SEARCHING FOR THE ONSET OF SPACE WEATHERING IN S-COMPLEX ASTEROIDS IN THE UV.

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Introduction: In past publications, we have demonstrated that for S-complex asteroids (1) the effects of the creation of nanophase iron ($npFe^0$) appear as a bluing (increase in reflectance with decreasing wavelength) in the UV/blue spectral range as well as reddening (increase in reflectance with increasing wavelength) and diminution of absorption features in the VNIR spectral region; and (2) these effects could appear in the UV/blue at earlier stages in the weathering process than in the VNIR [1,2]. This is attributed to the effects of the transition from volume scattering to surface scattering for the asteroidal material [1]. These previous studies have used a limited number of spacecraft observations of S-complex asteroids optimized at 300- to- 400 nm [1] and a relaxed wavelength interval of 320- to- 400 nm to look at high spectral resolution observations of S-complex asteroids obtained with the ground-based MMT telescope [2,3].

Understanding the S-Complex Changes: From our ground-based spectra, we have arbitrarily defined two “end-member” asteroids from the ground-based observations. Asteroid 18 Melpomene is a large main-belt S(V) asteroid with all spectral indications of having undergone space weathering (Fig. 1) [2]. In contrast, 7341 1991 VK is a near-Earth asteroid with a spectrum we deem to have been little weathered, and which has an orbit that would cause it to pass near Mars potentially allowing its surface to be periodically “refreshed” with less weathered material (Fig. 1) [3]. The spectrum of 7341 shows a sharp downturn at a slightly lower wavelength than 400 nm which is not present in the spectrum of 18 Melpomene: we have suggested that its absence in a weathered asteroid is the effect of space weathering. We have quantified this break by fitting lines of spectral intervals of 320 - 360 nm and 440 - 520 nm, chosen specifically to avoid spectral areas where we could see spectral effects of incomplete removal (e.g., Fraunhofer H, K, G lines). The intersection of these lines is imbedded in the spectrum of 7341 and occurs but is offset in the spectrum of 18; this intersection *does not occur* in spectra of differently-classed asteroids. We propose that the difference is a direct result of weathering, and find support for this in Cahill et al.’s laboratory work showing the Fresnel reflectance of iron from volume scattering to surface scattering [4].

For the S-complex asteroids with sufficient spectral resolution, this intersection is imbedded in the scatter of the spectrum in spectra from about 360 to 410 nm. If this break occurs within this spectral region, we should be able to identify less spectrally weathered objects at wavelengths where we could tap into larger data bases: UBV, SDSS filters. Figure 2 shows our plot of MMT spectra and laboratory spectra of ordinary chondrite meteorite samples binned across 360 to 440 nm, demonstrating that the divide between weathered and unweathered asteroids, and unweathered meteorite samples is still distinguishable. We defined a slope of 0.002/nm as the divide between weathered and unweathered S-complex surfaces in the UV/blue.

SDSS Photometry: A Weathering Onset Search. Under our scenario, the onset of space weathering first seen in S, Q asteroids would be a VNIR asteroid spectrum that does not show reddening and a diminished 1.0-µm mafic silicate band in depth, while the UV/blue part of the spectrum is beginning to show bluing. We want to search a large sample of asteroids in the solar system, so turn to the Sloan Digital Sky Survey. Adapting this to the five SDSS filters, however, requires accommodating the lack of spectral resolution. The *u*’-*g*’ color should provide evidence of the lower-wavelength bluing. Since the differences in mineralogy will dictate the differences in the 1.0-µm feature depth, evidence for onset requires looking for little to no change in the *r*’ - *i*’ color. In short, a Q-class asteroid with some bluing in the UV. The SDSS taxonomic study and tabulation [5,6] was used to identify Q-class asteroids. This number was further reduced by eliminating the photometry of those asteroids for whom the classification is less certain [5], and examining the colors. The r’ - i’ color was held to be very grey (flat). We discuss the distribution of objects that are identified as potentially showing the onset of space weathering; these determinations largely produce a list of potential observing targets, as we believe that additional spectral resolution is required to confirm this evidence for the onset of space weathering.

References: [1] Hendrix A. R. and Vilas F. (2006) *AJ, 13*2, 1396-1404. [2] Vilas F. and Hendrix A. R. (2013) *2013DPS* abstract #101.07. [3] DeMeo, F. et al. arXiv:1309.4839v1 [astro-ph.EP] 19 Sep 2013 [4] Cahill, J. et al. GRL 39, 2012[5] Carvano, J. et al. 2009.

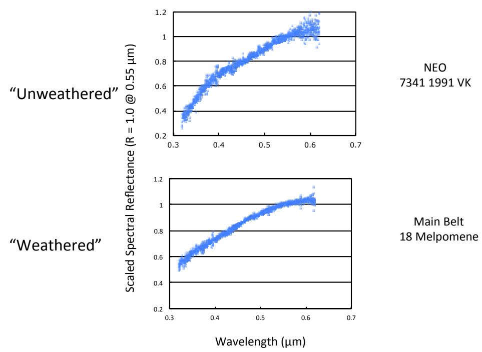

Fig. 1. Reflectance spectra of NEO asteroid 7541 1991 VK (an "unweathered" example) and main-belt asteroid 18 Melpomene (a "weathered' example).

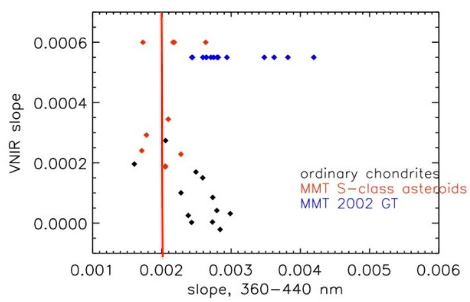

Fig. 2. Slope coimparison between UV/blue from 360 - 440 m and VNIR as in [1]. The UV/blue are from the spectra obtained using the MMT telescope.