

Space Weathering via Vapor Redeposition of Carbonaceous Material. M. P. Magnuson¹ and M. J. Loeffler^{2,3}.

¹Northern Arizona University, Department of Applied Physics and Materials Science, Flagstaff, AZ, ²Northern Arizona University, Department of Astronomy and Planetary Science, Flagstaff, AZ, ³Center for Materials Interfaces in Research and Applications, Northern Arizona University, Flagstaff, AZ

Introduction: The surfaces of airless bodies are constantly altered by micrometeorites, cosmic rays, and solar wind [1]. These interactions alter the optical and chemical properties of the surface regolith and are collectively referred to as space weathering [1,2]. Space weathered objects may differ drastically from their unaltered states in terms of spectral slope, reflectance and shape and strength of absorption features depending on the amount of weathering and the type of minerals present [2]. The majority of laboratory work regarding space weathering has focused on silicate-rich bodies [e.g., 1, 3-5]. These studies have clearly shown that both low energy ions (used to simulate solar wind ions) and laser irradiation (used to simulate micrometeorite impacts) alter the optical properties of these types of samples by chemically reducing the iron present, so that it forms iron nanoparticles [3].

Another group of airless bodies that have been less studied in the laboratory in regards to space weathering but are equally important those that contain carbon. For instance, carbonaceous, or C-type, asteroids play a vital role in understanding the evolution of the Solar System. These primitive bodies are thought to have formed at the dawn of the Solar System and thus by understanding how they have been weathered in the roughly 4 billion years since, researchers can provide insight into processes that were occurring during that time. The importance of understanding space weathering on C-type asteroids is also highlighted by the ongoing OSIRIS-REx sample return mission.

The current knowledge gap concerning space weathering of carbon-containing bodies is significantly larger than it is for these well-studied silicate samples. For instance, there is currently no well-established trend for space weathering of these bodies, as initial laboratory studies on CC meteorites and other carbon-containing samples have shown in cases spectral slope increases, while in other cases the spectral slope decreases in response to space weathering [6 – 10]. Additionally, some studies have shown that samples brighten [11], while others have shown that samples darken with irradiation [10]. At the very least, these findings suggest that space weathering on these carbon-containing bodies may be more complicated than on silicate-rich ones. This is supported by recent experiments that have suggested CC meteorite and analog

samples appear to show both of these spectral trends, depending on how much the sample has been irradiated [12-13]. Thus, given the complexity of space weathering of carbon-bearing minerals and the relative importance of this topic, we have begun a systematic study of space weathering relevant to C-type asteroids. Initial experiments have focused on the Murchison meteorite [14, 15]. Here we present results that aim to simulate vapor redeposition on these airless bodies. Specifically, here we study how thin coatings of graphite [C], produced via laser irradiation, affect the spectra of San Carlos olivine [$\text{Mg}_{1.8}\text{Fe}_{0.2}\text{SiO}_4$], forsterite [Mg_2SiO_4], and iron sulfide [FeS]. These minerals were chosen due to their relation with carbonaceous asteroids and/or their beneficial optical properties.

Methodology and Results: The San Carlos olivine, forsterite, and iron sulfide samples were made by grinding the respective material into grain sizes of 45-125 μm and then pressing into ~ 1 cm diameter pellets at 3,000, 1,000, and 1,000 psi respectively. A new graphite target disk similar in size to the targets was produced for each of the three experiments by slicing off the end of a graphite rod. The sample and corresponding graphite disk were then placed in an ultra-high vacuum chamber and pumped down to a pressure of $< 5.0 \times 10^{-8}$ Torr to simulate the airless environment of space. At this point we used a 1064nm pulsed-laser (48 mJ) to raster across and irradiate the graphite target. The evaporated material was deposited onto the sample pellet. Once irradiation was finished the sample was taken out of the vacuum chamber and analyzed ex-situ with both ultraviolet and infrared spectroscopy from 0.2 to 2.5 μm before being returned to the vacuum chamber. This process was repeated several times with increasing lengths of graphite irradiation. The thickness of the graphite layer was calibrated using microbalance gravimetry.

Here we will present the spectral evolution of each sample as a function of graphite deposit thickness. Typically characteristics describing space weathering, such as the changes in spectral slope, albedo and analysis of absorption feature changes if applicable, will also be quantified and compared to data currently found in the literature.

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