Critical Zone Observatories
U.S. NSF National Program

EDUCATION & OUTREACH

Critical Zone Observatories
U.S. NSF National Program

Mini-Landslide

Links:
This with extensions: http://bcczo.colorado.edu/eno/agi-czo.pdf
Video: https://youtu.be/9oCWkEIPK_4
Houses: http://bcczo.colorado.edu/eno/agi-houses-czo.pdf
Work Sheet: http://bcczo.colorado.edu/eno/agi-landslide-worksheet.pdf

In the week of September 9th, 2013
A stalled cold front over Colorado collided with warm air from the south, causing persistent, heavy rain. By September 15th, rainfall totaled 17 inches (430 mm) in Boulder County, more than 1000 landslides occurred, and many roads were damaged. One question is why landslides occurred in some locations and not others.

ACTIVITY SUMMARY
Students explore how different materials (sand, gravel, lava rock) with different water contents on different slopes result in landslides of different severity. They measure the severity by how far the landslide debris extends into model houses and roads placed in the flood plain. This activity is a small-scale model of a debris chute used by scientists to study landslide characteristics.

INTRODUCTION:
Not all hills and mountains are made of the same materials. There are different types of rock, sand and soil found everywhere. Have you played with sand before? How about modeling clay? If you made a castle out of each of these materials, which one would be more likely to fall down?
(Answer: The one made from sand.) One hillside covered with a certain material may be more stable than another of the same size and shape. Also, when you add water to different materials, it is hard to predict what might happen. Material properties matter to how well a hillslope holds up or how strong it is. Landslides are the result of gravity and friction acting on these different types of earth materials (rock, soil, sand, gravel, etc.).

Today, we are going to have some fun and learning about landslides by creating our own landslides. We are going to build houses, and see if they get wiped out by the landslides. Not all hills and mountains are made of the same materials, we are going to test different situations. Scientists and engineers perform these same experiments to understand how real-life landslides work—let’s give it a try!

LEARNING OBJECTIVES
After this activity, students should be able to:
• Define landslides as the result of gravity and friction acting on different types of earth (rock, soil, sand, gravel, etc.).
• Relate that different types of materials that create different landslide dynamics.
• Explain how adding water weight to landslide materials reduces friction, increasing landslide dangers.
• Describe how studying landslides allows scientists to determine where and when there are risks to buildings and people from landslides.

MATERIALS LIST
Each group needs:
• Model House Template and 1 sheet of cardstock (for construction of model houses)
• Transparent tape, scissors, markers, colored pencils, or crayons (to decorate houses)
• 2 small paper cups; one for water, one for test material
• Mini-Landslide Worksheet, one per student

To share with the entire class:
• 2 ft (.6 m) section of plastic downspout (~$5)
• 1 bag small bag of each: sand (~$20), pea gravel (~$4), and volcanic (lava) potting rock (~$6)
• 1 large, shallow, plastic waterproof tub (8-in x 14-in x 30-in, clear plastic is best but not necessary) (~$10-$20)
• Duct tape, scissors (to cut downspout plastic), ruler
• Stack of books, stool or chair, to support downspout
• Plastic scoop (optional, or use small paper cup)
• Plastic bins to hold, wet and store the sand, gravel and volcanic potting rock (optional)

ACTIVITY SUMMARY
Students explore how different materials (sand, gravel, lava rock) with different water contents on different slopes result in landslides of different severity. They measure the severity by how far the landslide debris extends into model houses and roads placed in the flood plain. This activity is a small-scale model of a debris chute used by scientists to study landslide characteristics.

INTRODUCTION:
Not all hills and mountains are made of the same materials. There are different types of rock, sand and soil found everywhere. Have you played with sand before? How about modeling clay? If you made a castle out of each of these materials, which one would be more likely to fall down?
(Answer: The one made from sand.) One hillside covered with a certain material may be more stable than another of the same size and shape. Also, when you add water to different materials, it is hard to predict what might happen. Material properties matter to how well a hillslope holds up or how strong it is. Landslides are the result of gravity and friction acting on these different types of earth materials (rock, soil, sand, gravel, etc.).

Today, we are going to have some fun and learning about landslides by creating our own landslides. We are going to build houses, and see if they get wiped out by the landslides. Not all hills and mountains are made of the same materials, we are going to test different situations. Scientists and engineers perform these same experiments to understand how real-life landslides work—let’s give it a try!

