# PROTOSOLAR IRRADIATION IN THE EARLY SOLAR SYSTEM: A HIBONITE PERSPECTIVE

Ming-Chang Liu[1,2], Larry R. Nittler[1], Conel M. O'D Alexander[1] and Typhoon Lee[2]. [1]Dept. of Terrestrial Magnetism, Carnegie Inst. of Washington. E-mail: mliu@dtm.ciw.edu. [2]Inst. of Astronomy and Astrophysics, Academia Sinica.

**Introduction:** Protosolar irradiation has been thought to have occurred in the solar nebula from both cosmochemical (the existence of $^{10}$Be) and astronomical (*Chandra* observations of young stellar objects) viewpoints [e.g., 1, 2]. The stable isotopes of Li, Be and B are primarily made by irradiation, and the isotopic compositions of these elements are strongly energy dependent [3, 4]. Therefore, a quantitative understanding of the Li-Be-B isotopic compositions of the oldest solids in the Solar System could help constrain the irradiation processes in the solar nebula.

The existence of $^{10}$Be in CM $^{26}$Al-free PLAty hibonite Crystals (PLACs) has been well established, indicating that PLACs experienced intense protosolar irradiation [5, 6]. On the other hand, low [Be] and high [B] in $^{26}$Al-bearing Spinel-HIBonite spherules (SHIBs) means that $^{10}$B excesses are unresolvable even if they were also irradiated [6]. Since the Li and B isotopic ratios in low [Be] hibonites were not affected by the decay of $^{7}$Be and $^{10}$Be, they can provide information about the sources of the Li and B, including spallation.

**Experimental:** Hibonite grains were hand-picked from a Murchison acid residue (courtesy of A.Davis, Univ. of Chicago) and analyzed with a NanoSIMS 50L ion microprobe. A 5 nA, 16 KeV $^{16}O^{-}$ primary beam ($\phi$ ~ 7-10 μm) was rastered over 15×15 $\mu m^2$ areas on polished, epoxy-mounted samples. Secondary ions were counted simultaneously with six electron multipliers (EMs). The data were corrected for instrumental mass fractionation and relative sensitivity factors by comparing the measurements with a NBS 612 glass. Literature data from [6] are also considered for comparison and discussion.

**Results and Discussion:** The $^{7}$Li/$^{6}$Li and $^{10}$B/$^{11}$B ratios of Be-poor hibonites appear to be consistent with the chondritic ratios within error (12.02 and 0.2476, respectively [7, 8]), with one exception (Mur-S15) showing $^{7}$Li/$^{6}$Li = 11.37±0.17 and $^{10}$B/$^{11}$B = 0.2589±0.0126 [6]. To explain the observed Li-Be-B isotopic compositions in CM hibonites, we consider *in-situ* protosolar irradiation of already-formed hibonite grains. The newly formed hibonite would contain refractory Be, but should be essentially free of the more volatile elements Li and B. Therefore, after irradiation, $^{7}$Li/$^{6}$Li and $^{10}$B/$^{11}$B in hibonite would be consistent with the spallation production ratios, which are ~1 and ~0.44, respectively. If chondritic Li and B were added to the irradiated hibonites at a later stage, the grains would form a linear array on a $^{7}$Li/$^{6}$Li-$^{10}$B/$^{11}$B plot, with the two end points being the chondritic and spallogenic ratios. We find that the Li and B isotopic compositions of Mur-S15 can be explained by in-situ irradiation of solids followed by dilution with ~16.7 times as much chondritic material. More Li and B measurements in low [Be] samples are being undertaken to constrain the irradiation histories of these grains.

**References:** [1] McKeegan et al. 2000. *Science* 289:1334. [2] Feigelson. et al. 2002. *ApJ* 572:335. [3] Fowler et al. 1961. *American J. of Physics* 29:393. [4] Ramaty et al. 1996. *ApJ* 456:525. [5] Marhas et al. 2002. *Science* 298:2182. [6] Liu et al. 2009. *GCA* 73:5051. [7] McDonough et al. 2003. *LPS* 34, #1931 (abstract). [8] Zhai et al. 1996. *GCA* 60:4877.