SELECTIVE UV-NIR REFLECTANCE SPECTRA OF CM CHONDRITES TO IDENTIFY PRISTINITY, AQUEOUS ALTERATION AND MILD METAMORPHISM IN UNDIFFERENTIATED ASTEROIDS

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Introduction: A couple of dark and primitive asteroids are future targets of the space based missions OSIRIS-REx and Hayabusa 2 [1,2]. Asteroids of the C complex in the Bus-DeMeo taxonomy are often targets for sample return missions, being characterized by their low albedos, and flat, mostly featureless spectra. Although, in general, the characterization of these primitive objects, and their association with meteorite analogs remains elusive or doubtous [3], the C class was first temptatively associated with the CI and CM groups of carbonaceous chondrites [4].

Narrow-band spectrophotometry programs help us to identify such extremely dark objects. Usually, the albedo, the position and particular strength of distinctive absorption bands, and the overall shape and slope of the spectra, are considered for a proper characterization, but many dark asteroids and comets lack of such distinctive features [3,4]. In any case, by using reflectance spectroscopy we are able to distinguish features that can be associated with the main minerals composing CM chondrites and these might be used for sampling unmetamorphosed regions of such asteroids [3,4]. On an ongoing study, we have been working with NASA Antarctic chondrites in order to understand the spectral differences among CM2 and CM1 chondrites, and their link with C-class asteroids.

Technical procedure: Polished sections of the selected meteorites were measured using an UV-Vis-nIR spectrometer as described in [3,5]. The reflectance spectra were obtained at least two times to get an average value for the reflectance in each wavelength, and no significant differences were found by rotating the sections. A Shimadzu UV3600 UV-Vis-NIR spectrometer was used to obtain the reflectance spectra of the meteorites listed in Table 1. The standard stage for the spectrometer is an Intregrating Sphere (ISR) with a working range of 0.2 to 2.6 μm, and operated under laboratory conditions (for more details see [6]). The sample beam interacts with the sections at a phase angle of 8º. A standard baseline was created for calibrating the detector, using a conventional $BaSO_4$ substrate. The area sampled during the measurements correspond to a slot of ~2×1 cm^2.

Meteorite	Group	Collection
LEW 87148	CM2	Antarctic, NASA
MAC 02606	CM2	Antarctic, NASA
MET 01070	CM1	Antarctic, NASA
MIL 07689	CM1	Antarctic, NASA
Murchison	CM2	IEEC-CSIC
QUE 97990	CM 2	Antarctic, NASA
QUE 99038	CM 2	Antarctic, NASA
QUE 99355	CM 2	Antarctic, NASA
SCO 06043	CM 1	Antarctic, NASA

Table 1: CMs selected for this study.

Results and discussion: CM chondrites exhibit quite heterogeneous spectra with features mostly associated with the extent of aqueous alteration [3-6]. Pervasive water alteration changes the bulk mineralogy transforming Fe-Ni grains into magnetite and troilite. Magnetite has also distinctive absorption bands in 0.48 and 1 μm respectively, and tochilinite has a noticeable feature at 1.3 μm [4]. A relationship between the albedo of the objects and the extent of aqueous alteration can be explained with the progressive leaching of iron from silicates as the alteration proceeds [7]. It is well known that leached iron, the most opaque phase in the visible range associated with aqueous alteration, is enveloped in magnetite and iron sulfide grains, so much less material would be available to absorb the incoming sunlight and this would naturally increase the albedo [8]. In general we found significant differences in the reflectance spectra of the specific CM studied. Some CMs (e.g. Murchison, MAC 02606, and SCO 06043) show a distinctive absorption feature at 0.22 μm whose assignation could be due to PAHs [9], or alternatively to the presence of Fe^{3+} in silicates [10]. Olivine absorption features exist near 0.31 μm in CM1 SCO 06043 and CM2 MAC 02606, that make them comparable with Murchison and Cold Bokkeveld [4]. On the other hand, most CMs are featureless and exhibit an almost flat spectral reflectance with weak features of olivine [4,11]. CM1 should contain phyllosilicates after extensive aqueous alteration but it seems rare not finding similar features in some specimens.

Conclusions: we conclude that pervasive aqueous alteration has significant effects in the reflectance spectra of C-class asteroids and might be the cause for the observed variations in CM1 reflectance spectra. In the UV range there are some interesting features that require more work, particularly at 0.22 µm whose assignation need to be assessed carefully. We will continue our exploration of such differences in order to get insight about remote detection of pristinity in future sample-return missions.

