

LESSON: Mapping Volcanoes

Grade Range	4th
Target Grade	4th
Duration	45-60 minutes
Location	Classroom

Objectives:

Mapping Volcanoes is designed as a pre-field trip activity where students will:

- read maps to understand patterns of volcanism;
- investigate the cause behind this pattern (plate tectonics);
- learn the processes and timeline of events for the May 18, 1980 eruption of Mount St. Helens; and
- use a map to identify the locations they will visit on their field trip and the part of the May 18, 1980 eruption they will explore.

Outcomes:

Use maps to identify large scale (global) and small scale (local) patterns as they relate to volcanism.

Learning Experience:

Students work in teams to map volcanoes of the world and identify patterns. Teacher provides engaging PowerPoint lesson. Students complete mapping worksheet to identify volcanic impact at Mount St. Helens.

Materials:

- PowerPoint presentation
- Plate Tectonic Map and Volcano Cards Set
- Student worksheet “Eruption Zone Coloring Worksheet”
- Colored pencils

Next Generation Science Standards:

Dimension from Framework	Connections to the 3 Dimensions
Science and Engineering Practice: <ul style="list-style-type: none">• Analyze and interpret data	Students use maps and data to make sense of phenomena.
Disciplinary Core Ideas: <ul style="list-style-type: none">• ESS2:B Plate Tectonics and Large-Scale System Interactions	Students understand that volcanoes occur near plate boundaries and map can help locate these features.
Crosscutting Concepts: <ul style="list-style-type: none">• Patterns	Students observe patterns on maps to make sense of the location of volcanoes and plate tectonics.

Common Core State Standards:

Common Core State Standard (CCSS)	Connections to CCSS
ELA	NA at this time
Math	NA at this time

Background:

Construction of the earth: The earth is built like an avocado. In the center of the earth is a dense, heavy core, largely composed of iron and nickel. It's solid on the inside and liquid on the inside. On the outside is the crust, a solid thin layer on the surface of the earth. Between the two is the mantle, which is stiff but moveable (like Silly Putty or a barely ripe avocado). It doesn't flow easily, but it can slowly move over time. Different parts of the mantle are warmer than others. These warmer areas move upwards and develop convection currents, like a lava lamp. The crust is broken into pieces like a jigsaw puzzle, which are carried along the slow-moving convection currents of the mantle. These broken pieces of crust are called tectonic plates. Tectonic plates move slowly (between less than 1 to 15 centimeters per year) and in different directions. These extremely slow movements have BIG effects; 80% of the world's earthquakes and volcanoes happen along or near the boundaries between tectonic plates!

Plate Tectonics and Boundaries: The different directions that the tectonic plates move in controls what happens:

1. **Plates slide:** The location where tectonic plates slide past each other is called a transform boundary. As the plates slide and grind horizontally past each other, they can catch and snag each other like Velcro, building pressure. Eventually this pressure can be released like a snapping, breaking rubber band, creating an earthquake. Examples of major faults at transform plate boundaries include the 1300 kilometer (800 mile) long San Andreas Fault in California which caused the infamous 1906 San Francisco earthquake and the Enriquillo Fault which caused the 2010 Haiti earthquake.
2. **Plates divide:** The location where tectonic plates move away from each other is called a divergent boundary. Lava comes up from below and fills in the ever-opening space between the two plates, creating new oceanic crust. Divergent plate boundaries are ocean-floor making machines! Over time, the lava at this kind of boundary builds up enough to form underwater mountain ranges called mid-ocean ridges. The Mid-Atlantic Ridge is an example of a divergent plate boundary.
3. **Plates collide:** The location where tectonic plates move towards each other is called a convergent boundary. There are two types:
 - a. The plates can lift each other up and build mountains. An example of this uplift is the Himalayas, where the Indian and the Eurasian Plates move towards each other. Mount Everest in the Himalayas continues to grow a few millimeters each year. In fact, Mount Everest has marine fossils high up on its slopes. It used to be at the bottom of the ocean!
 - b. One plate can go beneath the other plate in a process called subduction. This is what makes Mount St Helens! The Juan de Fuca plate moves under (subducts) the North American plate. As it subducts, it carries wet sediment and water from the ocean floor along with it. It sweats off the water, which percolates upward into the North American plate. The water in the North American plate causes rock to melt, forming magma. {See

PowerPoint notes}. If the magma is able to move upwards and come out of the earth as lava, a volcano is born! Subduction zones are also responsible for large earthquakes. Enormous pressure is built up in trenches where one plate is subducting beneath the other. This activity has caused some of the largest earthquakes in recent history, such as the 2011 Tōhoku earthquake and tsunami.

