Petrology and mineralogy of Northwest Africa 7397 lherzolitic shegottite

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Intoroduction: Martian meteorites are important samples for understanding geologic processes occurred on Mars. Shergottites, the largest group among Martian meteorites, are divided into three major groups based on their petrologic and mineralogical features; i.e., basaltic shergottites, olivine-phyric shergottites, and lherzolitic shergottites. Lherzolitic shergottites are expected to be derived from relatively primitive melts sampling the martian mantle [1], providing information about the igneous processes formed of Mars' mafic crust, as well as indirect information of martian mantle composition [2]. The petrologic and mineralogical features of lherzolitic shergottites are similar each other [3]. In addition, their crystallization and exposure ages are also identical each other. Accordingly, it is widely accepted that lherzolitic shergottites share the same original source on Mars, and were ejected by the same impact event, and finally fell on the Earth as separate falls [3]. Northwest Africa 7397 (hereafter, NWA 7397) is a newly found lherzolitic shergottite. In this study, we will describe the detail petrographic and mineralogical characteristics of NWA 7397. In addition, we will estimate shock pressure condition recorded in NWA 7397 on the basis of high-pressure mineral assemblage therein.

Samples and Experiments: A polished 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. The chemical compositions of individual minerals were determined with an electron probe micro-analyzer (EPMA). Phase identification of the minerals was conducted using a laser micro-Raman spectrometer. Part of the sample was excavated with a Focused Ion Beam (FIB) system. The excavated samples were scanned at the BL10XU beam line of SPring-8.

Results and Discussions: NWA 7397 has poikilitic and non-poikilitic portions. In the poikilitic portion, coarse-grained pyroxene oikocrysts enclose olivine (< ~500 µm) and chromite (< ~150 µm) grains. The coarse-grained pyroxenes are chemically zoned from core ($En_{71}Fs_{25}Wo_4$) to rim ($En_{65}Fs_{25}Wo_{10}$). In the non-poikilitic portion, the major constituents are olivine, pyroxene, and plagioclase (now maskelynite), with minor chromite, ilmenite, alkali feldspar, Ca-phosphate, and Fe-sulfide. Most pyroxenes are pigeonite with small amount of augite. Olivine (Fa_{38-40}) is more Fe-rich than those of the poikilitic portion (Fa_{29-37}). Our FE-SEM observations and EPMA analyses reveal that the petrologic and mineralogical features of NWA 7397 are similar with other lherzolitic shergottites, implying that NWA 7397 also shares the same original source on Mars with other lherzolitic shergottites. On the other hand, NWA 7397 would have originally been located at a shallower level within the lherzolitic shergottite igneous block because Fe contents of the olivine grains are higher than those of other lherzolitic shergottites [4]. Several melt-pockets were observed in the non-poikilitic portion. The existences of maskelynite and melt-pockets are obvious evidences for an impact event occurred on Mars. Some plagioclase entrained in the melt-pockets dissociate into (Na,Ca)-hexaluminosilicate (CAS) + stishovite. This is the first report of CAS and stishovite from lherzolitic shergottites. FIB-assisted synchorotron XRD analysis indicate that olivine grains next to the melt-pockets appear to be dissociated into bridgmanite + magnesiowüstite, although bridgmanite was vitrified due to residual heat during adiabatic decompression. With increasing a distance from the melt-pocket, olivine was transformed into the ringwoodtite-ahrensite solid solution. Based on the phase diagram of basaltic composition [5], the pressure and temperature conditions recorded in the melt-pocket are estimated to be ~25 GPa and 2300-2500 °C.

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