Lesson Three — Lava Layering

Making and Mapping a Volcano

(Original activity is from *Exploring the Moon,* a Teacher's Guide with Activities for Earth and Space Sciences, NASA Education Product EP-306 1994.)

Part 1—

Volcano Construction Experiments

About This Lesson

The focus of this activity is on the sequence of lava flows produced by multiple eruptions. Baking soda, vinegar, and play dough, are used to model fluid lava flows. Various colors of play dough identify different eruption events. Students will be asked to observe where the flows travel, make a model, and interpret the stratigraphy.

Objectives

Students will:

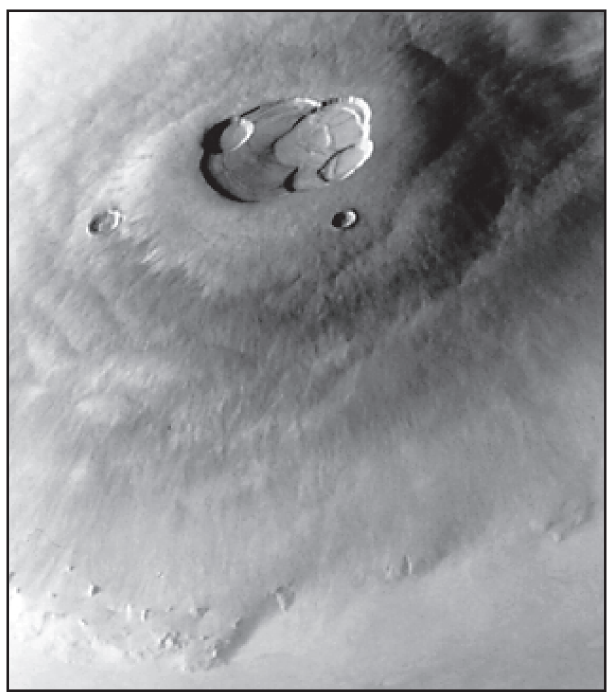
- construct a model volcano.
- follow a procedure to produce a sequence of lava flows.
- observe, draw, record, and interpret the history of the volcano.

Background

Volcanoes and/or lava flows are prominent features on all large rocky planetary bodies. Even some asteroid fragments show evidence of lava flows. Volcanism is one of the major geologic processes in the solar system. Mars has a long history of volcanic activity from the ancient volcanic areas of the southern highlands to the more recent major volcanoes of the Tharsis bulge. Olympus Mons is a volcanic mound over 20 km above the surrounding plains. This one volcano would cover the entire state of Arizona!

Where volcanic heat and water interact here on Earth, scientists are finding life. In the hot springs of Yellowstone Park they have found abundant life forms including some very small bacteria. There is a possibility that life may have found a place in the ancient volcanic terrain of Mars.

Some of the volcanoes on Mars are basaltic shield volcanoes like Earth's Hawaiian Islands. Interpretations of photographs and soil analyses from the Viking and Pathfinder missions indicate that many of the lava flows on Mars are probably basalt. Scientists believe that basalt is a very common rock type on all the large bodies of the inner solar system, including Earth.



Olympus Mons, a martian shield volcano, as seen by the Viking Orbiter.

In addition to shield volcanoes, there are dark, flat layers of basaltic lava flows that cover most of the large basins of Mars and the Earth's moon. The eruption sources for most of the basin lava flows are difficult to identify because source areas have been buried by younger flows.

Generally, the overall slope of the surface, local topographic relief (small cliffs and depressions), and eruption direction influence the path of lava flows. Detailed maps of the geology of Mars and the Moon from photographs reveal areas of complicated lava layering. The study of rock layering is called stratigraphy.

Older flows become covered by younger flows and/or become more pocked with impact craters. Field geologists use differences in roughness, color, and chemistry to differentiate between lava flows. Good orbital images allow them to follow the flow margins, channels, and levees to try to trace lava flows back to the source area.

Vocabulary

eruption, source, stratigraphy, slope, layers

Materials Per Volcano Team

- ❑ 1 paper cup, 100 ml (4 oz.) size, cut down to a height of 2.5 cm
- ❑ 2 paper cups, 150-200 ml (6-8 oz.) size
- ❑ cardboard, approximately 45 cm square (other materials may be used: cookie sheet or box lid)
- ❑ play dough or soft clay — at least 4 fist-size balls, each a different color
- ❑ tape
- ❑ spoon
- ❑ baking soda (4-10 spoonfuls depending on number of flows)
- ❑ vinegar, 100-150 ml (4-6 oz.) depending on number and size of flows
- ❑ paper towels
- ❑ marker or grease pencil
- ❑ paper and pencil
- ❑ optional food coloring to color the vinegar if desired, 4 colors; for example, red, yellow, blue, green
- ❑ Student Sheet, *Lava Layering - Part 1* (pgs. 19-20)

Procedure

Advanced Preparation

1. Review background information and procedure.
2. Gather materials.
3. Prepare play dough using recipes provided or purchase play dough.
4. Cover flat work area with newspaper to protect from spills.

