Earth Blocks: Modeling Geologic Events One Layer at a Time

Grade Level: 6–2

Learner Objectives:

Students will:

- Use the "Law of Superposition" to determine the chronological order of geological events
- Practice logic and observation by modeling rock layers at Mount Rainier
- Draw information and conclusions from a model

Setting: Classroom or outdoors

Timeframe: 45 minutes (or one class session)

Investigate Age Relationships By Playing the Hand Stacking Game—5 minutes

Demonstrate How to Use Earth Blocks—15 minutes

Explore Mount Rainier's History with Earth Blocks—25 minutes

USGS
science for a changing world

NATIONAL PARK SERVICE

Living with a Volcano in Your Backyard-An Educator's Guide with Emphasis on Mount Rainier

Prepared in collaboration with the National Park Service

U.S. Department of the Interior
U.S. Geological Survey

General Information Product 19

Overview

Students explore a riverbank with a geologist and learn about the Law of Superposition by arranging and interpreting Earth Blocks.

Materials:

Investigate Age Relationships By Playing the Hand Stacking Game

- Graphic *" Lahar Layers in the Nisqually River Valley"*

Demonstrate the Use of Earth Blocks

- Copies of *"Discover Layers—In the Field with a Geologist"* student reading sheet
- 6 to 8 sets of Earth Blocks (provided in the kit or photocopied)
- Graphic *"Modeling the Sequence of Layers with Earth Blocks 1 through 6"*

Explore Mount Rainier's History Using Earth Blocks

- Copies of *"Explore Mount Rainier's History with Earth Blocks"* student page
- Graphic *" Earth Blocks—Example"*

Vocabulary: Deposit, Electron Mudflow, glacier, lahar, lava flow, National Lahar, Law of Superposition, pyroclastic flow, radiometric dating, Round Pass Mudflow, stratigraphy, tephra, volcano

Skills: Compare, identify, discuss, infer, interpret, model, analyze

Benchmarks:

See benchmarks in Introduction.

Teacher Background

Geologists generally accept that events of the future will resemble those of the past. For this reason, they investigate the origin of rocky layers (***deposits***) set down by previous volcanic events. They recognize that understanding a ***volcano's*** general behavior patterns now can lead to a society that is better prepared because they can anticipate likely types of future volcanic activity.

Geologists have developed ingenious methods to identify the age, origin, and sequence of events that formed the rocky layers set into place by ***lava flows***, ***pyroclastic flows***, ***tephra*** fall, ***lahars*** and ***glacier***, stream and erosional processes. They conduct complex chemical analyses to determine the composition of rocks, their source, and the process that formed them. They perform sophisticated laboratory methods to identify the age of rock layers. Yet, one of the most useful methods requires little more than good observational skills, a small trowel or rock hammer, notebook and map, and a basic understanding of the ***Law of Superposition***. This fundamental principle, which states that younger layers will be on top of layers that are older, is one of the guiding principles of geological investigation.

This activity provides a glimpse into the methods used by geologists as they study the rocky layers at Mount Rainier. Students manipulate "***Earth Blocks***" into the likely sequences observed at Mount Rainier, and practice their logic skills as they employ the Law of Superposition. See the activity "***Shoebox Geologist***" for more in-depth information about the layers described here.

Sidebar 1 What is Radiometric Dating?

Some materials contain unstable radioactive isotopes that break down (decay) over time into stable isotopes. Scientists know the decay rate for certain isotopes and use this information to determine the age of rock deposits. The age of material is determined by comparing the amount of radioactive isotopes remaining in a material to the known decay rate of the isotopes in the material. The most common isotope used in *radiometric dating* is Carbon-14, which is found in charcoal and organic debris.

Earth Blocks

"***Earth Blocks***" represent different rock and sediment layers deposited by lahars, tephra fall, pyroclastic flows, lava flows and glaciation. "***Earth Blocks***" can be used in other activities throughout this chapter and on field trips to demonstrate layered sequences.We encourage students and teachers to use the blocks to model layers of rock and rock debris deposits that they may find at home or school.

How the blocks are used:

1. Students stack the blocks to build a layered sequence.
2. Students make observations about the processes that produced the layers.
3. Students interpret the layers by ranking them in age and describing what events occurred to produce the sequence.

The Blocks:

Some of the blocks show dates, which were obtained by a variety of dating methods including radiometric dating. Large lahar events that have happened at Mount Rainier have specific names and are given their own blocks. Blocks for specific tephra layers also show the volcano of origin.

Use the videos Understanding Volcanic Hazards and Perilous Beauty—The Hidden Dangers of Mount Rainier to familiarize students with volcanic processes and Mount Rainier's geologic history.

Procedure

What to do Before Class Begins:

Demonstrate Use of Earth Blocks and Explore Mount Rainier's History Using Earth Blocks

1. For each student group, make copies of the color "***Earth Blocks***" graphics at the end of this activity. You may choose to laminate or mount the cards on a hard surface such as cardboard or foam core.

2. Display the graphic "***Earth Blocks—Example***."

Investigate Age Relationships By Playing the Hand Stacking Game

Play the "***Hand Stacking Game***" to learn about the Law of Superposition. Also note the ideas in "***Extensions***."

1. Project the graphic "***Lahar Layers in the Nisqually River Valley***" to introduce students to what these layered sequences look like at Mount Rainier. Give examples of the types of deposits found at Mount Rainier (stream, glacial, lava flow, tephra, and lahar).

2. Explain to students that geologists interpret the geologic history of an area by studying layers. One method they use is called relative age dating. Students explore this concept by playing the "***Hand Stacking Game***" described below.

3. Divide the class into groups of four or five people.

a. Instruct one person in each group to place their hand flat on the table. The next person places their hand on top. Continue to stack hands until no more hands remain to be stacked. Ask which hands represent "newer" and "older" layers. See other ides in "***Extensions***."

c. Discuss the "Law of Superposition." This seemingly simple scientific principle was not recognized and understood until the seventeenth century. Think about why it took so long for the "law" to be recognized.

Demonstrate Use of Earth Blocks

Learn how geologists interpret layers by reading a story and using “***Earth Blocks***.”

1. Give each student a copy of the student page “***Discover Layers—In the Field with a Geologist***” and instruct them to read it.
2. After students complete their reading, use the “***Earth Blocks***” to show them examples of layers observed by the geologist in the field. Hold up an example of each type of block for everyone in the class to see. Explain what blocks represent. Point out any dates or information on the origin of the “***Earth Blocks***” so students know where to find this information in the future. Demonstrate their use with actual “***Earth Blocks***” or optionally with the graphic “***Earth Blocks—Examples***.”

