PETROGRAPHIC STUDY OF A COMPACT TYPE A CAI WITH PARTIAL MELTING PROCESS

A. Suzumura[1], Y. Seto[2] and S. Itoh[1], [1] Department of Earth and Planetary Science, Kyoto University. (suzumura.akimasa.83z@st.kyoto-u.ac.jp), [2] Department of Planetology, Kobe University (seto@crystal.kobe-u.ac.jp).

Introduction: Compact type A CAIs (CTAs) are expected to be formed in the earliest stage of the solar nebula and experienced a partial melting at least once (e.g., [1]). Thus, it is important to constrain the formation process of CTAs to understand the thermal processes in the early solar system. But, chemical compositions and isotopic compositions in CTAs, which are important indicators for estimating the formation process, may change due to partial melting. Therefore, it is necessary to interpret chemical compositions and isotopic compositions in consideration of partial melting. However, there are only a few studies referring to the formation processes of CTAs from the perspective of crystal growth in partial melting states (e.g., [2]).

Generally, spinel in CTAs is poikilitically enclosed in melilite or fassaite, and estimated to be an initially crystallized mineral from CAI melt [3]. Namely, spinel in CTAs is expected to preserve valuable information about the thermal histories such as partial melting processes. However, there are few studies of partial melting research focusing on spinel. Since spinel has a high melting point, focusing on spinel is expected to provide new insights on the higher temperature thermal processes. Therefore, we focus on the relationship between spinel grains and the surrounding minerals in CTAs.

Methods: The CTA (KU-N) is included in a polished thin section of Northwest Africa 7865 reduced CV3 carbonaceous chondrite. The preliminary study concluded that they experienced multiple partial melting process. We have undertaken petrographic and mineralogical investigations of the CTA (KU-N-02) focusing on the microtextures resulting from partial melting (local compositional zoning, grain morphology and relationships of crystallographic orientation), using a polarizing microscope, scanning electron microscope (SEM), transmission electron microscope (TEM) and electron back-scattered diffraction (EBSD).

Results & Discussion: In the KU-N-02 CTA, spinel crystals are enclosed in melilite or fassaite. The former (up to 50 μm in size) in melilite is substantially euhedral with rounded edges, while the latter (about 10 - 100 μm in size) in fassaite is almost euhedral with sharp edges.

In interior KU-N-02 CAI, single crystal melilite with spinel inclusions exhibits monotonic decrease of Al and increase of Mg from core to rim. This melilite crystal has a “normal” compositional zoning, whereas the area of about 10 μm wide around the spinel surfaces has Åk-rich composition in comparison. Small Al-Ti-diopside grains occurs as rims on spinel and between spinel grains enclosed in Åk-rich melilite area. By the EBSD analyses, both crystal orientations of Åk-rich melilite and Åk-poor melilite are same. As results, it is difficult to explain how Åk-rich part surrounding spinel in a melilite crystal crystallized by a single stage cooling. Åk-rich melilite part (~10μm) surrounding spinel is crystallized after Åk-poor host single melilite crystal. FIB sections were cut from KU-N-02 to observe the boundaries between spinel and melilite, in order to examine the formation process of Åk-rich melilite with TEM analysis. FIB sections mainly consist of spinel with small Al-Ti-diopside, Åk-rich melilite and perovskite. The grain boundaries in spinel grains show the significant curvature (concave inward), indicating that surfaces on the spinel had experienced partial melting.

Melilite forms eutectic system with both spinel and Al-Ti-diopside. The boundary area between spinel with Al-Ti-diopside and melilite had eutectically melted at a high temperature by some heating process, and then Mg/Al contents had been redistributed to melilite, spinel, and Al-Ti-diopside. This partial melting probably resulted in the unique morphology of the spinel enclosed in melilite and local composition zoning of the melilite. The rounded shape of spinel and Åk-rich zoning surrounding spinel in melilite could be an indicator of partial melting.

References: [1] S. B. Simon et al. (1999) Geochimica et Cosmochimica Acta 63:1233–1248. [2] N. Kawasaki et al., (2017) Geochimica et Cosmochimica Acta 201:83-102. [3] Stolper E. (1982) Geochimica et Cosmochimica Acta 46:2159-2180.