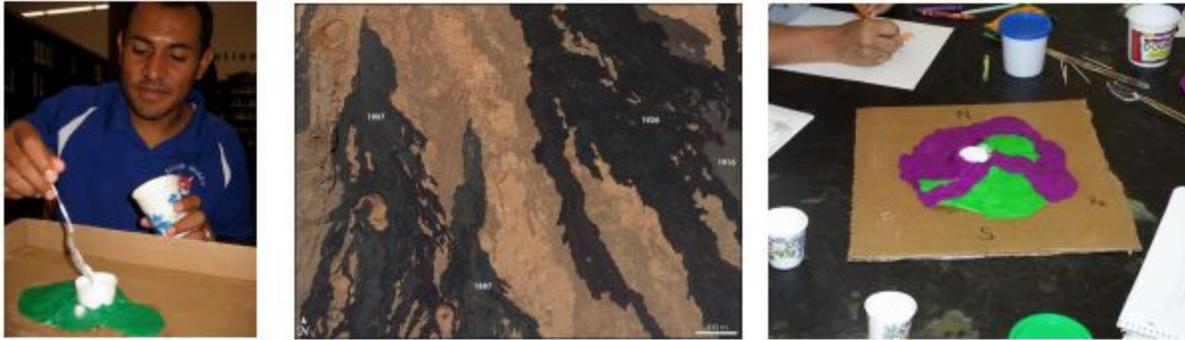


Mars Habitation

Lava Layering



By creating models of lava flows with playdough, students analyze the layers that form on a planet to understand its history.

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Materials were edited for the purpose and benefit of the University of Houston's Mars Rover Celebration.

Overview:

In this lesson plan students will:

- Sequence lava flows produced by multiple eruptions.
- Use baking soda, vinegar, and play dough to model fluid lava flows.
- Observe where the flows travel, make a model, and interpret the stratigraphy.

Process/Skills:

- Creativity and Innovation
- Critical Thinking and Problem Solving
- Communication
- Collaboration
- Flexibility and Adaptability
- Initiative and Self-Direction
- Productivity and Accountability
- Algebra
- Measurement
- Data Analysis and Probability

Time:

10 minute prep time
90 minute lesson time

Materials:

For Volcano Building (per group of students)

- 1 paper cup, 100ml (4oz) size, cut down to a height of 2.5cm
- 2 paper cups, 150 - 200ml (6-8 oz) size.
- Cardboard, ~ 45cm square (can substitute cookie sheet or a box lid)
- Play Dough or soft clay – at least 4 - 2 inch (2oz) balls, each a different color
- Tape (Scotch)
- Spoon
- Baking soda (1/4 cup)
- Vinegar, 100-150ml (4-6 oz) depending on number and size of flows
- Paper towels
- Marker or grease pencil

For observing and drawing volcanic layers (per group of students)

- Paper and pencil
- Colored pencils or crayons (3-4 colors)
- 2 Metric rulers
- Straight edge for cutting (such as dental floss or plastic picnic knife)
- Large width straw per student (5cm long)

- 5-10 toothpicks

Objectives:

1. Students will consider data and results to look for patterns and compare possible solutions.
2. Students will be able to:
 - a. Construct a model
 - b. Hypothesize how the model will behave (i.e., given different nose cone lengths)
 - c. Test the model

PREPARATION (~45 minutes)

You can use store bought playdough or create your own:

Preparing the homemade play dough

Stove-top recipe (best texture and lasts for months when refrigerated in an airtight container:

- 2 cups flour
 - 1-cup salt
 - 4 teaspoons cream of tartar
 - 1/3-cup oil, scant
 - 2 cups cold water food colorings (20 drops or less)
1. You will need 4 colors total.
 2. Make this large batch one color or divide ingredients in half to make 2 colors.
 3. Combine ingredients and cook mixture in a large saucepan, stirring constantly, until the dough forms a ball.
 4. Turn dough out onto a floured surface to cool.

No-cooking recipe:

- 2 cups flour
 - 1-cup salt
 - 6 teaspoons cream of tartar or alum
 - 2 tablespoons oil
 - 1-cup cold water food colorings (20 drops or less)
1. You will need 4 colors total.
 2. Make this large batch one color or divide ingredients in half to make 2 colors.
 3. Mix ingredients and kneed until smooth and elastic.
 4. Store in airtight containers.

STEP 1: ENGAGE (~5 minutes) Visualizing Cake Layers

Read the following to the students:

1. Fiction Story: You have baked a cake for your friend's birthday. It has 3 layers; all different flavors and covered in chocolate icing. When you bring the cake out to your friend, you are asked, "What flavors are in the cake." The flavors and their order are a mystery to everyone in the room but you. This is similar to rock layers. Often times, we are only able to see the top layer of rock or even just the soil on top, we aren't really sure what layers are below. By the end of this activity, you will be able to explain to your friends the types of relative dating techniques they can use to determine what flavors exist and what order they are in.