EXAMPLE

(Top)

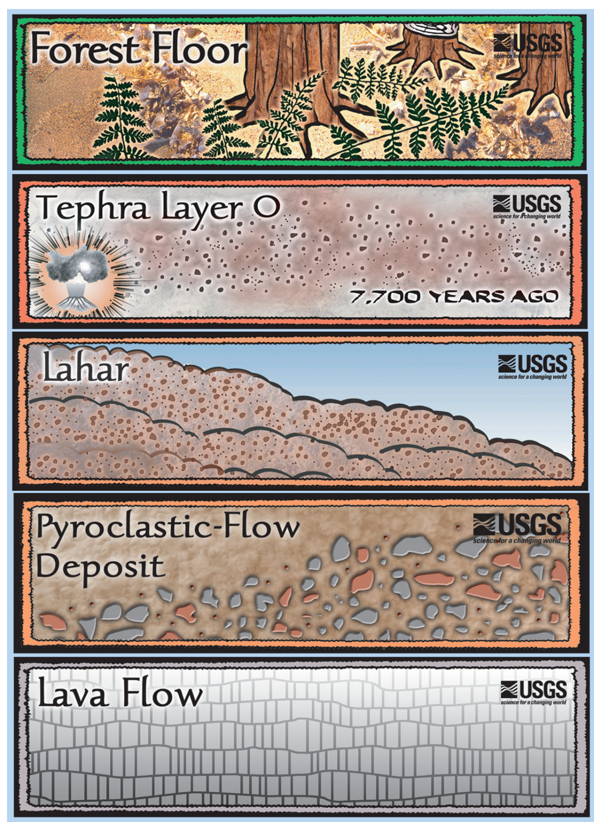
Forest Floor

Tephra 0
(7,700 years old)

Lahar

Pyroclastic Flow
Desposit

Lava Flow
(40,000 years) old



(Bottom)

Explore Volcano History with Earth Blocks

Students model layers using "***Earth Blocks***" and write interpretations on a student page.

1. Divide the class into groups of two or three students and give each a set of "***Earth Blocks***."

2. Provide each student with the four "***Explore Mount Rainier's History with Earth Blocks***" student pages.

3. Students arrange blocks into the layer sequences described on their student pages. With the teacher aiding, students should identify the geologic events that built each layer in their "***Earth Blocks***" sequence and answer questions on the student page.

4. Lead a class discussion. What interpretations did students make about the layers?

Adaptations

- Alternatively, students answer questions directly from the geologist notebook pages without use of the "***Earth Blocks***."
- ***Students draw their own Earth Blocks on strips of papers*** and arrange them in correct order before answering the questions.
- ***Take a field trip*** with your students to a nearby outcrop of rock layers, whether a riverbank, valley wall, or distant view of a volcano. Bring appropriate blocks, such as stream gravels, glacial deposits, etc. Instruct students to place blocks directly on the outcrop, or line them up in the appropriate order.
- ***Ask students to develop their own "Earth Blocks"*** that model an outcrop in their community or at other Cascade volcanoes.

Extensions

- ***Clothes hamper geology.***
  Introduce the concept of layers and the "Law of Superposition" by instructing students to envision a clothes hamper in their bedrooms.They come home from school on Monday and take off a red shirt and throw it into the hamper. On Tuesday, they toss in a green shirt. On Wednesday, they put in a yellow shirt, on Thursday, a purple shirt, and on Friday, a blue shirt. Each shirt represents a layer deposited by the student. Ask students which layer is oldest and which is the youngest? From this, ask students to derive the "Law of Superposition." Alternatively, students pile up jackets and sweaters worn that school day.

◆ ***Snow bank stratigraphy.***
If you live in an area where snow banks develop during the winter, take students to one of them and ask them to interpret the relative ages of the layers while hypothesizing about the events that created the layers.

◆ ***The earth's ticking clock—Radiometric dating***.
Use this extension activity to explain how radiometric dating works. Provide each student with a graham cracker and ask students to take exactly one minute to eat half of the graham cracker. After the one minute of eating the first half, instruct them to eat half of the remaining graham cracker, and split the remaining amount in half. Ask students to repeat this until the amount of graham cracker is so small that they can no longer divide it in half. The amount of time it takes for half of the graham cracker to be eaten is known as the half-life. Carbon-14 has a half-life of 5,730 years. Make sure students keep track of how long it takes them to reach the point when the graham cracker can no longer be split apart. At this point, the amount of cracker left represents the amount of Carbon-14 remaining when the sample has completely degraded to one molecule. The molecule cannot be split and so there is essentially no Carbon-14 left in the sample. Instruct the students to plot the relative size of the cracker (one half, one quarter, one eighth, etc.) versus time on graph paper. If the students were to find a sediment layer with a graham cracker in it that had degraded to one-eighth its original size, how old would the sediment layer be? Make an analogy to Carbon-14 dating.

◆ ***Design earth blocks with character.***
Make a set of "***Earth Blocks***" that include common physical characteristics found in the different tephra layers at Mount Rainier. You can find this information in published geologic papers on the website of the USGS Volcano Hazards Program. See **Internet Resources Page**.

Assessment

Look for students' understanding of the Law of Superposition. As the activity progresses, students should recognize that this principle enables scientists to determine the chronological order in which geological events happened. Students should understand why this law is helpful to volcanologists who seek to know the geological story or an area. Their understanding of past events helps them to determine the most likely geological events for the future, and ultimately the hazards. This process in due course saves lives and property and improves the well being of nearby communities.

Use questions on the student pages to assess students' ability to apply the principle of Superposition to real-world situations. After completing this lesson, students should be able to design their own data and observation tables. Students who select an incorrect response may be able to provide a justification for their answer that demonstrates understanding of the principle.

References

Cas, R.A.F., and Wright, J.V., 1987, Volcanic Successions Modern and Ancient—A geological approach to processes, products and successions: London, Allen and Unwin, 528 p.

Fisher, R.V., and Schmincke, H.U., 1984, Pyroclastic rocks: New York, N.Y., Springer-Verlag, 472 p.

Scott, K.M., Vallance, J.W., and Pringle, P.T., 1995, Sedimentology, behavior, and hazards of debris flows at Mount Rainier, Washington: U.S. Geological Survey Professional Paper 1547, 56 p., 1 pl.

Vallance, J.W., and Scott, K.M., 1997, The Osceola Mudflow from Mount Rainier: Sedimentology and hazard implications of a huge clay-rich debris flow: Geological Society of America Bulletin, February, 1997, v. 109: no. 2: p. 143–163, 6 tables.

