In-situ observations of shock-induced dehydration of goethite

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Hydrous minerals play a role as water carrier because of their high temperature stabilities and shock resistance. Water is present as a major component of the atmospheres, surfaces, and interiors of planets, and it is important to investigate the dehydration reactions in hydrous minerals by impact processes to understand the formation and evolution of planets and the origin of life. We presented the shock recovery experimental results on goethite last year. At that time, powdered samples were capsuled in steel containers although the containers were not completely closed and there was a small gap space for dehydrated water to escape freely. The results indicated partial dehydration and produced hematite. However, it remains an open question when the dehydration occurred and what effects are expected at the partial water pressure. This time we carry out direct observation of the dehydration reaction by *in-situ* x-ray diffraction using an x-ray free electron laser (XFEL) to confirm the dehydration of goethite.

We tried to prepared sintered bodies of goethite at high pressures but failed to have thin plates. Instead we prepared thin films of goethite powders glued by manicure (~200 mm thick). We used XFEL at Pohang with a flat panel x-ray detector to observe the diffractions and an optical laser to drive shock wave. The XFEL beam is 25 fs at 12 keV and focused ~20 mm diameter and optical laser beam with 150 ps FWHM, 800 nm wavelength, and ~1 mJ energy focused ~40 mm diameter. The samples were free standing and subject to vertical XFEL beam and 5 degree off optical laser beam from the normal.

We obtained a series of diffraction images as a function of delay time for optical laser irradiation. All the diffractions consisted of those from the starting goethite without manicure, detailed analyses for the strong peaks of hematite as the dehydration product revealed that the shoulders of goethite peaks contains part of hematite peaks at late delay times. This can confirm *in-situ* formation of hematite by the shock-induced dehydration of goethite. The nucleation and growth of hematite during shock compression are extreme fast, and can be explained to be quenchable from the previous shock recovery experiments. We did not measure the pressure directly, and we can evaluate the threshold pressure from the diffraction peak shit of the hematite. These results suggest dehydration of goethite at relatively low shock pressures. The usage of manicure glue will help powdered sample preparation for XFEL that requires thin enough samples and we will develop further to apply not only hydrous minerals but also silicates by the help of manicure for XFEL experiments.

We thank the PAL-XFEL team for their help. This research was partially supported by the National Natural Science Foundation of China (NSFC No. 41974099).

Keywords: Goethite, Dehydration, Laser shock compression, XFEL