LEARNING OBJECTIVES
After this activity, students should be able to:
• Define landslides as the result of gravity and friction acting on different types of earth (rock, soil, sand, gravel, etc.).
• Relate that different types of materials that create different landslide dynamics.
• Explain how adding water weight to landslide materials reduces friction, increasing landslide dangers.
• Describe how studying landslides allows scientists to determine where and when there are risks to buildings and people from landslides.

MATERIALS LIST
Each group needs:
• Model House Template and 1 sheet of cardstock (for construction of model houses)
• Transparent tape, scissors, markers, colored pencils, or crayons (to decorate houses)
• 2 small paper cups; one for water, one for test material
• Mini-Landslide Worksheet, one per student

To share with the entire class:
• 2 ft (.6 m) section of plastic downspout (~$5)
• 1 bag small bag of each: sand (~$20), pea gravel (~$4), and volcanic (lava) potting rock (~$6)
• 1 large, shallow, plastic waterproof tub (8-in x 14-in x 30-in, clear plastic is best but not necessary) (~$10-$20)
• Duct tape, scissors (to cut downspout plastic), ruler
• Stack of books, stool or chair, to support downspout
• Plastic scoop (optional, or use small paper cup)
• Plastic bins to hold, wet and store the sand, gravel and volcanic potting rock (optional)
PRE-REQ STUDENT KNOWLEDGE
It is helpful for students to have a basic understanding of gravity and friction which are critical to understanding landslides. In addition it is helpful to have a familiarity with geological events (volcanic eruptions, earthquakes and tsunamis) to better understand landslide causes and effects.

PROCEDURE
Before the Activity
• Set up the mini-landslide model activity in advance by first cutting the downspout in half so you have two equal sections. Tip: Cut through the narrow sides of the downspout to create the widest chutes.
• Duct tape one downspout chute section to the bottom of the plastic tub, in the middle of the tub, to create a shallow angle (Figure 1).
• Support the top end of the downspout by taping it to a stack of books, stool or chair.

WITH THE STUDENTS
Note: It is best if the three materials and chute are damp when performing the trials. The materials react differently when wet. Damp materials produce greater uniformity in spreading.
1. Divide the class into three teams (approximately 8-10 students per team).
2. Have each team use the Model House Template to construct three houses per team with the cardboard stock.
3. Assign each team to test the properties of one of the following materials: sand, gravel or lava rock. Each group performs three trials, assisted by the instructor, while the rest of the teams watch and record measurements on their worksheets.
4. Clean off the flood plain (tub) and having students place their houses in three locations relative to the debris chute. During the experiment trials, students will predict whether certain locations are safe from the landslide. Suggested locations: 1) Two inches in front of and two inches to side of the chute path, 2) four inches in front of and two inches to the other side of the chute path, 3) six inches directly in front of chute path (see Figure 2). Label houses: 1, 2, 3 with the numbers on the rooftops.
5. Ask students to predict whether each model house will be damaged or moved during each trial in the activity, and record their predictions on their worksheets. Which of the model buildings will be "damaged" (moved from their original location, or worse) during each landslide trial? Have students record their prediction on the worksheets.

TRIAL 1: EARTHQUAKE
6. Make sure the chute is at the shallowest angle allowed by the bin (see Figure 3). Using a small paper cup, place a one cup of sand at the top of the chute (Figure 3). The material should not slide down the chute at this shallow angle.
7. Next, increase the angle of the slope until material is on the verge of sliding. Simulate an earthquake, a common trigger for landslides, by shaking the chute. The material is not expected to go very far on this trial. It may not even make it out of the chute.
9. Secure the chute at this angle by placing books (or a stool or chair, as necessary) under it and taping it in place.

TRIAL 2: FLOOD
10. This time, place the material in the chute and have a student bring you a paper cup one-quarter full of water. Pour the water into hute above the material. Observe what happens (Figure 4). Have students record their observations on their worksheets.

TRIAL 3: 100 YEAR FLOOD
11. The third trial is similar to the second, except with more water. Use a paper cup half full of water. Pour the water into the chute and watch what happens. Have students record their observations on their worksheets.
12. Repeat the procedure with the other two teams for the other two materials.

RESULTS:
Conclude with a class discussion comparing results. How good were student predictions? What did you observe? How did the steepness of the chute make a difference in the damage caused by the landslides? How did the addition of water make a difference in the severity of the landslide damage? Which material caused the worst landslides? Which landslide scenario caused the most damage? What if we combined the materials? What were the best locations in the trials? Where would the safest location be on the flood plain?

