Stabilization and destabilization of continental lithosphere: Preservation of dynamic processes in North America's largest sample of continental lower crust

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The Athabasca Granulite Terrane (AGT) is North America's largest exposure of continental lower crust. The region is underlain by granulite-grade orthogneisses, mylonites, felsic granulites, mafic granulites, and rare eclogite. New results and compilation of over a decade of field mapping, thermobarometry, petrologic modeling, geochronology, and thermochronology permit reconstruction of >20,000 km^2 of Archean to Paleoproterozoic deep crust.

The AGT preserves evidence for two lower crustal granulite-grade events, separated by >600 m.y. of isobaric cooling, and culminating with >150 m.y. of multi-stage exhumation in the hanging wall of a thrust-sense shear zone. A 2.62-2.55 Ga event involved penetrative sub-horizontal fabric development and lower crustal flow at ~1.0-1.1 GPa, 700-800°C. Pervasive anatexis of Bt-bearing orthogneisses and production of dense garnetiferous restite accompanied mafic intra-plating of thick gabbroic sills near the base of tectonically thickened continental crust (~1.5 GPa, 800-1000°C). The second event involved sub-vertical fabric development, strain-partitioning in a block-type architecture, and fabric reactivation during intra-continental transpression at ca. 1.9-1.8 Ga. Emplacement of a lithospheric-scale mafic dike swarm facilitated amphibole dehydration melting and production of Grt-restite + tonalitic melt (~1.1 GPa, 750-850°C) at ca. 1.896 Ga.

Sub-horizontal fabrics and mafic granulite sills in the AGT represent excellent analogs for seismic reflectivity and lower crustal anisotropy, in addition to providing a field-based example of lower crustal flow during orogenesis. Rheology of continental lower crust appears dynamic and evolving. Penetrative flow of weak lower crust in the Neoarchean was followed by isobaric cooling, strengthening, and stabilization of continental lithosphere. Lithospheric-scale destabilization at similar metamorphic grades was marked by highly-partitioned Paleoproterozoic strain, steeply-dipping shear zones, and reactivation of Neoarchean fabrics in a strong, heterogeneous, and highly-anisotropic medium. Both events were accompanied by pervasive intra- and underplating of mafic magma, reflecting the dynamic locus for strain, metamorphism, and magmatism that occurs at the crust/upper mantle boundary.

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