Mount St. Helens Eruption

Mount St. Helens has been erupting for the last 275,000 years. This sounds really old, but Mount St. Helens is actually very young for a volcano. Mount St. Helens is also a very busy- or “active”- volcano. For the last 4,000 years, Mount St. Helens has been the most active volcano of the volcanoes in the Cascade Range. In March of 1980, scientists began to see signs of magma moving within Mount St. Helens. They recorded earthquakes created when magma rises towards the surface, cracking and shaking break as it moves. Soon, the magma inside the volcano heated up the water that was soaked in the ground, turning the water to steam that blew out small craters at the top of the mountain. Eventually, so much magma filled the inside of Mount St. Helens that it inflated the north side of the mountain like a balloon, creating a “bulge.” At first scientists needed special instruments to detect this bulge, but by late April to May, the bulge was so big that bulge that they no longer needed special equipment- the entire northern side of the mountain looked different. The way the magma filled Mount St. Helens and created the bulge is why the May 18 1980 eruption happened the way it did. This bulge was very heavy and very unstable. It began to fall down and fall apart at 8:32 a.m. on May 18, 1980 in the largest landslide ever witnessed by humans in recorded history. This landslide began the rapid, devastating chain of events of the May 18 1980 eruption.

Instructional Sequence Part 1:

ENGAGE

1. Start by asking students some guiding questions:

What is the earth made out of?

Is the earth solid?

What do you know about plate tectonics?

How do we know what the earth is made out of?

EXPLORE

2. Give each students a “Volcano Card.” Ask the students to line up and one at time use a sticky arrow at the location of his/her volcano.

3. Ask students to work with a partner to analyze the pattern and discuss what causes this pattern. (Give students 3 minutes).

4. Ask students pairs to share their ideas.

EXPLAIN

5. Start the PowerPoint presentation which explains how the earth is structured and how plate tectonics cause patterns in the location of volcanoes.

ELABORATE

6. Discuss the types of plate boundaries and the reason that boundaries cause different landforms and processes on the earth's surface.

7. Teach the students the plate tectonic handshakes and let them practice with a partner and share the Adams Family Plate Tectonic song.

EVALUATE

8. Ask the students to identify where we are on the map. Then ask the partners to decide what type of boundary we are located near. What landform is common in the area?

Instructional Sequence Part 2:

ENGAGE

9. Start by asking students some guiding questions:

Where is Mount St. Helens?

What is Mount St. Helens?

What are some other volcanoes that are in Washington or Oregon?

EXPLAIN

10. Continue the PowerPoint presentation which goes through the sequence of events during the 1980 eruption of Mount St. Helens.

11. Explain that the different parts of the eruption (landslide, mudflow, pyroclastic flow & lateral blast) affected the land in different ways and in different areas. Explain that the different zones on the map show the areas that were affected by the different parts of the eruption. Explain that they will see areas affected by these different parts of the eruption on their field trip.

EXPLORE

10. Pass out the student worksheet and colored pencils.

11. Instruct the students to color the different eruption zones on the worksheet and the matching boxes in the key. Each zone should be a different color and it should match the box in the "zones to color" section of the key.

12. Ask students to find all or some of:

- Their town (or at least which direction it is in)
- The route that their class will be taking on the field trip
- The lakes that they will see (can be used as a reference point on the trip)
- The crater rim (the new top of the volcano! This will certainly be a reference point).
- The buildings that your group will be visiting (JRO or SLC)

ELABORATE

14. Ask students to draw their travel route to Mount St. Helens and label which disturbance zones they will ride through. Ask:

- Which zone will they travel through first? (mudflow)
- Which zone will they travel through second? (lateral blast)

EVALUATE

15. Consider asking:

- Which part of the eruption (landslide, lateral blast, mudflow, or pyroclastic flow) traveled the farthest?
- *This is a tricky question, but it could get them thinking! The mudflow traveled downvalley the farthest distance from Mount St. Helens, but the lateral blast devastated an enormous area. They can learn more later about why, but emphasize again here that the different parts of the eruption affected different areas different ways!

Adaptations and Modifications:

16. If time allows, ask the students to write a story about.... about witnessing the eruption in a particular eruption zone. For example: tell a story from the perspective of a tree, or being a bird overhead.

Additional Background Information:

The Earth is complicated and there's a lot going on- more than is told than with the bare-bones introduction to plate tectonics. If students are interested, below are some side notes to help answer some potential questions.

Side note 1: Scientifically, it is better to categorize the layers of the earth as 1) core 2) asthenosphere and 3) lithosphere. If students are older consider doing this. Here the classification is on its mechanical properties (ie the lithosphere behaves as a solid, or at least takes thousands of years to deform. It comprises the crust AND the upper mantle.) The crust-mantle classification scheme is actually a chemical one. Perhaps over-information but if students are old enough, they might as well be getting the correct classification scheme.

Side note 2: The other 20 % or so of the world's earthquakes and volcanoes ALSO happen because of plate tectonics, but the story is more complicated.

