Shoebox Geologist

Grade Level: 6-10

Learner Objectives:

Students will:

- Learn about the types of deposits produced by volcanic processes
- Learn about the law of superposition
- Apply knowledge of geologic processes to create and interpret a model
- Measure and record data to create a stratigraphic column

Setting: Outdoors or in a tarped or uncarpeted classroom

Timeframe: 90 minutes (or two class sessions) plus 2–3 days drying time for models

"Interpreting a Stratigraphic Column of Books and Papers"–10 minutes

"Modeling Earth Events in a Shoebox" –40 minutes

"Interpreting Earth Events in a Shoebox" –40 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

Model depositional processes from volcanically active areas using sediments in a shoebox. Interpret geologic events from layers in a classmate's shoebox model and draw a stratigraphic column graphic.

Before

After

Activity last modified: November 9, 2007

Materials:

Introducing Rock and Sediment Layer Interpretation

- Class copies of ***"Shoebox Geologist Recipes"*** student page
- ***"Layers at Sunrise Ridge on Mount Rainier"*** graphic

Modeling Erosion and Deposition in a Shoebox

- 6–8 copies of ***"Shoebox Geologist Recipes"*** student page
- 6–8 copies of ***"Shoebox Geologist–Sequence of Events"*** student page
- 6–8 copies of ***"Shoebox Geologist–Interpretation of Events"*** student page
- 2–4 tarps (for indoor use only)
- Gravel
- Medium to coarse sand
- Sawdust
- Potting soil
- Dry cement powder or rock dust
- 4 or more varieties of colored sand
- Soil
- Fine white sand
- Twigs
- Human artifacts (bottle caps, match sticks, string, etc.)
- 6–8 shoeboxes
- 18–24 containers for mixing sediments (plastic bags, buckets or large beakers work well)
- Disposable gloves for students

Interpreting Volcanic Events from Layers in a Shoebox Model

- Copies of ***"Shoebox Geologist-Recipes"*** student page
- Copies of ***"Shoebox Geologist–Interpretation"*** student page
- 6–8 rulers
- 6–8 scissors
- spray bottle with water

Vocabulary: Deposit, Law of Superposition, stratigraphic column

Skills: Measure, demonstrate, compare, interpret, observe, apply, analyze, conclude

Benchmarks:

Science:

1 – Understands and uses scientific concepts and principles

1.2 – Recognize the components, structure, and organization of systems and the interconnections within and among them

Systems–describe how the parts of a system interact and influence each other

1.3 – Understand how interactions within and among systems cause changes in matter and energy

Processes and interactions in the earth system–describe the processes of constructive and destructive forces and how they continually change landforms on earth

2 – Knows and applies skills and processes of science and technology

2.1 – Develop abilities necessary to do scientific inquiry

Questioning–generate questions that can be answered though scientific investigations

Designing and conducting investigations–design, conduct, and evaluate scientific investigations, using appropriate equipment mathematics, and safety procedures

Explanation–use evidence from scientific investigations to think critically and logically to develop descriptions, explanations, and predictions

Modeling–correlate models of the behavior of objects, events, or processes to the behavior of the actual things; test models by predicting and observing actual behaviors or processes

Communication–communicate scientific procedures, investigations, and explanations orally, in writing, with computer-based technology, and in the language of mathematics

Geography:

1 – Uses maps, charts, and other geographic tools to understand the spatial arrangement of people, places, resources, and environments on Earth's surface

1.1 – Use and construct maps, charts, and other resources to gather and interpret geographic information

1.1.2b – Uses data and a variety of symbols and colors to create thematic maps, mental maps, and graphs depicting geographic information

1.2 – Recognize spatial patterns on Earth's surface and understand the processes that create these patterns

1.1.2a – Locate physical and human features and events on maps and globes

2 – Understands the complex physical and human characteristics of places and regions

2.1 – Describe the natural characteristics of places and regions and explain the causes of their characteristics

1.1.2 – Use observation, maps, and other tools to identify, compare, and contrast the physical characteristics of places and regions

Mathematics:

3 – Uses mathematical reasoning

3.1 – Analyze information

4 – Communicates knowledge and understanding in both everyday and mathematical language

3.1 – Gather information

Teacher Background

Earth processes, such as volcanic events, floods, landslides and glaciers, frequently leave behind evidence of their passing in the form of layers known by geologists as **deposits**. By studying deposits of recent Earth events, geologists are able to look at older deposits and identify the processes that caused them.

