THE DIAMETER AND DEPTH OF CRATERS ON 433 EROS.

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Abstract

The morphology and dimensions of over 100 craters on 433 Eros are obtained by combining the imaging and lidar data from the Near Earth Asteroid Rendezvous (NEAR) spacecraft. The relationship of depth and rim-height to diameter are tracked relative to crater degradation state, local slope, surface gravity, asteroid curvature and presence of nearby tectonics. The most important results reveal that craters with diameters in excess of 700m have rims that collapse on steep slopes possible due to gravity overcoming the strength of the target, and that extensive loose fill is present in these craters. We will discuss these and other results obtained from our survey, and their implications for the surface evolution and internal properties of Eros.

Regolith fill

The dimensions of craters, in conjunction with their degradation state provide insights into the amount of the regolith present on Eros. The craters are split into three degradation categories. Category 1 craters are the freshest ones seen on Eros. These typically possess little or no fill, and have a fairly crisp appearance with no superposed craters. Category 2 craters possess a more subdued appearance with more fill. They will sometimes possess smaller superposed craters. Category 3 craters are very subdued, possess significant infill and many superposed craters.

The data reveal that category 2 and 3 craters are always shallower relative to craters in category 1 especially at small scale. The shape of large craters, which are typical category 2 craters, are less sensitive to erosional processes and infilling and follow the trends seen for the typically smaller category 1 craters. A key observation is that the rim heights of category 1, 2 and 3 craters are statistically indistinguishable, indicating that most of the difference in crater depth measured is due to infilling from regolith, not rim collapse. Resulting estimates of this fill are on the order of 2 to 80m depending on the crater size, with an average of ~ 20m. Such a typical regolith depth could easily obliterate craters less than 200m in diameter if it is moved by seismic shaking, and could account for the deficit of small craters seen on Eros [1]. This amount of regolith also requires at a minimum a fairly weak Eros, with tensile yield strengths comparable to sand.

Collapsing rims

The comparisons of diameter-depth and rim-height with local slope, surface gravity, asteroid curvature and presence of nearby tectonics, indicates a robust result that craters >700m possess rims that tend to collapse on larger slope. The exact reason for why this happens is not yet clear, but might be the result of weakening of the target with increasing crater size to the point where gravity dominates crater formation and allows rims to collapse under their weight. Two factors could contribute to such weakening: the reduction of cratering strain rate which reduces the yield strength with increasing crater size [e.g., 2], and the presence of a greater number of weak flaws that can be activated during bigger impact events [3].

An estimate of the strength of Eros can be obtained if we consider strain rate weakening, where the target strength goes as $Y_s\dot{\varepsilon}^{-1/4}$where Y_s is the static strength of Eros and $\dot{\varepsilon}$ is the strain rate. The projectile velocity divided by its diameter is proportional to $\dot{\varepsilon}$. Using impact velocities of 5 km/s, and three different initial static strength models of Eros (a weak dry sand, a stronger slightly wet sand and an even stronger very wet sand model) and one strength-less, gravity dominated model, we find that the dry sand model equals the strengthless gravity model for craters with diameter∼700m. This diameter is where we see the rims of crater collapse on slopes, and points - like the regolith data - to Eros possessing an internal strength similar to dry sand.

Implications

Such an internal strength for Eros may not be unreasonable. The obvious presence of loose unconsolidated regolith on Eros, but the lack of crater benches [4] indicates that strength of Eros's subsurface cannot be very different from the loose material sitting on its surface. Recall that the experiments of Quaide and Oberbeck [5] require a fairly sharp strength contrast between layers of target for craters to form benches. Therefore, it is not unreasonable that the strength properties of much of Eros match those of this surface loose material, i.e. that of sand.

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