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Reflectance spectroscopy of cloudy pyroxenes from Millbillilli eucrite

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Abstract

We acquired reflectance spectra of a cloudy pyroxene separate from Millbillilli eucrite between 0.3 and 25 µm. Analysis of the spectra shows that opaque inclusions finely dispersed in eucritic pyroxenes affect near-infrared (NIR) spectral parameters, such as spectral slopes, band centers and band area ratios. The data may be useful for interpretation of spectral variations across the surface of 4 Vesta and for understanding the spectral diversity within the population of V-type asteroids.

1. Introduction

HED meteorites have been postulated to originate from a large main belt asteroid 4 Vesta – the target of the DAWN space mission. A number of smaller V-type asteroids have spectral similarities to HEDs and show variations in spectral parameters. Factors responsible for the observed spectral variations and certain discrepancies between the VNIR spectra of V-types and HEDs may include: differences in mineralogy, regolith roughness, temperature, space weathering, impact melting (see, e.g., [1] and references therein). Here we show how a possible enrichment of a V-type asteroid regolith in so-called "cloudy pyroxenes" may affect spectral parameters, such as NIR spectral slopes, band centers and band areas. Millbillilli eucrite is composed (in vol.%) of 49% exsolved-pigeonitic pyroxene, 46% plagioclase, 4% a silica phase, 0.7% ilmenite, 0.5% Fe-Cr spinel, and traces of metal and troilite [2]. Pyroxenes and plagioclases in Millbillilli and other eucrites may be "clouded" by finely disseminated submicron inclusions of opaques (mostly chromites and ilmenite)

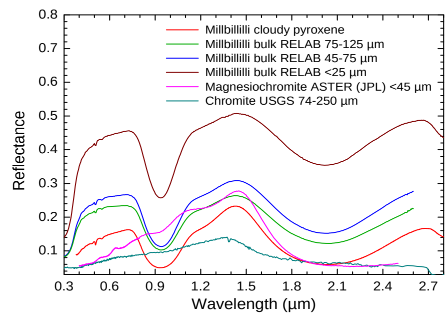

Figure 1: Reflectance spectrum of cloudy pyroxene compared to RELAB spectra of bulk Millbillilli dry-sieved powders and chromite spectra from ASTER and USGS spectral libraries.

[3]. The clouding possibly results from thermal metamorphism caused by a hot porous ejecta blanket on the eucrite parent body [3].

2. Experimental

Biconical reflectance spectra were acquired from 0.38 to 25 µm at i=e=20° using a "Seagull™" variable-angle reflectance accessory and three different spectrometers at the BESSY II synchrotron facility in Berlin. The spectra from 0.38 to 1 µm were measured using two Ocean Optics 4000 (UV-VIS and VIS-NIR) spectrometers relative to a pressed halon standard. The spectra from 1 to 25 µm were acquired using a Bruker VERTEX 80v FTIR-spectrometer relative to a gold-plated sandpaper standard.

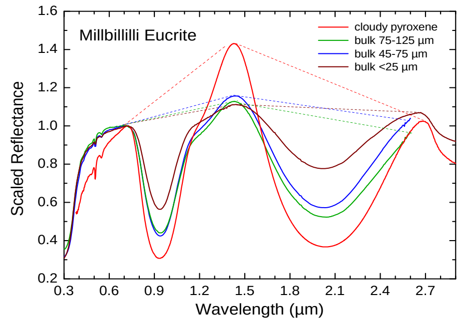

Figure 2: Reflectance spectrum of cloudy pyroxene compared to the RELAB spectra Millbillilli powders. All spectra are scaled to 1 at 0.72 µm.

3. Reflectance Spectra

The cloudy pyroxene separate is darker than bulk Millbillilli powders, including the coarse separates (Fig. 1). This is in part due to the large size of clouded pyroxene grains compared to bulk Millbillilli coarse separates, which are in fact aggregates of fine and coarse mineral grains. Fine opaques in cloudy pyroxenes provide an additional darkening effect. Fig. 2 demonstrates that the clouding significantly affects spectral slopes both in the VNIR range. Spectral reddening is evident at wavelengths shortward of 1.5 µm and mimics spectral effects usually attributed to space weathering, though the spectrum still shows intense electronic absorption bands both in the visible and in the near-infrared. However, space weathering experiments usually suggest the reddening over the whole NIR range, while the spectrum of cloudy pyroxene is characterized by the negative continuum at wavelengths longer than 1.5 µm. We suggest that the unusual continuum slope is due to fine chromite inclusions, since VNIR spectra of chromites are "reddish" below 1.5 µm and "bluish" at longer wavelengths (Fig. 2). Detailed mineralogical characterization of fine inclusions in the cloudy pyroxene grains is planned. We analyzed the NIR band parameters - BI and BII centers, BAR (Band Area Ratio) for the spectrum of cloudy pyroxene, in order to find out if an enrichment of V-type regoliths in thermally metamorphosed materials such as cloudy pyroxenes could explain reported spectral discrepancies between HED meteorites and V-type asteroids (see [1] and references therein). The BI center (0.939 µm) is not significantly affected by clouding, while the calculated BII center is shifted to shorter wavelength (1.977 µm) due to the negative spectral continuum over the band II. It suggests that enrichment in clouded silicates might cause the reported shift of spectral parameters for some V-types on the plot of the BI center *vs*. BII center (Fig. 5 in [1]) compared to HEDs. Our separate is much coarser than the HED samples spectrally analyzed in [1], so the data are not directly comparable, but our preliminary analysis indicates that the BAR value for the cloudy pyroxene spectrum is within the range typical of HEDs. Therefore, the clouding of regolith silicates, induced by thermal metamorphism, seems an unlikely mechanism to explain very high BARs of V-type asteroids (including Vesta) compared to the BARs typical of HED laboratory spectra. Mid-IR spectrum of the cloudy pyroxene is shown in Fig. 3 and will be discussed in this presentation as well.

Acknowledgements

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References

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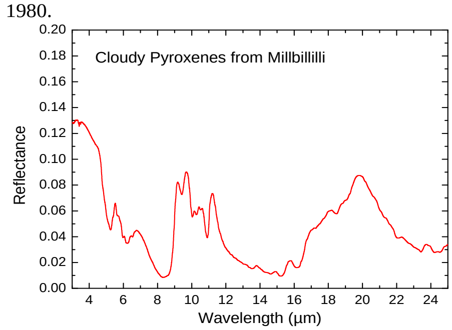

Figure 3: IR reflectance spectrum of a coarse-grained cloudy pyroxene separate from Millbillilli eucrite.