One of the fundamental principles of geology is the **Law of Superposition**. This law states that layers that are younger will be deposited on top of layers that are older. This law is a guiding principle of studying rock and soil layers. The Law of Superposition helps geologists determine the relative ages of earth events.

Geologists often portray these deposits in a vertical drawing called a **stratigraphic column**. Drawing a stratigraphic column can help students visualize a sequence of earth events.

Procedure

What to do before class begins:

1. Assemble items listed in ***"Materials"*** or collect similar items. For multiple groups in a classroom, you might need a standard bucket full of gravel, sand and organic material. Another option for classes working in natural areas out of doors is to have students collect and label materials on their own.

2. Instruct students to collect some materials, such as "human artifacts" (i.e., paper clips, buttons, etc.), and to bring a shoebox from home.

3. Go to the Recipes and mix materials as instructed.

4. The shoebox layers will remain more cohesive if you add quick-drying cement such as Plaster of Paris, at a ratio of approximately 4 rock materials to 1 quick-drying cement. Add the quick-drying cement but not the water to your source materials.

5. Label your materials for easy access and identification by students–tephra, lahar, forest floor, etc. You might choose to place a selection of materials in one-gallon bags, and deliver them to each student group.

Interpreting a Stratigraphic Column of Books and Papers

The Law of Superposition states that layers that are younger will be deposited on top of layers that are older. Illustrate this concept by having the class build a column of papers and books, followed by the drawing of a stratigraphic column on a projected transparency or board.

1. To illustrate the Law, create a stratigraphic column graphic as a class. Multiple students stack papers and books at one central location that is visible to all.

2. Afterwards, the class describes the events from first to last. Students verbally describe some characteristics of each book or paper layer. During this discussion draw and label the event sequence, from bottom to top, on an overhead transparency or board.

3. Instruct students to remove one or more books before the stratigraphic column graphic is finished. Ask if there is evidence that the event ever happened.

4. Discuss some of the geologic processes that might produce layers at Cascade volcanoes. Then, display the ***"Layers at Sunrise Ridge on Mount Rainier"*** graphic to show the class a true example of rock and sediment layers. Point out the different types of layers in the section. Refer students to the table on the ***"Shoebox Geologist Recipes"*** student page that describes the different layers produced by geologic processes.

5. Discuss gradual versus catastrophic processes and give examples: soils are formed by gradual processes; tephra desposits are deposited by a catastrophic process.

Modeling Earth Events in a Shoebox

Model the deposition and erosion of various geological processes using ingredients in a shoebox.

1. Conduct this activity outdoors or in a room free of carpets.

2. Place bags of materials on a resource table so that students can obtain them as needed.

3. Divide students into 4–5 person groups.

4. Each group requires a shoebox, spray bottle with water, containers for carrying materials to their work area, copies of **"Shoebox Geologist Recipes"** and **"Shoebox Geologist–Sequence of Events"** student pages. Students write their group number on the **"Shoebox Geologist–Sequence of Events"** student page.

5. Students should work in groups to decide the type and order of layers that they wish to construct in their shoebox. Encourage and model discussion along the following lines: ***"At the bottom of the box, I will make a stream bed. A lahar will flow over the top of the stream bed, followed by rocks from a pyroclastic flow, and a layer of volcanic ash. On top of that I will put a layer of rocks from a lahar, then two more layers of volcanic ash–each of different colors. Then, I will add rocks from another lahar, some human artifacts, another ash layer, and then forest floor on top."***

6. Students list their chosen layers in sequence from oldest to youngest (bottom to top) on the **"Shoebox Geologist– Sequence of Events"** student page. On the **"Shoebox Geologist Recipes"** student page, students circle their necessary ingredients, and place numbers on the page margin to show the order in which ingredients must be added.

