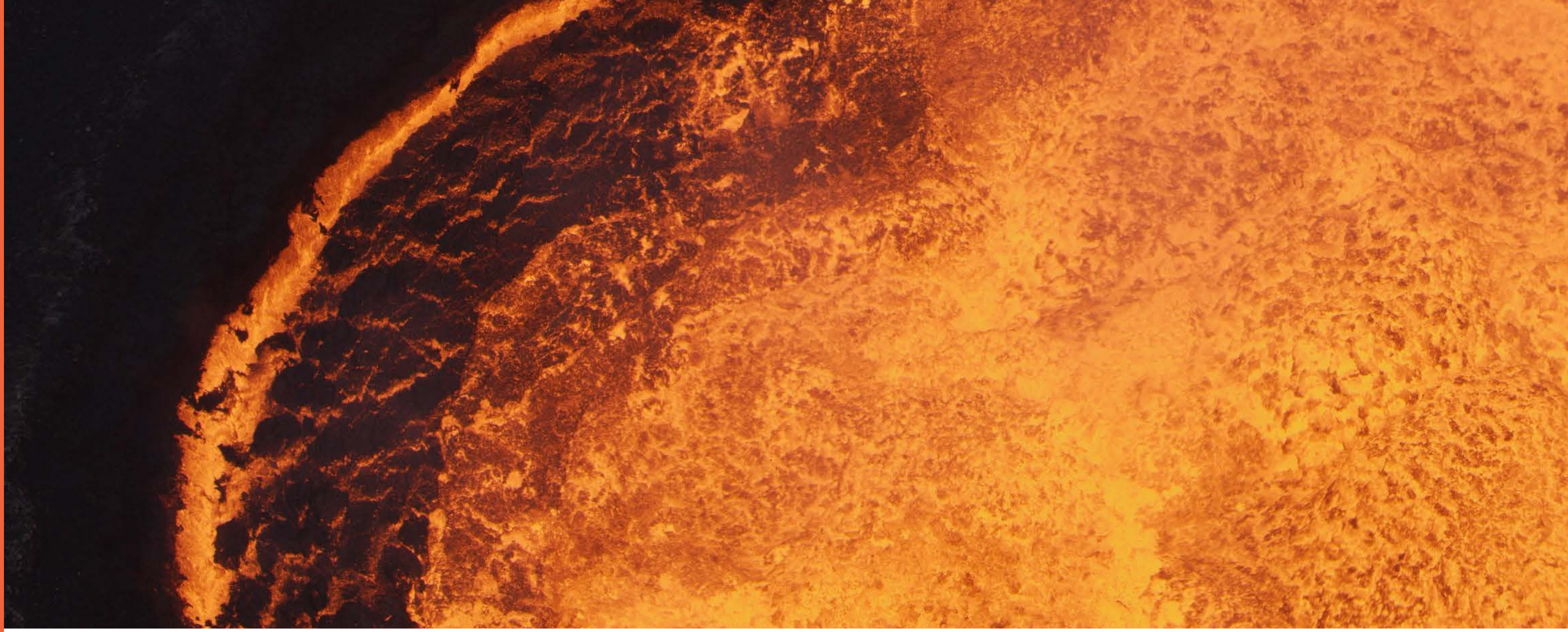
EDUCATOR GUIDE

VOLCANOES
THE FIRES of CREATION

An SK Films Release

DIGITAL CROSSING FILMS



Volcanoes Educator Guide

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INTRODUCTION TO GUIDE

THE *VOLCANOES* EDUCATOR GUIDE,

created by Discovery Place Education Studio in Charlotte, North Carolina, in partnership with SK Films, is appropriate for students in the primary grades (K–8). The guide is most useful when used as a companion to the film, but also valuable as a resource on its own. Teachers are strongly encouraged to adapt activities included in this guide to support specific state or national standards and the needs of their students. Activities developed for this guide support national Common Core math standards and the Next Generation Science Standards (NGSS). This guide focuses on the scientific understanding of geological process, human interactions with volcanoes, and career understandings of scientists who work in the field. It is packed full of fun and engaging activities that have been tested and approved by teachers and kids in a classroom setting. At the end of the guide, teachers can find additional resources to assist with cross-curricular planning.

Volcanoes explores Earth's most dangerous features. The film begins with a trip down a volcanic caldera with National Geographic photographer Carsten Peter. His team works together to keep themselves safe as they camp on the rim of the active Marum Crater. The film then follows the team as they lead expeditions to volcanoes all over the globe.

Volcanoes features up close views of active eruptions in Africa, Indonesia, Hawaii, Europe, and even under the ocean. Throughout the film, the narrator talks about the geological history of our earth and the physical forces that combine to form the spectacular forces of nature.

Volcanoes is an SK Films release of a Digital Crossing Production, directed and produced by Michael Dalton-Smith. The film has a run time of 40 minutes.

To learn more, visit *http://volcanoesfilm.com/*

Volcanoes Educator Guide

BACKGROUND

VOLCANOES EXPLORES THE IMPACT

of geologic hot zones and the people who study them. It was informed by volcanologists, who leave the safety of a four-wall office job to take a front seat at one of the most dangerous natural features on this planet. Their work not only allows us to appreciate the magnificent beauty of volcanoes, but also provides a crucial lifeline to protecting people living near them. This educator guide allows teachers to extend the viewing experience of the film to classroom activities that drive student interest and understanding of the people and places of ***Volcanoes***.

PEOPLE:

Volcanologists serve a vital role in keeping our global community safe. It is their scientific approach to understanding eruptions that equips local authorities to better predict major events and protect its citizens. In this film, several volcanologists played a major role in writing the content and supporting the safe filming of volcanoes over the planet.

DR. STEPHEN SPARKS

Professor of Earth Sciences, University of Bristol

Dr. Sparks is a world-leading expert on volcanology and geologic processes. Recently, he received the Vetlesten Prize from Columbia University for his contributions to our understanding of volcanoes. Early in his career, he was the first to apply mathematical and physical analytical techniques to understanding the volcanic processes. His work allowed scientists to form more accurate models of the physical triggers for different eruptive types and thus provide better monitoring systems for geologists around the world. In his career he has studied and modeled volcanic eruptions from all over the globe. His passion for volcanoes makes him one of the premier advocates and educators on volcanology.

DR. EDWARD YOUNG

UCLA professor of Geology, Geochemistry, and Cosmochemistry

Understanding volcanoes means understanding how our planet was formed. Volcanoes are the echoes of an ongoing destructive and constructive cycle that began with the birth of our planet. Few know as much about this history as Dr. Edward Young. He is an expert in the intersection of geology, chemistry, and the origins of our universe. His work was instrumental in our understanding of the impact between Theia and Earth: at the time, two planetesimals traveling in the same orbital field. Dr. Young's application of chemical processes to analyzing rocks from active volcanoes on our planet and the moon revealed a new understanding of the ancient collision that formed our planet as we now know it. His advice and guidance on the film ***Volcanoes*** illuminated an understanding of volcanoes in the history of our planet.

BACKGROUND

PLACES:

Volcanoes takes us on a journey around the globe. Through the eyes of adventurers and photographers, we see how volcanoes shape the different environs of our planet. In this film, we see volcanoes and their effects are equally as diverse as the people who explore them.

RING OF FIRE

The Ring of Fire is a chain of active volcanoes stretching from the pacific Indies, northward, and across the Pacific Ocean to the West Coast of the Americas. Over 425 active and dormant volcanoes call the Ring of Fire home. All but three of the 25 largest volcanic eruptions in the past 12,000 years occurred along this area of the globe. The intense geologic activity is the result of the Pacific tectonic plate converging with the surrounding plates on its east, north, and west side. As the denser oceanic crust subducts beneath the continental crust of the surrounding plates, the oceanic crust melts forming new magma, and seawater is also dragged into the hot mantle. The build up of newly molten rock and hot pressurized gas from sea water exert upward pressure on the crust above it, resulting in spectacular eruptions.

KILAUEA

Kilauea is an active shield volcano located on the big island of Hawaii. Known for being one of the more “gentle” of volcanoes, this active shield is nothing to take lightly. Kilauea has been erupting continuously for the past 35 years, causing significant property damage from its lava flow. Though erupting continuously, lava flow patterns often change suddenly and unpredictably. In 2018, an earthquake and new eruption opened two new lava vents in direct line of a Hawaiian neighborhood. An entire community had to be evacuated and as of the summer of 2018 the damage continues.

Unlike the stratovolcanoes along the Ring of Fire, Kilauea is formed from a rare geologic hot spot. Rather than occurring at plate boundaries like most volcanoes, this hot spot exists at the center of the Pacific plate. The mantle beneath Kilauea is relatively hotter than its surrounding areas and forms a plume that bubbles to the surface. The continuous upwelling of thin and hot magma makes the perfect island building machine. The Hawaiian hot spot is responsible for making all of the islands along the Hawaiian-Emperor seamount chain.

MOUNT VESUVIUS

Mount Vesuvius is a volcano located on the Naples Coast of Italy. It is most famously known for its AD79 eruption and consequent destruction of nearby Pompeii. To date, Pompeii serves as a perfect example of the hazards of a stratovolcano eruption. Its 79 eruption ejected a gas cloud that extended into the stratosphere of our atmosphere. The massive eruption released a pyroclastic flow that plowed down the mountain at an estimated speed of 6 meters per second. The intensely hot flow of rocks and debris rushed towards nearby towns and buried inhabitants before they had time to evacuate.

Today, Vesuvius also serves as a perfect example of the constructive forces of volcanoes. The soil that resulted from Vesuvius’s eruptions makes for some of the most fertile and rich agricultural areas in the region. The wine industry has exploded as vineyards pop up along the area that was once known for only destruction.

LESSON 1:
VOLCANIC SOIL

GRADE LEVEL K-2

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LESSON 1: **VOLCANIC SOIL**

GRADE LEVEL K-2
(1) 15 MINUTE PREP LESSON
(3) 45 MINUTE LESSONS

LESSON OVERVIEW:

Is volcanic soil really better for plant growth?
In this series of lessons, students conduct a scientific investigation of soil types on plant height. First, students begin by looking at different soils and recording their observations. Students then make predictions on which soil type will make plants grow taller. Finally, students will plant seeds in different soil types and take periodic measurements of plant height.

SCIENCE STANDARDS:

- K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.

MATH STANDARDS:

- Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps.
- Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.

SCIENCE & ENGINEERING STANDARDS:

- K2-ETS1-1. Ask questions based on observations to find more information about the natural and/or designed world(s).

FROM THE FILM:

In the film ***Volcanoes***, we see dangerous volcanoes surrounded by rich landscapes of plants and animals. Humans gravitate towards volcanic areas to find fertile soil for crop growth and useful minerals. In this lesson, students investigate the result of growing plants in volcanic soil.

MATERIALS:

- Plastic sandwich/snack bags
- Three soil types (You can dig some up from local sites like your home or the school. You can also purchase different types of potting soil at a local hardware store).
- Volcanic soil (available online and in hardware stores)
- Pea plant seeds
- Magnifying glasses
- Crayons or colored pencils
- Plastic cups
- ¼ cup measuring device
- Measuring blocks or rulers

LESSON 1: **VOLCANIC SOIL**

TEACHER PREP:

DAY 1:

To assemble the soil bags, use a permanent marker to label each bag with the "type" of the soil (one should be volcanic, the other two can be from soil around the school, your home, etc). Fill each bag with 2 tablespoons of the soil and seal.

DAY 2:

Before class, prepare plastic cups to grow pea plants. Students will fill the cups and plant the seeds. Beforehand, use a sharp object to pierce the bottom of each cup to drain water during the growing period.

Select a good area for the pea plants to grow. If your classroom does not get good sunlight, you may want to consider finding a safe place outside where the plants will not be disturbed for a period of 2-3 weeks. If you are growing inside, consider placing the cups on a baking sheet. Doing so will prevent excess water from draining out of the cups and on to the counter top.

TO DO:

BEFORE VIEWING THE FILM:

1. Ask students; do they know what a volcano looks like? Have students briefly stop for 5 minutes and draw what they imagine a volcano looks like. Afterwards, ask students:

> *"Do you predict that lots of animals live near a volcano?"*

> *"Do you predict that lots of plants grow on a volcano?"*

Inform students that they will soon watch the film, ***Volcanoes***. This is a film about the active volcanoes on planet earth. Ask students to pay special attention to what animals and plants they see living next to a volcano.

