

Non-Arrhenian Viscosity and Glass Transition Phenomena in Extreme Ultramafic Melts

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Accurate determination of the physical properties of silicate melts is key to predicting the dynamics of magmatic and volcanic systems. Melt viscosity is the main parameter controlling melt mobility and consequently heat and mass transport. This has led to numerous experimental investigations of silicate melt viscosity in the past. Technological advances have extended the accessible compositional and temperature range but experiments with strongly depolymerized melts have been restricted to high pressures and temperatures, where Arrhenian behavior is typically observed. However, these melts are expected to exhibit strongly non-Arrhenian behavior, making extrapolations from high temperatures based on an Arrhenian law erroneous and low temperature viscosity measurements crucial. The most depolymerized melt studied to date is peridotite [1,2].

To address this gap, we have used a novel combination of pulsed laser deposition to produce amorphous (confirmed by transmission electron microscopy (TEM)) thin films of olivine stoichiometry (confirmed by rutherford backscattering spectrometry and TEM, NBO/T~4) with fast differential scanning calorimetry to measure the glass transition at extremely high heating and cooling rates (3500–9500 K/s). We demonstrate that these thin films are glass, as they exhibit a reproducible glass transition upon heating. Applying a shift factor, we derive viscosities at these temperatures that extend the known viscosity range by about 7 log units. The new results in combination with existing high temperature data, are used to fit a Vogel-Fulcher-Tammann equation which allows an interpolation of viscosities as a function of temperature and that describes a strongly non-Arrhenian trend. Our results mark the counterpart to the most polymerized silicate melt (SiO₂, NBO/T=0) and will allow better predictions, i.e., improved models, of melt viscosities that lie within this vast compositional space.

[1] Dingwell D. B., Courtial P., Giordano D. and Nichols A. (2004) Viscosity of peridotite liquid. *Earth and Planetary Science Letters* **226**, 127–138.

[2] Di Genova D., Bondar D., Zandonà A., Valdivia P., Al-Mukadam R., Fei H., Withers A. C., Boffa Ballaran T., Kurnosov A., McCammon C., Deubener J. and Katsura T. (2023) Viscosity of anhydrous and hydrous peridotite melts. *Chem. Geol.* **625**, 121440.