MINERALOGICAL DIVERSITY ACROSS VESTA: IDENTIFICATION OF DIFFERENT LITHOLOGIES.
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Introduction: VIR, the visible-near infrared spectrometer aboard Dawn, is the primary instrument for mapping the surface mineralogy of Vesta [1]. Vesta’s spectrum has strong absorption features centered near 0.9 and 1.9 μm, indicative of Fe-bearing pyroxenes. The spectra of HED (howardite, eucrite and diogenite) meteorites have similar features. This led to the hypothesis that Vesta was the parent body of the HED clan [2, 3] and the discovery of a dynamical Vesta family of asteroids provided a further link between Vesta and HEDs. Data from the Dawn VIR (Visible InfraRed mapping Spectrometer) [4] characterize and map the mineral distribution on Vesta, strengthen the Vesta – HED linkage and provide new insights into Vesta’s formation and evolution. Global mapping of the distributions of HED lithologies by Dawn’s VIR imaging spectrometer provides the missing geologic context for these meteorites, permitting tests of petrologic models and increasing their scientific value.

Scientific background: Petrogenetic models for Vesta invoke different mechanisms for the HED formation. The classical models foresee widespread crystallization of olivine and diogenite (magma ocean models) while other models invoke olivine and diogenite rich lithologies formed via fractionation in multiple crustal plutons. The distribution of these lithologies on Vesta can provide constraints on the formation models and on the processes that were active in the primordial solar system.

Data Analysis: VIR acquired data during Approach, Survey, High Altitude Mapping (HAMO 1 and 2) and Low Altitude Mapping (LAMO) orbits that provided very good coverage of the surface. By the end of the Vesta phases, VIR had acquired more than 20,000,000 spectra. To analyze these data, several spectral indicators have been developed. Some of them are able to characterize the two main pyroxene bands at 0.9 and 1.9 μm (hereafter BI and BII).

Using these spectral parameters, Vesta mineralogy has been mapped. It has been found that different regions of Vesta are characterized by distinct band depths, widths, shapes and centers [6].

The surface composition is imprinted by the huge impact that formed Rhea silvia basin. This impact excavated a large amount of material and redistributed it on Vesta’s surface. Within the basin, the mineralogical composition is varied and we can recognize, primarily, diogenites and howardites. Orthopyroxene-rich materials (similar to diogenite) are present in the deepest parts of the basin and within its walls (fig. 1).

Significant amount s of olivine are predicted by the petrogenic models and its occurrence is demonstrated by some diogenites meteorites that are rich in olivine. Nevertheless, olivine has not been firmly detected in the Rhea silvia basin. It must be recalled that spectral detection of olivine when associated with orthopyroxene is difficult. Moreover, olivine in Rhea silvia might have been diluted during impact mixing.

Fig.1: BII center distribution in the south polar region. The dash line represents Rhea silvia and Venienia boundaries.

However, diogenites, howardites and also eucrites are identifiable on the rest of the surface of Vesta, and spectral maps reveal their geologic settings and can provide insights into their formation (fig.2).

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. We cannot recognize and map specific units of howardites, but their distributions on Vesta are indicative of a background material consistent with
breccias composed of eucrite and diogenite. The observed distribution is suggestive of significant gardening of surface materials.

Large eucrite-rich regions occur at equatorial/mid latitudes, hinting at remnants of Vesta’s old crust. These units are embedded in a howarditic background. Diogenitic lithology, other than that within the Rheasilvia basin, is exposed in an extensive ejecta blanket produced by the Rheasilvia-forming impact. The ejecta covers a broad portion of Vesta’s surface, spreading from Rheasilvia’s rim far to the North.

Olivine distribution is another key detection that can help in distinguishing between competing hypotheses. Traditional petrogenetic models for Vesta invoke widespread crystallization of olivine (magma ocean models), but the lack of olivine in a majority of the diogenite samples may suggest a reassessment of these theories. However, if olivine-rich lithologies formed via fractionation in multiple crustal plutons, more heterogeneously distributed, relatively shallow and ferroan olivine-rich diogenites (harzburgites) are expected.

The possible presence of olivine in the Northern Vestan hemisphere [5] can be help in distinguishing between competing petrogenetic hypotheses and can provide compelling evidence for or against an early magma ocean. However, further detailed analysis is needed to confirm olivine detection on Vesta and to assess its distribution.

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