**Quantifying the effect of fluorine on the viscosity of silica undersaturated melts in the NaAlSiO₄-KAlSiO₄ system**

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**Introduction**

Silk viscosity directly influences the movement of magma below and above the crust of the Earth. Physical properties like melt viscosity are dependent on the structure of a melt, which in turn depends on composition.

In magmatic systems, volatiles such as water, CO₂ and halogens have a large influence on viscosity. Fluorine, even in small amounts, has been shown to reduce the viscosity of most silicate melts (e.g. Dingwell et al. 1985; Dingwell 1987; Webb et al. 2004; Zimova and Webb 2007; Baasner et al. 2013 and others). We quantify the effect of fluorine as a function of sodium-potassium mixing along the nepheline-kalsilite join. Le Losq and Neuville (2013) have shown that the structures created from this mixing are not random and directly influence viscosity.

**Methods**

We calculated the chemical dependence of viscosity. This model overestimates the influence of viscosity on the Na-K mole% melts, except for Ne₂₅. However, the model correctly predicts that fluorine lowers viscosity of the melts.

**Sample Characterization**

Structure and properties of fluorine-bearing aluminosilicate melts: the system Na₂O-Al₂O₃-SiO₂-F at 1 atm. Contributions to Mineral Petrology 91, 205-220.

**Viscosity Results**

For our metaluminous or slightly peraluminous melts we observe that F reduces viscosity, which is also observed by Dingwell (1985), Zimova and Webb (2007), and others. The effect of F is greater at higher potassium concentrations. Compositions Ne₅₀, K₁₅₀ (ΔT²<12°C) and Ne₇₅, K₁₂₅ (ΔT²<48°C) saw the greatest reduction.

**Legend for all graphs**

- F-free (Na,K)AlSiO₄ glass
- F-bearing (Na,K)AlSiO₄ glass
- experimental data
- calculated viscosity (Giordano et al. 2008)

**Implications**

Comparison to Existing Viscosity Models

Empirical models (Giordano et al. 2008) calculate the chemical dependence of viscosity. This model overestimates the influence of fluorine on the viscosity of Na-K melts compositions, except for Ne₂₅. However, the model correctly predicts that fluorine lowers viscosity of the melts.

Application to Volcanic Processes

If a felsic basaltic melt containing dissolved fluorine were to erupt at the surface of the earth, it would be able to flow longer than a F-free lava at the same cooling rate. The F-free melt would reach the glass transition, where movement stops and glass is formed (~12 log Pa s), far before the F-bearing melt.