Flow deposit and erosion processes in granular collapse over sloping beds

Maxime Farin[1], Anne Mangeney[1], Olivier Roche[2]

[1]Institut de Physique du Globe de Paris, France, [2]Laboratoire Magmas et Volcans, Universite Blaise Pascal CNRS IRD, France

E-mail: mfarin@free.fr

Experimental granular column collapses were conducted over an inclined channel covered or not by an erodible bed of granular material in order to reproduce at laboratory scale granular flows and erosion processes of natural flows propagating over deposits formed by earlier events. The studied control parameters were the slope angle, the aspect ratio (i.e. height over length), volume and shape of the granular column released, and the thickness and compaction of the erodible bed.

For flows on a rigid (non erodible) bed, there is a critical slope angle θ_c between 10° and 16° that separates two different dynamics for granular flows. For slope angles below θ_c, the flow runout distance increases as a linear function of the column initial height. On slopes over θ_c, however, the runout distance is also dependent of the column volume, contrary to what was reported on the horizontal in former studies and extrapolated for higher slopes. Three regimes are observed during a granular collapse: an acceleration followed by a deceleration and a last slow propagation phase that appear for slope angles over θ_c and which duration increases for decreasing aspect ratio and increasing volume.

For flows on an erodible bed, erosion processes significantly boost the flow front propagation over the critical angle θ_c, mainly during the deceleration and the slow propagation phase. The granular avalanche excavates the erodible layer immediately at the flow front, behind which waves traveling downstream help entraining grains from the erodible bed. Erosion efficiency (i.e. depth and duration of excavation, waves amplitude and duration) is shown to increase as the slope angle and the column volume increase. It is also dependent on the thickness gradient in the initial column, and on the nature of the erodible bed: the maximum excavation depth and the duration of excavation are smaller as the degree of compaction of the erodible granular bed increases.

Erosion processes notably increase granular flows runout distance at inclinations close to the repose angle of the grains in particular for columns of small aspect ratio and great volume. The runout distance increase compared to the case on the rigid bed is shown to increase as the duration of bed mobilization increases. We demonstrate, moreover, that the flow runout distance on an erodible bed cannot be reproduced on a rigid rough bed by simply adding the entrained volume of erodible bed to the initial column volume. This suggests that a regular supply of mass by entrainment during the propagation is necessary to increase the flow runout distance.