NATURE OF THE "ORANGE" MATERIAL ON VESTA FROM DAWN. L. Le Corre[1], V. Reddy[1], N. Schmedemann[2], K. J. Becker[3], D. P. O'Brien[1], N. Yamashita[1], P. N. Peplowski[4], T. H. Prettyman[1], J.-Y. Li[1], E. A. Cloutis[5], B. W. Denevi[4], T. Kneissl[2], E. Palmer[1], R. W. Gaskell[1], A. Nathues[6], M. J. Gaffey[7], D. W. Mittlefehldt[8], W. B. Gary[9], H. Sierks[6], C. T. Russell[10], C. A. Raymond[11]. [1]Planetary Science Institute, Tucson, AZ (lecorre@psi.edu), [2]Freie Universitaet Berlin, Germany, [3]USGS, Flagstaff, AZ, [4]Johns Hopkins University, Laurel, MD, [5]University of Winnipeg, Canada, [6]MPS, Germany, [7]UND, USA, [8]NASA Johnson Space Center, Houston, TX, [9]NASA Goddard Spaceflight Center, Greenbelt, MD, [10]UCLA, CA, [11]JPL, Pasadena, CA.

Introduction: From ground-based observations of Vesta, it is well-known that the vestan surface has a large variation in albedo [1]. Analysis of images acquired by the Hubble Space Telescope allowed production of the first color maps of Vesta and showed a diverse surface in terms of reflectance [2]. Thanks to images collected by the Dawn spacecraft at Vesta, it became obvious that these specific units observed previously can be linked to geological features [3]. The presence of the darkest material mostly around impact craters and scattered in the Western hemisphere has been associated with carbonaceous chondrite contamination [4]; whereas the brightest materials are believed to result from exposure of unaltered material from the subsurface of Vesta [4] (in fresh looking impact crater rims and in Rheasilvia's ejecta and rim remants).

Here we focus on a distinct material characterized by a steep slope in the near-IR relative to all other kinds of materials found on Vesta. It was first detected when combining Dawn Framing Camera (FC) color images in Clementine false-color composites [5] during the Approach phase of the mission (100000 to 5200 km from Vesta). We investigate the mineralogical and elemental composition of this material and its relationship with the HEDs (Howardite-Eucrite-Diogenite group of meteorites).

Dawn data: For this study, we analyzed data from all instruments onboard the Dawn spacecraft. Morphology, composition and topography was derived from clear and color (7 filters in the near-IR) images from the FC [6]. VIR (Visible and IR spectrometer) spectra [7] from the Survey phase were used to derive approximate mineralogy using band parameters. From GRaND (Gamma Ray and Neutron Detector), we used maps of corrected Fe counting rate and neutron absorption.[8,9], and the composition parameter C_p [10].

Morphology of the units: Several types of orange material can be identified in the FC images, classified as follows:

Orange diffuse ejecta. We found two craters showing clearly this type of deposit, Oppia and Octavia craters (Fig. 1). In this case, the orange material seemed to be deposited as an ejecta blanket around the crater. Oppia corresponds to the "Leslie" feature observed by [11] and proposed to be olivine.

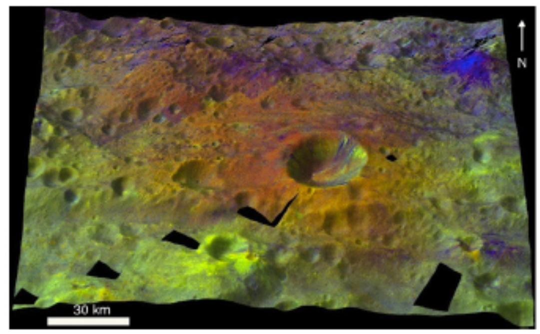

Figure 1: *Octavia crater and its orange ejecta at 60 m/pixel with "Clementine" color ratio composite (R=0.75/0.45 µm, B=0.75/0.92 µm, G=0.45/0.75 µm).*

Orange patches. These deposits have a characteristic lobate shape and possess sharp boundaries with the surrounding terrains (Fig. 2). They are smaller than the diffuse deposits.

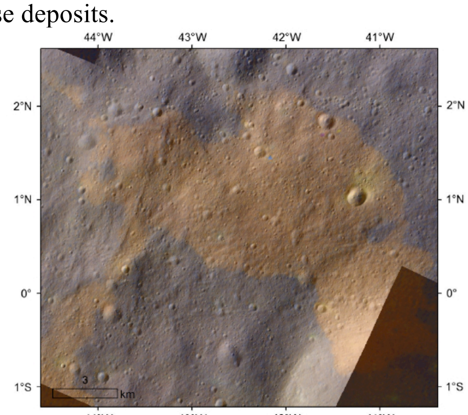

Figure 2: *Close-up view of part of an orange patch in Clementine color ratios overlaid on top of 16 m/pixel clear filter image. No difference in texture with nearby terrains is observed and no obvious topographic feature is associated with the orange material.*

Orange crater rays. Ejecta rays of orange material distributed radially around fresh-looking impact craters such as Cornelia or Rubria (Fig. 3).

Distribution across Vesta: We carried out a complete mapping of the orange material on Vesta based on 60 m/pixel FC maps (up to 50°N). The material is distributed across almost all longitudes in the equatorial region (30°S-30°N) but excluded from the Rheasilvia basin floor.

