IMPACT ON A LOW-GRAVITY WORLD: CRATER MORPHOLOGIES ON VESTA IN SOLAR SYSTEM CONTEXT. P. Schenk[1], and the DAWN Science Team, [1]Lunar and Planetary Institute, Houston, TX. (schenk@lpi.usra.edu)

Introduction: Dawn mapping [1] of Vesta has provides our first close look at impact crater formation processes on the previously unexplored largest asteroids / dwarf planets. Mapping of the largest previously visited asteroids (e.g., Lutetia) revealed only simple craters [2], and Vesta is the first silicate–rich asteroidal body examined significantly smaller than the Moon yet large enough to have complex craters, or predicted to do so.

Vesta is heavily cratered [3]. The morphology of craters of all classes and erosion states is examined by [4], but in this report we describe the shapes and morphologies of both simple and complex craters. This serves three objectives. The first is to examine the question of whether complex craters actually formed on Vesta and establish a reference shape of intact craters for determining the degree of erosion, mantling or relaxation of older craters, the second is to provide for comparison of complex crater formation processes on Vesta with other silicate bodies (e.g., the Moon), and third to determine the simple-to-complex crater transition in relatively fresh unmodified craters in comparison with prediction and with other terrestrial bodies, which from extrapolation of other data [5, 6] would be ~60-70 km on Vesta.

Impact crater morphologies on Vesta are determined from the global Framing Camera (FC) mosaic of Vesta at 20 meter resolution (except north of 55°N latitude where resolution is 65 meters). Shapes are determined using topographic data mapped at 65 m resolution from FC stereo imaging [7].

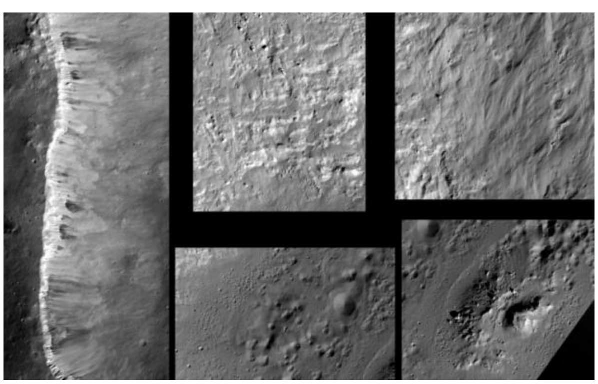

Figure 1: Elements of crater Marcia, the largest well-preserved crater on Vesta.

Crater Morphology: We focus here on those craters unmodified by erosion or mantling. While ancient craters as large as 250 km have been identified on Vesta [3,7], the global effects of ejecta produced from the two large impact basins at the south pole, Rheasilvia and Veneneia (D 505 and 395 km, respectively), have effectively mantled most impact craters formed prior to Rheasilvia with up to several kilometers of debris in many places (Schenk et al., 2012). Rheasilvia itself is estimated at roughly 1 Gyr in age [3,7], which is relatively young, and as a result, large intact, unmantled post-basin complex craters are relatively few. The largest such crater, Marcia, is only 65 by 72 km in size (Fig. 1), approximately the predicted diameter of the simple-to-complex transition on Vesta.

Simple Craters: Impact craters on Vesta smaller than ~30 km have a classic simple crater morphology, not radically dissimilar from lunar craters. Such craters have a bowl or inverted-cone profile shape highlighted by a sharply defined roughly circular rim scarp with outcrops of possible bedrock along the inner rimwall and lobate debris slides extending from the rim down to the bottom of the crater. Simple craters have depth/diameters that may be ~15% deeper than lunar equivalents (Fig. 3).

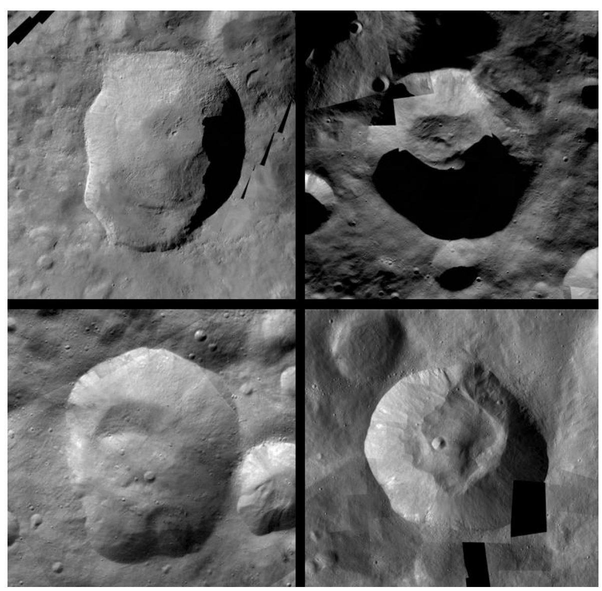

Figure 2: Examples of transitional/complex craters on Vesta. From top left: Marcia, D~62 km; unnamed, D=58 km; Caparronia, D=49 km; Pinaria, D=39 km.

