**Introduction:** The fossil record of $^{10}$Be ($\tau_{1/2}$ = 1.5 Myr) in refractory inclusions is a strong indication that their precursors had been intensely irradiated by energetic particles. Because $^{10}$Be has been observed even in FUN and some hibonite-bearing inclusions that have low ($^{26}$Al/$^{27}$Al)$_{0}$ or no detectable $^{26}$Al [1-3], it is evident that $^{10}$Be was, at least, widely spread in the formation region of CAIs. However, unlike the case of ($^{26}$Al/$^{27}$Al)$_{0}$, ($^{10}$Be/$^{9}$Be)$_{0}$ of CAIs seems to be heterogeneous [3]. If the variations of ($^{10}$Be/$^{9}$Be)$_{0}$ are derived from isotopic heterogeneity of precursor materials, it is expected to be observed in correlation with other isotopic anomalies.

In this study, we measured $^{10}$Be-$^{11}$B systematics of hibonite-bearing inclusions in which Ca and Ti isotopic compositions had been measured [4]. Hibonite-bearing inclusions are most appropriate samples for this kind of study because their isotopic anomalies in Ca and Ti suggest that they potentially preserve the isotopic signatures of the earliest solar system.

**Samples:** Five platelet hibonites, or PLACs (Kz1-11, MC-F9, -F19, -F23, and -F73), one HAL-type hibonite inclusion (Kz1-2), and one hibonite-pyroxene spherule (Kz1-9) were found from a thin section of Kainsaz (CO3.2) and fragments of freeze-thaw disaggregation of Murchison (CM2).

PLACs: Kz1-11, ~250 µm × ~250 µm in size, is an aggregate of blade-shape hibonite grains. Thin spinel and diopside rim structure (~10 µm) was observed. MC-F9, ~80 µm × ~60 µm in size, and MC-F23, ~90 µm × ~80 µm in size, are fragments of much larger hibonite grains. Spinel was observed between hibonite and remnants of matrix, which suggests that these inclusions originally consist of a hibonite grain and a spinel rim. MC-F19, ~110 µm × ~40 µm in size, and MC-F73, ~130 µm × ~5.0 µm in size, are also fragments of much larger hibonite grains.

HAL-type: Kz1-2, ~100 µm × ~100 µm in size, consists of a hibonite grain enclosed by a thin spinel rim (~5 µm). Small corundum grains (< a few µm) are found on the outer margin of hibonite. TiO$_2$ content of hibonite is extremely low (~0.1 wt.%). This inclusion has heavier isotopes of O, Ca, and Ti and show Mg-excess that correspond to ($^{26}$Al/$^{27}$Al)$_{0}$=(5.3±0.3) ×10$^{-5}$ [5].

Hib-Px spherules: Kz1-9, ~60 µm in diameter, is a spherule which consists of small hibonite grains enclosed in fassaite and a thin rim of diopside (~5 µm).

Except for Kz1-2, hibonite-bearing inclusions do not have significant $^{26}$Mg-excesses. Oxygen, Ca, and Ti isotopic compositions of the samples were previously reported [4].

**Analytical conditions:** $^{10}$Be-$^{11}$B systematics were measured using the Cameca ims-6f ion microprobe at Arizona State University. A -12.5 kV O ion beam of ~20 µm in diameter with an intensity of 2.5-6.0 nA was used. Secondary ions of +10.0 kV were collected under a mass resolving power of ~1800, sufficient to eliminate interferences from hydrides. The sensitivity factor (~0.37, with Be ionizing better) was determined using NBS610 and NBS612 glasses. The instrumental mass fractionation of B isotopes ($\delta^{11}$B = +35‰) was determined by BST-1 glass ($^{10}$B/$^{11}$B = 0.24718) prepared at ASU [3].

**Results:** The observed $^{9}$Be/$^{11}$B and $^{10}$B/$^{11}$B of standard glasses (NBS610, NBS612, and BST-1), Madagascar hibonite, and hibonite-bearing inclusions are shown in Figure 1. The $^{10}$B/$^{11}$B ratios of standard glasses are scattered within 2‰ (2σ, $^{10}$B/$^{11}$B = 0.24705 - 0.24795). Although its absolute value is not known, the $^{10}$B/$^{11}$B ratios of Madagascar hibonite are the same within 2σ errors (0.2463±0.0022 and 0.2480±0.0024) of the glass standard values.

All the samples show $^{10}$Be-excesses that are positively correlated with $^{9}$Be/$^{11}$B ratios. This indicates that $^{10}$Be-excesses of the samples are due to in situ decay of $^{10}$Be. The inferred ($^{10}$Be/$^{9}$Be)$_{0}$ from the whole data set of hibonite-bearing inclusions is (1.8±0.4) × 10$^{-3}$ with an intercept of $^{10}$B/$^{11}$B = 0.2502 ±0.0014 (2σ). Assuming that their intrinsic $^{10}$B/$^{11}$B is 0.2502, the inferred ($^{10}$Be/$^{9}$Be)$_{0}$ for MC-F23, MC-F73, and Kz1-11, which show high $^{9}$Be/$^{11}$B (>10) ratios, are (1.9±0.5) × 10$^{-3}$, (2.0±1.1) × 10$^{-3}$, and (1.5±0.8) × 10$^{-3}$, respectively.

**Discussions:** ($^{10}$Be/$^{9}$Be)$_{0}$ of $^{26}$Al-free hibonite-bearing inclusions: It is evident that the $^{10}$Be-excesses of the samples with no detectable $^{26}$Al are results of decay of $^{10}$Be. So, the present results are further evidence that $^{26}$Al and $^{10}$Be were derived from different sources. ($^{10}$Be/$^{9}$Be)$_{0}$ from our study are slightly higher than previous results ((0.4-1.8)×10$^{-3}$) [1-3, 6-9], though with large errors. One possible reason could...
be that the sensitivity factor for hibonite is slightly higher than that for standard glasses. In this case, we would overestimate ($^{10}$Be/$^9$Be)$_0$ of the samples. To avoid this kind of problem, an appropriate standard is needed to determine the sensitivity factor of hibonite. On the other hand, if the sensitivity factor of hibonite is not much different from those of glasses, the higher ($^{10}$Be/$^9$Be)$_0$ values of our samples could be real and then the $^{10}$Be abundance in the early solar system would be heterogeneous.

The relationship between ($^{10}$Be/$^9$Be)$_0$ and isotopic anomalies of Ca and Ti: $\delta^{50}$Ti and $\delta^{48}$Ca of the samples that were previously reported in [4] are shown in Figure 2. There is no obvious correlation between ($^{10}$Be/$^9$Be)$_0$ and isotopic anomalies in Ca and Ti. If $^{10}$Be was derived from a stellar source (e.g. SN), it is expected to be observed related to the isotopic anomalies in Ca and Ti. This seems to be consistent with the idea that $^{10}$Be was synthesized by the irradiation of energetic particles [e.g. 6].

It has been suggested that syntheses of short-lived nuclides by the irradiation of energetic particles only occurred at the innermost edge of the Solar Nebula and isotopic homogenization also occurred there [10]. If this is the case, the exclusive correlation between ($^{10}$Be/$^9$Be)$_0$ and isotopic anomalies in Ca and Ti should be observed. Our results support that the irradiation of energetic particles occurred not only at the innermost edge of the Solar Nebula but also at much outer part of the Solar nebular or in the molecular cloud [e.g. 11].

**References:**