CHARACTERIZATION OF POIKILITIC SHERGOTTITE PARENTAL MELTS AND WHAT THEY CAN TELL US ABOUT MARTIAN MAGMATISM

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Introduction: Martian meteorites are the only available physical samples from Mars that can be studied in laboratory settings here on Earth. The shergottites are the most common type of martian meteorites making up ~90% of the martian meteorite collection, and have mafic and ultramafic compositions. The shergottites are classified as basaltic, olivine-phyric, poikilitic, and gabbroic based on texture and minerology. Of these three subtypes, the poikilitic shergottites are the most abundant, comprising more than 20% of the martian meteorite collection [1,2]. Geochemically, poikilitic shergottites can be classified as enriched, intermediate, and depleted based on light rare earth element abundances and isotopic compositions.

Poikilitic shergottites are crucial to the study and understanding of martian magmatism and geological history, as they likely represent a major lithology of the martian crust [2-5]. What separates the poikilitic shergottites from the other shergottite subgroups is their unique bimodal texture. This bimodal texture can help shape the entire evolution of poikilitic shergottites as the early stage poikilitic texture is representative of slow cooling at depth, and the non-poikilitic late-stage interstitial texture is reflective of magma ascent and more rapid cooling [2,4].

Melt inclusions (MI) in each texture are representative of the parental magma compositions at the time of their formation as they are olivine-hosted, with olivine being the earliest crystallizing mineral in the poikilitic shergottites. Analyzing MI allows us to study the evolution of the parental melt of the sample starting at the crust-mantle boundary and moving up through to the surface [2,4]. By doing this, we can better constrain their parental melts, while also determining petrological links between the shergottite subgroups. We have conducted MI analysis on a suite of poikilitic shergottites to evaluate their parental melt compositions, thus, helping determine their sources and petrogenetic relations to the other shergottite subgroups.

Methods: We conducted MI analysis on five poikilitic shergottites. Two are enriched (Northwest Africa [NWA] 7755 and NWA 10618) and three are intermediate (NWA 11065, NWA 11043, Allan Hills [ALHA] 77005). Backscatter-electron (BSE) images were taken of a thin section for each sample using the *JEOL* JSM-5610 scanning electron microscope (SEM) at University of Las Vegas, Nevada (UNLV) to identify MI and their phases throughout the bimodal textures (Fig. 1). Following BSE imaging we then conducted in situ major and minor elemental analyses of the MI using UNLV's *JEOL* JXA-8900 electron probe micro-analyzer (EPMA). To get an accurate measurement of the present bulk composition (PBC) of each MI, we calculated the volumetrically-weighted average for each sample's mineral phases. To do so, we calculated their modal abundances with ImageJ software by point counting phases in BSE images. These modal abundance values were then normalized and multiplied by the average composition of each phase. Using the PBCs, we calculated the parental trapped liquid (PTL) compositions for each MI using Petrolog3, which allows for an accurate measurement of the magma composition at time of entrapment [4] as this software corrects for post entrapment processes (including diffusion) [7]. We also used MELTS software to account for 'Fe-Mg' loss [4,7,8].

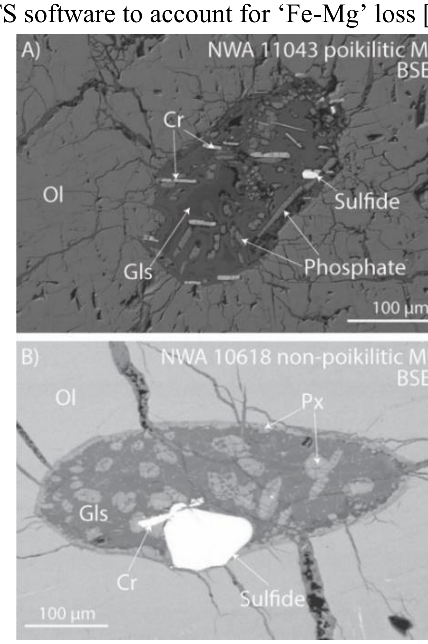

***Figure 1**: A) Poikilitic melt inclusion found in NWA 11043. B) Non-poikilitic melt inclusion found in NWA 10618. Ol = olivine, Px = pyroxene, Gls = glass, Cr = chromite.*