Transitional Craters: Of well-preserved impact craters on Vesta larger than 30 km, only 505-km diameter Rheasilvia has a fully expressed complex crater morphology (Veneneia being obscured or obliterated by the later Rheasilvia). Rheasilvia is broadly bowl-shaped but also has a prominent modified-conical central uplift and isolated slump features along the inner rim crest [8].

Among intact post-Rheasilvia impact craters larger than ~30 km, morphologies are neither simple nor complex (Fig. 2). These craters are broadly bowl-shapes with steep inner rimwalls and debris slides but most have a rounded but distinctly noncircular shape. They also have either broad flat floors or large arcuate to irregular mounds covering a broad crater floor (Fig. 2). The largest of these, Marcia (D~65 km) is broadly flat floored but also has a small central mound or massif that may be a putative central peak, but otherwise classical conical central peaks are not developed or preserved in any Vesta craters other than Rheasilvia. All craters identified as having "transitional" morphologies are also significantly shallower than the similar-sized simple craters (Fig. 3).

Accepting the transitional crater *d/D* curve (and the associated large basin *d/D* measurements) as the only preserved segment of the complex crater curve on Vesta, we can estimate the transition diameter *Dtr* for Vesta from the intersection of this with the well defined simple crater *d/D* curve (Fig. 3). This intercept or inflection occurs at *Dtr* ~ 28 km, roughly half that predicted from simple extrapolation of the measured *Dtr* of other silicate-rich planets (Fig. 1).

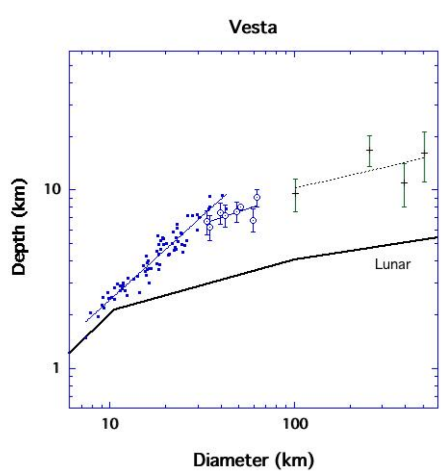

Figure 3. Observed crater shapes for fresh unmodified impact craters on Vesta. Solid circles are simple craters; open circles are 'transitional' craters. Largest basins are also shown separately.

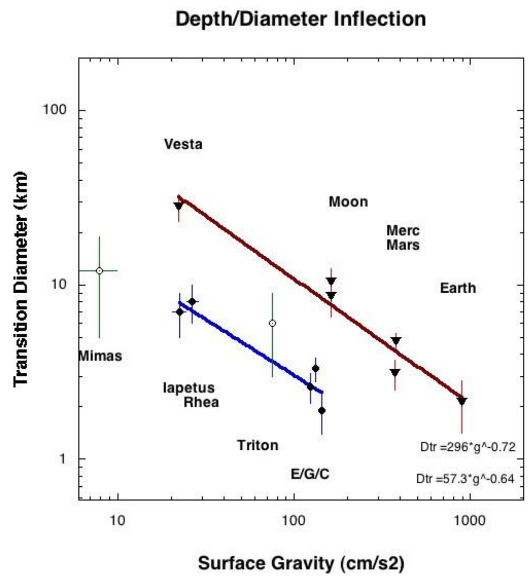

Figure 4: Updated simple-to-complex transition diameters for Solar System objects, based on the observed Vesta data and updated Cassini data [9]. Lines are best fits to icy and rocky targets.

Discussion: In addition to detailed descriptions of crater morphologies and some lunar comparisons, we will discuss the apparent morphologic transitions. At face value, the new *Dtr* trend for silicate targets when Vesta is included is *Dtr* ~ *D*^-0.7, indicating a weaker but still significant dependence on complex crater formation on surface gravity (Fig 4). One interpretation is that we are seeing the combined influence of gravity and strength on crater collapse and complex crater initiation. (The role of impact velocity remains indeterminant. It is also possible that even 60-km craters on Vesta formed in the strength rather than the gravity regime.) Thus the *g-Dtr* relationship may remain valid for all bodies but that strength is very important (as evidenced by the different ice and rock trends in Fig. 4) and that Vesta and the icy satellites of Saturn all have significantly weaker crustal strengths than their larger cousins; why is unclear.

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References: [1] Russell, C., et al., *Science*, 336, 684-687 (2012). [2] Voncent, J.-B., *PSS*, 66, 79-86 (2012). [3] Marchi, S., et al., *PSS*, 66, 87-95 (2012). [4] Vincent, J.-B., et al., *LPSC 43rd*, id 1415 (2012). [5] Pike, R., Proc. *11th LPSC*, 2159-2189 (1980). [6] Schenk, P., et al., in *Jupiter*, p. 427 (2004). [7] Jaumann, R., et al., *Science*, 336, 688-691 (2012). [8] Schenk, P., et al., *Science*, 336, 693-695 (2012). [9] White, O. et al., 223, 699-709, Icarus, (2013).