Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS24-10 Room:106 Time:May 23 14:45-15:00

Microtextures of unusual dark clasts in the Allende chondrite: Implications for their precursor and alteration processes

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Dark clasts (also known as dark inclusions) commonly occur in CV and CO chondrites. They range in texture from chondritic one, with chondrules and Ca-Al-rich inclusions (CAIs) embedded in a matrix, to aggregates consisting almost exclusively of fine-grained Fe-rich olivine. In the past, dark clasts were considered to be primary aggregates of condensates from the solar nebula[1]. However, more recent studies have shown that dark clasts exhibit evidence indicating parent-body alteration processes such as chondrule-pseudomorphs, fibrous and vesicular olivines[2,4], and thus they suggested that dark clasts underwent aqueous alteration and subsequent thermal metamorphism in the meteorite parent body. We found two unusual dark clasts from the Allende CV chondrite that are mineralogically different from the dark clasts studied in the past in many respects. Here we present the results of mineralogical and petrological study of those two dark clasts using an SEM-EDS, an EPMA-WDS, and a TEM-EDS.

The two dark clasts (~86 mm^2 and ~5 mm^2) were found in a polished thin section of the Allende meteorite (~1066 mm^2 in total area). Both clasts contain chondrule-pseudomorphs (~0.17 mm in avarage diameter), which are considerably smaller than chondrules (~0.49 mm) in the host meteorite. The entire clasts, including pseudomorphs, mainly consist of fine grains (<10 micron in diametrer) of Fe-rich olivine (~91 vol%) and Ca-rich pyroxene (6 vol%) and minor amounts of nepheline and opaque minerals (pentlandite and awaruite). From the criteria proposed by Krot et al. (1995a)[3], they can be classified as type B. Type B dark clasts are considered to have experienced extensive aqueous alteration and subsequent dehydration in the parent body[2,4]. Olivine grains in the dark clasts are very homogeneous in composition (~Fo_{60}) and most of them contain vesicles and Fe-Ni sulfide inclusions. Some of the pseudomorphs have abundant nepheline, spinel, and perovskite. Nepheline is known as a secondary mineral produced by Na-metasomatism of plagioclase and melilite in CAIs[6]. Perovskite and spinel are typical primary minerals in CAIs. Therefore these pseudomorphs were probably formed from CAIs.

The dark clasts are surrounded and intersected by Ca-rich veins. These veins have three layered structure. The central layer consists of andradite and kirschsteinite and other layers consist of hedenbergite-diopside pyroxene. The boundary between veins and the clasts is clear, whereas that of veins and surrounding Allende matrix is irregular and gradational.

Previous studies on type B dark clasts in Allende reported that chondrule pseudomorphs in dark clasts and chondrules in their host are similar in size distribution, and thus concluded that the precursor of dark clasts have a lithology identical to the host[4]. However pseudomorphs in the clasts we studied show much smaller sizes than chondrules in the Allende host. This suggests that the precursor lithology of the clasts was different from Allende. Other previous studies suggested that Ca-rich veins were formed by aqueous alteration that occurred after incorporation of the clasts into the host meteorite[5,7]. However our observations show that such veins are absent in the host meteorite. These results suggest that the veins probably formed in the precursor lithology of the dark clast, before incorporation of the dark clasts into the host meteorite. The presence of the veins penetrating one of the clasts indicates that the veins were formed after the dark clast lithology was converted to fine-grained aggregates by extensive alteration.

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[3]Krot et al. (1995a) Meteoritics, 30, 748-775.
[4]Kojima and Tomeoka. (1996) GCA, 60, 2651-2666.
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Keywords: dark clast, aqueous alteration, thermal metamorphism, Allende, carbonaceous chondrite