

**LASER SPACE WEATHERING OF METEORITES: A METHOD TO LINK THEM TO ASTEROIDS.** J. J. Gillis-Davis<sup>1</sup>, H. M. Kaluna<sup>1</sup>, and H. A. Ishii. University of Hawaii at Mānoa, Hawaii Institute of Geophysics and Planetology, Honolulu, HI (gillis@higp.hawaii.edu)

Linking meteorites to asteroid parent bodies is fundamental for understanding Solar System evolution. Meteorites afford detailed information about chemistry, mineralogy and thermal history of asteroid interiors, which are inaccessible by remote observation of asteroid exteriors. Sample return and spectral comparisons can connect the two. Only one sample return mission has provided ground-truth confirmation of earth-based or spacecraft spectral analyses, with two more sample return missions to come (i.e. OSIRIS-Rex and Haybusa-2). Linking meteorites and asteroids spectrally is made complicated by a process known as space weathering. Two principal contributions are solar-wind irradiation and micrometeorite impacts. Together these processes alter the observable spectral properties of surfaces (i.e. darken, redden or steepen the Visible-NIR continuum slope, and reduce diagnostic absorption features) and the chemistry (i.e. loss of volatiles like sulfur).

Laser weathering of meteorite powders (<75  $\mu\text{m}$  grain size) is useful in providing a spectral link between meteorites and asteroids. To reproduce the micrometeorite (1-10  $\mu\text{m}$  diameter) component of space weathering, we use a 1064 nm laser, with 30 mJ per pulse, 5–7 ns pulse duration, and 0.25 mm focused spot size. Meteorite and analog materials are iteratively laser weathered up to 800 Ma. After each interval of laser weathering (equivalent to 100, 200, 400, and 800 Ma computed from laser energy fluxes), spectra are measured from 0.35 to 2.5  $\mu\text{m}$  using a ASD fieldspec 4. These spectra are vital for linking meteorites to asteroid parent bodies and suggest the most spectrally similar parent body candidate is space-weathering dependent. In addition, these measurements are important for interpretation of spectra from missions investigating asteroids.

We report spectral responses to laser weathering of various materials and relate them to asteroid spectra. For instance, we relate spectra of laser weathered Murchison, a CM2 carbonaceous chondrite, to C-, Cg, and Cgh-type asteroids, while laser weathered Allende (CV3) are more similar to D- and K-type asteroids. These distinctions may stem from differences in mineralogy, petrographic grade, and status of carbon in space weathered rims. To understand which mineral might play a dominant role in these spectral trends, we laser weathered a natural mixture of 74% cronstedtite, 23% pyrite, and ~3% siderite. TEM analyses show submicroscopic carbon, which may cause spectral darkening and flattening. This observation is consistent with VIS/NIR data of low-reflectance materials on Mercury as measured in MESSENGER MDIS and MASCS data and for C-type asteroids. We also laser weathered a sample of Holbrook (L6) and an NWA ordinary chondrite as well as rocklette of troilite. These experiments allow us to connect ordinary chondrites spectrally and chemically (e.g., NEAR-Shoemaker XRS sulfur measurements of (433) Eros) to S-type asteroids. And finally, we laser weathered (1) Ceres-like mineral analogs: brucite, Epsom salt, lizardite, siderite, and different mixtures of these minerals. Some minerals appear resistant to space weathering (i.e., brucite), while diagnostic spectral bands of other minerals disappear (i.e., lizardite and Murchison) and/or shift (i.e., Epsom salt). In conclusion, spectra of laser weathered meteorite materials are most appropriate to compare with telescopic spectra of asteroids and provide the best hope for linking meteorites to asteroids.