VARIATIONS OF MINERALOGY, HYDRATION AND ORGANIC CONTENT WITHIN CM CHONDRITES DETERMINED BY MIR HYPERSPECTRAL IMAGING.

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Introduction: Studying the mineralogy and chemistry of chondrites is a good tool to reconstruct the early history and the evolution of our Solar System [e.g. 1,2]. In this study, we analyzed chondrites with different states of hydration to understand the variations of mineralogy, their hydration and organic content: Cold Bokkeveld (CM2.2), Murchison (CM2.5), Paris (CM2.7-2.9) and Tuxtuac (LL5) as a reference for no hydration. The samples were analyzed with minimal preparation and no extraction of organic matter, in order to enable a simultaneous in situ characterization and localization of mineral and organic phases as explored by previous researches [3,4,5,6].

Materials and methods: The meteorite samples were sliced using a diamond saw with a stainless-steel wire set with synthetic diamonds (MNHN, Paris). The cut was performed in dry condition order to avoid any modification of the samples' hydration state and organic content. The sample surfaces were analyzed by Mid-IR hyperspectral imaging (4000-800 cm^{-1}, 2.5-12.5 µm) in reflectance mode using a Cary 670 IR microscope (Agilent, Les Ulis, France) with a x15/NA 0.62 objective coupled with a Focal Plane array detector and a Globar source at the SMIS beamline (SOLEIL Synchrotron, Gif-sur-Yvette) [6,7]. This technique allows to analyze mm-sized surfaces with a pixel size of 5.5 x 5.5 μm^2. An improved data processing using a k-means clustering method was applied thanks to the open source software Quasar [8,9]. In order to complete the identification of mineral phases and organic compounds, we also performed Raman micro-spectroscopy on the same meteorite samples at the SMIS beamline using a DXR Raman spectrometer (Thermo Fischer,Les Ulis, France) equipped with a 532 nm laser used with a power of 0.5 mW [6]. The analyses were conducted using a x50 objective with a 25 µm slit aperture leading to a spot-size lower than 2 microns.

Results and discussion: A sequence of k-means clusterings on the hyperspectral data allows to identify and to localize the spectral families. This spectral families are attributed to different anhydrous and hydrated minerals by comparison with measurements of standards on the same setup, literature data [e.g. 6, 10, 11 and references therein] and Raman spectroscopy. This investigation gives access to modal mineralogies of samples consistent with literature values [12, 13]. We also analyzed the variability of spectral properties, such as band position or bandwidth of the SiO and OH stretching bands within each chondrite and among the considered chondrites. Our study shows how these parameters evolution and their local variability probe the different states of hydration of the samples, and illustrates the way hydrothermal alteration evolved in each CM parent body. Moreover, we designed a specific data processing bases on IR imaging to detect the aliphatic CH stretching bands and reveal the colocalization of organics and various mineral phases, and their hydration. We discuss the results in the context of aqueous alteration in the primary asteroidal parent bodies.

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