Zehfuss, P.H., Atwater, B.F., Vallance, J.W., Brenniman, H., and Brown, T.A., 2003, Holocene lahars and their by-products along the historical path of the White River between Mount Rainier and Seattle: *in* Swanson, T.W., ed, Western Cordillera and adjacent areas: Boulder, Colo., Geological Society of America Field Guide 4, p. 209–223.

Refer to **Internet Resources Page** for a list of resources available as a supplement to this activity.

Photo Credits

1. Lahar Layers in the Nisqually River Valley, Photo by Carolyn Driedger, USGS.

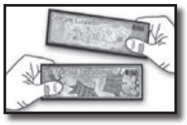
Discover Layers—In the Field with a Geologist

In the deep river valleys of the Cascade Range, hikers can observe eroded riverbanks made entirely of loose sand, cobbles, and boulders. Geologists use these layers to make interpretations about geologic events of the past. Now envision yourself visiting the riverbank with a geologist who is on the job in one of those river valleys.

You and the geologist wear sturdy boots and carry backpacks filled with collection bags, tape measures, notebooks, cameras and trowels, in addition to your first aid kit, snack food, water and extra clothing. After a short hike from the car, the two of you reach the riverbank and lean back for a full view. Together, you take photographs, measure the thickness of layers, and make sketches in your notebooks. The geologist reminds you that by the Law of Superposition, the oldest layers are on the bottom and the youngest are at the top. Next, you approach the riverbank. You use trowels to dig into the layers to obtain samples. You roll the dusty rock particles around in your hand, and examine them with a hand lens. In your notebooks you record information about the color and texture of the particles, and you are careful to describe where in the riverbank these samples were found. The two of you are always on the lookout for buried wood and leaves that can provide clues about the age and origin of the rocky layers. The geologist reaches into a backpack and pulls out a handful of white cloth collection bags, each with a blank paper label and string closure. Together, you fill the bags with samples of rocks, wood and charcoal, and you are careful to label the contents of each bag as you close it. When you return to the office, the two of you will use this evidence to develop a hypothesis about how and when the valley landscape was formed. With evidence recorded in your notebooks, in photographs, and on sample bag labels, you hike up valley to repeat the process at more locations along the riverbank.

Many different geologic events created the layers found along the riverbank including lahars (mudflows), pyroclastic flows, tephra (ash) fallout, glaciers, streams, lava flows, and organic composition. Your teacher will demonstrate the use of "***Earth Blocks***," which represent layers that geologists observe in the field.

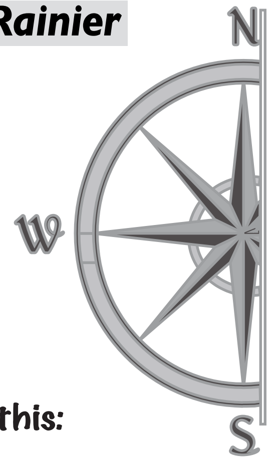
Name ______________________________



Explore Mount Rainier's History with Earth Blocks

Instructions: *Arrange the "Earth Blocks" in order—from oldest at the bottom to youngest at the top. Using the field notes below as your guide, answer all the questions on the following page. Use the "Law of Superposition."*

Observations on a High Mountain Ridge at Mount Rainier

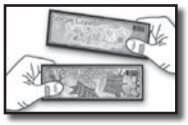


August 23
Latitude: 46°50' N Longitude: 121°45' W
Elevation: 3,069 meters (10,070 feet) On a high ridge west of Nisqually Glacier. Clear skies but chilly 10° C (50° F.) Saw two mountain goats and a marmot. A small avalanche of unstable rock broke loose and tossed dust into the air—lucky I did not get hit by any rocks!

Exposure on ridge is 6 meters (20 feet) high and looks like this:

(TOP)
Forest floor
Glacial deposits
Tephra (age unknown)
Tephra "Y" from Mount St. Helens, 3,700 years ago
Glacial deposits formed 10,000 years ago
Lava Flow
Pyroclastic flow
Lava flow
Lava flow 380,000 years ago
(BOTTOM)

Name ______________________



Explore Mount Rainier's History with Earth Blocks-continued

Questions for Observations on a High Mountain Ridge at Mount Rainier:

1. What is the age of Tephra layer Y?

2. Find the pyroclastic flow layer.
Is the pyroclastic flow older or younger than Tephra layer Y? Explain your choice.

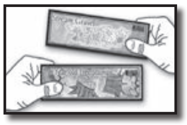
3. Find the tephra layer of unknown age. What can you learn about its age?

4. Are the lava flows and pyroclastic flows related? Explain how.

5. Write a paragraph about the geologic processes that occurred on this high mountain ridge.

Student Page

Name ______________________



Explore Mount Rainier's History with Earth Blocks

Observations of a Valley Riverbank at Mount Rainier

August 25
Latitude: 46°44' N   Longitude: 121°60' W
Elevation: 427 meters (1,400 feet) In the west side riverbank, Nisqually River valley just upstream of the Longmire bridge crossing. The river is low for this time of year. Lots of deer and mosquitoes!

Riverbank is about 4.5 meters (15 feet) high:

(TOP)
Forest Floor
Stream gravel
Lahar
Stream gravel
Lahar
Stream gravel
Electron Mudflow (lahar), 500 years ago
Stream gravel
Lahar
Round Pass Mudflow (lahar), 2,600 years ago
Tephra "O" Mount Mazama, 7,700 years ago
Glacial deposits
(BOTTOM)

Name ____________________________

Explore Mount Rainier's History with Earth Blocks-continued

Questions for Observations of a Valley Riverbank at Mount Rainier:

1. The age of the undated lahar between the Round Pass Mudflow and the Electron Mudflow is ____ years to ___ years old.

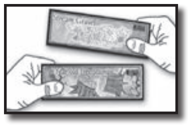
2. Name the principal geological process that follows after lahars (mudflows). Explain why.

3. Count how many lahars occurred in this valley between the Electron Mudflow (include it) and the present.

4. Write a paragraph about the geologic processes that occurred in the valley.

5. Summarize the similarities and differences between volcanic layers on the ridge and in the valley riverbank.

6. Rearrange your earth blocks into some new pattern. List the events from bottom to top. Write a paragraph that describes the events that formed these layers.



Explore Mount Rainier's History with Earth Blocks—Answers

Questions for Observations on a High Mountain Ridge at Mount Rainier:

1. What is the age of Tephra layer Y?
Tephra layer Y fell to the ground during an eruption 3,700 years ago.

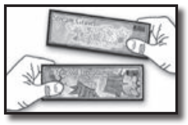
2. Find the layer of rock rubble left behind by a pyroclastic flow. Is the pyroclastic flow older or younger than Tephra layer Y? Explain your choice.
We know that the pyroclastic flow is older because it is a lower layer than Tephra Y.