7. Students consult their lists of events and required ingredients, and spread the ingredients into the shoebox in correct order, from bottom to top. Spray each layer with water, enough to moisten it well. After all layers have been emplaced in the shoebox, students should design a surface environment, simulating trees, and possibly, a stream, village, or animals.

8. Allow shoeboxes to dry for 2–3 days.

Interpreting Volcanic Events from Layers in a Shoebox Model

Interpret the shoebox layers by drawing a graphical representation of the stratigraphic column.

1. After the shoebox models are dry, students exchange their model for that of another group.

2. Give each group a **"Shoebox Geologist–Interpretation of Events"** student page. Each group should also have at hand their **"Shoebox Geologist Recipes"** student page distributed previously.

3. Instruct students to cut open the sides of the boxes carefully, using scissors, making any notations about initial observation of geologic events on the back of the student page.

4. Measure the thickness of each layer with a ruler, and then record their observations on the **"Shoebox Geologist–Interpretation of Events"** student page. ***Note: If the model is too dry and crumbly, use water from a spray bottle to dampen it.***

5. Instruct students to use the table from the **"Shoebox Geologist Recipes"** student page to identify the layers. Students should interpret the order of geologic events using the stratigraphic columns and the "Law of Superposition."

6. Pass back the **"Shoebox Geologist–Sequence of Events"** student pages from the previous section to the appropriate groups. Direct students to compare their interpretations to the list of actual events from the group that constructed the model.

7. Discuss as a class why interpreting layers is important. What are some difficulties in interpreting layers? Which layers were gradually deposited and which were deposited catastrophically?

Photo Instructions:

1. Choose Ingredients:

Choose type of ingredients and order of layers. Include vegetation and human artifacts.

2. Add layers to the box:

Add ingredients in the order that your group has chosen. Spray each layer well.

3. Fill the box–step 2:

Add layers that are easily distinguishable.

4. Tamp down layers:

Tamping or pressing firmly after each layer will help them solidify.

5. Cutting the box:

After box has dried–cut a slit in the front of the box.

6. Peeling back:

Slowly and carefully peel off the front and sides to reveal the layers.

7. Observe the layers:

Measure and analyze origin of layers.

Adaptations

- Stratigraphic columns can be created in a graduated cylinder or beaker.

Extensions

- **Photograph Your Shoebox**

  Make photographs of each opened shoebox and instruct students to label each layer using a computer graphics program.

- **Kitchen Layers in a Jar**

  Make your own layered sequence out of kitchen ingredients. Use ingredients such as cornmeal, cinnamon, oatmeal, flour, decorative sprinkles, and different colors of sugar to represent volcanic deposits (lahars, tephra, lava) and glacial or stream deposits.

  1. Fill a graduated cylinder or tall jar with layers of different ingredients. Add each ingredient so that layers are of different thickness. Each layer should contain material that looks similar to the type of deposit it represents.

  2. Instruct students to write and apply labels of each layer with a piece of masking tape.

  3. Instruct students to write a story about the series of events that occurred to deposit these layers.

- **Stratigraphic Columns from Other Regions?**

  Use library or Internet research to find stratigraphic columns of other geologic regions. Discuss how they are alike or different from stratigraphic columns in volcanic landscapes.

- **Write a Geologic Story**

  Instruct students to write the geologic story of the events that happened at the site of their shoebox geology.

- **Luscious Layers--build an edible model of Mount Rainier using simple kitchen products.**

  Conduct this activity as a teacher demonstration or in student groups. Prior to the class, bake three cake layers for your demonstration or for each student group. Assemble kitchen ingredients that represent a variety of eruptive products. For example, use cut and quartered cake layers as lava layers, crumbled cookies as loose rock layers deposited by pyroclastic flows, cocoa powder as tephra, canned whipped cream as glacier cover, and chocolate sauce as a lahar. Provide each group with a cookie tray, cake layers, and assembled kitchen ingredients, paper towels for cleanup, and plates and forks for eventual cake consumption. Build a stratovolcano by stacking ingredients into alternating layers. Take care to stack layers irregularly, as is typical of a stratovolcano. Remind students that most stratovolcanoes are not perfect cones. Pour chocolate sauce over the cake to illustrate a lahar. When the volcano cakes are completed, summarize the processes that build real stratovolcanoes, and review the Law of Superposition. Use a knife to carve out a section that exposes all layers, and then feed the cake to your volcano makers.

