Viscous flow behavior of tholeiitic and alkaline Fe-rich Martian Basalts

Oryaelle Magdalena Chevrel[1], David Baratoux[2], Kai-Uwe Hess[1], Donald Bruce Dingwell[1]

[1]University of Munich, Germany, [2]University Toulouse III, France

E-mail: chevrel@min.uni-muenchen.de

The chemical compositions of Martian basalts are enriched in iron with respect to terrestrial basalts. Their rheology is poorly known due to the lack of experimental data. Therefore, empirical models for the calculation of viscosity from composition are a priori not applicable a priori to these silicate melts. Here, we experimentally determine the viscosity of five synthetic silicate liquids having compositions representative of the diversity of Martian volcanic rocks over time including primary Martian mantle melts and alkali basalts. The concentric cylinder method has been employed between 1500 ℃ and the respective liquidus temperatures of these liquids. The viscosity near the glass transition has been derived from calorimetric measurements of the glass transition. Fitting parameters were obtained for the non-Arrhenian behavior of the melts viscosity over a wide temperature range. Comparison with empirical models reveals that Giordano et al., 2008 offers the best match with experimental results, whereas the model proposed by Hui and Zhang, 2007 is inappropriate for the compositions considered.
Melts thought to represent primary melts in the Amazonian period (<3.0 Ga) exhibit a slightly lower viscosity in comparison to those of the Hesperian period (age <3.7 Ga), but this difference is not deemed sufficient to produce an overall shift of Martian lava flow morphologies over time. Rather, the details of the crystallization sequence (and in particular the ability of some of these magmas to form spinifex texture) is proposed to be a dominant effect on the viscosity during Martian lava flow emplacement and may explain the lower range of viscosities (10^2 - 10^4 Pa ·s) inferred from lava flow morphology for the Amazonian period flows. In contrast, differences between the rheological behavior of tholeiitic vs trachy-basalts are significant enough to affect their emplacement as intrusive bodies or as effusive lava flows. The upper range of viscosities (10^6 - 10^8 Pa ·s) suggested from lava flow morphology may be explained by the occurrence of alkali basalt. Andesitic lavas are not required to explain these values. At superliquidus conditions, the Martian basalt viscosities are as low as those of the Fe-Ti-rich lunar basalts, similar to the lowest viscosities recorded for terrestrial ferrobasalts, suggesting fast ascent rate of magma. These low viscosities may be one of the key parameters to understand the abundance of primitive magmas at the surface of Mars (see Baratoux et al., this session).