STEP 2: EXPLORE (~35 minutes) Making a Volcano

1. Hand out the "Making and Mapping a Volcano." Ask students to read and answer the "Before you get started" question.
2. Have each group of students collect materials.
3. Students will be using the short 2.5 cm cup as the vent of the volcano for each eruption.
4. The students will create an eruption using the vinegar and baking soda and drawing a line around the edge of their eruption using a pencil or marker.
5. Once the line is drawn, students will mop up the liquid and cover the lava flow area with one color of the pre-made play dough.
6. They will then repeat this process 2 more times, each time with a different color of play dough, each time recording the shape, direction, color and thickness on pg 3 of "Making and Mapping a Volcano" sheet.
7. Ask groups to draw a map (birds-eye) view of the volcano page 4 of the "Making and Mapping a Volcano sheet." This may be made in actual size or they may make a scale drawing.
8. The map should include a North direction arrow.

9. Students will need to make careful observations and measurements to map the volcanoes accurately. Color and label the map using colored pencils or crayons.
10. Hand out "Student Sheet #1." Allow students time to complete the sheet using the "Relative Dating Techniques" sheet.
11. Student teams will trade volcanoes so that they will map a volcano with an "unknown" history. They may give the volcano a name if desired.
12. Hand out "Mapping an 'Unknown' Volcano." Ask groups to draw a map (birdseye) view of the "unknown" volcano on pg 2. The map should include a North direction arrow. Color and label the map.
13. 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 (core samples), river erosion and bank exposure, earthquakes, or road cuts and other excavations.
14. Have groups make a plan that shows on their map where they want to put the subsurface exposures by making marks on their drawing on pg 2 of the "Mapping an 'Unknown' Volcano."
15. They should indicate how the proposed cores and cuts will maximize the information they might gain from excavations. Limit the number of exposure each group may use (i.e. – five drill cores, one road cut and one river erosion.)
16. Students will observe the hidden layers through the cuts and cores. They will use these observations to draw dotted lines on the map indicating the approximate or inferred boundaries of the subsurface flows and to hypothesize the sequence of layers in the geologic column on pg 2 of the "Mapping an 'Unknown' Volcano."

STEP 3: EXPLAIN (~15 minutes) Create a Geologic Column

1. Students will draw a geologic column using colored pencils or crayons demonstrating the history of the area showing the oldest geologic activity at the bottom and youngest at the top.

STEP 4: ELABORATE (~15 minutes) Geologic Mapping from Satellite

1. Explain to students that we don't always have the luxury of a core sample or road/river cuts to help us put together a geologic history. When we observe other planets and moons using satellite imagery, we are only able to observe the lava flows from a bird's eye view, similar to the first step of determining the geologic history of their "unknown" volcano.
2. Students will use a geologic map from a satellite image of Mars volcanoes (F) Geologic Map of Pavonis Mons, in an attempt to put together a geologic history of the volcano without the use of core samples or road cuts.
3. Ask students to work together as a group to determine the geologic history of the volcano. As they work, they may want to draw and label the image.
4. Have students report their findings along with a description of the evidence they used to determine the history of the volcano. Teacher Tip: A copy of the geologic map is provided at the end of the lesson plan. A class set is recommended, printed in color and laminated.

STEP 5: EVALUATE (~10 minutes) Evaluate Proposed Solutions using Criteria

1. Student groups will share their original lava flow drawings from "Making and Mapping a Volcano" with the group working with their volcano.
2. Ask student groups to compare the history they have determined with the original history drawn from the original group that made the volcano.

3. Students will complete the “Student Sheet #2” based on these observations.
4. Use provided rubric to assess student progress.