3. Find the tephra layer of unknown age. What can you learn about its age?
The age of the undated tephra is between 3,700 years and the present.

4. Explain how the pyroclastic flows and lava flows are related.
Both formed during an eruption. The pyroclastic flow formed when hot gas-rich lava flows broke apart and tumbled down the sides of the volcano.

5. Write a paragraph about the geologic processes that occurred on this high mountain ridge.
Volcanic eruptions caused two lava flows. Collapse of hot ash clouds, or lava flows caused pyroclastic flows. Another lava flow covered the pyroclastic flow. A glacier spread loose rock over the ridge. Tephra from an eruption of Mount St. Helens covered the ridge. A second tephra layer formed. A glacier left behind loose rocks on the valley floor. Soil from the forest floor covers all of the layers underneath.

Name ______________________



Explore Mount Rainier's History with Earth Blocks—Answers-continued

Questions for Observations of a Valley Riverbank at Mount Rainier:

1. The age of the undated lahar layer between the ***Round Pass Mudflow*** and the ***Electron Mudflow*** is ____ years to ___ years old.
The tephra was formed between 2,600 and 500 years ago.

2. Name the principal geological process that follows after lahars (mudflows). Explain why.
Stream water transports loose sediments and redeposits it as layers of stream gravel.

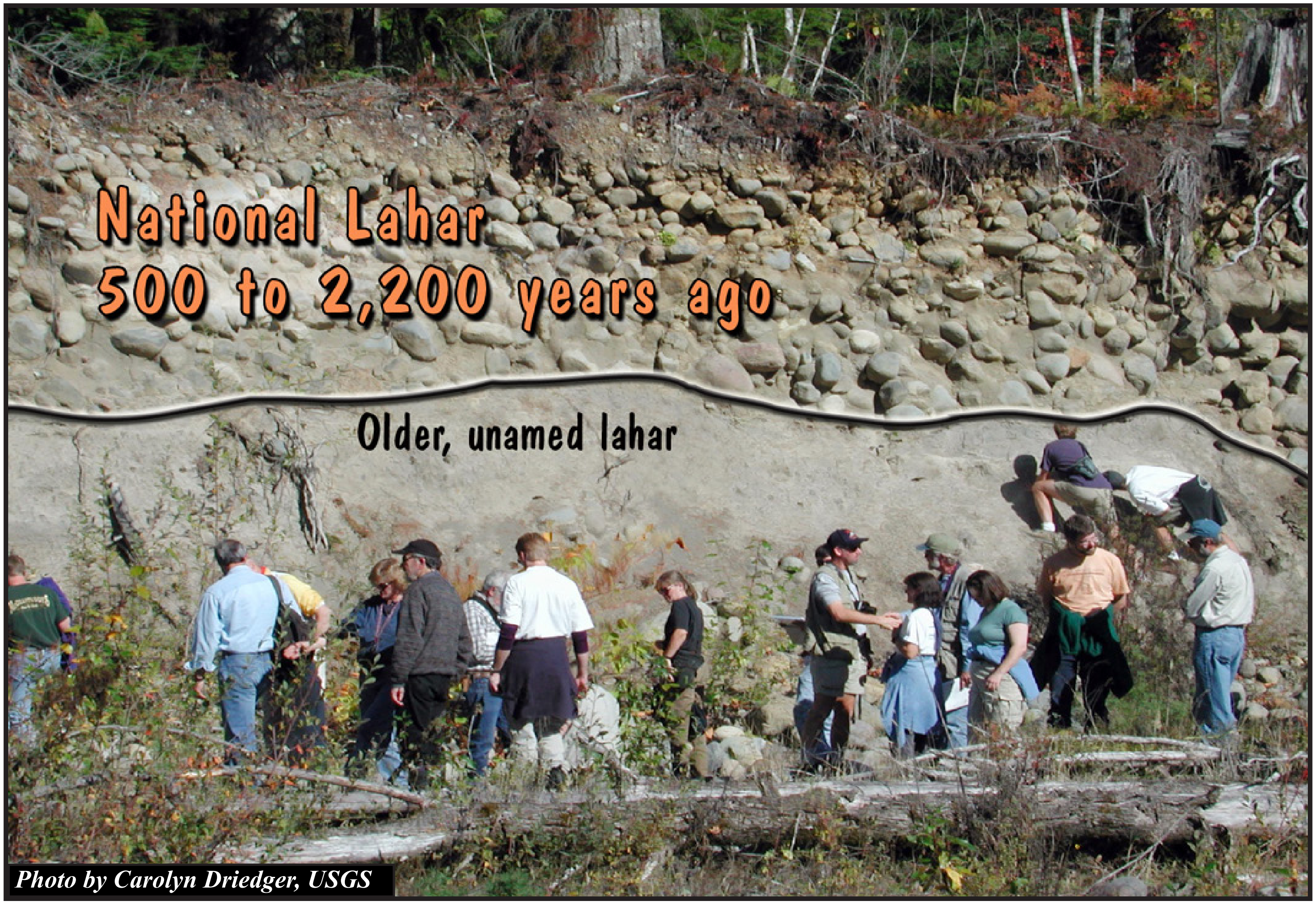
3. Count how many lahars occurred in this valley between the Electron Mudflow (include it) and the present.
Three lahars (including the Electron Mudflow) occurred.

4. Write a paragraph about the geologic processes that occurred in the valley.
Glacial deposits were first to form. Later, tephra from ancient Mount Mazama covered the glacial deposits. The Round Pass Mudflow and another lahar covered the valley floor. This surface was buried by gravel carried there by stream flow. The Electron Mudflow covered the valley floor. It was followed by more stream flow, which left stream gravel on the surface. Twice more, lahars flowed down valley and stream gravel covered the valley floor. Now a forest covers the valley floor.

