VARIATIONS OF APPARENT $^{10}Be/^{9}Be$ RATIOS IN LEOVILLE MRS-06 TYPE B1 CAI: CONSTRAINTS ON THE ORIGIN OF ^{10}Be and ^{26}Al. M. Chaussidon[1], F. Robert[2], S.S.Russel[3], M. Gounelle[4] and R.D. Ash[5], [1]CRPG-CNRS, BP20, 54501 Vandoeuvre-les-Nancy, France (chocho@crpg.cnrs-nancy.fr), [2]MNHN-CNRS, LEME, 61 rue Buffon, 75005 Paris, France (robert@cimrs1.mnhn.f), [3]Department of Mineralogy, The Natural History Museum, Cromwell Rd, London, SW7 5BD, UK (sarr@nhm.ac.uk),[4]CSNSM, Universite Paris 11,Batiment 104, 91405 Orsay Campus, France (gounelle@csn-hp.in2p3.fr), [5]Department of Geology, University of Maryland, College Park, Maryland 20742-4211, USA (rdash@geology.umd.edu).

Introduction: The in situ decay of ^{10}Be (half-life =1.5My) has been demonstrated in many Ca-Al-rich refractory inclusions (CAIs) of primitive meteorites by the positive correlations observed between $^{10}B/^{11}B$ and $^{9}Be/^{11}B$ ratios [1-4]. These correlations indicate that the $^{10}Be/^{9}Be$ ratios at the time of formation of these CAIs varied from $\approx 10^{-3}$ to 4×10^{-4}. Because ^{10}Be was most likely produced during irradiation of the protosolar nebula by the young Sun in its T-Tauri phase, it is important to assess whether a fraction (or all) of the ^{26}Al (half-life-0.7My) and/or ^{41}Ca (half-life=0.1My) observed in CAIs might have the same irradiation origin. In this respect it is necessary to elucidate (i) whether the range of $^{10}Be/^{9}Be$ ratios observed in CAIs reflects primary features (e.g. differences in the fluences of irradiation) or secondary processes (e.g. redistribution of trace B and/or Be in the CAI) and (ii) whether there is some kind of correlation between $^{10}Be/^{9}Be$ and $^{26}Al/^{27}Al$ ratios which could argue for or against a synchronicity between the two radioactive systems. Previous attempts to look for such a synchronicity were not decisive because of the still limited data set and of the error bars on the two isotope ratios [3-5].

We have thus looked at the Li-Be-B systematics in a Type B1 CAI (MRS-06 from the Leoville CV3 chondrite) for which previous studies by laser ablation MC-ICP-MS demonstrated the occurrence of strong perturbations of the Mg-Al system [6].

Petrographic description of Leoville MRS-06: Leoville MRS-6 is an oval, 1cm×3cm Type B1 CAI. The core is composed of spinel phenocrysts, surrounded by igneously intergrown melilite (Ak4-55),Ti, Al-rich diopside (Al_2O_3 = 16-23%, TiO_2 = 2-11%), and anorthite (An 98.8-99.6). Surrounding this core is a melilite-rich mantle with a similar chemical composition to the core melilite, and which encloses minor spinel grains. The CAI is completely rimmed by a 10 µm layer of spinel surrounded by Ti, Al-rich diopside. MRS-6 is extremely pristine. The only indications of secondary alteration are very rare µm-sized calcium carbonate grains and a rare unidentified submicron Na-rich phase. Trace elements in MRS-6 were measured by LA-ICP-MS. REEs are present at levels of typically 5-50 ×CI. The CAI exhibits a complementary REE pattern; melilite is enriched in LREEs over HREEs and has a positive Eu anomaly, and diopside is preferentially enriched in HREEs with a negative Eu anomaly. The REE pattern of the bulk CAI is approximately unfractionated.

