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Atom probe as a tool for understanding mineral physics and rock deformation: a case study of deformed wehrlite

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Here we report Atom Probe Tomography (APT) analyses of grain and phase boundaries of laboratory-deformed, fine-grained mixtures of clinopyroxene and olivine (Zhao, et al., 2019). The experiments show that the mixtures deform much more rapidly than either mineral endmember. This enhanced deformation in the two-phase material is due to stress-driven reactions at the phase boundaries. Lower effective viscosities of phase mixtures may be critical to the initiation of plate tectonics and the formation of mantle shear zones.

The hypothesis presented here is that the 'bulk rock' – a wehrlite – deforms rapidly because conversion of one phase to the other occurs at phase boundaries (e.g., Sundberg & Cooper, 2008). In this model, grain-scale transport of the shared (slowly-diffusing) mineralogical component Si^{4+} is not required. The near-boundary gradients of olivine-insoluble ions are presented as evidence of the phase transformation which either dissolves olivine into clinopyroxene or vice versa.

The resolving power of the APT makes it a promising tool for investigating the microphysics of rock deformation, bridging the atomic scale all the way to the plate-tectonic scale.

References:
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