DAY 1:

1. As a warm up, hand back the volcano picture drawings to the students. Ask: *"How would you draw the volcano differently after you watched the film?"*

2. If students have not already mentioned the plants and animals growing near volcanoes, remind them that the film claimed the rich soil made by volcanoes is perfect for growing food. Together as a class, you will investigate this claim by doing an experiment. You will grow peas in three different soil types, one of which is volcanic soil. You will measure the height of the peas and decide if the claims made in the film are correct.

3. Remind students that plants need soil in order to grow. The soil gives the plants minerals and nutrients to grow tall and healthy. However, not all soil is the same. Just like human food, some soils are more nutritious than others.

4. To start, you will first examine three different soils. Group students into pairs of two or groups of three. Give each group three bags of the soil types (assembly instructions found in the teacher prep section). Show students how to examine the soil with a magnifying glass and record their observations on the "Examining Soil" activity page(s). Allow students 10-15 minutes to examine the soil and record their observations.

5. Call the class back together and ask them to share their observations.

6. Have students make a prediction on what soil type will grow the tallest pea plants. Demonstrate how to write a prediction and allow students to fill in their own.

LESSON 1: VOLCANIC SOIL

DAY 2:

1. As a warm up, have a couple students read their pea plant predictions for the class.

2. Tell the class that today, they will be setting up the experiment to see what kind of soil allows the peas to grow the tallest. The directions for setting up the experiment are found on the "Pea Plant Experiment" activity page(s). Demonstrate how to set up one set of pea plants before you begin. Show students where they will keep the pea plants in the classroom (or outside if there is no good lighted area of your classroom).

3. Give students 15 minutes to set up their pea plants and move them to the area where they will grow.

4. Remind students that plants need more than just soil. They need water to "drink" and sunshine to make sugar.

5. Show students how to water the plants and allow them to do the same.

6. Optional, conclude class by reminding students of the different needs of plants and animals to grow and allow them to color in the "Photosynthesis" activity page(s).

DAY 3: (2-3 WEEKS LATER)

1. Have students retrieve their plants from the growing area.

2. Using a ruler or measuring blocks (depending on the age of students), demonstrate how to measure the height of the plants.

3. Allow students to measure and create a bar graph of the plant heights.

4. Ask students:

What were your original predictions?

Did the plants grow the way you thought they would?

What might be the reasons for unexpected results?

How does this make you think about plants growing near volcanoes?

Volcanic ash covers farmland after a recent eruption in Sinabung, Indonesia.

A mountain gorilla on Mount Nyiragongo in the Congo.

Examining Soil

Directions: **Your teacher will give you three soil bags.**

Observe with your eyes.

- **What color is it?**
- **What do you see with the magnifying glass?**
- **What shapes do you see?**

Observe with your fingers.

- **Open the bag.**
- **Pinch a small amount of soil between two fingers.**
- **What does it feel like?**
- **Is it wet? Dry? Rough? Smooth?**

Soil 1: Where is it from?: ______________________________

Draw what you see:

Observations: ____

____

Soil 2: Where is it from?: ____________________

Draw what you see:

Observations: ____________________

____

Volcanic Soil:

Draw what you see:

Observations: ____________________

____

My Prediction: Which soil is best?

I believe that the ____________________ soil will grow the tallest plant because ____________________ .

Pea Plant Experiment

Directions: **Obtain the materials from your teacher.**
Fill in the information on the plants labels (below).
Cut out the plant labels and tape the plant labels to the cups.
Fill each cup with soil.
Use your finger to press a small hole in the soil.
Place three seeds in the hole and cover seeds with ½ inch soil.
Water each day with ¼ cup water.

Group Names:

Soil Type:

Group Names:

Soil Type:

Group Names:

Soil Type:

Group Names:

Soil Type:

Photosynthesis

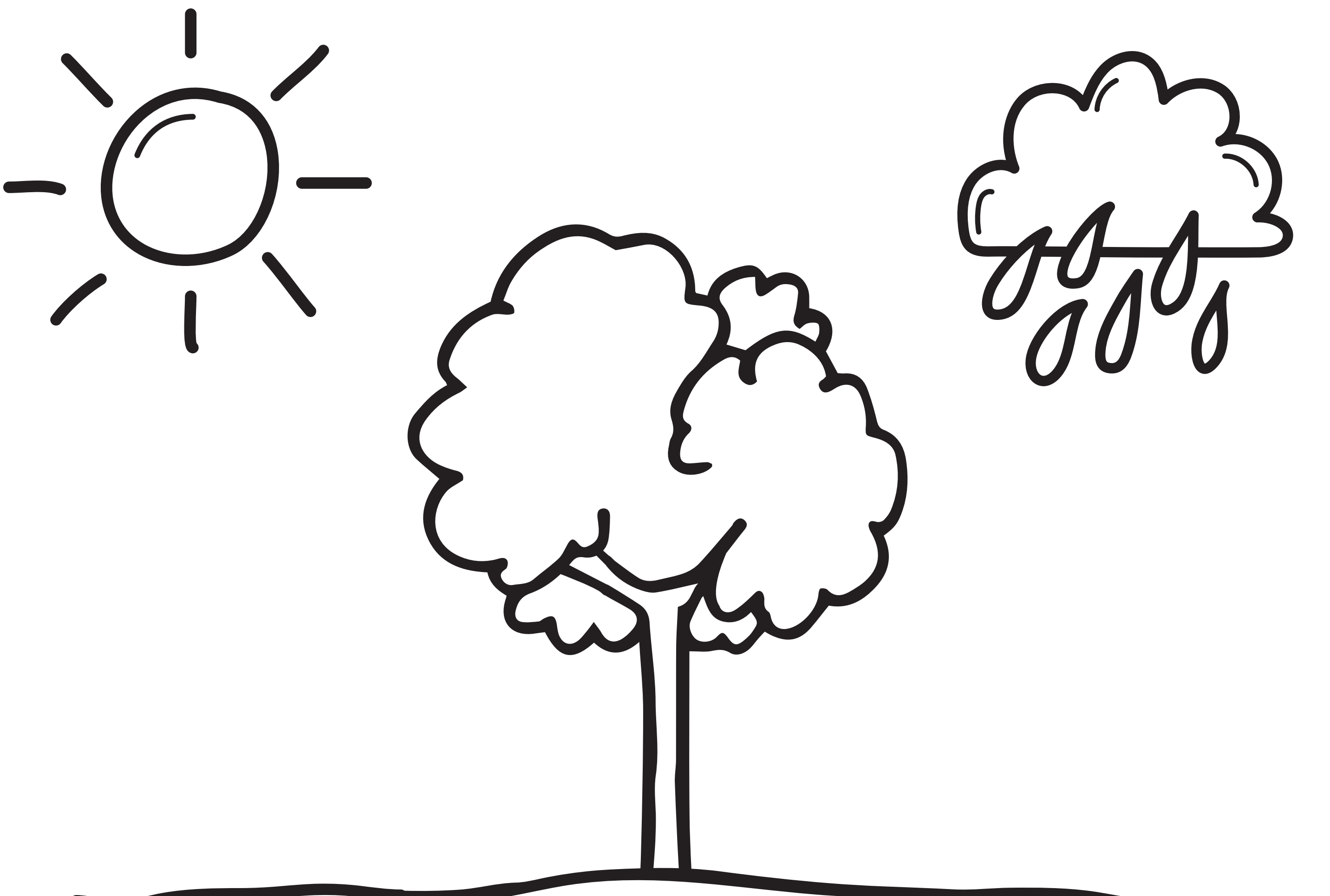
Directions: Plants have different needs than animals. Color in the image below. Fill in the information.

The sun gives plants

______________________________ .

The rain gives plants

______________________________ .



The soil gives plants

______________________________ .

LESSON 2:
DESIGNING SAFETY

GRADE LEVEL K-2

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LESSON 2: DESIGNING SAFETY

GRADE LEVEL K-2
(1) 15 MINUTE PREP LESSON
(3) 45 MINUTE LESSONS

LESSON OVERVIEW:

In this lesson, students engineer protective equipment for scientists working near volcanoes. To begin, students learn about the different needs of volcanologists when studying volcanoes. Afterwards, students examine different materials and identify those whose properties would help volcanologists. Finally, students put the information together to create safety goggles for volcanologists.

SCIENCE STANDARDS:

- 2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

SCIENCE AND ENGINEERING PRACTICES:

- K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

FROM THE FILM:

In the film ***Volcanoes***, we see all the different dangers that have to be faced by explorers and those that work in close proximity to volcanoes. In this activity, students learn about the properties of materials to create a piece of protective gear for volcanologists.

MATERIALS:

- Goggles
- Spray bottles
- Clear plastic bottles (cut in half)
- Aluminum foil
- Wax paper
- String
- Pipe cleaners
- Tape
- Plastic wrap
- Popsicle sticks
- Construction paper
- Crayons

LESSON 2: DESIGNING SAFETY

TEACHER PREP:

DAY 1:

You will need to find a pair of science goggles for each group of students. These are often found in the science lab of a school.

DAY 2:

Assemble the materials bags for students. This bag will have smaller pieces of the materials students can use later in the design challenge. They will examine these materials, record their properties, then return the bag to you.

Because these are just a "sample" of what they can use later, fill each bag with a small piece (such as a 3 inch piece of string or a square cut of alumni foil) of the following materials:

- Clear plastic bottles (cut in half)
- Aluminum foil
- Wax paper
- String
- Pipe cleaners
- Tape
- Plastic Wrap
- Popsicle sticks

It is also optional to add to the materials bag with other materials that you feel would be appropriate and useful.

TO DO:

BEFORE VIEWING THE FILM:

1. Using a sentence strip or projector, show students the word "volcanologist". If appropriate, practice sounding out the word with students. Ask students if they can make a prediction about what a volcanologist does. If they do not already guess the answer, show them the word "volcano" inside of volcanologist and tell them that a volcanologist is someone who studies volcanoes. Without giving more detail about a volcanologist's job, challenge students to draw what they think a volcanologist would look like at their work place. Inform students that they are going to watch a film called ***Volcanoes***. ***Volcanoes*** shows the life of people who study and photograph active volcanoes on our planet. Isn't that neat? Challenge students to pay special attention to the people exploring volcanoes when they work. Ask them to remember one way that their job might be dangerous and one way that they keep themselves safe.

DAY 1:

1. Gather students around and ask them to share what they remember about the film.

Why is it dangerous to explore a volcano?

What are some ways that they saw explorers keeping themselves safe?

2. Tell students that today, they are going to learn more about a day in the life of a volcanologist. To do this, you can show them a short video from National Geographic:

https://www.youtube.com/watch?v=ADnh2FcZwLg

Or read *Science Works: Be a Volcanologist* with the students. As you read or watch the video, ask students to circle words from the "Job Duties" activity page(s) that they observe the volcanologists doing on the job.

LESSON 2: **DESIGNING SAFETY**

DAY 1 CONTINUED:

3. At the end, ask the students to turn and talk. Brainstorm equipment that they believe would be helpful for a volcanologist to have on the job. *What would keep them safe and allow them to do their job duties?* At the end of the turn and talk, students should share out what they brainstormed. Record student ideas on the board. (Examples should be: walking sticks, gloves for touching hot objects, helmets to protect from falling rocks, etc.)

4. Note that they saw volcanologists had walking sticks to help them walk, helmets to keep their head safe, and technology to write and gather data. What they did not have, however, is something to protect their eyes. As a class, students will design goggles to help keep smoke and debris out of volcanologists' eyes. Group students in groups of 3 or 4.

5. Afterwards, present materials properties vocabulary to students. Opaque, translucent, transparent, flexible, rigid, smooth, rough, and any vocabulary you feel are appropriate for your students.

6. To begin, students should analyze a pair of science lab goggles (Goggles can usually be found in the science lab in the school. If your school has multiple kinds of goggles, you can mix up the type each group gets and do a compare and contrast activity). Give each group one pair of goggles and have them examine it. Students should mark their observations in the "Goggles Examination" activity page(s). When students are finished, lead a whole-class debrief.

DAY 2:

1. Review the parts of goggles with students as a warm up. Ask students,

> *What were the properties of the materials for the strap/ear piece?*
>
> *What were the properties for the eyepiece?*

2. Remind students that they will want materials that are smooth so they are comfortable for the scientists, transparent for the eye piece so they can see, not easily breakable and not porous so smoke and liquids can't get to their eyes.