Al-Mg isotopic characteristics of Leoville MRS-06: While all the points in the spinel-rich core and most of the points in the melilite-rich mantle show ^{26}Mg excesses in agreement with a $^{26}Al/^{27}A$ of 5×10^{-5}, all the points in the outermost 100µm show no detectable ^{26}Mg excess corresponding to a $^{26}Al/^{27}A$ of 0 [6]. Noticeably several points in the melilite-rich mantle show no ^{26}Mg excesses while 100µm apart these points the excesses are present. In addition, the points in the outermost 100µm show a wide range of mass fractionation of Mg isotopes (≈ 6‰ range in $\delta^{25}Mg$) on both sides of the homogeneous $\delta^{25}Mg$ value of the core ($\delta^{25}Mg$=+7.6‰) of the CAI. These observations were interpreted as suggesting a resetting of Mg isotopes in the outermost 100µm of the CAI after than ^{26}Al was totally decayed. This event was able to re-set the ^{26}Al clock in the outermost portion of the CAI and to fractionate Mg isotopes.

Analytical techniques: The Li-Be-B concentrations and isotopic compositions were measured with the Nancy ims 1270 ion microprobe according to procedures previously described [1]. Because of the low Li-Be-B contents of CAI, primary intensities between ≈50 and ≈100nA were used, which correspond to beam sizes of up to 80-100µm in diameter. The field aperture was always adjusted to collect only ions emitted from the central 30-50 µm portion of the spot. Special attention was paid to avoid spots where some localized enhanced concentrations of either Li or B were observed during the pre-sputtering (possibly due to contamination in cracks). The Li-Be-B concentrations were directly determined from the secondary beam intensities normalized to the primary beam intensity. Errors on isotopic and concentration ratios are given with 2 sigma error bars.

Li-Be-B results: The $^{7}Li/^{6}Li$ and $^{10}B/^{11}B$ ratios in Leoville MRS-06 vary from 11.02±0.21 to 11.82±0.07 (i.e. $\delta^{7}Li$ ranging from -83.9±18.7‰ to -16.8±5.8‰), and from 0.2457±0.0053 to 0.2980±0.0085 (i.e. $\delta^{11}B$ ranging from +5.9±21‰ to -170±28.7‰), respectively. The $^{7}Li/^{6}Li$ ratios show a broad trend decreasing from the spinel-rich core to the outermost 100µm margin (Fig 1). The $^{10}B/^{11}B$ ratios are positively correlated with the $^{9}Be/^{11}B$ ratios in a manner indicating the in situ decay of ^{10}Be (Fig 2). However a significant scatter is observed for high $^{9}Be/^{11}B$ ratios. If considered separately the spinel-rich region, the melilite-rich mantle and the outermost 100µm of the CAI yield $^{10}Be/^{9}Be$ ratios of $8.3\pm1.8\times10^{-4}$, $1.07\pm0.48\times10^{-3}$ and $5.4\pm3.8\times10^{-4}$, respectively. This tendency of low $^{10}Be/^{9}Be$ ratio in the center and the margin of the CAI is exemplified in Fig 3 where the $^{10}Be/^{9}Be$ ratios were calculated separately for each point assuming a common initial $^{10}B/^{11}B$ of 0.246. Fig 2 and 3 indicate perturbations of the ^{10}Be-B system in the rim of the CAI.

Interpretations: The extreme range in $^{10}Be/^{9}Be$ ratios (from 1.23×10^{-3} to 0.48×10^{-4}), if simply interpreted in terms of duration, indicates that a heating event may have caused the partial isotopic resetting of the ^{10}Be-B system in the margin on the order of 2 Myr after the formation of the CAI. Assuming an initial $^{26}Al/^{27}Al$ of 5×10^{-5} of the CAI (that of the spinel-rich core), this event would occur when the CAI had a $^{26}Al/^{27}Al$ ratio of 0.7×10^{-5}, compatible with the reset of Mg isotope ratios measured in the outermost rim [6].