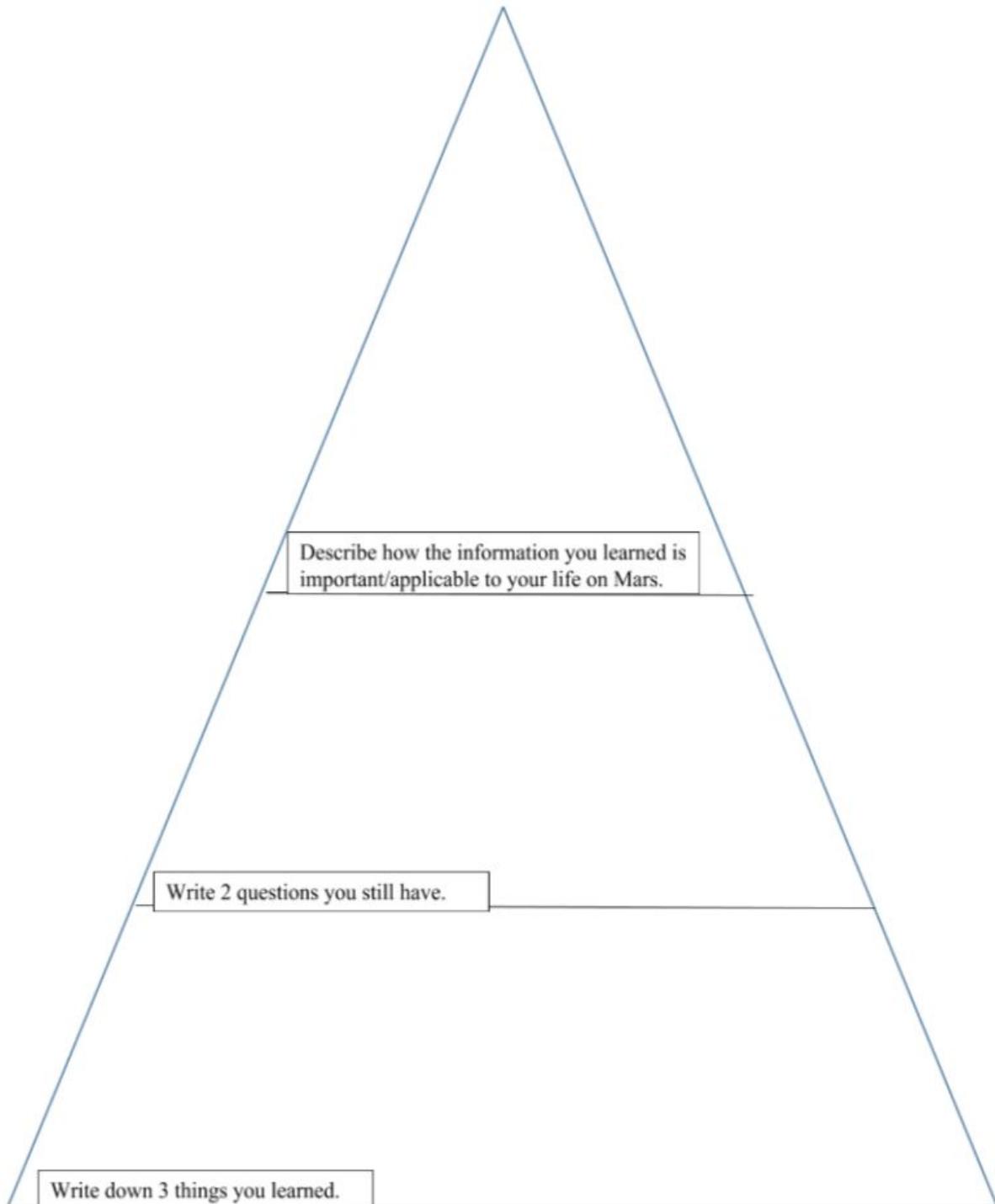
Extensions (optional)

1. Make connections to plate tectonics lessons
2. Difference between shield and stratovolcanoes
3. Types of eruptions
4. Types of lava’s
5. Where these volcanoes are typically found
6. Earth/Mars comparisons
 - a. Earth contains both shield and stratovolcanoes
 - b. Earth has plate tectonics and local tectonism
 - c. Mars mainly has shield volcanoes
 - d. Mars lacks plate tectonics, but does have local tectonism

STEP 6: WRITING

1. Writing to Learn - Use the 3-2-1 Pyramid Model (See Template) to reflect on today’s activities.

3-2-1 Pyramid Model for Learning



Student Handout - Making and Mapping a Volcano (1 of 4)

Essential Question: How do people reconstruct the date events in Earth's planetary history?

For this activity, you will be placed in the role of a volcanologist. Have you ever wanted to look inside or under a volcano? Have you ever wondered what is there that you cannot see? You will have the opportunity to not only create a volcano, but look inside an unknown volcano to see what its history is. Your mission will include the following 4 tasks:

1. Create a volcano model using baking soda, vinegar, and play dough.
2. Draw a geologic map of your volcano showing the sequence of volcanic events.
3. Use core sampling, road cuts/river cuts, and relative dating principles to determine the sequence of events of another volcano.
4. Observe a real geologic map of Mars and determine the sequence of events only using a bird's eye (map) view.

What is a "geologic map?"

You will be creating something called a geologic map. These are special maps that show certain geologic features such as rocks and faults. Different colors on a geologic map typically show different types of rocks or show the same type of rock, but different events in time. You can also occasionally find lines that represent faults and numbers representing the slope. For this activity today, we will only be concerned with different colors and sequencing of events.

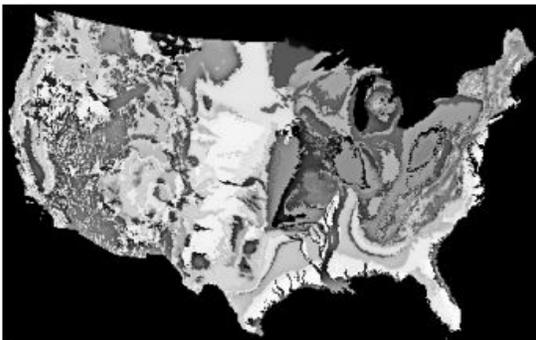


Photo courtesy of US Geological Survey

Student Handout - Making and Mapping a Volcano (2 of 4)

Before you get started:

Explain what techniques you believe your friends could use to determine the flavorings and sequence within the cake without cutting a slice of the cake.

