The investigation of back-transformation mechanisms of ringwoodite and majorite in the Yamato 75267 H6

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Many kinds of a high-pressure polymorph occur in the shock-melt veins and/or melt-pockets of shocked meteorites. Many previous studies investigated the formation processes of the high-pressure polymorphs occurring in the shocked meteorites. It is likely that the high-pressure polymorphs formed in the shocked meteorites back-transform into their low-pressure polymorphs during a decompression stage subsequent to a compression stage. However, few previous studies worked on the back-transformation mechanisms of the high-pressure polymorphs (Kimura et al., 2003; Hu and Sharp, 2017).

Several high-pressure polymorphs occur in the shock-melt vein of the Yamato (Y)-75267 H6 ordinary chondrite. The shock-melt vein is cut with a fusion crust. Parts of the high-pressure polymorphs have back-transformed to their low-pressure polymorphs due to the reheating induced by the adiabatic compression of surrounding air when the meteoroid passed the atmosphere (Kimura et al., 2003). In this study, we investigated the back-transformation processes from i) ringwoodite to olivine and ii) majorite to pyroxene in the shock-melt vein of Y-75267 by FE-SEM, EBSD, Raman spectroscopy, and FIB-TEM techniques.

We used the petrographic thin section of Y-75267 H6 ordinary chondrite of which mineralogy and petrology were described by Kimura et al. (2003). Most olivine grains (Fa_{18}) in the shock-melt vein are completely replaced with randomly-oriented fine-grained ringwoodite (Fa_{18}) assemblage. We selected three grains (Grain-A, -B, and -C) in the shock-melt vein to investigate the back-transformation mechanism from ringwoodite to olivine. The Grain-A, -B, and -C locate at ~360 μm, ~250 μm, and ~60 μm from the boundary between the shock-melt vein and the fusion crust, respectively. Although the Grain-A includes ringwoodite, olivine becomes dominant with approaching the fusion crust. Both the Grain-B and Grain-C consist of randomly-oriented olivine crystal assemblages. We propose that the back-transformation from ringwoodite to olivine proceeds by nucleation and grain-growth mechanism: nucleation occurs on the grain-boundaries between ringwoodite grains, and subsequently, olivine grains grow. The element diffusion does not induce the back-transformation from ringwoodite to olivine, because there are no differences in their chemical compositions. The back-transformation mechanism deduced from the present investigations coincides with the hypnosis obtained from the in situ back-transformation experiments from ringwoodite to olivine using a diamond anvil cell (Ming et al., 1991)

Polycrystalline majorite assemblages replace low-Ca pyroxene grains in the shock-melt vein. We selected two grains (Grain-D and -E) to investigate the back-transformation from majorite to low-Ca pyroxene. The Grain-D and -E are located at ~360 μm and ~220 μm from the boundary between the shock-melt vein and the fusion crust, respectively. Although the Grain-D consists of majorite, pyroxene-glass becomes dominant with approaching the fusion crust. Pyroxene-glass surrounds majorite crystals in the Grain-D. The Grain-E also consists of pyroxene-glass and in the grain, clinoenstatite becomes dominant with approaching the fusion crust. We propose that the back-transformation from majorite to pyroxene initiates by the vitrification of majorite and subsequently, nucleation and grain-growth occur in the vitrified majorite.

References

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