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Grain-scale alignment of melt in sheared partially molten rocks: implications for viscous anisotropy

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Presence of melt significantly influences rheological properties of partially molten rocks by providing fast diffusional pathways. Under stress, melt aligns at the grain scale and this alignment induces viscous anisotropy in the deforming aggregate. One of the consequences of viscous anisotropy is melt segregation into melt-rich sheets oriented at low angle to the shear plane on much larger scales than the grain scale. The magnitude and orientation of viscous anisotropy with respect to the applied stress are important parameters for constitutive models *(Takei and Holtzman 2009)* that must be constrained by experimental studies.

In this contribution, we analyze the shape preferred orientation (SPO) of individual grain-scale melt pockets in deformed partially molten mantle rocks. The starting materials were obtained by isostatically hot-pressing olivine + basalt and olivine + chromite + basalt powders. These partially molten rocks were deformed in general shear or torsion at a confining pressure, P_c = 300 MPa, temperature, T = 1200° – 1250°C, and strain rates of 10^{-3} – 10^{-5} $s^{-1}$to finite shear strains, γ, of 0.5 - 5. After the experiment, high resolution backscattered electron images were obtained using a SEM equipped with a field emission gun. Individual melt pockets were segmented and their SPO analyzed using the paror and surfor methods and Fourier transforms *(Heilbronner and Barret 2014)*.

Melt segregation into melt-rich sheets inclined at 15°-20° antithetic with respect to the shear plane occurs in three-phase system (olivine + chromite + basalt) and in two-phase systems (olivine + basalt) twisted to high strain. The SPO of individual melt pockets within the melt-rich bands is moderately strong (b/a $\approx$ 0.8) and is always steeper (20°-40°) than the average melt-rich band orientation. In the two-phase system (olivine + basalt) sheared to lower strains, no distinct melt-rich sheets are observed. Individual grain-scale melt pockets are oriented at 45°-55° antithetic with respect to the shear plane (i.e., sub-perpendicular to σ_3) with a strong SPO (b/a $\approx$ 0.7) that decreases with increasing finite strain.

Our observations of melt alignment at low strains are in agreement with observations performed on analogue materials (borneol, *Takei 2010*) and provide further constraints for the orientation of viscous anisotropy in the Earth's mantle. The systematic difference in grain-scale melt alignment between samples in which melt segregation did and did not occur - irrespective of the deformation geometry and mineralogy - suggests that melt segregation into bands leads to local stress rotation within the samples.