  Simplify preparations by purchasing a frosted layer cake. Gently lift cake layers to add crumbled cookies and cocoa powder. Run the chocolate sauce lahar over it. Cut the cake open to expose the layers. As a cheaper alternative, stack pancakes instead of cake layers.

Assessment

For assessment, review the stratigraphic columns and look for evidence of student recognition that each layer represents a geologic event. Students should be able to interpret the order of events by noting that the oldest evidence exists at the bottom while products of younger events are found at the top. Assess application to real–world situations by assigning interpretation of an additional ready-to-interpret geology shoebox. For older students assign an interpretation of layers at a local roadcut or stream cut in your community.

Resources

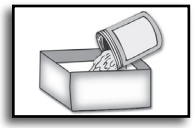
Cas, R.A.F., and Wright, J.V., 1987, Volcanic Successions Modern and Ancient–a geological approach to processes, products and successions: Allen and Unwin, London, 528 p.

Fisher, R.V., and Schmincke, H.U., Pyroclastic rocks: Springer–Verlag, New York, 1984, 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., 1pl.

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: GSA Bulletin, February, 1997, v. 109: no.2: p. 143–163, 6 tables.

Zehfuss, P.H., Atwater, B.F., Vallance, J.W., Brenniman, H., 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, Colorado, Geological Society of America Field Guide 4, p. 209-223.



Shoebox Geologist Recipes

Instructions: *Use this table to construct and interpret shoebox geologist models*

Layers	Materials in actual deposit	Recipe for deposit in shoebox	Mechanisms
TEPHRA (Volcanic Ash is fine-grained tephra)	Fragments of rock exploded out of the volcano (some bubbly) White, gray, yellow, orange, and brown in color	Colored sand, coarse natural sand, cement dust, sawdust, small gravel	Tephra falls from eruption plume or cloud
LAHAR (Volcanic Mudflow)	Boulders and cobbles in a mixture of water, mud, clay, dirt and tree debris	Mixture of dirt and gravel or crushed rock. Add just enough water to make it flow	Eruptions melt snow and ice; meltwater mixes with loose rocks and flows down river valleys
PYROCLASTIC FLOW	Coarse to fine-grained rock	Mixture of sand and gravel	Avalanche of hot, dry rocks capped by a cloud of rock dust and gases
STREAM GRAVEL	Overlapping layers of well-sorted and rounded stones, gravel, sand, silt	Gravel of variable sizes	Overlapping layers of well-sorted and rounded stones, gravel, sand, silt deposited in water
LAVA FLOW	Solid rock and often broken into large blocks	Mixture of fist-sized and smaller rocks	Lava erupts from volcanic vent and flows across surface of a volcano
LANDSLIDE or ROCKFALL	Boulders or large chunks of rock and dirt that have been displaced down slope	Clods of dirt or cobbles to represent large boulders	Rocks accumulate as a fan-like pile that is narrow at the source and broad down slope
FOREST FLOOR	Partially decomposed needles and leaves from trees and smaller plants; rock fragments	Twigs, bark needles and leaves, garden soil	Long-term accumulation of decomposed plant material mixed with rock fragments
HUMAN ARTIFACTS	Stone tools, litter piles, and other evidence of old dwellings and eating areas	Bottle caps, paper, string, match sticks, etc.	Litter remains from human occupation; may be buried by more recent volcanic layers

Student Page

Shoebox Geologist - Sequence of Events

Instructions: *Record the series of geological events that you show in your model from oldest to youngest.*

