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Integrated field and numerical modeling investigation of crustal flow mechanisms and trajectories in migmatite domes

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Integrated field-based and modeling studies provide information about the driving mechanisms and internal dynamics of migmatite domes, which are important structures for understanding the rheology of the lithosphere in orogens. Dome-forming processes range from extension (isostasy) driven flow to density (buoyancy) driven systems. Vertical flow (up or down) is on the scale of tens of km. End-member buoyancy-driven domes are typically Archean (e.g., Pilbara, Australia). Extension-driven systems include the migmatite domes in metamorphic core complexes of the northern North American Cordillera, as well as some domes in Variscan core complexes. The Entia dome of central Australia is a possible hybrid dome in which extension and density inversion were both involved in dome formation. The Entia is a “double dome”, comprised of a steep high-strain zone bordered by high melt-fraction migmatite (subdomes). Field and numerical modeling studies show that these are characteristics of extension-driven domes, which form when flowing deep crust ascends beneath normal faults in the upper crust. Entia dome migmatite shows abundant evidence for extension, in addition to sequences of cascading, cuspate folds (well displayed in amphibolite) that are not present in the carapace of the dome, that do not have a consistent axial planar fabric, and that developed primarily at subsolidus conditions. We propose that these folds developed in mafic layers that had a density contrast with granodioritic migmatite, and that they formed during sinking of a denser layer above the rising migmatite subdomes. Extension-driven flow of partially molten (granodioritic) crust was therefore accompanied by sinking of a dense, mafic, mid-crustal layer, resulting in complex P-T-d paths of different lithologic units within the dome. This scenario is consistent with field and 2D modeling results, which together show how a combination of structural geology, metamorphic petrology, and modeling can illuminate the driving forces and thermal-mechanical consequences of crustal flow in orogens.