MINERALOGIC VARIABILITY AMONG VESTOIDS. R. G. Mayne[1], J. M. Sunshine[2], S. J. Bus[3], T. J. McCoy[4], H. Y. McSween[1] , A. Gale[5], and C. M. Corrigan[6], [1]Earth and Planetary Sciences, University of Tennessee, Knoxville, TN 37996-1410 rmayne@utk.edu, [2]Dept. of Astronomy, University of Maryland, College Park, MD 20742, [3]Institute for Astronomy, 640 N. A'ohoku Place, Hilo, HI 96720, [4]Dept. of Mineral Sciences, Smithsonian Institution, Washington DC 20560-0119, [5]Dept. of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138 [6]The John Hopkins Applied Physics Lab., Laurel, MD 20723.

Introduction: Vesta is a unique asteroid, not only because of its large size and differentiated nature, but also because we have meteorites that are believed to have originated there: the Howardites (regolith breccias), Eucrites (basalts and gabbros), and Diogenites (cumulate orthopyroxenites) [1]. It is also one of the two targets for the *DAWN* mission due to launch this year [2]. This study aims to quantify both the petrology and spectra of unbrecciated eucrites, in order to better understand the variability of the basaltic crust of Vesta. This will allow identification of different eucrite rock-types and a more fundamental understanding of their characteristic spectra, which the *DAWN* spacecraft will observe on the surface of Vesta. Understanding the link between the spectral and petrologic variety of the eucrites may allow us to distinguish different igneous provinces on the surface, thereby using the eucrites as a spectral groundtruth for the data return from *DAWN.*

Pre-DAWN data application: *DAWN* is not scheduled to reach Vesta until 2011 [2]; however, the V-types (Vestoids), a group of asteroids believed to be derived from Vesta [3], offer the opportunity to utilize our combined petrology-spectra data-set prior to *DAWN*. Comparisons between eucrite spectra and individual Vestoids should allow us to constrain the minimum size of individual igneous terrains on the surface of Vesta. If the spectra suggest that more than one type of material is present on the Vestoids, i.e. the spectral signature of different eucrites, or both eucrites and diogenites, have been averaged over the hemisphere being measured, then it implies that the size of individual igneous provinces on Vesta is smaller than the Vestoids.

SpeX, a visible near-infrared (VISNIR) spectrograph at the NASA Infrared Telescope facility on Mauna Kea, was used to collect data for 15 Vestoids. Diameters for all the Vestoids were calculated using the same method as [4] using data from the online Asteroid Database Index. They ranged between 4.5 to 8km, with one, 3908 Nyx, having the much smaller diameter of 1 km. Each spectrum was then modeled using the Modified Gaussian Model (MGM) [5]. As a starting point each spectrum was modeled using two very simple mineral combinations: a single pyroxene composition and two pyroxene compositions, as this is the mineral that dominates the spectrum of Vesta and the HEDs [6]. These data were then compared to RELAB VISNIR spectra of 11 unbrecciated eucrites previously analyzed [7].

Although only preliminary modeling has been completed on these samples, the majority of the Vestoids show a good fit using the two-pyroxene model with MGM. It should be noted; however, that no Vestoid could be fit by the one-pyroxene model, which is in contrast to the results from the eucrites [7], where fine-grained, rapidly-cooled samples, probably representative of surface flows, were best modeled by one pyroxene. This suggests that none of the Vestoids studied consist entirely of the most rapidly-cooled sur-

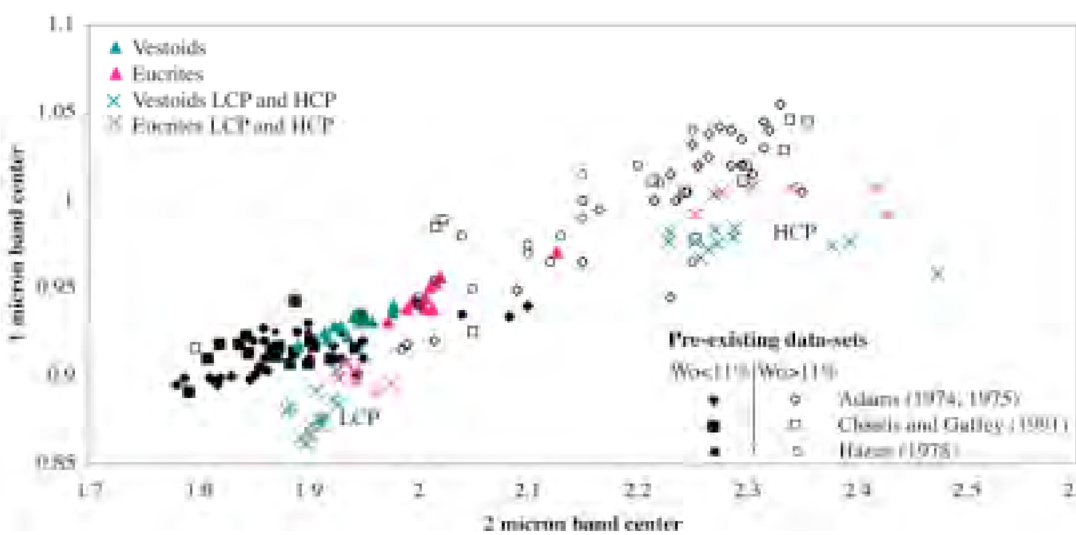

Figure 1: Calculated band centers for the Vestoid and eucrite spectra, compared to pre-existing data-sets of spectra for pyroxenes of known composition.

face material found in the eucrites.