Student Page

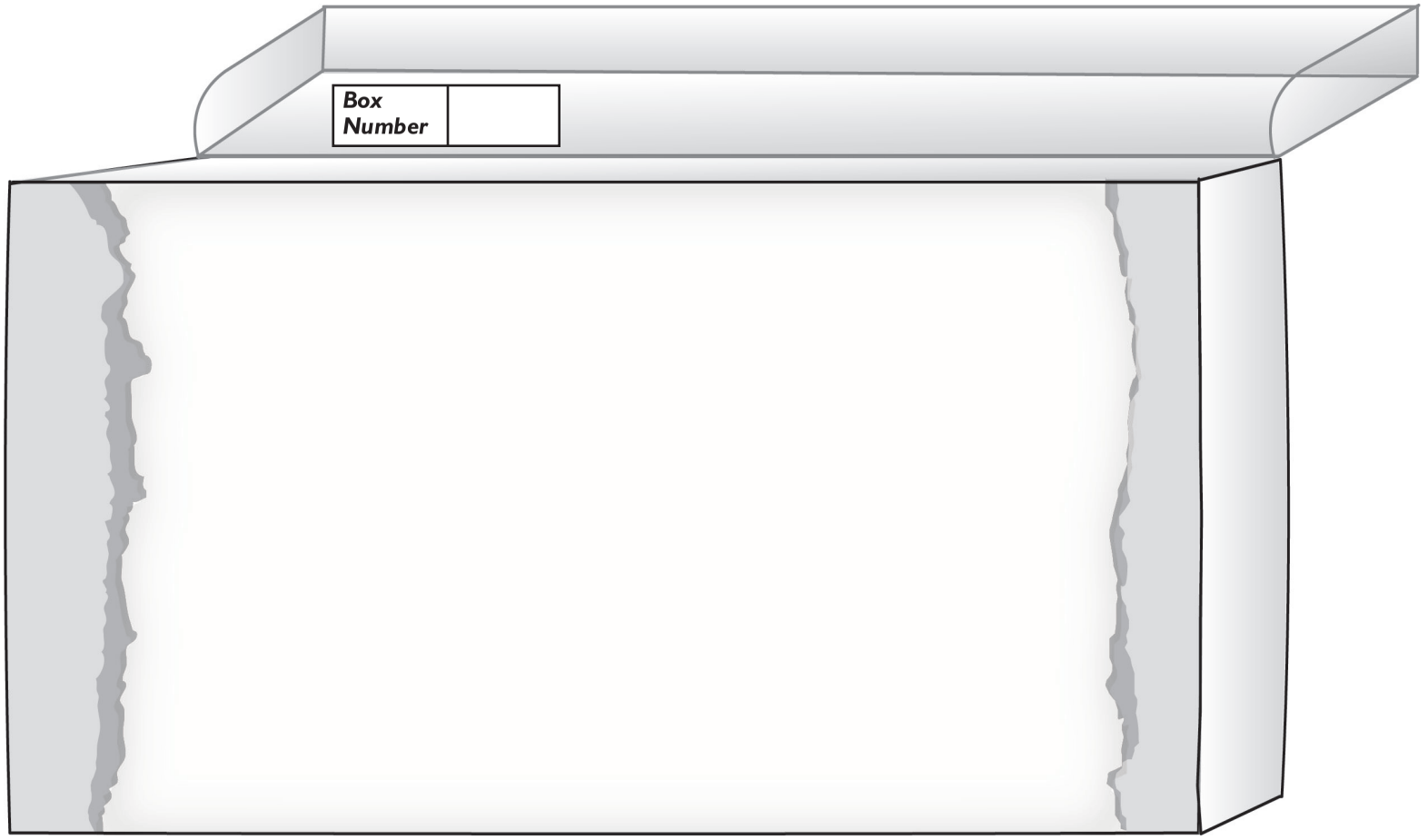
Team Names _____

Shoebox Geologist - Interpretation of Events

Student Page

Team Names _____

Instructions: *Draw the layers from the model you were given to interpret. Be sure to measure the thickness of each layer and accurately draw the layers in the rectangle below. Use shading and patterns to represent the different deposits. Label all layers in your stratigraphic column. On the back of the paper, describe the order of events. Which team's shoebox are you interpreting?*