3. Give each group a sample materials bag (please see teacher prep for contents) and the "Material Properties" activity page(s). Have students examine each material and record its properties. In order to test if the materials is porous, you or the students can place the material in front of a piece of paper towel and spray it with a water bottle. If the paper towel beneath is still dry, the material is not porous.

4. Finally, have students draw their ideas for how they plan to make to goggles and list the materials they will need.

The Volcanoes film crew prepares to descend into Marum Crater, Vanuatu

LESSON 2: **DESIGNING SAFETY**

DAY 3:

1. As a warm up, have some groups present their goggle design plans to the class.

2. Tell students that they will have 5 minutes to gather their materials and 20 minutes to build their goggles. At the end, students will test the goggles by first putting them on themselves, seeing if the goggles stay on their face, if they can properly see while wearing them, and if they are comfortable. Afterwards, to test if the goggles will protect the eyes of the scientists, they will take the goggles off, put them in front of a piece of construction paper, and spray them with water to see how much area is protected.

3. Allow students to gather the materials they listed on the “My Plan” activity page(s).

4. Give students 20 minutes to build, circulating to assist groups as they need it.

5. At the end of the time, remind students that it is okay if they are not completely finished. Sometimes engineers have to do a lot of work in a short amount of time and don’t fully finish their project. They still test their design regardless because it will help them make improvements.

6. Prompt students to start by trying to put the goggles on one of their teammates. Have the student rank the comfort and visibility of the goggles with the five stars on the “Testing” activity page(s).

7. Have students take off the goggles and place them on a piece of construction paper. You or the students can spray the goggles with water. Students should lift the goggles off and outline the space that remained dry with a crayon. This would be the area of the face that is protected by their design.

8. To conclude, you can have students look at each other’s designs and construction paper outline. Afterwards, lead a short class debrief on the lessons they learned throughout the process of engineering safety devices.

National Geographic Photographer Carsten Peter setting up camp on Marum Crater, Vanuatu.

What Does A Volcanologist Do?

Directions: **Watch a video or read a book. What is the scientist doing? Circle words the scientist does.**

Reading

Sitting at a desk

Walking

Writing

Talking to others

Using technology

Taking measurements

Answering the phone

Grabbing rocks

What other activities did you see? ______________________________

____

Goggle Examination

Directions: **Your teacher will give you goggles. Look at the goggles. Feel the texture of the goggles. Record your observations in the box.**

Word Bank:

Opaque	Translucent
Transparent	Clear
Smooth	Rough
Rigid	Flexible

Ear piece:

Ear piece:

Materials Properties

Directions: **Your teacher will give you a bag. The bag contains different materials. These are the materials you can use to make goggles. Examine each material. Record its properties.**

Word Bank:

Opaque	Translucent	Transparent	Clear
Smooth	Rough	Rigid	Flexible

Material Name:	Properties:
Plastic Water Bottle	
Aluminum Foil	
Wax Paper	
String	
Pipe Cleaners	
Tape	
Plastic Wrap	
Popsicle Sticks	
Other:	

My Plan

Directions: **Get in your project groups.**
Decide together: How will you build the goggles?
Draw your idea.
List the materials you need.

Drawing:

Materials:
I will need (number) of (material).

I will need ________________ **of** __________________________ .

I will need ________________ **of** __________________________ .

I will need ________________ **of** __________________________ .

I will need ________________ **of** __________________________ .

I will need ________________ **of** __________________________ .

Testing the Goggles

Directions: **Put the goggles on your face.**
Can you see well?
Is it comfortable?
Fill in the amount of stars you would give the goggles.

Vision:

☆ ☆ ☆ ☆ ☆

Comfort:

☆ ☆ ☆ ☆ ☆

LESSON 3:
RING OF FIRE

GRADE LEVEL 3-5

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LESSON 3: **RING OF FIRE**

GRADE LEVEL 3-5
(1) 15 MINUTE PREP LESSON
(2) 45 MINUTE LESSONS

LESSON OVERVIEW:

In this lesson, students will investigate recent claims regarding volcanic activity on the Ring of Fire. Students will begin by mapping locations and intensities of recent volcanic eruptions. Afterwards, students will graph the number of volcanic eruptions over time and draw conclusions on the claims that the Ring of Fire is increasing in intensity.

SCIENCE STANDARDS:

- Analyze and interpret data from maps to describe patterns of Earth's features.

MATH STANDARDS:

- Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs.

SCIENCE AND ENGINEERING PRACTICES:

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

FROM THE FILM:

Volcanoes follows the work of adventurers and photographers as they explore active volcanoes on our planet and visit the infamous Ring of Fire. What exactly is the Ring of Fire? How does its activity shape our world? In this lesson, students will investigate recent claims about the volcanic activity of the Ring of Fire.

MATERIALS:

- Crayons or colored pencils

LESSON 3: **RING OF FIRE**

TO DO:

BEFORE VIEWING THE FILM:

1. Tell students that soon, they are going to watch the film, ***Volcanoes***. This film follows photographers and adventurers as they get up close to some of the worlds active volcano sites. Give each student a sticky note. Have students put their name on the top of the sticky note. Tell students that you are going to ask four questions and they will form a hypothesis (educated guess) for what the answer might be. They should record their guesses on their sticky note.

Questions:

"How many active volcanoes do you think there are on the planet right now?"

"How many active volcanoes do you think are in the United States right now?"

"How do you think volcanoes affect us even if we don't live by them? Do they?"

"What would happen if more volcanoes started erupting on Earth?"

2. Have students place their sticky note on an anchor chart for you to revisit after watching the film.

DAY 1:

1. Have students collect their stick notes and return to their desk. As a warm up, review the answers to the four questions:

"How many active volcanoes do you think there are on the planet right now?" 1,500!

"How many active volcanoes do you think are in the United States right now?" 169!

"How do you think volcanoes affect us even if we don't live by them? Do they?" Volcanic activity produces rich soil and mining minerals that are useful in many different areas of our lives.

"What would happen if more volcanoes started erupting on earth?"

Many volcanoes produce an ash cloud during eruption. This ash cloud will block out sunlight and cool down Earth's temperatures. In Earth's past, when many volcanoes erupted at once, the ash and gas blocked out enough sunlight to drop temperatures, leading to the "Little Ice Age".

2. Remind students that the film mentioned that most of the active volcanoes on planet Earth lie on the Ring of Fire. First, we are going to explore where this ring of fire is located on Earth. Ask students: *do they think the United States is on the Ring of Fire? Why or why not?*

3. Give students the "Ring of Fire" activity page(s). This activity gives students the longitude and latitude of 20 of the major recent eruptions. Demonstrate how to use the longitude and latitude to place a dot on the map for the location of that volcano. Give students 20 minutes to complete the map.

4. Afterwards, have students describe the pattern they see on the map. *Can they shade in the ring of fire area in red? Is any part of the United States on the Ring of Fire?*

5. Finally, have students conclude, do they personally know anyone who might be affected by the Ring of Fire? *Does anyone they know live on or near it?*

DAY 2:

1. Display an image of the Ring of Fire on the globe for students to see. Have them compare it to their results from the "Ring of Fire" activity page(s). *What is the same? What is different about where they shaded?*

2. Tell students that recently, the Ring of Fire has been in the news. Here, you have the option to show a news clip of the Ring of Fire activity being discussed or read a short news article aloud for students. Some suggested videos and news links are:

https://www.youtube.com/watch?v=CoPPkUEN-dY (a CNN clip), https://www.youtube.com/watch?v=jpqUu0PLkmM (CBS news clip - Available only in the United States)

https://phys.org/news/2018-01-volcanos-earthquakes.html (a phys.org article)

LESSON 3: **RING OF FIRE**

DAY 2 CONTINUED:

Please note: When selecting articles, there are frequently running rumors that the activity in the Pacific ring is intensifying (a false claim). Many articles provide incorrect claims and some border on entirely false stories. This lesson is intended to teach skepticism when reading or watching the news and students will evaluate the claims made in these articles and find them to be false. It is your choice as an instructor as to whether you want to use a more moderate or extreme article as the anchor text for this lesson.

3. Remind students that it is important to be critical when reading or watching the news. All claims must be analyzed and double-checked before you accept them as true. Today, you are going to evaluate whether the claims that the Ring of Fire is "roaring to life" is true.

Is it really more dangerous to live on the Ring of Fire at the moment?

Can we expect more and stronger volcanoes and earthquakes?

4. In the "Volcanic Activity" activity page(s), students are given the number of volcano eruptions in the Ring of Fire for the past 60 years. Students should create a bar graph for the data set. Afterwards, students will answer comparative math questions to help them understand if geologic activity is truly happening around the Pacific.

5. Lead a whole-class debrief.

Are the news claims that the Ring of Fire is increasing in activity valid?

Why or why not?

What does this make students think about information they may learn by reading or watching the news?

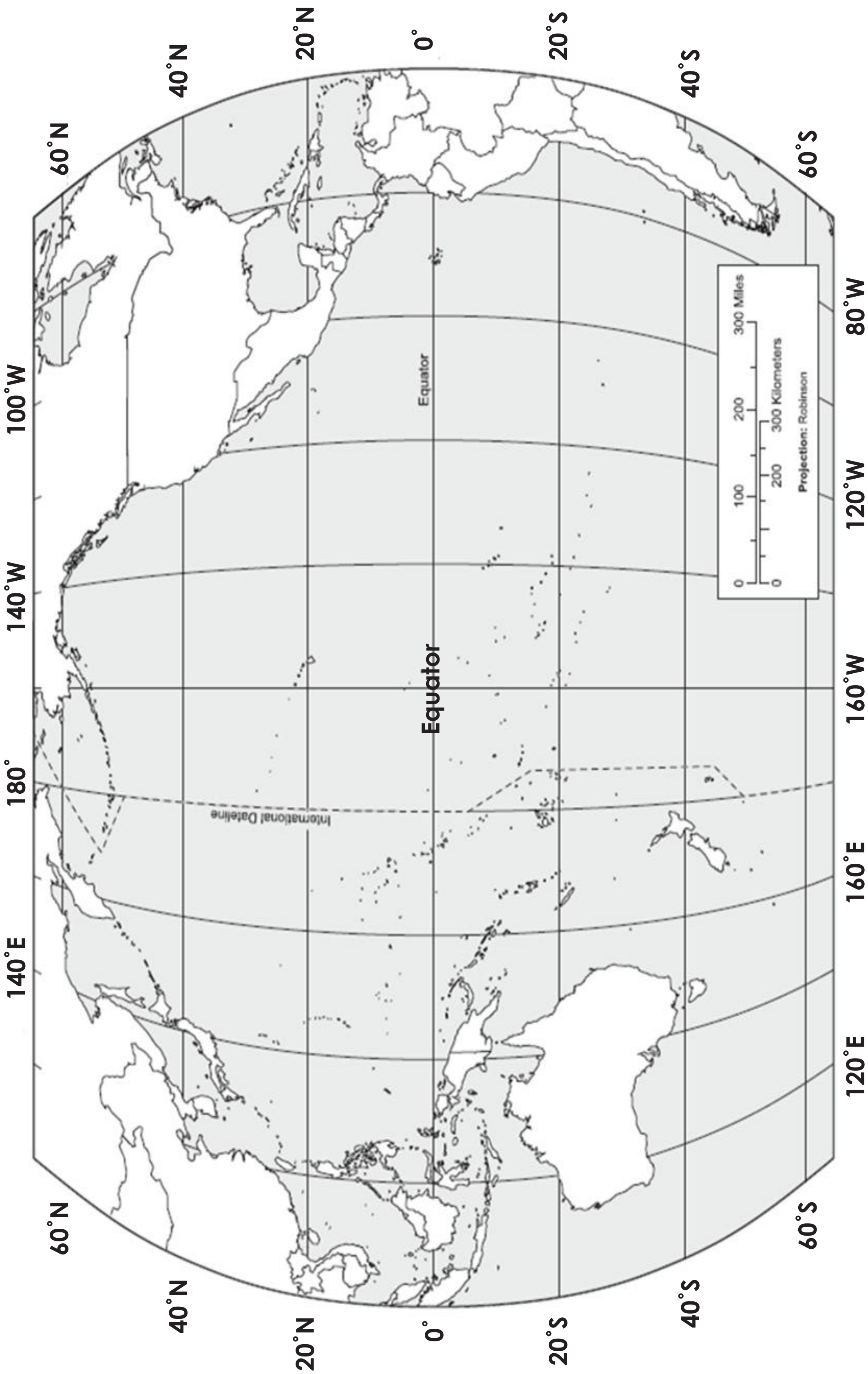
What advice would they give people when reading or watching the news?

