EGU2020-19579
https://doi.org/10.5194/egusphere-egu2020-19579
EGU General Assembly 2020

Investigating mantle melting temperatures on Earth, Mars and the Moon using Al-in-olivine thermometry

Eleanor Jennings[1,2], Iris Buisman[3], and Peter Coull[2]
[1]Birkbeck, University of London, Department of Earth and Planetary Sciences, London, UK (e.jennings@bbk.ac.uk)
[2]Centre for Planetary Sciences, UCL/Birkbeck, London, UK
[3]Department of Earth Sciences, University of Cambridge, UK

Al-in-olivine thermometry, based upon the temperature-dependent solubility of Al in the olivine crystal structure [1], has become a widely adopted method to investigate the crystallisation temperatures of primitive mantle melts on Earth [2]. The thermometer is calibrated using the Al contents of co-existing olivine and spinel: these phases are on or near the liquidus of primitive magmas, so the thermometer should access liquidus temperatures of mantle melts, thereby constraining the minimum mantle melting temperature. CFB-associated primitive melts have average olivine crystallisation temperatures well in excess of MORB, and back-calculation to the potential temperature of their mantle source regions suggests mantle thermal anomalies of several hundred degrees [3].

Whilst mantle thermal anomalies are moderately well-understood on Earth, relatively little is known about the melting conditions in the mantles of the Moon and Mars that led to the production of Maria basalts and Martian surface basalts and associated volcanic activity. Several samples returned from the Moon and basaltic meteorites from Mars (shergottites) are primitive and rich in both olivine and spinel, so would appear ideal samples for the application of Al-in-olivine thermometry to unravel their respective mantle melting conditions and, more generally, the thermal structures of those planetary interiors. In this study, we present preliminary investigations into a) five Apollo 12 primitive lunar basalts, and b) two olivine-phyric shergottites. We find that pervasive shock features make the trace Al concentrations of shergottitic olivines difficult to use, because high Al concentrations are associated with a fine micron to sub-micron network of K-rich melt veins, suggestive of fluid-mediated melt transport. On the other hand, olivine phenocrysts in all five lunar samples yield clear trends in Al contents and are excellent targets for Al-in-olivine studies. We present preliminary thermal results, as well as a newly-calibrated set of relevant thermodynamic parameters needed for back-calculating lunar melting temperatures. A fully quantitative assessment of lunar maria liquidus temperatures is, however, currently hampered by the limited calibration range of the Al-in-olivine thermometer and the unconstrained effect of high spinel TiO_2 contents on the results.

[1] Coogan, L. A., Saunders, A. D. & Wilson, R. N. Chem. Geol. **368**, 1–10 (2014).

[2] Trela, J. et al. Nat. Geosci. **10**, 451–456 (2017).

[3] Jennings, E. S., Gibson, S. A. & Maclennan, J. Chem. Geol. **529**, 119287 (2019).