Evidence for a Neoarchean Snowbird Tectonic Zone from the Athabasca Granulite Terrane

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Summary

The Athabasca granulite terrane, located north of Lake Athabasca in the western Canadian Shield, is North America's largest exposure of continental lower crust. The region is underlain by orthogneisses, paragneisses, felsic granulites, mafic granulites, and rare crustal eclogite. Over two decades of field mapping, structural analysis, thermobarometry, petrologic modeling, and geochronology permit reconstruction of >20,000 km^2 of Archean to Paleoproterozoic deep crust.

The East Athabasca mylonite triangle (Tantato domain) in the Athabasca granulite terrane preserves evidence for two groups of lower crustal granulite-grade events, separated by >650 m.y. of isobaric cooling, and culminating with >150 m.y. of exhumation in the hanging wall of a thrust-sense shear zone. A 2.61-2.54 Ga group of events involved penetrative sub-horizontal fabric development and lower crustal flow at 0.9-1.3 GPa, 700-900°C. Flow was contemporaneous with pervasive anatexis of Bt-bearing orthogneisses and production of garnetiferous felsic granulite restite during mafic intra-plating of thick gabbroic sills near the base of thickened continental crust (>1.5 GPa and >1,000°C). The second group of events involved sub-vertical fabric development, strain partitioning in a block-type architecture, and fabric reactivation during intracontinental dextral transpression at ca. 1.9-1.8 Ga. Emplacement of a lithospheric-scale mafic dike swarm locally facilitated amphibole dehydration melting and production of garnet restite + tonalitic melt (~1.1 GPa and 750-850°C) at 1.896 Ga.

This study focuses on evidence for Neoarchean lower crustal flow and crustal thickening in the central Snowbird Tectonic Zone (STZ). Penetrative top-to-the-SE ductile strain on sub-horizontal fabrics was concurrent with *HT-* to *UHT-HP* metamorphism in thickened continental crust. Neoarchean flow was synchronous with NE-striking sub-vertical fabric development along the Cora Lake shear zone, a crustal-scale ultramylonite structure within the Athabasca granulite terrane. The results are consistent with partitioned sub-horizontal NW- to SE-directed shortening and development of NE-trending structures in the Neoarchean that parallel the present-day NE-striking STZ. Correlations with along-strike Neoarchean strain suggest a Neoarchean birth and long-lived history for at least 800 km of this >2,800 km-long lineament.

Introduction

The STZ remains one of the most enigmatic features of the western Canadian Shield. Recent work in the central STZ reveals that its distinctive geometry is due primarily to the interaction of crosscutting Paleoproterozoic intracontinental thrust and strike-slip shear zones (Mahan and Williams, 2005). Although the geometry of much of the central STZ is due primarily to late stage tectonic reorganization and ca. 1.85 Ga uplift of continental lower crust, the results do not preclude a prominent Neoarchean history for this segment of the lineament (e.g., Dumond et al., In Press; In Review; Flowers et al., 2008; Mahan et al., 2008).

The East Athabasca mylonite triangle in the Athabasca granulite terrane represents part of the central STZ exposed north of Lake Athabasca. The triangle is sub-divided into three litho-tectonic domains: the Northwestern domain, the Upper Deck domain, and the Chipman domain. All domains contain evidence for high-pressure poly-metamorphism and lower crustal tectonism from ca. 2.63-1.9 Ga (Hanmer et al., 1994; Snoeyenbos et al., 1995; Williams et al., 1995; 2000; Williams and Hanmer, 2006; Mahan et al., 2003; 2006a; 2006b; 2008; Baldwin et al., 2003; 2004; 2006; 2007; Flowers et al., 2006a; 2006b; 2008; Dumond et al., 2008; In Press; In Review).

We present field, petrologic, and geochronologic evidence for NW-to-SE-directed Neoarchean strain accompanied by *HT-* to *UHT-HP* metamorphism in the East Athabasca mylonite triangle. We relate this record to that preserved in the Chesterfield domain of the western Churchill province. The correlation implies a >800 km-long region of top-to-the-SE strain that is sub-parallel to the present-day STZ and supports a Neoarchean collisional origin for at least part of this >2,800 km-long lineament (e.g., Jones et al., 2002; see also Sanborn-Barrie et al., 2001).

