

Long Runout Landslides: A Solution from Granular Mechanics

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ABSTRACT

Large landslides exhibit surprisingly long runout distances compared to a rigid body sliding from the same slope, and the mechanism of this phenomena has been studied for decades. This paper shows that the observed long runouts can be explained quite simply via a granular pile flowing downhill, while collapsing and spreading, without the need for frictional weakening that has traditionally been suggested to cause long runouts. Kinematics of the granular flow is divided into center of mass motion and spreading due to flattening of the flowing mass. We solve the center of mass motion analytically based on a frictional law valid for granular flow, and find that center of mass runout is similar to that of a rigid body. The spreading of the mass is estimated based on the shape of deposits observed in experiments with collapsing granular columns and numerical simulations of landslides. The spreading leads to a deposit angle much lower than the angle of repose or the dynamic friction angle, and is shown to be an important, often dominating, contribution to the total runout distance. The combination of the predicted center of mass runout and the spreading length gives the runout distance in a very good match to natural landslides.

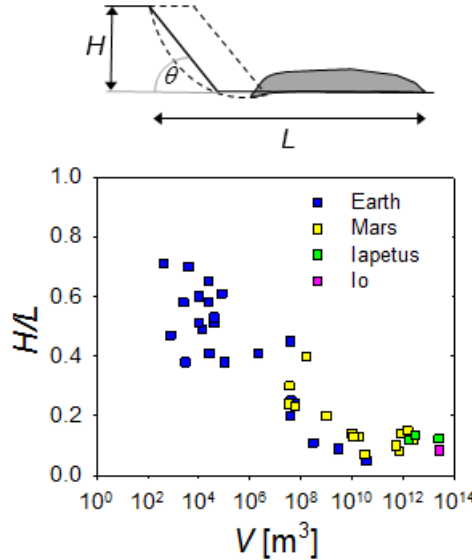


Fig. 1 Heim's ratio H/L as a function of landslide volume V , based on field data taken from Ref. [2]. Note that Heim's ratio for long runout landslides can reach values as low as 0.1, *i.e.* much lower than that for a rigid body.

References

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2. A. Lucas, A. Mangeney and J. P. Ampuero, Frictional velocity-weakening in landslides on Earth and on other planetary bodies, **Nat. Commun.** **5**, 1-9 (2014).
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