

CHASSIGNITE AND NAKHLITE PARENTAL MELTS DETERMINED FROM MELT INCLUSION ANALYSIS. A. M. Ostwald¹, A. Udry¹, J. Gross^{2,3,4}, and J. M. D. Day⁵. ¹University of Nevada, Las Vegas, Las Vegas, NV 89154; ostwald@unlv.nevada.edu, ²Rutgers University, Piscataway, NJ 08854; ³Dept. of Earth & Planetary Sciences, American Museum of Natural History, New York, NY 10024; ⁴NASA, Johnson Space Center, Mail Code X12, Houston, TX, 77058; ⁵Scripps Institution of Oceanography, La Jolla, CA 92037

Introduction: The 24-sample wide collection of chassignite and nakhlite meteorites share geochemical affinities and crystallization and ejection ages (1340 ± 40 Ma and 11 ± 1.5 Ma, respectively), and so comprise the largest suite of rocks with a single origin from Mars [1]. Despite a shared provenance, [2] found dissimilarities in rare earth element (REE) profiles between minerals in both nakhlites and chassignites suggesting complications in their petrogenesis. On the other-hand, more recent studies have found that nakhlites and chassignites originate from the same magmatic source, and were emplaced near one another after the residual chassignite parental melt underwent devolatilization of a Cl-rich fluid [1,3]. Moreover, studies have identified K₂O enrichments in nakhlite parental melt compositions for several samples [4-6], possibly due to metasomatism of the nakhlite source rock. Such K₂O enrichment may also be present in the chassignite parental melt if they share a common source with the nakhlites.

There are a limited number of studies that have addressed the petrogenetic relationship between the nakhlites and chassignites [1-3]. No studies have yet attempted a systematic and comparative analysis of the parental melt compositions of both chassignites and nakhlites with a single set of techniques. In order to understand the petrogenetic relationship, if any, between the nakhlites and chassignites, we are investigating their parental melt compositions by analyzing melt inclusions present in all cumulate phases of nakhlites Northwest Africa (NWA) 10645, Caleta el Cobre (CeC) 022, Gobernador Valadares, Miller Range (MIL) 090030, and MIL 090032, as well as the chassignites, Chassigny and NWA 2737. In evaluating each parental trapped liquid using melt inclusion analyses, we hope to produce a model to explain relationship between the chassignite and nakhlite sources.

Methods: We measured the compositions of each melt inclusion via electron probe microanalysis (EPMA), using methods described in [7]. For glass phases, including those with microlytic phases too small for individual analysis, we used a broad beam (5 μ m), both to prevent Na migration and to average the inhomogeneous glass composition. We took backscattered electron (BSE) images of each melt inclusion in addition to X-ray maps of individual elements of interest (e.g., Ca, K, Fe, Si, Mg). Modal abundances were calculated using *ImageJ* software. The parental bulk composition (PBC) was determined for each inclusion by

adjusting raw EPMA data for the modal and density contribution of each phase present.

Olivine-hosted melt inclusions were found in MIL 090030, MIL 090032, Gobernador Valadares, NWA 2737, and Chassigny. Pyroxene-hosted melt inclusions were found in NWA 10645, CeC 022, and MIL 090030. Melt inclusions exchange divalent cations with their host minerals [4,8]. For olivine-hosted melt inclusions, the effects of rehomogenization were corrected with the *Petrolog3* software, which requires an estimate for initial iron content (FeO_T) of the parental trapped liquid (PTL) [8]. We selected literature estimates 28.9 wt.% [4] and 22.2 wt.% [5] for nakhlites. For the Chassigny FeO_T, we have selected a value of 20.3 wt.% [9], and for NWA 2737 19 wt.% [10].

We corrected for the exchange of cations between melt inclusions and pyroxene hosts in the nakhlites with the *Rhyolite-MELTS* software[11]. We adjusted the modal abundances of each element present in each PBC until the observed host pyroxene was in equilibrium; the calculated composition was taken as the PTL for that inclusion.

Melt inclusion petrography: Melt inclusions in nakhlites are smaller on average (~40–50 μ m) than those found in chassignites (~100 μ m), and are typically less mineralogically complex (Fig. 1). Nakhlite melt inclusion assemblages usually contain a glass phase, microlytic pyroxene, and Fe-Ti oxide phases. Melt inclusions in chassignites are typically complex, containing phase assemblages with glass, low-Ca pyroxene, augite, and they may occur with or without kaersutite (amphibole), apatite, or Fe-Ti oxides. Chassignite melt inclusions appear to have undergone more shock than those in nakhlites, with shear displacement being common.

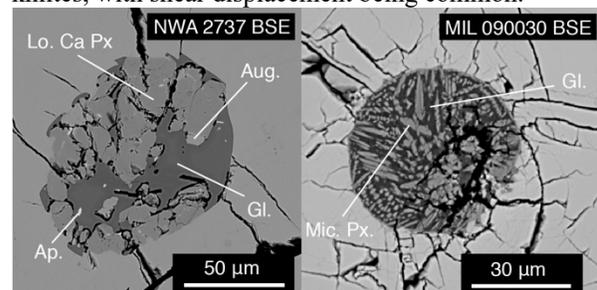


Fig. 1: (Right) BSE image of melt inclusion in chassignite NWA 2737. (Left) BSE image of nakhlite MIL 090030. Lo. Ca Px = low calcium pyroxene, Aug. = augite, Ap. = apatite, Gl. = glass, Mic. Px. = microlytic pyroxene.

