DAWN FC COLOR DATA: RESULTS OF ADVANCED PROCESSING FOR VESTA.

M. Hoffmann[1], A. Nathues[1], M. Schäfer[1], U. Christensen[1], H. Sierks[1], G. S. Thangjam[1], C. T. Russell[2], C. A. Raymond[3], P. Gutierrez-Marques[1], [1]Max Planck Institute for Solar System Research, Max-Planck-Strasse 2, 37191 Katlenburg-Lindau, Germany, [2]Institute of Geophysics and Planetary Physics, University of California, 3845 Slitcher Hall, 603 Charles E. Young Drive, East, Los Angeles, CA 90095-1567, USA, [3]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA.

Introduction: The Dawn Framing Camera (FC) [1] has imaged the entire visible surface of Vesta from three different orbits at spatial resolutions of ~250 m/pixel, ~60 m/pixel, and ~20 m/pixel. The FC is equipped with one clear and seven color filters, covering the wavelength range between 0.44 and 1.0 µm [1].

Data Processing: FC images exist in three standard levels from which we use level 1c that is corrected for the "in-field" stray light component [2]. Corrected I/F data is used for processing in our ISIS pipeline [3], which performs the photometric correction of the FC color data to standard viewing geometry using Hapke functions. The resulting reflectance data are map-projected in several steps, and co-registered to align the color frames, creating color cubes. For the present analysis, FC color data from HAMO and HAMO_2 orbits were used. The color mosaics generated by the ISIS pipeline were analyzed using ENVI and ArcGIS software. For the photometric correction of our FC data and the visualization of the results, we used the Vesta shape model (gaskell_vesta_20130522_dem.cub) derived from FC clear filter images by Gaskell [4].

Analysis and Results: The protoplanet Vesta demonstrates its early differentiation by a havily resurfaced crust that exbibits different lithologies dominated by howardites, eucrites, and diogenites. Vesta's surface exhibits also lithologies, which are affected by the in-fall of carbonaceous chondritic dark material (DM) [5, 6]. In addition, olvine bearing sites have been identified [7, 8, 9]. Dark material requires the presence of concentrated material from impact projectiles on the surface, despite the low surface gravity and mixing processes in a deep regolith. All this can be summarized as spectral variety, which is greater for Vesta than for any other known object in the Solar System of similar size. While the spectral shape and depth of the pyroxene band at 0.9 µm is diagnostic for the HED type, also the distribution of reflectances in the other FC spectral bands in the visual range hold significant information. We achieved the visualization of subtle differences in the spectral properties of the surface by conclusions on color ratios using multivariate analysis of the FC spectra. This resulted in the identification of end-members (peculiar extreme relative reflectances in individual transmission bands) in data space by their correlations and anti-correlations. Also non-linear spectral ratios have been identified, which enhance the contrast between individual Vesta materials. Located near the rims of the Veneneia and Rheasilvia basins, the Sextilia region reveals much of the variety of geologic context. We show this region here as a key example in the light of the new spectral ratios.

Sensitivity of color ratios to image artifacts is usually the consequence of strongly correlated data types. In this case individual differences tend to be small compared to error influences. On the other hand, non-correlation is responsible for "signals" much larger than the error level. By multivariate methods, the behavior of correlation can be identified and hence low-noise color ratios can be achieved. Consequently, such color ratio maps may become quite brilliant, as is shown in Fig. 1.

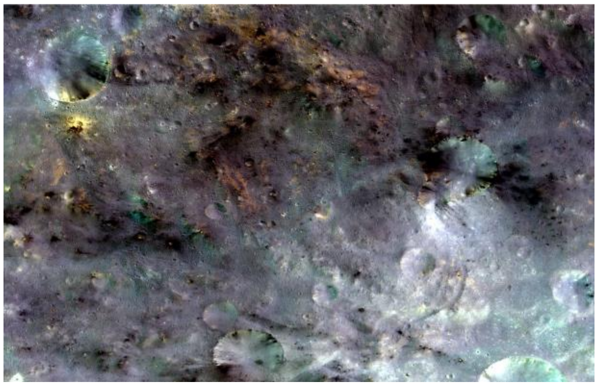

Figure 1: Dawn FC images of Vesta between craters Serena and Sextilia reveal significant spectral diversity in filters 0.44 µm, 0.55 µm, 0.65 µm, and 0.75 µm.

We have chosen the versatile cluster analysis as a multivariate tool because of its immediate correspondence of the input spectral data with the identification of low correlated properties as output data. An example of such non-correlation is the slope of the pyroxene band between 0.83 µm and 0.92 µm, and the slope in the blue part of the visual spectral range.

The interaction of spatial and spectral contrast at the boundaries, and the shape of features indicates the mobility and the kinematic of the relocation and mixing, which are now visible on the surface. A typical example is the region of the crater Aelia. This does not only show the signature of a spectral end-member for the shape in the short wavelength part of the visual spectrum. It also features very unusual linear sharp-bordered signs of material flow. Contrary to the shape of typical granular surface matter, which is observed elsewhere on Vesta, outstanding non-convex patterns frame unilateral layers of material with quite localized individual spectra.

Giant impacts have reshaped the surface and much of the deeper crust of Vesta. The resulting basins are now covered with a deep layer of regolith, which represents the outcome of intense mixing associated with the basin creation. However, younger impacts penetrate and probe this layer. In some cases, quite pure material from specific depths appears to be delivered to the present surface by this mechanism. The crater Antonia seems to be a key example for a fresh minor, but still sizeable, impact. Investigating this feature in triplets of selected non-linear color ratios, we demonstrate a complicated morphology. Not only crater forming mechanics, which have created a so called bi-modal crater by material flow on a slope [10] played a major role, but also the distribution of different materials in the subsurface.

Conclusions: Powerful color ratios in terms of the quantification of the spectral diversity on Vesta have been developed and enable us to analysis the surface and its processes in more detail [11].

In the case of the Antonia crater, the identification of an outstanding, locally confined diogenite site became possible. It is in good agreement with the model of individual magmatic plutons as a source of the observed diogenite, contrary to a global magma ocean model.

References: [1] Sierks, H. et al. (2011) Space Sci. Rev. 163, 263-327. [2] Kovacs, G., et al. (2013) Proc. SPIE 8889. [3] Anderson, J. A., et al. (2004) LPSC XXXV, 2039. [4] Gaskell, R., (2012) AAS, DPS XLIV, 209.03. [5] Reddy, V., et al. (2012) Icarus 221, 544-559. [6] Nathues, A., et al. (2014a) LPSC XLV. [7] Thangjam, G. et al. (2013) Meteoritics and Planet. Sci. 48, 2199-2210. [8] Thangjam, G., et al. (2014) LPSC XLV. [9] Nathues, A. et al., (2014b) LPSC XLV. [10] Krohn, K., et al. (2013) LPSC XLIV, 1949. [11] Hoffmann, M., et al. (2014) in preparation.