction

Understanding the extent and character of welding orogens is a key component of unravelling the dynamics of supercontinent aggregation. Laurentia has long been recognized as a product of Paleoproterozoic assembly (Hoffman, 1988) of Earth's first accepted supercontinent, *Nuna* (Reddy and Evans, 2009). Many of Laurentia's welding orogens are considered keystones in actualistic models of Precambrian tectonics (Hoffman and Bowring, 1984; Corrigan et al., 2009 and references therein). Ironically, the most poorly known part of Laurentia is that part which lies at the heart of *Nuna*: the western Churchill Province. The western Churchill Province comprises nearly one-third of the landmass of the Canadian Shield but is more poorly known than other cratons, such as Slave and Superior, due to its lack of infrastructure access. The extent to which this Archean craton has been reworked in the Paleoproterozoic is controversial and crucial to understanding how *Nuna* aggregated.

End member models for evolution of the western Churchill Province have emphasized (Lewry et al., 1985; Hoffman, 1990) or de-emphasized (Hanmer et al., 1995; Williams and Hanmer, 2006) the extent to which it was amalgamated during the Paleoproterozoic, based in large part on the disparate tectonometamorphic record from different crustal levels of its constituent Rae and Hearne cratons. Recent studies (Carson et al., 2004a,b; Berman, 2007; St-Onge et al., 2009 and references therein) have shown that penetrative Paleoproterozoic tectonometamorphism related to early collisional stages of the Trans-Hudson orogeny are recorded in the mid-crust of the Rae on both sides of Hudson Bay (Fig. 1). This event has been related to collision of the Meta Incognita microcontinent (St-Onge et al., 2009; Berman et al., 2010a), and was concurrent with peri-cratonic and intraoceanic accretion that accompanied an initial rapid phase of consumption of the Manikewan ocean (Corrigan et al., 2009).

The Woodburn Lake area (Fig. 1) is an unusually well exposed upper crustal segment of the Rae craton, and as such affords a unique window on the structural architecture of a reworked

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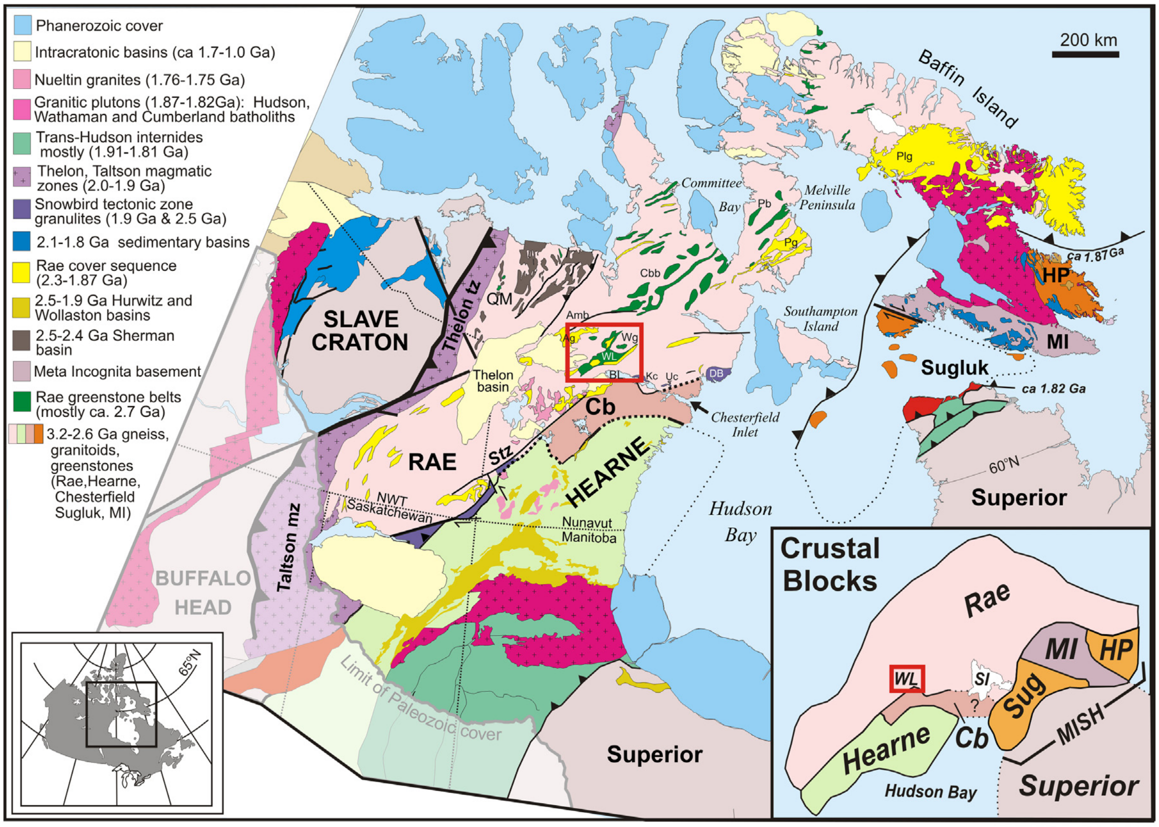

