VESTA IMPACT CRATERS: RHEASILVIA OVER VENENEIA. B. A. Ivanov[1], and D. Kamyshenkov[1,2], [1]Institute for Dynamics of Geospheres, RAS, 119334, Moscow, Russia (baivanov@idg.chph.ras.ru, boris.ivanov@univie.ac.at, boris_a_ivanov@mail.ru), [2]Moscow Institute of Physics and Technology, Institutskii per. 9, Dolgoprudny, Moscow Region, 141700, Russia (kdv88@yandex.ru).

Introduction: The Dawn mission to the asteroid Vesta delivers valuable new data about this differentiated planetary body. The largest South Pole impact crater Rheasilvia (~500 km in diameter) overlaps the older basin Veneneia (~400 km in diameter). Here we present the continuation of 2D numerical modeling [1, 2] of the largest impact structure formation with self-gravity [3] and the acoustic fluidization model [4]. Detailed report is submitted for publication [5].

Target: Two types of the model "Vesta" have been constructed with ANEOS-based "basalt", "dunite", and "iron" to reproduce crust, mantle, and the core. Target 1: Crust thickness of ~20 km and iron core radius of ~120 km, and Target 1: Crust thickness of ~20 km and iron core radius of ~120 km.

Rheasilvia: A set of model runs reproduces well the Rheasilvia diameter, but in all runs the maximum depth of the final crater is larger than reported in [6] – see Fig. 1. The "best" fit allows us propose the range of 5.5 km/s impactors within diameter range of 37 to 44 km.

Veneneia: A few model runs for Veneneia give limited model results as the pristine crater profile is deformed by later Rheasilvia formation. As a starting point we use the same acoustic fluidization model parameters as for Rheasilvia modeling. The "best" to date fit is found for Target 2 and 5.5 km/s impact of a 37-km diameter projectile. Here only the crater slope near surface may be treated as quite similar to the reported in [6] slope (Fig. 2).

Excavation depth: Maximum depth of the escaped material is published elsewhere [2, 5]. Here we present maximum excavation depth as a function of the impactor diameter (Fig. 3) and the modeled crater diameter (Fig. 4). Excavated material is defined as material displaced above the target initial surface and beyond the transient crater profile. For the "best fit" model runs (Fig. 1) the material at the crater rim originates from initial depths of 30 to 40 km. For Target 1 the excavation of some "mantle" (located deeper 20 km) material looks to be inevitable.

Crater overlapping: To give a perception of Rheasilvia formation over the older Veneneia crater we construct a simple cartoon (Fig. 5). For the assumed angular distance of 30^{o} between Veneneia and Rheasilvia centers the escape of some material from the Veneneia central uplift seems to be inevitable. The Rheasilvia impact seems to occur at the inner crater wall of Veneneia. It means that the surface material just at the impact point was severely disturbed by the previous impact. For more natural oblique impacts the orientation of the projectile trajectory relative to the older crater may be critical, and it deserves much more complicated 3D modeling in a future.

Discussion and outlook: The lack of definite traces of olivine-bearing minerals in Dawn's spectral images [7] seems to be in a contradiction with observed "mantle" Vestoids [8]. The presented 2D modeling limits the excavation depth for 400 to 500-km diameter Vestian craters with the range of 30 to 40 km. The depth of escaped material is factor of 1.5 less. If the lack of olivine signature in mineral spectra means the lack of olivine at these depths make hard the idea of visibly mantle asteroids in crater-related Vesta family.

A partial relief of the contradiction may be found in the idea of non-spherical layering of Vesta. As shown in Fig. 5, large old craters may deliver relatively deep material close to the surface to be ejected by later impacts. However in this case some traces of non-escaped ejecta should mark such a situation at the Vesta surface. The problem solution may be re-iterated with more complicated description of the mantle/lower crust interface. The interface may be not spherical but constructed as a layer of multiple dykes and sills of mafic material. If so, the excavation of mafic material may be an occasional event, not linearly depended on the crater diameter.

The non-spherically layered Vesta with geochemical and mechanical (fracture porosity) heterogeneities may be a useful starting point for the future analysis.

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References: [1] Ivanov B. A. *et al.* (2011) *LPSC 42^d^*, Abstract #1717. [2] Ivanov B. A. and H. J. Melosh (2012) *LPSC 43^rd^*, Abstract #2148. [3] Ivanov B.A. et al. (2010) *GSA Spec. Pap.*, 465, 29-49. [4] Melosh H.J. & B.A. Ivanov (1999) *AREPS, 27*, 385-415. [5] Ivanov B. A. and H. J. Melosh (2013) *JGR South Pole Special Issue*, submitted. [6] Schenk P. et al. (2012) *Science*, *336*, 694-697. [7] Russell C.T *et al.* (2012) *Science*, *336*, 684-686. [8] Reddy V. *et al.* (2011) *Icarus, 212*, 175-179.

