Melting of the Martian mantle and the origin of olivine-phyric shergottites: Constraints from Al-in-olivine thermometry and thermodynamic modelling

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Mars has been volcanically active throughout much of its geological history. Direct evidence of recent (< 500 Ma) Martian magmatism has conveniently been delivered to us on Earth in the form of shergottite meteorites, allowing the petrological investigation of the Martian interior. Recent melting on Mars requires that parts of its interior have retained enough heat over time that mantle can buoyantly rise and undergo decompression melting, i.e. plume melting. We apply the recently-calibrated Al-in-olivine geothermometer to two olivine-phyric shergottites. High crystallisation temperatures of 1100 – 1400 °C support the hypothesis of their high-temperature origin as near-primary mantle melts. The relatively low Fo contents of the olivines (Fo_{63}-Fo_{73} cores) imply that their parental melts originated from the partial melting of a relatively high Fe/Mg mantle. We have thermodynamically modelled phase relations of plausible Martian mantle compositions in THERMOCALC and PERPLEX. The results are used to reconstruct isentropic thermal pathways from melting to emplacement: this allow us to examine melting conditions, including potential temperature and lithospheric thickness (or melt fraction) from a thermal perspective, and does indeed imply that elevated mantle temperatures are required to generate shergottites. The modelled phase relations indicate that garnet may be absent from the solidus in melting regions of the Martian mantle, which has implications for the interpretation of magma REE patterns in terms of mantle melting.

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