Using Clay Models to Understand Volcanic Mudflows

by Eric Laney and Steve Mattox

Gravity is a subtle but ubiquitous force that influences nearly all geologic processes from the formation of ores to the flow of glaciers and rivers. Gravity also determines the path some materials take as they flow down volcanoes. Lava flows, mudflows (also called lahars), and pyroclastic flows are three such materials. Understanding the factors that influence their path is critical to protecting lives and property. In this lesson, we focus on mudflows and demonstrate simple ways for students to predict their paths using 3-D clay models. Students are then asked to transfer their new knowledge to a real volcano.

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Lahars are fine-grained Earth materials that move with a high degree of fluidity. They commonly form by hot ash falling on glaciers. The hot ash melts part of the glacier and the muddy mixture flows down the flank of the volcano. Shallow intrusions of magma or the growth of lava domes can also trigger lahars. Even heavy rains on poorly consolidated ash can form volcanic mudflows. Since recorded time they have caused over 30,000 fatalities and billions of dollars in economic losses. Although recent dramatic lahars have occurred in Columbia, Indonesia, and the Philippines, the risk associated with this volcanic hazard is just as high at some Cascade Range volcanoes, especially Mount Rainier in Washington (Hoblitt et al. 1998).

Stratovolcanoes are steep-sided, symmetrical cones with a basal diameter of about 10 km and heights up to 2.4 km. They are constructed of alternating layers of lava flows, volcanic ash, cinders, and blocks. They commonly erupt from central vents located at their summits. The production and path of lahars will be influenced by the location and style of eruption or melting event. For example, a small, ash-producing eruption on a calm day might melt ice across the summit and send low-volume lahars down numerous valleys. The same eruption, on a day with westerly winds, might send lahars down valleys on the east flank of the mountain. Although we will provide basic information about lahars, a complete description is provided by the U.S. Geological Survey (see Resources). In this activity we want to model the formation of lahars and provide students with opportunities to predict their path and then test their predictions.

To engage the students we ask them to make a simple line drawing of erupting volcanoes (Mattox 2000). Students commonly draw stratovolcanoes erupting lava and/or pyroclasts (e.g., ash, pumice, or cinders). Although we have used this activity with hundreds of students and preservice teachers, no one has ever drawn a lahar (perhaps because we live in the Midwest). If one of your students does draw a lahar, ask her or him how it formed and what determines where it goes. If no one draws a lahar, acknowledge the hazards they do know (lava flows, pyroclasts, ash clouds, etc.) and indicate that the day's lesson is on lahars, a lesser-known but important volcanic hazard.

Watching a video prior to the activity might help your students to better understand lahars. Several videos are available. Perhaps the easiest to obtain is the 1997 Hollywood film *Dante's Peak*. On the DVD, Chapter 30 has a segment from 1:18:40 to 1:22:56 that shows the onset of melting ice and the generation of a very fluid mudflow. The clip shows the general nature and power of a lahar, but is a bit overly dramatic and includes a van being swept away. Far superior is the U.S. Geological Survey's *At Risk: Volcano Hazards from Mount Hood, Oregon*, which provides minutes of lahar footage from the eruption at Mount St. Helens and Mount Hood (see Resources). The video also summarizes the formation of lahars and provides meaningful examples of predicted flow paths.

Model preparation

Models can be prepared ahead of time by the teacher or during class by small groups of three to five students. Figure 1 includes a materials list and instructions for building the models. The size and shape of the valleys are not critical but there should be at least one in each quadrant. Each volcano model will be unique, but it will share basic features of stratovolcanoes with deep glacial valleys. To simplify cleanup, cover the model in clear plastic wrap. To assist students during the activity, add place names to each valley, place directional indicators (north, south, etc.), and locate several hypothetical towns on the periphery of the cone.

In a cup, have students mix a slurry of mostly soil or sand and a small amount of water. Ideally, the mixture should have the consistency of wet cement (so it flows under its own weight, but not too fast). The slurry will be poured onto the clay volcano at different locations and in different volumes.

Modeling mudflows

Science teachers commonly use models to make abstract concepts or unavailable features more concrete in their students' learning (Gilbert and Watt Ireton 2003). Scientists commonly need to observe 3-D features or models and record their data and observations in a two-dimensional format. For example, a geologist might map a volcano or run lab models and then record data on a two-dimensional map. Your students will benefit by mimicking this process.

Here we propose several hypothetical questions to assist students in constructing their understanding of what factors influence the movement of lahars. We drew a simplified two-dimensional map of the 3-D model to assist students in recording their observations (Figure 2). Individual models and maps will be different, but drawings such as Figure 2 are easy to make and can be done by hand. Furthermore, the questions are generalized and can be applied to any model and two-dimensional map.

We suggest two ways to model the lahars. Ideally, individual students at a work station or in small groups of

PHOTO COURTESY OF USGS

FIGURE 1 **Making the volcano model**

Materials (per volcano)

- cardboard (cut in 30 x 30 cm squares)
- cup (a few)
- modeling clay (about 1.4 kg per model, about $7)
- plastic wrap (about 30 x 30 cm square)
- sand or mud (about 200 ml)
- toothpicks (for flags on model)
- water (as needed)

Procedure

On a 30 × 30 cm piece of cardboard construct a 7–10 cm tall cone of clay with a circular base of about 25 cm in diameter. This represents the topography of a common stratovolcano. Using either fingers or a spoon, carve a shallow crater at the summit of the cone and deep, U-shaped valleys in the flanks. Mark hypothetical towns with blue flags.