The Ring of Fire encircles much of the Pacific Ocean.

Ring of Fire

Directions: **The table below lists all of the major volcanic eruption locations. Use the longitude and latitude to place a star on the map for that volcano.**

Name:	Latitude:	Longitude:
Abu	34	131
Acamarachi	-23	-67
Acatenango	14	-90
Adams	46	-121
Adams Seamount	-25	-129
Adatara	37	140
Agrigan	18	145
Agua	14	-90
Aguilera	-50	-73
Agung	-8	115
Ahyi	20	145
Akademia Nauk	53	159
Akagi	36	139
Akan	43	144
Akhtang	55	158
Akita-Komaga-take	39	140
Akita-Yake-yama	39	140
Akuseki-jima	29	129
Akutan	54	-165
Alaid	50	155


60˚N
40˚N
20˚N
0˚
20˚S
40˚S
60˚S
100˚W
140˚W
180˚
140˚E
80˚W
120˚W
160˚W
160˚E
120˚E
Equator
Equator
International Dateline
0 100 200 300 Miles
0 200 300 Kilometers
Projection: Robinson

Ring of Fire

Conclusions:

What pattern do you see in volcano location?

____

Shade in the area you believe to be the "Ring of Fire". Why do you believe they call it the "Ring of Fire"?

____

____

Volcanic Activity

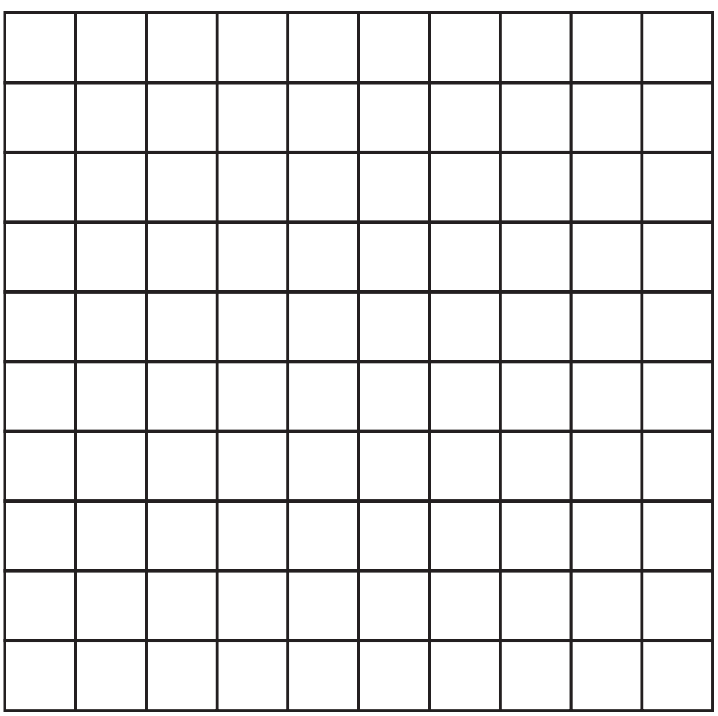
Directions:

In the table below, the number of volcanic eruptions in the Ring of Fire is listed by decade. Use the information to create a bar graph.
Answer the questions. Are there really more eruptions happening now?

Decade:	Number of Major Volcanic Eruptions:
1950	70
1960	85
1970	90
1980	80
1990	80
2000	75

Create a bar graph of volcanic eruptions.

Number of Eruptions



Decade

Volcanic Activity

Analyze:

1. What decade had the most volcanic eruptions? ______________________ .

2. What decade had the least volcanic eruptions? ______________________ .

3. How many volcanoes erupted in the most recent decade? ___________ .

4. Is this more or less than previous decades? ___________________________ .

Conclude:

Many news articles claim that there is an increase in activity in the Ring of Fire. Think like a scientist. Look at the data. Do you think the Ring of Fire is increasing in activity? Why or why not?

____

____

____

____

LESSON 4:
LIVING NEAR A VOLCANO

GRADE LEVEL 3-5

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LESSON 4: **LIVING NEAR A VOLCANO**

GRADE LEVEL 3-5
(1) 15 MINUTE PREP LESSON
(3) 45 MINUTE LESSONS

LESSON OVERVIEW:

Is it possible to build a volcano-safe home?
In this lesson, students will learn about the challenge engineers face when designing homes for people living close to volcanoes. First, students will learn about the environmental issues that face individuals living near active volcanoes. Afterwards, students will create a plan for engineering a safer building in volcanic areas, build a model, and then test its effectiveness at withstanding hazards.

SCIENCE STANDARDS:

- 4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

SCIENCE AND ENGINEERING PRACTICES:

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

FROM THE FILM:

In the film ***Volcanoes***, photographers visit several towns situated near active volcanoes. Some towns are archaeological sites whilst others still have thriving communities living in close proximity. In this lesson, students learn how environmental engineers think about building structures near volcanoes so they have a better chance of withstanding forces, perhaps allowing people to return after eruptions.

MATERIALS:

- Crayons/colored pencils
- Scissors
- Cardboard or foam board, cut into square foot pieces (1 per group of students)
- Materials for Building:
  Please note, these are materials that are easy to build with and frequently found in classrooms. They are useful, but not an exhaustive list of things you might offer students to use. Teachers should feel free to add or subtract from this list
  - Card stock
  - Cardboard
  - Construction paper
  - Aluminum foil
  - Wax paper
  - Tape
  - Glue
  - Paper clips
  - Toothpicks
  - Pipe cleaners
  - Straws
- Materials for testing:
  - Fan
  - Cup of sand
  - Cup of mud

LESSON 4:
LIVING NEAR A VOLCANO

TEACHER PREP:

DAY 1:

During this lesson, you are introducing students to the design challenge of building a structure for the town of Capas near Mount Pinatubo in the Philippines. If you find it to be helpful, you may want to locate some images of the Mount Pinatubo eruption for students to see the kind of damage/legacy it left behind.

DAY 2:

Before class, cut out 1 square foot cardboard or foam board pieces for student groups to build on. You will need one piece per group. When students are planning their design, it is helpful for them to be able to touch and manipulate the materials, even if they aren't allowed to build yet. Consider creating material sample bags. Inside each bag, place a small piece of the materials that will be available for them to build with later.

Set up the materials tables and decide on any material limitations you are going to set. (This can range from only allowing students to take 3 materials or only allowing them to take certain lengths of materials).

DAY 3:

Prepare to test the students' house designs. Set up a desk at the front of the room. Using a couple of books, create an inclined area for students to place their square foot foundations. Make sure the area is close enough to an outlet that you can plug in a fan. Fill a bucket with sand and have a cup ready for scooping. Create a bucket of "mud" by mixing equal parts dirt and water. This will be the lahar of the volcano. Have a cup ready for scooping. It is recommended that you get a large deep baking pan for students to hold at the low end of the inclined plane. The pan will then collect any of the excess sand and mud (ash and lahar) that falls downward.

TO DO:

BEFORE VIEWING THE FILM:

1. Ask students:

Do they think it's possible to live near an active volcano?

Why or why not?

Allow several students to share their ideas with the class. Inform students that amazingly enough, many people live close to active volcanoes on Earth. As they will soon see in the film ***Volcanoes***, these active geologic sites are rich areas for mining minerals and growing crops. Because of the wealth of natural resources, many people take the risk of working and living near active volcanoes. Challenge students to imagine what it would be like to live near an active volcano. Give students 10 minutes to do a stop and jot of their predictions. Challenge them to be creative, remind them that there is not a right or wrong answer, we are just imagining!

DAY 1:

1. Ask students to share what they remember about towns near active volcanoes. Have several students share their thoughts with the class.

2. Tell students that living near an active volcano is hazardous, but still possible. People must expect to evacuate their home if the volcanic flow ever changed directions. Typically, however, people have to learn how to adapt to the more regular and daily challenges of living in a volcanic zone.

3. Inform students that they will be building a structure for the town of Capas. Capas is located near the volcano Mount Pinatubo. After 500 years of lying dormant, Mount Pinatubo erupted in 1991. At the time, the towns surrounding the volcano were largely unprepared for the eruption. Most structures failed and whole cities had to be evacuated. Today, Capas is once again growing in population and needs your help. *Can we help build a safer city?*

LESSON 4: LIVING NEAR A VOLCANO

DAY 1 CONTINUED:

4. To begin, students will learn about the different hazards that occurred during the Mount Pinatubo eruption in the "Volcanic Hazards" activity page(s). Students will read about each hazard and use their imagination hat. After they read each hazard, they should imagine a home in their head. What would happen to the home when this hazard reached it? They should then draw and write a short description of their predictions. Do a think aloud for the first hazard, "lateral wind". The term "lateral winds" refers to the rapidly traveling super-heated gases of a pyroclastic flow

5. Put students in groups of 3-4. Ask them to visit their drawings and brainstorm the question: *what could they do to protect a building from this hazard?*

5. Tell students that first, they must create a plan. As a team, decide on the design of the building and any surrounding protective structures. They must draw their plan on the "Our Plan" activity page(s) and list the materials they will need. Give students 10-15 minutes to arrive at a plan.

6. Inform students that they will be constrained in the amount of time they have to build. After they gather their materials they will have the remainder of this class period to build their idea (minus five minutes for clean up). Tomorrow, however, they will have 20 more minutes to complete their building. Afterwards, you will begin testing their designs!

DAY 2:

1. As a warm up, have students share ideas from the brainstorm yesterday. *How could you build buildings that might survive volcanic eruptions?* Remind students that the buildings have been evacuated.

2. Give each group a building chip, found in the "Capas City Building Chips" activity page(s). This will be the building they must create for the town.

3. Show students the materials that will be available to them and any constraints you decide to include. (You can do this by displaying the material names on the board. Or give each group "samples" of the materials to allow the students to physically manipulate the materials when planning but is more time intensive to prepare).

4. Show students how they will test the design. Each group will get a 1 square foot piece of cardboard or foam board. The will need to build the building so that it is attached to this flat piece. You will then tilt the piece 20 degrees to simulate the angle of living on the side of a mountain. Then you will stress test their designs to mimic the hazards of a volcano:

- You will create lateral winds with a fan to see if it stands still.
- You will pour sand on the roof to see if the ash collects or falls off.
- You will pour a muddy lahar (see teacher prep notes) from the high side of the board to see if the building stands up or any gets in.

Mt. Vesuvius looms in the background of the city of Naples, Italy. It's infamous eruption in 79 AD destroyed the nearby towns of Pompeii and Herculaneum.

LESSON 4:
LIVING NEAR A VOLCANO

DAY 3:

1. As a warm up, ask students to share challenges they faced while building yesterday. After a few groups have shared their ideas, remind students that scientists and engineers encounter challenges every day. They never view these as failures but as ways to re-imagine a new solution.

2. Allow students another 20 minutes to build.

3. Bring the class back together. One group at a time, bring them to the front and ask them about their design. *How do they think it will work?* Test their design with the following procedure:

- You will create lateral winds with a fan to see if it stands still.
- You will pour sand on the roof to see if the ash collects or falls off.
- You will pour a muddy lahar (see teacher prep notes) from the high side of the board to see if the building stands up or any gets in.
- At the end, ask students, *how are they thinking differently now about living next to a natural hazard like a volcano?*
- *What would they do differently if they got a chance to rebuild their design?*

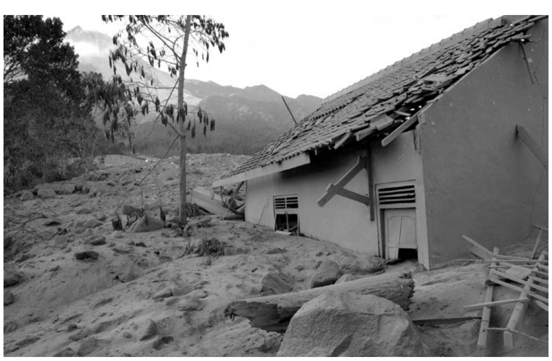
A home sits next to a fissure spewing lava from the active Kilauea volcano on the Big Island of Hawaii. Hundreds of homes were destroyed during the 2018 eruption.

