Li AND B ISOTOPIC VARIATIONS IN ALLENDE TYPE B1 CAI 3529-41 : TRACES OF INCORPORATION OF SHORT-LIVED 7Be AND 10Be.

M. Chaussidon[1], F. Robert[2] and K. D. McKeegan[3], [1]CRPG-CNRS, BP 20, 54501 Vandoeuvre-l s-Nancy, France (chocho@crpg.cnrs-nancy.fr), [2] Museum National d'Histoire Naturelle, LEME-CNRS, 61 rue Buffon, 75005 Paris, France (robert@cimrs1.mnhn.fr), [3]Department of Earth and Space Sciences, UCLA, Los Angeles, CA 90095-1567, USA (mckeegan@ess.ucla.edu).

Introduction: Li-Be-B elements are powerful tracers of irradiation processes because (i) their isotopic production ratio (e.g. for Li, ^{7}Li/^{6}Li = 2.5) are very different from average chondritic ratios (^{7}Li/^{6}Li = 12.02), (ii) their abundance is approximately 6 orders of magnitude lower than that of their progenitors (mainly O) during spallation reactions and (iii) two short lived isotopes of Be exist, ^{7}Be ($T_{1/2}$ = 53 days) and ^{10}Be ($T_{1/2}$ = 1.5 My). Several studies of B isotopic variations in CAIs from carbonaceous chondrites and from hibonites grains in Murchison have shown that ^{10}Be was widespread in the early solar system [1-4]. The presence of ^{10}Be in CAIs has been taken as a strong argument in favor of an irradiation of CAIs or of CAIs precursors by the early Sun [1] and seems thus to be a very promising tool to decipher the source of other short-lived radionuclides such as ^{26}Al, ^{41}Ca and ^{53}Mn. However, it has been recently proposed that ^{10}Be could be of presolar origin, produced during stopping of GCRs in the molecular could core parent of the Solar system [5]. One way to resolve the origin of ^{10}Be would be to find traces in CAIs of the incorporation of ^{7}Be since, because of its very short half-life, it cannot be inherited from a presolar stage and is a real "smoking gun" for Solar system irradiation. Such traces have not yet been unambiguously found. We found large Li isotopic variations in one Allende type B CAI (USNM 3515) that can be modeled by a relaxation by diffusion of Li isotopic variations due to the in situ decay of ^{7}Be [6]. However, no additional argument in favor of this process could be found from a detailed study of the mineralogy and petrology of this CAI [7]. In addition this CAI contains anomalously high B concentrations which prevent the detection of ^{10}Be.

We present here a detailed study of Li and B isotopic variations in another Allende type B CAI (3529-41) in which ^{10}Be can be easily detected and in which the systematics of the Li-Be-B distribution seems more simple than in USNM 3515. In 3529-41, it is possible to discriminate the effects of secondary post-magmatic perturbations on the Li and Be distribution from correlations between concentrations of Li-Be and major elements.

Sample and techniques: Allende 3529-41 is a classical type B1 CAI previously studied for mineralogy and ^{26}Al distribution [8]. It contains a rim of dominantly melilite (with spinel, anorthite and fassaite as accessory phases) and a spinel-rich core with fassaite and anorthite. 3529-41 contains some traces of alteration and shows obvious signs for post-magmatic perturbations. Its ^{26}Al/^{27}Al ratio was determined at 4.1(±1.2)×10^{-5} from the analysis of anorthite and fassaite, but it was shown that significant perturbations of the ^{26}Al/Mg system were present in melilites. The Li-Be-B concentrations and isotopic compositions were measured at CRPG-CNRS with the ims 1270. 42 spots were analysed in melilite, 12 in fassaite and 13 in anorthite. The Li and B isotopic compositions were systematically corrected for GCR spallation of the Allende meteroid, assuming a flux of 25 protons/cm^{2}/sec and an exposure age of 10 My.

^{10}Be incorporation in 3529-41: In agreement with previous analyses [1], a clear ^{10}Be isochron is present in 3529-41 (Fig. 1) yielding a ^{10}Be/^{9}Be ratio of 8.8 (±0.6) × 10^{-4} and an initial B isotopic ratio ^{10}B/^{11}B = 0.2538 ± 0.0015 (i.e. δ^{11}B = -26±6). The ^{10}Be isochron is well behaved : only two spots show B isotopic compositions which seem to differ significantly from the best fit line : one melilite with a δ^{11}B = -89 ± 5 and a fassaite with a δ^{11}B = +48 ± 47 . Much less perturbations of the ^{10}Be/B system are observed than for the ^{26}Al/Mg system [8]. This might be related to the fact that the half life of ^{10}Be is twice that of ^{26}Al.

Strategy to find traces of incorporation of live ^{7}Be in 3529-41: Our previous ion probe examinations of CAIs have shown that the Li concentrations could be highly variable (up to 3 orders of magnitude) at a small scale [6, 9]. The major difficulty in looking for traces of in situ decay of ^{7}Be is thus to be able to discriminate which of the Li concentration variations are primary. Because Li, contrary to Be, is not a very refractory element (50% condensation temperatures of 1225 K for Li [10] and of 1500 K for Be [11]), it is likely that most of the Li which is present in the CAI was introduced during a low temperature alteration event of the CAI (or of its precursors) and was subsequently redistributed through partial melting and crystal fractionation, as proposed for Na [12].

