IDENTIFICATION OF VESTA SURFACE UNITS WITH PRINCIPAL COMPONENT ANALYSIS BY USING DAWN FRAMING CAMERA IMAGERY.

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Introduction: Asteroid (4) Vesta is the largest differentiated asteroid in the main belt that is mostly intact until today. NASA's Dawn mission entered orbit around 4 Vesta on July 16, 2011 to begin its year-long mapping mission from three different orbital altitudes. The Dawn Framing Cameras (FCs) are a pair of identical imagers (one is redundant) that map the entire illuminated surface in seven color filters (0.44-1.0 µm) and a clear at spatial resolutions of up to 20 meters/pixel [1]. The FC color spectra are diagnostic for some physical surface properties as well as the basic mineralogy of the Vestan surface. Thus the various generated higher level FC color data products are useful to discriminate surface lithologies [2]. Beside the use of surface color ratio maps (e.g., Fig. 1) statistical techniques, like for example, the Principal Component Analysis (PCA) can be used to discriminate surface lithologies.

Data Reduction and Analysis: The Dawn FC raw images were calibrated by using standard calibration steps (bias-, dark removal, flat fielding etc.) plus an algorithm that allowed us to remove most of the "in-field" stray light component of the instrument. Higher level data products were processed with a pipeline developed at MPS, named 'Mule', which uses applications from the ISIS software (created by USGS). FC color images were converted to reflectance (I/F) by dividing the observed radiance by the solar irradiance from a normally solar-illuminated Lambertian disk, and photometrically-corrected to standard viewing geometry (30° incidence, 0° emergence and 30° phase angles). Sub pixel coregistration was applied to align the seven color frames in order to create color cubes containing the entire illuminated surface from late Approach and Survey data. PCA analysis of these cubes was performed by using ENVI/IDL routines.

Methodology: Since multispectral data bands are often highly correlated, principal component transformation is used to generate uncorrelated output bands by reducing the dimensionality of multivariate data sets. This is achieved by computing a new set of orthogonal axes originating at the data mean and rotated in such a way that the data variance is maximized. The first vector defines the largest source of variation, the second vector the second largest and so forth.

First Results: As can be inferred from Figs. 2 – 5 the transformation of FC spectral reflectance data to PC space can be used to discriminate lithologies on the surface of Vesta. The identified principal components are linked to the variations of albedo, of continuum slope and of the 1-µm absorption band strength. For example, the extremal ROIs selected in PC space of Figs. 2 and 4 are related to two of the large ejecta blankets on Vesta (see Figs. 3 and 5). Further detailing is required to test whether the PCA technique is capable to identify also weak and small-scale lithologies which are less obvious in the color maps.

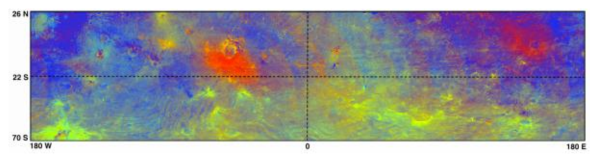

Fig. 1: FC color map from late approach data (RC3b) using color ratios similar to the ones used for the Moon with the Clementine instrument [Red (750/430 nm); Green (750/920 nm); Blue (430/750 nm)].

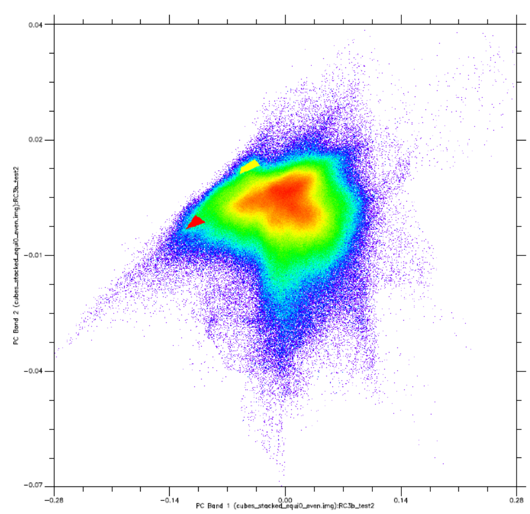

Fig. 2: PC band 1 versus PC band 2 for the entire surface displayed in Fig.1. The selected red and yellow ROIs contain data from the Vestan surface highlighted in Fig. 3.

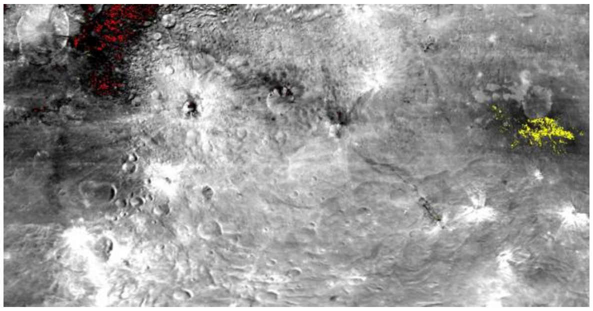

Fig.3: The ejecta blankets of the "Snowman" craters (red dots) and of the Oppia crater (yellow dots) are distinct in PC space (see Fig. 2).

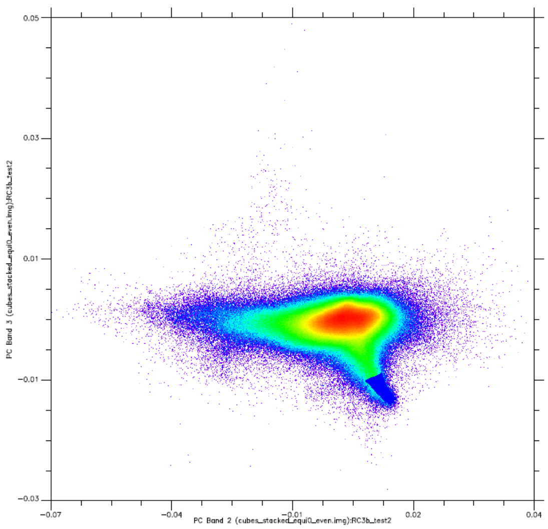

Fig. 4: PC band 2 versus PC band 3 for the entire surface displayed in Fig.1. The selected blue ROI contains data from the Vestan surface highlighted in Fig. 5.

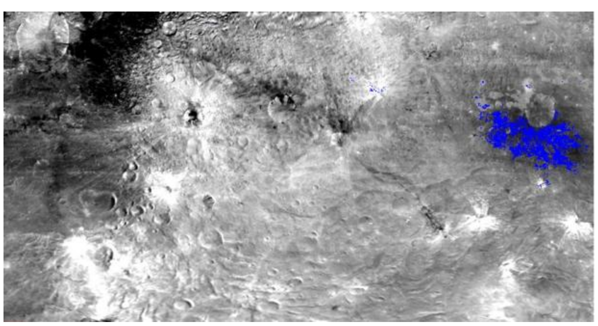

Fig. 5: The ejecta blanket of the Oppia crater (blue) is clearly distinct in PC space (see Fig.4).

References: [1] Sierks et al., (2011). *Space Science Review*, [2] Le. Corre et al., (2011) *Icarus, Volume 216, Issue 2, p. 376-386.*