In-situ viscometry of primitive lunar magmas at high pressure and high temperature

N. RAI[1,2], J.-P PERRILLAT[3], M. MEZOUAR[4], A. COLIN[5], S. PETITGIRARD[6] AND W. VAN WESTRENEN [7]

[1]Centre for Planetary Science at UCL/Birkbeck, University of London, London, United Kingdom.
[2]Department of Earth Sciences, Natural History Museum, London, United Kingdom.
[3]Laboratoire de Géologie de Lyon, UMR5276, Université Claude Bernard Lyon1 – CNRS – Ens de Lyon, Villeurbanne, France.
[4]European Synchrotron Radiation Facility, Grenoble, France.
[5]Institut de Physique du Glode de Paris, Paris, France
[6]Bayerisches Geoinstitut, University of Bayreuth, Bayreuth, Germany.
[7]Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, The Netherlands.

Understanding the dynamics of the magmatic evolution of the interior of the Moon requires accurate knowledge of the viscosity of lunar magmas at high pressure and high temperature conditions. Here, we present an experimentally measured viscosity dataset for three Apollo green, orange and black glasses compositions, characterized by a wide range of titanium contents, at lunar-relevant pressure-temperature range of ~1.1 – 2.4 GPa and 1830 - 2090 K. *In-situ* viscometry using the falling sphere technique shows that the viscosity of lunar melts varies between ~ 0.13 and 0.87 Pa-s depending on temperature, pressure and composition. Viscosity decreases with increasing temperature with activation energies for viscous flow of E_a = 201 kJ/mol and E_a = 106 kJ/mol for low-titanium (Ti) and high-Ti melts, respectively. Pressure is found to increase the viscosity of these intermediate polymerized melts by a factor of ~ 1.5 between 1.1 and 2.4 GPa. At constant *P-T* conditions (~ 1.3 GPa, ~ 1840 K), viscosity decreases by a factor of three from low-Ti to high-Ti lunar magma, reflecting the structural effects of Si and Ti on melt viscosity. Our results indicate that under identical conditions of *P-T*, the high-Ti melt would exhibit maximum mobility while the low-Ti melt would show least mobility. Viscosity coefficients for most lunar melts are found to be lower than those of common terrestrial basalts, consistent with observations of thin and wide-spread lavas flows on the lunar surface.