Materials/Equipment (per group):

- 1 paper cup, 100ml (3 oz) size, cut down to a height of 2.5cm (~1") measured from the bottom up
- 2 cups, 150-200ml (6 - 8 oz) size.
- Cardboard, ~ 45cm square (can substitute cookie sheet or a box lid)
- Play Dough or soft clay – three - 2 inch (2 oz) balls, each a different color
- Tape (Scotch)
- Spoon
- Baking soda (~1/4 cup)
- Vinegar, 100-150ml (~4 oz)
- Paper towels (~6 sheets)
- #2 pencil
- 8 ½ " X 11" Paper
- Colored pencils or crayons
- 2 Metric rulers
- Straight edge for cutting (plastic knife or dental floss)
- Clear regular drinking straw
- 5-10 toothpicks

Student Handout - Making and Mapping a Volcano (3 of 4)

Procedures:

1. Take one paper cup that has been cut to a height of 2.5cm and secure it onto the cardboard. (You may use a small piece of tape on the outside bottom of the cup.) This short cup is your eruption source (vent) and the cardboard is the original land surface.
2. On the edges of the cardboard, mark North, South, East and West.
3. Fill a large paper cup about ¼ full with baking soda (unless your teacher has pre-measured quantities ready for you.)
4. Pour about ¼ cup of vinegar into a cup (unless your teacher has pre-measured quantities ready for you). You will use this for all your volcanic eruptions.
5. Place 1 heaping spoonful of baking soda in the short cup in your tray.
6. You are not ready to create an eruption. Slowly pour a small amount of vinegar into your source cup and watch the eruption of simulated “lava.”
7. When the lava stops erupting, quickly draw around the flow edge with a pencil.
8. Wipe up the fluid with paper towels and dispose of the paper towels in the trash.
9. As best you can, use a thin layer of play dough to cover the entire area where “lava” flowed.
10. On the student sheet, record information about the flow.
11. Repeat steps 5-10 for each color of play dough available.
12. Wash your hands after you have finished the eruptions.

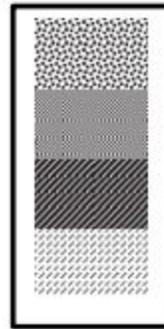
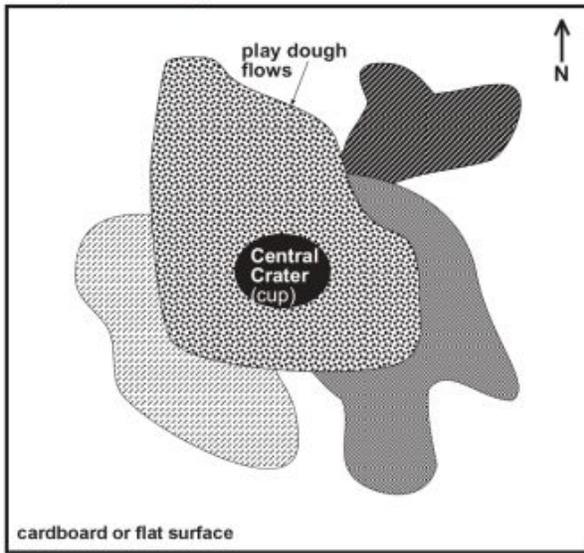
Eruption#	Color of Eruption	Draw the Shape of the eruption	Direction of the Eruption	Thickness of Eruption
1				
2				
3				
4 (Optional)				

Student Handout - Making and Mapping a Volcano (4 of 4)

Bird's Eye (Map) View Drawing:

Draw your finished volcano from above. Color each layer to match the color of the "lava" flow. Include a geologic column as a key. A geologic column shows the sequence of lava flows from oldest (bottom) to youngest (top). A sample is provided below.

Sample Drawing:



****Note:** Color has not been included in this sample. Yours should include the color of the lava flow.

Your Drawing and Column:

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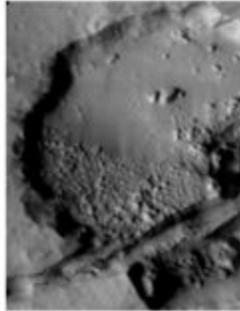
RELATIVE AGE DATING TECHNIQUE

Relative Age Dating Principles

Scientists use two basic rules or principles to help determine the relative age of craters or other features on a surface. They are as follows:

1. Cross-Cutting Relationships:

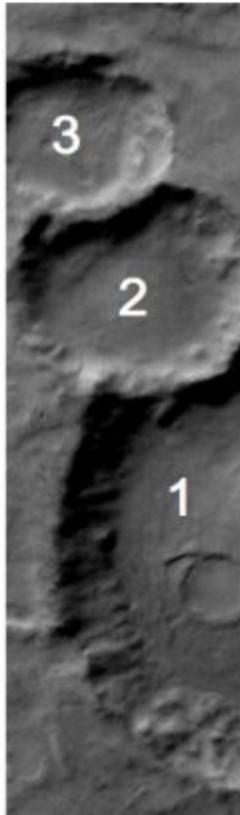
- A crater (or any other feature) can be cut by another feature.
- The feature cut is older than the feature that cut it.



Crater shown here is older than the fracture (crack) that cut through it.

2. Principle of Superposition

- When one feature is on top of another feature, the feature on top is younger.
- The feature on the bottom is the older feature.



Crater #1 is partly covered by crater #2, so crater #1 is older.

