

Viscosity and structure of fayalite liquid at high pressure up to 9GPa

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Viscosity of magma is a crucial transport property of melts that influences a variety of important igneous processes, both during the evolution of the early Earth and in the present day mantle [1]. Previous experimental work on polymerized silicate melts e.g. [2] show a decrease in viscosity with increasing pressure. Viscosities of depolymerized silicate melts are poorly documented at mantle P-T due to experimental difficulties.

Here we present the results of *in situ* experiments on the viscosity and structure of pure fayalite melt at high pressure. Fayalite consists of isolated silica tetrahedra, so is as depolymerized as possible for a silicate melt. Viscosity measurements were carried out using the falling sphere viscometry technique e.g. [3]. Viscosity was found to decrease along the fayalite liquidus up to ~9GPa.

The structure and compressibility of fayalite melt was studied up to 7.5GPa. The coordination of the Fe-O bond was found to increase gradually from ambient pressure to 7.5GPa [4]. Higher coordination numbers allow for a more densely packed structure, resulting in a longer and hence weaker Fe-O bond, causing a decrease in viscosity [5]. The results suggest that deep Fe-rich melts will have a high density, but will be very mobile due to their low viscosity. Compressibility of the melt is derived from extrapolation of the structure factor to $q=0 \text{ \AA}^{-1}$. This enables the determination of density as a function of P with an unprecedented P resolution. This is a promising method to extract the equation of state of non-crystalline materials at mantle P.

[1] Ghosh and Karki (2011) *Geochim. Cosmochim. Acta.* 75, 4591-4600. [2] Kushiro (1976) *JGR* 81(35), 6347-6350. [3] Liebske *et al.* (2005) *EPSL* 240, 589-604. [4] Sanloup *et al.* *Geochim. Cosmochim. Acta.* Accepted. [5] Reid *et al.* (2003) *Phys Earth. Planet. Inter.* 139, 45-54.

Origin of curved CSDs: Heterogeneous nucleation of crystals in crystallizing magmas

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Crystal size distributions (CSDs) are becoming a routine method to quantitatively describe textures of plutonic and volcanic rocks. Simple batch or open system crystallization models involving homogeneous nucleation and crystal growth predict linear trends in the logarithmic population density vs. crystal size space. Since numerous magmatic rocks show concave-up curves, their origin was interpreted as due to multiple crystallization stages or population mixing. Many crystal populations in magmatic rocks also have a non-random, clustered, spatial distribution whose origin remains unclear. We show that both curved CSDs and clustering of crystals can be self-consistently explained by crystallization involving heterogeneous nucleation on crystal surfaces.

We performed three-dimensional numerical simulations of melt crystallization by homogeneous and heterogeneous nucleation and crystal growth. The rates of heterogeneous and homogeneous nucleation were coupled in order to simulate texture with a characteristic ratio of heterogeneous to homogeneous nuclei (H). Quantitative parameters describing sizes, contact, and spatial relationships of crystals were evaluated as functions of the H -ratio.

As H increases above ~2, the CSD evolves from straight to progressively curved, the number of neighbors around a crystal increases, and the clustering index, R , decreases below unity. At $H > 10$, the resulting texture gains porphyritic appearance, and for $H > 200$, the crystallization proceeds as radial growth of heterogeneous nuclei on isolated centers and a spherulitic texture develops. Numerical simulations with variable nucleation and growth rate functions indicate that these results are general and robust, thus solely depend on the H -ratio. This approach allows meaningful determination of the role of the heterogeneous nucleation in natural samples without of a detailed knowledge of the underlying kinetics of crystallization.

Our simulations are consistent with the number of heterogeneous nuclei being about an order of magnitude predominant over the number of homogeneous nuclei in ordinary magmatic rocks with curved CSDs, without involvement of mechanical mineral-melt interactions or late magmatic coarsening.