Classroom Procedure

1. This activity may be done individually or in cooperative teams. Groups of 2-4 usually work well.
2. Follow procedure on Student Sheet, *Lava Layering-Part 1.*
3. Discuss the progression of flows, noting that the youngest is on top and the oldest is on the bottom.
4. If Lava Layering Part 2 will be completed at a later time, be sure to cover the volcanoes securely with plastic.

Recipes

Play Dough (stove-top recipe)

Best texture and lasts for months when refrigerated in an air tight container.

2 cups flour *1/3 cup oil, scant*
1 cup salt *2 cups cold water*
4 teaspoons cream of tartar
food colorings (20 drops more or less)

Make this large batch one color or divide ingredients in half to make 2 colors. You will need 4 colors total. Combine ingredients and cook mixture in a large sauce pan, stirring constantly, until the dough forms a ball. Turn dough out onto a floured surface to cool. Then kneed until smooth and elastic. Cool completely; refrigerate in air tight containers.

Play Dough (no-cooking recipe)

2 cups flour *2 tablespoons oil*
1 cup salt *1 cup cold water*
6 teaspoons alum or cream of tartar
food colorings (as above)

Make this large batch one color or divide ingredients in half to make 2 colors. You will need at least 4 colors. Mix ingredients and kneed until smooth and elastic. Store in air tight containers.

Lava Layering — Part 1

Materials

- ❑ 1 paper cup, 100 ml (4 oz.) size, cut down to a height of 2.5 cm
- ❑ 2 paper cups, 150-200 ml (6-8 oz.) size
- ❑ cardboard or other surface, approx. 45 cm sq.
- ❑ playdough or soft clay, 4 fist size balls, each a different color.
- ❑ tape
- ❑ spoon
- ❑ baking soda, 50 ml (1/4 cup)
- ❑ vinegar, 100 ml (1/2 cup)
- ❑ paper towels
- ❑ marker or grease pencil
- ❑ paper and pencil
- ❑ optional: food coloring to color vinegar if desired.

Procedure

1. Take one paper cup that has been cut to a height of 2.5 cm and secure it onto the cardboard. (You may use a small loop of tape on the outside bottom of the cup.) This short cup is your eruption source and the cardboard is the original land surface.
2. Mark North, South, East, and West on the edges of the cardboard.
3. Fill a large paper cup about half full with baking soda.
4. Place one heaping spoonful of baking soda in the short cup.
5. Pour vinegar into a large paper cup leaving it half full.
   (optional: Fill 4 cups with 25 ml (1/8 cup) of vinegar. To each paper cup of vinegar add 3 drops of food coloring; make each cup a different color to match playdough. Set them aside.)
6. Set aside 4 balls of playdough, each in a different color.
7. You are now ready to create an eruption. Slowly pour a small amount of vinegar into your source cup and watch the eruption of simulated lava.
8. When the lava stops, quickly draw around the flow edge with a pencil or marker.
9. Wipe up the fluid with paper towels.
10. As best you can, use a thin layer of playdough to cover the entire area where lava flowed. Exact placement is not necessary. Match flow color and playdough if available.
11. On a separate sheet of paper record information about the flow. Indicate color, shape, direction of flow, and thickness. Indicate where this flow is in the sequence; first, second, etc.
12. Repeat steps 7 - 11 for each color of play dough available. Four to six flows show a good example of a shield volcano.

NOTES: You may add fresh baking soda to the source cup or spoon out excess vinegar from the source cup as needed. Be sure you mark where the lava flows go over previous flows as well as on the cardboard. Cover the entire area of each succeeding flow. This will resemble a strange layer cake with new flows overlapping old ones.

Results

1. Look down on your volcano and describe what you see. Add your written description to the paper where you recorded the information about the flows. Include observations of flows covering or overlapping other flows. Make a quick sketch.

2. Where is the oldest flow?

3. Where is the youngest flow?

4. Did the flows always follow the same path? (be specific)

5. What do you think influences the path direction of lava flows?

6. If you had not watched the eruptions, how would you know that there are many different layers of lava? Give at least 2 reasons.

7. Which of the reasons listed in answer 6 could be used to identify real lava layers on Earth?

8. What are other ways to distinguish between older and younger layered lava flows on Earth?

9. Which of the reasons listed in answer 8 could be used to identify lava layers on Mars or the Moon?

10. What are other ways to distinguish between older and younger layered lava flows on Mars or the Moon? Look at orbital photographs if possible.