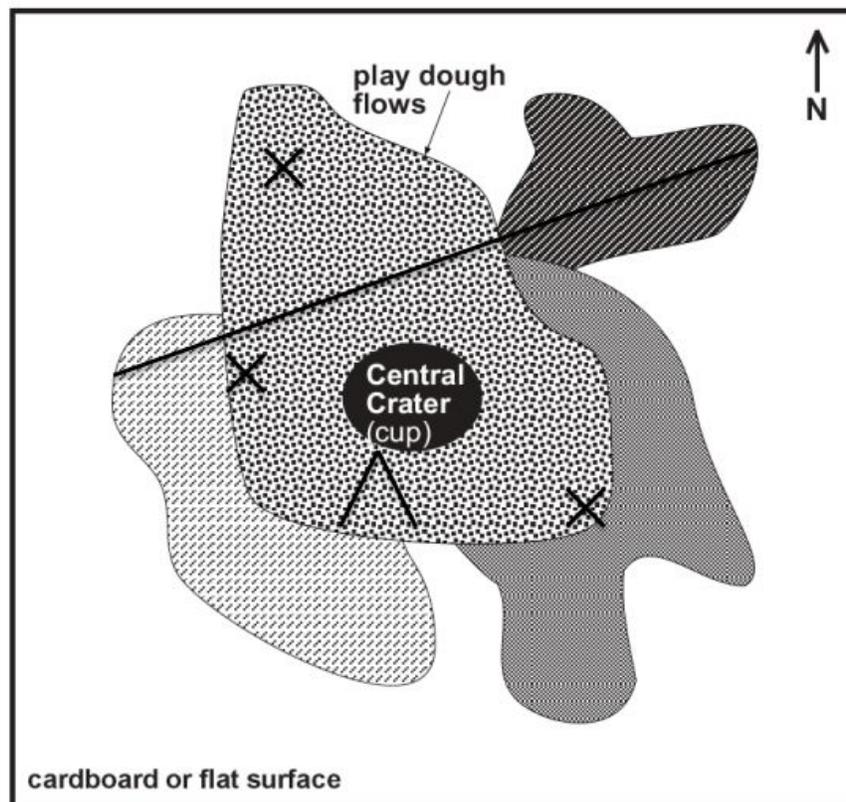
Crater #2 is partly covered by crater #3, which makes crater #2 older than #3.

By inference then, crater #1 is the oldest and crater #3 is the youngest.

Student Handout - Mapping an "Unknown" Volcano (1 of 2)

Procedures:

1. Trade your volcano another group so that you each must map a volcano with an "unknown" history.
2. Draw a map (bird's eye view) of the volcano. The map should include a North direction arrow. Make careful observation and measurements to map the volcanoes accurately.
3. Color and label the map using a key (legend).
4. Make a plan on your map showing where you intend to put the subsurface exposures. Mark 3 drill cores (core samples) with an "X," draw a straight line across the area you will road cut, and draw a "V" across the area that will be a river erosion (V facing downslope). Your teacher will tell you how many of each you have available. (See example)



Student Handout - Mapping an "Unknown" Volcano (2 of 2)

5. Make the cut and cores.
 - a. Remove drill cores by pushing a straw vertically into the play dough, twisting, 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.
 - b. River valleys may be made by cutting and removing a "V" shape in the side of the volcano (open part of the "V" facing down slope).
 - c. To make road cuts, use dental floss to cut and remove a strip about 1 cm wide and as deep as you from any part of the volcano.
6. Observe the hidden layers. Interpret the data and draw dotted lines (with the appropriate colored pencil or crayon) on the map indicating the approximate or inferred boundaries of the subsurface.
7. Once you have made all of your observations, create a geologic column representing the sequence of events (bottom is oldest, top is youngest).
8. Compare the history you have determined with the original group.

Your Drawing and Column:

