EXPERIMENTAL SIMULATION OF NANOPHASE IRON PRODUCTION IN LUNAR SPACE WEATHERING. Hong Tang [1, 2], Shijie Wang [*1], Xiongyao Li [1], [1]State Key Laboratory of Environment Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550002; [2]Graduate University of the Chinese Academy of Sciences, Beijing 100049; [*]Corresponding Author: wangshijie@vip.skleg.cn

Introduction: The exposed lunar surface is subjected to a variety of processes which modified the lunar surface, which is known as "space weathering". Meteorite (largely for micrometeorite) bombardment, and the particles implantation from solar wind, solar flares and cosmic rays are two main processes. The most important product of space weathering is the presence of abundant nanophase iron (np-Fe^0) in the lunar soil, existing both within the agglutinatic glass and on the surfaces of soil grains. The state of np-Fe^0 is considered to be associated with the space weathering processes. The np-Fe^0 in the agglutinatic glass is mainly formed by micrometeorites bombardments, which locally melt the lunar surface materials and reduce the ferrous minerals to metal irons with the hydrogen implanted from solar wind. And the np-Fe^0 as inclusions within a thin (50-200nm) amorphous rim found on many lunar soil grains is produced by vapor deposition and sputtering deposition [1, 2].

It is well known that the presence of the np-Fe^0 would change the properties of lunar soil, but which state of np-Fe^0 would play the key role, and how the np-Fe^0 affects the properties quantitatively are still not clear [3, 4]. So, the simulation of np-Fe^0 production in the laboratory is necessary to further investigating of lunar soil properties. In the study, an experiment using microwave heating and magnetron sputtering techniques to simulating np-Fe^0 both in glass phase and on the grain surface is proposed.

Experiment and results: Quick and selective heating are the characters of microwave heating [5]. It might suit to simulate the formation of molten glass with np-Fe^0. For the high content in lunar soil and the high dielectric loss, ilmenite ($TiFeO_3$) is selected to be a sample for producing np-Fe^0 in the glass phase by microwave heating. The samples were sifted through 200 meshes sieve in order to coupling well with the microwave energy, and then heated in a NJZ4-2 microwave furnace with 2.45GHz and 4KW at a low pressure (~100Pa) put in a silicon carbide crucible. The samples can be quickly heated to 1300℃ for the fine microwave-absorbing property [5]. They had been held for 2, 5, 8, and 30 minutes respectively, and then cooled down quickly in argon flow. Scanning electron microscope (SEM) was used to observe the characters of products. The SEM images and the EDS analysis showed that lots of metal iron grains were produced and dispersed randomly in the glass phase. Comparing with the four samples, that had been held for 8 minutes at 1300℃ has the most submicron iron grains which size are about 100-500 nm (Figure 1). The other samples have been found to rarely forming submicron iron grains.

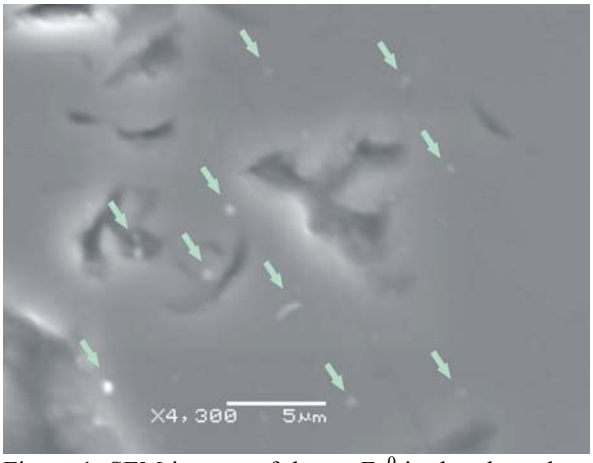

Figure 1. SEM images of the np-Fe^0 in the glass phase by microwave heated (hold 8 minutes). The arrows point to the np-Fe^0.

Magnetron sputtering is a physical vapor deposition (PVD) technique which might simulate well with the process of vapor deposition on the lunar soil grains. In the experiment, the iron target is bombarded by energetic ions generated in discharged plasma; following the target atom escaped and then deposited on the sample surface. For the similarity of chemical and physical properties of CLRS-2 (Chinese Lunar Regolith Simulant), it was selected for the magnetron sputtering experiment. The chemical, physical, and geological properties of CLRS-2 are similar to Apollo 11 high-Ti basaltic lunar soil. Major components of CLRS-2 are pyroxene, plagioclase, olivine, ilmenite and volcanic glass. And the average particle size is about 80-110μm. A magnetron sputtering ion plating system was used in the simulated experiment. The metal iron target (99.9 wt %) was bombarded by argon ions and np-Fe^0 grains had deposited on the CLRS-2 grains surfaces through controlling the electric current and time. Analyzing by transmission electron microscopy (TEM), it is found that the np-Fe^0 grains have deposited on the CLRS-2 grains surfaces asymmetrically. The general size of np-Fe^0 is about 20-30nm (Figure 2).

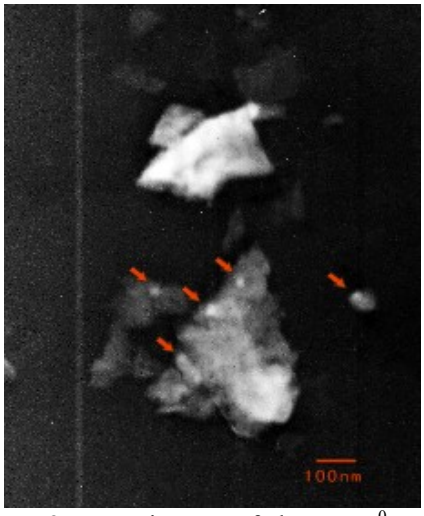

Figure 2. TEM images of the np-Fe^0 on the silicate minerals surfaces of the CLRS-2 by magnetron sputtered. The arrows point to the np-Fe^0.

Conclusion: Microwave heating and magnetron sputtering simulate the formation of the np-Fe^0 in the lunar soil successfully. The result shows that the size and distribution of the np-Fe^0 are similar to those in lunar sample.

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