**CHANGE OF ASTEROID REFLECTANCE SPECTRA BY SPACE WEATHERING: PULSE LASER IRRADIATION ON METEORITE SAMPLES.** S. Sasaki[1], Y. Ueda[1], E. Kurahashi[1], M. Loeffler[2], T. Hiroi[3], [1]Department of Earth and Planetary Science, The University of Tokyo, Tokyo 113-0033, JAPAN (sho@eps.s.u-tokyo.ac.jp), [2]Department of Engineering Physics, University of Virginia, Charlottesville, VA 22904-4745, [3]Department of Geological Sciences, Brown University, RI 02912.

**Introduction:** There are spectral mismatches between S-type asteroids and ordinary chondrites [1]. S-type asteroids exhibit more overall depletion and reddening of spectra, and more weakening of absorption bands relative to ordinary chondrites. These spectral mismatches are explained by the so-called “space weathering”. Hapke et al. [2] proposed that the spectral change should be caused by formation of nanophase metallic iron particles. High-velocity dust particle impacts as well as sputtering by solar wind would be responsible for vapor formation. Nanophase iron particles are confirmed in the rim of lunar soil grains [3-5]. Recent ground-based and spacecraft observations confirmed the strong link between S-type asteroids and ordinary chondrites [1].

Our group succeeded in reproducing the optical property change expected as space weathering, using nano-second pulse laser irradiation simulating high-velocity dust impacts [6-9]. Using a transmission electron microscope (TEM), we confirmed the formation of nanophase iron particles within the vapor-deposited rim of laser-irradiated olivine and pyroxene grains [10-12]. ESR (Electron Spin Resonance) measurements confirmed that the olivine reflectance should decrease more with the increasing amount of nanophase iron particles [13].

Here we show that reflectance spectra of ordinary chondrites are darkened and reddened by pulse laser irradiation simulating the space weathering. Reflectance spectra of carbonaceous meteorite Allende is also changed by pulse laser irradiation.

**Pulse Laser Irradiation:** To simulate space weathering, we use a solid-state Nd-YAG pulse laser beam with pulse duration of 6-8 nanoseconds [6,7], which is comparable with real dust impacts. We irradiate pellet samples (8mm to 12mm in diameter) of meteorite powder with grain radius smaller than 75 micron under vacuum (2 - $3 \times 10^{-5}$ torr). Smaller pellet holders were newly manufactured for the irradiation on small amount of meteorite samples. Energy of each laser pulse is 5-30mJ and pulse footprint on samples is 0.5mm in diameter. A semi-automatic X-Y stage was used for a uniform irradiation. After the pulse laser irradiation, bidirectional reflectance spectra of samples were measured by instruments at University of Tokyo and at Tsukuba Space Center of NASDA. Both instruments are manufactured by JASCO and basically identical. Incidence and emergence angles are 30 and 0 deg from the vertical, respectively.

**Spectral changes of meteorite samples:** We irradiate Moorabie (L3), Allegan (H5), and NWA055 (L4), and irradiation results are shown in Figs. 1, 2, and 3, respectively. Significant reflectance decreases were observed when ordinary chondrites were irradiated by pulse laser. Change of reflectance spectra of Moorabie was measured by larger pellet (20mm in diameter) and irradiation area is about $10 \times 10 mm^2$. Repetitive irradiation would have saturated the spectral change. Significant spectral decreases were observed even when irradiation time was once at NWA055 (in Fig. 3) or even when the irradiation pulse laser energy was lower (10mJ) at Allegan (in Fig. 2). Significant reddening was obtained upon the alteration of Moorabie and Allegan. As for NWA055, not only the visible reflectance but also infrared reflectance was decreased largely, and resulting reddening is weaker.

In all three ordinary chondrite samples, the spectral decreases were more significant compared with pure olivine or pyroxene. It is partly because the initial reflectances of those ordinary chondrites at 1067nm (pulse laser wavelength) are darker and about 50% of olivine and those meteorite samples absorbed more laser energy. Contained iron in ordinary chondrite would have also contributed the space weathering. However, during comminution by a mortar, metallic grains in chondrite were not comminuted and they rather grow by ductility. Then the fine grain fractions (<75micron) we used were depleted in iron compared with the original compositions. More iron grains should probably promote the spectral change by supplying nanophase iron particles.

The pulse laser irradiation on carbonaceous meteorite Allende (CV3) also changed the reflectance spectrum. Irradiated sample showed a redder spectrum. However, the change of reflectance is in the same order of the spectral difference between pellet and powder samples. Since the packing of powders makes the surface flatter and brighter, the pellet sample would show bluer spectra than the powder sample. This effect was corrected and applied to the measurement of Tagish Lake meteorite sample [14].

