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Spectral reflectance diversity of HED meteorites as a function of grain size, olivine content and shock

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Abstract

The spectral reflectance properties of a suite of 13 HED meteorites were examined to determine how grain size variations alter HED spectral properties and how powder spectra compare to slabs. We have found that the mineralogical diversity of HEDs causes spectral properties such as absorption band positions and depths to vary widely. The <45 µm fractions of the HEDs are always brighter across the 0.35-2.5 µm range than slabs and larger grain size fractions. With increasing grain size, pyroxene absorption band depths increase while reflectance decreases. However, this is only strictly true when comparing the <45 to 45-90 µm fractions. For larger grain sizes (90-250 and 250-500 µm) reflectance and band depths may decrease, remain unchanged, or increase relative to the 45-90 µm size spectra. Slab spectra are also diverse and can be brighter or darker than these larger size fractions. Band saturation parameters suggest that pyroxene bands become saturated in the 60-170 µm range, with band I saturating at a smaller size than band II. Abundant olivine can cause HED bands to move well outside the traditional HED field. Shock can also cause pyroxene absorption bands to move to longer wavelengths. Comparison of trajectories related to various spectral metrics suggests that the effects of changing HED grain size can be separated from the effects of adding CM2 material to HEDs.

1. Introduction

Images from the Dawn spacecraft Framing Camera (FC) have revealed the widespread occurrence of dark regions on the surface of Vesta with a variety of morphologies and brightnesses. In order to address possible causes of these albedo variations, we have examined the spectral reflectance properties of a suite of mineralogically diverse howardite-eucrite-diogenite (HED) meteorites in both slab form, and as a function of grain size for powders. The goal is to determine how HED grain size variations relate to albedo variations, the range of change in albedo as a function of grain size, as well as how key spectral parameters vary with grain size, composition, and shock. The overall goal of this study is to determine how variations in these HEDs properties cause variations in various spectral parameters, and whether changes in these properties can be uniquely recognized; in other words do variations in each of these parameters lead to unique spectral changes?

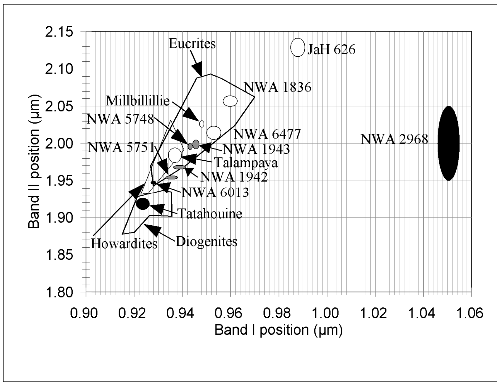
2. Experimental procedure

A suite of 13 HED meteorites were spectrally characterized. The samples were measured as slabs and then crushed by hand and dry sieved to produce <45, 45-90, 90-250, and 250-500 µm size fractions. Spectra were measured at the University of Winnipeg HOSERLab using an ASD FieldSpec Pro HR spectrometer, from 0.35-2.5 µm at *i*=30 and *e*=0°, relative to Spectralon ®. Spectral resolution varies from 2-7 nm. Samples were illuminated with an in-house 100W QTH collimated light source.

3. Spectral diversity of HEDs

Our HED sample suite includes 5 eucrites (JaH 626, Millbillillie, NWA 1836, NWA 6477, Talampaya), 3 diogenites (NWA 2968, NWA 6013, Tatahouine), and 5 howardites (NWA 1942, NWA 1943, NWA 5748, NWA 5751, PRA 04401). Of these, JaH 626 is a shocked eucrite and NWA 2968 is a very olivinerich (>95%) diogenite. Figure 1 shows the band I and II positions of our samples compared to the range for HEDs from [1]. Both JaH 626 and NWA 2968 plot well outside the traditional HED field [1]. The other HEDs plot within, or close to, the pre-defined HED fields.

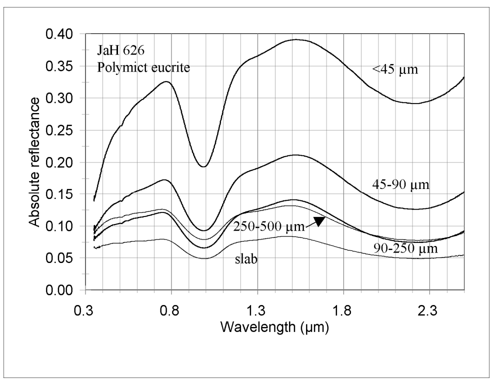
Figure 1. Band I vs II centers for HEDs



3.1 JaH 626

While JaH 626 exhibits band centers longward of the other eucrites, it resembles them in terms of band depths and spectral shape (Figure 2), but is darker than most of our eucrites. The movement of the absorption band centers to longer wavelengths is consistent with Fe^{2+} absorption bands in glassy mafic materials. The lower albedo is consistent with how shock tends to disperse opaques within silicates (seen in shock blackened chondrites [3]).

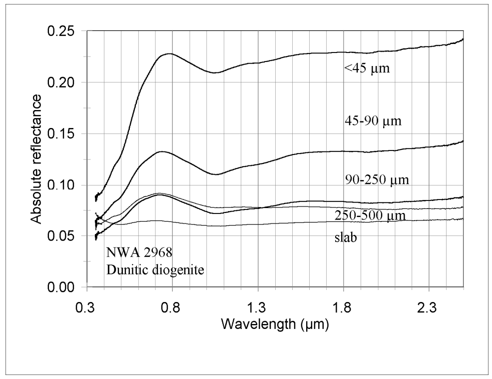
Figure 2. Slab and powder spectra of JaH 626.



3.2 NWA 2968

This dunitic diogenite exhibits an olivine-dominated spectrum, as expected, with band I plotting near the expected value for pure olivine [2]. Absolute reflectance and band depths are less than expected for pure olivine, and likely attributable to finely-dispersed opaques. The dominance of olivine also results in a very weak 2 µm region pyroxene band (Figure 3).

Figure 3. Slab and powder spectra of NWA 2968.



4. Summary and conclusions

We have found that HEDs exhibit a high degree of spectral diversity. In particular abundant olivine and shock effects can alter many spectral metrics that have been used to define the canonical HED classes. The spectral properties of these "anomalous" HEDs are consistent with expectations, and indicate that much more spectral (and compositional) diversity may be found on the surface of Vesta than expected from "traditional" HEDs.

Acknowledgements

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References

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