HIGH-PRESSURE DISSOCIATION OF OLIVINE IN NORTH WEST AFRICA 7397 LHERZOLITIC SHERGOTTITE

M. Yoshida[1], M. Miyahara[1], A. Yamaguchi[2], N. Tomioka[3], T. Sakai[4], H. Ohfuji[4], F. Maeda[5], I. Ohira[5], E. Ohtani[5], S. Kamada[6], H. Suga[1], T. Ohigashi[7] and Y. Inagaki[7]
[1]Graduate School of Science, Hiroshima Univ., [2]NIPR, [3]Kochi Institute for Core Sample Research JAMSTEC, [4]Geodynamics Research Center, Ehime Univ., [5]Graduate School of Science, Tohoku Univ., [6]Frontier Research Institute for Interdisciplinary Sciences,Tohoku Univ., [7]UVSOR Synchrotron, Institute for Molecular Science.

Introduction: Many kinds of high-pressure polymorphs occur in and around the shock-melt veins or melt-pockets in heavily shocked meteorites. The clarification of formation mechanisms high-pressure polymorphs is an important issue not only for planetary science but also the deep Earth science (e.g., [1]). Most Martian meteorites show clear shock textures induced by the intense impact events on the Martian surface. Most shergottites have melt-pockets including glass. Despite heavily impact events occurred on the Martian surface, high-pressure polymorphs in lherzolitic shergottites were reported only from Yamato 000047 and GRV 020090 [2,3]. In this study, we describe several phase transformations and dissociation textures of olivine around the melt-pockets of the Northwest Africa 7397 (hereafter, NWA 7397) lherzolitic shergottite. In addition, we estimate shock pressure condition recorded in NWA 7397 on the basis of the high-pressure polymorph assemblages therein.

Samples and Experiments: NWA 7397 is a newly found lherzolitic shergottite [4]. A polished petrographic thin section of NWA 7397 with area ~ 1×1 cm^2 was prepared for this study. A field-emission gun scanning electron microscope (FE-SEM) was employed for detailed textual observations. Chemical compositions of constituents were determined by a wavelength-dispersive electron probe microanalyzer (EPMA). Phase identification of the constituents was conducted using a laser micro-Raman spectrometer. Parts of the sample were extracted and processed to be thin slices using a Focused Ion Beam (FIB) system. The thin slices were scanned at the BL10XU beam line of SPring-8 for X-ray diffraction pattern (XRD) analysis. The phase transformation mechanisms of high-pressure polymorphs in the thin slices were investigated by a transmission electron microscope (TEM). The redox state of iron was measured by scanning transmission X-ray microscopy (STXM). STXM analysis was conducted at BL4U, UVSOR.

Results and Discussions: NWA 7397 studied here has poikilitic and non-poikilitic portions. Detailed petrolographic and mineralogical features of the NWA 7397 were described in Yoshida et al. (2016) [4]. Most plagioclase have transformed into maskelynite. Several melt-pockets were observed in the non-poikilitic portions. The existences of maskelynite and melt-pockets are obvious evidence for an impact event occurred on Mars. The chemical composition of olivine ($Fa_{38\text{-}40}$) grains in the non-poikilitic portions are homogeneous. Some olivine grains are next to the melt-pockets. Back-scattered electron (BSE) images depicted that the olivine grain next to the melt-pocket has a dissociation texture. With increasing distance from the melt-pocket, the olivine grain shows a segmentation texture instead of the dissociation texture. The portion nearest the melt-pocket is Fe-rich compared to the original olivine ($Fa_{38\text{-}40}$), and do not retain ideal chemical formula for olivine. With increasing distance from the melt-pocket, the chemical composition approaches that of the original olivine. There is no clear evidences for melting in the olivine grain, because the boundary between the olivine grain and melt-pocket is sharp. It is possible that iron dissolved in the melt of the melt-pocket migrated into the olivine grain. Raman spectra corresponding to the Si-O stretching mode of olivine (~850–860 and ~820–830 cm^{-1}) were not observed from the portion nearest the melt-pocket. Alternatively**,** broad Raman shift appeared around 660–670 cm^{-1}, which coincides with pyroxene-glass. Thin slices of the olivine grain with the dissociation and segmentation textures were extracted by FIB. XRD analyses and TEM observations indicated that the olivine grain with the dissociation texture consists mainly of vitrified bridgmanite and magnesiowüstite. The bridgmanite would have transformed to glass due to residual heat during adiabatic decompression. Fe NEXAFS analyses indicated that Fe (III) oxide-hydroxides also occur in the olivine grain with the dissociation texture. It is likely that the Fe (III) oxide-hydroxides are not the alteration products of olivine formed on the Earth. The Fe (III) oxide-hydroxides may be the remnants of ε-FeOOH formed by the reaction between olivine and H_2O during the impact event occurred on the Martian surface. The olivine grain with the segmentation texture includes ringwoodite besides olivine. Based on Wang et al. (1997) [5], the pressure and temperature conditions of olivine grain next to the melt-pocket are estimated to be ~26 GPa and higher than 1200 °C. Additionally, some plagioclases entrained in the melt-pockets dissociate into (Na,Ca)-hexaluminosilicate (CAS) + stishovite [4]. Based on the phase diagram of basaltic composition [6], the pressure and temperature conditions recorded in the melt-pocket are estimated to be 25 GPa and 2300–2500°C.

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