FORSTERITE-BEARING TYPE B CAI WITH A RELICT ERINGAITE-BEARING ULTRA-REFRACTORY CAI

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Introduction: Forsterite-bearing Type B (FoB) Ca,Al-rich inclusions (CAIs) are a rare type of coarse-grained igneous CAIs found almost exclusively in CV3 chondrites [1–5]. Here we describe the mineralogy, petrography, and oxygen-isotope compositions of a FoB CAI *Al-2* from Allende containing a relict eringaite-bearing ultra-refractory (UR) inclusion. Eringaite is a Sc-rich garnet [$Ca_3(Sc,Y,Ti)_2Si_3O_{12}$] that has been recently identified in a cluster of UR inclusion fragments within an amoeboid olivine aggregate in Vigarano [6].

Results: The Allende CAI *Al-2* is a coarse-grained igneous inclusion, ~7×8 mm^2 in size, composed mainly of Al,Ti-diopside, melilite, spinel, and forsterite; anorthite is accessory. Forsterite is heterogeneously distributed in the CAI: the forsterite-rich and spinel-rich (forsterite-poor) lithologies can be identified. The CAI mantle, ~0.6 mm thick, composed of melilite, anorthite, spinel, and minor hibonite, is forsterite-free. Secondary minerals replacing melilite in the CAI core and mantle include grossular, monticellite, Ti-free Al-diopside, wollastonite, and wadalite. In the peripheral portion, melilite and anorthite are replaced by nepheline, sodalite, and ferroan olivine. The CAI also contains several voids filled by hedenbergite and andradite.

The spinel-rich lithology contains a relict UR CAI composed of multiple irregularly-shaped objects made of spinel, Y-bearing perovskite, and eringaite and surrounded by Sc-rich pyroxene (Fig. 1a). Spinel, perovskite, eringaite, and Sc-pyroxene in the relict CAI and Al,Ti-diopside of the host inclusion have ^{16}O-rich compositions: $\Delta^{17}O$ ranges from –19 to –25±1.8‰ (2σ) (Fig. 1b). This is in contrast to two other UR CAI-bearing inclusions in CVs analyzed – *3N-24* in a FoB CAI from NWA 3118 and *33E-1* in a FTA CAI from Efremovka [4]. In *3N-24*, Zr,Sc,Y-rich oxides and Zr,Sc-rich pyroxene have ^{16}O-poor compositions ($\Delta^{17}O$ ~ −2 to −5‰), whereas spinel in *3N-24* as well as spinel and Al-diopside in the host CAI are ^{16}O-rich ($\Delta^{17}O$ ~ −23‰). In *33E-1*, Zr,Sc,Y-rich oxides, Y-rich perovskite, and Zr,Sc,Y-rich pyroxenes are ^{16}O-depleted ($\Delta^{17}O$ ~ −2 to −5‰) compared to Al,Ti-diopside of the FTA CAI ($\Delta^{17}O$ ~ −23‰). We infer that (*i*) UR CAI-bearing compound inclusions recorded variations in O-isotope compositions of nebular gas during the earliest stages of the Solar System evolution, and (*ii*) FoB CAIs formed by melting and evaporation to different degrees of aggregates of refractory inclusions and forsterite condensates [3].

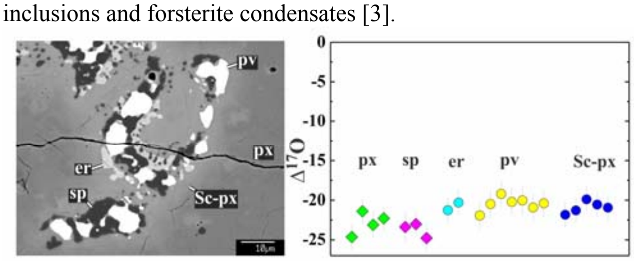

Fig. 1. (a) BSE image and (b) $\Delta^{17}O$ values of individual minerals in the UR CAI *Al-2*. er = eringaite; pv = perovskite; px = Al,Ti-diopside; Sc-px = Sc-rich Al,Ti-diopside; sp = spinel.

References: [1] Clayton et al. 1984. *GCA* 48:533. [2] Wark et al. 1987. *GCA* 51:607. [3] Bullock et al. 2012. *MAPS* 47:2128. [4] Ivanova et al. 2012. *MAPS* 47:2107. [5] Krot et al. 2014. *GCA* 145:206. [6] Ma. 2012. *MAPS* 47 (Suppl.):#5015.