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Irradiation of meteorites: decoding space weathering on low albedo asteroids

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Abstract

Space weathering (SpWe) processes such as micrometeorite bombardment or solar wind ion irradiation produce changes on the surface of airless bodies, impeding us to decipher their composition from their spectra. This effect has been widely studied for the case of the Moon and S-type asteroids and is now investigated for primitive asteroids [1].

In order to understand the influence of SpWe on carbonaceous materials and to support current sample return missions (Hayabusa2/JAXA and OSIRIS-REx/NASA), we performed 40 keV He^+ and Ar^+ ion irradiation of carbonaceous chondrites (CCs) as a simulation of solar wind irradiation of C-complex asteroids. We used reflectance spectroscopy (0.4-16 µm) to probe our samples.

We studied several types of CCs [2-4] as they span a wide range of albedos (from 2-5% for CI/CM to 15-18% for CV/CO), initial composition (matrix- or chondrules-rich) and did not suffer the same thermal history (aqueous alteration or metamorphism). We proposed new insights on the effects of SpWe on low albedo asteroids based on these experiments. We recently performed new irradiation experiments on other meteorites (CK, CR and CM with different degrees of aqueous alteration) to test further our model. We will present the new results and discuss them regarding our previous study.

Micro-reflectance spectra were also acquired (2.5-12 µm) using a spot size of 20 µm and scanning large areas (from mm^2 to cm^2) of the samples (13 mm diameter pellets), both on virgin and irradiated areas (see Fig.1). Spectral maps allowed us characterizing the heterogeneity of the meteorites at the 20 µm spatial scale [5].

Compositional heterogeneity of the pristine materials and irradiation effects were compared to each other as a function of the irradiation dose, to determine which spectral features are more sensitive to SpWe. Results were then compared with the IR spectral capabilities of instruments onboard Hayabusa2 and OSIRIS-REx, to provide these missions with spectral criteria on how to distinguish SpWe from compositional heterogeneity effects at the asteroid, and in view of surface selection for sample return.

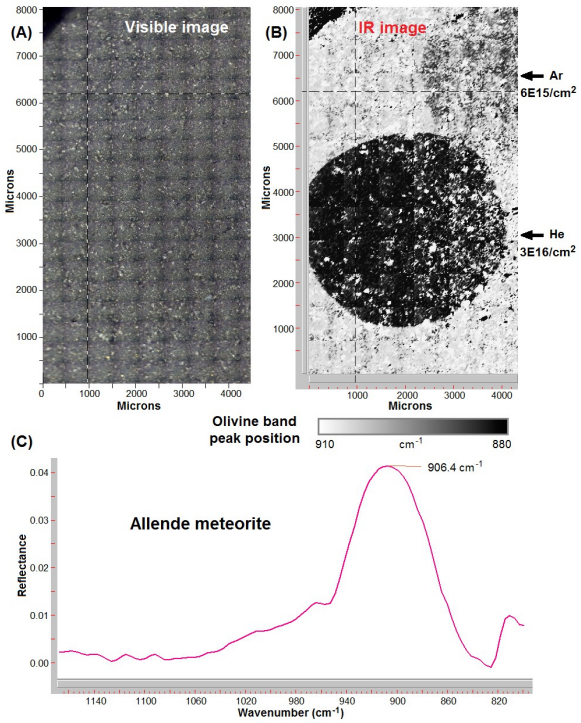

Figure 1: Mid-IR spectral imaging of the Allende meteorite, with two irradiation spots at different ion dose. Panel (A): visible image showing the typical heterogeneous composition of the meteorite pellet. Panel (B): IR map showing the peak position of the 11-µm band in gray scales, with white for short and black for long wavelength peak position. Panel (C): a typical matrix spectrum of Allende with the prominent 11-µm anhydrous silicates band collected on one spot of ~20 µm.

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