THE RHEASILVIA CRATER ON VESTA: NUMERICAL MODELING.

B. A. Ivanov[1], H. J. Melosh[2], [1]Institute for Dynamics of Geospheres, RAS, 119334, Moscow, Russia (baivanov@idg.chph.ras.ru), [2]Departments of Earth and Atmospheric Sciences, Purdue University, Civil Engineering Building, Room 3237, 550 Stadium Mall Drive, West Lafayette IN 47907 (jmelosh@purdue.edu).

Introduction: The Dawn mission to the asteroid Vesta delivers valuable new data about this differentiated planetary body [1]. The largest South Pole impact crater Rheasilvia (~500 km in diameter) overlaps older basin (~375 km in diameter) [2]. Here we continue (see [3] for the beginning) to use 2D numerical models of largest impact structure formation with self-gravity [4] and the acoustic fluidization model [5].

Numerical Model: The SALEB hydrodynamic solver [4] is used to model the solid material motion due to impact. The details of the target construction and modeling are the same as in [3] but with twice better spatial resolution.

Projectile and spatial resolution. Model basalt projectiles (density of 2.858 g/cm^3) with an impact velocity of 5.5 km/s (2.25, 11, and 22 km/s in selected model runs) have various radii ranging from 40 to 96 km (mostly larger than ~40 km assumed in [7]). Our spatial resolution varies from 20 to 50 cells per projectile radius (CPPR) with a cell size of 0.93x0.93 km in the cross section. As in the previous work [3] for selected runs we use twice more coarse ~2x2 km resolution.

Results: The last year presentation [3] used the HST model to compare with model results. In [3] we were in favor of a relatively large projectile of ~70 to 80 km in diameter (for the vertical impact). New DAWN images constrain the largest Rheasilvia impact structure with the diameter of ~500 km [2]. Moreover DTM's allows us to see the relief of Rheasilvia central mound [8]. Model runs with 50 to 80 km diameter projectiles and standard rock strength/dry friction properties [4] produce a simple bowl-shape crater, and we use the temporary dry friction decrease presented with the acoustic fluidization (AF) model [5]

Transient cavity radius (measured horizontally) is measured at the crater profile crossing the initial target contour at the moment when radial component of the particle velocity change direction from outward (ejection) to downward (collapse) – see Fig A7 in [4]. Pi-scaling of transient crater diameter and maximum depth is shown in Fig. 1. We find that the transient diameter (measured horizontally) changes linearly with the projectile diameter at the constant impact velocity. Consequently, points for π_D are scattered almost horizontally for a range of π_2 values. It looks like an interesting result for spherical targets.

Final craters are measured in a mapping-like style: "horizontal" distances are measured along the base surface (we use the initial spherical shape; fitting of the final target shape with an ellipse will change the profile). In this representation the diameter will be larger than measured horizontally from rim crest to rim crest. Figs. 2-4 demonstrate selected model crater profiles.

In this work we study the influence of a temporary frictional strength decrease parameterized with the AF-model where the most important parameter is found to be the decay time, T_{dec}, in the assumed exponential rule for the AF softening force amplitude decreases as exp(-time/T_{dec}). We find a systematic change of the impact crater profile for various projectile diameters and impact velocities for the variation of T_{dec} from 400 s to 1400 s. We find that the implementation of the diffusion of the AF amplitude parameter out of the zone of decreased friction allow us to stop the near surface motion and to get a reasonable central mound shape (Figs. 2 and 4). Without such diffusion the central mound continues to collapse too long time flattening the central mound (Fig. 3; the AF diffusion does not change the central uplift amplitude). In the limits of the AF model such diffusion of internal vibrations looks pretty natural.

All model runs allow us to plot pressure and velocity fields for any moment of time. Fig. 5 illustrates the maximum shock pressure isobars and the temperature field for selected model runs at 5.5 km/s. Very small amount of material is compressed above 40 GPa, and the voluminous impact melting looks improbable for low (<5.5 km/s) impact velocities. The volume of significantly heated material is relatively small, and during the transient crater grows it deforms in a relatively thin veneer coating the internal crater surface. Modeled higher velocity impacts (11 and 22 km/s), naturally, demonstrate appreciate impact melt production. However the melt is also creates only a thin lining at the cavity surface.

Conclusions: Results of our reconnaissance modeling demonstrate the possibility of the central mound formation due to the transient crater collapse facilitated with a friction-softening mechanism (presenteded here with the AF model). At low (5.5 km/s) impact velocity the layer of sufficiently heated material under the crater is relatively thin.

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References: [1] Russel C. T. et al. (2011) *AGUFM*, presentation U21B-01. [2] Schenk P. et al. (2011) *AGUFM*, presentation U21B-03. [3] Ivanov B. A. et al. (2011) *LPSC*, *42*, #1717. [4] Ivanov B.A. et al. (2010) *GSA Spec. Pap.*, 465, 29-49. [5] Melosh H.J. & B.A. Ivanov (1999) *AREPS*, *27*, 385-415. [6] Ruzicka A. *et al.* (1997) *MAPS*, *32*, 825-840. [7] Asphaug E. (1997) *MAPS, 32*, 965-980. [8] Russel C. Et al. (2011) *EPSC-DPS Joint Meeting 2011 Press Notice PN EPSC-DPS 2011/06*, Figure 2. [9] [10] . [11] . [12] . [13] [14] . [15] .

