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Rozprawa doktorska p.t. "*Numerical modeling of granular material collapses in the context of analysis of Martian landslide dynamics*".

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Summary

Landslides, debris flows and avalanches sculpt the surface morphology on Earth as well as on other planets. They constitute one of the most efficient weathering processes currently active on Mars. On Earth, mass failure results in the destruction of human lives and infrastructures. Since the first pictures returned from Viking Orbiters, the numerous landslides identified along the canyons of Valles Marineris have been the subject of considerable controversy as potential clues of the presence of liquid water on Mars in the past.

Numerous numerical works have been carried out on real landslides cases using DTM (Digital Topographic Model) so as to improve our understanding of their development by comparing results with field observations. Many previous studies have been based on run-out analysis in relation to mean dissipation calibration via the friction coefficient. The geometry of the landslide may also play an important role in landsliding and mass spreading but it is usually unknown. This research has aimed at understanding the factors that control the initiation and run-out of large landslides wherever they occur. It is important to note that Martian landslides have all these similar terrestrial features.

The collapse of a granular column is of great interest in this context and has been recognized as an important phenomenon useful for studying transient granular flow conditions and for modeling geophysical flows of granular materials. In this work, we

present a systematic numerical study of the axi-symmetric and dam-break rectangular collapse of granular columns. We use the 3D Discrete Element Method (DEM) with spherical representations of the particles and systematically study the sensitivity of the outcome with respect to the key model parameters.

We have numerically investigated the collapse and the spreading of rectangular and axisymmetric columns of grains onto a vertical and sloping plane using the Discrete Element method. The results qualitatively match the analyses the experimental results. Quantitative relationships between the column aspect ratio, initial volume and normalized run-out distance were established. The simulations confirm the existence of a linear and a power-law dependence on the aspect ratio of the initial column, as observed experimentally. Also, comparison between our numerical results and published data on the Valles Marineris landslides on Mars shows, if one assumes that the physical processes are length-scale independent, that energy dissipation for these natural flows is much lower than that of typical dry frictional granular materials. However, slope effects are not strong enough to explain the high mobility of Martian landslides. As a result, other geological processes should play a key role into the dynamics of Martian landslides. The fact that landslides can travel larger distances than expected from simple frictional and/or slope arguments has led us to hypothesise that fluids or ice play a significant role in reducing solid friction. The very low friction angles for Martian landslides could be due to propagation directly on ice, like the Sherman landslide on Earth. The absence of detection of surface ice by either Mars Express/OMEGA or the MRO/CRISM spectrometers could be then due to a thin dust cover. It is possible, alternatively, that fossil ice is covered by glacial till, a non consolidated rocky material that would be easily removed by the propagating debris. Some landslides in Valles Marineris propagated with a friction angle which is even weaker, which is also consistent with propagation on ice. It may be hypothesized that the difference in friction angle for Martian landslides results from the differences in the quantity and size of rock pieces of glacial tills on fossil ice.