

OXYGEN ISOTOPIC COMPOSITIONS OF W-L RIM IN TWO CAIS FROM KAINSAZ CO3 CARBONACEOUS CHONDRITES

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Introduction: Ca-, Al-rich inclusions (CAIs) are the oldest known Solar System objects (4567.2 ± 0.6 Myr; 4567.30 ± 0.16 Myr)[1,2] that were formed in a short time interval. They are often surrounded by thin mono- or bi-mineralic rims known as Wark-Lovering (W-L) rims [3]. Unaltered W-L rims are composed of the same primary high temperature minerals as CAIs, such as melilite, spinel, pyroxene, hibonite, perovskite, anorthite and olivine. CAIs and their W-L rims offer a record of conditions during the earliest stages of Solar System formation in the inner regions of the solar accretion disk [4,5]. Therefore, textural, chemical and isotopic compositions of W-L rims can be used to probe nebular or parent body conditions at the time of their formation. CAIs are known to have large O isotopic anomalies with $\delta^{17,18}\text{O}$ down to ~ -50 permil relative to the SMOW value [6]. Previous oxygen isotope analyses revealed that rims also formed in an environment similar to that for the CAI main body. We report here the results of O isotopes in W-L rims of two CAIs from the Kainsaz (CO3) carbonaceous meteorites.

Samples and Experiments: Analyses were performed for an altered FTA (K2-9, $180 \mu\text{m} \times 160 \mu\text{m}$ in size) and a CTA (K2-10, $300 \mu\text{m} \times 250 \mu\text{m}$ in size) from the Kainsaz meteorites. The Cameca NanoSIMS 50L ion microprobe at the Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences was used to measure the oxygen isotope ratios in the two CAIs. A focused Cs^+ primary beam of 16 keV, ~ 100 pA was defocused to produce a spot of about $1.5 \times 2 \mu\text{m}$. ^{16}O and ^{18}O were measured simultaneously using multi-collection Faraday Cup (FC) and ^{17}O was measured simultaneously using mono-collection electron multiplier (EM), respectively. The instrument was set to give a mass resolving power (MRP) ~ 6000 (Cameca NanoSIMS definition, based on the measured peak width containing 80% of the ion beam; see [7]) on the ^{17}O detector, sufficient to resolve the ^{16}OH peak from that of ^{17}O (contribution of ^{16}OH typically ≤ 25 ppm). Oxygen isotope compositions are reported as per mil deviations from standard mean ocean water (SMOW) and as ^{16}O excesses relative to terrestrial samples ($\Delta^{17}\text{O} = \delta^{17}\text{O} - 0.52 \delta^{18}\text{O}$). Under the analytical conditions employed, the internal (1σ) precision of individual oxygen isotope analyses is typically better than 0.5 ‰ for $\delta^{18}\text{O}$ and < 1 ‰ for $\delta^{17}\text{O}$.

Results and discussion: Inclusion K2-9 contains 15 vol% spinel, 10 vol% melilite, 4 vol% olivine, 5 vol% Ca-rich pyroxene, 1 vol% perovskite, and 65 vol% altered minerals in the core. K2-10 contains 15 vol% spinel, 60 vol% melilite, 2 vol% olivine + perovskite, 5 vol% Ca-rich pyroxene, and 18 vol% altered minerals. The W-L rims are $\sim 30 \mu\text{m}$ (K2-9) and $20 \mu\text{m}$ (K2-10) thick, respectively, and composed of, from innermost to outermost, spinel, melilite + perovskite, Ca-rich pyroxene and olivine layer. The oxygen isotope measurements for the W-L rims of K2-9 and K2-10 CAIs plot within error of the Carbonaceous Chondrite Anhydrous Minerals (CCAM). This indicates that the inclusion has not been significantly affected by mass-dependent fractionation processes. The O isotopic compositions of minerals in W-L rim from K2-9 mostly fall into ^{16}O -rich cluster ($\delta^{18}\text{O}$: $-28.8 \sim -41.7$ ‰, $\delta^{17}\text{O}$: $-32.4 \sim -41.7$ ‰, $\Delta^{17}\text{O}$: $-19.6 \sim -23.3$ ‰), however, the O isotopic compositions of minerals in core from K2-9 are more ^{16}O -poor compositions ($\Delta^{17}\text{O}$: $-6.6 \sim -10.1$ ‰). The O isotopic compositions of K2-10 are similar with K2-9, and the O isotopic compositions of W-L are richer than the core of that. High-precision O isotopic spot analyses in W-L rims of K2-9 and K2-10 CAIs show that the two CAIs and their W-L rims formed in an ^{16}O -rich gaseous reservoir, like the majority of CAIs in other chondrite groups. As described above, the two CAIs contain feldspathoids in the cores, which are typical alteration products and are common in CO carbonaceous chondrites [8,9]. The isotopically heterogeneous CAIs subsequently experienced oxygen-isotope exchange in an ^{16}O -poor nebular gas when CAIs altered.

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