PETROGRAPHY OF A COMPACT TYPE A CAI INCLUDING BUBBLE-LIKE VOIDS FROM NINGQINAG CARBONACEOUS METEORITE.
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Introduction: Calcium-, aluminum-rich inclusions (CAIs) are considered to have formed in the early solar system, and hence the physical and chemical processes may be preserved in CAIs. Bubble-like voids have been reported in melilite crystals of CAIs [1-4]. However, processes of the formation have not been clarified. In order to reveal the bubble formation, we studied petrology and chemical distribution of a Type A CAI containing bubble-like voids from Ningqiang carbonaceous chondrite.

Experimental: Petrographic and chemical analyses were performed with using a FE-SEM (JEOL JSM-7000F) equipped with an EDS (Oxford XMAX-150) and an EBSD detector (HKL channel 5).

Results: A hibonite-bearing coarse-grained compact Type A CAI, named as HKN01, in a thin section of Ningqiang (C3-ung) meteorite was studied. The CAI appears nearly round shape surrounded by Wark-Lovering rim (~2.5 mm in diameter). The most abundant mineral is melilite in the CAI. From petrographic textures of melilite, the CAI consists of two different mosaic regions: (1) large melilite crystals and (2) small melilite crystals.

(1) The large melilite crystals (> 150 μm in size) are anhedral with reverse chemical zonation. The crystals include spinel (from ~2 up to ~35 μm), perovskite and clinopyroxene (< 5 μm in size), and rarely hibonite (< 20 μm in size) and refractory metal alloy (~1 μm in size). The clinopyroxene often coexists with the perovskite and spinel as surrounding rind (< 2 μm in thickness). Bubble-like voids (< 30 μm) appear within melilite and at grain boundaries of melilite. The voids are sometimes partially fringed by clinopyroxene. Alteration minerals such as plagioclase, feldspathoids, and Fe-bearing pyroxene have often replaced melilite along cracks.

(2) The small melilite crystals are from ~3 to ~50 μm with concentric reverse zonation in composition for each crystal. Perovskite (< 3 μm), spinel and hibonite (from ~2 to 15 μm) exist at grain boundary of melilite crystals and in melilite crystals. Clinopyroxene locates at grain boundary of melilite and surrounding voids. Small round-shaped voids (< 5 μm) are observed at grain boundaries of melilite.

The Wark-Lovering rim totally encloses the object with varying thickness from ~ 50 to ~ 300 μm. The rim consists of fine grains (< 10 μm) of melilite, spinel, perovskite, hibonite and clonopyroxene, with a layer sequence of melilite, spinel, melilite, and clinopyroxene toward outside of the CAI,.

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A NEW MECHANISM FOR COMPOUND CHONDRULE FORMATION: COLLISIONS OF SUPERCOOLED DROPLETS.
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Some chondrules consist of two or more chondrules fused together. They are called compound chondrules. We focus on three features of compound chondrules [1]. First, most (80% of primaries and 90% of secondaries) of compound chondrules have non-porphyritic texture while non-porphyritic chondrules are minor components of chondrites. Second, in most of compound chondrules, larger ones keep round shapes, and smaller ones are deformed. It means that larger ones crystallized earlier than smaller ones, and smaller ones stuck later. Finally, about 20% of non-porphyritic chondrules are compounds, and in contrast, only 0.5% of porphyritic ones are compounds. In previous studies, these three features are remained to explain.

We propose a new scenario for compound chondrule formation reproducing these features; collisions of supercooled droplets form compound chondrules. This scenario is based on experimental facts that completely molten dust droplets are not crystallized at their liquidus or solidus, and supercooled droplets turn into non-porphyritic chondrules after crystallization [2]. The scenario can explain why most of compound chondrules are non-porphyritic. Experimental studies reveal that supercooled droplets do not crystallize spontaneously at a temperature slightly below liquidus, and supercooled droplets crystallize owing to collision [2]. Then we can obtain the second feature that larger ones of compound chondrules keep round shapes while smaller ones are deformed, because larger ones are likely to be collided more than smaller ones. We also calculate the duration of compound chondrule formation for reproducing the fraction, 20% of non-porphyritic ones, and we find that the fraction of compound chondrules can be explained if the duration of supercooling is of the order of 10^4 seconds. This result is consistent with planetesimal bow shock model for chondrule formation [3].

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