Erosion by lava at Rimae Posidonius on the Moon

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Rille topographic data collection

High-resolution (~50 m/pixel) NAC footprints, stereo DTMs and LOLA tracks from NASA’s LROC were the key sources of topographical input parameters for the model. Data collection was facilitated by an extensive use of the ArcGIS™ software, which enables creation of stacks of individual image layers. Lava thicknesses were not constrained by high-flow marks on rille walls, thus we choose a value of 10 m, consistent with estimates on individual lunar flows (Schaber, 1973; Gifford and El-Baz, 1981), and allow for thickness to vary down to 3 m, to explore how flow regime also varies as a function of lava thickness.

Background

According to Hulme (1973), lunar sinuous rilles may be the result of erosion by low-viscosity, high-density and high-temperature turbulent flows of mare basalts.

The analytical-numerical model developed by Williams et al. (1998) to investigate thermal erosion by turbulent lava under various conditions on the Earth and the Moon involves both a physical and geochemical approach, and calculates erosion rates and depths with time as a function of distance from the source.

The flow is one-dimensional (in the x-direction), with thermal erosion in the z-direction. Lava erupts as a turbulent flow with a mixed interior. Lava rheology changes due to assimilation of eroded substrate, 2) the lava temperature decreases as the flow moves downstream, and 3) flow thickness increases as velocity decreases (thickness is used as proxy for flow rate).

1-D flow rates are obtained by multiplying flow velocity by flow thickness and width.

Rille length, width, slope

Depth values of 55-65 m are found at the source region. As we move downstream, depths decrease to ~35-40 m until values of 30-35 m are measured near the rille terminus. At a few rille sections, the measured depth is much smaller (due to flows that have partially filled the area). The slope of the ground varies between 0.8° and 1.6°, which are used as upper and lower end values. Rille width is in the range 200-300 m and an average value of 250 m is chosen.

After accounting for the meandering path, the rille length is determined to be ~180 km.

Erosion rates and depths

Channelized 5-10-m-thick lavas could have erupted as turbulent flows on the Moon, if erupted near their liquidus temperature. Erosion rates vary between 0.32 - 1 m/day for a 10-m-thick flow. Total lava volumes (151-189 km³) lie in the range obtained in modeling the Rima Prinz rille (Hurwitz et al. 2013). A 10-m-thick flow better explains observations.

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References