

THE EVOLUTION OF POIKILITIC SHERGOTTITE MAGMAS FROM MANTLE TO CRUST

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Introduction: Shergottites are the most common type of martian meteorites, making up ~90% of the martian meteorite collection, and have mafic and ultramafic compositions. The poikilitic shergottites are the most abundant shergottites, consisting of more than 20% of total samples [1,2]. Geochemically, poikilitic shergottites can be classified into enriched, intermediate, and depleted based on light rare earth element abundances and isotopic compositions [2-5]. The poikilitic shergottites have a unique bimodal texture representing the entire magmatic evolution of a poikilitic shergottite. Domain 1, the early stage poikilitic texture, is representative of slow cooling at depth (early-stage mineral assemblages). Domain 2, the non-poikilitic late-stage interstitial texture, is reflective of magmatic ascent and rapid cooling (late-stage mineral assemblages) [2,4]. Melt inclusions (MI) in each texture are olivine-hosted, with olivine being the earliest crystallizing mineral in the poikilitic shergottites. Thus, the MI can be representative of the compositions at the time of their formation. Here, we conducted major and trace element MI analyses on mineral phases located in MI to better constrain parental magma compositions, as the melt evolves from one domain to another, while also examining potential crustal contamination in the melt [2,4]. Through ¹⁷⁶Lu/¹⁷⁷Hf and ¹⁴⁷Sm/¹⁴³Nd isotopic analyses of mineral separates, we will determine crystallization ages and isotopic compositions for two poikilitic shergottites to constrain time of formation, sources, and therefore potential distribution of the shergottite suite on Mars.

Methods: We examined a suite of five meteorites including: Allan Hills (ALHA) 77005, Northwest Africa (NWA) 11065, NWA 7755, NWA 10618, and NWA 11043 by conducting melt inclusion analyses in both poikilitic and non-poikilitic textures. *In situ* major and minor elemental analyses of the MI using the JEOL JXA-8900 electron probe micro-analyzer (EPMA) at University of Nevada, Las Vegas (UNLV). A total of 14 MI were analyzed, 6 from domain 1, and 9 from domain 2. The parental trapped liquid (PTL) compositions were calculated for each MI using the present bulk composition (PBC) and *Petrolog3*, which allows for an accurate measurement of the magma composition at time of entrapment [4]. We conducted our thermodynamic modeling using MELTS software [4-8]. *In situ* analyses of trace elements within the MI were conducted at UNLV using the ESI 193 nm Excimer NWR193 laser ablation system, which is coupled with an iCAPTM Qc inductively coupled plasma mass spectrometry (ICP-MS). ¹⁷⁶Lu/¹⁷⁷Hf and ¹⁴⁷Sm/¹⁴³Nd isotopic analyses were conducted on two poikilitic shergottites NWA 7755 and NWA 11043 at University of Houston (UH) using methods outlined in [9-11]

Results: The olivine hosted MI have compositions of Fo₅₇₋₇₁. The Mg# [= 100*molar MgO/(MgO+FeO)] of olivine hosting MIs in domain 1 has a range of 40–50, while the olivine Mg# in domain 2 MI is 35–47. Melt inclusions in domains 1 and 2 exhibit similar CaO contents, ranging from 3–10 wt.%. The Al₂O₃ content generally shows an increase from MI in domain 1 (8–16 wt.%) to MI in domain 2 (9–21 wt.%). The SiO₂ measured in MI in domain 1 and 2 is the same (40–55 wt.%). Potassium enrichment (>1 K₂O wt.%) is seen in MI in domain 1 (1 MI) and domain 2 (4 MI), showing enrichment is more prevalent in domain 2. The K₂O/Na₂O is variable (0.02–1.9) throughout the MI in both domains. The ¹⁷⁶Lu/¹⁷⁷Hf versus ¹⁷⁶Hf/¹⁷⁷Hf 5-point isochron yielded a crystallization age of 223 ± 46 Ma (MSWD = 0.24), and an initial ¹⁷⁶Hf/¹⁷⁷Hf ratio of 0.282167 ± 0.00001 for NWA 7755.

Discussion: The overlap of the poikilitic shergottite PTL compositions with olivine-phyric PTL composition ranges from previous studies [2,4,12-14] suggest that poikilitic shergottites and olivine-phyric shergottites may share a petrological link and similar petrogenesis/magmatic history. The PTL compositions of poikilitic shergottites are not as primitive and cover a smaller Mg# range (36–50) compared to that of the olivine-phyric PTL ranges (20–56). The variability of the K₂O/Na₂O ratio between the samples suggest that poikilitic shergottites may go through a common process during melt evolution resulting in the addition of K-rich metasomatized material. Parallel rare earth element profiles of the MI compared to bulk rock trace element data for all analyzed samples suggest that the MI are all sampling melts from a single source. Northwest Africa 7755's crystallization age and ¹⁷⁶Lu/¹⁷⁷Hf composition is identical within uncertainty to other enriched shergottites ages and source compositions suggesting NWA 7755 shares a long-lived geochemical source with these samples [12].

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