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The effect of redox state on the viscosity of an Fe-rich phonolitic liquid.

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The chemical composition of silicate liquids exerts a strong influence on their chemical properties. The property variations are significant in a petrological sense. The viscosity, for example, can vary enough to influence eruptability and eruptive style. The petrogenesis of phonolites, in particular has been widely discussed in terms of their relative eruptability based on their low inferred viscosity.

Preliminary indications from synthetic systems have documented an influence of iron redox state on viscosity. The occurrence of Fe-rich phonolite permits the evaluation of the influence of iron oxidation state on viscosity in natural liquids under experimentally advantageous conditions. In particular, the phonolitic liquid varies from highly oxidized to highly reduced over an experimentally accessible range of fO2.

In this study all experiments have been carried out on phonolite glasses of the composition found at Oldoinyo Lengai volcano - Tanzania. (48.54% SiO_2, 16.70% Al_2O_3, 1.18% TiO_2, 7.85% Fe_2O_3, 5.98% CaO, 1.12% MgO, 10.02% Na_2O, 4.68% K_2O (agpaitic index =1.29). The starting glass was synthesized from oxide and carbonate powders in air at 1500˚C and subsequently re-melted at 1200˚C,where it was homogenised by stirring.

The viscosity was measured at high temperature using the concentric cylinder redox viscometry strategy we have developed previously. The melt was continuously stirred and the fO2 was set at successive values using CO-CO_2 mixes. For each redox step the melt was sampled for analysis (electron microprobe, Fe redox titration) and for low temperature viscometry using the micropenetration method.

A significant variation in viscosity with redox state is observed at high temperature. Melt viscosity decreases with decreasing oxidation state. The results are parameterised in terms of T-fO2. These results indicate that, in general, redox state may have a significant effect on multicomponent melt viscosity and that therefore, this possibility must be investigated experimentally in other multicomponent melt compositions.