Experimental Study of Sedimentation in Pyroclastic Density Currents

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Motivation

Pyroclastic density currents (PDCs) are composed of pumice and ash at high temperatures (>400°C) that travel at high velocities (>100 km/hr) for large distances (>10 km). These volcanic events are very destructive and therefore are difficult to study in nature. Experimental modeling of currents on a laboratory scale is useful to explore parameters that control PDC behavior. Our experiments address the following questions:

• What factors affect how far a pyroclastic density current will travel?
• How are transport processes recorded by deposits?
• How much of the initial current mass fractionates into the coignimbrite plume?

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Our experiments are dynamically similar to dilute natural PDCs.

Methods

• 2B x 2B x 8.5 ft. tank for unconfined currents
• A conveyor belt feeds powder down a chute to generate currents
• Experimental parameters can be varied (temperature, duration, eruption rate, particle distribution)
• Orthogonal laser sheets to illuminate dilute currents
• 3000 fps camera to study particle-particle interaction
• Seven 30 fps cameras sensitive to red, green, and blue

Results

Data

Sedimentation maps show the amount of sediment deposited by each current.

Experimental parameters:

Eruption rate: .12 g/s
Current mass: 72.1 g
Initial powder temperature: T = 23.0°C
Ambient temperature: T = 17.3°C

Currents with high eruption rates and short durations produce proximally thicker but distally thinner deposits.

Future Research

• Develop sedimentation model as a function of current parameters.
• Explore effects of particle distribution on current transport and deposition.
• Describe how current “residence time” at one position is reflected by the deposit.
• Quantify coignimbrite fractionation.

Acknowledgements and References

We thank Tim Gooding for exceptional help with lasers and equipment. I would like to thank Ben Andrews and Rob Dennen for being amazing mentors and making this a truly wonderful experience. Thanks also goes to Lu Cottrell, Gene Hunt, and Virginia Power for all their contributions to the NSH program. This work was funded by the SI Consortium for Unlocking the Mysteries of the Universe, NMNH Small Grants Program, funds from the Director’s Office, and National Science Foundation: Natural History Research Experiences (REU Site, EAR-106269).


Clarke, A. B., Voight, B., 2000. Schematic showing deposition as a function of eruption parameters.

Top view of currents at 50 second intervals.

Different particles are used to simulate volcanic currents with broad size and density distributions.

(Above images, from left to right)
Red, green, and blue channels together, just red, just green, and cross-sectional view.

Sedimentation

Sediment traps are placed at known locations to measure deposition throughout the tank during each experiment.

64 sediment traps arrayed on the floor.
Traps have been collected and remnants of the deposit can be seen.

Effects of Eruption Duration and Rate

Effects of Initial Current Mass

Sedimentation maps show the amount of sediment deposited by each current.

Hot currents produce noticeably narrower deposits and have shorter run-out distances.

Currents with high eruption rates show oscillating patterns of transport and deposition.

Long duration currents show spreading of air. Hot currents have narrower deposits because liftoff prevents lateral spreading.

At fast eruption rates, more energy is put into the system which makes the currents denser and thicker, therefore they travel faster and farther (these are density driven currents).

Increased duration does not increase run out, but does affect transport processes. For example, long duration currents oscillate laterally.

Deposits can all be fed with third order polynomials relating mass to isopach area. Depositional curves shift in predictable ways in response to changes in eruption parameters.

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