Many impact craters on Vesta are formed on slopes. This might explain their asymmetric interior morphology and ejecta distribution [1]. By conducting three-dimensional numerical simulations we have investigated the effect of slopes on the morphology of impact craters. Our results suggest an explanation for the formation of specific features of craters on Vesta, so-called bimodal craters.

Results

- Topography influences both the ejection angle and the crater collapse.
- Explanation for the formation of craters with bimodal morphology, such as Helena [4].
- Important properties controlling the cratering process in topographically rough terrains
  - Point of impact relative to the slope
  - Impact trajectory

Further studies are intended to explain the formation of these different types of craters observed on asteroids.

Effect of target topography

The morphology of the impact crater depends on

- Impact velocity and angle, slope height and angle (see e.g. [9])
- Impact position relative to the slope

References:


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Fig. 1: “Helena” (lat 41.4°, long 122.5°)  
Top view and color-coded perspective view (right) and detailed geologic map showing the downhill ejecta (yellow, left). Images from [3].

Fig. 2: Simulation setup

- Numerical Code: iSALE-3D [5,6]
- Systematic variation of slopes (θ) and slope heights (H), impact angles (α), γ, and velocities (U), projectile diameters (L) and material properties (friction coeff., cohesion)
- Gravity g: 0.22 m/s² (Vesta)
- dunite (ANEOS) with 25% porosity (i.e. compaction model [7])

Fig. 3: This figure shows a 900 m size projectile impacting at an angle of 30° and with a velocity of 5 km/s bottom, top and in the middle of a slope (45°, 4 km height).

Fig. 4: Characteristics of Impacts Into slopes  
Impacts into slopes might cause slope instabilities and different types of avalanches, rock- or landslides.

Fig. 5: Simulations (see Fig. 3) suggest that Helena was formed by a very oblique impact hitting the slope bottom, approaching from downhill direction (here: α=15°, L=900 m, U=5 km/s).

Formations of “Helena”

- Sagging of material from uphill towards the crater center results in a sharp rim uphill.
- Material from the slope accumulates downhill and superimposes the deposition of ejecta.
- The direction of ejection flow is strongly influenced by the slope.
- In this particular case no material is deposited uphill (i.e. downrange) => Forbidden zone downrange, and not uprange!