EFFECTS OF SPACE WEATHERING ON REFLECTANCE SPECTRA OF UREILITES: A PROOF-OF-CONCEPT STUDY. C.A. Goodrich[1], J. Gillis-Davis[2], E. Cloutis[3], D. Applin[3], C. Hibbits[4], R. Klima[4], R. Christoffersen[5], M. Fries[6] and S. Decker[7]. [1]Lunar and Planetary Institute, Houston, TX USA (goodrich@lpi.usra.edu); [2]HIGP, Univ. HI Manoa, Honolulu HI USA (gillis@higp.hawaii.edu); [3]Dept. Geogr., Univ. Winnipeg, Winnipeg, MB Canada; [4]Johns Hopkins Univ./APL, Laurel, MD USA; [5]Jacobs, NASA JSC, Houston TX USA; [6]ARES, NASA JSC, Houston TX USA; [7]Meteorite-Museum, Oberwesel Germany.

Introduction: Ureilites are differentiated meteorites that contain as much carbon as the most carbon-rich carbonaceous chondrites (CCs) [1,9]. Reflectance spectra of ureilites are similar to those of some CCs [2]. Hence, ureilitic asteroids may end up classified as C-type asteroids, which are presumed to be primitive. We began space weathering studies of ureilites with the goals of predicting UV-VIS-IR spectra of ureilitic asteroids, and identifying features that could distinguish differentiated from primitive dark asteroids. Ureilite spectra could be significantly altered by space weathering, based on space weathering studies of CCs and other C-rich materials [3-7].

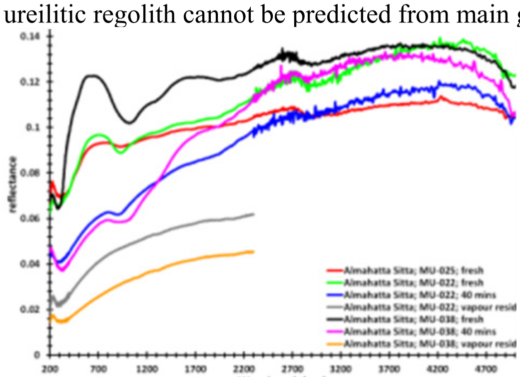
Samples and Methods: Three ureilitic samples from the 2008 fall Almahata Sitta [8,9] were used for initial work: MS-MU-022, -025 and -038. A chip from each sample was used for a thin section. The remainder of each sample was ground and dry-sieved to <75 µm grain size to simulate regolith [5,10]. Thin sections were studied by SEM/EMPA. Aliquots of the powders were studied by UV–IR and Raman spectroscopy, and XRD. Space weathering of -022 and -038 was simulated by pulsed laser irradiation [4,11] in 40 one-minute intervals. Spectra were measured after 6000, 12000, 24000, 36000, and 48000 accumulated laser shots – an estimated exposure age of 800,000 years. The irradiated powders were studied with the same suite of instruments as the non-irradiated samples.

Results: MS-MU-038 is a low-shock olivine-rich ureilite of Fo ~76. MS-MU-022 is a medium-shock olivine-opx ureilite of Fo ~89. Both -038 and -022 contain graphite, metal and sulfide in lower abundance (≤1 vol. %) than most ureilites. MS-MU-025 is a highly-shocked olivine (core Fo ~79) + pigeonite ureilite with extensive shock-smelting [12], mosaicism, and finely dispersed metal and sulfide. Metal and sulfide also occur as large veins.

Pre-irradiation reflectance spectra of all samples show low albedo (0.08-0.1 percent at 0.7 µm) and a steep UVVIS (~0.3-0.7 µm) continuum. The absence of terrestrial iron (hydr)oxides is shown by the absence of bands near 0.22, 0.5 and 0.9 µm. MS-MU-038 exhibits olivine absorption between 1.05 and 1.10 µm. MS-MU-022 exhibits the characteristic two absorption bands of pyroxene, near 1 µm and near 2 µm. Its overall lower reflectance relative to -038 could be due to higher shock level. MS-MU-025 shows the lowest overall reflectance and shallowest absorptions, due to very high shock and high abundances of metal and sulfide. All samples show a 0.23 µm peak attributable to graphite. Raman spectra show the D and G bands of graphite.

In response to laser irradiation, spectra of -038 and -022 became increasingly redder and darker, and lost spectral contrast. The change in absolute reflectance at 740 nm, and the overall reddening, was greater for -038. These and other differences could be caused by even small differences in abundance of graphite and metal/sulfide or shock level between samples. Comparing spectra of the irradiated samples with SMASS [13] asteroid classes and albedo data shows similarities of the mafic absorptions to K-type asteroids (linked to CO and CV) and the continuum to D-type (low albedo, very red). Raman spectra show changes in the graphite and pyroxene bands due to amorphization.

Conclusions: 1) UV-IR spectra of non-space-weathered ureilites vary, due to variations in olivine/pyroxene, graphite, metal, and sulfide abundances, and shock state. These variations must be understood as a baseline for studying space weathering; 2) Space weathering causes significant changes in UV–IR spectra of ureilites. Amorphization of carbon could contribute to disguising ureilitic asteroids as CC-like. Such effects may be even stronger in most ureilites (which contain more graphite) than in our test samples. 3) The most highly shocked samples from Almahata Sitta, such as -025, may already show effects of space weathering [e.g., 14]. 4) Spectral properties of ureilitic regolith cannot be predicted from main group ureilites. Systematic space weathering studies are required.



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