Jadeite originating from plagioclase in L6 and H6 chondrites

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Introduction

High-pressure and -temperature synthetic experiments indicate that albite dissociates into jadeite + silica phase with increasing pressure and temperature condition. Most terrestrial jadeite are formed by regional metamorphism and silica phase is always accompanied with the jadeite. Extraterrestrial jadeite was reported by Kimura et al. (2000) [1] for the first time. Albitic feldspar in and around the shock-melt veins of L6 and H6 chondrites is replaced with jadeite with maintaining its original chemical composition. However, silica phase was not detected from the albitic feldspar including jadeite. Absence of silica phase has been enigma for a long period. Accordingly, we investigated jadeite replacing albitic feldspar in Yamato 791384 L6 (hereafter, Y-791384) and Yamato 75100 H6 (hereafter, Y-75100) ordinary chondrites in detail to clarify a dissociation mechanism from albite to jadeite + silica phase with a FIB-TEM technique.

Materials and experimental methods

A petrographic thin section was prepared from Y-791384 and Y-75100 chip samples including several shock-melt veins. Mineralogy was determined using a Laser micro-Raman spectrometer. We employed a FEG-SEM for textural observations. Chemical compositions were determined using a wavelength-dispersive electron micro-probe analyzer (EMPA). A slice of a target area to be studied by a transmission electron microscope (TEM) was prepared by a Focused Ion Beam (FIB) system. We used also a scanning TEM (STEM) with an EDS detector system.

Results and discussion

Detailed petrological and mineralogical descriptions of the chondritic host-rocks and shock-melt veins of Y-791384 and Y-75100 are given in several previous studies [1-4]. We focused our investigations on six albitic feldspar in and around the shock-melt veins of Y-791384 and Y-75100. Raman spectrum corresponding to jadeite (375, 697 and 1039 cm^{-1}) was recorded from the albitic feldspars entrained in the shock-melt vein, implying that jadeite was formed subsequent to the breakdown of the albitic feldspar. Granular texture was observed in the albitic feldspar, which is similar to albitic feldspar including jadeite in Sahara 98222 L6 chondrite [5]. We prepared the TEM slices of the albitic feldspar including jadeite using a FIB system. Many massive or network-like assemblages of jadeite crystal exist in the albitic feldspar grains. Jadeite crystal is surrounded by amorphous or poorly-crystallized material having pseudomorph texture. The chemical composition of the amorphous or poorly-crystallized material obtained by STEM-EDS are varied, and plotted between jadeite and silica phase. Stishovite is likely as a silica phase in the dissociated albitic feldspar entrained in the shock-melt veins studied here because estimated pressure conditions recorded in the shock-melt veins of Y-791384 and Y-75100 based on the equilibrated assemblages of high-pressure polymorphs are ~15 GPa or more [2-4]. However, we could not find crystalline silica phase in the albitic feldspar grains. When albite dissociates into to jadeite + silica phase, long distance atomic diffusion is required. Accordingly, the dissociation reaction would be diffusion-controlled and time-dependent. High-pressure and -temperature synthetic experiments demonstrate that the nucleation rate of stishovite is significantly slower than that of jadeite [6]. Absence of stishovite will be due to the critical differences of kinetics between jadeite and stishovite in addition to incomplete concentration of Si. Silica phase would be hardly formed under the limited short duration of equilibrium high-pressure and -temperature condition induced by a dynamic event. The crystallization of jadeite from amorphized (or poorly-crystallized) albite would not be also achieved completely in the limited duration of equilibrium high-pressure and -temperature condition, thus leading to form residual amorphous (or poorly-crystallized) material with varied chemical compositions.

References:

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