GEOLOGIC MAP OF THE NORTHERN HEMISPHERE OF VESTA BASED ON DAWN FC IMAGES.

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Introduction: The Dawn spacecraft spent ~1 year in orbit around Vesta and completely imaged the surface of the asteroid [1] before leaving for its next target, the asteroid Ceres. In an early phase of the mission, the southern and equatorial regions were imaged, allowing the production of several geologic quadrangle maps [2]. Later in the mission, during the second High Altitude Mapping Orbit (HAMO-2), the northern hemisphere became illuminated and visible. Here we present a geologic map of the northern vestan hemisphere, from 21°N to 85°N, derived mainly from HAMO-2 observations. Detailed studies of specific geologic features within this hemisphere are presented elsewhere [e.g., 3,4].

Dataset: High-resolution images were acquired by the Framing Camera [5] with ~20 m/pixel resolution during the Low Altitude Mapping Orbit (LAMO), but only cover the southern part of the study area (21°N to 45°N). For areas farther north, LAMO images are supplemented with HAMO-2 images, which have a resolution of about 70 m/pixel. Unfortunately, due to observational constraints, considerable shadowing is present north of 75°. During the departure phase, images of the north pole area with even lower spatial resolutions were acquired. From these data, an albedo mosaic and a stereo-photogrammetric digital terrain model [6] were produced, which serve as a basis for our geologic map. For the geologic mapping at a scale of 1:500,000, all data were incorporated into a Geographic Information System (ArcGIS).

Geologic map units: Within the northern hemisphere, we identified several key geologic units, including:

ch - Cratered highland material: This unit is characterized by a high density of impact craters and an absence of large-scale tectonic features. The crater density is the highest found on the asteroid. This unit is the most ubiquitous unit of the northern hemisphere and is also present in the equatorial region. Craters are mostly subdued or degraded; fresh craters are small (<5 km in diameter). Lineations of variable morphology are present: ridges or troughs, frequently highly subdued, in average 7 km long and 1.5 km wide. Lineations in the form of faint albedo patterns are also present. These features have mostly a N-S trend. The topography of the unit is variable: the unit is found in topographic lows associated with large ruined degraded craters (basins), as well as plateaus. A ubiquitous low albedo area is present within latitudes from 21°N (southern edge) to approximately 60°N and longitudes from 80°E to 130°E. This area continues to the south outside the map area and corresponds to the global E-W albedo dichotomy [7]. The unit probably represents the oldest terrain on Vesta. Lineations are interpreted as surface disturbance by discontinuous ejecta material, probably from two or more craters. However, no clear relation with any specific source crater is found. Hence, it is possible that the locations of these impacts are outside the northern hemisphere.

Sf – Saturnalia Formation: This unit shares many characteristics of unit ch and it is distinguished by the presence of large scale ridges and troughs. On average, the ridges are 18 km in length. Troughs are on average 43 km long and 2 km deep. The unit forms a band around the asteroid at ~35°N. At around 240°E, the unit has its largest N-S extent. Both E-W trending ridges and troughs are present and have a fresh appearance. At ~60°E, the unit is less extensive in the N-S direction and is characterized by a very subdued ridge. At around 120°E, subdued ridges and troughs have a NW-SE trend and extend to latitudes up to 80°N. These tectonic features are superimposed on degraded basins, such as the yet unnamed basin between Bellicia and Lucinia craters. Unit Sf is interpreted as the old terrain of Vesta tectonically affected by the Veneneia impact [8].

uc – Undifferentiated crater material: This unit consists of rim, wall, and floor deposits of fresh/subdued craters with continuous/partially sharp rim. The unit has a smooth and weakly cratered surface, but heavily buried craters are still visible. The unit represents continuous ejecta material. Mass wasting materials (unit mw) often overlay the crater floors.

dem – Discontinuous ejecta material: Unit dem is characterized by curvilinear or rope-like ridges and troughs, radial and sub-radial to fresh craters. The surface is smooth and the underlying topography is visible, indicating a relatively thin unit. Secondary crater chains with a radial distribution around the source crater are present. Several units are associated with such terrain: large low albedo areas (unit dc), small high albedo areas (unit bc), and rocky crater wall outcrops (unit cwo). This unit represents the thin and discontinuous ejecta material of relatively young fresh craters. For relatively older but still fresh craters, this unit is indistinguishable from the surrounding units (ch, Sf).

<u>dc/bc and dcr/bcr – Dark/bright crater material and dark/bright crater ray material:</u> Compared to global values, this unit is defined by low/high albedo deposits, which frequently coat the underlying units and are associated with ejecta material or with crater walls. Where small scale rays are present, the unit is mapped as dcr/bcr. Dark-toned material might have an exogenous origin or have been excavated during the impact [9]. A possible impact melt origin for some of the dark material is suggested where a lobate morphology is present (unit dl). Bright material might represent uncontaminated indigenous basaltic soil [9].