Fig. 1. Simplified geology of the northern Canadian Shield. Red box denotes location of Fig. 2. Greenstone belts and basins: Wg, Woodburn belt; Cb, Committee Bay belt; Pb, Prince Albert belt; Pg, Penrhyn Group; Amg, Amer group; Plg, Piling Group. Inset: location of Fig. 1 within North America.
Modified after Berman et al. (2005).

Archean craton. In this contribution we present new structural, geochronological and thermobarometric data that establish its regional architecture and tectonometamorphic history and discuss their implications for the extent of reworking during Nuna aggregation.

2. Regional geology

The western Churchill Province extends from Baffin Island, Nunavut to the Phanerozoic cover of western Canada (Fig. 1). On a regional scale, it is dominated by Neoarchean, amphibolite- to granulite-grade granitoid gneisses and greenstone belts, and comprises two main Archean cratonic blocks, the Rae and Hearne, separated by a Paleoproterozoic suture (Fig. 1, Wallis, 1970; Gibb and Walcott, 1971; Hoffman, 1988; Berman et al., 2007). Between the Rae and Hearne lies the Chesterfield block (Fig. 1, inset), a terrane interpreted to have accreted to the Rae in the latest Neoarchean (Berman et al., 2007). Geological relationships on Baffin Island suggest that the Meta Incognita microcontinent (MISH; Fig. 1, inset) accreted to the Rae at 1.88–1.865 Ga (St-Onge et al., 2009), following its pre-1.90 Ga collision with several other blocks (Sugluk block: Wodicka et al., 2011; Hall Peninsula block: Berman et al., 2013).

The north-central Rae craton, which forms the backdrop of this study, is remote and much of it has only been mapped at reconnaissance scale. Hence tectonic models for its Archean and Proterozoic evolution have been formulated at the broadest scale (Hoffman, 1988) with local exceptions (Sanborn-Barrie et al., 2001; Carson et al., 2004a,b). It is largely composed of Meso- to Neoarchean granodioritic to tonalitic orthogneisses and volcano-sedimentary rocks of the 2.9–2.68 Ga Mary River, Prince Albert and Woodburn Lake groups (Zaleski et al., 2000, 2001; Skulski et al., 2003; Wodicka et al., 2011). The latter two groups form a nearly 1000 km long greenstone belt characterized by distinctive Neoarchean quartzite and komatiitic-volcanic rocks, interpreted to have been deposited in a cratonic rift, flanked by older Mesoarchean basement. These greenstone belts are intruded by voluminous ca. 2.68–2.58 Ga tonalite–granodiorite and felsic plutons (Skulski et al., 2003; Davis et al., 2006; Ashton, 1988; Davis and Zaleski, 1998; Zaleski et al., 2000; Skulski et al., 2003; van Breemen et al., 2005).

The Neoarchean greenstone belts and their basement were variably reworked at moderate to high pressures during the ca. 2.56–2.30 Ga Arrowsmith and 2.56–2.50 MacQuoid orogenies (Berman, 2010; Berman et al., 2013; Pehrsson et al., 2011). Four Paleoproterozoic assemblages which collectively comprise the Rae cover sequence were subsequently deposited and are now preserved in a number of structural basins, including the Amer, Penrhyn and Ketyet River (Rainbird et al., 2010).

Mid-Paleoproterozoic tectonothermal reworking of the westernmost Rae craton occurred during the ca. 1.98–1.91 Ga Taltson orogeny (Bostock et al., 1987; Bostock and van Breemen, 1994; McDonough et al., 2000; Ashton et al., 2009). Further reworking of the Rae during the younger Hudsonian orogeny is recognized to have taken place in several discrete phases. The 1.9–1.865 Ga Snowbird orogeny (Berman et al., 2007) involved ca. 1.9 Ga accretion of the Hearne craton to the Rae (Berman et al., 2007, 2013) and 1.88–1.865 Ga accretion of the composite Meta Incognita–Sugluk terrane (St-Onge et al., 2002; Berman et al., 2005; Corrigan et al., 2009; Fig. 1). Subsequent collision of the Sask craton and Superior Province on the southern flank of the Hearne craton at 1.84–1.81 Ga