Volcanic Hazards

Directions:

Read the descriptions for hazards. Imagine a home in your mind. What would happen to the home during that hazard? Draw your idea. Write your idea as a sentence.

<table>
<tr><th>Volcanic Hazards:</th><th>What Would Happen To A Home?</th></tr>
<tr><td>Ash Cloud:
The volcanic explosion pulverizes rock. The mountain bursts open. Some of the rock of the mountain turns to ash. The ash cloud expands upwards. Eventually, the ash cloud will rain down. Because the ash is rock, it is very heavy. Ash is twice as heavy as rain and snow.
</td><td>Draw Your Idea:

Write Your Idea:
____
____________________</td></tr>
<tr><td>Lahars:
Lahars are large mudslides. Falling dirt and rock from the volcano mix with water. The super hot mud will flow down the mountain. When a lahar dries, it’s like cement.
</td><td>Draw Your Idea:

Write Your Idea:
____
____________________</td></tr>
</table>

Volcanic Hazards

Directions:

Read the descriptions for hazards. Imagine a home in your mind. What would happen to the home during that hazard? Draw your idea. Write your idea as a sentence.

Volcanic Hazards:	What Would Happen To A Home?
Lateral Winds: Volcanic eruptions release a lot of pressure, which can be felt as a strong wind. The wind travels parallel to the ground and flows from the center of the volcano outward.	**Draw Your Idea:** **Write Your Idea:** ______________________________ ______________________________

Capas City Building Chips

City Bank:
2 stories tall

Movie Theatre:
3 stories tall

Hotel:
2 stories tall

Grocery Store:
2 stories tall

Home:
1 story tall

Home:
1 story tall

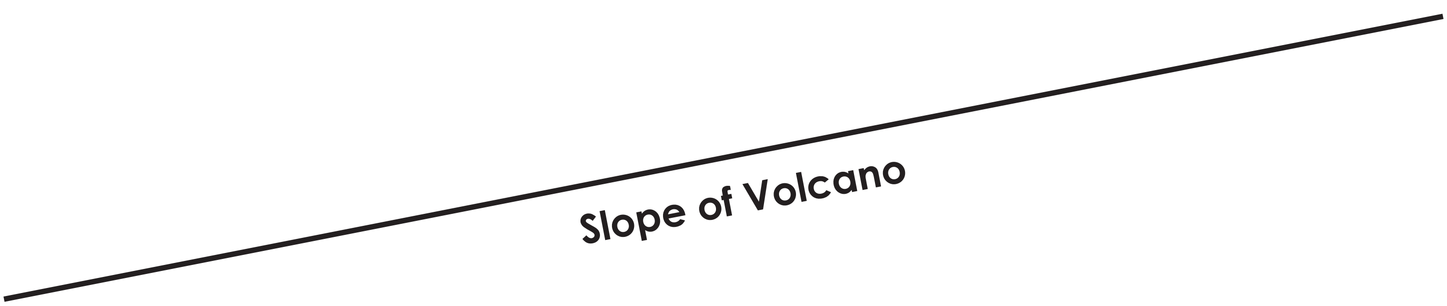
Our Plan

Directions:

Decide as a team, how you will build your building.

Draw your idea below. List the materials you will need.

Drawing:



Materials:

____

____

____

LESSON 5:
TECTONIC BOUNDARIES

GRADE LEVEL 6-8

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LESSON 5: TECTONIC BOUNDARIES

GRADE LEVEL 6-8
(1) 15 MINUTE PREP LESSON
(2) 45 MINUTE OR (1) 90 MINUTE LESSON(S)

LESSON OVERVIEW:

In this series of lessons, students conduct an investigation into plate tectonics and landforms. Students begin by learning about the formation of Earth's interior layers. Students test the boundary to simulate the three types of plate interactions. Afterwards, students conclude what kind of land formations occur at each. Finally, students examine a global map of plate boundaries and make predictions on what kinds of landforms are found at each.

SCIENCE STANDARDS:

- MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

SCIENCE AND ENGINEERING PRACTICES:

- MS-ETS1-4. Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.

FROM THE FILM:

The film ***Volcanoes*** speaks about the volcanic activity that is caused by the different kinds of plate boundaries that are capable of building a volcano. In this lesson, students will investigate plate dynamics.

MATERIALS:

- Sandwich bags
- Sand
- Pebbles or fish tank rocks
- Styrofoam, crumbled into small pieces
- Crayons or colored pencils
- Play dough

LESSON 5:
TECTONIC BOUNDARIES

TEACHER PREP:

DAY 1:

Prepare Theia and Earth bags. Using a sharpie, label 8 (or however many lab groups you have) sandwich bags "Earth" and 8 labeled "Theia". Fill Earth with 250 ml of sand and 250 ml of pebbles or fish gravel. Fill Theia with 250ml of crumbled Styrofoam.

DAY 2:

Prepare a lab kit for each group. Each kit should have a container of play dough and cup of gravel. To allow for easier clean up, it is recommended you have students perform the experiment in a shallow bin rather than directly on the tables.

TO DO:

BEFORE VIEWING THE FILM:

1. Ask students: *"Do you know how a volcano is made?"* Allow students to offer their ideas, recording them on the left hand side of a t-chart. Inform students that soon, they will view the film ***Volcanoes***. ***Volcanoes*** explores Earth's beginnings and identifies rocks and magma as key components of volcanoes. Ask students to pay special attention and be prepared to discuss how volcanoes are formed when they return to the class.

DAY 1:

1. As a warm up, have students share their memories from the film. *How are volcanoes made?* Record their new ideas on the right hand side of the t-chart, noting how their ideas have evolved.

2. Note that they mentioned tectonic plates in their responses. Most volcanoes on earth form from tectonic plate interactions. Tectonic plates, however, form much more than just volcanoes. Over the next couple days, you are going to explore other ways that tectonic plates influence the shape of earth.

3. To begin, revisit the formation of Earth. When Earth was not yet a full planet, it was orbiting the Sun with another planetesimal in its path, Theia. Eventually, Theia collided with Earth. Parts of the two planets fused together and their elements were mixed.

4. Give students the bags labeled Theia and Earth. Tell students to simulate the collision of Theia and Earth by pouring each of these bags into a beaker or cup. Remember, the energy of the collision was so strong that the Earth's outer layers were liquefied into molten rock. This allowed the minerals that were part of Theia and Earth to mix. We will simulate this by stirring the beaker. Prompt students to stir the beaker three times.

Iceland sits on the mid-Atlantic ridge and is a hotspot for volcanic and geologic activity.

LESSON 5: **TECTONIC BOUNDARIES**

DAY 1 CONTINUED:

5. Remind students that the planets were made of different minerals. Like they have learned before, all minerals have different properties. One of those important properties is density. Density is the amount of mass something has per its volume e.g. a ball bearing. Very dense objects are relatively heavy, even when they are small. Less dense objects are light, even when they are large e.g. a beach ball.

6. Remind the students that the debris in their beakers have different densities just like the minerals that make up the early Earth. Eventually, these densities will influence the anatomy of the Planet. To model this, have students either stir or shake the beaker for one minute. At the end, all of the denser material should have moved towards the bottom of the beaker and the less dense material will rise to the top. Have students note this layering effect in their beakers. This layering effect also happened to Earth. Show students an image of the four layers of the Earth on the board. Describe the properties of each layer and have students color in and label their own diagram in the "Anatomy of Earth" activity page(s).

- Inner core: The inner core is the hottest part of the planet at temperatures between 9,000 and 13,000 degrees Fahrenheit. The layer is mostly iron and the most dense layer.
- Outer core: Composed mostly of iron and nickel in liquid form, this layer is between 7,000 and 9,000 degrees.
- Mantle: The mantle is hot (between 900 and 7,000 degrees Fahrenheit) and moves as a semi-solid rock. The rocks flows in a liquid-like motion around the globe.
- Crust: The outermost layer of earth is solid, cool, and thin. The crust is made up of three different rock types and divided into separate pieces called tectonic plates. There are two types of crust: continental crust (less dense, carries land) oceanic crust (thinner but more dense, carries ocean).

DAY 2:

1. As a warm up, review the layers of the Earth with students.

2. Remind students that the crust of the earth is cool and hard while the mantle beneath it is hot, liquid, and flowing. This dynamic creates a unique feature of Earth: tectonic plates. The crust is not one continuous solid piece but is broken up into many smaller pieces, or tectonic plates. These plates are floating on top of the magma mantle. Just like rafts in a river, they flow in the direction of the magma beneath them. Because of this, plates can crash into each or slip past each other as they flow along the mantle.

3. Teach students that there are three major types of plate interactions. Divergent plates separate away from each other. To help students remember this, have them practice a hand signal. They should hold their hands together (touching palm to palm), then when you say divergent, they separate them apart. Convergent plates move towards each other. Practice a hand signal for this by having students hold their hands apart. When you say convergent, they bring their hands together in a loud clap. Transform plates slide past each other. Practice a hand signal by having students hold their arms in front of them, palms touching. When you say transverse, they should slide one palm forward and move one palm back towards themselves.

4. Play a quick game of "Simon Says" to help students internalize the vocabulary.

LESSON 5: **TECTONIC BOUNDARIES**

DAY 2 CONTINUED:

5. These three types of plate boundaries can shape the crust of earth. In order to investigate how, students will conduct a short lab simulation. In the lab, students should flatten out play dough into two four-inch squares. The play dough squares will simulate the tectonic plates. Have students place the plates side by side. On top of the plates, students should pour a cup of gravel. The gravel represents the looser crust found on top of the plates. Students should simulate the three kinds of plate boundaries by pulling them apart, pushing them together, then sliding them past each other. After each boundary simulation, students should record what they observed happened to the looser gravel crust. They should analyze the results and predict what kind of landform this would be on earth. Afterwards, they should place the boundaries side by side again and recover them evenly with gravel. They can then try simulation of the next plate boundary type.

When completing, *The Plate Boundaries* worksheet (Page 48), students should find that divergent boundaries create rifts (and ridges when magma wells up), transform boundaries create faults and convergent boundaries create mountains and ridges.

6. Afterwards, review with students what they observed and make explicit connections between boundary types and landforms.

7. Finally, have students look at an image of the tectonic plates on Earth and their movement. Have students use the information to predict what kind of landforms will be located at each area. Afterwards, they can use a computing device to research if their predictions were correct and learn the proper names of the landforms in that area.

The Predicting Landforms worksheet (Page 49) has the following landforms and boundaries:

1. San Andreas Fault (transform)

2. Andes Mountains (convergent)

3. Mid Atlantic Ridge (divergent)

4.Red Sea Rift (divergent)

5. Himalayas (convergent)

Folded limestone on Crete, Greece, which is located above a subduction zone between the African, Aegean and Eurasian plates.

Anatomy of Earth

Directions:

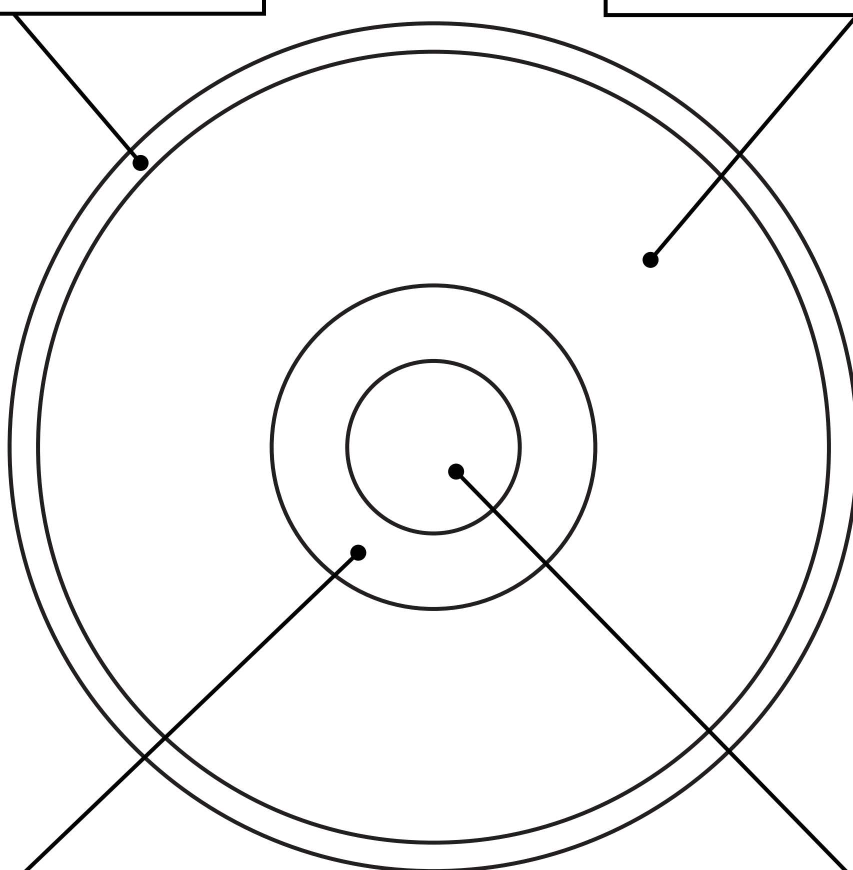
Color the layered diagram of the Earth below. Label each layer with the correct name and describe its properties.