Stratigraphy/Discussion: The high density of craters of unit ch indicates that the unit is the oldest unit in the mapped area. In places, the terrain has been affected by tectonism, possibly due to a large impact (e.g., the Veneneia basin). In such areas, the terrain mapped as unit Sf, might be younger due to the formation of ridges and troughs. The unit Sf preserves, however, a similar high density of craters as unit ch. The degraded craters Domitia and Albana could be of similar or younger age. Lineations superpose the above units and craters. Such features could be ejecta material related to one or more large impacts. Stratigraphically younger terrains are represented by unit uc, which in places is superimposed by mass wasting material. A stratigraphy among the different occurrences of unit uc can be tentatively constructed. For example, unit uc of the craters Floronia, Torquata, Bellicia and Licinia lacks an association with unit dc, which might indicate immature surfaces. Thus, unit uc of those craters could represent somewhat older crater ejecta material. Of similar age or relatively younger could be craters Caparronia and Licinia, which show relatively sharper rims. Crater Scantia, which shows a widespread discontinuous ejecta material could be even younger. The presence of unit dc together with a discontinuous ejecta material at the craters Mamilia and Pomponia might suggest a still younger relative age. The freshest and therefore youngest unit uc occurs in association with rays of dark and bright material (unit dcr/bcr) of the Arruntia crater. The unit uc associated with Marcia crater (10°N/190°E) might have a stratigraphically similar position as Arruntia. However, all these stratigraphic relationships need to be thoroughly tested with crater counts to help establish the validity of such putative stratigraphy.

References: [1] Russell C. T. et al. (2012) *GSA Ann. Meet.,* 152-1. [2] Yingst R. A. et al. (2012) *EGU, Gen. Ass.,* 6225. [3] Blewett D. T. et al. (2012) *GSA Ann. Meet.,* 152-9. [4] Scully J. (2012) *DPS Meet. 44,* #207.08. [5] Sierks H. et al. (2011) *Space Sci Rev.* [6] Preusker et al. (2012) *LPSC 43,* #2012. [7] Reddy et al. (2012) *Science Vol. 336,* pp. 700-704. [8] Jaumann et al. (2012) *Science Vol. 336,* pp. 687-690. [9] McCord et al. (2012) *Nature Vol. 491*, pp.83-85.

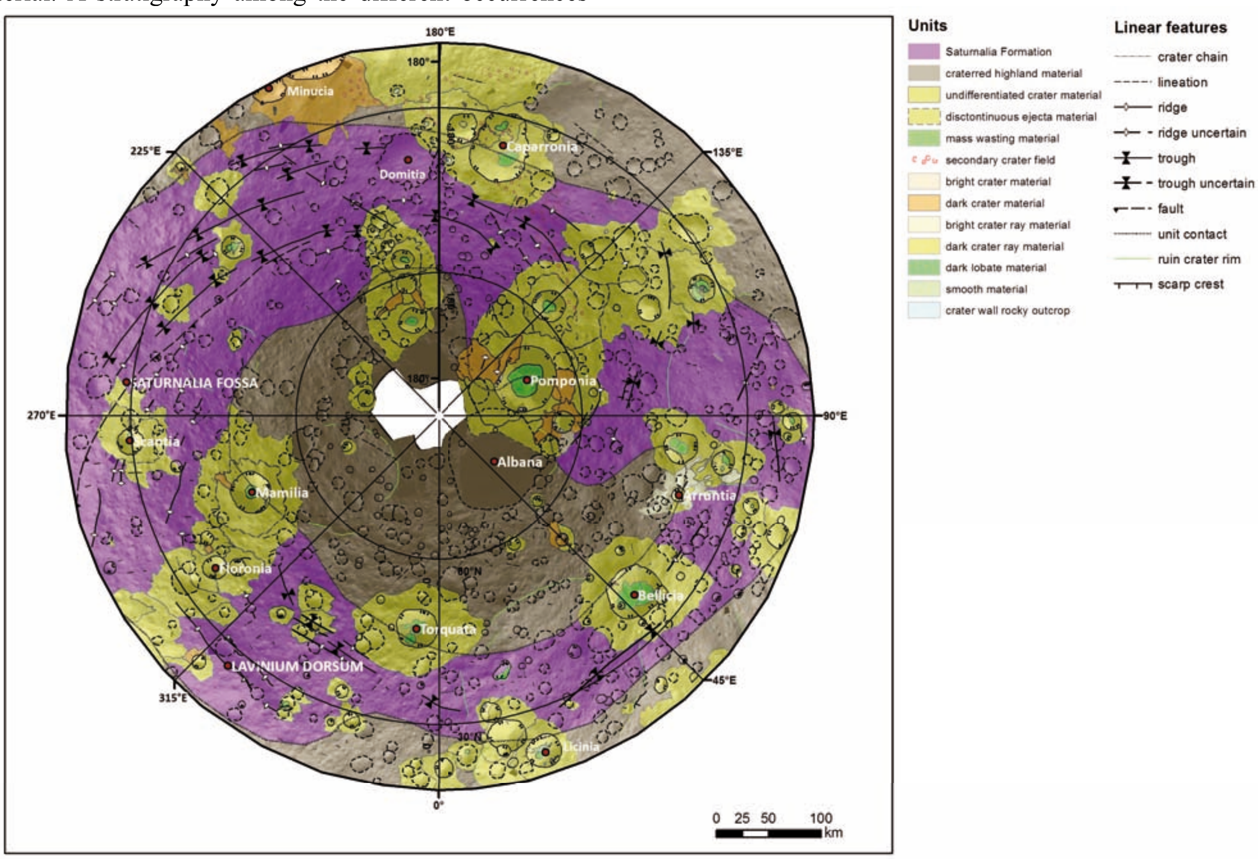

Fig. 1: Preliminary geologic map of the northern hemisphere of Vesta.