**REFERENCES:** [1] Chapman C. R., *Meteorit. Planet. Sci.*, **31**, 699-725, 1996. [2] Hapke B. et al., *Moon*, **13**, 339-353, 1975. [3] Keller L. P., and D. S. McKay, *Science*, **261**, 1305-1307, 1993. [4] Pieters C. M., et al. *Meteorit. Planet. Sci.*, **35**, 1101-1107, 2000. [5] Taylor, L. A., et al. *J. Geophys. Res*., **106**, 27985-27999, 2001. [6] Yamada M., et al. *Antarctic Meteorites* XXIII, 173-176, Nat. Inst. Polar Res., 1998. [7] Yamada M., et al. *Earth Planets Space*, **51**, 1255-1265, 1999. [8] Hiroi T., and S. Sasaki, *Meteorit. Planet. Sci.*, **36**, 1587-1596, 2001. [9] Hiroi, T., et al. *Earth Planets Space*, **53**, 1071-1075, 2001. [10] Sasaki S., et al. *Nature*, **410**, 555-557, 2001. [11] Sasaki S., et al. *Adv. Space Res.*, **29**, 783-788, 2002. [12] Sasaki S., et al. *Adv. Space Res.*, **31**, 2537-2542, 2003. [13] Kurahashi, E. et al. *Earth Planets Space*, **54**, e5-e7, 2002.

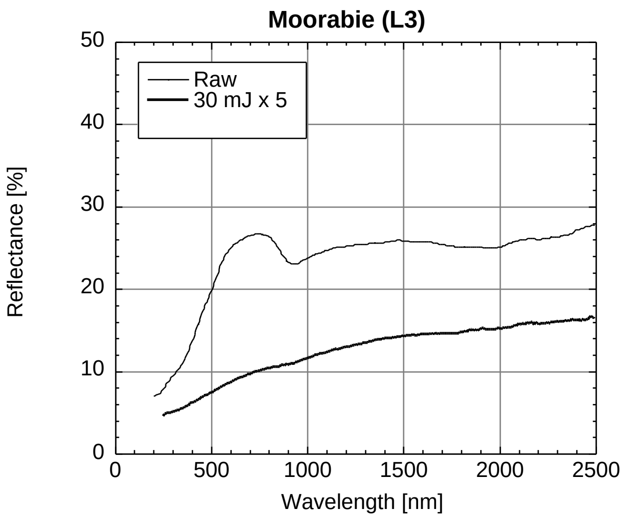


Fig. 1 Reflectance spectra of Moorabiel (L3). Spectra of raw and laser-irradiated pellet samples.

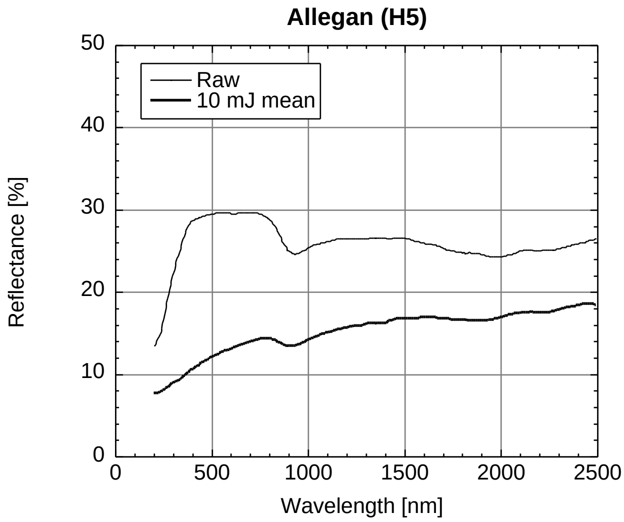


Fig. 2 Reflectance spectra of Allegan (H5). Spectra of raw and laser-irradiated pellets.

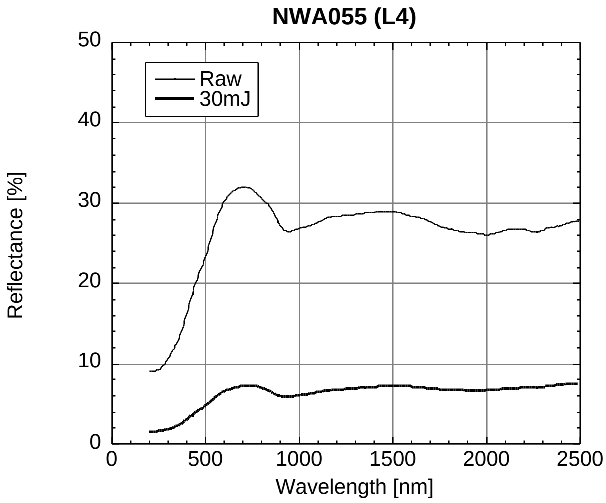


Fig. 3 Reflectance spectra of NWA055 (H4). Spectra of raw and laser- irradiated pellets.