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Some influences of rock strength and strain rate on propagation of rock avalanches

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Rock avalanches are extreme and destructive mass movements in which large volumes of rock (typically >1 million cubic metres) travel at high speeds, covering large distances, and the occurrence of which is highly unpredictable. The “size effect” in rock avalanches, whereby those with larger volumes produce greater spreading efficiency (as defined by an increase in normalised runout) or lower farboschung angle (defined as the tangent of the ratio of fall height to runout length), is well known. Studies have shown that rock strength is a controlling factor in the mobility of rock avalanches – that is, mass movements involving lower strength rock are generally found to produce greater mobility as evidenced by the spread of deposits or low farboschung angle. However, there are conflicting ideas as to how and why this influence is manifested.

This paper discusses different theories of rock comminution in light of numerical simulations of rock clasts undergoing normal and shear induced loading, experimental work on rock avalanche behaviour, and dynamic fracture mechanics. In doing so, we introduce the idea of thresholds of strain rate for the production of dynamic fragmentation (as opposed to pseudo-static clast crushing) that are based, inter alia, on static rock strength. To do this, we refer to data from physical models using rock analogue materials, field data on chalk cliff collapses, and field statistics from documented rock avalanches. The roles of normal and shear loading and loading rate within a rock avalanche are examined numerically using 3D Discrete Element Method models of rock clasts loaded to failure. Results may help to reconcile the observations that large rock avalanches in stronger materials tend not to fragment as much as those in weaker materials and also possess lower mobility, while small cliff collapses (typically > 1000 cubic metres) in weak chalk can exhibit rock avalanche-like behaviour at much smaller volumes.