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Compatibility of deformation between upper crust and flowing partially molten crust in "hot" orogens

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Partial melting in the mid-lower orogenic crust results in substantial rheological weakening and dramatic lateral and vertical variations in crustal viscosity. The rheological changes associated with abundant partial melting may be profound, resulting in the partitioning of deformation between a rigid upper crust and a flowing channel of partial melt. Determining the nature of flow in the deep orogenic crust and the partitioning (or coupling) of deformation across rheologically distinct layers is fundamental to our understanding of lithospheric deformation in “hot” orogens.

Two migmatite-cored gneiss domes (the Okanogan dome, Washington State and the Naxos dome, Greece) are exposed in cordilleran-style metamorphic core complexes. In both domes, metasedimentary rocks mantling a core of anatectic migmatite are exposed below crustal detachments. Structural observations from migmatites in both domes indicate that deformation took place in the presence of melt (e.g. leucosome in dilatancy sites) and the crystallization of dome migmatites was coeval with detachment faulting and upper crustal extension. In the Okanogan dome, both mid to lower crustal rocks (magmatic to solid-state fabrics) and upper crustal units (en echelon graben) record NW-SE extension. A continuous structural section exposed on the western margin of the Okanogan dome documents that structural fabrics acquired in the migmatite domain are systematically reoriented and deformed at higher structural levels at the rheological interface between the flowing partially molten layer and the Okanogan detachment. These structural features record consistent strain/kinematics under a single deformational regime in which upper crustal extensional was mechani-

cally coupled at the transient rheological interface with flow in the migmatite domain.

In the Naxos dome, foliation in the metasedimentary units that mantle the migmatitic core define a simple dome geometry and have consistent lineations (NNE orientation) and kinematics (Top to the N). Migmatitic foliation, defined by thin biotite layers, defines a different pattern with complexly folded internal geometry and smaller sub-domal features partially wrapped by entrained marble layers. Flow directions, obtained through application of the anisotropy of magnetic susceptibility (AMS) in the Naxos migmatites indicate that flow in the migmatite domain was mechanically decoupled from deformation in the upper crust, however the bulk strain patterns of deformation in the migmatitic core of the Naxos dome are consistent with the mantling units.

These data suggest that flow of the partially molten mid-lower crust may be either mechanically coupled (attachment) or decoupled (detachment) to upper crustal deformation across detachment faults. Regardless of the nature of mechanical coupling at the transient rheological interface between melt present deformation (e.g. migmatite domains) and subsolidus deformation (e.g. detachment faults, upper crust), the bulk flow pattern recorded in these migmatite domains shows a remarkable strain compatibility to those in detachments and the upper crust. These observations further suggest that despite the intrinsic heterogeneity of migmatites, they flow in bulk on a large scale. Therefore, the kinematics of flow in the partially molten crust may be controlled by larger-scale boundary conditions than those developed in the structures that exhume the partially molten layer.