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The effect of CM2 carbonaceous chondrites on reflectance spectra of HED meteorites

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Abstract

A number of HED meteorites contain varying amounts of carbonaceous chondrite-type material, most often of CM2 type. Its presence reduces overall reflectance (0.3-2.5 µm) and pyroxene band depths. If the CM2 material is red-sloped, it can cause pyroxene band I and II minima to move to longer wavelengths; band centers can be recovered with a reasonably high degree of accuracy by dividing out straight-line continua. CM2 chondrites are weakly featured compared to HEDs, and as a result, CM2-type absorption bands (e.g., at 0.7 and 1.0-1.3 µm) do not appear in HED reflectance spectra even at CM2 abundances as high as 60% in intimate mixtures (the highest abundance investigated) and 90% in areal mixtures. Thus, direct detection of CM2 material is not feasible except where it is volumetrically dominant. By contrast, increasing HED grain size causes a decrease in overall reflectance but an increase in pyroxene band depths. Thus, in at least a qualitative sense, the effects of CM2 can be discriminated from increasing HED grain size.

1. Introduction

The presence of low-albedo terrains on asteroid 4 Vesta, as imaged by the Dawn Framing Camera, indicates some change in material properties. Interpretations of these low-albedo regions include an increase in average grain size, exposed rocks/bedrock, or the presence of a darkening agent. Many HEDs contain varying amounts of CM2 xenoliths; in the case of the howardite PRA 04401, visible CM2 material occupies approximately half of the sample [1]. To determine whether the presence of CM2 material could account for low-albedo regions on Vesta we studied the spectra of a CM2-bearing howardite (PRA 04401) and intimate and areal mixtures of the Millbillillie eucrite + Murchison CM2 carbonaceous chondrite.

2. Experimental procedure

Reflectance spectra were acquired at the University of Winnipeg HOSERLab using an ASD FieldSpec Pro HR spectrometer. Spectra were acquired from 0.35 to 2.5 µm with 1 nm spectral output. Sample spectra were measured at *i*=30º and *e*=0º relative to Spectralon ®, using a collimated 100 W QTH light source. Samples were measured as slabs and then crushed by hand with an alumina mortar and pestle and dry sieved to produce various size fractions.

PRA 04401 was spectrally characterized as a slab and for <45, 45-90, and 90-250 µm grain sizes. Eucrite+CM2 powdered (<45 µm grain size) intimate mixtures were prepared using the Millbillillie eucrite and Murchison CM2 chondrite with the following abundances of CM2: 5, 10, 20, 30, 40, 50, and 60 wt.%. Areal mixtures were generated mathematically from the end member spectra at 10 wt.% intervals.

3. Results

The PRA 04401 sample contained ~40% visible CM2 clasts. Figure 1 shows its <45 µm spectrum, as well as the Millbillillie and Murchison end members. The PRA 04401 spectrum is characterized by subdued pyroxene absorption bands and lower reflectance than Millbillillie, but is more strongly featured and brighter than Murchison.

Both the intimate and areal mixture spectra of Millbillillie + Murchison show a gradual decrease in reflectance and pyroxene band depths, as expected. The intimate mixture spectrum that most closely matches PRA 04401 contains approximately the same amount of CM2 as PRA 04401 (Figure 2).

Figure 1. Reflectance spectra of <45 µm fractions of PRA 04401, Millbillillie, and Murchison.

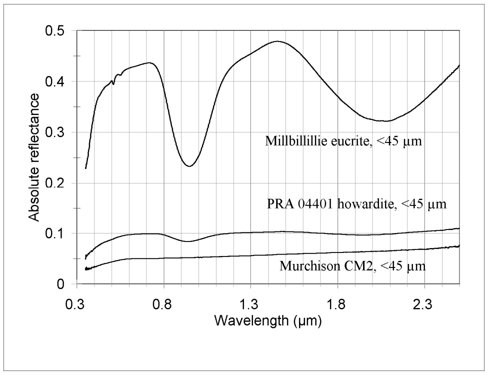
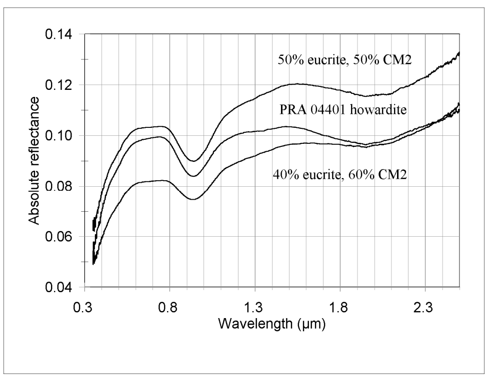


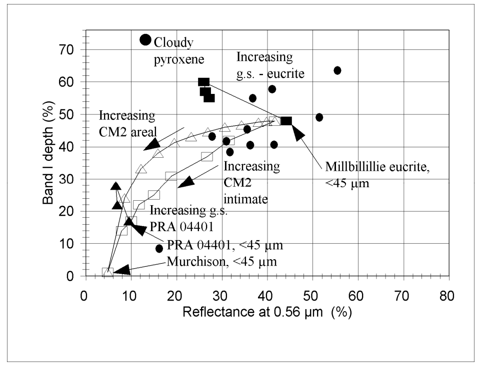
Figure 2. PRA 04401 spectrum and closest spectral matches of the intimate Millbillillie + Murchison mixtures.



4. Discussion

In order to determine whether CM2-bearing terrains can be distinguished from increasing HED grain size (both result in lower albedo) we examined spectral parameters, such as band depths and band saturation [2]. We found that the sense of spectral changes differs between these two mechanisms - increasing pyroxene band depths with increasing grain size (at least when going from <45 to 45-90 µm size powders) and decreasing band depths with increasing CM2 abundance (Figure 3). The band saturation parameter, t, of [2] also showed good separation between these two mechanisms.

Figure 3. Reflectance at 0.56 µm vs. band I depth for Euc+CM2 intimate mixtures (open squares), areal mixtures (open circles), and PRA 04401 and Millbillillie as a function of grain size.



5. Summary and conclusions

There can be significant overlap between many spectral parameters for HEDs compared to CM2-bearing HEDs. As a result, it is difficult to confidently discriminate changes in HED grain size from addition of CM2 material. Their separability increases as the amount of CM2 material increases. No one spectral parameter can confidently discriminate between them; the application of multiple spectral parameters is recommended. The spectral parameters identified here are most useful in measuring relative rather than absolute changes in HED properties.

Acknowledgements

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References

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