GLOBAL DISTRIBUTION OF CRATER EJECTA ON ASTEROIDS.

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Introduction: The lack of optical maturity of some asteroids, e. g.., 4 Vesta, indicates that either space weathering processes are inhibited on their surfaces or fresh material was recently distributed all over them. One of the inhibition mechanisms, namely, protection of asteroid surface from solar wind by magnetosphere, was considered in [1]. Here the possibility of global covering of asteroids by impact ejecta is studied.

Calculation of ejecta thickness distribution: The ejecta thickness as a function of crater diameter D_{cr} and the distance R from the crater was derived for flat surfaces (e.g., [2,3]), when the ejecta paths d_e are much shorter than the radius of the target body. This "flat" approximation is valid for the Earth and the Moon. For asteroids, gravity g is much smaller than for the Moon, so the velocities v_e of most ejecta are of the same order of magnitude as the escape velocity v_{esc}, and the ejecta paths d_e are comparable to asteroid sizes. In this case the distance of ejecta flight along the surface of a spherical asteroid (ejection angle being 45° to the surface) is:

$$d_e = D_a \mathrm{atan}[v_e^2/(v_{esc}^2 - v_e^2)] \qquad (1)$$

where D_a is asteroid diameter. If $v_e << v_{esc}$, then $d_e << D_a$, and Eq. (1) takes the form $d_e = v_e^2/\mathrm{g}$ known for flat surfaces and used in [2,3]. Substituting (1) in the derivation described in [2,3], obtain the average thickness T of ejecta at a distance R from the crater.

The results of calculations of $T(R)$ for craters of various diameters on Vesta are presented in Fig.1. The ejecta may be assumed globally distributed, if, even at the point opposite to the impact (i.e., at a distance πD_a from the impact), their average thickness is greater than typical size $l \approx 100\mu\mathrm{m}$ of regolith particles. Though ejecta distribution is not continuous, having ray structure, the criterion may be taken as a first approximation. All craters shown in Fig.1 satisfy this criterion, the minimum crater diameter being 5 km. For larger craters, the ejecta coming from the opposite directions may overlay each other.

The craters shown in Fig.1 are gravity-controlled, since $D_{cr}/2 > \sigma/\rho g$, where $\sigma \approx 10^7 \mathrm{dyn/cm}^2$ and $\rho \approx 3\mathrm{g/cm}^3$ are strength and density of surface material (cracked silicate), respectively. For such craters, a good approximation for the average thickness T of ejecta at a distance R from the crater edge is:

$$T_g = 0.017(D_{cr}/2)(D_{cr}/2R)^{2.18} \qquad (2)$$

Note that (2) differs from the approximation for "flat" case [2,3] $T = 0.04(D_{cr}/2)[D_{cr}/(2R+D_{cr})]^3$, the first factor in (2) being an order of magnitude less because of ejecta escape, and the decrease with R being slower.

Eq. (2) may be inverted to obtain the distance from crater edge where the average ejecta thickness T is achieved:

$$R_g = 0.154(D_{cr}/2)(D_{cr}/2T)^{0.46} \qquad (3)$$

For strength-controlled craters ($D_{cr}/2 < \sigma/\rho g$) a good fit for ejecta thickness is

$$T_s = 0.1(R_{min}D_{cr}/2)^{1/2}(D_{cr}/2R)^{2.55} \qquad (4)$$

where R is the distance from crater center and $R_{min} = 0.3\sigma/\rho g$ is the minimum distance of ejecta flight (which is achieved from crater edge). In this case ejecta thickness depend on asteroid gravity: $T_s \propto \mathrm{g}^{-1/2}$. The inversion of (4) yields:

$$R_s = 0.31(D_{cr}/2)(R_{min}D_{cr}/2T^2)^{0.196} \qquad (5)$$

Strength-controlled craters are dominant on small asteroids, being the only possible case on silicate bodies of $D_a < \approx 50$ km. For a silicate body of $D_a = 100$ km ($\mathrm{g} \approx 4\ \mathrm{cm/s}^2$), strength-controlled crater formation occurs up to $D_{cr} = 35$ km.

The approximations (2)-(5) give good fit for ejecta distances far from crater edge and the point opposite to the impact. E.g., for $D_a = 100$ km and $T = 100\mu\mathrm{m}$, Eq. (5) yields $R_s = \pi D_a$ at $D_{cr} = 2.3$ km, whereas the exact value is $D_{cr} = 1$ km.

Conclusions: The lack of optical maturity for asteroids may result from recent impact events that might provide global covering of asteroids by crater ejecta. The average thickness of ejecta exceed typical size of regolith particles (100 µm) all over the asteroid surface for craters of $D_{cr} \geq 5$ km on Vesta, and for craters of $D_{cr} \geq 1$ km on silicate asteroids of diameters 100 km.

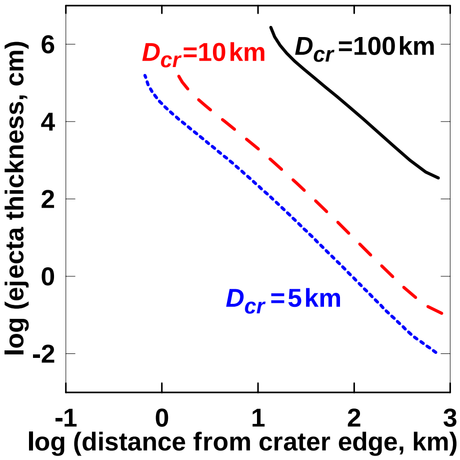

Fig.1 The average thickness of ejecta for craters of different diametes on Vesta and vs distance from crater rim.

Acknowledgment: I thank T. B. McCord and L. V. Moroz for stimulating this work.

References: [1] Starukhina L.V. and McCord T.B. (2012) *LPSC 43th*, abstract #1288. [2] Ivanov B. A. (1976) *Proc. Lunar Sci. Conf. 7th*, 2947- 2965. [3] Ivanov B. A. (1979) *Meteoritika 38*, 68-85 [in Russian].