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Estimation of space weathering rates based on reflectance spectra of a regolith-breccia meteorite

MISU, Takaaki[1*], NAKAMURA, Tomoki[1], SASAKI, Sho[2], HIROI Takahiro[3]

[1]Graduate School of Science, Tohoku University, [2]RISE Project, National Astronomical Observatory of Japan, [3]Department of Geological Sciences, Brown University

Space weathering is the term used for color alternation of asteroid surfaces from light to dark. This results from micrometeorite bombardment and cosmic-ray exposure, which generates metallic Fe nano-particles in the outermost layer of mineral particles at the asteroid surfaces. Because of space weathering, reflectance spectra of ordinary chondrites slightly differ from those of S-type asteroids that are parent bodies of ordinary chondrites. Therefore, when we establish the asteroid-meteorite connection based on the reflectance spectra, we must consider the effect of space weathering. Regolith breccia Tsukuba H chondrite is affected by space weathering on the asteroid surface of its parent body and shows characteristic dark-light structure. The dark portion is heavily weathered because of exposure to solar winds on the asteroid surface, while the light portion is not weathered because it was buried inside of the asteroid. Therefore the dark portion contains large amounts of cosmogenic and solar-wind derived noble gases, but the light portion is depleted in such noble gases.

In this study I compared dark potions and light potions of the Tsukuba meteorite in terms of mineralogy and reflectance spectra and investigated space weathering effects on this meteorite. Electron probe micro-analyzer (EPMA) analysis revealed that mineral chemistry of the dark potions and the light potions are the same. I applied the reflectance spectrometer for obtaining diffuse reflectance spectra of both dark and light potions. For comparison of the reflectance spectra, MGM (Modified Gaussian Model) is used. The results indicate that the band strength and areas of spectra derived from the dark potions are much lower than those of spectra from the light potions. Using the band strength and areas as parameters, we evaluate space weathering rates of S-type asteroids based on changes in reflectance spectra and cosmic-ray exposure ages of the Tsukuba meteorite. We use calculated results of cosmic-ray exposure age of the Tsukuba meteorite reported in a previous work. Applying the space weathering rates determined in this study to the reflectance spectra of S-type asteroids, we may be able to obtain surface ages of the asteroids only from reflectance spectra, which will greatly contribute to decipher the origin and evolution of asteroid belt in the solar system.