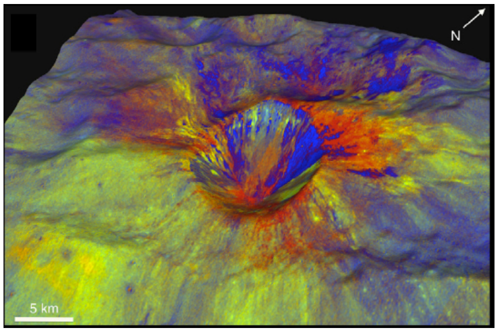

Figure 3: *Perspective view of the Rubria crater as seen by FC and overlaid on topography.*

Color properties: Based on analysis of FC data, we found that all orange material deposits have similar color spectra with a red slope. The only difference between them is the depth of the pyroxene Band I, which can vary with the background: weaker for darker surface, and deeper for brighter surface. Generally, orange patches have higher 0.75-μm albedo than other orange deposits.

Composition: We explored several options for the composition of this material (that could explain the red spectral slope) and after analyzing the Dawn data we ruled out the olivine option [11] and the metal option. Our detailed reasoning is described in [12].

Mineralogy and HEDs. The range of pyroxene "compositions" that we derived for 17 sites of orange material is between $Fs_{38\text{-}46}Wo_{8\text{-}11}$ with an average of $Fs_{42}Wo_9$ (Fig. 4). This narrow pyroxene chemistry range observed among the 17 sites suggests similar composition and formation mechanism. The pyroxene chemistry plot in the transition region between cumulate eucrites (CE) and basaltic eucrites and at the upper end of basaltic eucrite-rich howardites (Fig. 4).

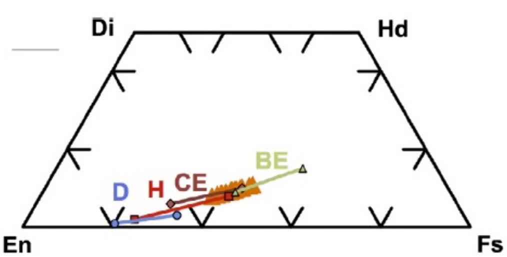

Figure 4: *Pyroxene quadrilateral including the orange material sites from the VIR data and the ranges of mean pyroxene compositions for cumulate eucrite (CE), basaltic eucrite (BE), diogenite (D) and howardite (H). It is important to note that the ranges shown here represent mean pyroxene chemistries derived from spectral data and not laboratory data.*

In addition, Band I center and BAR values of the orange material sites are most consistent with those of basaltic eucrites and not with diogenites. Using preliminary total iron (wt.%) calibration developed with HED spectral data we estimated the iron abundance for the 17 sites for which we extracted VIR spectra. The range of iron abundance for these sites is very narrow (13.5–14.2 wt.%) with a mean of 13.8 wt.%, consistent with basaltic eucrites and/or howardites.

Elemental composition. Arruntia and Octavia ejecta are found to have compositions consistent with howardites with no CE admixture according to C_p analysis (Fig. 5). Oppia also has a howardite-like composition, however a CE admixture of ~25% is allowed by the GRaND measurements. Using the Fe counting rate translated in Fe abundance, we found that the three sites are consistent with howardites/polymict eucrite, with Octavia matching some basaltic eucrites and Oppia getting close to cumulate eucrite data points.

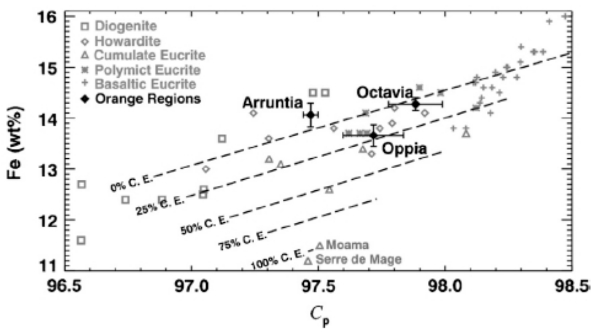

Figure 5: *Fe abundances plotted against the high-energy gamma-ray derived Cp values for 57 HED whole-rock elemental compositions. Arruntia, Octavia, and Oppia regions of interest are represented in black diamonds. Black dash lines indicate trendlines for non-CE and CE admixtures.*

Impact melt hypothesis: The two HED impact melt samples that plot closest to the orange material in BI center vs. BAR in both parameter spaces are LEW85303 (impact melt matrix) and Macibini (impact melt clast). The diversity of BI center positions of the samples could reflect the different nature of the original material that has been impacted and melted. Combining the interpretations from topography, geomorphology, color parameters from the FC, curve matching and band parameters from the VIR spectral data, the most probable analog for the orange material on Vesta is impact melt dominated howarditic material.

References:

[1] Bobrovnikoff 1929. [2] Li et al. 2010 *Icarus*. [3] Reddy et al. 2013 *Icarus*. [4] Reddy et al. 2012 *Science*. [5] Reddy et al. 2012 *Icarus*. [6] Sierks et al. 2011 *Space Sci. Rev*. [7] DeSanctis et al. 2011 *Space Sci. Rev*. [8] Prettyman et al. 2013 *MAPS*. [9] Yamashita et al. 2013 *MAPS*. [10] Peplowski et al. 2013 *MAPS*. [11] Gaffey et al. 1997 *Icarus*. [12] Le Corre et al. 2013 *Icarus*.