GEOSCIENTIFIC MAPPING OF VESTA BY THE DAWN MISSION.

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Introduction: The geologic objectives of the Dawn Mission [1] are to derive Vesta's shape, map the surface geology, understand the geological context and contribute to the determination of the asteroids' origin and evolution. Geomorphology and distribution of surface features will provide evidence for impact cratering, tectonic activity, volcanism, and regolith processes. Spectral measurements of the surface will provide evidence of the compositional characteristics of geological units. Age information, as derived from crater size-frequency distributions, provides the stratigraphic context for the structural and compositional mapping results into the stratigraphic context and thus revealing the geologic history of Vesta.

Geology: The surface of Vesta is of basaltic nature, geologically highly diverse [e.g. 2], and fractionated, and on which volcanism occurred in the early stages of Vesta's geologic history. Vesta's most dominant topographic feature known so far is a large basin near the south pole that averages 460 km in diameter, with an average depth below the rim of 13±3 km that is interpreted as a single crater [3]. Several other depressions, also interpreted to be craters by [3], have 160 km diameter features 6±3 km deep, located at 20° N, 70° W, and another of 150 km across, 8±3 km deep, located at 10° N, 270° W, which are also reported to be a geologic feature in spectroscopic ground-based data [4]. The overall relief of Vesta ranges from -12 km to +12 km.

Mapping Approach: The surface topography is key for any mapping approach because it defines Vesta's shape, provides the base for georeferencing and opens a three-dimensional view. In particular, stereoscopic imagery makes a major contribution to topographic mapping and is important for characterizing the geologic context of planetary bodies [e.g.5]. While photogeology provides the qualitative interpretation of two-dimensional images, the third dimension is needed for quantitative geological analyses. Information on the physical surface properties by the means of multiphase angle observations additionally supports geologic context characterization. The lithology of geological units is based on spectral information that will be georeferenced to the high-resolution camera image mosaics [e.g. 6]. The Dawn mission is equipped with a framing camera (FC), a visible and infrared mapping spectrometer (VIR) and a gamma-ray and neutron detector (GRaND) [1]. Science data will be collected during the approach to Vesta, and in discrete orbit phases - Survey Orbit, High Altitude Mapping Orbit (HAMO), and Low Altitude Mapping Orbit (LAMO). The Survey Orbit will last 17 days and will start when the spacecraft has established a circular polar orbit at a radius of 3000 km with a beta angle of 10°. HAMO-1, at 950 km radius (β=30°), will primarily be used for optical mapping and reflectance spectroscopy. A second HAMO (HAMO-2) phase (β=45°) will take place during departure to acquire images of areas that have become illuminated since HAMO-1 mapping, and to fill gaps in coverage. LAMO at a 460-km radius near-polar circular orbit (β=45°) is the penultimate science phase at Vesta and will primarily be used to collect gamma ray and neutron spectra and to determine the gravitational field, but will also collect imagery and visible and IR spectral data. The Dawn FC will obtain images of Vesta in the clear filter and in at least 3 color filters over at least 80% of the surface, with a resolution of better than 100 m per pixel, and a signal-to-noise ratio of better than 50. Stereo coverage of the FC will be used to obtain a topographic model of the surface of Vesta with an expected vertical accuracy better than 10 m (cf. Fig. 1). The spatial resolution of the FC will be up to 17 m/pixel per pixel in LAMO. Standard image maps of Vesta with a scale of 1:500,000 are planned. Vesta will be covered with 15 individual sheets in sinusoidal projection (spherical form with planetocentric latitude) and one sheet at each polar region in Lambert azimuthally equal-area projection that can be subdivided into smaller segments based on the regional and local mapping during LAMO. VIR image cubes will add spectral information in the 0.25-5 µm range.

Geoscientific Topics: The major geoscientific topics for mapping Vesta are:

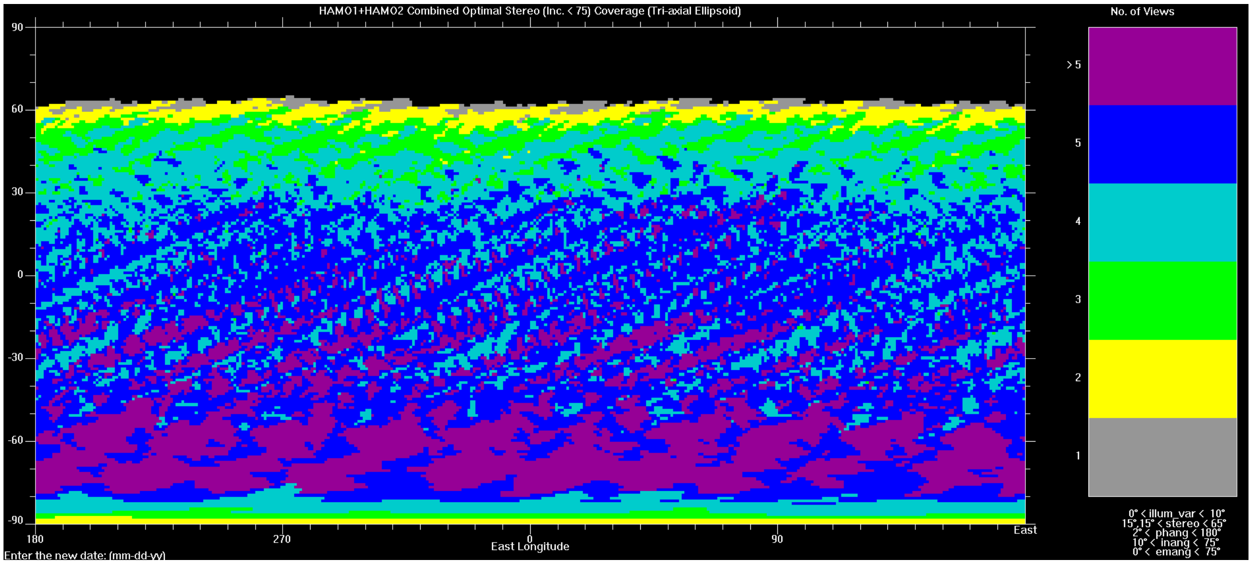

Fig. 1. Multiple image coverage of Vesta's surface in the HAMO orbit. Vertical axis is latitude from -90° to +90°, and horizontal axis is longitude from -180° to +180°. Yellow shows where two images will be obtained; dark blue where 5 images will be obtained.

- Impact cratering: the morphology of impact craters will provide access to surface properties such as target strength, the structure and physical state of surface materials, as well as erosion and volcanic processes. The crater size-frequency distribution enables age determination and thus defines the stratigraphic position of geologic units in time. Age determination of Vestian cratering, in turn, will allow to probe into the violent history of the early Main Asteroid Belt
- Volcanology: According to the chronology of the Howardite-Eucrite-Diogenite (HED) suite of meteorites, melting, fractionation, and volcanism occurred in the early stage of Vesta's geologic history, during which time the asteroid is thought to have completely differentiated. Eruptions of basaltic magmas may have buried the original surface at least partially; whereas impacts, in particular the impact crater on Vesta's south pole, excavated into olivine-enriched material that belongs to the upper mantle, providing stratigraphic evidence for the crustal structure.
- Tectonics: the surface expressions of crustal stresses are tectonic features that are either due to volcanic processes like ridges or graben induced by dikes, disruption of the crust by impacts, and accretional and tidal processes.
- Regolith: gradation, alteration, erosion, and mass wasting on the surface are indicative of surface processes induced by space weathering that produce a debris layer on the surface which contains information about the surface alteration history.
- Lithology: the composition of surface units defines their mineralogical and geochemical state, and thus constrains their origin and thermal evolution.
- Stratigraphy of the crust: large impact craters and basins excavate deeply into the crust and thus reveal its vertical structure.

Topography: A three-dimensional "Virtual Vesta" was developed by the Dawn team to enable accurate planning for the topographic investigation in terms of data acquisition, software development, mapping approaches and determination of the accuracy of the topographic techniques being used. A rendering of the model is shown in Fig 2. As a result of this study, the team will employ both stereophotogrammetry (stereo) and stereophotoclinometry (SPC) to develop a topographic model of Vesta. Stereo mapping is superior early on because Dawn's polar sun-synchronous HAMO orbit produces a data set with nearly constant illumination. The SPC technique, used throughout the mission for optical navigation, takes advantage of the varying illumination of the surface across all orbit phases. The stereo and photoclinometric models will be reconciled and merged with the gravity reference frame to produce the final Vesta topographic model.

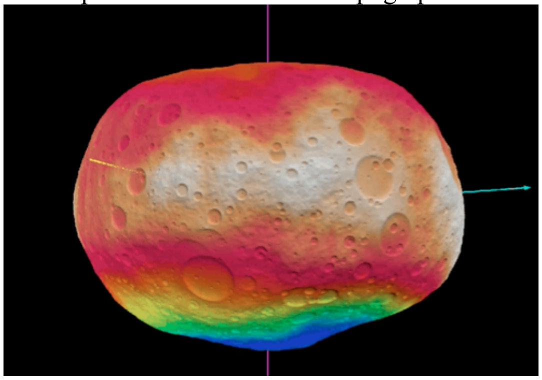

Fig. 2. Virtual Vesta with color-coded altitude super imposed.

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