DO ASTEROIDS EXHIBIT DIFFERENT SPACE WEATHERING STYLES? E. M. MacLennan[1], J. P. Emery[1], M. P. Lucas[1], N. Pinilla-Alonso[1,2], [1]Earth & Planetary Sciences Department, University of Tennessee, Knoxville, TN 37996 (emaclenn@utk.edu); [2]Florida Space Institute, University of Central Florida, Orlando, FL 32816.

Introduction: Solar wind exposure and micrometeoroid bombardment are known to cause mineralogical changes in the upper few microns of silicate grains (by forming amorphous "composition" rims with embedded nano-phase Fe^0; $npFe^0$), which in turn affect the light-scattering properties [1]. Subsequently, observed changes in the albedo, spectral slope, and absorption band depths observed on silicate surfaces (e.g. the Moon) are used as proxies for the amount of alteration due to increased $npFe^0$ [2]. Additionally, samples returned from Itokawa by the Hayabusa spacecraft also showed regolith grains containing $npFe^0$ particles, similar in size to those found in lunar samples, in a composition rim [3].

Observations of the Moon have allowed for the understanding of a "lunar-style" of space weathering, characterized by a decrease in albedo, increase in spectral slope, and suppresion of absorption bands [2]. However, images (from spacecraft missions) of (243) Ida and (433) Eros suggest that different space weathering "styles" exist among the silicate-bearing (olivine and pyroxene) S-complex asteroids (e.g., [4]). While Eros generally shows only an albedo difference [5], Ida's surface only shows changes in spectral slope and band depth [6]. In many space weathering studies, it is often assumed that the lunar style is relevant, or only one or two of the observed changes (albedo, spectral slope, and band depth) are taken into account. There has yet to be a comprehensive investigation among the asteroid population, involving all three observable changes relevant to space weathering and not assuming lunar-style space weathering.

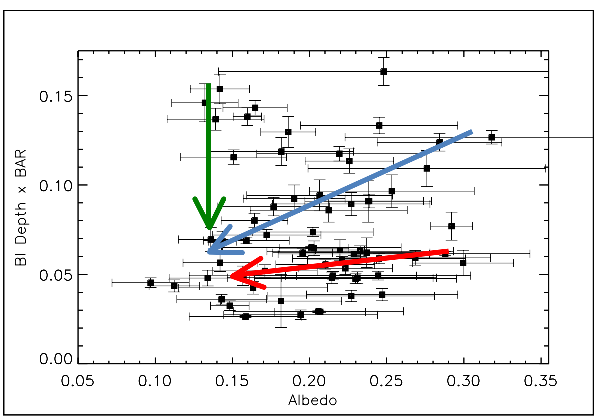

Figure 1 - Band depth (corrected for relative olivine/pyroxene abundance) vs. albedo for 76 asteroids. The space weathering trends as seen on the Moon, Ida, and Eros are shown by the blue, green and red arrows, respectively.

In addition to searching for different space weathering styles, this sudy aims to quantify the factors (solar wind exposure, regolith grain size, mineralogy, and surface age) affecting the degree of space weathering. It has already been shown that asteroids with higher olivine abundance and older surface ages show increased evidence of space weathering [7]. It is suggested by [8] that smaller regolith particles, which have more surface area per volume, should enhance the spectral effects associated with space weathering, but this has yet to be observationally tested for asteroid regoliths.

Hypotheses: We hypothesize that the space weathering styles seen on Eros and Ida also exist on other asteroid surfaces. We also hypothesize that increased solar wind exposure, smaller regolith particles, higher olivine abundance, and older asteroid surfaces will exhibit enhanced evidence of space weathering.

Methods: The aim of this project is to search for and characterize different styles of space weathering among S-complex asteroids and quantifying the dependence of space weathering on solar wind exposure, regolith grain size, mineralogy, and surface age.

To accomplish our goals we begin by deriving spectral parameters from Visible-NIR (0.4 to 2.5 μm) spectra for a few hundred S-complex asteroids. S-complex asteroids exhibit diagnostic absorption features near 1 & 2 microns due to ferrous iron situated within the mafic silicate minerals olivine and pyroxene. Most of the spectral data is taken from existing databases (e.g., MIT-UH-IRTF Joint Campaign for NEO Reconnaissance [9]). However, we are also tar-

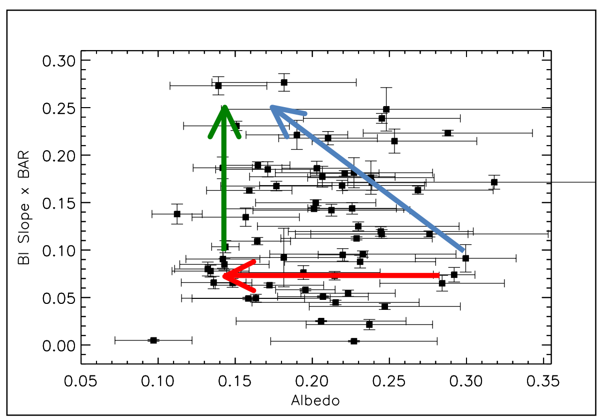

Figure 2 - Spectral slope (corrected for relative olivine/pyroxene abundance) vs. albedo for the same objects in Figure 1. Arrow colors are the same as in Figure 1.

geting an additional 52 S-complex asteroids using IRTF-SpeX of which we will have grain size estimates (from a separate project), in a currently ongoing telescopic spectral survey. Spectral slopes, absorption band depths and other relevant band parameters are calculated using the SARA band analysis code developed and tested by [10]. Geometric albedos are calculated using thermal emission data from the WISE [11] survey.

Search for Space Weathering Styles: With our large set of asteroid albedos, band depths, and spectral slopes (Figures 1 and 2) we can begin to identify objects that undergo different space weathering "pathways" (e.g., surfaces that experience albedo changes but no spectral reddening). Since the spectral slope and band depth can also be affected by the mineralogy (relative olivine/pyroxene abundance) we perform a first order correction by multiplying by the band area ratio (BAR), which is proportional to the relative olivine/pyroxene abundance [12]. Doing this allows us to compare asteroids spanning different mineralogies.

Space Weathering Factors: Another goal of this project is to quantify the influence of solar wind exposure, regolith grain size, mineralogy, and surface age on the degree of space weathering. At the conference we will focus on asteroids in which we will have grain size estimates from thermal infrared data. The approach here is to approximate an un-weathered spectrum for each object, by using a bootstrap method involving a combination of laboratory spectra from the NASA RELAB facility and Hapke's radiative transfer model [8]. Using estimated mineralogy from the set of corrected band parameters [12][13][14] the expected un-weathered albedo, spectral slope, and band depth will be compared to the observed quantities to determine the degree of space weathering and its dependence on regolith grain size. The same approach will be used to quantify the degree of space weathering as a function of solar wind exposure (dependent on the heliocentric distance), mineralogy (relative olivine/pyroxene abundance), and surface age (for asteroids belonging to a dynamical family).

Preliminary Results: Figures 1 and 2 show results for a fraction of our total sample. Upon visual inspection of Figure 1, it seems that several objects lie on the band depth/albedo space weathering trends that are seen on the Moon and on Eros. It is not clear whether distinct trends exist in the spectral slope/albedo values. Observational factors that influence the spectral slope could potentially mask the signature from space weathering. After further processing of additional objects we will present results for our entire sample at the conference.

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