TEXTURAL EVIDENCE FOR A FOB-LIKE PRECURSOR AND A MULTISTAGE EVOLUTION HISTORY OF AN ALLENDE FORSTERITE-BEARING TYPE C CAI. Shaofan Che and Adrian J. Brearley, Department of Earth and Planetary Sciences, MSC03-2040, University of New Mexico, Albuquerque, NM 87131, USA. (E-mail: shaofanche@unm.edu; brearley@unm.edu).

**Introduction:** Type C CAIs are very rare compared with other CAIs, and are characterized by their anorthite-rich, forsterite-deficient bulk compositions, enrichment in light Mg isotopes and high Si/Mg ratios [e.g., 1]. Their intermediate compositions between other CAIs and chondrules, in addition to their textural and mineralogical similarities to Al-rich chondrules, make Type Cs very important for understanding the relationship between CAIs and chondrules. There has been a constant debate on the origin of Type Cs, and three models have received the most attention: gas-liquid condensation at high total pressure and high dust/gas ratio [1], melting of a spinel-rich Type A CAI-like precursor [e.g., 2], and melting of a Type B CAI-like precursor in the chondrule-forming region [3,4]. Here we report observations on an Allende forsterite-bearing Type C CAI 04.

**Methods:** X-ray elemental mapping, backscattered electron (BSE) imaging, and electron probe microanalysis (EPMA) were conducted on CAI 04 from an Allende polished thin section.

**Results:** CAI 04 has a diameter of about 2 mm wide and is apparently an igneous inclusion as indicated by its spherical appearance and the dominant ophitic to subophitic texture (Fig. 1). Three texturally different regions exist in this CAI: (1) a forsterite-bearing core mainly composed of elongated prismatic anorthite crystals (~200μm long), anhedral Al-Ti-rich diopside (~100×50μm), rare, anhedral forsterite grains (as large as 150×100μm); (2) a coarse-grained inner mantle composed of lath-shaped anorthite (average size: ~500×200μm), euhedral Al-Ti-rich diopside (as large as 500×250μm), and spinel (5-15μm) as palisade, framoids and separate grains enclosed in anorthite and diopside; (3) an outer mantle texturally similar to the inner mantle, but with finer grain sizes, consisting of lath-shaped anorthite and diopside, minor forsterite. On the periphery of the CAI is a 10μm thick, discontinuous MgO-rich subcalcic pyroxene rim partly separated from the interior of the CAI by Fe-Ni sulfide. There is an olivine-rich matrix-like rim outside the CAI, that contains abundant porous hedenbergite and andradite nodules within it.

Nepheline±sodalite has replaced anorthite in a zone 100-200 μm wide on the outer part of the inclusion, giving way to the presence of ubiquitous sodalite with...
minor nepheline, partially replacing anorthite at grain boundaries and along fractures in the interior of the inclusion. Hedenbergite+andradite has replaced Al-Ti-rich diopside along the rims. Rims of Fe enrichment have developed around spinel grains. The degree of Fe-enrichment of spinel is more advanced when associated with fractures and grain boundaries.

Aluminum-Ti-rich diopside has a wide compositional range, with low Al₂O₃ (3.9-6.5 wt%), Cr₂O₃ (0.32-0.39 wt%) and TiO₂ (0.98-1.94 wt%) contents in the outer mantle of the CAI, compared with compositions in the inner mantle and core (7.8-18.9 wt% Al₂O₃, 0.35-0.72 wt% Cr₂O₃ and 1.9-3.1 wt% TiO₂). Individual Al-Ti-diopside grains display oscillatory zoning, similar to those in an Allende Type B1 CAI [5]. Anorthite is compositionally homogeneous (An₉₉.₀). Forsterite (Fa₁.₁-₃.₀) contains ~1.0 wt% CaO.

**Discussion:** Origin of forsterite. The high abundance of anorthite, Al-Ti-rich diopside and spinel, combined with the igneous texture implies that CAI 04 is a Type C inclusion. It is distinct from other Type Cs, which are commonly lack forsterite. Since the forsterite grains in CAI 04 do not show textural evidence for crystallization from a melt, there are two possibilities for the origin of forsterite: assimilated ferromagnesian chondrule fragments [3] or relict grains from the precursor. Forsterite described in [3] is restricted to the outer layer, similar to the small forsterite grains in the outer mantle of CAI 04; however, a chondrule origin for the forsterite in the core is at odds with the inferred chronology of Type C CAI-chondrule compound objects in which CAIs formed before chondrules [e.g., 6]. An alternative origin for the forsterite in the core is a relic from a precursor. The absence of mellilite is more consistent with a forsterite-bearing Type B CAI-like precursor [3,4]. The bulk compositions of inner mantles of some FoBs [7] plot in the spinel+anorthite field on the forsterite-gehlenite-anorthite ternary diagram, and are interpreted as having experienced addition of SiO from the ambient gas during melting. These FoB inclusions thus are possible precursors for CAI 04.

The alkali-halogen zonal sequence. The alkali-halogen zonal sequence can be accounted for by open-system metasomatism. During this process, Ca was preferentially lost into the matrix and subsequently precipitated around the CAI, forming an aureole of hedenbergite+andradite nodules around the periphery of the CAI [8]. The Ca-Fe-rich nodules (hedenbergite+andradite+wollastonite+Fe-Ni sulfide) in the core may have been produced by this process [9].

A multistage evolution history. The three texturally different regions in CAI 04 indicate a multistage melting history. The FoB CAI-like precursor experienced partial melting, with forsterite being the relict. Subsequently, another partial melting event only affected the outer part of the CAI, forming the fine-grained outer mantle. The texture of the outer mantle is similar to that of an Allende chondrule-bearing Type C CAI 93 [3], and it is interpreted as being remelted, followed by rapid crystallization, in the chondrule formation region in that study. Experimental results [4] also support this mechanism.

**Conclusions:** A FoB-like precursor is suggested for CAI 04 in which forsterite in the core probably represents a relict from the precursor while forsterite in the outer mantle may be chondrule fragments. Textural observations are consistent with a multistage melting history followed by open-system alkali-iron-halogen metasomatism within a parent body environment.

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