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マーチソン隕石を用いたC型小惑星における宇宙風化作用の再現実験
Experimental reproduction of space weathering of C-type asteroids by laser heating of Murchison CM2 chondrite

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It has been known that space weathering on S-type asteroids results in reddening of reflectance spectra due to production of Nano Fe and FeS particles in the outermost layers of silicate crystals (Noguchi et al. 2011). In the case of C-type asteroids, however, little has been known on the space weathering effects. Based on the observation of family type asteroids, Nesvorny et al. (2005) revealed that the reflectance spectra of C-type asteroids become bluer as the asteroids getting older.

In this study, we performed reproduction experiments of space weathering on C-type asteroids by laser heating on a primitive meteorite. Pulse laser (5 - 15 mJ) with a diameter of 0.5 mm exposed to a pellet of Murchison CM2 meteorite. The reflectance spectra in a range of 0.25 - 14 micrometer were measured before and after laser shooting in order to see heating effects on the spectra. As for the precise measurement of 2.7 micron band caused by structured water in phyllosilicates, physisorption water on the surface of the samples was removed by heating the samples at ~100 degrees Celsius in a nitrogen atmosphere.

The results of spectroscopy showed that the laser heating made Murchison spectra darker and bluer. The spectra became bluer and darker with increasing intensity of laser beam. The change of the spectra was significant in the range from 0.3 to 1.8 um. These results were coincident with the tendency of the space-weathered spectra of C-type asteroids. Transmission electron microscope observation indicated two apparent changes in the laser-heated area on the pellet of Murchison. First, many nano-particles (10 - 50 nm in diameter) of ferroan sulfide were newly formed by melting of FeS-rich material tochilinite. The particles were identified as Fe3S4 and were distributed around small bubbles. Second, Fe-rich serpentine became amorphous in the Fe3S4 nano-particles-rich regions.

The amorphization of Fe-rich serpentine is mainly responsible for the "bluing" of the Murchison spectra, because Hiroi et al. (1999) showed that the breakdown of serpentine lowers the slope of visible and near infrared spectra, especially shorter wavelength range. On the other hand, darkening of the Murchison spectra seems to have resulted from production of Fe3S4 nano-particles. Tiny sulfide particles coated the surfaces of serpentines,were able to reduce reflectivity greatly.

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