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Understanding the Space Weathering of Returned Samples through Coordinated Analysis of Experimental Analogs

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The surfaces of airless bodies are continually modified by solar wind irradiation and micrometeorite bombardment, a process known as space weathering. These mechanisms alter the chemistry, microstructure, and spectral properties of surface regoliths which complicates our interpretation of remote sensing data. Considerable work has been done to understand the space weathering of lunar and ordinary chondritic materials, but work focused on hydrated, organic-rich materials is still at an early stage. In advance of sample return, we can simulate space weathering processes in the laboratory with carbonaceous chondrite analog materials and characterize the resulting spectral, chemical, and microstructural effects of constituent space weathering processes. Here we perform coordinated analysis of carbonaceous chondrites which have been experienced pulsed laser irradiation to simulate micrometeoroid bombardment, and through ion irradiation with 1keV H^+ and 4 keV He^+ to simulate solar wind bombardment. To investigate changes in the spectral properties of these samples we perform reflectance spectroscopy across the visible and near-infrared wavelengths (0.35 – 2.50 μm) and micro-FTIR hyperspectral imaging (2.5 – 20 μm). These analyses reveal simulated space weathering causes significant changes in spectral brightness and slope for the samples across different wavelengths. We perform two-step laser desorption mass spectrometry, transmission electron microscopy, and energy-dispersive X-ray spectroscopy to understand changes in the organic and inorganic chemistry of these samples. These analyses reveal changes in the organic functional group chemistry of the samples surfaces, and the production of novel microstructural and chemical features as a result of simulated weathering processes. Our results indicate that the constituent space weathering processes (e.g., micrometeoroid bombardment vs. solar wind irradiation) may have competing effects on the spectral properties for space weathered carbonaceous materials. Similarly, the microstructural and chemical effects of these individual weathering processes may be unique and distinct from each other. We will discuss the implications of these results on our understanding of airless body surface processes and for the analysis of returned samples from asteroids Bennu and Ryugu by the OSIRIS-REx and Hayabusa2 missions, respectively.