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Mineralogy of Vesta: a key to the origin of Main Belt

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Abstract

Vesta's spectrum has absorption features at 0.9 and 1.9 micron, indicative of Fe-bearing pyroxenes, and the spectra of HED (howardite, eucrite and diogenite) meteorites have similar features, leading to the hypothesis that Vesta is the parent body of the HED clan [1,2,3]. The data from VIR [4,5,6] aboard of Dawn mission characterized and mapped the mineral distribution on Vesta, providing new insight into Vesta's formation and evolution. VIR acquired data during all the Dawn mission phases. The coverage obtained allows a near global study of Vesta's surface mineralogy, permitting the mapping of the mineral distribution on Vesta. VIR data strengthened the Vesta–HED linkage, discovered the extensive region of hydrated materials and their association with the low albedo materials, discovered olivine in an unexpected location, providing new insights into Vesta's formation and evolution.

1. Results

Vesta spectra are dominated by pyroxene bands, but the global spectral observations of Vesta revealed several unexpected features and large variation in the pyroxenes mineralogy. Vesta presents complex geology/topography and the mineral distribution is often correlated with geological and topographical structures. VIR discloses the mineralogical variation of Vesta's crustal stratigraphy on local and global scales. Ejecta from large craters have distinct spectral behaviors, and materials exposed in the craters show distinct spectra on floors and rims. Maps of spectral parameters show surface and subsurface unit compositions in their stratigraphic context.

Most of the VIR spectra are consistent with a surface covered by a howardite-like regolith containing varying proportions of eucrite and diogenite at different locations [5,6], with a significant gardening of surface materials. The surface mineralogy is imprinted by the huge impact that formed the Rheasilvia basin. Within the basin, the mineralogical composition is different, with primarily diogenites and howardites. Orthopyroxene-rich materials are present in the deepest parts of the basin and within its walls (Fig.1). Diogenitic lithology, other than that within the Rheasilvia basin, is exposed in an broad region extending from Rheasilvia to the Northern region.

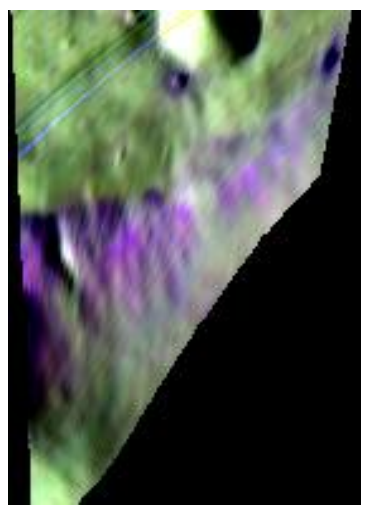

Fig.1 Projected VIR image of Rheasilvia rim-Matronalia Rupes, showing the diogenite rich terrains (violet) on the slopes of the rupes.

Large eucrite-rich regions occur at equatorial/mid latitudes, suggesting remnants of Vesta's old crust, but these regions are also characterized by a low albedo, consistent with the mixture of chondritic material to the original Vestan soil.

A relatively large amount of olivine has been discovered in the northern hemisphere, far from the deeply excavated southern basins [7], and very small and localized enrichments of olivine have been recently suggested [8].

Several morphological properties of Brumalia Tholus , a hill on Vesta, suggest that this topographic high most likely formed as a magmatic intrusion. The presence of more orthopyroxene-rich material relative to surrounding supports the hypothesis of magmatic intrusions on Vesta [9].

The global albedo map of Vesta [10] reveals the presence of different types of terrains: bright material (BM) and dark material (DM) [11,12,13]. Dark materials are distributed unevenly [11], and their spectra often present a signature of about 2.8 micron [14,15,16]. The OH absorption is distributed across Vesta's surface and it is mainly associated with the low albedo material. The distribution of hydrated mineral phases indicates ancient processes that differ from those believed to be responsible for OH on other airless bodies.

2.Conclusion

Vesta is completely different with respect any other asteroid seen so far from space mission and similar to a small planet. The origin of Vestan OH, mainly linked with the presence of carbonaceous materials, provides new insight into the delivery of hydrous materials in the main belt, and may offer new scenarios on the delivery of hydrous minerals in the inner solar system.

Vesta mineralogy is surprisingly rich in signs of its past history: Dawn observations of Vesta are a key to understanding the evolution of the solar system.

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