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Experimental Investigations of Granular Matter Flow Regimes leading to Insight into Lahar Flow Dynamics

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Abstract

The flow of granular material governs numerous natural processes including the aeolian dynamics of sand dune formation, sub-aerial and submarine mass flows, the collective dynamics of ice blocks floating on the ocean, avalanches of debris and snow, as well as volcanic granular-fluid flow processes, such as pyroclastic density currents, volcanogenic debris flows and lahars.

Lahars are a particularly important type of granular flow, in regards to its possible effect on human life; they are debris and water-based flows, initiated by volcanic processes. A fascinating aspect about granular matter is the co-existence of behaviour similar to two or all three of the classical states of matter (solid, liquid, gas) and their frequent transitions between these behaviours. Despite the ubiquity of these transitions in nature and industry, the fundamental physics of granular matter remains a mystery, to the extent that a unified theory to describe the motion and behaviour of granular matter is still absent.

This study is an attempt to simulate lahars and their erosion/deposition mechanics in the laboratory by making use of a rotating drum. A rotating drum can be treated as an analogue for a lahar because it allows for erosion and deposition to occur as an active region of material flows over a passive, erodible bed. In nature these processes are transitory and highly dynamic, but an experimental analogue allows for the processes to be observed in a steady system.

Results include detailed maps of the various regions in a flowing granular material cor-

related to the speed of rotation of the flows. The changing status of the active and passive regions allows for measurements of the erosion mechanics within the drum. Also, potentially identified are two new phenomena; high speed rotations appear to include features similar to Kelvin-Helmholtz instabilities, and enclosed regions of sub-rotation, which are referred to as self-enclosed circulation cells (SECCs).

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Apologies to anyone who feels they should be listed here but aren't - your omission was not intentional, and should be seen as a reflection of my poor memory, rather than your lack of contribution.

Declaration

I hereby declare that this thesis is my own work and effort and that it has not been submitted anywhere for any award. Where other sources of information have been used, they have been acknowledged.

Adam Neather, August 2, 2017

Jim Jones

Shane Cronin

Gert Lube

"One can scoop up poppy seeds with a ladle as easily as if they were water and, when dipping the ladle, the seeds flow in a continuous stream."

- Titus Lucretius Carus, ca. 90 to 55 BCE

Quoted in Sands, Powders, and Grains: An Introduction to the Physics of Granular Materials (Springer, New York, 2000) by D. Jacques.

"If you sneeze into it, and it goes everywhere, then it's a powder."

- Dr. Marco Brenna, 28th November 2012

Quoted at the Geological Society of New Zealand annual conference BBQ.

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