Layer:

Properties:

Layer:

Properties:



Layer:

Properties:

Layer:

Properties:

Plate Boundary Lab

Directions:

1. Make two tectonic plates: Using your hands, shape play dough into two flat squares that are approximately 4 inches on each side.

2. Place the plates side by side. Cover the plates with a cup of gravel. This will represent the looser rock material of the upper crust.

3. For the divergent boundary, move the plates apart from each other.

4. Record your observations by drawing what you see in the chart.

5. What is this landform on Earth? List your ideas.

6. Reset the plate boundary by scooping all of the gravel back into the cup. Place the two plates back to side by side again. Repeat steps 2-5 for transverse and convergent plate boundaries.

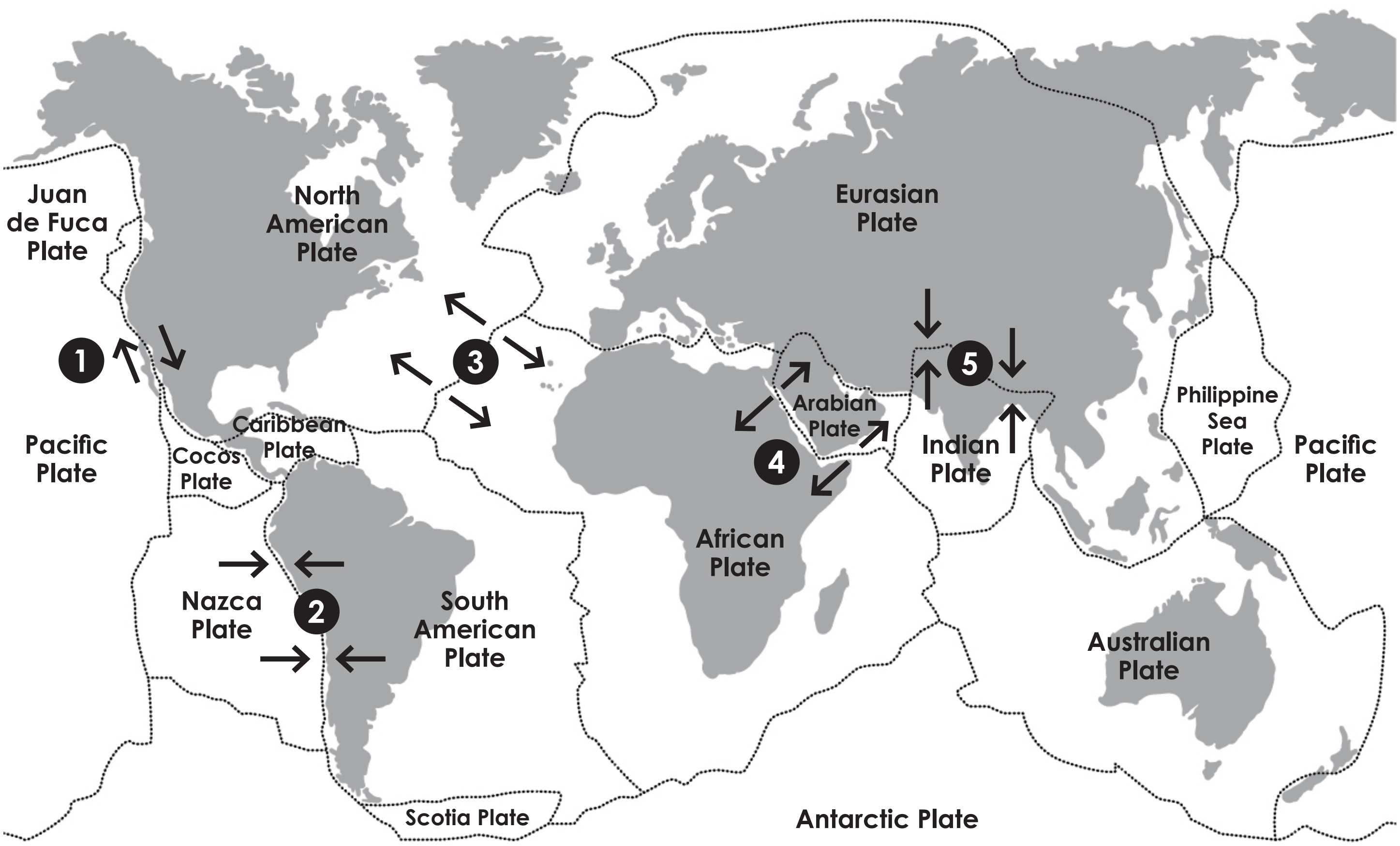
Plate Boundary Type	Observations	What landform could this be?
Divergent:		
Transform:		
Convergent:		

Predicting Landforms

Directions:

1. Below is an image of Earth. The lines on the image show the boundaries of tectonic plates. The arrows show the movement of the plates. For each area noted, identify the plate boundary type and predict the landform you would find there.

2. Afterwards, use the internet or research device to check your predictions. What is the proper name of the landforms actually found in that region?



LESSON 6: **PREDICTING ERUPTIONS**

GRADE LEVEL 6-8

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LESSON 6: **PREDICTING ERUPTIONS**

GRADE LEVEL 6-8
(1) 15 MINUTE PREP LESSON
(2) 45 MINUTE OR (1) 90 MINUTE LESSON(S)

LESSON OVERVIEW:

In this lesson, students form a plan for warning towns near volcanoes of imminent eruptions. First, students begin by studying several case studies of different volcanoes that have erupted in the past. Students will identify patterns in the data and decide on the best predictors of volcanic eruptions. Finally, students will participate in a simulation of being a geologist.

SCIENCE STANDARDS:

- MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

SCIENCE AND ENGINEERING PRACTICES:

- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

FROM THE FILM:

The film ***Volcanoes*** speaks about the difficulties of predicting volcanic eruptions. There are many different tools we use to track volcanic activity, and our technology is ever-evolving. This lesson challenges students to evaluate our technologies and create a plan for those that live near volcanoes.

MATERIALS:

- Blank paper
- Rulers
- Pens or pencils

LESSON 6: **PREDICTING ERUPTIONS**

TEACHER PREP:

DAY 1:

Students will be sending "tweets" during this lesson. It is up to the teacher to decide how they would like to structure this activity. Students can write down their "tweets" on white boards and hold them above their head. Alternatively, there are many online and school friendly platforms that allow students to post ideas or answer questions. Socrative.com is an excellent example. Before you begin, decide on which platform you will use, create an account, and test to ensure it is working properly.

TO DO:

BEFORE VIEWING THE FILM:

1. Tell students that soon, they are going to watch the film ***Volcanoes***. This film follows photographers and adventurers as they get up close to active volcano sites around the world. Give each student a sticky note. Have students put their name on the top of the sticky note. Tell students that you are going to ask them some questions and have them form a hypothesis (educated guess) for what the answer might be. They should record their guesses on their sticky note.

Questions:

"How many active volcanoes do you think there are on the planet right now?"

"How many people do you think live near an active volcano?"

"How many people have die from volcanoes a year (on average)?"

2. Have students place their sticky note on an anchor chart for you to revisit after watching the film.

DAY 1:

1. Have students collect their stick notes and bring them back to their desk. As a warm up, review the answers to the four questions:

Questions:

"How many active volcanoes do you think there are on the planet right now?" 1,500!

"How many people around the world do you think live near active volcanoes?" 500 million

"How many people are killed by volcanoes each year (on average)?" 540

2. Remind students that the film says predicting eruptions can be very difficult. There are multiple tools and instruments scientists have developed to monitor volcanic activity and predict imminent large eruptions. Over the next two days, students will investigate ways that we predict the eruptions of volcanic activity, their reliability, and develop a plan to help towns warn their citizens of upcoming eruptions.

3. Begin by defining an active volcano and dormant volcano. An active volcano is one that is having present moment lava, magma, or pyroclastic (rock) eruptions. A dormant volcano is a volcano that is not currently erupting but still could. A volcano is labeled as extinct if it has not erupted in more than 10,000 years.

LESSON 6: **PREDICTING ERUPTIONS**

DAY 1 CONTINUED:

4. In order to learn about warning signs that a dormant volcano is about to be active, students will conduct a case study of different volcanic eruptions. Group students into reading pairs. Give each reading pair one of the volcano case studies. Instruct students to read the passage, and underline two things: dates and geologic events the happened before the volcano exploded. Afterwards, they should create a timeline on a blank sheet of paper that includes the dates and events that happened before and during the volcanic eruption.

5. Give each pair of students a piece of tape and instruct them to tape it on the wall of the classroom. Give students 5 minutes to do a gallery walk. Students should visit each timeline and note patterns that they observe. *What geologic events appear to happen at all of the volcanoes?*

6. If students have not already made the connection, illustrate that the common events can be used as good warning signs that a volcano might erupt. Review the current tools that we use to measure and track these geologic warning events:

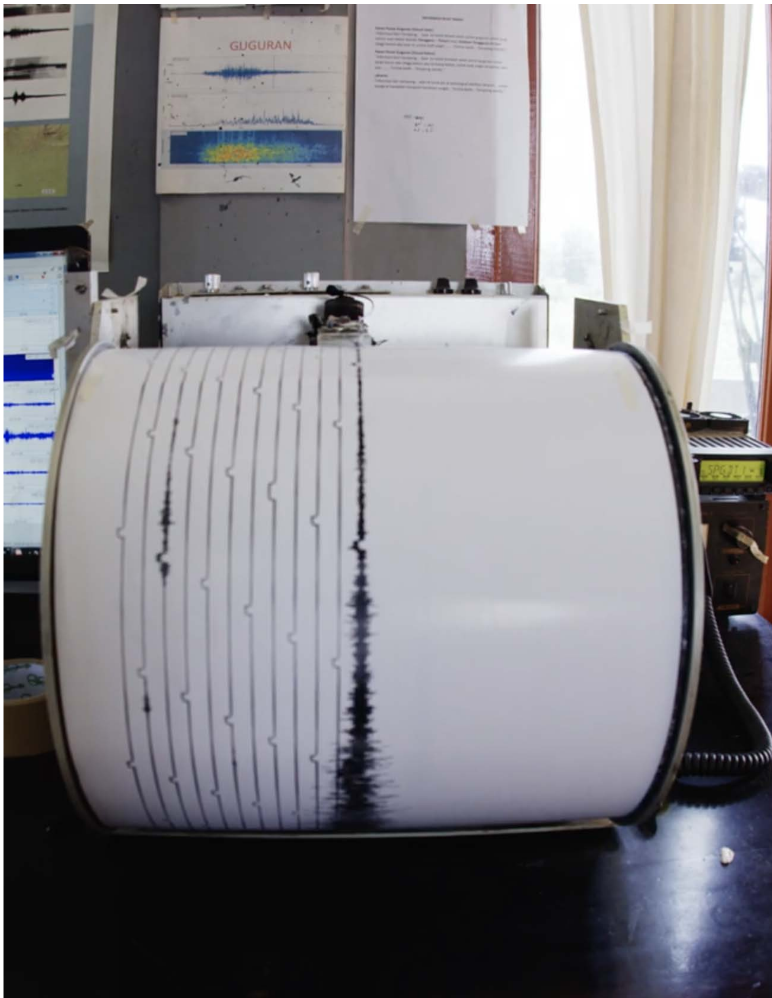
- Seismometer: This instrument is used to measure the presence and strength of earthquakes around a volcano. Though earthquakes are common even around dormant volcanoes, an increase and/or peak in seismic activity can indicate an upcoming eruption. Scientists look for an increase in earthquakes to at least 10 quakes a day for warnings that a volcanic eruption is imminent.
- Tiltmeter: This instrument allows scientists to measure to slope of the volcano. Before a volcano erupts, it is common for a lava dome to swell underneath the volcano surface. This causes the slopes of the volcano to increase in angle. Geologists name this warning sign a "ground deformation." A tiltmeter measures the angle or slope of the volcanic sides to detect swelling lava domes.
- Photography: Scientists often use video and photographs to track changes of volcanoes over time. These images are incredible important in recording the presence and frequency of steam ejections, called phreatic eruptions.

