Mapping Vesta: A Geological Overview

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Introduction: Observations from the Dawn [1] spacecraft enable derivation of 4Vesta's shape, facilitate mapping of the surface geology and provided the first evidence for Vesta's geological evolution. The Dawn spacecraft is equipped with a framing camera (FC) [2], a visible and infrared mapping spectrometer (VIR) [3] and a gamma-ray and neutron detector (GRaND) [4].

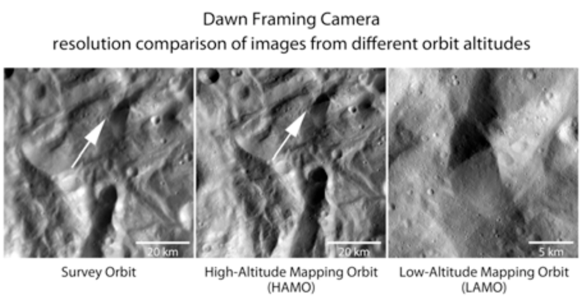

Fig 1: The Dawn surface mapping approach

Science data were acquired from the approach to Vesta, a circular polar (Survey) orbit at an altitude of 2700 km providing ~ 230 m/pix camera scale, a circular high altitude mapping orbit (HAMO) at 700 km altitude with a camera scale of ~ 65 m/pixel. and currently Dawn is orbiting Vesta in a low altitude mapping orbit (LAMO) at 210 km altitude yielding a global image coverage of ~ 20 m/pixel at the time of LPSC (Fig. 1). Geomorphology and distribution of surface features provide evidence for impact cratering, tectonic activity, regolith and probable volcanic processes. Craters with dark rays, bright rays, and dark rim streaks have been observed, suggesting buried stratigraphy. The largest fresh craters retain a simple bowl-shaped morphology, with depth/diameter ratios roughly comparable to lunar values. The largest crater Rheasilvia, a ~ 500 km depression at the south pole, includes an incomplete inward facing cuspate scarp and a large central mound surrounded by unusual complex arcuate ridge and groove patterns. A set of large equatorial troughs is related to the south polar structures. The northern hemisphere is heavily cratered displaying a large variety of ancient degraded and fresh sharp craters.

Major Geological Findings:

1. Vesta's surface is characterized by diverse geology including impact craters of all sizes, a variety of ejecta blankets, large troughs extending around the equatorial region, enigmatic dark material, and considerable evidence for mass wasting (Fig. 2, 3, 4)[5].

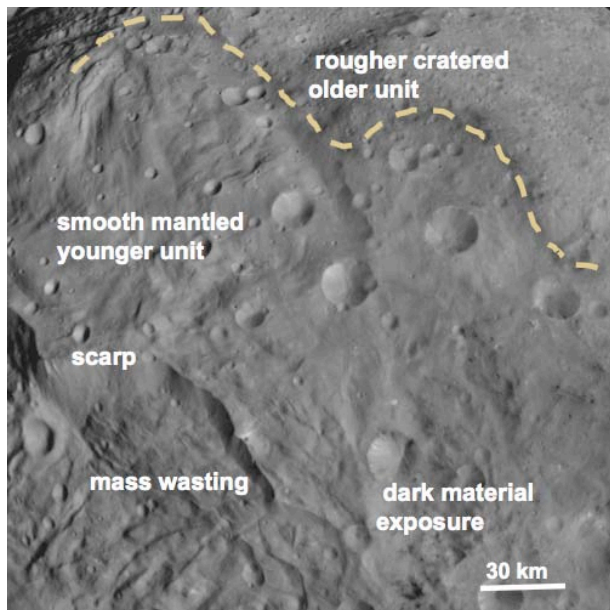

Fig 2: Geologic surface features on Vesta

2. Dawn confirms the large impact basin covering Vesta's south pole (Rheasilvia), inferred from the Hubble Space Telescope images, and reveals evidence for an earlier, underlying large basin [6].
3. Vesta's global tectonic patterns (two distinct sets of large troughs) strongly correlate with the locations of the two south polar impact basins, and were likely created by the formation of the basins [7].
4. Impact craters on Vesta range from fresh to highly degraded, comparable to the Moon, indicating an intensive cratering history over the age of the solar system [8].
5. Impact craters on Vesta have characteristics similar to those on smaller asteroids as well as those on the Moon and Mars, making Vesta a transitional body between asteroids and planets.
6. The primary crust is covered by a thick (100 meters

to a few kilometers), multilayered, sheet of debris (regolith) formed by the accumulation of ejecta from the numerous impacts that have resurfaced Vesta over time.

7. Vesta exhibits rugged topography ranging from -22 km to 19 km relative to a best fit ellipsoidal shape. Vesta's topography has a much greater range in elevation relative to its radius (15%) than the Moon and Mars (1%) or the Earth (0.3%), but less than highly battered smaller asteroids like Lutetia (40%). This also identifies Vesta as a transitional body between asteroids and planets.

8. The surface of Vesta exhibits very steep topographic slopes that are near to the angle of respose. Impacts onto these steep surfaces, followed by slope failure, makes resurfacing due to impacts and their associated gravitational forces and seismic activity an important geologic process on Vesta that significantly alters the morphology of geologic features and adds to the complexity of its geologic history (Fig. 4).