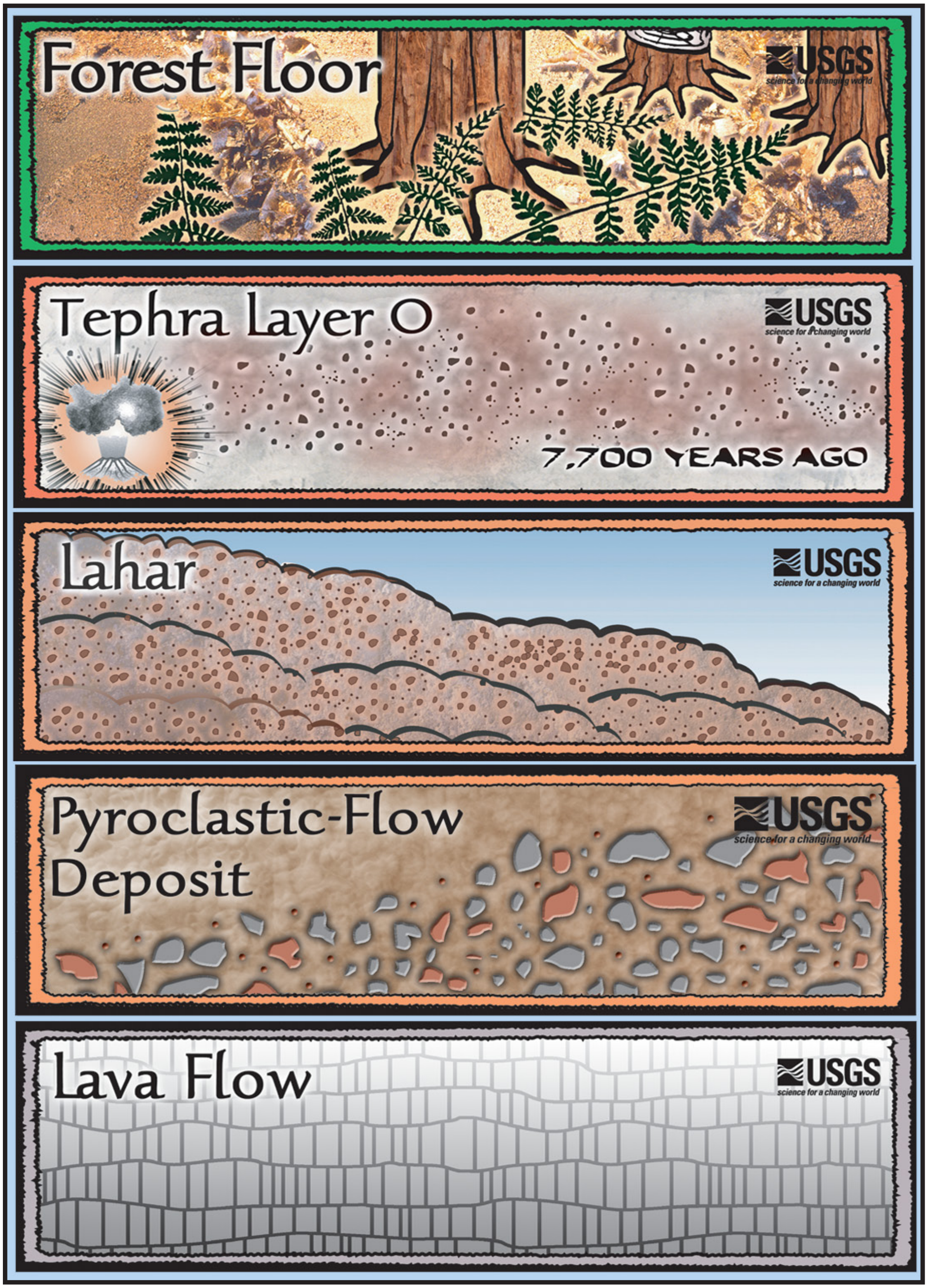
5. Summarize the similarities and differences between volcanic layers on the ridge and in the valley riverbank.
The ridge top consists of lava flows and tephra layers, while the valley riverbank principally consists of lahar and stream gravel layers. Both areas have been ashioned by a variety of geologic processes.

6. Rearrange your earth blocks into some new pattern. List the events from bottom to top. Write a paragraph that describes the events that formed these layers.

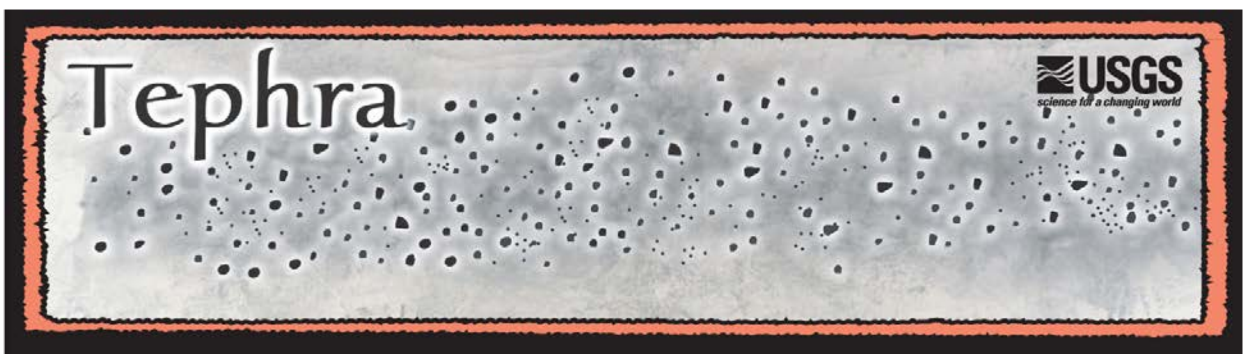
Lahar Layers in the Nisqually River Valley