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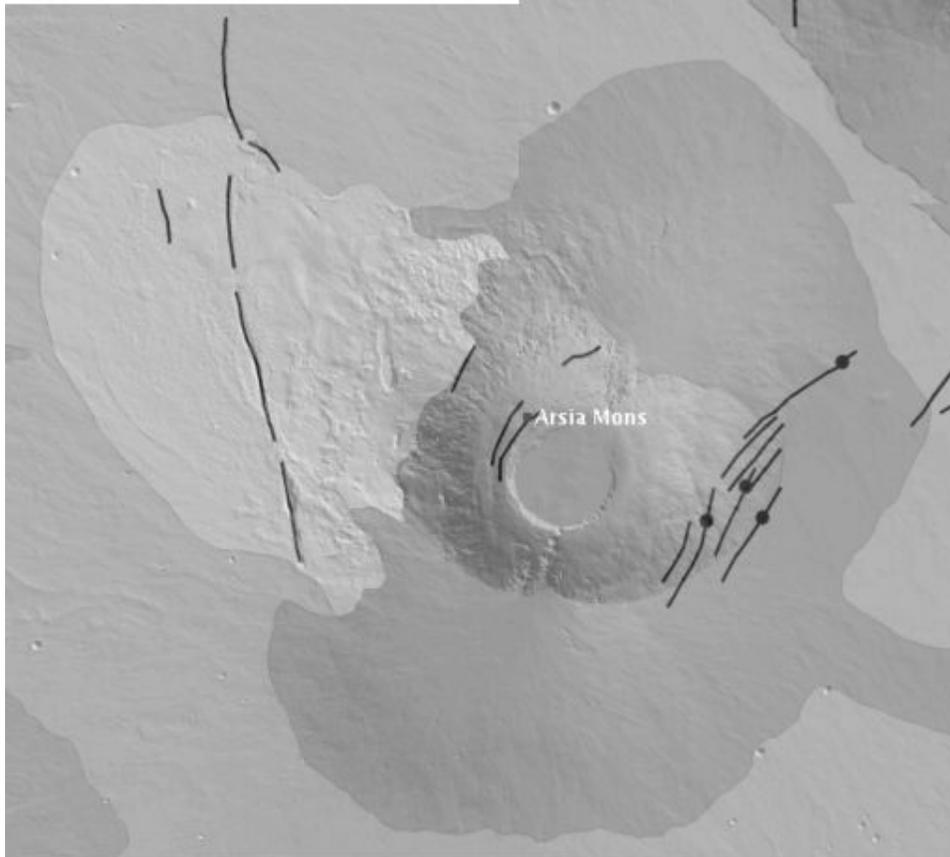
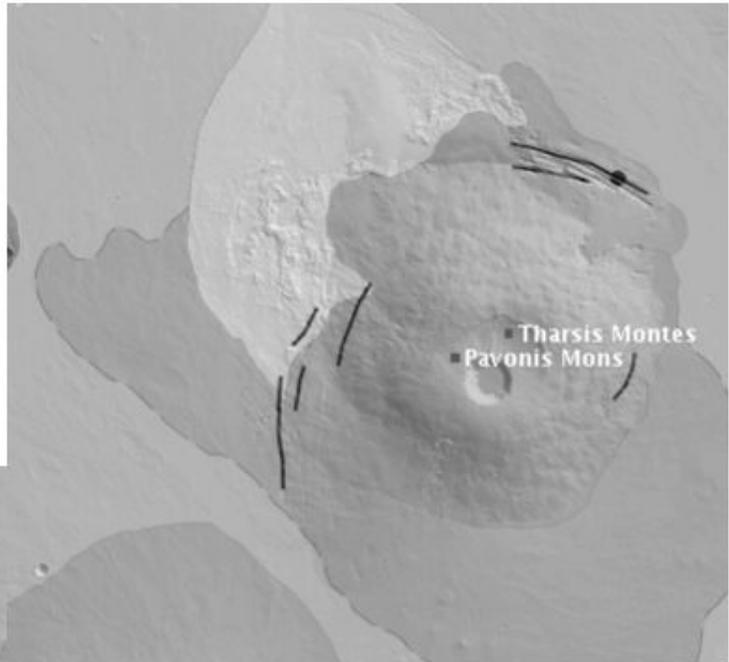
Student Handout - Student Sheet #2 (2 of 2)

3. **The Cake:** Think back to the story your teacher told you about your friend's birthday cake. With your new understanding, what techniques would you recommend to your friends to determine the flavors and order of the layers within the cake? Be sure to use the new vocabulary you have learned in your explanation.

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

Student Handout - Geologic Map of Pavonis Mons

Geologic Map courtesy of
Mars Space Flight Facility /
Arizona State University



Teacher Guide - Single Sheet Option for Student Sheet #1 and Student Sheet #2

1. **Observe:** Looking down at your volcano, describe what you see. Include an explanation of where flows occur and in what sequence.
 2. **Paths:** Did the flows always follow the same path? What do you think influences the path direction of lava flows?
 3. **Layering:** If you had not watched the eruptions, how would you know that there are many different layers of lava? What techniques would you try? Could you use these techniques with real lava flows?
 4. **Sequencing:** How did you distinguish between older and younger strata (layers)? What techniques would you use to identify the sequence of events? Could these same techniques be used on Earth or Mars? Why or why not?
-
1. **Geologic History:** How close was your group in determining the geologic history of the lava flows from the “unknown” volcano? Did you need more information? If given the opportunity, where would you collect additional information? Why?
 2. **Techniques:** What are the advantages of knowing the relative dating techniques and tools such as core sampling and road cuts that scientists use?
 3. **The Cake:** Think back to the story your teacher told you about your friend’s birthday cake. With your new understanding, what techniques would you recommend to your friends to determine the flavors and order of the layers within the cake? Be sure to use the new vocabulary you have learned in your explanation.
 4. **Mars:** Why would it be harder to map lava flows on Mars using spacecraft photos?

Teacher Guide - Volume Reference Page

In this activity, it would be important to distinguish between area and volume. While the activity itself really only addresses the area of the lava flow, scientists technically determine the volume of the eruption. This is important data when establishing the overall scale of the eruption.

Scientists will study the volume and morphology of a lava flow by mapping and comparing the topography (the study of the planet's surface shape and features) before and after lava eruption. Contour maps are a widely available source of topographic data, containing a record of changes at volcanoes due to lava eruption.

Below you will find a graphic that demonstrates the difference in volume of different volcanic eruptions to demonstrate the scale of the eruption.

