# Hot! Hot! Hot!

Volcano Unit Plan

Lauren Huntington

## TABLE OF CONTENTS

**Rationale**

This unit plan on volcanoes was developed for seventh grade students in the state of Wyoming. Teaching the subject of volcanoes to students in Wyoming is unique due to the fact that we live next-door to the Yellowstone super volcano. Most students will be familiar with Yellowstone, and most are probably aware it is a volcano, but they most likely do not know why it's a volcano and what makes it a volcano. They should gain those understandings throughout this unit, as many lessons try to relate the information to the Yellowstone super volcano.

Most students will also still relate volcanos only to cone-shaped mountains that explode with magma. The goals of this unit are to introduce students to where volcanic regions occur on Earth and why, in relation to plate tectonics, as well as explain how hot spots form. They will also explore different types of volcanos, the physical and chemical properties of magma and how it flows, what causes a volcano to erupt and the different types of eruptions that occur.

Students will use newly acquired information to observe different types of volcanic rocks, develop an understanding that volcanic ash is not burned substance, but pieces of volcanic rock, and use what they've learned about volcanic hazards to simulate preparation for a volcanic hazard themselves.

This unit will take students on a journey of volcanic exploration with the use of a web quest, inquiry lab exercises, demonstrations, videos, observations, readings, and engaging discussions. Students will complete a learning cycle that engages, explores, explains, elaborates, and evaluates every day. Students will be assessed in a variety of ways throughout the unit, both formatively and summatively, depending on the focus of the lesson. Many lessons will be assessed on demonstrating understanding through turning in laboratory worksheets, writing reflections, and participating in observations, activities, and discussions. All of the what the students have learned will come together for a final project, which will allow students to turn the classroom into their own Volcano museum. Students will collaborate in pairs or groups to select a volcano that exists on Earth that they can research, and create a museum artifact about that volcano. Visitors to the museum want to be drawn to their exhibit and learn as much as they can about each volcano. Students can select to present their information in a poster, brochure, hanging cube, model, newspaper, collage, video, or any creative path they may choose. This project will be assessed based on a rubric. The resources available to my classroom make this all possible. Students have access to iPads, computers, lab supplies, and art supplies within the classroom to make this unit successful. Completion time for this unit is 3-4 weeks.

**Objectives**

**Students will be able to:**

- Identify where volcanic regions on Earth occur and explain why
- Explain how hot spots form
- Differentiate between different types of volcanos and their characteristics, and classify them
- Explain the chemical and physical properties of magma and identify what factors determine its viscosity
- Describe what happens when a volcano erupts
- Relate chemical gas reactions to a volcanic eruption
- Identify landforms that lava and ash create, as well as examine other distinct features of volcanic areas. I.E. geysers
- Observe a variety of volcanic rocks and explain their forms, and how they were formed
- Apply information about volcanic hazards to simulate preparation for a hazardous situation
- Research, organize, and present information about a selected volcano

**Next Generation Science Standards**

- **MS-ESS2 Earth's Systems (http://www.nextgenscience.org/msess2-earth-systems)**

  **MS-ESS2-1.** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

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

  **MS-ESS2-3**. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

  Science and Engineering Practices: Developing and Using Models

  Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

  Develop and use a model to describe phenomena. (MS-ESS2-1),(MS-ESS2-6)

  Develop a model to describe unobservable mechanisms. (MS-ESS2-4)

  Planning and Carrying Out Investigations

  Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

  Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. (MS-ESS2-5)

  Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

Analyze and interpret data to provide evidence for phenomena. (MS-ESS2-3)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. (MS-ESS2-2)

Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

Science findings are frequently revised and/or reinterpreted based on new evidence. (MS-ESS2-3)

Crosscutting Concepts

Patterns

Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3)

Cause and Effect

Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)

Scale Proportion and Quantity

Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS2-2)

Systems and System Models

Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. (MS-ESS2-6)

Energy and Matter

Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)

Stability and Change

Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1)

- **MS-ESS3 Earth and Human Activity (http://www.nextgenscience.org/msess3-earth-human-activity)**

**MS-ESS3-1**. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**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

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5)

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

Analyze and interpret data to determine similarities and differences in findings. (MS-ESS3-2)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1)

Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-ESS3-4)

Crosscutting Concepts

Patterns

Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

Cause and Effect

Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)

Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1),(MS-ESS3-4)

Stability and Change

Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

Connections to Engineering, Technology, and  Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1),(MS-ESS3-4)

The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2),(MS-ESS3-3)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-ESS3-4)

**Pre/Post Assessment Description**

Students will be pre-assessed on their knowledge about volcanoes with a objective, multiple choice, matching, and true/false assessment. The pre-assessment will determine any adjustments that need to be made to the unit plan. The same assessment will be administered at the end of the unit to measure the growth of the students.

