Geophysical Research Abstracts
Vol. 19, EGU2017-8743, 2017
EGU General Assembly 2017
© Author(s) 2017. CC Attribution 3.0 License.

Mobility of partially molten crust, heat and mass transfer, and the stabilization of continents

Christian Teyssier (1), Donna L. Whitney (1), and Patrice F. Rey (2)

(1) Department of Earth Sciences, University of Minnesota, Minneapolis, United States (teyssier@umn.edu), (2) School of Geosciences, The University of Sydney, Sydney, Australia

The core of orogens typically consists of migmatite terrains and associated crustal-derived granite bodies (typically leucogranite) that represent former partially molten crust. Metamorphic investigations indicate that migmatites crystallize at low pressure (cordierite stability) but also contain inclusions of refractory material (mafic, aluminous) that preserve evidence of crystallization at high pressure (HP), including HP granulite and eclogite (1.0-1.5 GPa), and in some cases ultrahigh pressure (2.5-3.0 GPa) when the continental crust was subducted (i.e. Norwegian Caledonides). These observations indicate that the partially molten crust originates in the deep crust or at mantle depths, traverses the entire orogenic crust, and crystallizes at shallow depth, in some cases at the near-surface ($\sim$2 km depth) based on low-T thermochronology. Metamorphic assemblages generally show that this nearly isothermal decompression is rapid based on disequilibrium textures (symplectites). Therefore, the mobility of partially molten crust results in one of the most significant heat and mass transfer mechanisms in orogens. Field relations also indicate that emplacement of partially molten crust is the youngest major event in orogeny, and tectonic activity essentially ceases after the partially molten crust is exhumed. This suggests that flow and emplacement of partially molten crust stabilize the orogenic crust and signal the end of orogeny.

Numerical modeling (open source software Underworld; Moresi et al., 2007, PEPI 163) provides useful insight into the mechanisms of exhumation of partially molten crust. For example, extension of thickened crust with T-dependent viscosity shows that extension of the shallow crust initially drives the mobility of the lowest viscosity crust (T>700°C), which begins to flow in a channel toward the zone of extension. This convergent flow generates channel collision and the formation of a double-dome of foliation (two subdomes separated by a steep high strain zone). In turn, the rapid exhumation of low-viscosity deep crust within and between the two subdomes enhances localization of extension in the shallow crust; the positive feedback between exhumation of low-viscosity crust and localization of shallow crust extension explains the exhuming power of migmatite domes, the rapid isothermal decompression of dome rocks (order of 1.0-1.5 GPa), and the crystallization of melt at shallow depth followed by rapid cooling. Modeling results indicate that the mobility of low-viscosity (partially molten) crust is a major process for transferring heat and mass during the late stages of orogeny.