EJECTA REACCRETION ON RAPIDLY ROTATING ASTEROIDS: IMPLICATIONS FOR 433 EROS AND 243 IDA :

Paul Geissler, Jean-Marc Petit and Richard Greenberg, Lunar and Planetary Laboratory, University of Arizona, Tucson AZ 85721

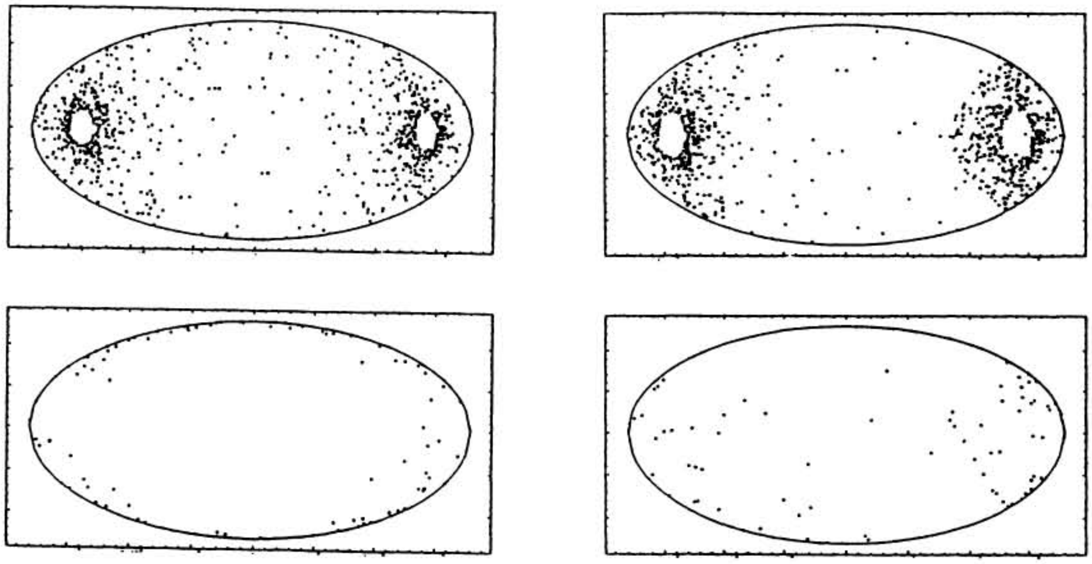
The morphology of crater ejecta blankets and the distribution of impact-derived regolith on asteroids such as 433 Eros and 243 Ida may vary markedly with surface location, due to their low gravity, nonspherical shape and rapid rotation. We have modelled the processes of ejecta reaccretion and regolith redistribution for the specific cases of Eros and Ida with a 3-dimensional numerical simulation which tracks the orbits of particles launched from the surface of a rotating triaxial ellipsoid. The results predict radically different ejecta distributions for rapidly rotating asteroids, depending upon the assumed initial ejecta launch velocity.

At low ejection speeds (V << Vesc), craters form well-defined ejecta blankets which are asymmetric in morphology between leading and trailing rotational surfaces (Figure 1). Ejecta blankets on rotational leading surfaces have sharp boundaries in the direction of rotation, at a threshold beyond which ejecta is catapulted into orbit by the rotational velocity. The net effect of cratering at low ejecta launch velocities is to produce a thick regolith which is evenly distributed across the surface of the asteroid (Figure 2).

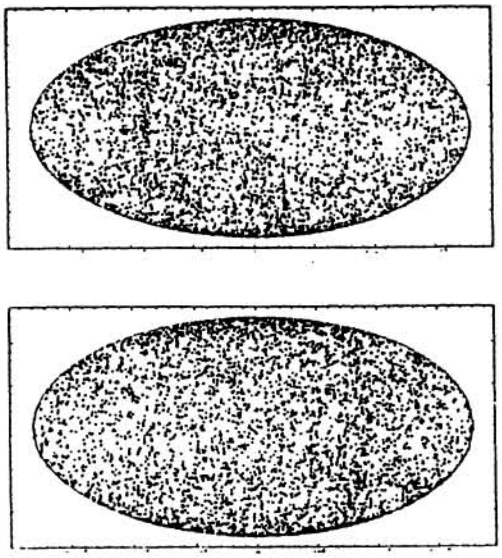
In contrast, no clearly defined ejecta blankets are formed when ejecta is launched at higher initial velocities (V ~ Vesc). Most of the ejecta escapes, while that which is retained is preferentially derived from the rotational trailing surfaces. These particles spend a significant time in temporary orbit around the asteroid, in comparison to the asteroid's rotation period, and tend to be swept up onto the rotational leading surfaces upon reimpact. The net effect of impact cratering with high ejecta launch velocities is to produce a thinner and less uniform soil cover, with concentrations on the asteroids' rotational leading surfaces (Figure 3).

Theoretical results for Ida are qualitatively similar to those for Eros. The absence of well-defined ejecta blankets and the asymmetric distribution of ejecta blocks on Ida (Belton et al., Science, 265, 1543) suggest that ejecta may be launched at speeds sufficient to disperse debris far from the source craters. Because of limitations in resolution and coverage of the Galileo observations, the interpretation of dynamical effects on surface morphology and the implications of high ejecta velocities and erosion rates must be regarded as tentative; the definitive observations will be made at Eros, where the entire surface will be imaged by an orbiting spacecraft with sufficient resolution to map soil, blocks and ejecta blankets in detail. NEAR will have an opportunity to answer fundamental questions raised by the Galileo flybys. The results will shed light on the basic physics of impact cratering in low gravity regimes.

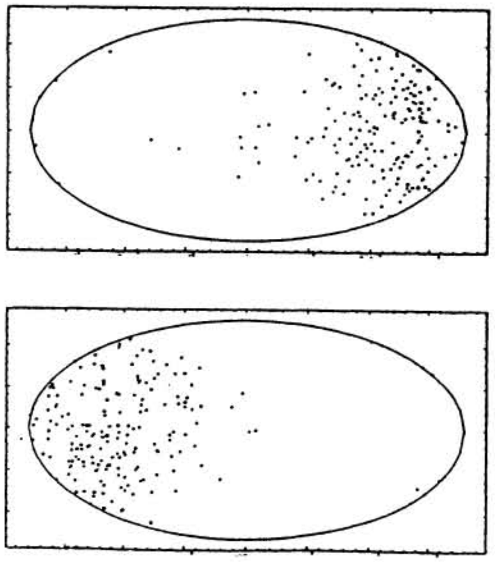
Ejecta Reaccretion on Eros and Ida: Geissler P. E. et al.



1. The effect of rotation on the morphology of crater ejecta blankets on a triaxial ellipsoid with the dimensions of Eros and a density of 2.7 g cm^{-3}. At left is the non-rotating case, for which the locations where particles reimpact the surface (shown by dots) are symmetric across the asteroid. On the right is shown the results of the simulation when the ellipsoid is rotated at the spin rate of Eros. The rotation axis is in the plane of the paper, with the leading surface on the right in the upper diagram and on the left in the lower diagram, which shows the opposite side of the asteroid.



2. Reimpact sites of particles launched at 11.8 m/s, or half of the average escape velocity, from random locations on the surface of a model asteroid with the dimensions of Eros. Almost 95% of the particles launched in this low velocity case return to the model asteroid, most within one rotation period.



3. Reimpact sites of particles launched at 28 m/s. The landing locations in this high velocity case are sharply nonuniform, most occurring on the leading surfaces of both sides of the asteroid.