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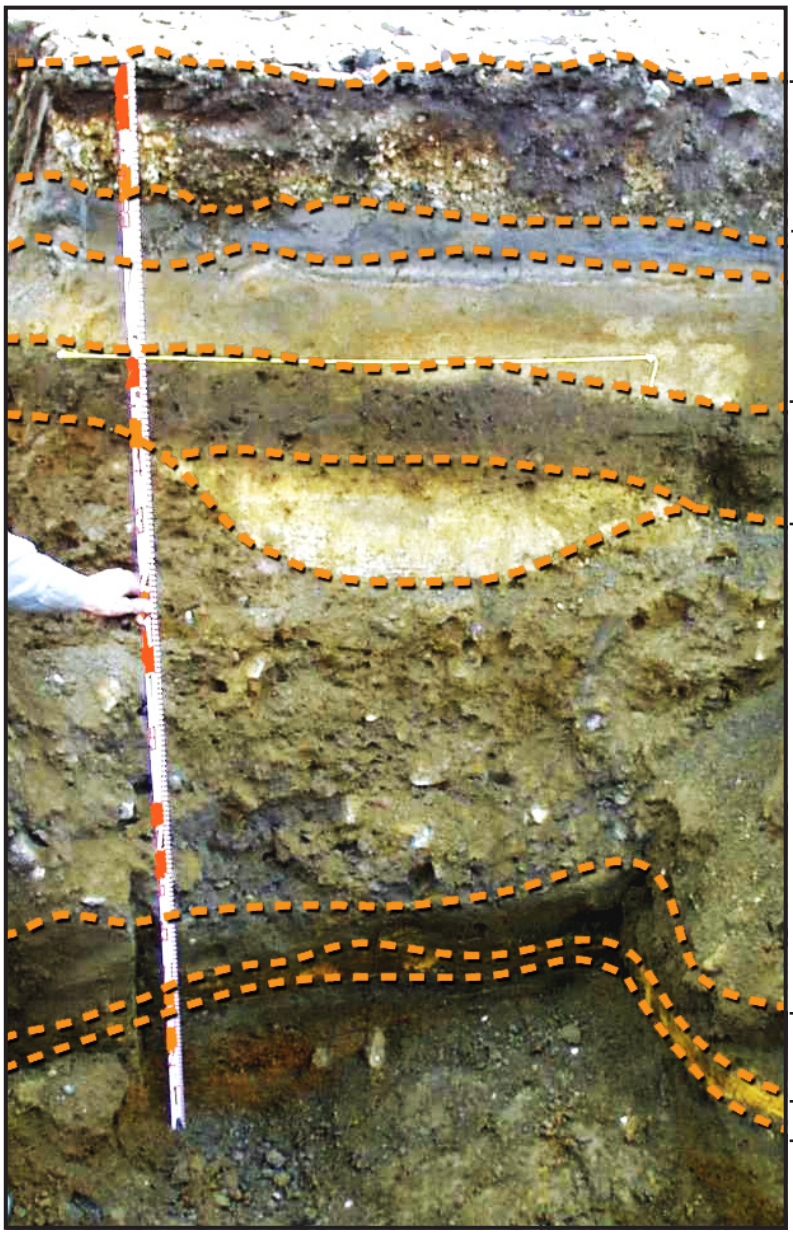
Graphic Page

Layers at Sunrise Ridge on Mount Rainier



Modern Ground Surface

Mount Rainier C-layer tephra
~ 2,200 years ago

Mount St. Helen's P-layer tephra
2,500-3,000 years ago

Mount St. Helen's Y-layer tephra
~3,300-3,700 years ago

Old Soil

Mount Rainier F-layer tephra
(in pocket), ~5,000 years ago

Possible Osceola Lahar
~5,700 years ago

Old Soil

Mount Mazama O-layer tephra ~7,700 years ago

Forest fire material in old soil
~7,700 years ago