Fe-alteration of spinel in a fine-grained CAI from the Efremovka CV3 chondrite

Daiju Kashima[1]; Timothy Fagan[1]

[1] Earth Sciences, Waseda Univ.

Most calcium-aluminum-rich inclusions (CAIs) in chondritic meteorites formed initially in the solar nebula and were altered after the formation of 1^{st} -generation minerals. Alteration affected the initial isotopic and elemental compositions of 1^{st} -generation minerals. Different alteration events might have occurred in the solar nebula or in chondrite parent bodies.

This study focuses on the formation of Fe-bearing spinel in a fine-grained CAI (FGI-12) from the CV3 chondrite Efremovka. During previous work [1], variations in Fe-abundance of spinel were noted in this CAI; however, the compositional range of spinel composition was not determined. The goal of this study is to determine controls on spinel composition in FGI-12 from a systematic survey of spinel location and Fe/(Fe+Mg). The occurrence and composition of spinel grains from FGI-12 were compared with those of an adjacent coarse-grained type B1 CAI (CGI-10).

Spinel grains in the two adjacent CAIs were mapped and analyzed to evaluate variations in Fe/Mg. First, we made a back-scattered electron (BSE) mosaic of FGI-12, and identified spinel grains and composite grains larger than approximately 4 micrometer in diameter. A grid system was used to count the grains. For CGI-10, reflected light photomicrographs were collected and put together in a mosaic. A grid was placed on the mosaic and one spinel grain in each grid-box was selected for electron microprobe analysis (EPMA). Quantitative analyses of spinel grains were collected by EPMA using the JEOL JXA-8900 WD/ED combined micro-analyzer at Waseda University. Well-characterized oxides, silicates and, for one element (V), metal were used as standards, and abundances were detected by WDS. A focused beam and 15 kV accelerating voltage were used for all analyses. Analyses from FGI-12 were collected using a current of 1.0×10^{-8} A; a current of 2.0×10^{-8} A was used for analyses from CGI-10. The following elements were analyzed: Na; Mg; Al; Si; K; Ca; Ti; V; Cr; Mn; Fe; Zn. We corrected the Ti interference on V and the V interference on Cr using EPMA software.

The fine-grained CAI is approximately 1.7x1.1mm across in the plane of the thin section and consists mostly of spinel-cored nodules connected by a fine-grained diopside-rich matrix. Melilites surround some of the spinel grains. The spinel grains form irregularly shaped aggregates that range up to 30micrometer across. During EPMA some high Ca and Si contents were detected, but these are attributed to beam overlap with adjacent silicates. Spinel grains in FGI-12 are basically $MgAl_2O_4$-$FeAl_2O_4$ solid solutions. Most analyses yield less than 4.5 wt% FeO, but FeO ranges up to 9.0 wt%. Iron concentrations in spinel show a positive correlation with proximity to the CAI margin.

The coarse-grained CAI (CGI-10) has a round surface, approximately 5.0x4.4mm across in the plane of the thin section. Most of the spinel grains are approximately 5-10 micrometer across and occur as inclusions in much coarser crystals of melilite, pyroxene and anorthite. Similar to the FGI-12 spinel, the spinel from CGI-10 consists mostly of $MgAl_2O_4$-$FeAl_2O_4$ solid solution, and the more FeO-rich grains occur close to the CAI margin. However, the spinel in CGI-10 is not as Fe-rich (maximum of 2.3 FeO wt% in CGI-10).

In both CAIs, the Fe-rich spinel grains tend to occur near the edge of the CAI rim, suggesting that FeO-alteration occurred after CAI formation. The higher FeO-contents of FGI-12 are probably due to the greater porosity of this CAI. Fe-bearing spinel can form in the nebula if dust-enrichment is high. But this process should produce Cr-rich spinel [2], which was not observed. We infer that the Fe-alteration of spinel occurred after incorporation of the CAIs into the Efremovka parent body.

References: [1] Fagan T.J. et al., 2004. Meteor. Planet. Sci., 39: 1257-1272. [2] Ebel D. and Grossman L. 2000. Geoch. Cosmochim. Acta, 64:339-366.