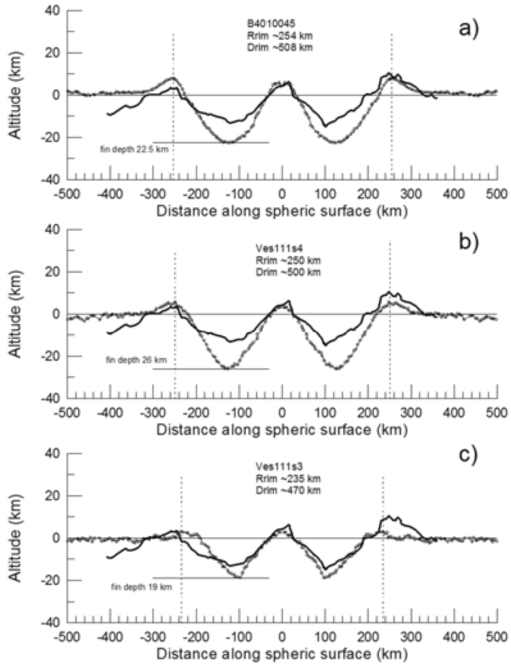

Fig. 1. "Best" fit crater profiles for vertical impact of a spherical basaltic projectile at 5.5 km/s. Model run names and crater depth and diameters are shown in each panel. Thick black curve is the published Rheasilvia cross-section [6]. a- Target-2, D_p=37.3 km; b - Target-1, D_p=44 km; c - Target-1, D_p=37.3 km. Profiles in (a) and (b) are close to 500 km in diameter. The profile in (c) shows the smallest circular trough depth.

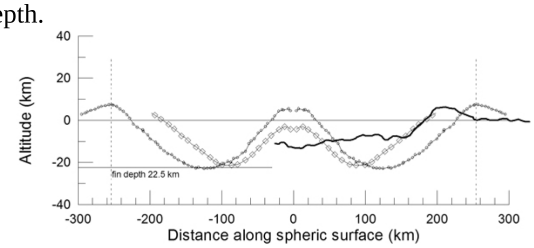

Fig. 2. Model profiles for Rheasilvia and Veneneia (diamonds) in comparison with the published Veneneia profile from [6] (black solid curve).

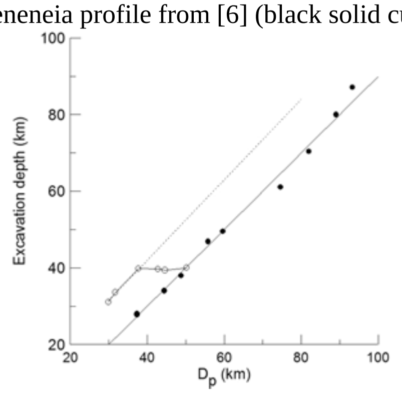

Fig. 3. Maximum depth of excavation in Target 1 (black circles) and in Target 2 (open circles) vs. projectile diameter D_p. In Target 2 the depth of excavation vary approximately as 1.05 D_p (dashed line) until it reaches the crust/mantle boundary at the depth of 40 km. Maximum excavation depth in Target 1 (crust thickness of 20 km) in the modeled range grows up as D_p -10 km (solid line).

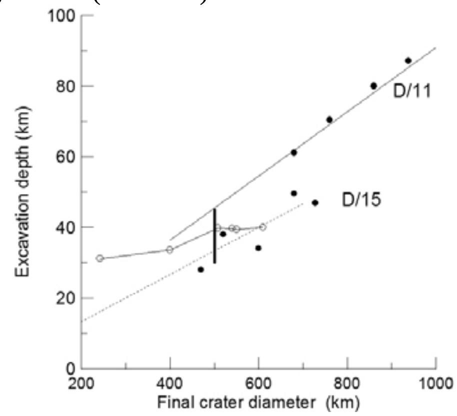

Fig. 4. The same data as in Fig. 3 plotted against the modeled rim crater diameter. The possible range for *D*=500 km is 30 to 45 km (thick black vertical line). In Target 1 smaller craters (*D*<~700 km) the excavation depth may be approximated roughly as *D*/15. Larger craters tend to follow *D*/10 excavation depth.

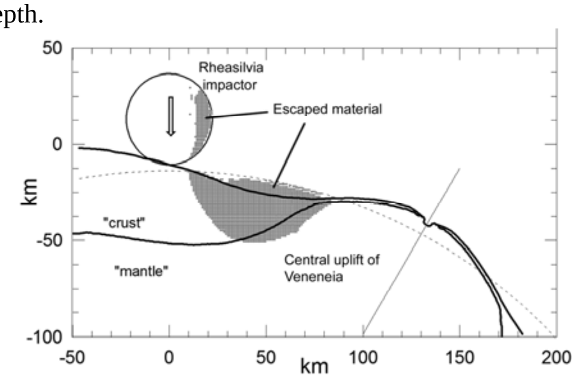

Fig. 5. Schematic position of the impactor would create Rheasilvia at the background of the previously formed Veneneia crater. Gray dots (giving the gray shading due to overlapping) shows the position of escaped material (computed for the spherical target outlined with the dashed curve). For the angular distance of 30° between Veneneia and Rheasilvia craters, the younger impact seems to be able to eject a part of the Veneneia central mound with escape velocities. The situation is modeled under assumption of 40 km "basaltic" crust over "dunite" mantle - Target 2 (modified from [5]).