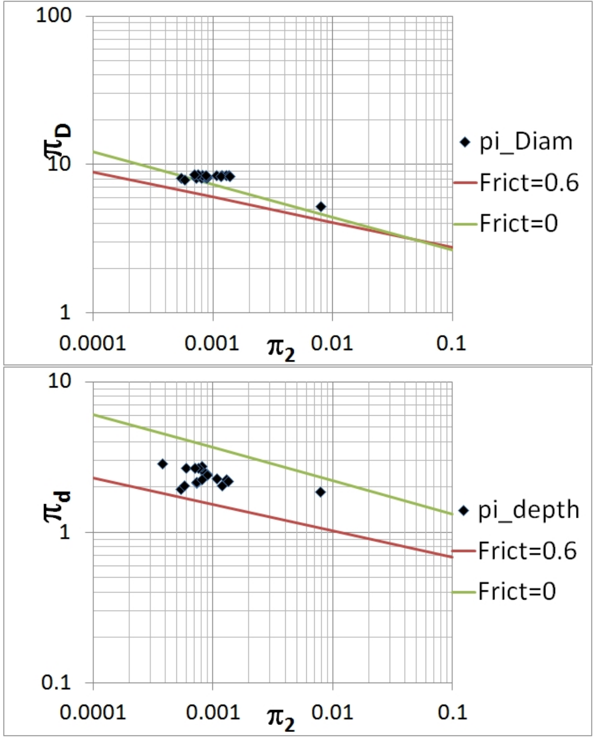

Fig. 1. Pi-scaled transient crater diameter and depth for impacts with 5.5 km/s (points around π_2=0.001) in comparison with low velocity (2.25 km/s) impact of a 90-km spherical projectile ($\pi_2 \sim 0.0078$). Straight lines are for power laws for "hydrodynamic" friction-less material and for dry friction flat-surface target.

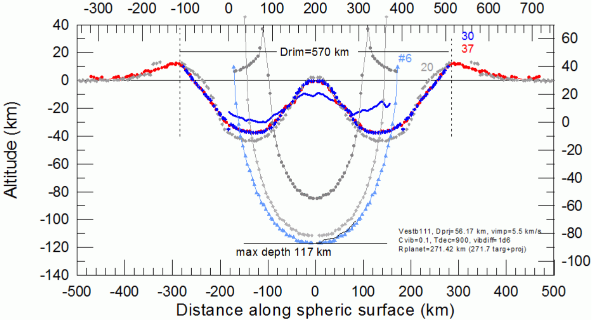

Fig. 2. Evolution of the transient cavity for the vertical impact of a spherical (Dproj=56 km) basaltic projectile at 5.5 km/s. The profile is shown relative the initial spherical surface of the target. Thick blue curve shows the published [8] crossection for the central mound in Rheasilvia (right vertical scale in km).

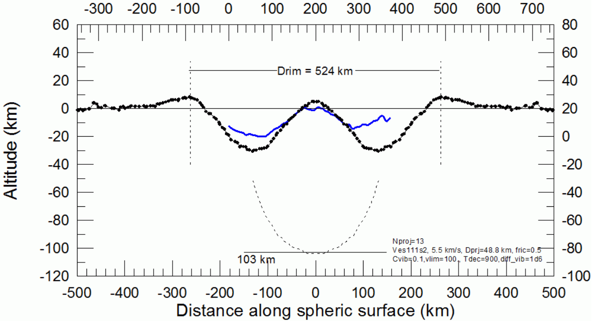

Fig. 3. Final crater profile for the vertical impact of a spherical (Dproj=49 km) basaltic projectile at 2.25 km/s. Thick blue curve is the published [8] crossection for the central mound in Rheasilvia (right vertical scale in km).

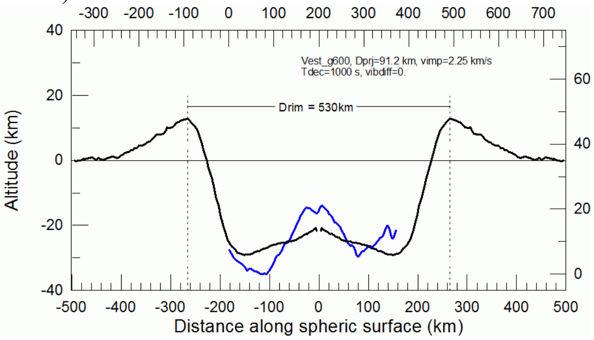

Fig. 4. Final crater profile for the vertical impact of a spherical (Dproj=91 km) basaltic projectile at 2.25 km/s. Thick blue curve is the published [8] crossection for the central mound in Rheasilvia (right vertical scale in km).

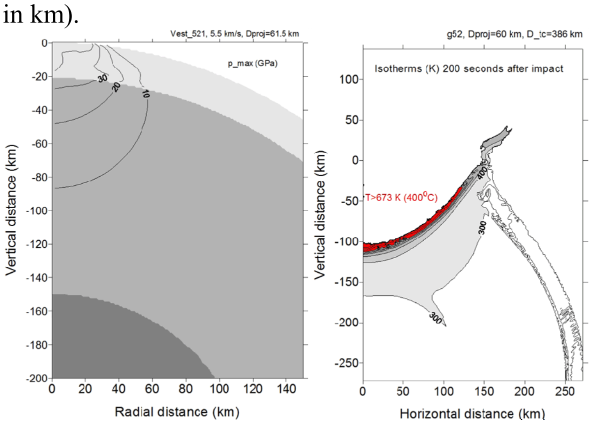

Fig. 5. Isobars (left) and rock temperature field 200 s after impact of a 60-km body at 5.5 km/s.