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Erosion and strain scaling tests for the characterization of water-saturated granular materials used in analogue mountain building experiments

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Experimental modelling of relief and river dynamics commonly uses mixtures of water and granular materials such as sands, rock and plastic powders (Schumm et al., 1987 ; Hasbargen and Paola, 2000 ; Crave et al., 2000 ; Hancock and Willgoose, 2001 ; Lague et al., 2003 ; Graveleau et al., 2005). In Graveleau et al. (abstract, this session), we have used different water-saturated granular materials to modelize the morphologic evolution of active forelands. Our objective is to study the coupling processes between Tectonics, Erosion and Sedimentation that control relief formation and crustal deformation.

To determine analog material composition and rheology and improve scaling between our experimental models and natural landscapes, we have performed several laboratory tests to determine their physical properties. These analyses have been conducted using two different experimental devices.

The first one is used to estimate erosion and transport laws of our analog material. It consists in an inclined rectangular box filled with the analog material to be tested. Erosion and transport processes are modelized using a rainfall system that induced water runoff at the surface of the material. The rainfall system is the same used in our analog experiments of mountain building. Water and sediments output fluxes are accurately measured at the box outlet (cumulative weight curves). These measurements are done for different initial surface slope conditions (from 0° to 25°) to study the relation between slope and erosion rate.

Typically, our analog materials exhibit erosion rates in the range of 1-10 mm/h depending on their composition and grain shape.

Sediment flux curves are compared with the evolution predicted by a classical stream power erosion-transport law (Q = k $\times$ A^m $\times$ S^n), which is justified by the observation of river-like sediment transport mode in our experiments. Using stream power law numerical solutions, exponents m and n are calibrated to fit the experimental data. At first order, the result of this calibration indicates that the water saturated granular material we used have very similar parameters as natural river systems.

The second device is used to measure the mechanical properties. It consists in a box filled with water-saturated material that moves toward a frictionless backstop equipped with a strain gauge. Shortening typically generates a sand-wedge composed by successive forward thrust faults. Continuous measurements of the force acting on the backstop show strength profiles that exhibit standard stress-strain curves characteristic of elastic/frictional material behavior. The observed strain hardening prior to failure and strain softening leading to a stable strength are consistent with those of natural rocks.

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