

High-pressure viscometry of polymerized silicate melts and limitations of the Eyring equation

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ABSTRACT

In situ falling-sphere measurements of viscosity have been performed to determine the viscosity of dacite melt (68 wt% SiO₂) from 1.5 to 7.1 GPa at temperatures between 1730 and 1950 K, using the T-25 MA8 multianvil apparatus at the GSECARS 13-ID-D beamline at the Advanced Photon Source, Argonne National Lab. The viscosity of dacite melt decreases between 1.5 and 7.1 GPa. At 1.5 GPa and 1825 K the viscosity is 86.6 ± 17.3 Pa·s, whereas at 6.6 GPa and 1900 K it is 2.8 ± 0.6 Pa·s. The negative pressure dependence of viscosity results in an activation volume of -12.4 ± 1.4 cm³/mol at 1800 K and -5.1 ± 0.9 cm³/mol at 1900 K. These new data are compared with viscosities estimated from the Eyring equation using oxygen self-diffusion data for the same bulk composition at high pressures. The Eyring equation generally predicts viscosities that are greater than measured viscosities. In addition, the Eyring equation predicts a minimum viscosity at 5 GPa, but no minimum was seen in our falling sphere data set. These discrepancies suggest that the mechanisms for viscous flow and self-diffusion of oxygen in polymerized melts may differ at high pressures, thus limiting the utility of the Eyring equation for high-pressure extrapolations. Further development of the Adam-Gibbs theory may provide an alternative for relating self-diffusion and viscosity at high pressures.