How can a mini-landslide model like this help us understand the many different conditions and results from real landslides? How would students apply what they’ve learned to real-world landslide situations?
Activity Extensions

Have students re-design and place their own new buildings to survive a landslide. Give them some limited supplies and a building size constraint, perhaps about one cubic inch (2.5 cm2). Each landslide material made a different pattern after it came down the chute. Have the students investigate more about the patterns made by the different materials. Then, have them create an informational flyer for an imaginary town that could be affected by a landslide from one of those materials.

Scientist often use modeling to simulate natural disasters. They create different types of models for different purposes, such as mathematical models, computer models, conceptual models and prototype models. Have students investigate when and why different types of models are used.

Have students work in groups of three or four to design, build and test strong mountains that can support houses through a rainstorm. Details are as follows:

1. Gather the following materials: topsoil, random objects (weed blocker, tulle, cotton balls, toothpicks, Popsicle® sticks), LEGO® pieces (3-4 pieces per group), plastic bins (1 per group), and a "rain-maker" (a plastic cup with holes punched in the bottom).

2. Have students brainstorm the things that make landslides happen.
   • Natural causes: flooding and heavy erosion from wind or water, poor soil structure, vibrational force (earthquakes or volcanoes), groundwater pumping
   • Human causes: deforestation (the impact of taking roots out of soil), construction

3. Have students design their mountains. Each should include their material in their designs, which include a plastic bin with a soil/sand/gravel mixture, some LEGO pieces to build a house, and a cup of random materials (the fewer, the better – recommend 2 cotton balls, 1 Popsicle stick, 2 toothpicks, 1 piece of mesh or tulle – scale the amount based on their ages).

4. Tell students that they have two chances to build a mountain out of these materials. Explain the challenge and requirements:
   • Make your mountain as tall as possible. (This keeps groups from settling for small mounds that won’t erode.)
   • The mountain may not be anchored by the sides of the plastic bin: it must be free-standing.
   • No unrealistic designs. For example, do not permit students to drape a cloth over an entire mountain. The additional materials should not be visible; in other words, all materials must be used to internally strengthen the mountain.

5. Before building, give students the materials they have to work with and the bins with soil mixture. Have them draw the mountain design with labels and details. Have them get their design approved before building.

6. Once approved, they can build, test, re-build, re-test. At the end, leave time for clean-up (there is lots!) and some time for them to each reflect (in writing) what worked and what they would do differently next time.

References


Landslide Simulation. Environmental Geology, Geology Education, Mansfield University, Mansfield, PA. Accessed February 15, 2006. (Excellent video animation provides a realistic view of how landslide processes work and the damage that can be done by them; large, 2 MB file) http://www.geologyeducation.com/blackboard/lan/landsld.gif
### Educational Standards

NGSS: Next Generation Science Standards - Science

Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a

**This Performance Expectation focuses on the following**

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables</td>
<td>Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.</td>
<td></td>
</tr>
</tbody>
</table>

**This Performance Expectation focuses on the following**

<table>
<thead>
<tr>
<th>Science &amp; Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.</td>
<td>A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. Testing a solution involves investigating how well it performs under a range of likely conditions.</td>
<td>Cause and effect relationships are routinely identified, tested, and used to explain change. Scientist improve existing methods or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands.</td>
</tr>
</tbody>
</table>

### What is the critical zone?

The NSF-supported Program serves the international scientific community through research, infrastructure, data, and models. We focus on how components of the Critical Zone interact, shape Earth’s surface, and support life. A permeable layer from the tops of the trees to the bottom of the groundwater. An environment where rock, soil, water, air, and living organisms interact and shape the Earth’s surface. Water and atmospheric gases move through the porous Critical Zone, and living systems thrive in its surface and subsurface environments, shaped over time by biota, geology, and climate. All this activity transforms rock and biomass into the central component of the Critical Zone - soil; it also creates one of the most heterogeneous and complex regions on Earth. Please visit us at

### Acknowledgements

The Boulder creek CZO would like to thank the school of Engineering PLUS for letting us modify their NSF funded Integrated Teaching and Learning Program at the College of Engineering, University of Colorado Boulder. The contents of this digital library curriculum were developed under grants from the Fund for the Improvement of Postsecondary Education (FIPSE), U.S. Department of Education and National Science Foundation (GK-12 grant no. 0338326). However, these contents do not necessarily represent the policies of the Department of Education or National Science Foundation, and you should not assume endorsement by the federal government.

04/24/2019