THE RHEOLOGICAL EVOLUTION OF PLANETARY BASALTS DURING COOLING AND CRYSTALLIZATION

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ABSTRACT

Basaltic lavas cover large portions of the surface of the Earth and other planets and moons. Planetary basalts are compositionally different from terrestrial basalts, and show a variety of unique large-scale lava flow morphologies unobserved on Earth. They are usually assumed to be much more fluid than basalts on Earth, such as Hawaiian basalt, but their rheology is largely unknown.

I synthesized several synthetic silicate melts representing igneous rock compositions of Mars, Mercury, the Moon, Io and Vesta. I measured their viscosity by concentric cylinder and parallel plate viscometry. Planetary melts cover a wide range of viscosity at their liquidus, overlapping with terrestrial basaltic melts. I present a new viscosity model for planetary basalts.

During crystallization, the rheological behavior changes from Newtonian to pseudoplastic. Combining rheology experiments with field observations, the rheological conditions of the pahoehoe to ‘a‘a morphological transition for Hawaiian basalt were determined in strain rate-viscosity space. This transition occurs at temperatures around 1185±15°C. For Mercurian lavas, this transition is predicted to occur around 1250±30°C. Our experimental results suggest, that the large smooth volcanic plains on Mercury’s northern hemisphere are due to flood basalt volcanism rather than unusually fluid lavas. We also show that lunar KREEP lavas may form rilles through levee construction rather than thermo-mechanical erosion.