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### Hyperspectral spectroscopy of carbonaceous chondrite Mighei in the visible-infrared range

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**Introduction:** Microimaging spectroscopy is a useful tool for spectral characterization of rocks and meteorites with no need of any treatment of the samples. In this study, spectral data in visible-infrared range were collected on CM2 carbonaceous chondrite powders, Mighei, of which modal composition determined by XRD is olivine (15.6%); enstatite (6.6%); calcite (1.1%); magnetite (3.6); cronstedtite (45%); Mg-rich serpentine (23%); and FeS (4.6%) [1]. Other minor phases consist of Mg serpentine, epsomite, diopside, pigeonite, refractory inclusions, brucite, chrysotile [2].

**Instrument setup:** The imaging spectrometer installed in SPIM is a spare of the spectrometer on Dawn spacecraft [3,4]. It works in the 0.22-5.05  $\mu\text{m}$  spectral range, with a spatial resolution of 38x38  $\mu\text{m}$  on the target. Two bidimensional focal plane arrays, one for the visible between 0.22 and 1.05  $\mu\text{m}$  (spectral resolution of 2 nm) and one for the IR between 0.95 and 5.05  $\mu\text{m}$  (spectral resolution of 12 nm) allow to obtaining the spectral coverage. The illumination and emission angles are 30° and 0° with respect to the normal to the sample surface, respectively.

**Results:** Data were collected on powders <200 $\mu\text{m}$ . Given the high spatial resolution of SPIM, every spectrum profile could be a mixture of several spectral contribution of different minerals. Thus, as first step all potentially spectral endmembers were identified, keeping into account the mineralogical phases found in literature. In most the pixel spectra CO<sub>2</sub> features related bands at 4.25 $\mu\text{m}$  occur; whereas only in some of the pixels occur H<sub>2</sub>O band at 1.9 $\mu\text{m}$ . The spectrum in fig. 1 shows 1  $\mu\text{m}$  broad band absorption that can be attributable to crystal

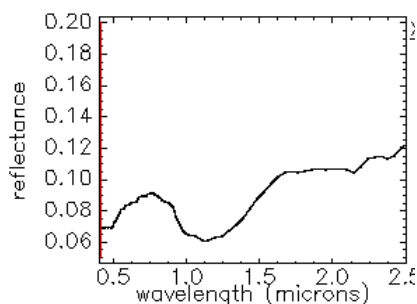


Fig.1 Pixel spectrum of magnetite in Mighei

field transitions in octahedrally coordinated Fe<sup>2+</sup> in magnetite (fig.1). In fact, respect to silicate minerals, magnetite spectra are characterized by low reflectance, a weak absorption band near 0.48  $\mu\text{m}$  likely due to a spin-forbidden absorption band, and a broad absorption band centered beyond 1.0  $\mu\text{m}$  that is attributable to Fe<sup>2+</sup> [5]. However, we have to consider that olivine is present in Mighei and could have variable composition. Fayalitic olivine from library data (Relab, Usgs) also shows one broad feature near 1.0  $\mu\text{m}$  band similar, except for the higher reflectance value, to the absorption band plotted in fig.1.

In fig.2, the comparison between one pixel spectrum and the kerogen spectrum is shown. The absorptions in the range between 3-3.5  $\mu\text{m}$  could be ascribed to C-H compounds.