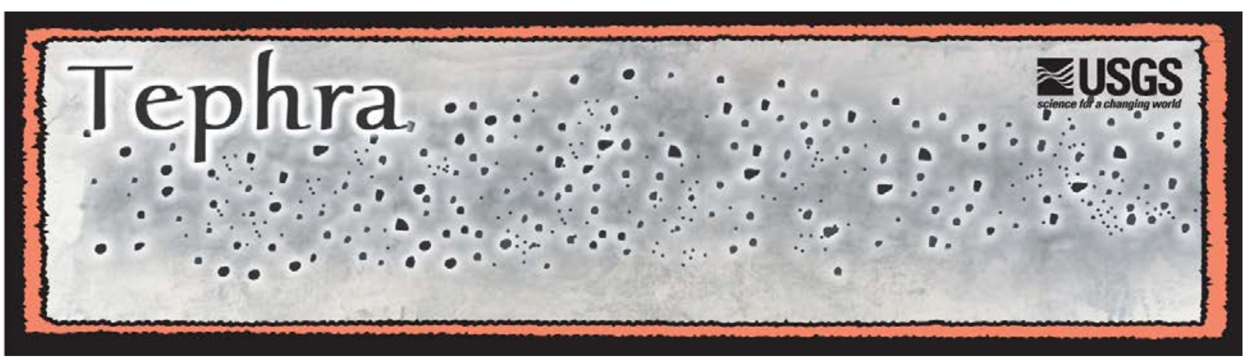


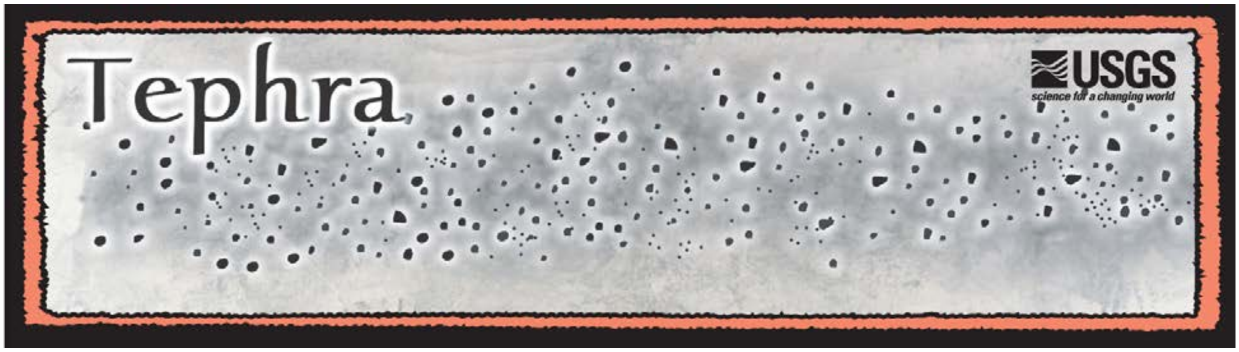
Earth Blocks—Example

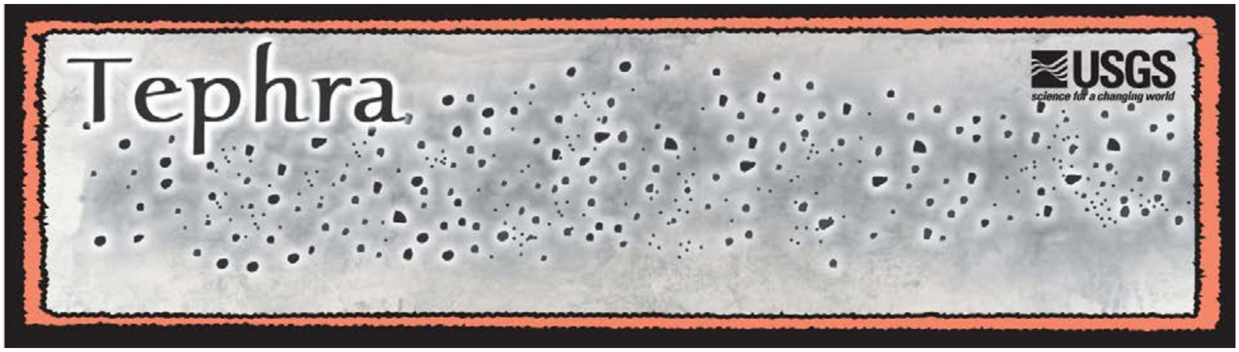


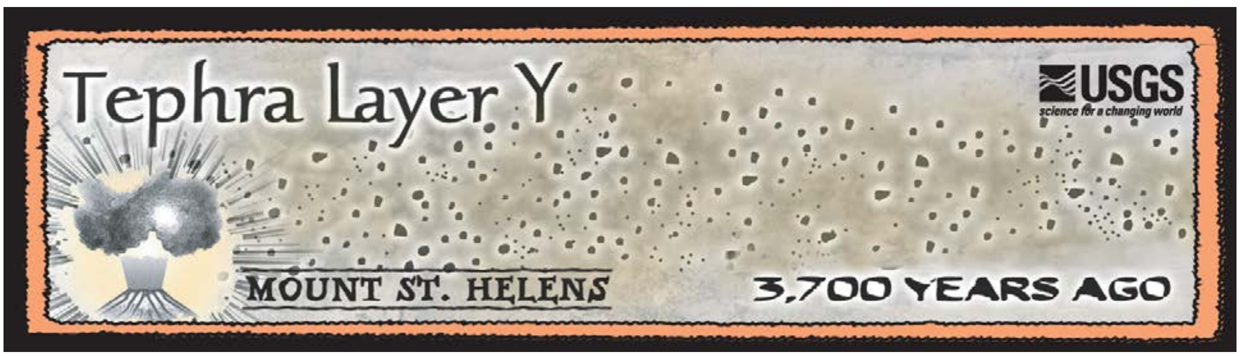
Earth Blocks For Activities

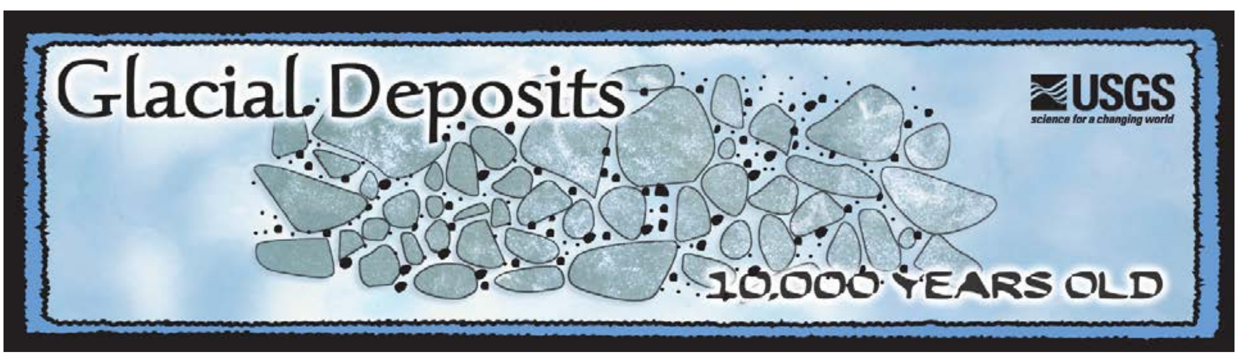


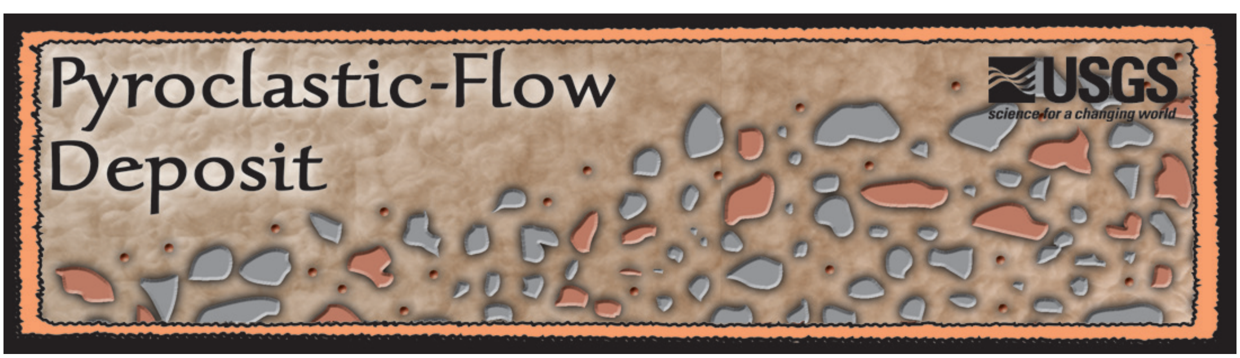



Tephra
USGS
science for a changing world


Tephra
USGS
science for a changing world


Tephra Layer Y
USGS
science for a changing world
MOUNT ST. HELENS
3,700 YEARS AGO