Vestoid vs. eucrite compositions: Band centers were calculated for all spectra, both using MGM and the method outlined by [8]. Band Area Ratios (BAR) were also calculated; however, it should be noted that when using VISNIR data extending to ~2.5 µm, we do not observe the 2-µm pyroxene band in its entirety. This limits the accuracy of the BAR, making it a minimum value, and likely affects the derived 2-µm band center. However, the band centers and BARs should be internally consistent with respect to each other as the same end point was taken in each case.

Figure 1 shows the relationship between band 1 and band 2 centers for all samples after [9]. The eucrite samples can be seen to lie on the high-Ca (>11% Wo) side of this compositional trend. Most of these eucrites contain more than one pyroxene, as confirmed by electron microprobe analysis. However, the average composition of each is >11% Wo (Table 1). The Vestoids occur on the low-Ca side (<11% Wo). This result implies that not one of the Vestoids studied consists of just eucritic material; there must be a diognite component. The diogenites are orthopyroxenites, and therefore contain Ca-poor (low Wo) pyroxenes.

	Wo	En	Fs
ALH A81001	18.6	36.1	45.3
BTN 00300	20.8	32.7	46.4
Chervony Kut	14.7	33.3	52.0
EET 87520	22.6	33.4	44.0
GRA 98098	13.7	34.8	51.5
Ibitira	17.6	36.3	46.0
MAC 02522	14.9	30.9	54.1
MET 01081	13.5	34.3	52.2
Moama	11.4	53.3	35.4
Moore County	15.1	43.9	41.0
PCA 91078	11.2	34.9	53.8

Table 1: Measure average pyroxene compositions for the eucrites studied.

Hemispheric averaging of eucrite and diogenite terrain would drive the average pyroxene composition to lower Wo values, as is observed; alternatively, some of the Vestoids may consist of material that is predominantly howardite at a fine-scale, which would result in a mixed spectrum.

The values derived for the Low-Ca (LCP) and High-Ca pyroxene (LCP) bands from the two-pyroxene model of MGM tend to lie below the defined trend. This may be due to the fact that [9] employed a different technique (not MGM) for calculating the band centers; therefore, the resulting values are different. What is interesting, however, is that the LCP points for eucrites plot at longer wavelengths than the LCP in Vestoids. The basaltic eucrites do, on average, have a composition that is richer in Fe, as well as Ca, than the diogenites [10], and this is reflected in the Vestoid spectra, suggesting again that the Vestoids studied have at least some diogenitic component.

The role of plagioclase: The effect of plagioclase on pyroxene-dominated spectra, such as the eucrites', is largely unknown, as only a few preliminary quantitative calibrations for plagioclase-pyroxene mixtures currently exist e.g. [11]. In order to establish if plagioclase has any discernable impact upon the spectra, artificial powders of plagioclase-pyroxene mixtures were produced [12]. They represent a vital tool for interpreting the actual effect, if any, that plagioclase has on the spectra of samples with these eucrite mineralogies. Future work will concentrate on how best to model these mixtures using MGM and to see if the plagioclase component of the spectrum can be isolated, and, if so, how it changes with increasing concentration. This will allow better interpretation of both the eucrite and Vestoid spectra.

Variability on Vesta: After examining the spectra of the Vestoids and comparing them to the unbrecciated eucrites, a few conclusions can be drawn. No Vestoid consists of a rock-type containing just one pyroxene, which would be suggestive of quickly cooled, surface basalt. All the Vestoids studied appear to have at least some diogenite component, suggesting either that hemispheric averaging of different rock compositions has occurred, or that the Vestoids contain abundant howardite. The former would mean that each unit contributing to the average has a spatial extent smaller than the area being measured, whereas the latter might suggest a much thicker consolidated regolith layer than previously thought.

This study has implications for *DAWN*, because in order to distinguish different basaltic rock-types on the surface of Vesta, the instrumentation onboard must have a spatial resolution of less than the size of the individual units, which, if hemispheric averaging is taking place, may be sub-km in size.

References: [1] Drake (2001) *MAPS 36* 501-513 [2] Russell et al. (2002) *Proc. ACM Conf.* 63-66 [3] Binzel and XU (1993) *Science 260*, 186-191 [4] Burbine et al. (2001) *MAPS 36*, 761-781 [5] Sunshine (1990) *JGR*, *95*, 6955-6966 [6] McCord et al. (1979) *Science 168*, 1445-1447 [7] Mayne et al. (2006) *LPSC XXVII*, Abstract #1796 [8] Gaffey et al. (1993) *Icarus 106*, 573-602 [9] Adams (1974) *JGR 79*, 4829-4836 [10] Mittlefehldt et al. (1998) In: *Planetary Materials* [11] McFadden and Gaffey (1978) *MAPS 13*, 556 [12] Corrigan et al. (2007) This volume.