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Distribution of melt during Poiseuille flow of partially molten rocks

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The mechanisms of melt extraction from the Earth's partially molten mantle are a key factor in the chemical and physical evolution of our planet and therefore are the topic of intense research. Since such processes cannot be observed directly, most of our understanding of the dynamics of partially molten rock relies on numerical models. Laboratory experiments are important for testing the validity of models at scales that we can observe.

We designed a set of experiments to investigate the role of viscous anisotropy on melt segregation in partially molten rocks through Poiseuille flow. Partially molten rock samples composed of forsterite plus a few percent melt of different composition (anorthite, albite or lithium silicate) were prepared from high-purity nano-powders and taken to T= 1300^{o}C at P = 0.1 MPa. The melt composition was varied in order to vary its viscosity. The partially molten samples were then extruded through a channel of circular cross section under a fixed pressure gradient. Different extrusion assemblies and consequently different flow geometries were explored.

The melt distribution in the channel was subsequently mapped using image analysis on backscattered electron microscopy images and energy dispersive x-ray spectroscopy maps. In all experiments, melt segregates from the center toward the outer radius of the channel with the melt fraction at the outer radius increasing to at least twice that at the center. Furthermore, melt enriched areas are also observed in the center of the channel. The shape of the melt distribution depends on the extrusion geometry and on the melt viscosity.

The segregation of melt toward the outer radius of the channel is consistent with the base-state melt segregation as predicted by viscous anisotropy theory developed by Takei and Holtzman (2009) and Takei and Katz (2014). However, the melt distribution profiles observed in our experiments have steeper gradients than the base-state melt segregation profiles described in the numerical solutions presented by Allwright & Katz (2014). This discrepancy may be related to the propagation of melt-enriched bands within the base state.