Geophysical Research Abstracts
Vol. 16, EGU2014-9805-1, 2014
EGU General Assembly 2014

Phase mixing induced by granular fluid pump during mantle strain localization

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Mantle viscous strain localization is often attributed to feedbacks between grain boundary sliding (GBS) and phase mixing, as GBS could promote mixing through grain switching, and phase mixing would enhance grain-size-sensitive granular flow through grain boundary pinning. However, although GBS and phase mixing are intimately related, recent data show that GBS alone cannot end-up with randomly mixed phases. Here we show natural observations of an ultramylonitic shear zone from the Ronda peridotite (Spain) where both GBS and phase mixing occur. Microprobe analyses and coupled EDX/EBSD data first document enrichment in pyroxenes and amphibole concomitant with both phase mixing and complete randomization of the olivine fabric in fine-grained layers (5-20 microns) where strain has been localized. Both the fabric randomization and some microstructural observations indicate that these layers mostly deformed by granular flow, i.e. by GBS. Based on petrological pseudo-sections, we also show that phase enrichment does not result from metamorphic reaction, but instead from dissolution-precipitation phenomena. Finally, we document in adjacent areas a change of olivine fabric geometry that highlights syn-tectonic water draining towards fine-grained layers. While olivine fabric switches from E-type (moderately hydrated fabric) to C-type (highly hydrated fabric) towards fine-grained layers, it changes from E-type to D-type (highly hydrated fabric) in coarse-grained bands between E/C-type layers. Altogether, our findings suggest that water converges as a result of GBS-induced creep cavitation and subsequent granular fluid pump in fine-grained layers. We propose that phase mixing originates here from such a creep cavitation through dissolution-precipitation of secondary phases in newly formed cavities, giving rise to a key process for the relationships between GBS and phase mixing, and hence, for the origin of viscous strain localization in the upper mantle.