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Dawn at Vesta: distribution of different minerals

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Abstract

Data from the Dawn VIR (Visible InfraRed mapping Spectrometer) instrument [1, 2] have been used to characterize and map the mineral distribution on Vesta. The results strengthen the Vesta – HED linkage and provide new insights into Vesta's formation and evolution.

1. Introduction

VIR acquired data during Approach, Survey, High Altitude Mapping (HAMO) and Low Altitude Mapping (LAMO) orbits that provided very good coverage of the surface. Additional data will be acquired HAMO-2, covering the Northern hemisphere. Data of high quality, from 0.2 to 5 microns in 864 spectral channels have been acquired. The VIR nominal pixel resolution ranges from 1.3 km (Approach phase) to 0.18-0.07 km (LAMO). The coverage obtained, allows a near global study of Vesta's surface mineralogy.

2. Vesta Spectra

Dawn VIR spectra are characterized by pyroxene absorptions (fig.1) at 0.9 and 1.9 µm (hereafter BI and BII). Different regions of Vesta are characterized by distinctly different band depths, widths, shapes and centers [3]. Beyond ~3.5 µm, thermal emission of the surface becomes increasingly important, and the spectral variations also reflect diurnal changes with the corresponding surface temperature changes (fig.1).

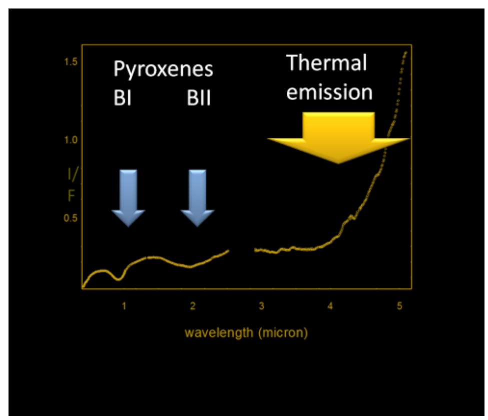

Figure 1: Vesta global mean spectrum.

Vesta exhibits spectral variations at both large and small scales, but the materials on the surface are always dominated by rocks formed via mafic magmatism, as indicated by the ubiquitous BI and BII pyroxene signatures. These bands are caused by absorption of photons, primarily by Fe^{2+}, and their exact position and shape are driven by the relative proportion of Fe to Mg in the M1 and M2 sites of pyroxene crystal structures.

3. Minerals distribution

Large units on Vesta show spectrally distinct characteristics. Some of those different units can be interpreted to be composed by material richer in diogenite (based on pyroxenes band depths and band centers) and some others composed by eucrite-rich howardite units. In particular, VIR data strongly

indicate that the south polar region (Rheasilvia) has its own spectral characteristics: deeper and wider band depths, average band centers at shorter wavelengths, quite uniform spectral behavior of the central mound (fig.2). These spectral behaviors indicate the presence of Mg-pyroxene-rich terrains in Rheasilvia. On the contrary, the equatorial areas have swallower band depths and average band centers at slightly longer wavelengths.
Equatorial regions are prevalently characterized by band centers at longer wavelengths (average BI=0.930μm and BII=1.96μm) and typically have intermediate to shallow band depths. In contrast, band centers in Rheasilvia basin are at shorter wavelengths (average BI=0.926μm and BII=1.94μm) and these often correspond to the deepest pyroxene absorption bands.

The BI and BII centers in the VIR spectra form a trend from diogenites to eucrites, and most plot in the howardites region. Band center values are not uniformly distributed on Vesta, but they differ systematically between the equatorial and southern regions, and that the band center values often correlate inversely with band depths. The VIR spectra are thus consistent with a surface covered by a howardite-like regolith containing varying proportions of eucrite and diogenite at different locations. This firmly supports the link between Vesta and the HEDs, providing geologic context for these samples allowing further understand the formation and evolution of Vesta.

VIR data also demonstrate that Vesta's surface and subsurface show variations at local scales, i.e. bright and dark localized areas. Study of geological structures at scales of tens of kilometers, in particular impact craters with copious ejecta and mass movements, often show associated spectral differences.

Moreover, VIR detected weak but clear variations at 2.8 μm that could be due to OH [4] . The distribution is uneven on Vesta and we are working to better define the strengths of these spectral variations. Several hypothesis are considered as possible sources of OH. Associations of 2.8 μm band with morphological structures are seen that indicate complex process responsible for OH.

Vesta exhibits large spectral variations that often reflect geological structures, indicating a complex geological and evolutionary history, more similar to that of the terrestrial planets than to other asteroids visited by spacecraft.

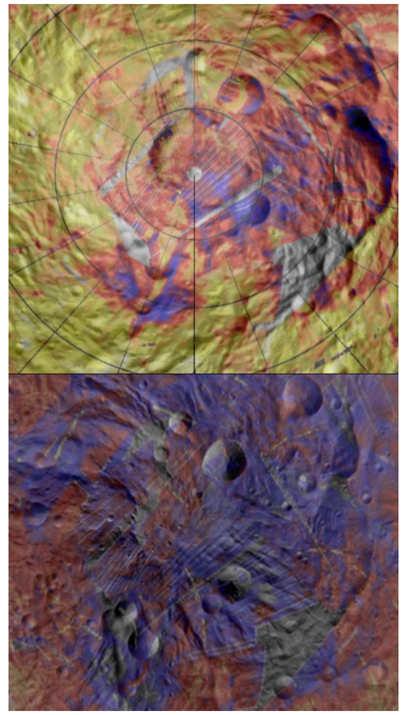

Figure 2: Sterographic projections of spectral parameters obtained by VIR: a) BII centers; b) BII depths.

References

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