FIGURE 2 **Map showing a top-down view of a volcano with a summit crater, glaciers (white), glacial valleys, and intervening ridges (gray).**

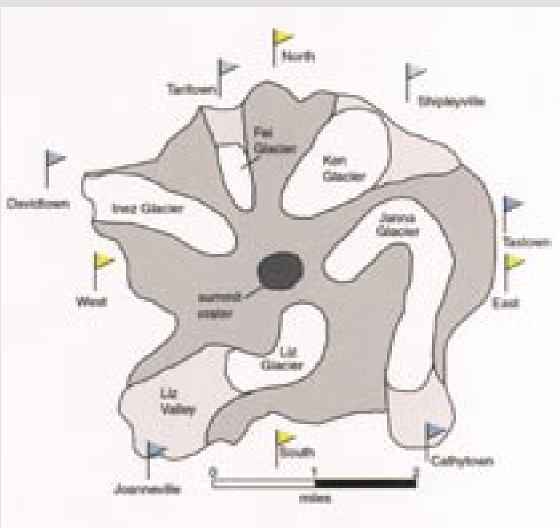


FIGURE 3 **Student questions**

1. A small volume of hot ash falls directly on Inez Glacier. Will Davidtown be threatened by this mudflow? Justify your answer.
2. A large volume of hot ash falls directly on Ken Glacier. Will Shipleyville be threatened by this mudflow? Justify your answer.
3. A long-lived shallow intrusion of magma starts melting glacial ice. The melting ice mixes with nearby soft ash deposits near Janna Glacier. Will Tastown be threatened by this lahar? Will Cathytown be threatened by this lahar? Justify your answers.
4. Heavy spring rains fall on the south side of the volcano. The rains trigger old ash deposits to start flowing down the Liz Valley. The slurry turns into a lahar. The rains last for several days. What city might be threatened by this lahar? Justify your answer.
5. Generate and test your own scenarios.

three to five (with students wearing safety goggles) pour the mud slurry on the 3-D models to test their own scenarios or those presented in the student questions (see Figure 3). In this case, the teacher serves as a facilitator. Alternatively, the teacher might pour the mud on a single model to demonstrate some or all of these possibilities to the class and guide the students through the questions (Figure 3). It takes about 15 minutes to construct the model and 20–30 minutes to answer the questions. After the activity, peel the plastic wrap off the model and discard it along with any left over slurry. Form the modeling clay into a ball and stow it in its air-tight container (we found that the clay dries out and begins to crack after a month or two).

Assessment and extensions

We use a summative assessment with students after they have successfully completed the activity with the 3-D clay model and the map (Figure 2). We have also developed a short map exercise that serves as an authentic assessment. Geologists at the U.S. Geological Survey have produced lahar hazard maps for many Cascade volcanoes (see Resources). In this exercise we guide students through an examination of Mount Rainier, a stratovolcano near Seattle, Washington. Mount Rainier poses a high risk for lahars. Students will interpret maps and answer a series of questions (see Figure 4).

As an extension, students can investigate other volcanoes with significant risk for lahars. Instruct students

FIGURE 4 **Mt. Rainier lahar worksheet**

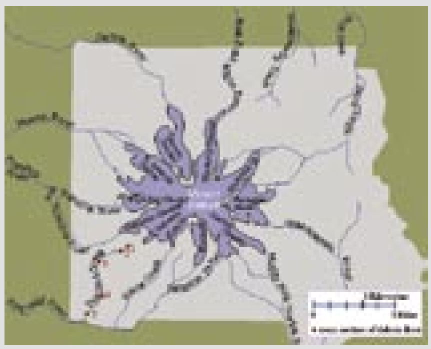
Read the questions carefully before answering.

1. What is a lahar?
2. During an eruption, the rapid melting of what features on Mount Rainier combined with mud and debris may cause a lahar?
3. (True or False) Lahars, like rivers, tend to flow toward low areas such as river valleys.
4. (True or False) Because of lahars' attraction toward low areas they tend to follow the paths of rivers.

For the following questions use the maps below. Larger versions can be downloaded from websites found in References.

(Topinka 1997)

1. What is the height in feet of Mount Rainier?
2. If the Tahoma Glacier were to melt creating a lahar, what river would it likely flow into?
3. If the Carbon Glacier were to form a large lahar, would the town of Ashford be in danger? If not, what town would be?
4. The towns of _____________ and _____________along the _____________ River may need to be evacuated if the S. Tohoma and Kautz Glaciers form a lahar.
5. During a large eruption, massive lahars flowing along the Puyallup, Carbon, and White River may combine and flow into which body of water? ___________ Before entering this body of water the heavily populated city of _____________ along the coast may receive large-scale damage.
6. A lahar formed at the Nisqually Glacier and traveling down the Nisqually River would have to travel approximately how many miles to reach Alder Lake?
   50 miles 25 miles 5 miles 10 miles



(Scott, Pringle, and Vallance 1992)

to write at least one page covering an example of a historic lahar (e.g., Nevado del Ruiz or Mount Pinatubo) or describe the current risk at a Cascade volcano. Students can write on any volcano of their choosing, but it must be one that has not been covered in class. The essay should include history, location, and hazard statistics, and should conclude with ways people can be more prepared for lahars. ■

Resources

U.S. Geological Survey—*usgs.gov*

U.S. Geological Survey, *At Risk: Volcano Hazards from Mount Hood, Oregon*—Northwest Interpretive Association, 3029 Spirit Lake Highway, Castle Rock, WA 98611, (360) 274-2127.Cascade lahar hazard maps—*vulcan.wr.usgs.gov*

References

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