## Unit Vocabulary

- **aa:** A slow moving type of lava that hardens fro form rough chunks; cooler than pahoehoe.
- **ash clouds:** burnt material that shoots out of the top of a volcano and forms a cloud
- **basalt:** A dark, dense, igneous rock with a fine texture, found in oceanic crust.
- **batholith:** a mass of rock formed when a large body of magma cools inside the crust.
- **cadera:** the large hole at the top of a volcano formed when the roof of a volcano's magma chamber collapses.
- **chemical property:** any property of a substance that produces a change in the composition of matter.
- **cinder cone:** a steep, cone-shaped hill or small mountain made of volcanic ash, cinders, and bombs piled up and around a volcano's opening.
- **composite volcano:** a tall, cone-shaped mountain in which layers of lava alternate with layers of ash and other volcanic materials.
- **convection:** the transfer of heat by movement of fluid.
- **convergent boundary:** a plate boundary where two plates move toward each other.
- **crater:** a bow-shaped area that forms around a volcano's central opening.
- **crust:** the layer of rock that forms Earth's outer surface.
- **dike:** a slab of volcanic rock formed when magma forces itself across rock layers.
- **divergent boundary:** a plate boundary where two plates move away from each other.
- **dormant:** describes a volcano that is not currently active, but that may become active in the future.
- **element:** a substance that cannot be broken down into other substances.
- **extinct:** describes a volcano that is no longer active and is unlikely to erupt again.
- **extrusive rock:** igneous rock that forms from lava on Earth's surface.
- **geothermal activity:** the heating of underground water by magma.
- **geyser:** a fountain of water and steam that build up pressure underground and erupts at regular intervals.
- **granite:** a usually light-colored igneous rock that is found in continental crust.
- **hot spot:** an area where magma from deep within the mantle melts through the crust above it.
- **igneous rock:** a type of rock that forms from cooling of molten rock at or below the surface.
- **intrusive rock:** igneous rock that forms when magma hardens beneath Earth's surface.
- **island arc:** a string of islands formed by the volcanoes along a deep-ocean trench.

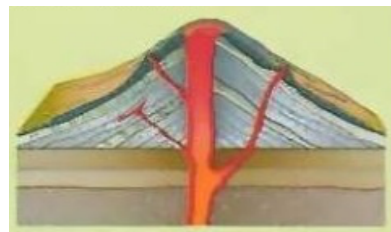
- **lava:** liquid magma that reaches the surface; also the rock formed when liquid lava hardens.
- **lava flow:** the area covered by lava as it pours out of a volcano's vent.
- **magma:** the molten mixture of rock-forming substances, gases, and water from the mantle.
- **magma chamber:** the pocket beneath a volcano where magma collects.
- **mantle:** the layer of hot, solid material between Earth's crust and core.
- **pahoehoe:** a hot, fast-moving type of lava that hardens to form smooth, roselike coils.
- **physical property:** any characteristic of a substance that can be observed or measured without changing the composition line of a substance.
- **pipe:** a long tube through which magma moves from the magma chamber to Earth's surface.
- **plateau:** a large area of flat land elevated high above sea level.
- **pyroclastic flow:** the expulsion of ash, cinders, bombs, and gases during an explosive volcanic eruption.
- **Ring of Fire:** a major belt of volcanoes that rims the Pacific Ocean.
- **shield volcano:** a wide, gently sloping mountain made of layers of lava and formed by quiet eruptions.
- **silica:** a material found in magma that is formed from the elements oxygen and silicon.
- **sill:** a slab of volcanic rock formed when magma squeezes between layers of rock.
- **subduction:** the process by which oceanic crust sinks beneath a deep-ocean trench and back into the mantle at a convergent plate boundary.
- **subduction zone:** A region of Earth's crust where tectonic plates meet.
- **tephra:** fragmental material produced by a volcanic eruption regardless of composition, fragment size or emplacement mechanism.
- **vent:** the opening through which molten rock and gas leave a volcano.
- **viscosity:** the resistance of a liquid to flowing.
- **volcanic neck:** a deposti fo hardened magma in a volcano's pipe.
- **volcano:** a weak spot in the crust where magma has come to the surface.

**Volcano Unit Assessment**
**(Teacher Copy)**

**Matching**

Match the type of volcano to the correct picture by drawing a line to connect the two.