7. To conclude, ask students *"Do all of these warning signals appear to work equally well in predicting eruptions?"* Allow students to offer their ideas. Review the case of Nevado del Ruiz, who was not evacuated because the earthquakes appeared to end. Shortly after, however, the volcano erupted and killed thousands of people living near by.

DAY 2:

1. As a warm up, give students the three tools/warning sign pairs and ask them to rank them in order of "most reliable" to "least reliable" warning signs: Earthquakes and seismographs; tiltmeters and ground deformation; photography and phreatic eruptions.

A seismometer (or seisomograph) like this one in Indonesia, measures the motion of the ground caused by events like earthquakes and volcanic eruptions.



LESSON 6:
PREDICTING ERUPTIONS

DAY 2 CONTINUED:

2. After allowing several students to share their ranking, remind students that alone, no one of these warning signals is perfect. Geologists study warning signals as a group and must make decisions about when to warn towns to evacuate. Ask students:

"Why is it important to evacuate neighboring towns before the eruption begins?"

"What do you think are the consequences of evacuating a town too early or causing a false alarm?"

3. If students have not already identified the reasons why accurate evacuation predictions are important, review the two major concerns: trust and economy. It is important to get evacuation predictions correct because too many false evacuations will cause the towns to lose trust in you as a scientist. Like the boy who cried wolf, people may stop believing in your predictions and then stay on the volcano when it actually erupts. Likewise, scientists must be mindful that evacuations cause a large stress on the economy. Not only does it shut down all business in the town (people cannot make money), it also forces people to spend money to stay in hotels and accommodations in other locations.

4. To explore the role of geologists in predicting eruptions and calling for evacuations, students will assume the role of a geologist monitoring a volcano. Each day, geologists must send out a "tweet" for the town telling them if an eruption is likely and if they should prepare to evacuate or evacuate immediately.

5. To begin, give each student a copy of the "Predicting Eruptions" activity page(s). Assign one of the five volcanoes to each student. Inform students that you will give them five days of data (from the Teacher Slides: Volcano Data page(s)) for them to graph on the "Predicting Eruptions" activity page(s). They should create a point plot and connect each point with a line. After each set of five days, they must indicate how likely an eruption will occur. Finally, they must send out a "tweet" to the town that follows the following format:

To the people living near [Volcano name], a volcanic eruption is [how likely they think an eruption is about to occur], the geologic station recommends that you [student recommendation of continue normal activity, prepare to evacuate, evacuate immediately, etc].

- There are many different online platforms for students to display the false tweets without actually using twitter. One recommended site is socrative.com. It is recommended that you create a teacher account before the class begins.

6. After each round of tweets, reveal to students the state of the volcano (from the Teacher Slides: Volcano Data page(s)).

7. At the end, ask students to raise their hands if they were able to evacuate the town before the eruption but not as a false alarm. Remind students that in the film ***Volcanoes***, the scientists indicated that it is still very difficult to predict eruptions. Because of this, we still have hundreds of deaths from volcanic eruptions each year. Ask students to conclude with a brainstorm: "*How might they be able to more accurately warn citizens of erupting volcanoes and help evacuate towns?"*

The lava lake inside Marum crater, Vanuatu.

Mount St. Helens

Case Study:

For 123 years, Mount St. Helens remained dormant. The large sleeping volcano was a favorite spot for hikers and outdoor enthusiasts. Thousands of people of visited the national park to fish, camp, and play.

On March 16th, 1980, three small earthquakes were measured at the park ranger station. The earthquakes were so small most visitors did not notice them. Each day after that, the number of earthquakes steadily increased. By the week of March 26th, an average of 10 earthquakes were occurring daily.

On March 27th a helicopter tourist company flew a group around the crater of the still dormant volcano. During flight, the group observed a small steam explosion blow a 15 meter hole in the top of the mountain. The group took pictures and passed them to the United States Geological Service when they returned. For the next two weeks, small spots of steam could be seen shooting out of the top of the volcano. By April 22nd, however, all steam activity ceased. Because there were no small steam eruptions, the park rangers believed the volcano was returning to dormancy and did not issue an evacuation.

Geologists, however, started to notice a bulge forming in part of the mountain. Like the mountain was growing fatter, they could see part of it growing in size. By May 17th, the bulge was growing at 2 meters per day. Finally, on May 18th, a final earthquake occurred followed by the immediate eruption of the volcano. The blast from the volcano was so large the ash cloud circled the Earth for 15 days. 57 people died.

Mount St. Helens

Before eruption, 1980.

After eruption, 1982.

Mount Pinatubo

Case Study:

Mount Pinatubo is found on an island of the Philippines. The island is densely populated with large towns and tourist sites. Mount Pinatubo had not erupted in 500 years. For the past 500 years, small bursts of steam would shoot from a hot spring on the volcano. On July 16th, 1990, a magnitude 7.8 quake shook the volcano. This earthquake was followed by a series of smaller earthquakes and increase in steam activity for one week. After the week, however, the volcano appeared to return to dormancy.

In March and April 1991, earthquakes returned and steam activity increased again. The steam explosions created three craters towards the top of the volcano. For the next three months, steam explosions continued to increase in frequency. On June 7th, the first magma explosion erupted. Though the eruption was weak, geologists decided to evacuate the area. On June 15th, a large explosive eruption demolished the area, resulting in one of the largest volcanic eruptions in history.

Before eruption, 1991.

After eruption, 2008.

Nevado Del Ruiz

Case Study:

Nevado Del Ruiz is a volcano located in the Andes Mountains. In November 1985, the volcano began to experience earthquakes. For the next two months, geologists recorded 10 earthquakes per day. Scientists observed small spouts of steam shot from the top of the volcano each day. Scientists feared that a major eruption would come soon. By February 1985, however, the earthquakes and steam ejections stopped. Geologists still feared an eruption, but town politicians refused to evacuate. They believed that the volcano would not erupt because the earthquakes stopped.

The volcano stayed silent for several more months. On October 1985, one year after earthquakes began, a large eruption shook the volcano. The volcano exploded in a major and sudden eruption. The eruption was so strong, people could not evacuate. In the end, 25,000 people had died.

Before eruption, 1985.

After eruption, 2007.

Predicting Eruptions

Directions:

You will be given a set of data from a volcano. Graph the data over time on the graphs below. After each day, send out a "tweet" to the town warning them of any likely volcanic eruptions. Obtain the actual results of your volcano from your teacher and add or subtract "credibility points" to your score

