LIGHT LITHOPHILE ELEMENT (Li, Be, B) ABUNDANCES IN MICROCHONDRULES IN CH CHONDRITES: INSIGHTS INTO VOLATILE BEHAVIOR DURING CHONDRULE FORMATION Adrian J. Brearley and Graham D. Layne, Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131, USA.

We have measured the major and minor element compositions of glassy and cryptocrystalline microchondrules in three CH chondrites by broad beam electron microprobe analysis. The chondrules are all SiO_2-rich, and pyroxene normative, but fall into two distinct compositional groups based on their FeO content (low FeO and high FeO). The concentrations of the light lithophile elements (LLE: Li, Be, B) have been determined in selected chondrules by ion microprobe. Be is positively correlated with Al showing that its behavior is strongly refractory, and it is also negatively correlated with the most volatile LLE, B. This negative correlation suggests that the volatile abundance of this group of chondrules is related to the volatile content of the precursor, not volatile loss during chondrule formation.

Introduction The CH chondrites [1] are an unusual group of unequilibrated carbonaceous chondrites, which have a variety of properties that differ from all other carbonaceous chondrite groups. Most notably, they are extremely enriched in Fe,Ni metal, are very depleted in volatile elements and have components (chondrules, lithic fragments, metal, CAI etc.) with a remarkably small grain size [1-5]. The origin of CH chondrites is currently not well-understood, but most workers regard them as being of nebular origin [1-4] although [5] has presented arguments for a mixed origin for the CH chondrites, involving processing of nebular material within a regolith.

Several workers have also noted that the CH chondrites contain a very high relative abundance of small (<200μm) cryptocrystalline or glassy chondrules in comparison with other chondrule types [1-4]. In order to examine the origin of these chondrules we have measured the concentrations of selected major, minor and trace elements of chondrules from three CH chondrites by electron and ion microprobe analysis. In particular we have concentrated on the behavior of the light lithophile elements, Li, Be and B in these chondrules as little is known about their behavior during chondrule formation. Cosmochemically, these elements have extremely different volatilities and can, potentially, provide important constraints on the role of volatilization during chondrule formation.

Samples. Since the discovery of ALH 85085, several other chondrites with similar chemical and petrographic characteristics have been discovered in Antarctica and in the Saharan desert [1]. The Antarctic CH chondrites appear to resemble ALH 85085 very closely in terms of grain size, modal abundance of metal and chemical composition. In comparison, the Saharan CH chondrites appear to be slightly different in having a larger mean chondrule diameter [1], although the metal abundance appears to be very similar. We have studied CH chondrites with both characteristics, namely Acfer 182, Acfer 214 and PAT 91546. Acfer 182 and 214 are paired meteorites, along with Acfer 207 [1], based on their close petrologic similarities and degree of weathering, which is extensive in both samples. We selected several glassy and cryptocrystalline chondrules from all three meteorites and determined their bulk major and minor element compositions by broad beam electron microprobe analysis. A subset of these chondrules were then analyzed for Li, Be and B and REE using the Cameca 4f IMS instrument at the UNM/SNL Ion Microprobe Facility. For some of the larger chondrules we were able to measure both REE and Li, Be and B on the same chondrule, but for some of the smaller chondrules this was not possible.

Results. BSE imaging and electron microprobe analyses of glassy and cryptocrystalline chondrules show that they are typically very homogeneous in character with no evidence of microcrystals or chemical heterogeneities, except thin SiO_2-rich rims in some examples. Variations in composition from one analysis spot to another are extremely small. Electron microprobe analyses show that, in general, the major and minor element compositions of chondrules in all three meteorites are remarkably similar, consistent with a common genesis, although there are a few minor exceptions, noted below. Compositionally the chondrules fall into two distinct groups based on their Fe content, consistent with the observations of [1]. The majority of the chondrules analyzed are SiO_2-rich, pyroxene normative and have extremely low FeO contents (<2.2 wt% FeO), but a few rare chondrules with significantly higher FeO (> 8 wt%) also occur. The Mg contents of the FeO-poor group lie in the range 38-43 wt% MgO. As is commonly the case for bulk compositions of chondrules, all the glassy chondrules in Acfer 182/214 and PAT 91546 have CI Ca/Al ratios. The CaO and