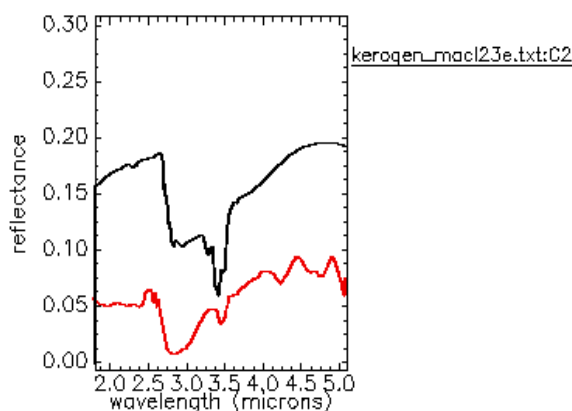


Fig.2 Pixel spectrum of carbonaceous matter detected in Mighei

In the 2.7-3.0  $\mu\text{m}$  range there are features related to different phyllosilicates and perhaps sulfates. For example, in fig.3, the plot shows a pixel spectrum whose absorption features could be attributable to Fe-serpentine, cronstedtite. In the same spectrum another two broad absorptions around 4.3 and 4.8  $\mu\text{m}$  could be due to SO<sub>4</sub> overtone and combination bands in sulfates.

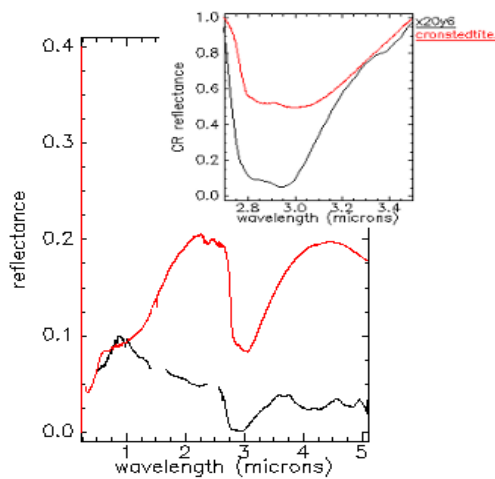


Fig.3 Pixel spectrum of Fe-serpentine in Mighei

Moreover, Mg-serpentine and antigorite (fig.3-4) were identified analyzing this range between 2.7-3 $\mu$ m.

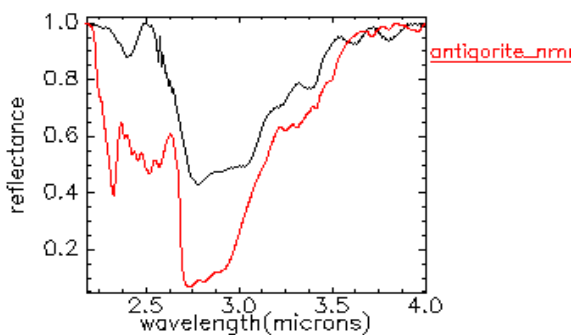


Fig.4 Continuum removed pixel spectrum of antigorite found in Mighei

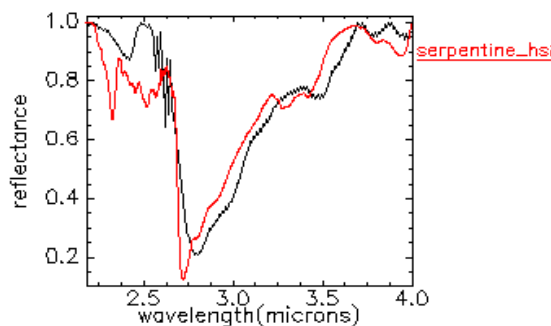


Fig.5 Continuum removed pixel spectrum of serpentine found in Mighei

**Conclusions:** These preliminary results show that SPIM spectral imager allows to identify several spectral species on carbonaceous chondrites that corresponds to different minerals. This is interesting for multiple reasons: for carbonaceous chondrites spectral investigations itself; to help in computing inversion models in supporting of remote sensed spectral data of C-type asteroids, like Ceres, but also for detecting minerals such as phyllosilicates and sulfates that are common on other environments like Mars.

**References:** [1] Howard, 2008, abs#5160, JGR, 90, 1151–1154. [2] Vdovykin, G. P., 1973, The Mighei Meteorite, Space Science Reviews, 14, 6, pp.832-879. [3] De Angelis S., et al., Rev. Sci.Instrum., 86, 2015. [4] De Sanctis M.C., et al., Space Sci. Rev., 163, 329-369, 2011. [5] Cloutis et al. Icarus 212, 2011, 180–209.

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