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# Dissociation of pigeonite in shock melt vein/pocket of Martian shergottites: Implications for impact events on Mars

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It is widely accepted that SNC (Shergottites-Nakhlites-Chassignites) meteorites with a meteorite Allan Hills 84001 are derived from Mars. Among the currently recognized 104 Martian meteorites, shergottite is the largest group with 88 members (Meteoritical Bulletin Database). Shergottites are basaltic, olivine-phyric, or lherzolitic igneous rocks probably formed near the surface of Mars. They are characterized by high degree of shock metamorphism [1, 2, 3, 4]. The shock metamorphic features and high-pressure phases in Martian meteorites provide crucial information about the nature and history of impact events on Mars [4]. In this study, we investigated shock-induced features and high-pressure minerals in two basaltic shergottites Northwest Africa (NWA) 856 and Zagami.

We conducted petrographic and mineralogical observations on polished thin sections of the samples using optical microscope, field emission scanning electron microscope (FE-SEM), micro-Raman spectrometer and electron probe micro analyzer (EPMA). Some identified high-pressure minerals were extracted from the thin sections by micro drill and processed by focused ion beam system (FIB) to thin slices. The prepared slices were investigated by synchrotron X-ray diffraction experiments and transmission electron microscope (TEM).

NWA 856 and Zagami have a basaltic texture, mainly composed of two pyroxenes (pigeonite, augite) and plagioclase glass (maskelynite). They contain many shock-induced melt pockets. A shock melt vein is also observed in Zagami. In pigeonite grains adjacent to these melt pocket/vein, we found a dissociation texture of pigeonite not reported so far. The grain margins of the pigeonite adjacent to the melt pocket/vein seem to have dissociated into at least two different phases with different brightness (gray and white) in SEM-BSE images. The gray phase seems to have an idiomorphic crystal habit, whereas the white phase is interstitial. Raman spectroscopy showed that the untransformed part retains the original pigeonite (clinopyroxene) structure, but the dissociated part seems to contain ringwoodite and majorite-pyrope garnet with pyroxene. The Raman bands of pyroxene associated with this assemblage are relatively broad than that of the original pigeonite. The intensity of the peak at around 1000 $cm^{-1}$ is significantly weaker than that of the original pigeonite. These features imply that this part contains pyroxene glass [5, 6]. This dissociation reaction is more coarse-grained and advanced in Zagami than in NWA 856.

Phase relation of diopside ($CaMgSi_2O_6$) shows that diopside dissociates into majoritic garnet + (Ca, Mg)$SiO_3$-perovskite at 18-22 GPa and 1400-1800 degree C, whereas into ringwoodite + stishovite at the same pressure and 1000-1400 degree C [7]. The assemblage of ringwoodite + majorite-pyrope garnet in the basaltic shergottites could be formed by dissociation of pigeonite at 18-22 GPa and around 1400 degree C or in a increasing temperature from $<$1400 degree C to $>$1400 degree C. The Raman signals of the possible pyroxene glass might have been derived from that of vitrified (Ca, Mg)$SiO_3$-perovskite. Since wadsleyite or akimotoite were not identified, the pressure range may be more restricted to be 19-20 GPa.

References

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