Parental trapped liquid (PTL) compositions:

The chassignite PTL compositions are significantly elevated with respect to MgO in nakhlite PTL compositions (Fig. 2). Nakhlite PTLs range from 1.3 to 5.8 wt.% MgO for each inclusion, while NWA 2737 contains 8.0 – 8.8 wt.% MgO and Chassigny has 12.8 – 13.5 wt.% MgO. Chassignite PTL compositions also generally contain less Al₂O₃ than nakhlite PTL compositions. Chassigny and NWA 2737 PTL compositions contain 5.0-7.6 wt.% Al₂O₃, whereas the nakhlite MIL 090030 contains 10.2 wt.% Al₂O₃ (Fig. 2). Chassignite and nakhlite PTL compositions overlap in CaO and MnO abundance.

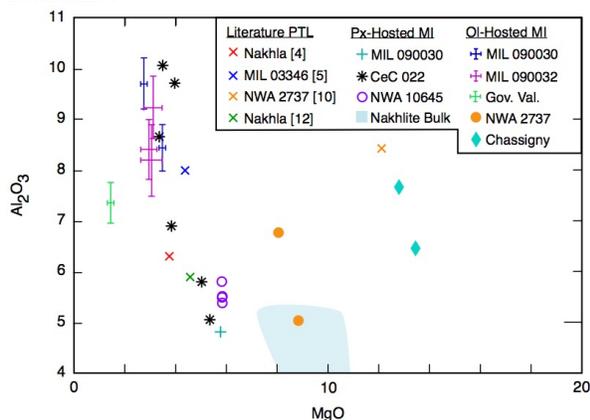


Fig. 2: MgO versus Al₂O₃ diagram containing calculated PTL compositions for nakhlites and chassignites. MI = melt inclusion, Ol = olivine, Px = pyroxene. Error bars indicate compositional range from varying FeO_T estimates.

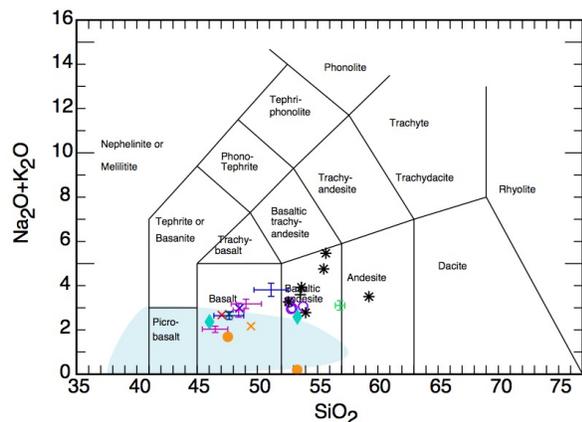


Fig. 3: Total alkali (Na₂O+K₂O) versus silica diagram for nakhlite and chassignite PTL compositions. Error bars indicate compositional range from varying FeO_T estimates.

The amount of Na₂O and K₂O is generally lower in the chassignite PTL compositions (Fig. 3). The Chassigny PTL contains as little as 0.2 wt.% Na₂O and K₂O, with K₂O comprising 0.03 wt.% of the composition. NWA 2737 contains as much 2.5 wt.% K₂O and Na₂O, with 0.7 wt.% K₂O. The chassignite and nakhlite PTL compositions share similar values for silica, with

the suite ranging from basaltic to andesitic in composition (Fig. 2).

Discussion: Chassignite PTLs are typically more primitive (contain higher MgO) and contain less Al₂O₃ and alkali elements than do the nakhlite PTLs. Chassignite melt inclusions also contain amphibole and apatite, two volatile-bearing phases reported by [3] and [10]. Given that the chassignite PTLs appear more primitive than the nakhlites, but otherwise are similar in major element chemistry to the nakhlites, it is possible that they share a similar source.

While NWA 2737 contains the most depleted melt inclusion in terms of K₂O, the Chassigny-hosted melt inclusions have PTL compositions that overlap the nakhlite PTL compositions relative to K₂O contents. K₂O enrichment due to boundary layer effects is possible, especially in small melt inclusions [4,7]. However, melt inclusions in the chassignites are large on average (~100 μm). It is then possible that the Chassigny parental melt originates from the same source as the nakhlite parental melts, which may have been enriched in K₂O prior to melting by metasomatism. It is further possible that K₂O was introduced to the melts by some open-system process during ascent of the magma, leading to progressive enrichment of K₂O in NWA 2737 and the general enrichment of the rest of the suite. Additional analysis of melt inclusions in Chassigny and NWA 2737, as well as a systematic comparison of major elements that are both affected and unaffected by boundary layer effects, will be necessary to determine the cause of K₂O enrichment in chassignite and nakhlite meteorites.

Additional work will determine the PTL for more melt inclusions present in Chassigny and NWA 2737. We will also produce fractional crystallization models using the calculated PTL compositions to determine the crystallization history of the melts present in both nakhlites and chassignites in order to determine whether or not they are co-genetic.

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