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Migmatite dome dynamics and the flow of partially molten crust

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It is now well established that many orogens are underlain by a region of partially molten crust. This low-viscosity crust is imaged seismically in active orogens and is exposed in gneiss/migmatite domes that are typically associated with metamorphic core complexes (mcc) in exhumed orogens. What is the relationship between flow in the partially molten crust and the exhumation of migmatite domes? The partially molten crust may have risen in domes by isostasy-dominated flow (compensation of overlying extended upper crust) or buoyancy-dominated flow (diapirism). The directions and rates of flow of partially molten crust govern the transfer of mass and heat in orogens and are therefore first-order parameters in describing and understanding orogeny. Diapiric flow results in predictable structures, metamorphic paths, and histories of melt crystallization relative to deformation and P-T conditions. Isostasy-driven flow produces complex patterns of structures and P-T trajectories that reflect the ascent of partially molten crust and the interaction with extension kinematics at shallower depths.

2D modeling shows that upper crust extension triggers the flow of low-viscosity deep crust. This crust converges toward the zone of extension to form contraction structures at depth, with two uprising domes (double domes of foliation) that are separated by a vertical high strain zone. In 2D models, contraction structures in the domes are coeval with extension structures around and above the domes, such that the first-order geometry is not very different from diapiric structures, even when buoyancy is turned off in the models. Migmatite domes commonly show complex internal geometries compared to the mantling units, and the 2D modeling results based on isostasy-driven flow provide an alternative to buoyancy flow (diapiric/convective) to account for this structural contrast. Model results also challenge the traditional view that the internal structures of domes are relics of the early convergence history. For example, nappe-like structures may correspond to upward double domes that are overturned by more complex flow or by the influence of detachment-related shear, and are therefore some of the youngest structures. Modeling results suggest that, in general, migmatite domes reflect the dynamic link between extension/transtension of upper crust and flow of the orogenic partially molten layer at depth.