The Be partition coefficients between melilite and CAI melt were determined experimentally allowing to predict the trend of [Be] versus X_{Ak} of melilite compatible with closed system crystal fractionation [13]. From these partition coefficients (plus data for an and fass), and from correlations between [Li], [Be], X_{Ak}, [Na_2O] it is possible to evidence spots in the CAIs were the Li-Be concentrations are not compatible with crystal fractionation. These spots (24 over 42 in melilite, 1 over 12 in fassaite and 5 over 13 in anorthite) most likely correspond to zones where the Li and Be distributions were modified after the last melting event by non magmatic secondary processes. They show mostly $^{7}Li/^{6}Li$ ratios close to chondritic. On the contrary the spots consistent with magmatic partitioning of Li and Be show Li isotopic variations positively correlated with $^{9}Be/^{6}Li$ ratios (Fig. 2) indicating the incorporation of live ^{7}Be ($^{7}Be/^{9}Be = 0.0049 \pm 0.0013$) in the CAI.

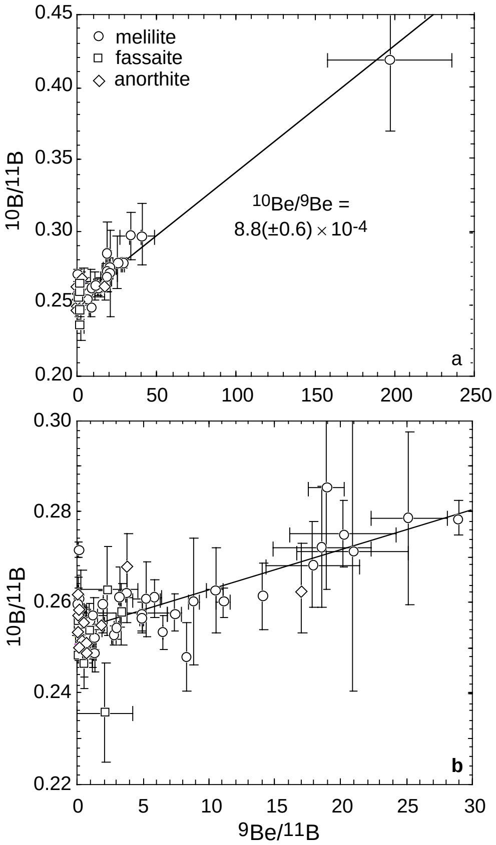

Fig. 1 : ^{10}Be isochron in Allende CAI 3529-41. (all spots)

Conclusions and implications : The present data show the incorporation of short lived ^{7}Be and ^{10}Be in Allende CAI 3529-41. The Be isotopic ratios are in good agreement with irradiation calculations performed in the framework of the X-wind model [14, 15]. The amount of ^{7}Be observed in 3529-41 is explained by the last irradiation events taking place during the mean life of ^{7}Be while ^{10}Be is accumulated along a longer period. No presolar source for ^{10}Be is required to explain the amount observed in CAIs.

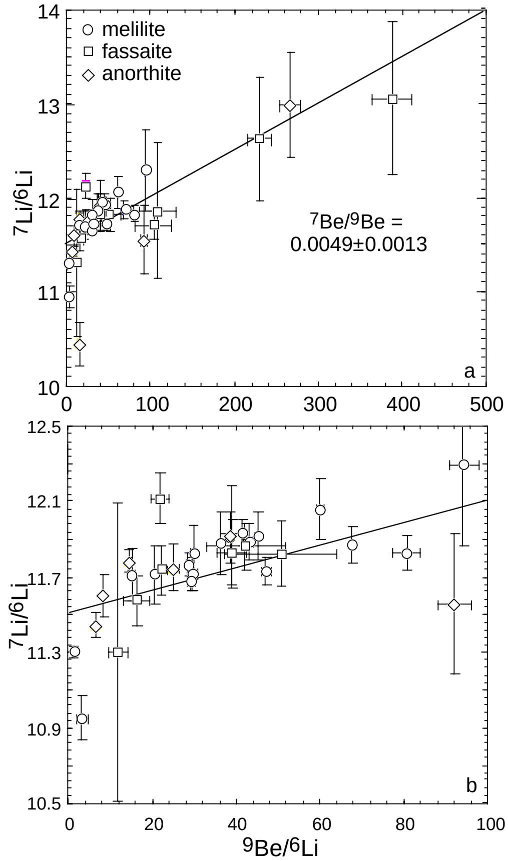

Fig. 2 : ^{7}Be isochron in Allende CAI 3529-41. (spots with magmatic partitioning of Li and Be)

References: [1] McKeegan K. D. et al. (2000) *Science* 289, 1334-1337. [2] Sugiura N. et al. (2001) *Meteorit. Planet. Sci.* 36, 1397-1408. [3] Marhas K. K. et al. (2002) *Science* 298, 2182-2185. [4] MacPherson G. J. et al. (2003) *Geochim. Cosmochim. Acta* 67, 3165-3179. [5] Desch S. J. et al. (2003) *LPSC XXXIV*, #1394. [6] Chaussidon M. et al. (2002). *LPSC XXXIII*, # 1563. [7] Paque J. M. et al. (2003) *LPSC XXXIV*, # 1401. [8] Podosek F. A. et al. (1991) *Geochim. Cosmochim. Acta* 55, 1083-1110. [9] Chaussidon M. et al. (2001) *LPSC XXXII*, #1862. [10] Wai C. M. and Wasson J. T. (1977) *Earth Planet Sci. Lett.* 36, 1-13. [11] Lauretta D. S. and Lodders K. (1997) *Earth Planet Sci. Lett.* 146, 315-327. [12] Beckett et al. (2000) *Geochim. Cosmochim. Acta* 64, 2519-2534. [13] Beckett et al. (1990) *Geochim. Cosmochim. Acta* 54, 1755-1774. [14] Gounelle M. et al. (2003) *LPSC XXXIV*, #1833. [15] Leya I. et al. (2003) *LPSC XXXIV*, #1268.