Glacial Deposits
USGS
science for a changing world
10,000 YEARS OLD


Pyroclastic-Flow
Deposit
USGS
science for a changing world

Pyroclastic-Flow Deposit

science for a changing world

Lava Flow

science for a changing world

Lava Flow

science for a changing world

Lava Flow

science for a changing world

Lava Flow

science for a changing world

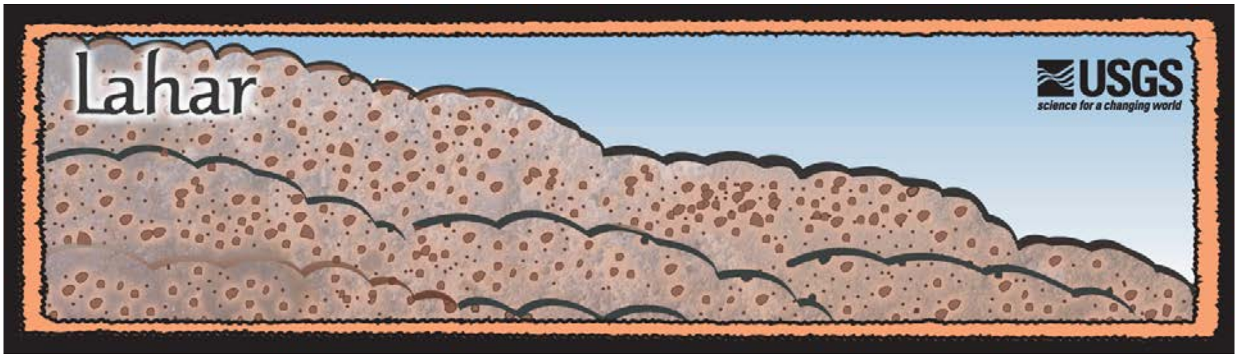

Lava Flow
USGS
science for a changing world
≈380,000 YEARS AGO

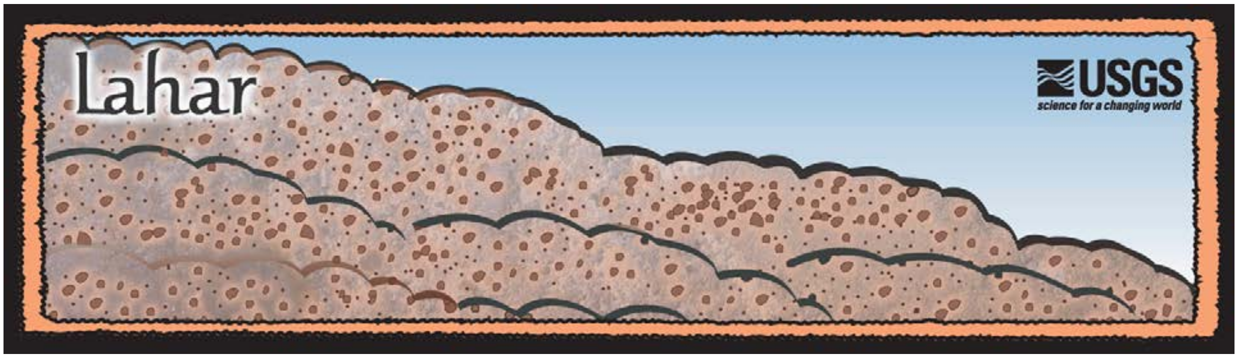

Stream Gravel
USGS
science for a changing world

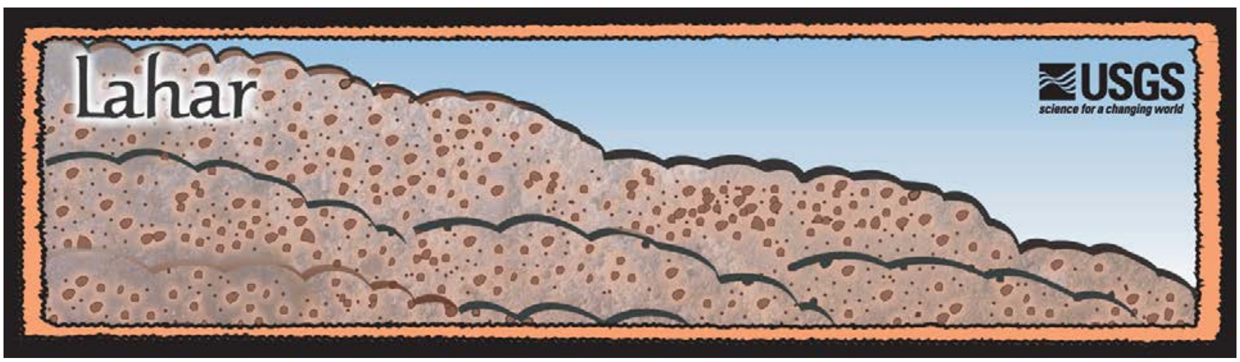

Stream Gravel
USGS
science for a changing world

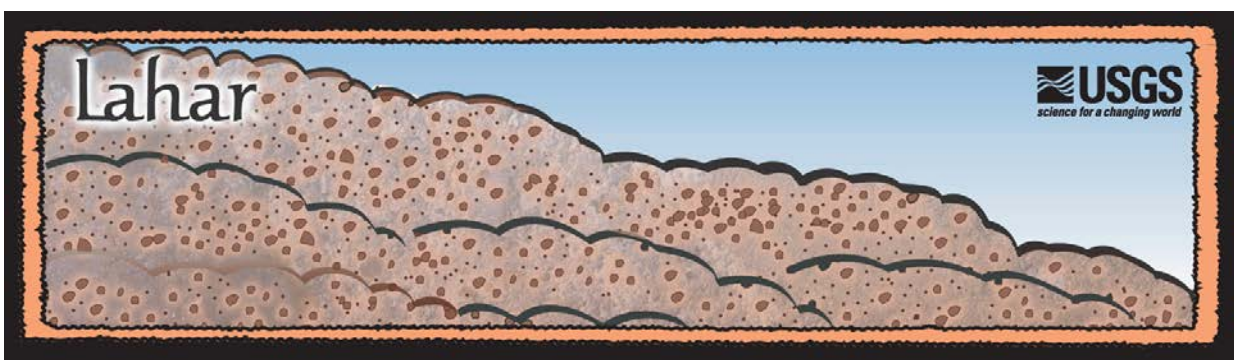

