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Hyperspectral Imaging of HEDs: a new Approach to Investigate VNIR Spectral Properties of Meteorites.

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Introduction: Howardite, Eucrite and Diogenite (HED) meteorites show igneous-like characteristics (e.g. composition, texture) and they are supposed to be material from 4Vesta [e.g. 1]. In fact, these achondrites, measured as a whole sample (e.g. powders), have visible and near-infrared (VNIR) spectra analogue to those of Vesta's asteroid family [2,3]. In the last decade more work has been done to study the spectral properties of bulk rocks, considering the spectral analysis of cut surfaces [e.g. 4]. These studies highlighted the important influence that rock texture can play on the spectral variability of different igneous rocks and on the capability to retrieve mineralogical information from VNIR spectra. Moreover, recently, researchers begin to work on VNIR spectral imaging on instruments that has a relative high spatial resolution (e.g. tens to hundreds of microns) contributing to improve our knowledge of reflectance spectra properties of rocks or meteorites [e.g. 5,6]. An integration of different datasets must be considered to resolve the mineralogical information from the spectral characteristics (reflectance, absorption bands) and to understand the influence of rock texture on spectra (e.g. form, size, distribution of crystals) and so to obtain a better comprehension of pixel spectra. Here we propose a preliminary study on spectral imaging of HED samples belonging to the collections of the Museo di Storia Naturale dell'Università di Firenze, integrating the hyperspectral images acquired with the SPectral IMager (SPIM) [7] with the mineral chemistry as well as Scanning Electron Microscope (SEM) element maps and petrographic description.

Methods: The samples have been investigated through optical microscopy on thin sections to have a clear description of the mineral assemblages and of rock textures. The chemistry of the principal mineral phases was determined by electron microprobe analyses. Whereas, maps of different elements have been acquired by SEM images. All of these data sets were preparatory for the interpretation of spectral characteristics and variability, giving the key to understand the minerals present in a pixel and their distribution and relationship between phases in our hyperspectral image. Hyperspectral images were acquired at the SPIM facility of IAPS in the wavelength range from 0.2 to 5.1 μ m, with a spectral resolution of 2 nm in the visible and 12 nm in the infrared. The target is illuminated with an angle of 30° whereas the emission is collected at 0°. LabSphere® spectralon and infragold are considered as standard for the visible to near-infrared (0.2-2.5 μ m) and for the short-wavelength infrared (2.5-5.0 μ m), respectively. The sample is scanned moving the sample-holder with 38 μ m-wide steps. The total width of the slit is 9 mm, and the spectral resolution can be considered in the order of 38 μ m [7].

Preliminary Results: A first result is the presence of a high spectral heterogeneity since the pixel resolution is higher or closer to the crystal size present in the investigated samples. Un-supervised and Supervised classifications permit to isolate the principal phases, like pyroxene, olivine and plagioclase, recognizing them from their reflectance and/or the presence of diagnostic absorptions (see [8]). Moreover, when crystals are in order of some hundreds of microns it is possible to reconstruct the crystal distribution as well as to differentiate the composition of the hosting pyroxene crystal and of the exsolution lamellae if lamellae are large (tens of micron). Moreover, we have seen that when crystals of few microns of an absorbing phase (i.e. pyroxene) are surrounded by a more transparent phase (i.e. plagioclase) the spectra are strongly characterized by the absorption bands of the first phase but the reflectance and absorption depths are influenced by the second phase.

Future Work: The spectral variability on our images clearly permits to recognize the rock forming phases and to differentiate samples containing different minerals. Mineral distribution can also be retrieved, considering the spatial resolution of our images, but more work is needed to understand the limits. Integrating the analysis of visible and near-infrared spectral imaging with mineral chemistry and mineral distribution will give us more indication to optimize the interpretation pixel per pixel.

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