Geophysical Research Abstracts, Vol. 7, 08804, 2005
SRef-ID: 1607-7962/gra/EGU05-A-08804

Landsliding in red kidney beans

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We have conducted a series of physical experiments that address the process of bedrock landsliding in fractured cohesive rock. The experimental setup consists of a box of dry red kidney beans (Phaseolus vulgaris); beans weigh ˜0.5 g and are approximately ellipsoidal in shape, ˜1.5 x 0.6 x 0.6 cm. One side panel is dropped continuously and smoothly. Discrete slide events occur in response to this base-level fall, and event mass recorded via a 2-5 second sampling by a digital scale with a precision of ś0.5g.

Slide events occur over a variety of sizes and by a variety of mechanisms. Small events (from one to ten beans, ˜0.5-5 g) occur frequently and may originate anywhere on the hillslope. The occurrence of multiple small events can leave the surface relatively pitted, with local relief up to 3 or 4 times the dimensions of the beans. Very occasionally small slide events do not deliver beans to the base-level but accumulate at a lower elevation. Large slide events will tend to grow or propagate as they develop and ultimately may involve the entire slope. Such slope-clearing events smooth the surface. There are clear implications for the morphology (at an appropriate length-scale) of hillslopes and the site history of landslides.

The statistics of slide events was determined for a variety of box shapes (specifically for the ratio of depth into the simulated hillslope and width along the hillslope) and rates of base-level fall. In each case, we find a well-defined power-law behavior over only a limited range of slide mass. A consistent rollover occurs above a critical slide mass, such that there are relatively fewer large slide events than predicted from the power-law behavior at smaller masses. We have yet to observe similar high-end rollovers from the few data sets of real landslides, although there is a hint of such behavior in sand-pile experiments inspired by Per Bak's notion of self-organized criticality.

It is possible that such high-end rollover is a function of hillslope length, which in some experiments was continuously increasing such that the potentially largest slide mass was concomitantly increasing. Simple numerical models based on this explanation predict the observed high-end roll-over. However, such a roll-over is observed where hillslope length has reached a steady-state and it appears another explanation must exist. Whatever the explanation might be, one reason why this observed high-end roll-over is not observed in natural data sets (in which the raw data is in terms of landslide area) is that the shapes of landslides are not self-similar.