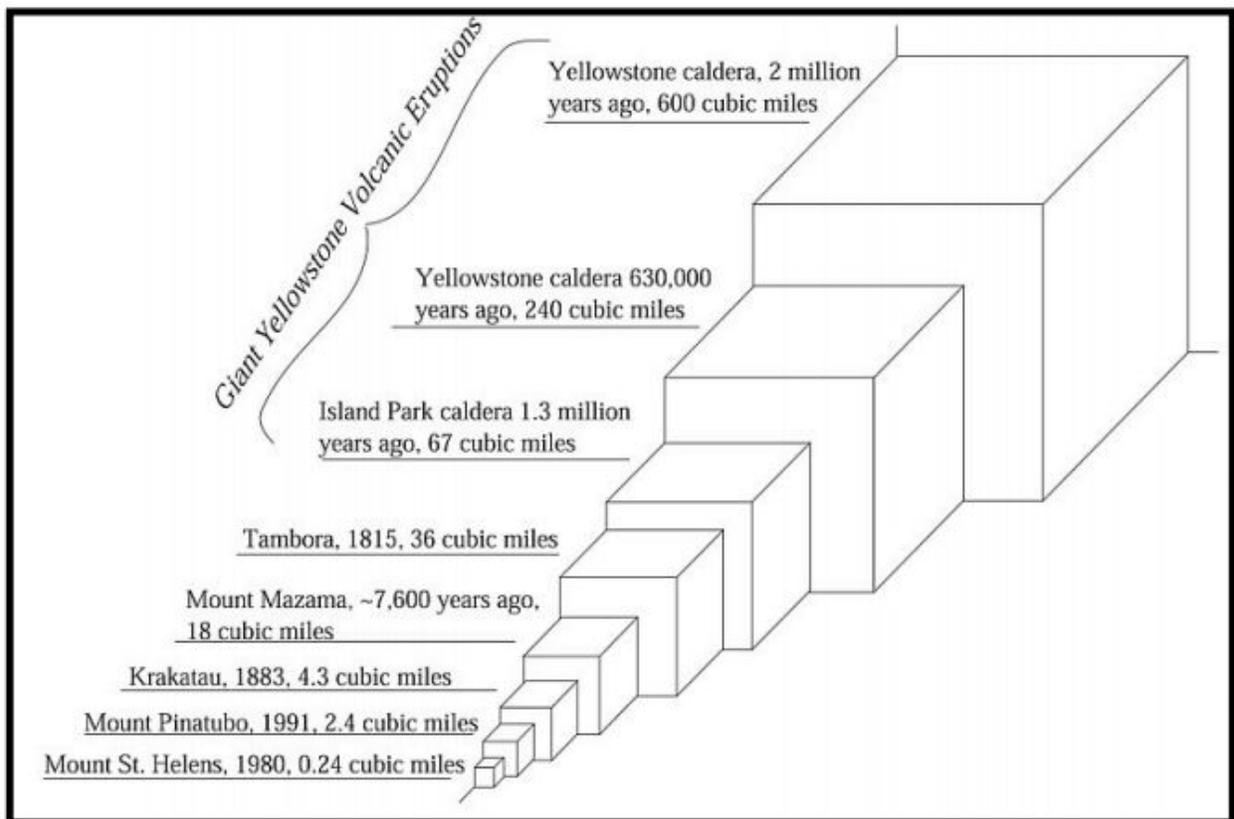


Diagram Courtesy of US Geological Survey

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 20km above the surrounding plains. This one volcano would cover the entire state of Arizona.

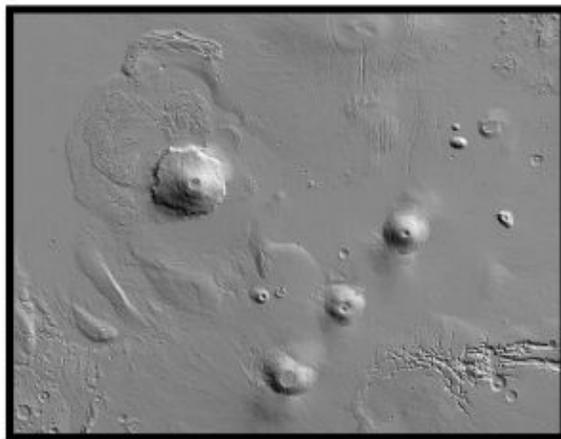
Where volcanic heat and water interact here on Earth, scientists are finding life. In the hot springs of Yellowstone Park they have found abundant life forms including some very small bacteria. There is a possibility that life may have found a place in the ancient volcanic terrain of Mars.

Some of the volcanoes on Mars are **basaltic shield volcanoes** like Earth's Hawaiian Islands. Interpretations of photographs and soil analyses from the Viking (1976) and Pathfinder (1997) 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.

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 difference 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.

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 new data to add to the knowledge of Mars through new orbital spacecraft and lander missions.

Relative dating is also known as stratigraphy. **Stratigraphy** is the science of rock strata, or layers. Layering occurs over time, so rock layers hold the key to understanding the geological events of the past. Here are the four fundamental principles of stratigraphy:

The Principle of Original Horizontality:

When rock layers are laid down on the surface, they form in horizontal layers. This means that non-horizontal rock layers were tilted or folded after they were deposited.

The Principle of Lateral Continuity:

Rock layers typically extend for quite a distance over the surface—from a few meters to hundreds of kilometers, depending on how they were deposited. This is important because scientists can correlate layers at one location to layers at another, sometimes on entirely different continents. This is critical for stratigraphic correlation.



