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Space Weathering on Mercury: Simulation of Plagioclase Weathering

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Space Weathering

Space weathering is a process to explain optical property changes such as darkening, reddening, and attenuation of absorption bands on airless silicate bodies. The space weathering is caused by the formation of nanophase metallic iron particles in amorphous surface coatings from the deposition of ferrous silicate vapor, which was formed by high velocity dust impacts as well as irradiation of the solar wind ions. Nanophase iron particles have been confirmed in the lunar soil coating [1]. Moreover, experimental studies using pulse laser showed the formation of nanophase ion particles on the surface should control the spectral darkening and reddening (Fig. 1) [2].

Mercury observation

Mariner 10 showed and MESSENGER spacecraft confirmed that Mercury has more impact craters associated with bright rays (and ejecta) than the Moon. The space weathering rate on Mercury might be slower than that on the Moon, although dust flux and solar wind flux causing the weathering should be one order of magnitude of greater on Mercury than on the Moon [3]. The Mercury Atmospheric and Surface Composition Spectrometer (MASCS) on board MESSENGER measured reflectance spectra from Mercury's surface during the two flybys in 2008 [4]. Wavelength range is between 0.2 and 1.3 microns. Spectral absorption in the UV range shows that the ferrous oxide (Fe^{2+}) content in average surface/subsurface material is as low as a few weight percent. This could explain apparent low weathering rate on Mercury. MASCS spectra show variation in the slope, which can be explained by lunar-like maturity trend due to the difference of space weathering degree.

Controlling Process of Space Weathering

Growth of size of nanophase iron could have lowered the weathering degree. Size of nanophase iron particles should increase by Ostwald ripening under high temperature of several 100C [5] . And repeated irradiation by high velocity dust impacts as well as solar wind ions may also increase the size of nanophase iron. Growth of nanophase iron particles was observed by repeating irradiation of pulse laser simulating the space weathering (Fig. 1) [2].

The difference of weathering rate would be explained simply by compositional difference. The other possibility for attenuating space weathering on Mercury would be deeper mixing depth. The surface mixing by impacts on Mercury is greater than that on the Moon, because of higher impact flux and velocity of incoming meteoroid bodies.

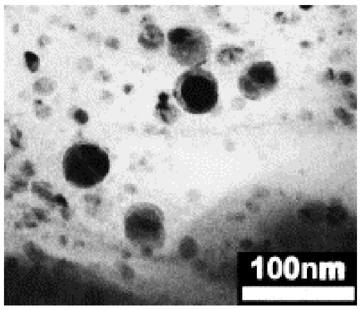

Fig. 1. Nanophase iron particles within amorphous rim around an olivine grain after repeating nano-second pulse laser irradiation. Most of particles are from several to 20 nm in diameter. Some particles have diameter larger than 50 nm and have shell-like structure, which suggests particle growth by repeating laser irradiation.

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Simulation of Plagioclase Weathering

The difference of space weathering between the Moon and Mercury might be also due to the compositional effect. Mercury surface is considered to be plagioclase-rich like the highland of the Moon. We started experimental simulation of space weathering on Mercury (and the Moon) using anorthite samples. Although pure anorthite is in lack of iron, addition of iron-bearing material could alter the anorthite reflectance. Preliminary experiments show that laser irradiation on pure anorthite should not alter its spectrum largely We find that the addition of small amount of pyroxene can change the anorthite reflectance upon laser irradiation (darkening/reddening of visible spectrum). Addition of 5% ilmenite can enhanced the spectral change (darkening/reddening drastically (Fig. 2).

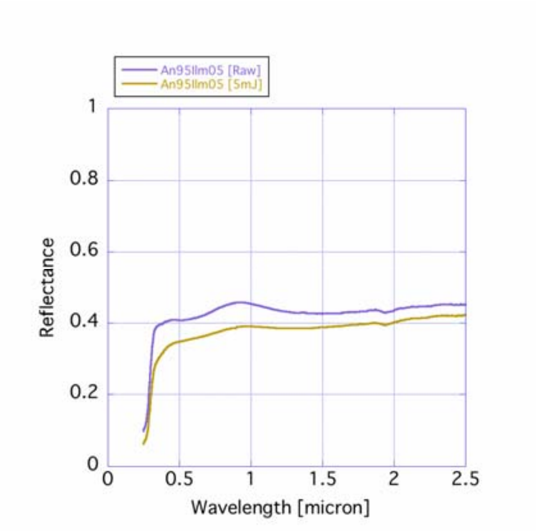

Fig. 2 Reflectance spectra of anorthite (95%) – ilmenite (5%) mixture. The spectrum before laser irradiation and the specrum after 5mJ irradiation.

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