Lahars as landscape modifiers: how repeated lahar emplacement affects flow behaviour.

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Lahars are volcanically-generated mudflows (debris flows to hyper-concentrated stream flows) that travel down valleys, with catastrophic consequences. They have caused the deaths of >37,000 people since 1600 AD, and destroy any buildings and infrastructure in their path. Lahars change the morphology of the drainage networks down which they flow, and can reoccur repeatedly within single drainage networks over timescales of days to centuries. Field studies have noted how they can interact with existing stream-flow, potentially changing the behaviour of the lahar. However, the nature of these flows means that direct measurements of their behaviour and properties is difficult and hazardous. The BSG provided funding through the Early Career Researcher Grants award to build a new, specially designed flume facility at the University of Hull to enable analogue modelling of lahars under a variety of conditions.

Aims

1. Develop a novel flume facility designed to accommodate repeated lahar experiments
2. Test how existing stream-flow affects the velocity and run-out distance of lahars
3. Test how the deposits of lahars affect the velocity and run-out distance of subsequent lahars
4. Develop techniques for using Gigapan and video photogrammetry to record and interpret lahar parameters for both experimental and field studies. Lahars are increasingly captured on video, yet little is done to obtain quantitative data from the footage

Methods

A 4 m by 1 m flume was specially constructed in early 2015 to simulate lahars (Fig 1). The flume is pivoted, so that the upper 2 m portion of the flume can be raised or lowered allowing experiments to be run over a variety of slope angles (0-45 degrees). Mixtures of sediment (clay, sand and gravel) are mixed by hand and loaded into a remotely-operated feeder box. Experiments are captured using a variety of cutting-edge techniques in recording flow behaviour and analysing deposit morphology such as HD video cameras, terrestrial laser-scanning, Gigapan and structure-from-motion photogrammetry.

The project is in the testing stage and a variety of different experiments have been done to test the capability of the flume. The first series of experiments investigated the effect of changing sediment concentration over a variety of different slopes (5-45°). A second series of experiments investigated the effect of streamflow on lahar velocity and run-out. Water was run down the flume at rates of 0, 0.11, 0.17 and 0.22 ls^{-1}. Lahars were then released into the existing streamflow on varied slope angles (15-45°).

Results

The lahar flume was able to simulate known lahar behaviours and deposits including channels, levees and grain-size grading. An increase in slope angle has a strong positive correlation with velocity and run-out distances, typical for laminar flow. An increase in sediment concentration has a strong negative correlation with velocity and runout distances, due to increasing yield strength. An increase in streamflow has a strong positive correlation with velocity and run-out distance, likely due to decreasing bed friction and increasing water content of the lahars.

This preliminary data was presented at the VMSG Annual Meeting in 2016 (poster available here), with plans to present at the BSG 2016 Annual Meeting. Preliminary data from these early experiments will form pump-prime data for RCUK funding. The flume continues to be used for experiments and is a lasting legacy.

Figure 1. Lahar simulation flume, set at 35 degrees. The feeder box is operated remotely using an electronic winch.