Part 2—

Volcano Mapping Extensions

About This Activity

Students will simulate a mapping and field exercise. It is very similar to the first steps that geologists employ when they map and interpret the geologic history of an area. Student teams will map and study the volcanoes produced by another team in Lava Layering, Part 1. Lava Layering, Part 2 is designed to promote the use of higher order thinking skills and encourages the questioning, predicting, testing, and interpreting sequence that is important to scientific inquiry.

Objectives

Students will:

- produce a map of an unknown volcano and show the sequence of lava flows.
- interpret the map data and infer the subsurface extent of the flows.
- predict where excavations will give the most information.
- simulate both natural and human excavations.
- write a short geologic history of the volcano.

Background

In the solar system, volcanism is a major process active now and in the past. All the large, solid inner solar system planetary bodies have surface features that have been interpreted as lava flows and volcanoes. Mars has spectacular volcanoes. Where volcanic heat and water are close together, hot springs likely formed. These thermal springs could have harbored microbial life.

The thought processes and sequence of observing, taking data, and interpreting that students use when completing this exercise are very similar to the real investigations done by field geologists. Photo geologists use pictures taken by planes and spacecraft to interpret the history of a planet's surface. If they can get to the surface, they do field work by making maps and collecting samples. Geologists used pictures taken from Mars orbit to interpret the history of the planet's surface. Soon there will be some new data to add to the knowledge of Mars. The Mars Global Surveyor arrived at Mars in the fall of '97 and will return photos and other data about the surface of Mars. Pathfinder landed on July 4, 1997, and returned valuable data on weather, rocks and soil.

Materials

- ❑ volcano made of play dough from Lava Layering - Part 1, one volcano per team
- ❑ colored pencils or crayons
- ❑ metric rulers (two per group)
- ❑ straight edge for cutting (dental floss and wire cut play dough if knives are not permissible)
- ❑ large width straws (one per group, or one 5 cm-long piece per student.)
- ❑ Student Sheet, *Lava Layering - Part 2* (pgs. 25-26)
- ❑ toothpicks, 5-10 per volcano

Procedure

Advanced Preparation

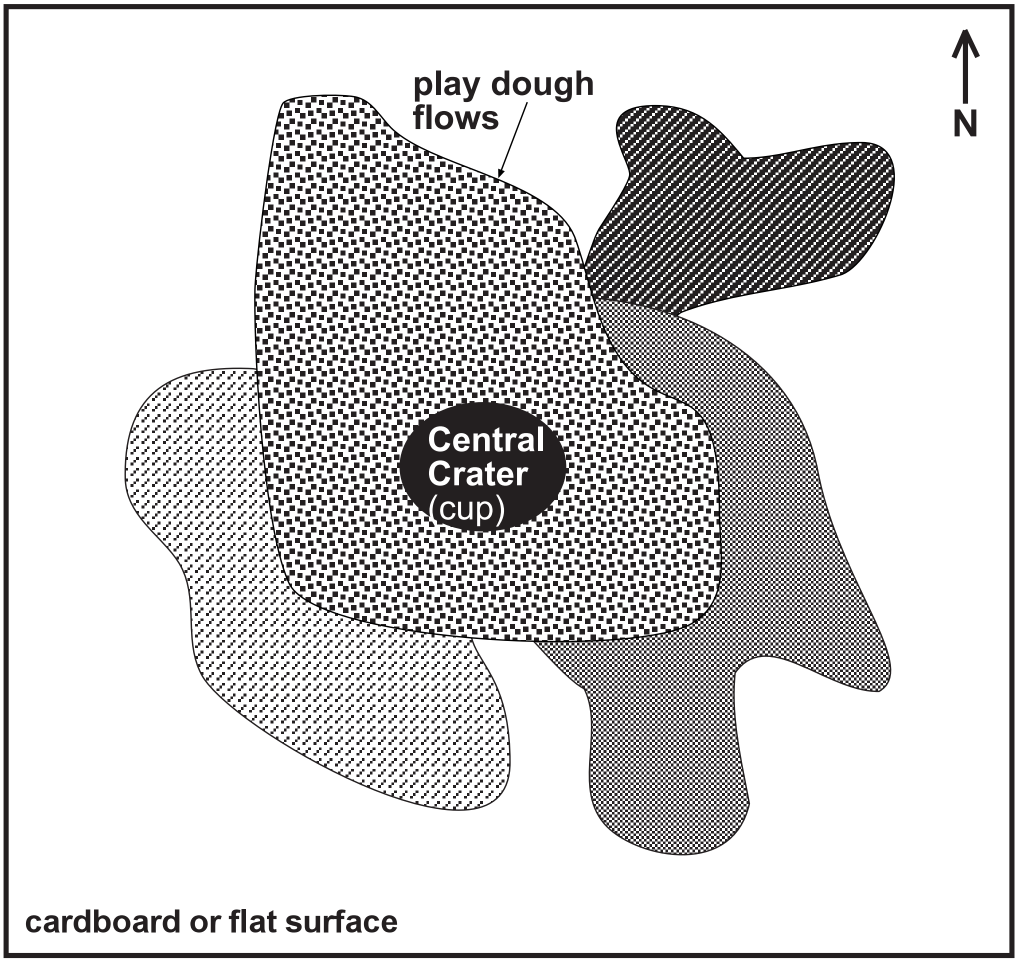
1. Gather materials.
2. Read procedure and background.
3. Small groups of students assemble volcanoes according to directions in Lava Layering- Part 1.
4. Mapping may be done immediately after volcano assembly or several days later. The play dough volcano must be covered with plastic if left more than a few hours.
5. Review map skills such as keys, scales, and measuring techniques.

