

ORIGIN OF OLIVINE-PHYRIC SHERGOTTITES

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Overview: In this study, we apply Al-in-Olivine geothermometry [1] to address competing petrogenetic models regarding enriched and depleted olivine-phyric shergottites. The thermometer is based on Al partitioning within olivine-spinel (Ol-Sp, spinel defined as the solid solution between spinel *sensu stricto* and chromite [Mg,Fe][Al,Cr]₂O₄) co-saturated igneous systems, and is well-calibrated at 1atm, 1250–1450°C, FMQ+1.3 to FMQ–1.5, reproducing experimental temperatures within ±22°C. Further, experiments at IW–1 from [2] and 1GPa data from [3] do not display systematic deviation from the current calibration, indicating the thermometer is distinctly applicable to a diverse suite of planetary redox states, interior pressures, and magmatic compositions [4].

Background: Several of the Ol-phyric shergottites are interpreted as crystallized primary melts from the martian mantle [5-9]. In particular, large MgO-rich Ol phenocrysts (hosting chromite inclusions) are the primary liquidus phase, where sub-sequent ascent and/or eruption resulted in rapid cooling and formation of a pyroxene, plagioclase, and ulvöspinel groundmass [5,10-12]. However, petrogenesis of the shergottites is clouded due to their various degrees of enrichment or depletion of light rare earth elements (LREE) and *f*O₂, for example. Two competing modes of origin suggest: (**model 1**) in addition to a LREE depleted mantle reservoir, an enriched LREE mantle source was also produced during magma ocean differentiation where mantle cumulates hybridized with a trapped late-stage enriched crust-like component and an oxidant [13-19], or (**model 2**) shergottite magmas are derived from a depleted source, where some magmas acquire a LREE enrichment and higher *f*O₂ during magma-wallrock interactions in the oxidized and enriched martian crust [20-24]. Regardless of origin, the chromite-hosting Ol phenocrysts can provide a direct link to parental melts or cumulus components of the martian interior [13,20,25,26].

Thought Experiment & Preliminary Data: The incorporation of enriched crust-like components will inherently reduce the melting temperature of a given reservoir relative to a primordial non-hybridized ultramafic cumulate [2,27]. This means that melts produced from a hybridized source will have a lower thermal crystallization regime relative to primary melts derived from a non-hybridized ultramafic source [2]. Thus, if enriched Ol-phyric shergottites are derived from **model 2**, then both enriched- and depleted- shergottites will have recorded similar Ol-Sp co-crystallization temperatures. If **model 1** is correct, co-crystallization temperatures of enriched shergottites will be distinctly lower than their depleted equivalents. As proof-of-concept, we have collected preliminary Al-in-Ol data to estimate the Ol-Sp co-saturation temperature of depleted Ol-phyric shergottite Northwest Africa (NWA) 5789 (~1360°C) and compare with the experimental co-saturation temperature of depleted shergottite Yamato 980459 (~1350°C [26]), which is nearly identical in texture, mineralogy, and bulk chemistry to NWA 5789 [12]. Estimated co-crystallization temperatures utilizing Al-in-olivine geothermometry are in excellent agreement with experimental constraints. Ongoing work is evaluating the estimated co-crystallization temperatures of depleted, intermediate, and enriched Ol-phyric shergottites to assess mantle heterogeneity (or lack thereof) within the martian interior.

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