MELT INCLUSION ANALYSES TO CONSTRAIN PARENTAL MAGMA COMPOSITIONS OF THE NAKHLITE METEORITES.

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Introduction: Nakhlite meteorites originate from a single location on Mars, and the 22 unpaired samples represent the largest suite of igneous rocks from another planet [1]. Despite geochemical evidence for heterogeneity in parental magma compositions [1,2], only three nakhlites (Nakhla, Governador Valadares, and Miller Range [MIL] 03346) have established parental melt compositions [e.g., 3,4,5]. We are conducting a study on the melt inclusions (pockets of trapped parental melt) present in a comprehensive suite of nakhlites to possibly constrain their parental melt compositions as well as distinguish metasomatic alteration or crustal contamination. Identifying the parental melt composition(s) of the nakhlite meteorites will help to constrain geochemical heterogeneities present in the martian mantle and crust. We present here initial findings on the parental melt compositions present in both the olivine- and pyroxene-hosted inclusions of four nakhlites: Governador Valadares, MIL 090030, MIL 090032, and a new find; Northwest Africa (NWA) 10645.

Methods: We measured major and minor elemental compositions of the different minerals and glasses present in the melt inclusions of each sample through electron microprobe analysis using methods found in [6]. Melt inclusions continue to exchange divalent cations (Mg, Fe) with their host crystals in the subsolidus, typically resulting in a net Fe-loss [7]. We corrected olivine-hosted melt compositions for the effects of rehomogenization with *Petrolog3*, which requires an estimated initial FeO_T and the known Fo# of the host mineral. We selected FeO_T values from two proposed parental melt compositions, both using *in situ* microanalytical techniques without experimental rehomogenization. Reference [3] found a FeO_T of 28.9 wt.% in the olivine-hosted inclusions of Nakhla, whereas [5] calculates an FeO_T of 22.2 wt.% in the augite-hosted inclusions of MIL 03346. Corrections for cation exchange between pyroxene and melt were made in Rhyolite_MELTS [8]. The modal contribution of pyroxene in the trapped liquid compositions was adjusted until pyroxene was in equilibrium, and the resultant liquid composition was then inferred to be the parental trapped liquid composition.

Results: Texturally, olivine-hosted inclusions are complex and frequently contain pyroxene microlites in high-Si glassy phases in addition to olivine and oxides. Pyroxene inclusions are simple glass surrounded by wall augite, and they occasionally contain large Ti oxides. Calculated parental trapped liquids in olivine-hosted melt inclusions contain 0.5-1.0 wt.% K_2O and 1.4-2.0 wt.% Na_2O, while pyroxene-hosted inclusion compositions contain 0.7-3.0 wt.% K_2O and 0.6-2.4 wt.% Na_2O. Olivine-hosted inclusions have P2O5 concentrations ranging from 0.5-1.1 wt.%, contrasted with 0.1-0.4 wt.% in pyroxene-hosted inclusions. Pyroxene-hosted inclusions are also more siliceous, containing an average of 53.1 wt.% SiO_2 compared to an average of 48.8 wt.% SiO_2 in olivine-hosted inclusions. Olivine-hosted MgO values range from 1.3-3.6 wt.%, while pyroxene-hosted MgO is 5.8 wt.%. Aluminum oxide in olivine-hosted inclusions averages at 8.4 wt.% against 5.4 wt.% in pyroxene-hosted ones. Melt inclusions hosted in olivine show a distinct evolutionary trend when alkali elements (Na_2O and K_2O) are compared to silica, and are primarily basaltic in composition; melt inclusions hosted in pyroxene, however, show no evolutionary trends and are andesitic basalt.

Discussion: There is significant major and minor element variation in the trapped liquids hosted by olivine and pyroxene (the two primary cumulus phases present in nakhlites), as well as textural dissimilarities between the two types of inclusions. Cumulus pyroxene is possibly a late-stage phase enclosing a more evolved melt composition than the melt entrapped in earlier-crystallizing olivine, resulting in a relative K enrichment. Olivine-hosted inclusions in the four nakhlites reveal distinct compositional evolution that may originate from a single source composition. Significant chemical differences between olivine- and pyroxene-hosted inclusions may result from fractional crystallization (the removal of primitive solid phases), or from the presence of xenocrystic olivine from a distinct parental magma. In light of these findings, a larger study encompassing more samples is warranted.

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