Composite Volcano **(Middle)**



Shield Volcano **(Bottom)**

Cinder Cone Volcano **(Top)**

**Multiple Choice**
Select the best answer and write the letter on the line.

1. _______ Where are most volcanoes found?

a. On mountains
b. Europe
**c. Along plate boundaries**

2. _______ A major volcanic belt formed by many volcanoes that rim the Pacific Ocean is called

**a. The Ring of Fire**
b. The Volcanic Belt
c. Explosivo

3. ______ A volcano that is erupting, or has erupted recently is classified as

**a. Active**
b. Dormant
c. Extinct

4. ______ A volcano that hasn't erupted in recent history, but could erupt is classified as

a. Active
b. Extinct
**c. Dormant**

5. ______ A volcano that will never erupt again is considered.

a. Dormant
**b. Extinct**
c. Active

6. ______ An area where material from deep within the mantle rises and then melts, forming magma is called a

**a. Hot Spot**
b. Magma pool
c. Hot Spring

7. ______ When groundwater is heated in hot rock near shallow magma bodies a ______ can form

a. Batholith
b. Dike
**c. Geyser**

8. ______ When magma heats underground water, the result may be a

a. lava flow
**b. hot spring**
c. hot spot

9. ______ The tendency of a fluid to resist flowing is called

a. Static
**b. Viscosity**
c. Resistance

10. ______ The major ingredient in Magma is

**a. silica**
b. basalt
c. Carbon Dioxide

11. ______ What two main factors affect magma's viscosity?

a. Altitude and season
b. Location and Temperature
**c. Temperature and Silica content**

12. ______ As temperature of magma increases, its viscosity

a. affects the magma's silica content
**b. increases**
c. stays the same

13. ______ What are the two types of volcanic eruptions?

a. Eruptive and Lazy
**b. Effusive and Explosive**
c. Gaseous and Liquid

14. ______ What causes some eruptions to be explosive and others to be quiet?

**a. Differences in gas and silica content**
b. Differences in altitude and location
c. Differences in temperature and time of year

15. ______ Which step in a volcanic eruption occurs just before the volcano erupt?

a. Magma collects in the magma chamber
b. Lava hardens to form volcanic rock
**c. Expanding gases push magma through a pipe**

16. ______ The collapse of a volcano's magma chamber may produce a

a. crater
b. island arc
**c. caldera**

17. ______ The bowl shaped area around a volcano's vent is a

**a. crater**
b. island arc
c. caldera

18. ______ Volcanic ash is

**a. small pieces of cooled lava**
b. burned substance
c. smoke and fire

19. ______ As a volcano erupts, what force pushes magma out of a volcano onto the surface?

a. Flowing water
**b. The force of expanding gases**
c. The Jedi Force

20. ______ What do lava flows made of pahoehoe and aa indicate about the type of volcanic eruption that occurred?

a. The eruption was explosive
**b. The eruption was effusive**
c. The eruption was dangerous

**True or False.**
Circle whether the state is true or false.

21. **True** or False. There are between 50 and 100 hot spots around the world.

22. **True** or False. A volcano is a weak spot in the Earth's crust where molten material comes to the surface

23. **True** or False. Yellowstone National Park marks a hot spot under the North American plate.

24. **True** or False. How fast lava flows depends on the properties of the magma from which it formed including its silica content and temperature.

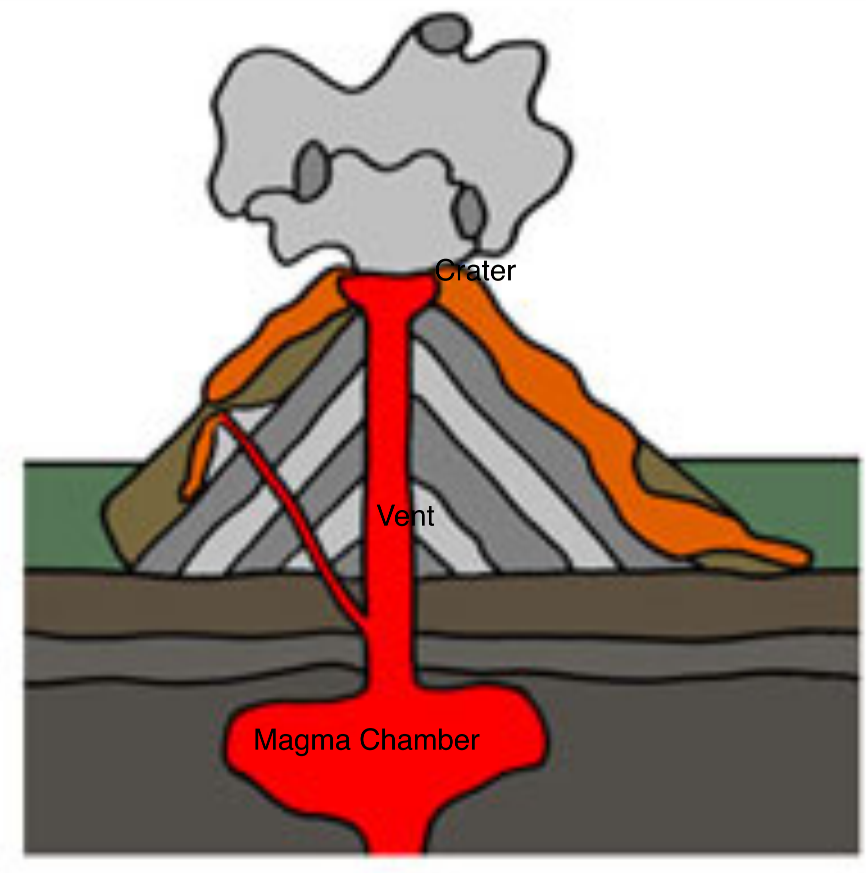
25. **True** or False. Dormant volcanoes can become active at any time.