Photo courtesy of NASA

The Principle of Superposition: As layers accumulate through time, older layers are buried beneath younger layers. If geologists can determine which way was originally “up” in a stack of layers, they can put those strata in the correct historical order.

The Principle of Faunal Succession:

Fossils change through a vertical succession (sequence) of rock layers. The same vertical changes in fossils occurred in different places. The observation that fossils change in a consistent manner through stratigraphic successions can be extended to the entire world.

Scientists can use tools to determine the stratigraphy of an area. Some of these tools are man-made while others are natural. These are **outcrops and cores**.

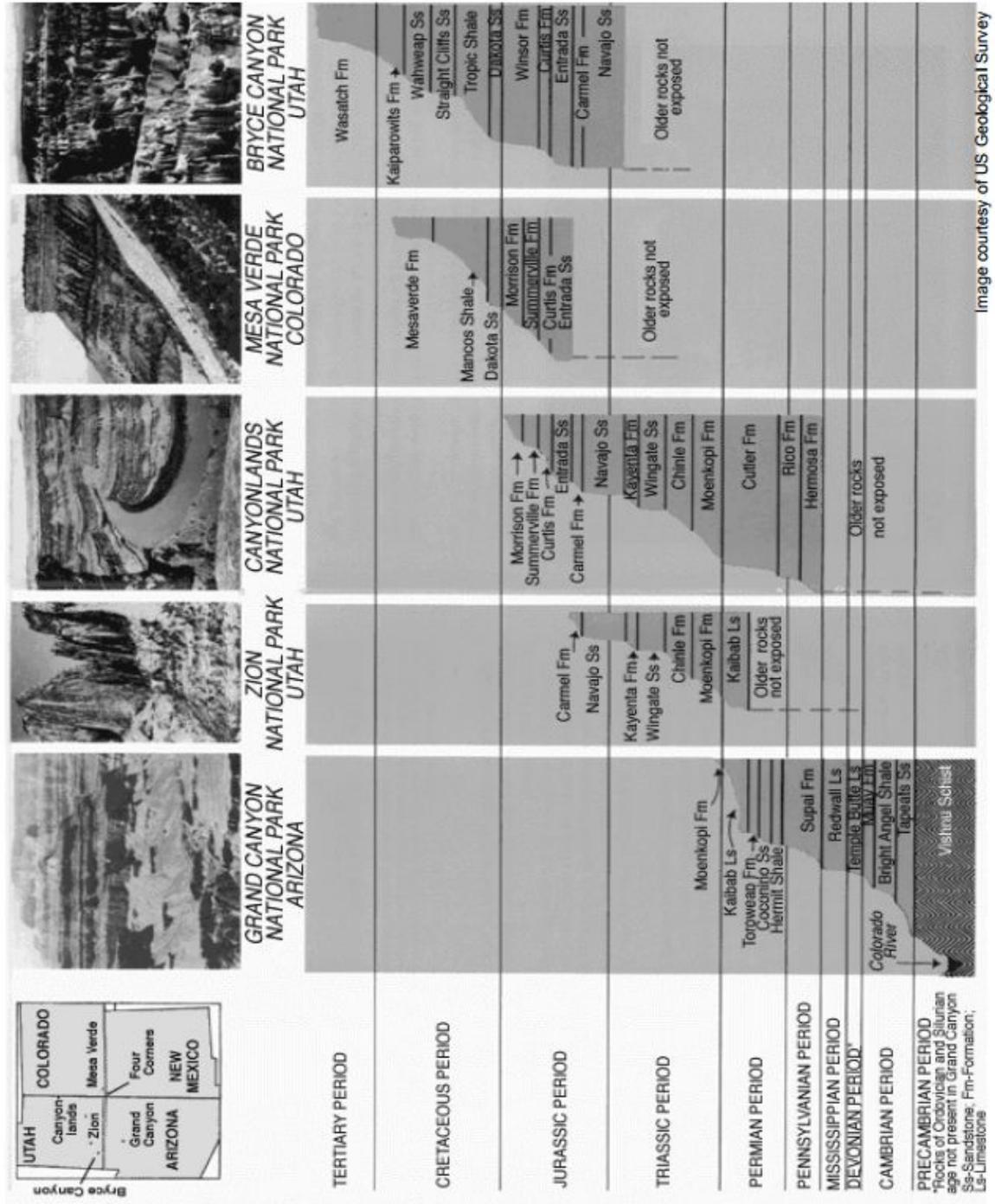
Cores can also be called **Drill Cores** or **Core Samples**. Cores are a sample of rock, soil, snow, or ice that can be collected by driving a large hollow tube down into the crust or undisturbed material, then pulling out the sample. Cores can show a variation in rock types in a vertical column and allow us to see what layers are below the surface that we cannot see.



Photo Courtesy of University of Oregon College of Oceanic and Atmospheric Sciences

Outcrops are breaks in the surface. **Natural outcrops** include streambeds, cliffs, caverns or fault blocks. These are exposed from weathering and erosion and will show the stratigraphy of an area. **Man-made outcrops** consist of road cuts for highways that behave like a scalpel.

Teacher Guide - Grand Canyon Stratigraphic Column



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