Crater depth-to-diameter ratio and surface properties of (4)Vesta.

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Dawn at Vesta

Tthe Dawn spacecraft is orbiting asteroid (4)Vesta since July 2011 and the Framing Camera (Sierks et al, 2011) on board has already acquired several thousand images of the asteroid surface, revealing a complex landscape (Jaumann et al, 2012). The current scale of $\sim$ 70 meter per pixel (High Altitude Mapping Orbit, HAMO) brought up many details that help us to understand how the surface has evolved since its creation. The topography is dominated by craters of all sizes and shapes, from fresh simple ball shaped craters to giant basins as seen in the southern hemisphere. Craters of different ages or state of degradation can be seen all over the surface, some have very sharp rims and simple morphology, whereas others are highly eroded and have sometimes been filled by local avalanches. In this study we look at crater morphology as a tool to investigate local physical properties of the surface, for instance we want to understand whether there is a correlation between the depth-to-diameter ratio (d/D) of fresh craters and geological units of the surface. We look also at the presence of avalanches and other morphological features that can reveal more about the physical properties of the surface material in different regions of Vesta.

Why is d/D relevant ?

For small craters in strength regime, we expect the variation of depth with respect to diameter to follow a near linear law (Grieve, 2007) with a constant slope for a given terrain. The ratio depends on properties of both impactor (structure, velocity, direction of impact) and local surface (strength, structure) but since the population of impactors is about the same at each point of the surface, the variation of d/D for fresh craters reflects mainly the variation of surface properties, and can help us to better identify or constrain different geological units. We have done this study for asteroid (21)Lutetia (Vincent et al, 2012) and found a very good correlation between regions of constant d/D and geological units. This effect must be even more clearly visible on Vesta where part of the body might have experienced stronger resurfacing than other asteroids, due to the presence of the large south polar basins. However other authors have investigated this topic for the small craters on Mercury and did not find any correlation between d/D and terrain (Andre & Watters, 2008), so the question remains open.

Preliminary results

As of the end of HAMO, we have measured the depth and diameter of about 500 craters ranging from 3 to 63 km and distributed across the surface in all regions observed by the spacecraft (from +40° and -90° of latitude). On a global scale, the d/D distribution on Vesta is very similar to what was observed on other small rocky objects in the Solar System. Values follow a Gaussian distribution peaking at 0.18. Small craters (up to 30km in diameter) cover the whole range of d/D (from 0.05 to 0.4) whereas larger ones are in a narrow peak centered on the mean value of 0.18. This is consistent with crater depth/diameter ratios for the asteroid (21)Lutetia, which vary between 0.05 and 0.35 (Vincent et al, 2012) and with the general crater depth/diameter ratios for simple craters determined by Melosh (1989) that equals 0.2. An histogram of all measurements is presented in Fig. 1. The variation of d/D is also indicative of the transition between strength and gravity regime of crater formation and this should appear as an inflexion in the plot of d/D, or coud be responsible for the narrowing of the distribution for craters with a diameter greater than 30km. DAWN is now in Low Altitude Mapping Orbit and the better resolution ($\sim$ 20m/px) will help us to refine this measurements.

The global picture

As more craters are added to the study, we are building a map depicting the variations of d/D over the whole surface. We find that the North-South dichotomy is also present in this dataset. Indeed the distribution of d/D in the Northern hemisphere is narrower that in the Southern one, and craters are on average shallower. The fine distribution of d/D, as a map of regional differences in surface properties will be compared with our current understanding of the different geological terrains. Further-

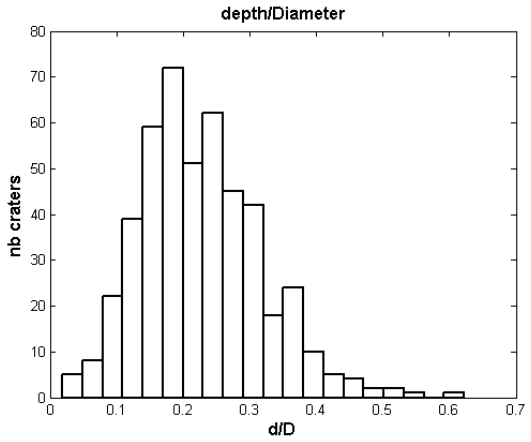

Figure 1: Histogram of depth-to-Diameter ratio for 500 craters between +40° and -90° of latitude. Extreme values larger than 0.4 are due to uncertainties of the analyzing tool, which sometimes underestimates the diameter of eroded craters.

more, we want to see how Vesta compares with other bodies in terms of crater morphology and d/D. For instance avalanches and very asymmetric craters are seen in some regions of Vesta, but they have been seen as well in specific areas of other asteroids, although on a different scale. We will discuss how to link all these observations in order to understand better the processes occurring on the surface of small bodies.

References

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