Evidence for Neoarchean strain and metamorphism in the central STZ

All three domains in the East Athabasca mylonite triangle preserve evidence for penetrative strain and *HT-* to *UHT-HP* metamorphism in the Neoarchean. The Northwestern domain is primarily underlain by the ca. 2.63-2.6 Ga multi-phase Mary batholith. The batholith contains an early, penetrative sub-horizontal gneissic foliation (S_1) defined by aggregates of Grt and ribbons of Opx + Hb + Kfs + Pl + Qtz at conditions of 0.9-1.0 GPa and 700-800°C. Kinematics are compatible with top-to-the-ESE granulite-grade lower crustal flow. Results from EPMA Th-U-total Pb monazite geochronology applied to syn-S_1 migmatite support Neoarchean (ca. 2.60-2.55 Ga) garnet growth and melt-enhanced flow (Dumond et al., In Press).

The Upper Deck domain is underlain by migmatitic orthogneisses, Ky- and Opx-bearing felsic granulites, mafic granulites, and rare crustal eclogite (Baldwin et al., 2003; 2004; 2006; 2007; Snoeyenbos et al., 1995; Dumond et al., In Review). Early, gently-dipping fabrics (S_1) in the felsic granulites are defined by kyanite, garnetite, and leucosome. Layers of eclogite and mafic granulite also define the S_1 fabric. Pseudosection modeling of the felsic granulite protolith bulk composition produces the observed peak assemblage of Grt + Opx + Qtz + Ilm + Rt + melt + ternary feldspar at >1.5 GPa and >1,000°C. Results from EPMA Th-U-total Pb monazite geochronology support garnet growth, melting, and lower crustal flow at ca. 2.61-2.55 Ga. Low-Th monazite depleted in Ca and enriched in Eu is linked to growth of grossular-rich Grt in the felsic granulite during crustal thickening at 2539 ± 21 Ma (2σ, MSWD = 3.0, n = 4) (Dumond et al., In Review).

The Chipman domain is partly underlain by km-scale sheets of felsic and mafic granulite. Early, gently-dipping gneissic fabrics in the mafic granulite sheets (S_1) are defined by the *HP*-granulite assemblage: Grt + Cpx + Qtz ± Pl at conditions of 1.3 GPa and 850-900°C (Mahan et al., 2008). The S_1 metamorphic assemblage is dated by high precision ID-TIMS U-Pb zircon geochronology at ca. 2.55 Ga (Flowers et al., 2008). S_1 fabrics are overprinted by the steeply NW-dipping, >200 km-long Cora Lake shear zone separating the Chipman domain from the Northwestern and Upper Deck domains. Field and petrologic observations suggest that a component of granulite- to amphibolite-grade sinistral strike-slip shearing occurred along the Cora Lake shear zone in the Neoarchean (Mahan et al., 2008).

Discussion and Conclusions

Evidence from the East Athabasca mylonite triangle supports the occurrence of a regional *HT*- to *UHT-HP* granulite facies group of events accompanied by lower crustal flow and crustal thickening during NW-SE shortening in the Neoarchean (ca. 2.61-2.54 Ga). Areas of Neoarchean strain along strike of the STZ are correlated with the record documented in the triangle, including: the Chesterfield domain (Berman et al., 2007) and the Kramanituar granulite complex (Sanborn-Barrie et al., 2001). Specifically, sub-horizontal, top-to-the-SE lower crustal flow in the East Athabasca mylonite triangle correlates with, and may represent a deeper crustal expression of, Neoarchean SE-vergent thrusting observed or inferred along the Tyrell shear zone in the Yathkyed Lake supracrustal belt (MacLachlan et al., 2005) and along the Big Lake shear zone that floors the Cross Bay plutonic complex further NE (Hanmer et al., 2006). Southeast-vergent deformation is also similar in age to ca. 2.55 Ga north-side-up strain along the Southern shear zone adjacent to the Kramanituar complex (Sanborn-Barrie et al., 2001). These correlations imply a >800 km-long belt of SE-vergent contraction resulting in a NE-trending deformation front that is sub-parallel to the present-day STZ. We conclude that a Neoarchean collisional origin is evident for at least part of this lineament.

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