Volatile abundances and H isotope signatures of melt inclusions and nominally anhydrous minerals in the nakhlites and chassignites

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Water and other volatiles play an important role in partial melting of mantle sources of primary magmas and their eruption and crystallization histories. The lack of pervasive alteration or shock melting in nakhlites and chassignites suggests that their nominally anhydrous minerals and melt inclusions may provide clues to the volatile abundances and H isotope compositions of their parent magmas. The abundances of H_2O, CO_2, F, S, and Cl and the H isotope signatures of nominally anhydrous minerals and the melt inclusions were measured in 7 nakhlites and 2 chassignites using standard SIMS techniques. The volatile abundances in the olivine and pyroxene in the nakhlites are lower than those of typical terrestrial basalts, mantle xenolithes, and megacrysts. The δD values for olivine are low and overlap with the terrestrial range (-350 to +100‰). The clinopyroxene shows a wide range of δD, the largest in Governador Valadares (+200 to 1250‰). The olivines in chassignite have water abundances that are similar to those of mantle olivine (140 to 280 ppm) and low δD values (-67 to +86‰). Most inclusions in the nakhlites and chassignites have low water abundances and, by Martian meteorite standards, modest D enrichment. If the compositions of the nominally anhydrous minerals are primary, then the δD value of the parent magma is low. H isotopes provide clues to why the water contents of the melt inclusions are low. Degassing reduces the δD of the magma due to vapor-liquid equilibrium isotopic fractionation. The positive correlation between water and δD in melt inclusions in Governador Valadares suggests that its parent magma degassed. The negative correlation between H_2O and δD in Yamato 000593 suggests diffusive H loss. In the majority of the meteorites studied, however, there is no significant correlation between H_2O and δD. Given the low water contents, any contamination may be complicating the interpretation of δD values. The low volatile abundances in the nakhlites and chassignites suggest that either the parent magmas degassed or volatiles were depleted in the source region of their parental melts.

Identification, interpretation and significance of fluid inclusions trapped in immiscible fluid systems

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Fluid immiscibility is an important process in the Earth's crust and upper mantle and fluid inclusions provide the most direct evidence for the occurrence of fluid immiscibility. Fluid inclusions trapped from immiscible fluids provide information concerning the physical and chemical environment attending various geological processes. However, the identification of fluid inclusions trapped from immiscible fluids and their interpretation remain topics of discussion. Here we summarize techniques that should be used to identify and confirm that fluid inclusions were trapped from immiscible fluids, and outline techniques that should be used to obtain useful information from these inclusions.

The experienced inclusionist always envisions a phase diagram when observing fluid inclusions with the microscope, and uses this diagram to place constraints on the composition and homogenization temperature and trapping conditions of the inclusions. Thus, it is important that inclusionists be familiar with the phase relations of the more common fluid systems that serve as models for many fluids that occur in nature, including H_2O, H_2O-NaCl, H_2O-CO_2, and H_2O-NaCl-CO_2. Phase equilibria for these simple fluid systems provide the basis to understand the physical and chemical environment of inclusions trapped in immiscible fluid systems. In this presentation the PVTX properties of these systems will be reviewed using examples of the correct techniques for recognizing and interpreting fluid inclusions trapped in immiscible fluid systems.