Field-based Constraints on Lower Crustal Flow From the World's Largest Exposure of Lower Continental Crust, Northern Saskatchewan, Canada[†§]

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Flow of lower continental crust is inferred to exert a primary control on surface topography and leads to extensive lateral re-distribution of mass and heat in collisional orogens, e.g. the Himalyan-Tibetan system. Previous work has yielded important predictions about the behavior and geometry of lower continental crust during orogenesis: namely, it is rheologically weak (Kohlstedt et al. 1995); it flows under the influence of a topographic or tectonic load (Clark and Royden, 2000); and it is characterized by pervasive shallow fabrics and high-T deformation mechanisms (Rutter and Brodie, 1992). Arguably the world's largest exposure of lower contiental crust that still preserves much of its deep crustal character is the central portion of the Snowbird Tectonic Zone in the western Canadian Shield. Recent fieldwork along a ca. 100 km-long transect of this exposure is characterized by an early, penetrative shallow fabric.

A 40-km-long segment of this transect in charnockite and granodiorite orthogneisses is characterized by km-scale domains of shallow, granulite-grade gneissic foliation (S_1) with a spectacular rodding lineation (L_1) defined by: 1) discontinuous ribbons of recrystallized Pl + Qtz + Hb + Cpx + Opx, aggregates of Grt, in addition to mm- to cm-scale core-and-mantle structure in Pl and Kfs, and 2) sub-continuous, 10s of cm-long rods of compositional banding. Isoclinally-folded compositional layering is locally preserved perpendicular to L_1. We interpret L_1 as a composite lineation with both intersection and strectching components. Thermobarometric data, microstructural, and kinematic observations are compatible with high-grade (700-800°C) ductile, top-to-the-ESE flow during production of S_1 at 1.0-1.1 GPa (30-40 km paleodepths) in the Neoarchean.

S_1 is variably transposed into upright, open, shallowly plunging F_2 folds with sub-horizontal NW-striking enveloping surfaces. The locally weakly folded S_1 is locally overprinted by <10 m-wide penetrative high-strain zones, characterized by transposition of S_1 into steeply-dipping, NE-striking foliation (S_2). D_2 high-strain zones contain shallow SW-plunging stretching lineations (locally L-tectonites) and dextral, oblique-slip kinematics. D_2 low-strain zones locally preserve Type 2 (mushroom-crescent) fold interference patterns resulting from superposition of upright F_2 folds with sub-vertical NE-striking axial planes onto isoclinal, recumbent F_1 folds.

Metamorphic reactions that led to Grt-production during development of S_1 were intrinsically syn-kinematic, with garnet growing in the Na-rich mantles of recrystallized Pl-porphyroclasts. Relatively H_2O-poor and/or CO_2-rich conditions are required by the remarkable preservation of fine-grained microstructures and absence of pervasive grain-size coarsening or recrystallization in the S_1 tectonite. We speculate that the shallow S_1 tectonite exposed in the central Snowbird tectonic zone transect represents a unique and important field-based analog for the nature of deep crustal reflectivity and lower crustal flow in collisional orogens. Our results suggest that the strength of the lower continental crust is dynamic and evolving. In this particular case, flow of relatively weak lower crust during production of S_1 was followed by a period of near-isobaric cooling and strengthening of the lower crust. Subsequent deformation events produced steep fabrics (e.g. S_2), 10s of m- to 100s of km-scale moderately- to steeply-dipping shear zones, and local reactivation of S_1, reflecting the dramatic effects of strain-partitioning in a heterogeneous and anisotropic medium.

[†]**Dumond, G., Goncalves, P., Williams, M.L., Bowring, S.A., 2005, Field-based Constraints on Lower Crustal Flow From the World's Largest Exposure of Lower Continental Crust, Northern Saskatchewan, Canada, Eos Trans. AGU, 86(52), Fall Meet. Suppl., Abstract V21A-0592.**

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