Results: We analyzed 6 olivine-hosted MI in the poikilitic texture, and 7 MI in the non-poikilitic texture. The average size of the MI analyzed was ~120 µm with the largest MI at 400 µm and the smallest at 50 µm. There was no observed correlation between MI size and texture. All analyzed MI were polymineralic, which included phases such as glass, pyroxene, phosphates, oxides, and sulfides. All MI had a feldspathic glass phase, while some MI also exhibited another homogeneous high-silica glass phase along with the feldspathic glass (Figure 1). Some feldspathic glass phases were enriched in potassium (K). The olivine hosts of the MI had compositions of Fo57–71. The Mg# [= 100 x molar MgO/(MgO+FeO)] for the MI in the poikilitic texture in the suite was ~37–49, while the MI in the non-poikilitic texture were ~32–52. Potassium enrichment (>1 K_2O wt.%) is seen in MI in the poikilitic texture and non-poikilitic texture, but is more common in MI in the non-poikilitic texture. Melt inclusions in the poikilitic texture exhibited CaO content of ~6–10 wt.%, while MI in the non-poikilitic texture showed ~1–16 wt.%. The Al_2O_3 content generally showed an increase from MI in the poikilitic texture (~1–9 wt.%) to MI in the non-poikilitic texture (~8–21 wt.%). The SiO_2 increased significantly from the MI in poikilitic texture (~46–56 wt.%) to MI in the non-poikilitic texture (~45–68 wt.%). The K_2O/Na_2O is variable (~0.02–1.9) throughout the MI in both the poikilitic and non-poikilitic textures (Figure 2).

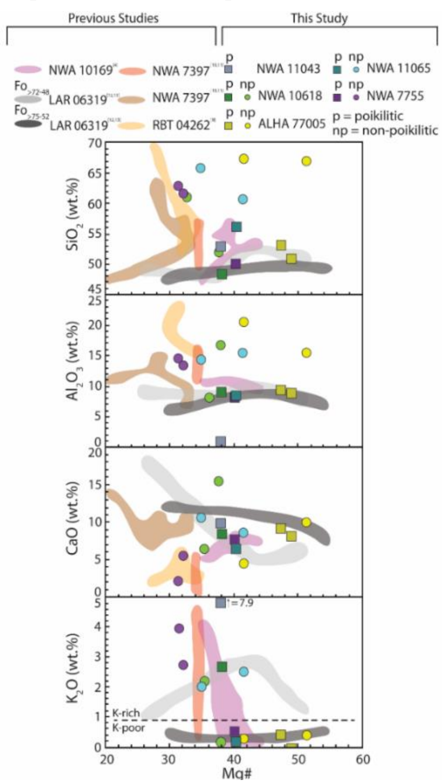

***Figure 2**: Mg# of calculated PTL compositions from melt inclusions are plotted against K_2O, CaO, Al_2O, and SiO_2, for shergottites in this study and previous studies. The enriched poikilitic shergottite PTL compositions are represented by RBT 04262 [9], NWA 7397 [10,11], NWA 10169 [4], NWA 10618 and NWA 7755. The enriched olivine-phyric shergottite PTL composition is represented by LAR 06319 [12,13]. The intermediate poikilitic shergottite PTL compositions are represented by NWA 11065, NWA 11043, and ALHA 77005. p = poikilitic np = non-poikilitic*

Discussion: The overlap of the poikilitic shergottite PTL compositions with the olivine-phyric PTL composition ranges suggest that poikilitic shergottites and olivine-phyric shergottites may share a petrological link and similar petrogenesis/magmatic history, including shergottites such as NWAs 10618, 7755, 11065, 10169, 7397, Roberts Massif (RBT) 04626, and Larkman Nunatak (LAR) 06319. The PTL compositions of poikilitic shergottites do not seem to be as primitive and cover a smaller Mg# range (~32–52) than that of the olivine-phyric PTL ranges (~20–56), as seen in Fig. 2. Based on its Mg#, ALHA 77005 has the most primitive PTL of the poikilitic shergottites measured in our study, while also having the most primitive host olivine compositions. Also based on Mg#, the intermediate shergottites exhibit slightly more primitive host olivine than the enriched shergottites leading to slightly more primitive PTL compositions for the intermediate shergottites.

The variability of K_2O/Na_2O 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, which is evident in this study (NWA 10618, NWA 11065, and NWA 7755) and previous studies [4,9]. Each of the K-rich melt inclusions in our study have K_2O/Na_2O ratios >1.30 wt.%, while all the K-poor melt inclusions had K_2O/Na_2O ratios <0.60 wt.% indicating that the K-enrichment is likely inherited from an enriched source or occurs during a magmatic process. The K-enrichment is likely a result of assimilation or alteration in the crust, and not by a metasomatized mantle source or fractionation of K-poor mineral phases.

No significant PTL compositions were calculated for MI in NWA 11043 non-poikilitic texture, likely due to terrestrial alteration. Furthermore, the K_2O (7.9 wt.%) is high and Al_2O_3 (0.39 wt.%) is low for the PTL composition representing the MI in the poikilitic texture in NWA 11043, obvious outliers in our data, suggesting the poikilitic texture may also be affected by terrestrial alteration.

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