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Flow of ultra-hot Precambrian orogens and the making of crustal layering in Phanerozoic orogenic plateaux

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Reassessment of structural / metamorphic properties of ultra-hot Precambrian orogens and shortening of model weak lithospheres support a syn-convergence flow mode on an orogen scale, with a large component of horizontal finite elongation parallel to the orogen. This orogen-scale flow mode combines distributed shortening, gravity-driven flow, lateral escape, and three-dimensional mass redistribution of buried supracrustal rocks, magmas and migmatites in a thick fluid lower crust. This combination preserves a nearly flat surface and Moho. The upper crust maintains a nearly constant thickness by real-time erosion and near-field clastic sedimentation and by ablation at its base by burial of pop-downs into the lower crust. Steady state regime of these orogens is allowed by activation of an attachment layer that maintains kinematic compatibility between the thin and dominantly plastic upper crust and a thick "water bed" of lower crust. Because very thin lithospheres of orogenic plateaux and Precambrian hot orogens have similar thermomechanical structures, bulk orogenic flow comparable to that governing Precambrian hot orogens should actually operate through today's orogenic plateaux as well. Thus, syn-convergence flow fabrics documented on exposed crustal sections of ancient hot orogens that have not undergone collapse may be used to infer the nature of flow fabrics that are imaged by geophysical techniques beneath orogenic plateaux.

We provide a detailed geological perspective on syn-convergence crustal flow in relation to magma emplacement and partial melting on a wide oblique crustal transition of the Neoarchean ultra-hot orogen of Southern India. We document sub-horizontal bulk longitudinal flow of the partially molten lower crust over a protracted period of 60 Ma. Bulk flow results from the interplay of (1) pervasive longitudinal transtensional flow of the partially molten crust, (2) longitudinal coaxial flow on flat fabrics in early plutons, (3) distributed, orogen-normal shortening, (4) emplacement of late prolate shape plutons in the direction of flow, and (5) late, conjugate strike-slip shearing. The macroscopic- to regional scale tectonoplutonic pattern produced by longitudinal flow forms a flat composite anisotropy throughout the lower crust.

In the light of GPS data, these results suggest that bulk longitudinal flow accounts for observed deformation of the Tibetan plateau as well as for its seismic structure. This flow mode may be preferred to lateral, east-directed channel flow because it combines both lateral gravity-driven thinning and distributed, orogen-normal shortening of the crust. These results further suggest that lower crustal seismic reflectivity in orogenic belts may not necessarily images fabrics produced by extensional tectonics, as commonly thought, but crustal layering produced by syn-convergence lateral flow.