THE MISSING DIOGENITIC ASTEROIDS: WHAT CAN VESTOIDS TELL US ABOUT VESTA?

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Introduction: Vesta is one of the largest bodies in the asteroid belt and has long been known to have similar absorption features in the visible and near-infrared wavelength regions to the HED (howardite, eucrite, diogenite) meteorites. Eucrites are basalts and gabbros that are mostly composed of pyroxene and anorthite-rich plagioclase while diogenites are predominantly composed of magnesian orthopyroxene. Howardites are polymict breccias that contain mineral and lithic fragments of both eucritic and diogenitic materials. Vesta was one of the targets of NASA's Dawn mission, which spectrally and chemically mapped its surface. Vesta's surface is primarily composed of eucritic and howarditic material with diogenitic regions being much less common [1]. Numerous smaller bodies (Vestoids) in the Vesta family and throughout the inner asteroid belt also have reflectance spectra similar to HEDs [2]. Vestoids have also been identified far from Vesta in the middle and outer part of the asteroid belt. A few eucrites have been found to have oxygen isotopic values that differ from "typical" HEDs [3] and appear to be more evidence that other differentiated parent bodies besides Vesta existed.

Using previously derived formulas [4], we calculated the bulk pyroxene mineralogies of forty-nine main-belt and Mars-crossing V-types using band centers derived from their reflectance spectra. Our goal is to see what we can tell about Vesta from analyzing the Vestoids. Vesta is a relatively unique body since it has been orbited by a spacecraft and can be linked to both large (Vestoids) and small (HED) fragments.

Data: We analyzed publicly available main-belt and Mars-crossing V-type bodies that had spectra in the visible and near-infrared. The near-infrared reflectance spectra were all taken using SpeX at the NASA Infrared Telescope Facility (IRTF). Visible spectra were spliced to the near-infrared spectra when necessary so the reflectance peak located at ~0.7-0.8 μm would be part of each analyzed spectrum.

Analysis: Band I and Band II centers, respectively, were calculated from seventy-one V-type reflectance spectra taken of forty-nine bodies. Fs and Wo contents were then calculated from the band centers. A temperature correction was applied to all band centers since all the asteroids have surface temperatures lower than room temperature. We then determined bulk pyroxene compositions using previously derived formulas. For objects with multiple spectra, we averaged the calculated bulk pyroxene compositions. One object, (10537) 1991 RY_{16}, had a Band I center consistent with a significant olivine component [5].

Results: Consistent with other studies [6], we find that diogenitic Vestoids are rare. Approximately half of the V-types had interpreted bulk pyroxene mineralogies consistent with eucrites. Most of the remaining V-types had bulk pyroxene mineralogies consistent with eucrites/howardites or howardites. Only one body, (3155) Lee, had a bulk pyroxene mineralogy consistent with howardites/diogenites. However, diogenites are much more common among HED falls and finds since diogenites comprise approximately twenty percent of known HEDs.

To explain the absence of diogenitic Vestoids, we propose that the diogenitic regions in Vesta's crust were relatively thin. Modeling by Wilson & Keil [7] suggested that "deep" intrusions on Vesta would have had thicknesses of only 3 meters or less. If the diogenitic regions in the eucritic crust were not very thick then the formation of craters on Vesta would have only produced "small" diogenite fragments that could have only come to Earth as meteorites. Diogenitic bodies would not be observed since diogenitic Vestoids would not be large enough to be characterized from Earth. These "thin" diogenitic intrusions must have formed as part of an extensive network on Vesta for diogenites to consistently fall to Earth and also be abundant components of howardites.

Conclusions: Diogenitic Vestoids appear extremely rare whereas eucritic and howarditic Vestoids appear much more common. One possibility for this discrepancy is that diogenitic intrusions are extremely "thin" but widespread in Vesta's eucritic crust. Diogenitic material can be ejected as small fragments from Vesta but not as multi-kilometer diogenitic bodies that are observable from Earth.

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