LIGHT LITHOPHILE ELEMENT MICRODISTRIBUTIONS IN PYROXENES OF THE MARTIAN METEORITES.  C. D. Williams, M. Wadhwa, D. R. Bell, and R. Hervig. 1 School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404, USA

Introduction: The light lithophile elements (LLE) such as Li, B, and Be, along with F and H, can be useful as tracers of magmatic-hydrothermal processes. The abundances and zonation patterns of these elements in primary igneous minerals in the martian meteorites may shed light on the volatile contents of the Mars mantle and the magmas derived from it. In recent years, several studies have attempted to address the question of the degassing of water from martian magmas using the distributions of light elements with volatile affinities (Li and B, in particular) in the pyroxenes of some of the martian meteorites [1-7]. However, the results from these studies have been somewhat ambiguous and controversial, and have raised additional questions regarding the role of secondary processes such as diffusional equilibration in producing the observed distributions of light lithophile elements in these pyroxenes. It has been shown that combining the information from abundances and isotopic compositions of LLE in martian pyroxenes may help to better address these questions ([e.g., 6].

In an attempt to address the questions related to the degassing of martian magmas during their emplacement and crystallization and the effects of igneous fractionation and subsolidus equilibration, we have initiated an investigation of the abundances and isotope systematics of light lithophile elements of pyroxenes of several shergottites and nakhlites, and we plan to extend our analyses to the abundances of F (which appears to act crystal-chemically in a manner similar to OH). Here we report some preliminary results from this investigation that include LLE abundances in pyroxenes of three shergottites (basaltic shergottites Shergotty and Zagami as well as the olivine-phyric shergottite SaU 005) and one nakhlite (Yamato 000593).

Analytical Procedures: All measurements were made on polished thin sections of Shergotty, Zagami, SaU 005 and Yamato 000593. Major element zonations in pyroxene grains were mapped by backscattered electron imaging on a JEOL 845 scanning electron microscope at Arizona State University (ASU) and were used to locate suitable areas for the ion microprobe analyses. To eliminate B contamination prior to the ion microprobe analyses, each thin section was washed in a 1.82% manitol solution and rinsed in ultra pure water, and then was immediately gold coated. The abundances of Li, Be, B, and Ti were measured using the Cameca ims-6f ion microprobe at ASU using methods similar to those described by [8-10]. Ion microprobe analyses were conducted with a 3 nA O+ beam with a spot diameter of 20 to 30 μm. The counts at the masses of interest, i.e., [Li, Be, B, 47Ti, 30Si], were integrated for 2, 2, 5, 1, and 5 seconds, respectively, for each cycle and each measurement consisted of 50 cycles.

Results and Discussion: Figures 1-3 show the measured concentrations of Li, B and Be plotted versus the TiO2 contents of pyroxenes from the three shergottites (Shergotty, Zagami and SaU 005) and the nakhlite Yamato 000593. The abundances of these elements have been reported previously for other shergottites (including Shergotty, Zagami and NWA 480 [1-5]) and nakhlites (including Nakhla, Lafayette, MIL 03346 and NWA 817 [6,7]) and these are shown for comparison in these figures as the light and dark gray shaded areas, respectively.

As can be seen in Fig. 1, pigeonite crystals of the basaltic shergottites Shergotty and Zagami (for which volatile degassing of their parent magmas has been suggested [1,2]) show a gradual decrease in Li abundances as TiO2 contents increase from cores to rims, consistent with previous studies [1,2,5]. Note that although the Li abundances reported here for Shergotty and Zagami pyroxenes fall within the range reported previously, they do fall towards the low end of this range. Abundances of Li in pigeonites of the olivine-phyric shergottite SaU 005 are the lowest observed for any martian meteorite, and appear to be uniform (~1 ppm) over the range of TiO2 contents. Augite crystals of Yamato 000593 define a much narrower range in TiO2 contents, and may show a slight decrease of Li abundances with TiO2 contents.

The abundances of B show a substantial scatter in Shergotty and SaU 005 (with concentrations tending to be higher in the cores), although they are fairly constant in Zagami, with increasing TiO2 contents (Fig. 2). The B data reported here for Zagami are consistent with those reported previously by [5]. Given that Shergotty and Zagami have very similar petrographic histories, this suggests that the higher and more variable B concentrations in Shergotty (and SaU 005) may be due to incomplete removal of surface B contamination. Yamato 000593 augites have uniformly low B concentrations that increase very slightly with increasing TiO2 contents (Fig. 2).

The abundances of Be in pyroxenes of all martian meteorites analyzed here show increases as their TiO2
contents increase (Fig. 3). This is consistent with the incompatible behavior of Be during igneous fractionation processes.

The distributions of the Li and B reported here in pyroxenes of the three shergottites (Shergotty, Zagami and SaU 005) and nakhlite Yamato 00059 are currently most consistent with subsolidus diffusional processes (as suggested by [7]), while Be distributions may be recording igneous fractionation processes. Further analyses of F abundances and Li isotopic compositions of these same pyroxenes will help to better assess the roles of processes such as magmatic degassing, igneous fractionation and subsolidus diffusion in the petrogenesis of the martian meteorites.

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