- a. Volcanoes can happen from something called hotspot magmatism. The mantle/asthenosphere is not the same temperature everywhere. Some parts of the mantle are very hot and can make volcanoes above these very hot spots, regardless of whether it is at a plate boundary or not. A famous example is Hawaii, with its active volcanoes. To the east of the active Hawaiian volcanoes is a trail of older, extinct volcanoes called the

Hawaiian-Emperor seamount chain. The reason this chain forms is because the Pacific plate moves over the hotspot, which has remained seemingly stationary over time. Other hotspot volcanism locations include western Africa (with its now active Mount Cameroon) with its trail extending to the west into the Atlantic and Yellowstone with its older trail in the Snake River Plain of Idaho.

- b. Tectonic plates do not necessarily move as one giant block. They can stretch, compress, and rotate. In the Pacific Northwest, the crust is rotating clockwise – see the UNAVCO “Tectonic Motions of the Western US”) poster.
- c. Volcanoes can form in the middle of tectonic plates where the crust is pulling itself apart. The western United States contain many examples of this, with old lava flows and cinder cones in Nevada, Utah, New Mexico, and more. In eastern Africa, the crust has pulled itself apart so much that it will eventually separate and break into two separate tectonic plates. It has already pulled itself apart so much that it is making oceanic crust.
- d. Earthquakes can happen where old plate boundaries or other tectonic stresses used to be. For example the Magnitude 7 to 8 New Madrid earthquakes which happened in Missouri in 1811 and 1812 were due to very old tectonic stresses that built up when what is now North America was part of the supercontinent Rodinia. The continent began to split, similar to what is currently happening in East Africa, building up stresses that took millions of years to be released.

Side note 3: What happens at tectonic plate boundaries also depend on what types of tectonic plates are involved: continental or oceanic. Oceanic crust is thin (about 3 miles thick) and dense. Continental crust is thick (about 10 to 30 miles thick) and has a low density. If two plates, one with oceanic and one with continental crust move towards each other, the thin, dense plate will go beneath the thick, less-dense plate. This is what happens at the boundary between the Juan de Fuca and the North American plates, which creates the volcanoes of the Cascades!

Side note 4: What happens at tectonic plate boundaries also depends on how fast the plates are moving. For example, the Caribbean plate and the North American plate both move to the west. However, the North American plate is moving faster than the Caribbean plate. It overtakes it and pushes beneath the Caribbean plate. This is what makes the volcanoes of the eastern Caribbean!

Side note 5: The heat inside the earth is caused by the radioactive decay of uranium and thorium deep in the earth’s mantle.

Side note 6: The different kinds of boundaries are what they are for a few different reasons: 1) Divergent boundaries form at the location between two mantle convection currents that are moving in opposite directions. It begins when an old plate splits (like what is currently happening in East Africa). As new crust is being continually formed, it is carried farther and farther away from the divergent boundary as the plate rides the convection current like an inner tube on a lazy river. Over time, however, the plate begins to cool and as it cools, it becomes more dense. Eventually it can become denser than the mantle beneath it and can begin to sink from one end. When one plate sinks below another, a subduction zone is formed. Once one end begins to sink, the weight of it begins to pull the rest of the plate below. This process of “slab-pull” is considered the main driving force for subduction.

Side note 7: Subduction can also create mountain ranges from magma that has never erupted. When magma formed by subduction rises through the crust, it doesn't always make it to the surface and erupt. When these large blobs of magma cool and slowly crystallize, they become the building blocks for large mountain ranges, such as the Sierra Nevada Range in California and the Andes in South America.

Side note 8: It might seem pretty weird that water melts rocks in subduction zones, but it's true! Lava contains a lot of silica and oxygen, which bond together and form pyramid-shaped molecules called silica tetrahedra. These silica tetrahedra can also bond together, eventually forming polymer chains. Eventually, with more and more bonding, crystals form and magma solidifies. However, adding water breaks these chains and thus melts the rock.

Credits

Volcano Card Photo Sources:

Bezymianny (Global Volcanism Program), Erta Ale (Indrik Myneur), Etna (mustseeplaces.eu), Kilauea (USGS), Eyjafjallajökull (National Geographic), Merapi (<http://keyworldtourism.blogspot.com>), Mayon (philnews.ph), Popocatepetl (Twitter:@AidaLiraL), Sakurajima (AP Photo/Kyodo News), Santa Maria (geology.com), Soufriere Hills (mniaalive.com), Vesuvius (forbes.com), Erebus (USGS), Puyehue Cordon Caulle (<http://resources1.news.com.au>), Colima (César Cantú), Mount St. Helens (USGS), Nyiragongo (Wikimedia Commons), Redoubt (R. Clucas), Sabancaya (volcano.si.edu), Tongariro (dailymail.co.uk), Arenal (volcanoarenal.com), Galeras (<http://www.rutacol.com/>), Tungurahua (Getty Images), Lascar (cgd.ucar.edu), Tavurur (Washington Post), Tambora (<http://www.topindonesiaholidays.com>), Krakatau (www.swisseduc.ch), Pavlof (www.aim.org)

Plate Tectonics Map from Global Volcanism Program This Dynamic Planet

Eruption Zone coloring worksheet adapted from USFS PNWRS Disturbance Zone Map