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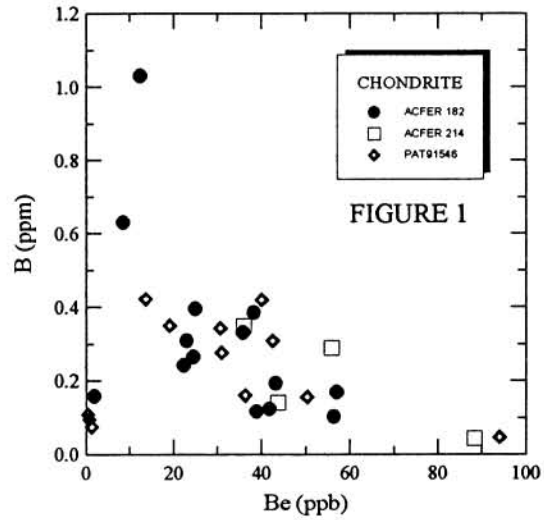
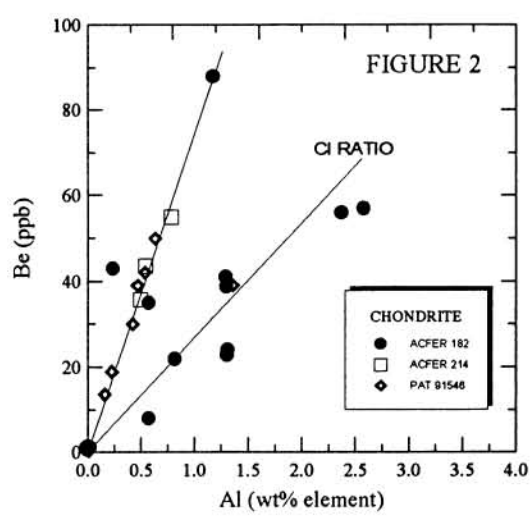
Al_2O_3 contents of these chondrules show a relative large range from ~0.25 wt% up to ~5.5 wt% (for both elements) in the most extreme case, but most chondrules have CaO contents <1wt%. In comparison, the FeO-rich chondrule group is characterized by much lower refractory element abundances and also differs from the FeO-poor group by having uncorrelated Mn and Fe.

Ion microprobe analyses of the light lithophile elements Li, Be and B in these chondrules show that they have variable concentrations from one chondrule to another. Fig 1 shows the compositional relationships between Be and B in chondrules from Acfer 182/214 and PAT 91546. It is evident that there is a strong, inverse correlation between B and Be, with a few exceptions which are dominated by chondrules with very low Be abundances. In comparison the relationships between Li and B and Li and Be are much more complex, indicating that the carriers of these elements are different. There is no apparent relationship between Li and Be or B.



We have examined the behavior of the LLE in relation to other elements measured by electron microprobe. One of the clearest relationships is that between Be and Al. In PAT 91546 these two elements show a strong positive correlation (Figure 2) consistent with the view that Be can be considered to be a refractory element and is strongly linked in its behavior to Al. Only one chondrule, with a lower Be/Al ratio, plots off this correlation line. However, the correlation line for the data in PAT 91546 is significantly different from the average CI line. In comparison, the data for Acfer 182/214 show much more complex behavior, with a weak, but less clear positive correlation between Be and Al. A combination of the two datasets appears to clarify this situation. Several of the chondrules from Acfer 182/214 have compositions which plot exactly on the correlation line defined by the data from PAT 91546, while the remaining points all plot at values which lie on, or close to the CI Be/Al ratio line. These data suggest that two distinct populations of chondrules exist within the glassy, cryptocrystalline group which have distinct Be/Al ratios resulting from differences in their precursor refractory element components. One possibility is that these represent two distinct reservoirs of material with different precursor Be/Al ratios, although this would require no mixing between these two different components prior to chondrule formation.



Relative to CI chondrites, the abundances of Li, Be and B are variable. In most chondrules Be abundances are between 0.3 and 3 x CI, whereas Li and B tend to be more depleted, ranging from 0.05 to 0.8 and 0.1 to 0.7 x CI, respectively. As discussed above Be is refractory and has the highest condensation temperature with Li and B showing progressively lower condensation temperatures. For most chondrules, the abundances of these elements decrease as a function of decreasing condensation temperature. However, several chondrules have depletion patterns in which B is enriched relative to Li, indicating that the behavior of volatile elements is not simply related to volatility. This is also underscored by the strong inverse correlation between Be and B (Figure 1), which points towards a compositional control of the precursor materials rather than volatile loss during chondrule formation as the main control on the volatile content of this group of chondrules.

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