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Space weathering on low albedo asteroids

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Abstract

In this study we analyze visible and near-infrared wavelength spectral data of 42 Ch/Cgh-type asteroids compared to spectra of 106 CM meteorites in order to investigate the possible effects of space weathering on low albedo asteroids. In this report of our first results, we focus on two of the largest, well-studied asteroids: 13 Egeria and 38 Leda.

1. Introduction

Assuming that primitive asteroids are the parent bodies of carbonaceous chondrites, a comparison between meteorites and their parent-body asteroids should reveal the spectral effects of alteration processes on asteroid surfaces. In this work, we begin with a fairly well-established meteorite-asteroid link: several studies have shown excellent evidence that links the CM meteorites with the Ch/Cgh asteroids [1]. Assuming this link, we reason that differences between spectra of particulate samples of the CM meteorites and spectra of the regolith of the asteroids can be due to either differences in textural properties, or differences in chemistry/mineralogy caused by surface processes on the asteroid. The goal of this work is to predict what the OSIRIS-REx mission will see at asteroid 1999RQ36 in order to support the technical development of mission observations.

2. Data reduction

The suggested link between CM meteorites and Ch/Cgh asteroids is generally based on two quantities that distinguish these objects from other meteorites and asteroids, and make their association relatively uncontroversial. They both possess an absorption feature at 0.7μm, and they both have low albedos. First we choose asteroids according to the Bus-DeMeo taxonomy and according to what is available from our colleague S. Fornasier [2,3]. These asteroids are classified Cgh and Ch type because they have a strong absorption band at 0.7μm due to an Fe^{2+}-Fe^{3+} transition. We have obtained spectra of 42 of these asteroids. Next, we take all of the Brown University Reflectance Laboratory (RELAB) spectra of unaltered CM meteorites showing the 0.7μm band with a signal-to-noise ratio (SNR) greater than 7 and with the band center between 0.6 and 0.8μm: we have obtained 46 spectra of these meteorites. To determine which meteorites showed the 0.7μm band, we fit the continuum across the band, removed the slope of the continuum, and fit polynomials of different degrees to the band until the band strength SNR was maximized. All of the spectra are normalized to 1.0 at 0.55μm. To examine the spectral differences between our hypothetical pure meteorites and the space weathered asteroid surfaces, we simply divide the spectrum of an asteroid by the spectra of the meteorites. We also measured several important spectral parameters such as the slopes in the visible range (0.45-0.70μm) and the near-infrared range (1.1-1.45μm); the absorption band center and the depth of the 0.7μm band.

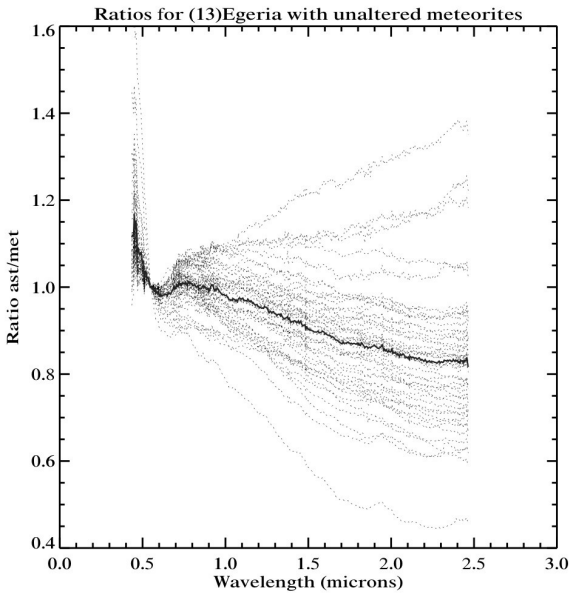

Figure 1: Spectral comparison of asteroid Egeria and unaltered meteorites.

3. Results

In Figures 1 and 2, we present combination plots of relative reflectance vs. wavelength for asteroids 13 Egeria (Ch-type) and 38 Leda (Cgh-type). Shown in dotted lines are the ratios (asteroid/meteorite) for each meteorite in our collection, over-plotted in thick line with the average of the ratios. We chose this type of ratio plot to be consistent with other studies showing the spectral effects of surface alteration on higher-albedo asteroids [4]. One can see that the asteroids are brighter than the meteorites in the visible region and darker than the meteorites in the NIR region: this suggests that there is a general blueing of the spectra. If our selection of asteroids truly represent parent bodies of our selection of meteorites, then this blueing could be the spectral signal of space weathering on low-albedo objects.

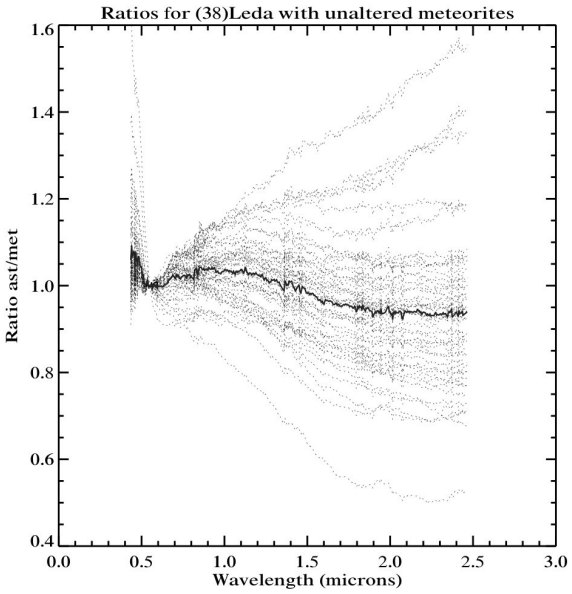

Figure 2: Spectral comparison of asteroid Leda and unaltered meteorites.

This result agrees with the results of Moroz et al. [5], but does not agree with the model for the spectral effects of space weathering presented by Lazzarin et al. [6]. A quantitative description is shown in Table 1. Presented are the spectral parameters that measure the change from the value for the asteroid and the average value for the meteorites. There is indeed a neutralization of the spectral slopes, especially in the visible range, and a little increase in the brightness of the asteroids as compared to the meteorites. Spectral changes to the absorption band do not seem to be significant.

Table 1: Changes in spectral features

ΔParameters	13 Egeria	38 Leda
Visible slope [0.45-0.7μm] (μm^{-1})	-0.472	-0.150
Near Infrared slope [1.1-1.45μm] (μm^{-1})	-0.240	-0.156
Albedo (%)	+0.034	+0.013
Center of the 0.7μm band (μm)	-0.029	-0.004
Depth of the 0.7μm band	-0.004	-0.008

4. Summary and Conclusions

We have shown that for these two asteroids, 13 Egeria and 38 Leda, there is a "blueing" of the spectra relative to unaltered meteorites. These are only 2 asteroids from our sample of 42 bodies, so we expect to be able to present a more statistical study at our next report. Other questions we will investigate will include a study of the experimentally heated or irradiated meteorite samples in the RELAB collection to see if they show comparable spectral trends relative to the unaltered meteorites.

Acknowledgements

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