April 2018

Synthesizing Field and Experimental Observations to Investigate the Behavior of Pyroclastic Density Currents

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Abstract
One of the major hazards associated with volcanic eruptions are pyroclastic density currents (PDCs), which are fast-moving volcanic avalanches consisting of ash, boulders, and gas. Because of their unpredictability, studying PDCs in real time is dangerous and difficult. Therefore, we investigate the deposits produced by PDCs and use granular flow experiments to simulate PDCs in the laboratory. The experimental results allow us to understand sediment transport and erosional processes at small scales, and then we can extrapolate those results to natural PDCs. By better understanding what controls PDC behavior, we hope to ultimately improve risk assessment for these dangerous flows.

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What is a pyroclastic density current?

Pyroclastic density currents (PDCs) are:
- Ground-hugging mixtures of volcanic gases and solid particles ranging in diameter from microns to meters
- Highly unpredictable and capable of traveling 100s of kilometers at 100s of degrees C, making direct observation difficult
- The most deadly phenomenon associated with explosive volcanic eruptions

PDCs consist of two main regions:
1. A dilute upper ash cloud that obscures the view of the interior
2. A dense basal portion that transports >95% of the flow mass and controls overall flow behavior

Field observations – Wave-like features

We observe wave-like mixing features throughout the PDC deposits at Mount St Helens.

The wave-like features are:
- Self-similar in form
- Varied in size by over two orders of magnitude
- Found both at unit contacts and within individual units
- Most commonly formed on top of earlier PDC deposits

What causes flow to travel further?
- Higher slope (light to dark)
- Fluidization (blue vs orange)

Effect of bed characteristics on flow behavior

How does the diameter of particles in the bed affect flow behavior?
- No significant change except for when particles are 80 microns

Estimating flow thickness using experimental results:

Using relationships derived from experiments, we can constrain the PDC thickness based on the height of wave-like features observed in the field.
Estimates for flow thickness:
- Tallest waves: ~8 m
- Shortest waves: <0.15 m

Wave-like features form due to granular shear instabilities:
- Previous numerical and experimental studies attribute the formation of similar wave-like features to granular shear instabilities

Future Work

In future work we will:
- Investigate applicability of the Instability Growth Criterion to experimental flows
- Use experimental results to decrease error on velocity estimates
- Explore what affects extreme behavior at high slopes

References and Acknowledgements

[Insert references and acknowledgements here]

Eruption of Mount St Helens – May 18, 1980

Following months of precursory activity, the eruption of Mount St Helens began with the largest landslide in recorded history at 8:32 a.m. on May 18, 1980.

Soon after the landslide, the eruption transitioned to a typical eruption with large, sustained ash plume (at right). Later in the afternoon, the ash column began to collapse, producing at least three periods of PDC activity.

Scaled, analogue granular flow experiments

Through a series of over 120 scaled, granular flow experiments we investigate:
- How does fluidization (i.e. internal gas) affect the flow?
- What controls the initiation of erosion and by what processes does the flow erode?
- How does the nature of the bed (angle, size of particles) affect flow behavior?

Experimental observations – Wave-like features

What controls wave height?

Height of waves formed in fluidized flows are ~1/4 the total flow height.