Oxygen isotopes in isolated olivine grains from Murchison: A separate origin from chondrule olivines.

Iffat Jabeen[1], Hajime Hiyagon[2]

[1] Earth and Planetary Sci., Univ. of Tokyo, [2] Dept. Earth & Planet. Sci., Univ. Tokyo

Olivine in carbonaceous chondrites is one of the dominant components of chondrules and occurs as isolated grains in matrix as well. The origin of such isolated grains is still under debate whether these are condensates or crystallized from chondrule melts. [1,2]. Up to now, only a few oxygen isotope studies have been made for isolated grains in CI and CO chondrites [3,4]. In order to understand their origin and formation processes, we conducted SEM-EDS analyses, Cathodo-luminescence (CL) imaging and ion microprobe analyses of oxygen isotopes for isolated olivine grains and chondrule olivines from Murchison CM2 chondrite.

Isolated olivine grains (125 to 250 micrometer mesh size) separated by a freeze-thaw disaggregation method, were handpicked and mounted with epoxy along with a San Carlos olivine standard on a glass disk (25mm in diameter) and polished. We also prepared a thin section of Murchison, with which a San Carlos olivine grain was mounted and polished together. Oxygen isotope analyses were performed using a CAMECA IMS 6F ion microprobe according to a method described in [5]. San Carlos olivine standard [6] was repeatedly analyzed before, during and after the sample runs. The precision (1 sigma) of the analyses was +/-1.1 permil for delta-17O and +/-1.2 permil for delta-18O. We also used a synthetic forsterite standard to examine a possible matrix effect for different Fa content in olivine. However, we found almost no matrix effect (only ~1 permil difference in delta-18O) between San Carlos olivine and pure forsterite in the present analytical conditions.

Five analyses groups were selected; (i) Mg-rich isolated olivines (MgOl), (ii) Mg-rich chondrule olivines (MgChOl), (iii) Fe-rich isolated olivines (FeOl), which, however, are most likely fragments of Fe-rich chondrules, (iv) Fe-rich chondrule olivines (FeChOl) and, (v) isolated olivines with Mg-rich core (Ol-core) and Fe-rich rim (Ol-rim).

In the O-three isotope diagram, Mg-rich chondrule olivines (MgChOl) and Fe-rich chondrule olivines (FeChOl) show different distributions: MgChOl data fall along the CCAM line with delta-18O from -3.8 to 5.4 permil, while FeChOl data fall more close to but ~2 permil below the terrestrial fractionation (TF) line. The distribution of the Fe-rich isolated olivine (FeOl) data is indistinguishable from that of FeChOl, suggesting a common origin. Similarities in their chemical composition and the presense of melt inclusions in Fe-rich isolated olivines also support this view.

On the other hand, Mg-rich isolated olivines (MgOl) are O-isotopically distinct from any other groups. The distribution of the MgOl data starts somewhere near the CCAM line but expands far towards the right side of this line. This makes clear contrast to the Mg-rich chondrule olivine data, which fit well on the CCAM line. Matrix effect is not likely the cause for this deviation because we see almost no matrix effect even for the pure forsterite. The present O-isotope results, therefore, strongly suggest a separate origin for the Mg-rich isolated olivines. Their refractory nature (high CaO contents of up to ~0.7 wt% and low MnO contents of 0.0-0.06 wt%) may suggest condensation origin for the Mg-rich isolated olivines. However, the relationship between these grains and AOAs is unclear, both of which are very different in the grain size and O-isotopes.

References:

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