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PPS24-P16 Room:Convention Hall Time:May 23 18:15-19:30

Investigation of iron-nanoparticles in Martian meteorite olivine using electron microscopy

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1. Introduction

Olivine crystals in Martian meteorites are often dark-brown colored because they were heavily altered probably by a shock event to escape the planet. It is suggested that this change results from iron metal and magnetite nanoparticles segregated in olivine [1-3]. Mikouchi et al. [4] performed shock experiments and proposed that either iron metal or magnetite by the temperature difference during the shock event. However, the relation between the morphologies of them and shock condition is still unclear. The purpose of this study is to obtain new insights into the formation of the iron nanoparticles, through a detailed investigation of Northwest Africa 1950 shergottite which potentially includes both iron metal and magnetite nanoparticles, using advanced electron microscopic techniques.

2. Sample and Experimental methods

NWA1950 is a lherzolitic shergottite and its dominant phases are olivine (~55wt%), pyroxenes (~35wt%) and maskelynite (~8wt%) [5].

Scanning electron microscopy (SEM), transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) were mainly used for the observation. In the SEM observation, identification of the crystallographic orientation using electron back-scatter diffraction (EBSD) was performed. The mineral species of nanoparticles observed in crashed olivine fragments and thin film specimens prepared by a focused ion beam (FIB) instrument were identified by nano-beam electron diffraction (NBED) and the measurement of lattice spacing in high-resolution TEM images. In the STEM observation, Z contrast images and composition images were acquired by the high-angle annular dark-field (HAADF) detector and STEM-EDS, respectively.

3. Results

During the observation of the crushed olivine fragments using TEM, relatively large (more than 100 nm) iron metal particles were frequently found, as well as spherical iron metal nanoparticles of a few tens of nanometers reported in the previous works. In addition, iron metal nanoparticles surrounded with magnetite-shell were discovered, although they were very rare. According to these findings, the distribution of such large iron particles was investigated by SEM. As a result, platy domains of olivine with a more iron content than the surrounding olivine matrix and Fe-abundant bright particles arranged inside the plates were observed. EBSD analysis in SEM revealed that these platy domains are parallel to several fundamental lattice planes.

Thin film specimens were prepared by FIB to investigate these domains and bright particles in detail. According to TEM/STEM observations, the bright particles observed in SEM-BSE images have a film-like form of a few tens of nanometers thick, obliquely formed in the platy olivine domains (Fig. 1). They were confirmed as iron metals by usingNBED. Furthermore, very thin, thread-like iron metal particles as well as the fine spherical particles were found only outside the domains in the Z contrast images by HAADF-STEM (Fig. 1). Silica-abundant area was not found around metal iron by the composition STEM image either.

4. Conclusions

In this study, various forms of iron metal particles and their characteristic distribution in the parent olivine crystals were found by the combined observation using SEM, TEM and STEM. Moreover, an interesting structure, iron particles surrounded with magnetite-shells, was also discovered. These findings combined with further observation and analysis may be able to be applied to better understand remote sensing results and elucidation of temperature-pressure history by strong shock metamorphism.

References

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