DISSOCIATION FROM PLAGIOCLASE INTO JADEITE + COESITE IN A SHOCKED LL7 CHONDRITE

M. Miyahara[1], E. Ohtani[2], A. Yamaguchi[3]

[1]Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima Univ., Higashi-Hiroshima, 739-8526, Japan (miyahara@hiroshima-u.ac.jp), [2]Department of Earth Sciences, Graduate School of Science, Tohoku Univ., Japan. [3]National Institute of Polar Research, Japan.

Introduction: Many ordinary chondrites were heavily shocked on their parent-bodies. Shock-indueced melt veins occurr in the heavily shocked ordinary chondrites, and many kinds of high-pressure polymorohs form in and around the shcok-melt veins (e.g., [1][2]). Phase equilibrium diagram deduced through static high-pressure and high-temperature synthetic experiments indicate that albite transforms to $NaAlSi_3O_8$ with hollandite-structure (lingunite) or $CaFe_2O_4$-type $NaAlSiO_4$ + stishovite subsequent to jadeite + SiO_2 phase with increasing pressure and temperature conditions (e.g., [3][4]). Albite is one of major constituents of ordinary chondrites. Previous studies report that albite grains entrained in or next to the shock-melt veins transform into jadeite without accompanying a silica phase [1][2][5], which has been an eigma for a decade. Considering the kinetics of dissociation reaction of albite, the missing silica phase issue is due to the delayed nucleation of silica phase comparing with jadeite [6][7]. However, we discovered albitic grains replaced with jadeite + coesite in one of heavily shocked LL-type ordinary chondrites for the first time. The natures and occurrences of the albitic grains will be reported in this study, and the duration of shock pulse required for the dissociation reaction besides shock pressure condition were also estimated.

Materials and experimental methods: Northwest Africa 8275 (hereafter NWA 8275) is classified into LL7. A perolographic thin section of NWA 8275 was prepared for this study. The detail textural observations of the thin section were conducted by a field-emission scanning electron microscope (FE-SEM). The chemical compositions of constituents were determined by an electron micro-probe analyzer (EMPA). Individual mineral was identified by a laser micro-Raman spectrometer. Several portions were excavated by a focused ion beam (FIB) system for a transmission electron microscope (TEM) observation. A chemical composition of each mineral was determined under a scanning TEM (STEM) mode with an X-ray energy dispersive (EDS) detector.

Results and discussion: NWA 8275 studied here shows a typical equilibrated chondrite texture. Several relic chondrules are observed although no matrices are remained. Major constituents are olivine ($Fa_{29.1-30.8}$), low-Ca pyroxene ($Fs_{24.4-25.6}En_{70.5-72.9}Wo_{2.0-4.3}$) and plagioclase ($Ab_{75.3-94.4}An_{2.8-22.7}Or_{1.9-5.7}$). A small amount of Ca-pyroxene grain ($Fs_{10.4-11.9}En_{45.3-47.2}Wo_{38.8-42.1}$) also occurs. Plagioclase (grain size: > ~100 μm across) can be divided into two groups; i.e., albite-like ($Ab_{88.3-94.4}An_{2.8-5.7}Or_{2.8-5.7}$) and oligoclase-like ($Ab_{75.3-81.8}An_{16.2-22.7}$ $Or_{1.9-2.7}$). Several amounts of K-feldspar ($Ab_{7.2-34.1}An_{2.1-7.1}Or_{63.1-89.6}$) also occurs. Most K-feldspar occurs in the albite-like feldspar grains as an exsolution lamella. Many isolated metallic Fe-Ni and iron sulfide grains (grain size: > ~50 μm across), and phosphate minerals (grain size: > ~100 μm across) also occur. The equilibrium temperature was estimated using two pyroxene thermometer [8], and the estimated equilibrium temperature is 1246 K. Pervasive shock-melt veins were observed. High-pressure polymorphs of olivine or pyroxene were not identified in the shock-melt veins. Many fine-grained dendritic crystals occur in the plagioclase (both albite-like and oligoclase-like) grains entrained in or adjacent to the shock-melt veins. Most plagioclase grains entrained in the shock-melt veins are completely replaced with the fine-grained dendritic crystals. The bulk-compositions of these completely replaced with the fine-grained dendritic crystals appear to be those of original plagioclase in the host-rock although some of them appear to be mixtures of albite-like and oligoclase-lile ones. TEM observations and STEM-EDS analyses indicate that the fine-grained dendritic crystal is jadeite. The interstices of the jadeite crystals are filled with coesite. Considering the coexistence of jadeite and coesite, the shock pressure condition recorded in the shock-melt veins of NWA 8275 could be estimated to be about 3-12 GPa (e.g., [4]), which is similar to the shock pressure condition of the shock-melt veins of LL5 ordinary chondrite [9]. The duration of high-pressure condition recoded in the shock-melt veins of NWA 8275 was estimated using the phase transformation rate of albite [6]. The required duration of high-pressure condition for the dissociation reaction from albite into jadeite + coesite can be constrained by silica phase (as the replacement of albite) formation rate, because its nucleation rate is considerably delayed compared with jadeite. The estimated duration of high-pressure condition is about 5 seconds based on the silica phase transformation rate, which is similar to the estimation of shock pulse recorded in the shocked L6 ordinary chondrite [1].

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