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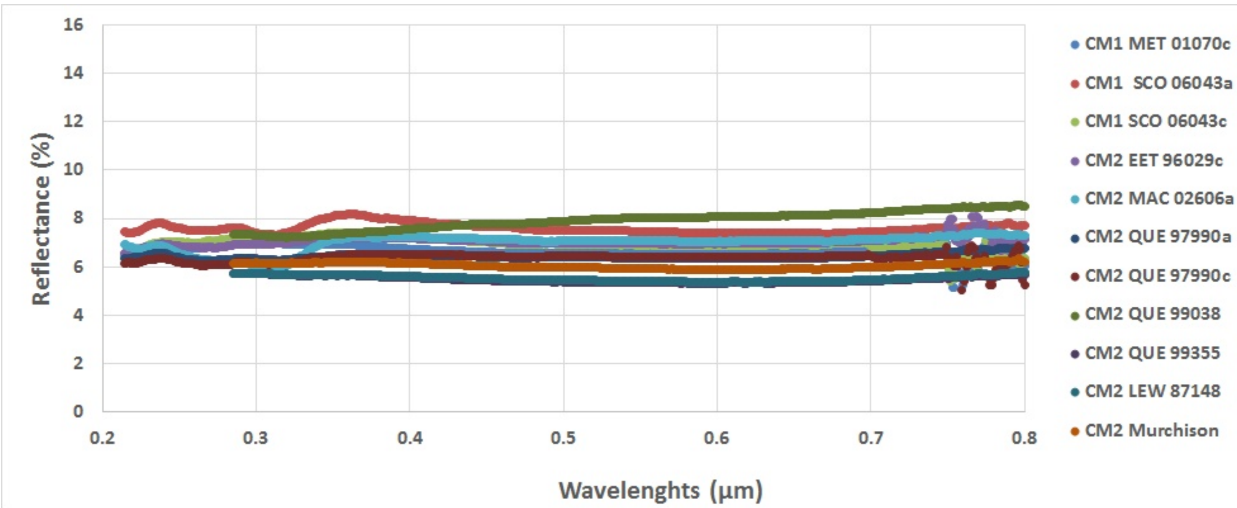

Figure 1. Reflectance spectra of the CM chondrites scaled and normalized to unity at 0.55 µm from 0.2 to 0.8 µm.

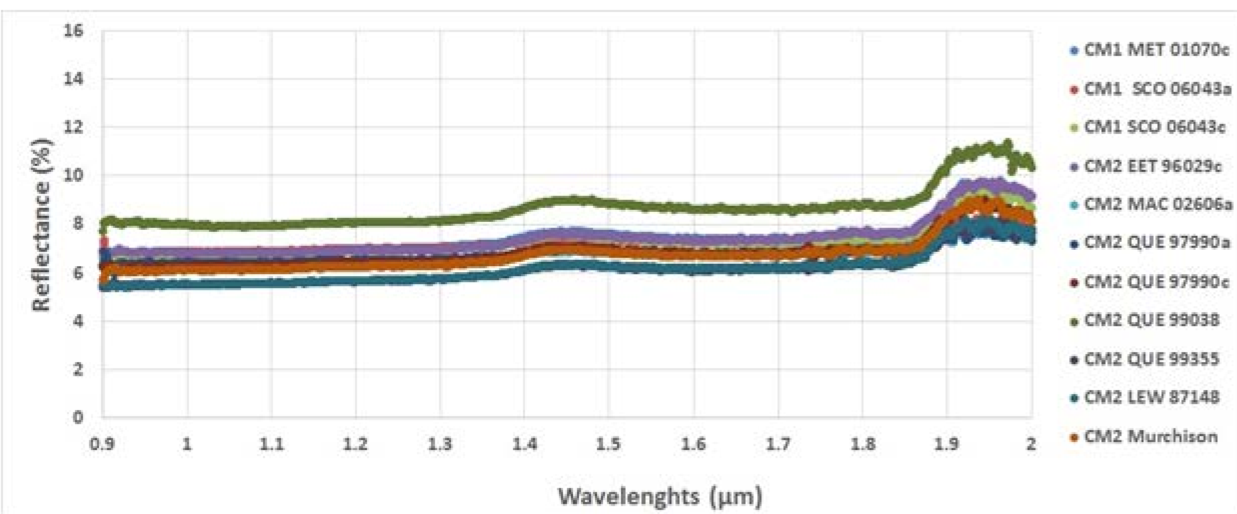

Figure 2. Reflectance spectra of the CM chondrites scaled and normalized to unity at 0.55 µm from 0.9 to 2.0 µm.