Stream Gravel
USGS
science for a changing world

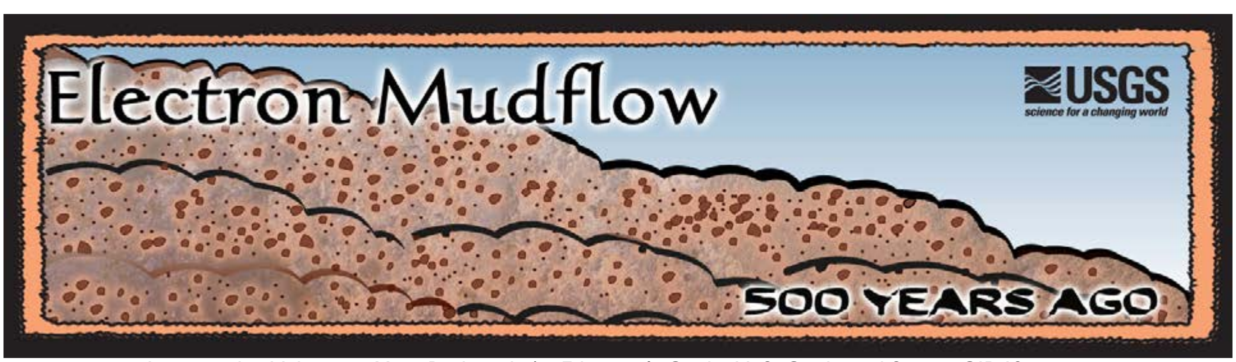

Stream Gravel
USGS
science for a changing world

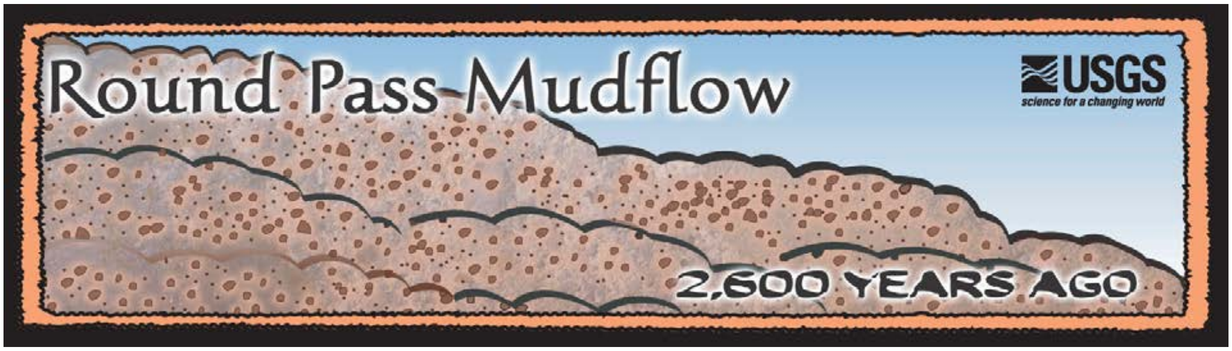

Lahar
USGS
science for a changing world

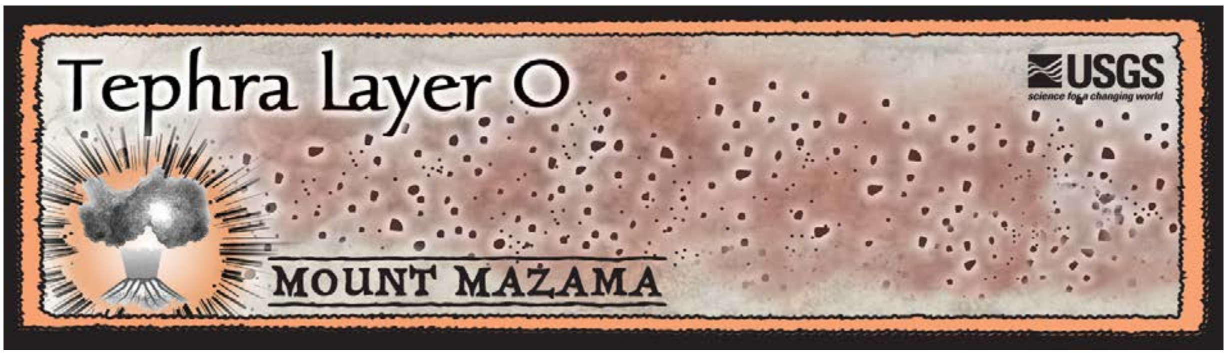

Lahar
USGS
science for a changing world

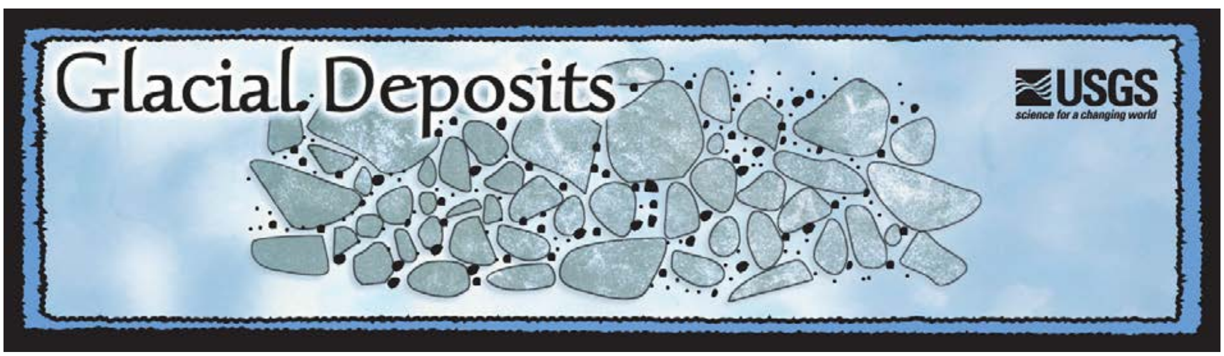

Lahar
USGS
science for a changing world


Lahar
USGS
science for a changing world


Electron Mudflow
USGS
science for a changing world
500 YEARS AGO


Round Pass Mudflow
USGS
science for a changing world
2,600 YEARS AGO


Tephra Layer O
USGS
science for a changing world
MOUNT MAZAMA


Glacial Deposits
USGS
science for a changing world