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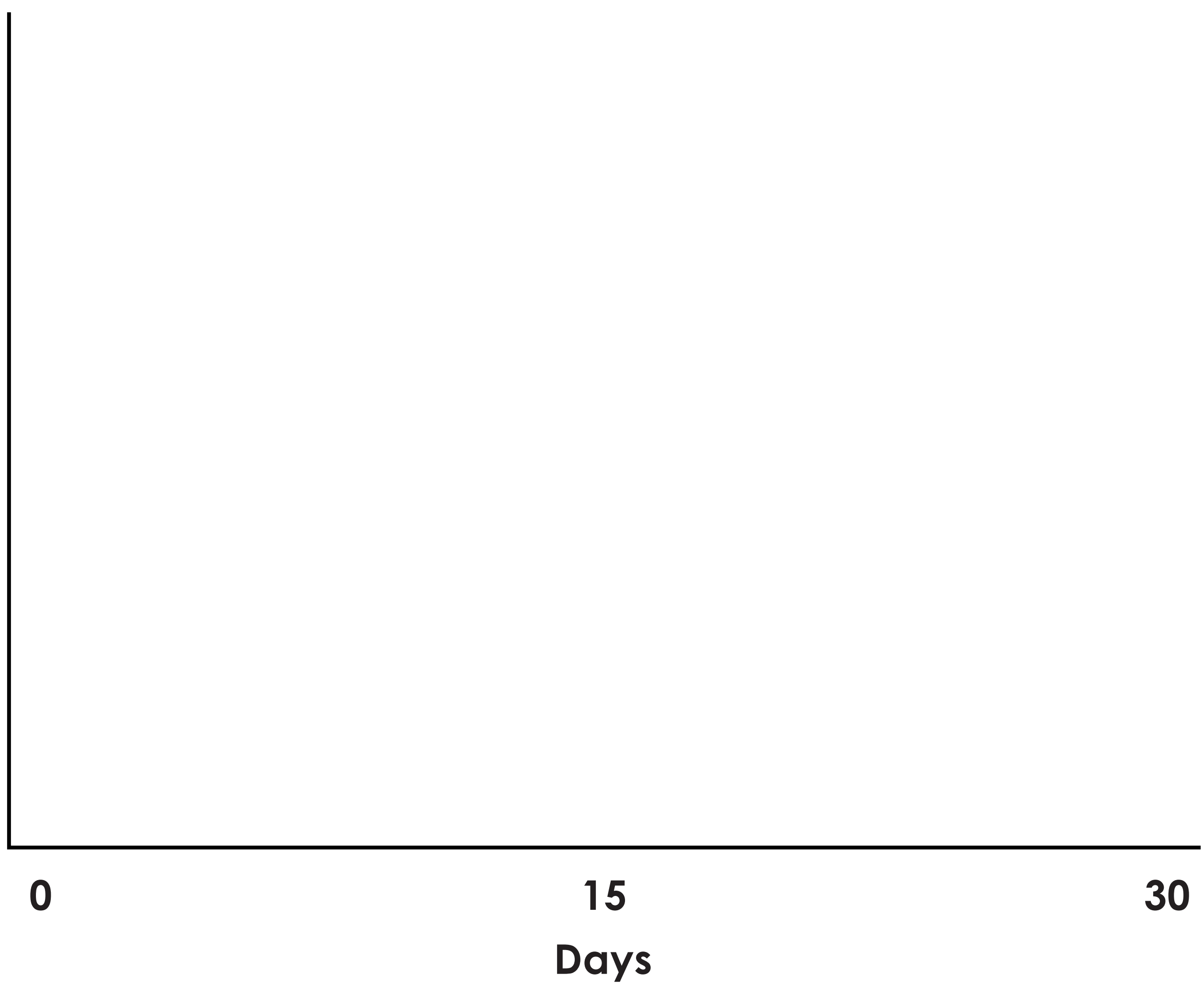
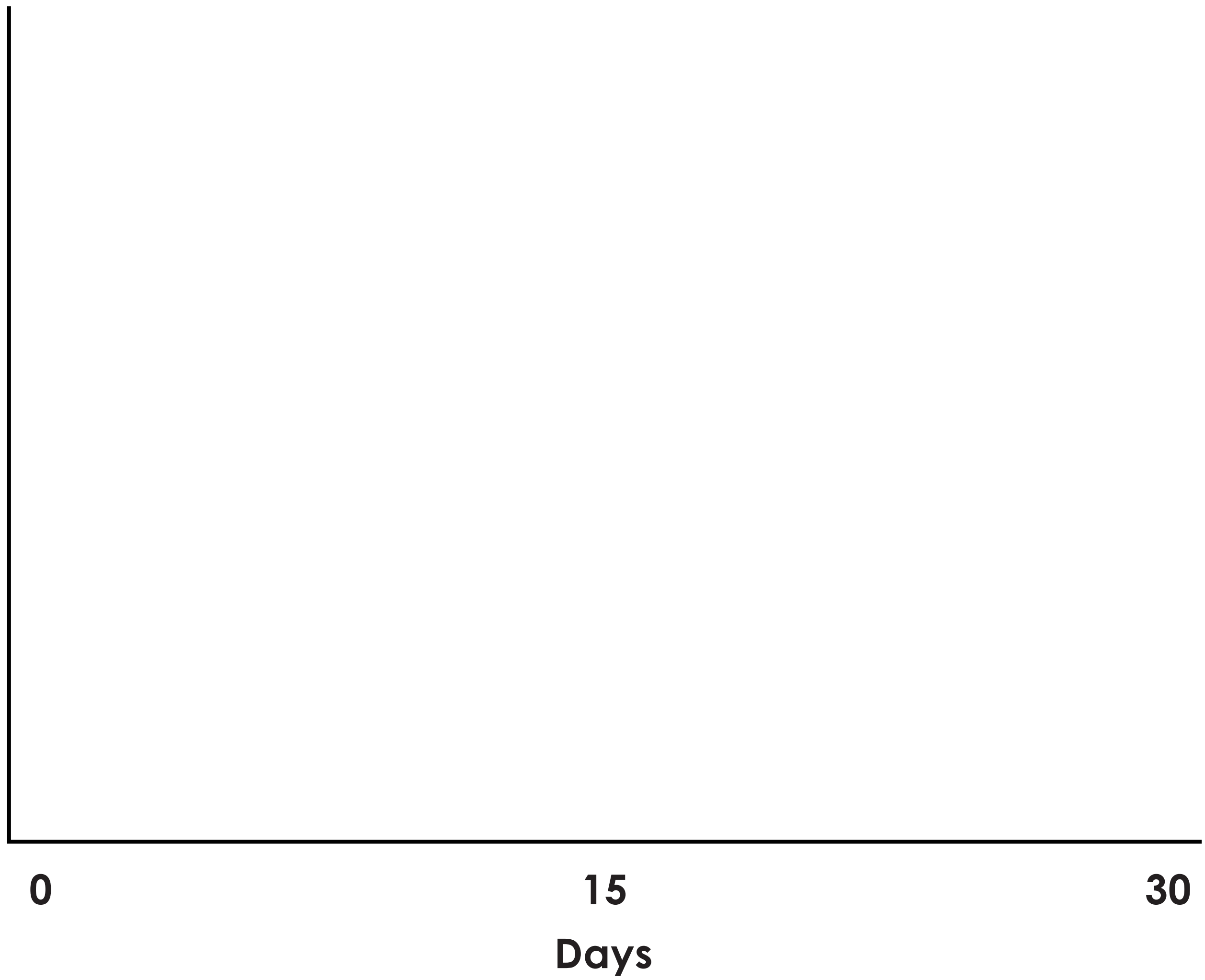
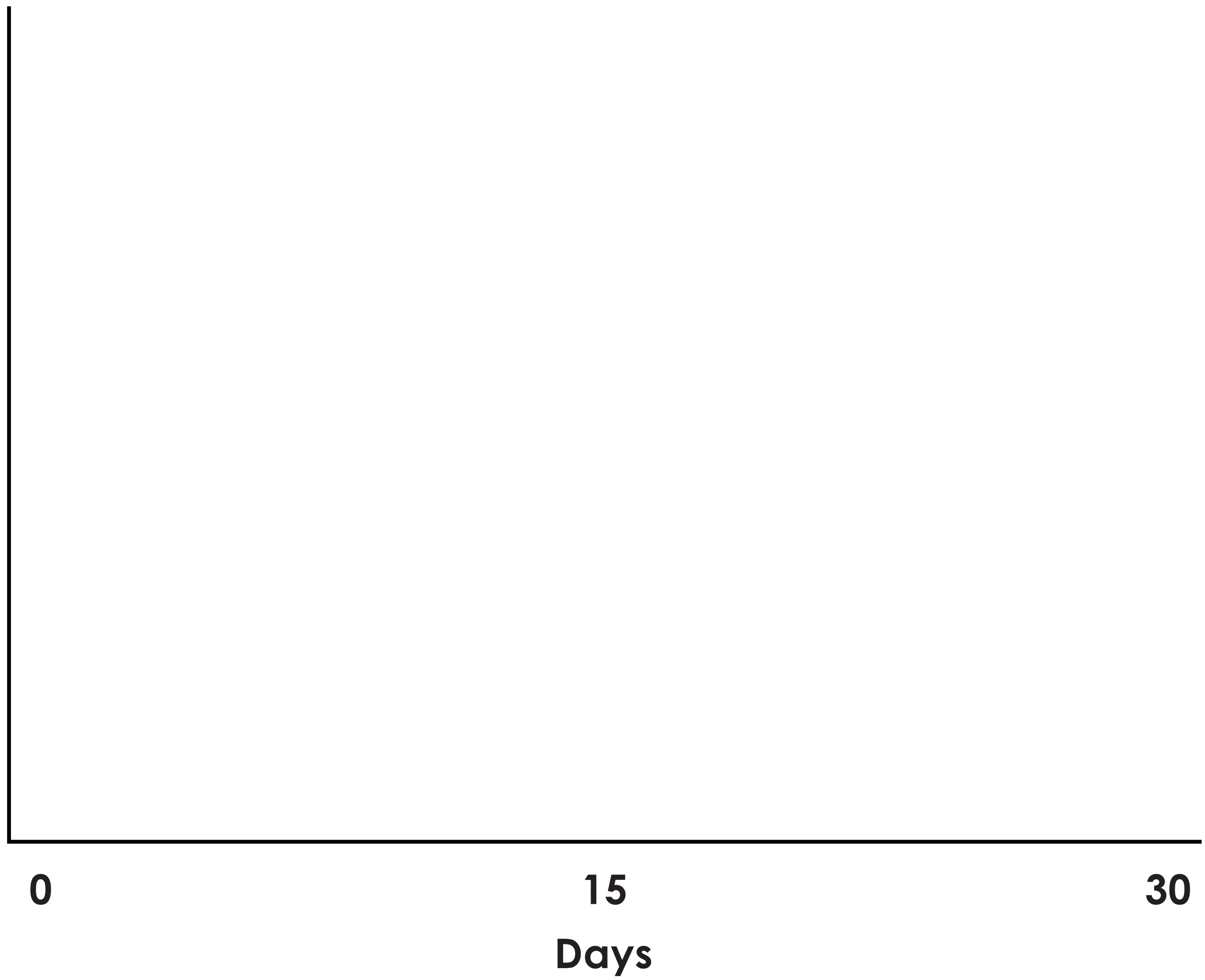
Number of Earthquakes



Tiltmeter: Angle of Volcanic Slope



Number of Phreatic Ejections



Results:

After each five days, send a "tweet" in the following format:

**To the people living near [Volcano name],
a volcanic eruption is [how likely they think an eruption is about to occur],
the geologic station recommends that you [student recommendation
to continue normal activity, prepare to evacuate, evacuate immediately, etc].**

Day 5 Tweet:

Credibility Points: ___________

Day 10 Tweet:

Credibility Points: ___________

Day 15 Tweet:

Credibility Points: ___________

Results:

After each five days, send a "tweet" in the following format:

To the people living near [Volcano name],
a volcanic eruption is [how likely they think an eruption is about to occur],
the geologic station recommends that you [student recommendation
to continue normal activity, prepare to evacuate, evacuate immediately, etc].

Day 20 Tweet:

Credibility Points: __________

Day 25 Tweet:

Credibility Points: __________

Day 30 Tweet:

Credibility Points: __________

LESSON 6: **PREDICTING ERUPTIONS**

TEACHER SLIDES: VOLCANO DATA

Show students slides one at a time. Allow students time to graph data and then send out a geologist tweet. After they have sent out a tweet for each data slide, show them the status of the volcanoes. Students should compare their status to the warning they give people living near the volcano. If they evacuated people early, they should subtract 10 credibility points. If they did not evacuate people on time, they should subtract 100 credibility points.

DATA:

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	1	22	2
2	1	22	2
3	2	22	2
4	1	22	2
5	1	22	2

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	2	15	6
2	1	15	6
3	2	14	6
4	0	15	6
5	0	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	0	30	2
2	0	30	2
3	0	30	2
4	1	31	2
5	2	31	2

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	3	33	3
2	2	33	3
3	3	33	3
4	3	33	3
5	3	33	3

RESULTS:

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	1	22	2
2	1	22	2
3	2	22	2
4	1	22	2
5	1	22	2

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	2	15	6
2	1	15	6
3	2	14	6
4	0	15	6
5	0	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	0	30	2
2	0	30	2
3	0	30	2
4	1	31	2
5	2	31	2

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
1	3	33	3
2	2	33	3
3	3	33	3
4	3	33	3
5	3	33	3

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	0	22	2
7	1	22	2
8	2	22	2
9	2	22	2
10	2	22	2

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	0	15	6
7	0	15	6
8	1	14	6
9	0	15	6
10	0	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	2	31	4
7	2	31	2
8	2	31	2
9	2	31	2
10	3	31	2

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
6	3	33	3
7	3	33	3
8	3	33	3
9	3	33	3
10	3	34	4

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	2	22	4
12	2	23	6
13	2	24	6
14	3	25	4
15	3	26	4

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	2	15	6
12	3	15	6
13	4	14	6
14	5	15	6
15	6	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	4	32	5
12	6	32	6
13	8	33	0
14	7	33	0
15	10	33	0

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
11	3	33	4
12	4	35	6
13	5	36	6
14	6	38	6
15	8	38	6

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	4	26	6
17	5	26	5
18	6	26	6
19	7	27	6
20	7	27	6

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	5	15	6
17	4	15	6
18	3	15	6
19	2	15	6
20	1	15	6

Mount Shasta

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	10	34	0
17	11	34	0
18	12	35	0
19	10	35	0
20	11	36	0

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
16	8	38	6
17	9	38	8
18	8	38	8
19	9	38	8
20	8	38	4

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Cleveland

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
21	9	27	6
22	8	27	6
23	9	27	10
24	11	27	10
25	10	27	10

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
21	2	15	6
22	2	15	6
23	3	15	6
24	4	15	6
25	2	15	6

Mount Shasta

	ACTIVE

Mount Cleveland

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
21	9	38	12
22	11	38	10
23	15	38	9
24	16	38	12
25	15	38	10

Mount Hood Oregon

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Cleveland

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Hood Oregon

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
26	12	27	11
27	15	27	12
28	16	27	15
29	17	27	15
30	18	27	15

Yellowstone Caldera

Day:	Earthquake Count:	Tiltmeter:	Phreatic Ejections
26	1	15	6
27	2	15	6
28	5	15	6
29	2	15	6
30	1	15	6

Mount Shasta

ACTIVE

Mount Cleveland

ACTIVE

Mount Hood Oregon

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Yellowstone Caldera

Volcano Status:	Dormant
If you issued an evacuation:	-10 credibility points
If you did not:	+10 credibility points

Mount Shasta

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

Mount Cleveland

Volcano Status:	ACTIVE
If you issued an evacuation:	+100 credibility points
If you did not:	-100 credibility points

ADDITIONAL RESOURCES:

AMERICAN MUSEUM OF NATURAL HISTORY:

https://www.amnh.org/explore/science-bulletins/(watch)/earth/documentaries/yellowstone-monitoring-the-fire-below

The AMNH provides a host of interactive media lessons on its museum website. This lesson covers the Yellowstone caldera and the scientists who monitor its activity. Students get an idea of how geologist work and can observe simulations of volcanic activity.

PBS LEARNING MEDIA:

https://www.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.volcanerupt/volcanic-eruptions-and-hazards/?#.W2M5_NhKjWY

This site contains and interactive webquest that educates students on the types and causes of volcanic eruption. At the bottom of the page, the site links to several different educational videos of volcanoes around the globe.

LIVE SCIENCE:

https://www.livescience.com/27295-volcanoes.html

Live Science provides an excellent reference material for teachers and students looking to dive deeper into the terminology and morphology of volcanic eruptions.

UNITED STATES GEOLOGICAL SURVEY:

https://volcanoes.usgs.gov/vhp/predict_flash.html

The USGS provides a rich collection of interactive materials for students to explore volcanoes in the safety of their own classroom. This particular activity shows students to tools and techniques volcanologists use to predict eruptions. Afterwards, students analyze actual data from Mount St. Helens to predict the 1980's eruption.

NOVA:

http://www.pbs.org/wgbh/nova/vesuvius/predict.html

NOVA writes excellent articles on a host of geological topics. This particular article helps students understand how scientists monitor volcanic activity.

Volcanoes Educator Guide

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VOLCANOES
THE FIRES of CREATION

An SK Films Release

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