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

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Introduction: Li-Be-B elements are powerful tracers of irradiation processes because (i) their isotopic production ratio (e.g. for Li, 7Li/6Li = 2.5) are very different from average chondritic ratios (7Li/6Li = 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, 7Be (T 1/2 = 53 days) and 10Be (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 7Be was widespread in the early solar system [1-4]. The presence of 10Be 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 26Al, 41Ca and 53Mn. However, it has been recently proposed that 10Be 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 10Be would be to find traces in CAIs of the incorporation of 7Be 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 7Be [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 10Be.

We present here a detailed study of Li and B isotopic variations in another Allende type B CAI (3529-41) in which 10Be 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 26Al 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 26Al/27Al ratio was determined at 4.1(±1.2)×10^{-2} from the analysis of anorthite and fassaite, but it was shown that significant perturbations of the 26Al/27Al 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 meteoroid, assuming a flux of 25 protons/cm^2/sec and an exposure age of 10 My.

10Be incorporation in 3529-41: In agreement with previous analyses [1], a clear 10Be isochron is present in 3529-41 (Fig. 1) yielding a 10Be/9Be ratio of 8.8 (±0.6) × 10^{-3} and an initial B isotopic ratio 10B/11B = 0.2538 ± 0.0015 (i.e. δ 11B = -26±6). The 10Be 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 11B = -89 ± 5 and a fassaite with a δ 11B = +48 ± 47. Much less perturbations of the 10Be/B system are observed than for the 26Al/Mg system [8]. This might be related to the fact that the half life of 10Be is twice that of 26Al.

Strategy to find traces of incorporation of live 7Be 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 7Be 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 $[\text{Be}]$ versus $X_{\text{Ak}}$ of melilite compatible with closed system crystal fractionation [13]. From these partition coefficients (plus data for an and fass), and from correlations between $[\text{Li}]$, $[\text{Be}]$, $X_{\text{Ak}}$, [Na$_2$O] 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 $^{7}\text{Li}/^{6}\text{Li}$ ratios close to chondritic. On the contrary the spots consistent with magmatic partitioning of Li and Be show Li isotopic variations positively correlated with $^{9}\text{Be}/^{6}\text{Li}$ ratios (Fig. 2) indicating the incorporation of live $^{7}\text{Be}$ ($^{7}\text{Be}/^{6}\text{Be} = 0.0049 \pm 0.0013$) in the CAI.

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

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

**Conclusions and implications**: The present data show the incorporation of short lived $^{7}\text{Be}$ and $^{10}\text{Be}$ 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 $^{7}\text{Be}$ observed in 3529-41 is explained by the last irradiation events taking place during the mean life of $^{7}\text{Be}$ while $^{10}\text{Be}$ is accumulated along a longer period. No presolar source for $^{10}\text{Be}$ is required to explain the amount observed in CAIs.