

CHEMICAL HETEROGENEITIES AMONG MELT COMPOSITIONS HOSTED IN MELT INCLUSIONS IN NAKHLITES AND CHASSIGNITES.

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Introduction: The cumulate nakhlite and chassignite martian meteorites, with 29 total unpaired samples and shared crystallization (~1.3 Ga) and ejection ages (~11 Ma), make up the largest single-origin suite of samples from Mars [1]. There are few constraints on the nakhlite and chassignite relative petrogenetic histories despite their shared provenance. Furthermore, work on nakhlite petrogenesis has focused on its two cumulus phases, olivine and clinopyroxene. While some work suggests that the two phases are cogenetic and originate from the same parental magma [1,2], other work suggests the olivine is xenocrystic [e.g., 3]. To address the petrogenetic history of nakhlites and chassignites, we examined the major, minor, and trace elements present in melt inclusions (pockets of trapped melt) that occur in samples from both classes in an effort to recreate their parental melt compositions.

Methods: We conducted major and minor element analysis with two electron probe microanalyzers (EMPA), the JEOL JXA-8200 Superprobe at Rutgers University, and the JEOL JXA-8900 at the University of Nevada Las Vegas (UNLV) using methods outlined in [4]. Analyzed samples include chassignites Northwest Africa (NWA) 2737 and Chassigny, and nakhlites Caleta el Cobre (CeC) 022, Miller Range (MIL) 090030, MIL 090032, Gobernador Valadares, and NWA 10645. We collected backscattered electron images and X-ray maps for each inclusion. The parental bulk composition was calculated by averaging the bulk composition using modal contribution and density of each phase. Parental trapped liquid (PTL) compositions for olivine-hosted inclusions were determined using *Petrolog3* [5]. Pyroxene-hosted PTL compositions were determined with the Rhyolite-MELTS thermodynamic calculator [6].

We conducted trace element analysis on melt inclusions using the Thermo Fisher Scientific iCAP Qc inductively coupled plasma mass spectrometer and Elemental Scientific NWR UP213 laser ablation (LA-ICP-MS) system at Scripps Institution of Oceanography. We used a 3.5 J/cm² fluence, 5 Hz rep rate, and a beam size between 50 and 100 µm. Trace element mapping on melt inclusions was conducted on the iCAP Qc ICP-MS and NWR193 laser ablation system at UNLV. We used a 12 J/cm² fluence, 10 Hz rep rate, and a 12 second scan speed with a 24 µm square spot for all analyses. Trace element data and maps were processed on *iolite4* [7].

Results: Melt inclusions in nakhlites are typically glassy, containing oxides and microlytic pyroxene. Rarely, nakhlite melt inclusions are polycrystalline, containing pyroxene, glass, and other minor phases. Melt inclusions in chassignites are polycrystalline, and contain glass, orthopyroxene, clinopyroxene, amphibole, and minor phases. Chassignite PTLs are more MgO-rich (8–14 wt.%) than nakhlite PTLs (1–6 wt.%). Fractionation models using chassignite PTLs do not replicate bulk nakhlite mineralogy. Rare earth element (REE) abundances for all melt inclusions analyzed parallel those of bulk rock compositions, however, individual REE and other trace element ratios (particularly Zr/Y and Nb/Y) of melt inclusions display variations and deviate from the bulk rock values. Trace element mapping of polycrystalline melt inclusions reveals heterogeneities, while glassy melt inclusions are homogenous.

Discussion: Parallel REE abundances in all nakhlite and chassignite melt inclusions indicate a single mantle source for all parental melts. However, inconsistencies in trace element ratios may be due to heterogeneities in inclusions, or reequilibration of the host mineral in a new magma leading to diffusion throughout the host mineral and between the host mineral and melt inclusion [8,9]. Some trace elements (such as Zr, Y, and Nb in olivine) have similar compatibilities, and may be equally affected by diffusive reequilibration with a host. Olivine-hosted glassy melt inclusions in nakhlites display little trace element heterogeneity and plot together on Zr/Y and Nb/Y diagrams but apart from bulk rock values. Thus, nakhlite olivine (with a unique Zr/Y, Nb/Y signature) may have formed separately from, and was entrained with, the bulk nakhlite magma (with another Zr/Y, Nb/Y signature). Pyroxene-hosted glassy melt inclusions show significant scatter in Zr/Y and Nb/Y space, likely as Zr, Y, and Nb have different compatibilities in pyroxene and are thus undergo different rates of diffusion during reequilibration. Variability in ratios of elements with similar compatibilities between bulk rock and melt inclusions have been shown to represent different degrees of partial melting resulting in unique parental melts from a single source in Hawaiian basalts [9]. Reequilibration of cumulate minerals and the possibility for multiple parental melts in the suite is evidence for magma storage, indicating that the petrogenetic history of the nakhlites and chassignites is complex.

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