Flow of lower continental crust beneath Laurentia: Neoarchean sub-horizontal ductile flow in the Athabasca Granulite Terrane, Western Canadian Shield

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The Athabasca Granulite Terrane (AGT) is the largest known exposure of Laurentian lower continental crust. It is preserved in the hanging wall of the Legs Lake shear zone, a ca. 1.85 Ga thrust-sense structure that aided exhumation of >20,000 km^2 of HP-HT granulite-grade gneisses in the eastern Rae Province of the western Canadian Shield. The dominant tectonic fabric in a 40 km-long transect across two shear zone-bounded, litho-tectonic domains in the AGT is a penetrative, early shallow fabric (S_1).

The Lower Deck domain of the East Athabasca mylonite triangle (EAmt) exhibits km- to m-scale domains of shallow, granulite-grade gneissic foliation (S_1) in granitoid orthogneisses. The gneisses contain a pentrative stretching lineation (L_1) defined by discontinuous ribbons and porphyroclasts of recrystallized Kfs + Pl + Qtz + Hb ± Opx, Grt aggregates, and elongate mafic enclaves. Long rods of compositional banding on the S_1 fabric represent intersection lineations that correspond to hinges of isoclinally-folded (F_1) sheets of granite-granodiorite-charnockite (S_0). Thermobarometric, microstructural, and kinematic data are compatible with high-grade (700-800°C) ductile, top-to-the-ESE flow during sub-horizontal L>>>S strain at 1.0-1.1 GPa. High-resolution, in-situ electron microprobe U-Th-Pb geochronology on syn-kinematic and syn-metamorphic Mnz constrains timing of S_1 at ca. 2.62-2.55 Ga.

The Upper Deck domain of the EAmt is locally underlain by Grt-rich, Sil/Ky ± Opx + Qtz + Kfs felsic granulite ribbon mylonite, interpreted as the restitic product of extensive melting of meta-igneous protoliths in deep continental crust. Locally, the dominant fabric is sub-horizontal and defined by recrystallized ternary feldspar, Ky blades, Qtz ribbons, and zoned Grt aggregates with grossular-rich annuli. Preliminary modeling suggests high-Grs Grt grew at pressures in excess of 1.4-1.5 GPa following near-UHT-melting at 1.0-1.1 GPa. Low-Th, Eu-enriched, and Ca-depleted Mnz included in high-Grs Grt rims directly date the time of partial melt extraction, breakdown of Pl, and growth of Grt during high-P metamorphism at ca. 2.58-2.5 Ga. Data are consistent with protracted partial-melting during injection of a mafic intra-plate and intense sub-horizontal fabric development followed by crustal thickening.

The early shallow fabric represents flow of lower continental crust beneath Laurentia in the Neoarchean. We speculate that the fabric correlates with deep crustal reflectivity imaged by the Lithoprobe SNORCLE deep seismic reflection line in the southwestern Slave craton, dated at ca. 2.65-2.58 Ga. The overprinting of shallow fabrics by localized, NE-striking steep fabrics and shear zones point to rheologic strengthening of weak Laurentian deep crust syn- to post-2.5 Ga.

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