HIGH PRECISION OXYGEN ISOTOPE SYSTEMATICS OF A TYPE B1 CAI FROM LEOVILLE (CV3)

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Introduction: Oxygen three-isotope ratios of Ca-, Al-rich inclusions (CAIs) often show a large range of heterogeneity among different mineral phases in a single inclusion [e.g., 1–2], which may reflect the complex history of CAIs in both the solar nebula and the parent asteroids. Here, we report new highly precise and accurate Secondary Ion Mass Spectrometer (SIMS) analyses of a type B1 CAI from Leoville (3535-1), which was previously studied for Mg and Si isotope fractionation and ^{26}Al-^{26}Mg chronology [3–5]. This is a large pristine CAI (6×8 mm) with a 0.5-mm-thick melilite mantle. Secondary minerals, such as nepheline, are absent in this CAI.

SIMS Analyses: An IMS-1280 at WiscSIMS was used for analysis, which yields analytical uncertainties of a single 15 µm spot of 0.3–0.4 ‰ (2SD) for δ^{18}O and δ^{17}O [6]. To obtain accurate δ^{18}O and δ^{17}O values from minerals in the CAI, we used natural and synthetic mineral standards for spinel, melilite, and anorthite. For fassaite, synthetic glass standards with major element compositions similar to fassaite in the type B CAIs were synthesized. Homogeneity of oxygen isotope ratios and SIMS matrix correction factors were carefully evaluated for individual standards.

Results: Oxygen isotope ratios of spinel, fassaite, and anorthite plot near the lower end of the CCAM line [1] with δ^{18}O values of −44 ‰ to −40 ‰. The Δ^{17}O values of spinel, fassaite, and anorthite are −23.6 ‰, from −23.8 ‰ to −21.5 ‰, and −22.9 ‰, respectively. The highest δ^{18}O and Δ^{17}O values were obtained from fassaite within the melilite mantle. These data plot along the slope 1.0 line in δ^{18}O vs. δ^{17}O diagram, but are displaced to the right side of CCAM line. Melilite data plot at δ^{18}O and δ^{17}O of ~+11 ‰ and ~+4 ‰, respectively, correponding to a Δ^{17}O value of −1.5 ‰. Melilite data are also significantly higher in δ^{18}O relative to the CCAM.

Discussion: Slightly elevated Δ^{17}O values of anorthite and some fassaite compared to spinel could be caused by limited oxygen isotopic exchange with solar nebular gas when the CAI was reheated within 0.1 Ma of the earliest recorded events of the solar system [5]. Oxygen isotope ratios of melilite are not in equilibrium with other minerals and show high δ^{18}O values, suggesting isotopic exchange at low temperature, possibly with parent body fluid or with nebular gas. However, simple diffusive isotopic exchange between CAI minerals and nebula gas or parent body fluid may not explain ^{16}O-poor melilite in the entire CAI, while preserving the ^{16}O-rich signature in anorthite [2, 7].

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