Effects of debris-flow composition on runout distance and depositional mechanisms in laboratory experiments

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Introduction

Debris-flow composition

- Debris-flow composition is i.e., hended in generally neglected in runout distance predictions.
- The effects of debris-flow composition on debris-flow depositional mechanisms is poorly understood.

Need for small-scale experiments

- The effects of debris-flow composition on runout distance and depositional mechanisms have been largely neglected for practical reasons.
- Experiments enable detailed control of boundary conditions, such as debris-flow composition. However, unconfin ed experimental debris flows with self-formed levees and a marked lobe have only been formed in the large-scale USGS laboratory flume, and have not been formed in smaller-scale flumes to date.

Objectives

- We aimed to:
  - Experimentally create unconfined small-scale debris flows that show similar flow behavior, grain segregation and deposit morphology as natural debris flows.
  - Evaluate the effects of debris-flow composition on runout distance and depositional mechanisms.

Methods

Experimental setup

- We experimentally created 190 debris flows.
- Flume (Fig. 1): Channel: >0.01 inclination, 0.12 m wide, 2 m long.
- Outflow plan: 10° inclination, initial ~1 cm thick sand bed.
- Hatch to drain debris flow to prevent overflow of the initial deposit.

Data collection

- Key experimental results:
  - The small-scale experimental debris flows comprised multiple surges, coarse particles accumulated at the flow front, and were subsequently shouldered aside to deposit in lateral levees by a more liquefied flow body. This resulted in strong sorting, with the coarsest particles concentrated in lateral levees and at the frontal margin (Fig. 3).

Discussion

- Sediment sorting and morphology of the experimental debris flows is similar to natural debris flows (Fig. 7).
- Width-to-depth ratio of the experimental debris flow channels is in the range of natural debris flows. Runout length (or travel distance) is relatively restricted and at the lower range of natural debris flows (Fig. 8).
- Lobe height generally determined by the frontal accumulation of coarse particles, not by yield strength.

Conclusions

- We experimentally created unconfined small-scale debris flows with self-formed levees and a marked depositional lobe.
- Flow dynamics, deposit morphology and sediment sorting were similar to natural debris flows.
- Debris-flow composition has a profound effect on runout distance and depositional mechanism.
- There is an optimum runout distance for gravel and clay fractions, whereas runout increases with water fraction (latter result not shown on this poster).
- Debris-flow deposition is primarily governed by friction at the flow front in most debris flows, but in debris flows with a very high clay content high viscosity and yield strength govern deposition.

Future experimental work:

- Debris-flow fans: studying the autogenic dynamics of debris-flow fans (Fig. 9).
- Debris-flow erosion: studying the erosive potential of debris-flows of various composition (Fig. 10).

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References

- Rickenmann, 1999
- De Ruig & Hoozemans, 1986
- Typical range of natural debris flows
- Fig. 1: Experimental setup. A. View of the experimental setup. B. In situ overview of the experimental setup.