Classroom Procedure

(This activity can easily be simplified as needed.)

1. Have teams trade volcanoes so that they will map a volcano with an "unknown" history. They may give the volcano a name if desired.
2. Ask groups to draw a map (birds-eye view) of the volcano. This may be made in actual size or they may make a scale drawing. The map should include a North direction arrow. An example drawn on the board or overhead may be helpful if students are not familiar with transferring measurements to a grid. Students will need to make careful observations and measurements to map the volcanoes accurately. Color and label the map.
3. Answer the questions on Student Sheet. **Note:** Some volcanoes may be more complex than others—each will be different!! There may be flows that are completely covered, some flows that have two separate lobes, and some flows for which the sequential relationship can not be determined at the surface.
4. Lead the students to question what they cannot see below the surface. Where do the flows extend under the exposed surface? Lead them to name ways they can see what is below the surface without lifting the play dough. They may suggest drill holes or cores, river erosion and bank exposure, earthquakes, or road cuts and other excavations.
5. Have groups make a plan that shows on their map where they want to put the subsurface exposures. They should indicate how the proposed cores and cuts will maximize the information they might gain from excavations. Limit the number of exposures each group may use, i.e., five drill cores and one road cut and one river erosion.
6. Make the cuts or cores.
   - Remove drill core by pushing a straw vertically into the play dough, twisting if necessary, and withdrawing the straw. Blow through the open end of the straw to remove the core. Put the core on a toothpick and place it by the hole for reference.
   - River valleys may be made by cutting and removing a "v" shape in the side of the volcano (open part of "v" facing down slope).
   - To make road cuts, use knife or dental floss to cut and remove a strip about 1 cm wide and as deep as you want from any part of the volcano.
   - To make earthquake exposures, make a single cut and lift or drop one side of the fault line. Some support will be necessary.
7. Record cuts and cores on the map and in notes. Be sure to use location information, i.e., core # 2 is located on the blue flow in the Northeast quadrant of the volcano.
8. Observe hidden layers. Interpret data and draw dotted lines on the map indicating the approximate or inferred boundaries of the subsurface flows.
9. On a separate paper, write a short history of the volcano that relates sequence of flows and relative volumes of flows (or make a geologic column, a map key to the history that shows oldest geologic activity at the bottom and youngest at the top). Math classes may try to figure the volume of the various flows.
10. Compare the history developed by mapping in Part 2 with the original history from the group that made the volcano in Part 1. Write how they are similar or different.
11. Conduct debriefings at several stages of this activity.

Example of bird's eye view map of lava flows.



Lava Layering — Part 2

Directions

Make a map of a volcano model. Do this from a birds eye view. Label flows and features.

1. How many flows can you see on your map?

2. Beside the map make a list of the lava flows, starting with the youngest flow at the top and finishing with the oldest flow at the bottom. Example: Top flow is a long, skinny, green flow.

3. Can you easily determine the sequence of flows (which came first, which came last) or are there some flows where you can't say which are younger or older? Put a question mark by the uncertain flows in the list on the map.

4. Are there parts of any flows that might be covered? Which ones?

5. What would you need to tell the sequence and shape of each flow? How could you get that information without lifting the play dough?

6. Think about what techniques will help you learn more about the interior of your volcano. Your teacher will lead a class discussion about these techniques before you experiment. Stop here and wait for the teacher to continue.

7. Document why each proposed experiment will be helpful in revealing information about your volcano. Conduct the experiments and record locations and the information gained.

8. Finish your map. On a piece of paper, write a description of the sequence that tells the history of the volcano. Compare your sequence to the history written by the group that originally made the volcano. Was your interpretation accurate? Explain.

9. Why would it be harder to map lava flows on Mars using spacecraft photos?