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Redox viscometry of ferropicrite melt

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The rheology governs the dynamics of magmas at all scales (i.e. partial melting, magmatic chamber emplacement, lava flow behavior). It is also a fundamental constraint on volcanic morphology and landforms. Most terrestrial volcanic flows have moderate iron contents up to 10 wt% but some basalts show contain up to 16 wt%. These ferropicrites range from the Archean to recent, typically forming thin isolated flows near the base of thick lava piles in large igneous provinces, are not well understood. Although ferropicrites are rare on Earth´s surface they are believed to be abundant on Mars. Analyses of Martian rocks (from remote sensing data, in situ measurements and meteorite analyses) display up to 20 wt% FeO. Studying these compositions will help to constrain the physical nature and evolution of the volcanism on Mars.

The influence of iron on the structure and properties of magmatic melts, remains controversial. Simple system investigations indicate an as yet insufficiently parameterized influence of the oxidation state of iron on the rheology and other properties of silicate melts. The dependence of shear viscosity on the oxidation state of ferrosilicate melts has been measured using the concentric cylinder method and a gas mixing furnace. Previously, two different simple Fe-bearing systems have been studied: (i) anorthite-diopside eutectic composition (AnDi) with variable amount of Fe (up to 20 wt%) as a basalt analog and (ii) sodium disilicate (NS2) with up to 30 wt % Fe. Two natural compositions have been previously investigated, a phonolite and a pantellerite. Here, the compositional range has been extended to the more complex ferropicrite composition using the Adirondack class rock, a typical martian basalt (with low Al content and Fe up to 18,7 wt%). The experimental procedure involves a continuous measurement of viscosity at constant temperature during stepwise reduction state. The melt is reduced by flowing CO2 and then successively reducing mixtures of CO2-CO. The composition and oxidation state of the melt is monitored by obtaining a melt sample after each redox equilibrium step. The melts are sampled by dipping an alumina rod into the sample and drawing out a drop of liquid, which is then plunged into water for quenching. The resulting glasses are analyzed by electron microprobe, and the volumetric potassium dichromate titration is employed to determine FeO content. So far we observed a very low viscosity for high iron content samples and a decrease of the viscosity with increasing Fe content. Moreover, the viscosity of all melts investigated to date decreases with melt reduction. The viscosity decrease is, in general, a nonlinear function of oxidation state expressed as Fe2+/Fetot and can be fitted using logarithmic equation. The range of viscosity is compared to previous experimental studies and will help to understand morphological observations.