9. Relatively dark material of unknown origin is intermixed in the regolith layers and partially excavated by younger impacts yielding dark outcrops, rays and ejecta. The distribution of dark material is not uniform but clusters at specific regions [9, 10]

10. In contrast to models and expectations from the mineralogy of the HEDs, direct evidence for volcanic activity is lacking so far. This may be due to a dearth of large scale volcanic features on Vesta and/or to the volcanism ending early in Vesta's evolution so that the evidence has been destroyed and covered up by extensive subsequent cratering, regolith formation, and resurfacing.

11. In general, Vesta's geology is more like the Moon and rocky planets than other asteroids.

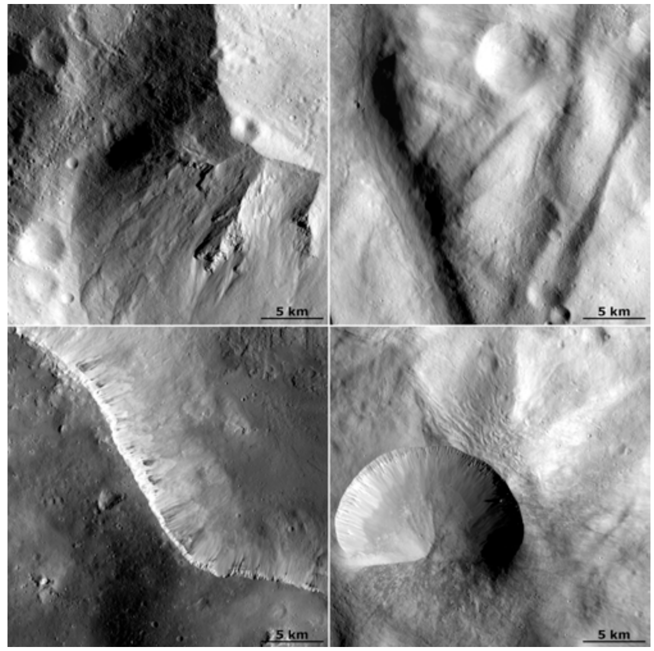

Fig 4: Surface processes on Vesta: (left) mass wasting and talus formation from scarps that also include bright and dark material (bottom); (right) surface mantling and slumping of fine material (top) and slumping of material within a crater located on a slope either due to ballistic ejecta deposit or rim failure (bottom).

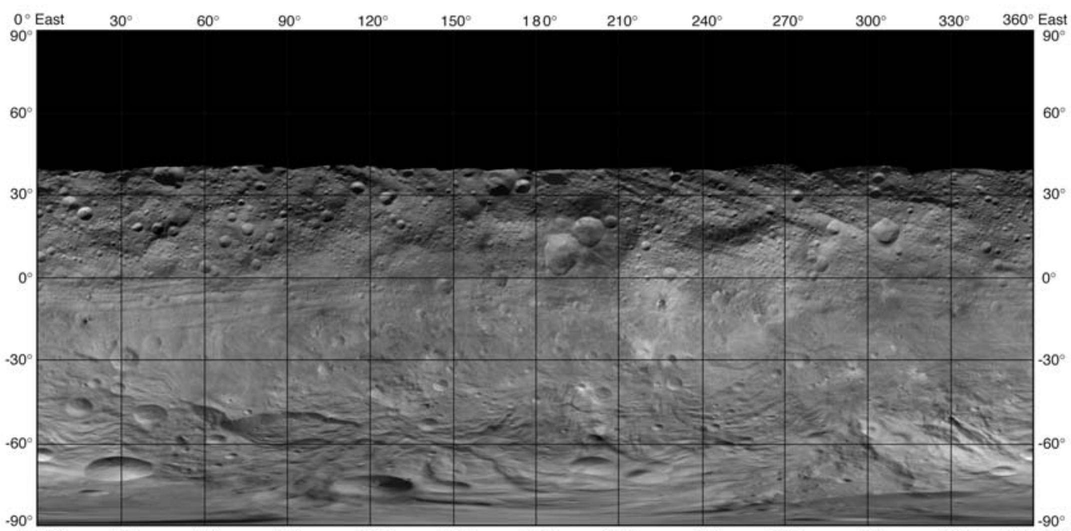

Fig. 4: Mosaic of Vesta's southern and equatorial region

References: [1] Russell and Raymond, 2011, Space Sci. Rev., 163, pp. 3-23, DOI 10.1007/s11214-011-9836-2; [2] Sierks, et al., 2011, Space Sci. Rev., 163, pp. 263-327, DOI 10.1007/s11214-011-9745-4; [3] De Sanctis et al., 2011, Space Sci. Rev. 163, pp. 329-369, DOI 10.1007/s11214-010-9668-5; [4] Prettyman et al., 2011, Space Sci Rev., 163, pp. 371-459, DOI 10.1007/s11214-011-9862-0; [5] Jaumann et al., 2011, AGU #U21-B02; [6] Schenk et al., 2012, LPSC 43; [7] Buczkowski, et al., 2011, AGU, #U21-B05, [8] Marchi et al., 2012, LPSC 43; [9] McCord et al., 2012, LPSC 43; [10] Jaumann et al., 2012, LPSC 43.