These perturbations of the $^{10}Be/B$ and $^{26}Al/Mg$ systems can be interpreted in one of two ways. In fact, another type of information is suggested from Fig 3: it seems that a gradient of $^{10}Be/^{9}Be$ ratios may be present in the CAI with low ratios in the center of the CAI and high ratios in the zone between 100 and 500 µm from the rim. Such high ratios could be artifacts if the thermal perturbation event of the CAI has yielded a decrease of the $^{9}Be/^{11}B$ ratios after the decay of ^{10}Be. This would suppose either that Be is more mobile than B in case of a closed system perturbation, or that B has been introduced in the CAI in case of an opened system perturbation. Note that available diffusion coefficients for Mg [7] and B [4] predict in the case of anorthite that if Mg isotopes are reset over 100µm, B isotopes would only be reset over ≈10µm.

Alternatively, Fig 3 may reflect the fact that part of the ^{10}Be was produced in situ by an irradiation of the already-formed, isolated CAI. This irradiation is also indicated by the $\delta^{7}Li$ gradient (Fig 1) towards low $\delta^{7}Li$ [8] which may result from the mixing with a spallogenic component localized at the inclusion rim. In such conditions the production rate of ^{10}Be may depend on depth. Note that because of the high concentration of Al in the CAI, such in situ irradiation of the CAI would produce a negligible amount of ^{26}Al. The ^{26}Al initially in the CAI would thus be required (i) to have formed during a prior irradiation of the precursors later assembled to form the CAI or (ii) to have a presolar nucleosynthetic origin. Interestingly irradiation and heating-evaporation of the CAI margin may be coeval.

References: [1] McKeegan K. D. et al. (2000) *Science, 90,* 1334-1337. [2] Sugiura N. et al. et al. (2000) *Meteoritics & Planet. Sci., 35,* A154. [3] McPherson G. J. and Huss G. R. (2001) *LPS XXXII*, Abstract #1882. [4] Sugiura N. et al. et al. (2001) *Meteoritics & Planet. Sci., 36,* 1397-1408. [5] McKeegan K. D. et al. (2001) *LPS XXXII*, Abstract #2175. [6] Ash R. D. et al. (2002) *LPS XXXIII*, Abstract #2063. [7] La Tourette T. and Wasserburg G. J. (1997) *LPS XXVIII*, Abstract p781. [8] Chaussidon M. and Robert F. (2001) *LPS XXXII*, Abstract #1862.

Fig 1 : Li isotopic composition in Leoville MRS-06 versus distance to the rim of the CAI.

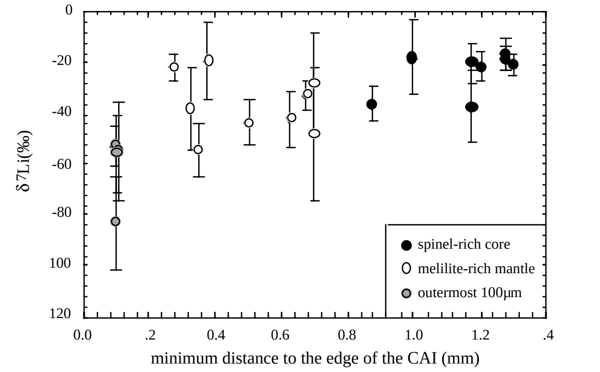

Fig 2 : ^{10}B excesses in Leoville MRS-06 showing the in situ decay of ^{10}Be (same symbols than in Fig 1).

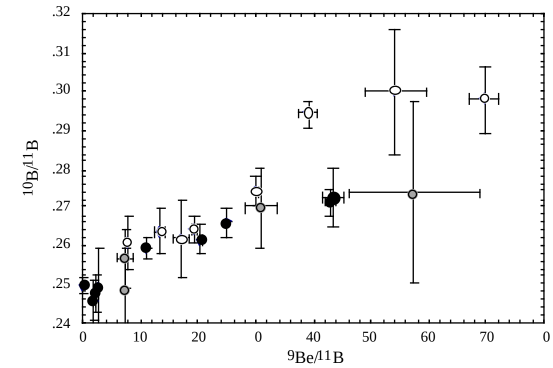

Fig 3 : variations of $^{10}Be/^{9}Be$ ratios versus distance to the rim (same symbols than in Fig 1).