HEAVY SHOCK METAMORPHISM OF THE ENRICHED LHERZOLITIC SHERGOTTITE NORTHWEST AFRICA 7755. A. C. Zhang\textsuperscript{1}, S. Z. Wang\textsuperscript{1}, R. L. Pang\textsuperscript{1}, J. N. Chen\textsuperscript{1}, L. X. Gu\textsuperscript{2}, and R. C. Wang\textsuperscript{1},
\textsuperscript{1}School of Earth Sciences and Engineering, Nanjing University, Nanjing 210046, China (aczhang@nju.edu.cn); \textsuperscript{2}Institute of Geology and Geophysics, Chinese Academy of Science, Beijing 100029, China.

Introduction: Dynamic collision is a widespread process during the evolution of planets and asteroids in our solar system. It modifies the morphology of planets and asteroids, petrologic textures, crystal structures of minerals, and isotopic systematics of rocks, and launched meteorites from their parent bodies. Therefore, deciphering the shock metamorphism of meteorites can constrain the dynamic histories of their parent bodies \cite{1}. Northwest Africa (NWA) 7755 is a newly found lherzolitic shergottite. Howarth et al. \cite{2} has described the petrography of NWA 7755 briefly and suggested that it is an enriched lherzolitic shergottite based on the calculated bulk compositions of rare earth elements. They focused on the coarse-grained apatite in NWA 7755 and constrained the evolution of Cl-rich fluids in Martian magmas \cite{2}. They proposed that some of the apatite grains in NWA 7755 have been affected by shock metamorphism and could not be used to reveal the Cl-rich nature of Martian magmas \cite{2}. However, no detailed features about shock metamorphism have been documented in NWA 7755 yet. Here, we report the detailed petrographic and mineralogical features of NWA 7755 to constrain its shock metamorphism. Our data reveal that NWA 7755 is one of the heavily shocked Martian meteorites and represents a unique launch event on Mars. Partial transformation from apatite to tuite also resulted in fractional devolatization of Cl relative to F.

Results: NWA 7755 contains abundant maskelynite. Melt veins and pockets are also common. The melt veins vary in width from a few micrometers to ~100 µm. Most of the melt veins are dominated by fine-grained mineral assemblages (usually <2 µm in size). A few relatively wide melt veins contain relict mineral fragments of olivine, maskelynite, Ca-phosphate minerals, and chromite. Almost all of the olivine fragments (~Fa40) within melt veins have either transformed to ringwoodite, (Mg,Fe)\textsubscript{2}SiO\textsubscript{4} glass, or dissociated to bridgmanite and magnesiowüstite (Fig. 1). Spatially, the dissociation textures of olivine were observed mainly at the central parts of melt veins. Merrillite grains in melt veins have completely transformed to tuite (Fig. 2). However, the apatite grain shown in Fig. 2 only partially transformed to tuite. A few chromite fragments of ~10 µm are also observed in melt veins. However, no high-pressure polymorphs of chromite were found based on their Raman spectra.

The fine-grained mineral assemblage in melt veins are composed mainly of silicate minerals, minor magnesiowustite, sulfide, Ca-phosphate, and Fe-phosphide minerals (Fig. 3). These silicate grains usually show well defined grain boundaries, and some of them contain fine-grained magnesiowüstite. All the silicate grains give diffusive diffraction rings, indicating an amorphous state. The Raman spectra of the fine-grained silicate grains exhibit two broad peaks at 664 cm\textsuperscript{-1} and at 976 cm\textsuperscript{-1}, respectively, comparable to that of the vitrified bridgmanite \cite{3}. In addition, potential high-pressure polymorphs (coesite and stishovite) of silica, which are usually associated with K-rich glass, are also observed in NWA 7755, based on their textures and Z-contrasts in BSE images.

![Figure 1. BSE images of ringwoodite in NWA 7755.](image)
minerals in NWA 7755 were determined with a SEM-EDS detector. The apatite in the host rock of NWA 7755 contains varying contents of F (0.8–2.3 wt%) and Cl (2.1–4.6 wt%) between different grains. These results are comparable to the EPMA compositions of apatite described in Ref. 2. The molar ratio of Cl/F for apatite ranges in 0.5–3.1. However, the apatite grain that has partially transformed to tuite (shown in Fig. 2) contains 2.3–2.8 wt% F and low Cl (0.4–0.6 wt%). The molar ratio of Cl/F for the partially transformed apatite grain is approximately 0.1. The merrillite in the host rock and the tuite in melt veins have comparable compositions. Both merrillite and tuite contain a few weight percent of Na₂O, MgO, and FeO.

Figure 2. BSE images of tuite in NWA 7755.

Figure 3. Bright field TEM image of the fine-grained mineral assemblage in a melt vein from NWA 7755.

Discussion: (1) **P-T conditions of shock metamorphism.** Maskelynite is widely present in NWA 7755, indicating heavy shock metamorphism. However, it is difficult to constrain the precise shock pressure based on the presence of maskelynite [4]. Olivine grains within and adjacent to melt veins/pockets have either transformed to ringwoodite, glass, or dissociated into bridgmanite plus magnesiowüstite. This indicates a lower limit of shock pressure and temperature at 23 GPa and 1600 °C, respectively [5]. However, the coexistence of bridgmanite and magnesiowüstite in fine-grained mineral assemblage indicates that the melt veins formed at a pressure of ~24 GPa and a temperature of 1800–2000 °C [6].

(2) **Comparison with other enriched lherzolitic shergottites.** All the four enriched lherzolitic shergottites contain abundant maskelynite and melt veins or pockets [2, 7–9]. This indicates that all of them have been heavily shocked on the parent body. However, no high-pressure minerals have been reported in RBT 04261/2 and NWA 7397 [7, 9]. In GRV 020090, four high-pressure minerals (ringwoodite, akimotoite, majorite, and tuite) have reported [8]. They suggested a shock pressure of 18–20 GPa and a temperature of ~1800 °C [8]. Compared with GRV 020090, akimotoite and majorite are absent in NWA 7755. Instead, NWA 7755 contains vitrified bridgmanite. This difference indicates that the two enriched lherzolitic shergottites have subjected to different shock loads. NWA 7755 experienced higher shock pressure than GRV 020090. The NWA 7755 meteorite should represent a unique launch event on Mars, different from other enriched lherzolitic shergottites.

(3) **Shock-induced fractional devolatilization of apatite.** The SEM-EDS results revealed that the partially transformed apatite grain contains lower Cl contents and low molar Cl/F ratios than the apatite grains in the host rock. This indicates that the shock metamorphism has led to the devolatilization of Cl in the apatite grains, consistent with the conclusion by Ref. 2. However, the F contents appear unaffected, which could be related the stronger electronegativity of F compared with Cl. Although the apatite grains in the host rocks might have not been affected by the severe shock metamorphism, the devolatilization of Cl in apatite has important implications. First, it affects the evaluation on the fluid evolution in shocked extraterrestrial materials [2]. Second, it is expected that the devolatilization of Cl in apatite during shock metamorphism may cause the enrichment of heavy Cl isotope in apatite, which is one of important issues in recent literature (e.g., [10]).


**Acknowledgements:** This study was supported by NSFC (41373065, 41673078) and the Fundamental Research Funds for the Central Universities.