Using Asteroid-Meteorite Connections to Quantify Space Weathering

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Solar wind exposure and micrometeoroid bombardment are known to cause mineralogical changes in silicate regolith grains on asteroid surfaces. These space weathering processes affect light-scattering properties of regolith by forming amorphous rims, which contain embedded nano-phase iron. The resulting asteroid spectral parameters (spectral slope and band depth) can be compared to meteorite spectral parameters in order to quantify the spectral alteration due to space weathering as a "space-weathering index". This index is used to investigate and characterize potentially influential factors relevant to space weathering: 1) the relative olivine/pyroxene abundance, 2) the amount of FeO within olivine and/or pyroxene, 3) heliocentric distance, and 4) regolith grain size. We hypothesize that space weathering would be enhanced for asteroids with more olivine, higher Fe contents, smaller mean heliocentric distance, and smaller average regolith grain size. This analysis is performed on olivine-dominated asteroids (relating to pallasites, brachinites, and R chondrites), pyroxene-dominated basaltic (HED-like) asteroids, and ordinary chondrite-like asteroids with the goal of determining the relevant factors that influence the amount of space weathering on asteroids.

The large (> 250) sample of asteroids we used is taken from public databases such as the PDS and the MITHNEOS project, which house visible to near-infrared reflectance spectra, as well as our own spectral survey carried out on the NASA IRTF. After performing a band parameter analysis on these spectra, we separated them into the compositional groups mentioned above. Meteorite and lab-irradiated meteorite and mineral samples, mostly sourced from RELAB, are used to quantify the amount of space weathering exhibited by the asteroid spectra. This space-weathering index is used to test the hypotheses across all the compositional groups. Corroborating laboratory experiments, we show that olivine-dominated asteroids are more affected by space weathering processes. Because this method relies on accurate asteroid-meteorite connections, we are able to estimate the average petrologic type (i.e., degree of metamorphism) of the population of ordinary chondrite-like asteroids.