**Short Answer**
Please answer in complete sentences.

What is more likely to be dangerous — a volcano that erupts frequently, or a volcano that has been inactive for a hundred years? Why?

**Label**
Label the parts of the volcano listed below on the diagram.

Magma Chamber Vent Crater



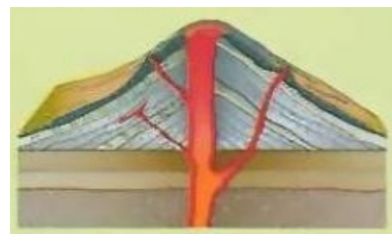
**Volcano Unit Assessment**
**(Student Copy)**

**Matching**

Match the type of volcano to the correct picture by drawing a line to connect the two.

Composite Volcano

Shield Volcano



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**True or False.**
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23. True or False. Yellowstone National Park marks a hot spot under the North American plate.

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25. True or False. Dormant volcanoes can become active at any time.

**Short Answer**
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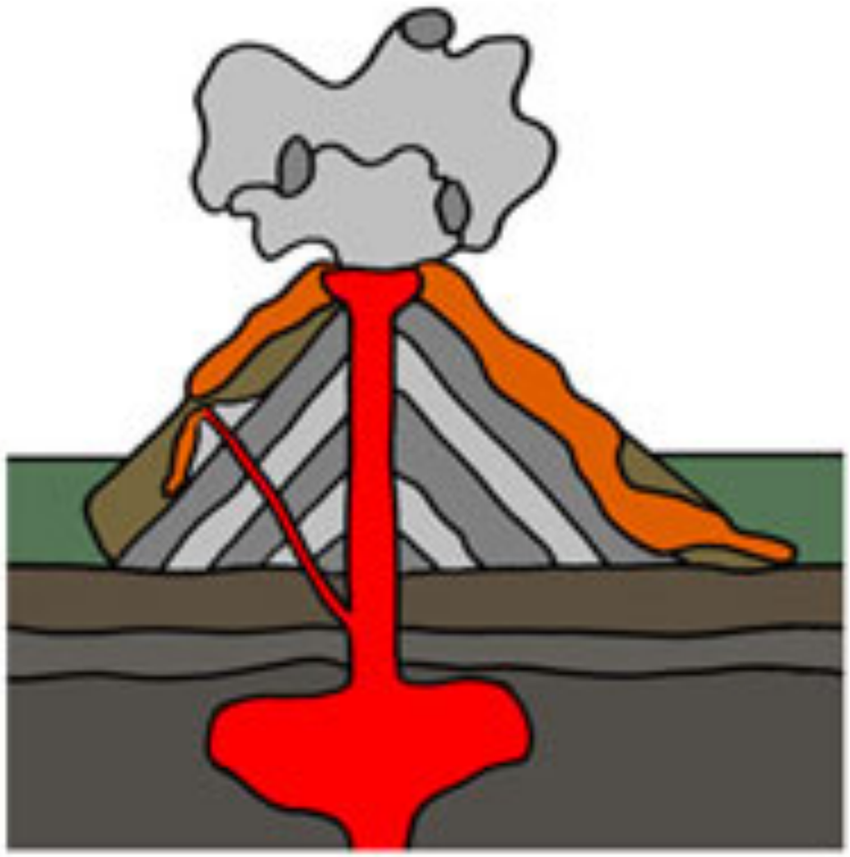
**Label**
Label the parts of the volcano listed below on the diagram.

Magma Chamber      Vent      Crater



**Lesson #1**
**An Eruption of Exploration Web Quest**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

This lesson is intended to be the introductory lesson in a volcano unit. The students build their independent learning skills, as well as knowledge on volcanoes by performing a web quest using provided links and simulations to research and answer specific questions regarding volcano, magma, eruption and rock types, locations, and volcanic features (handout attached). The lesson opens with a pre-assessment journal entry and discussion about volcanoes. This lesson is written to students in Wyoming, where Yellowstone is a common theme.

**Duration:** 2 50 minute class periods or 1 90 minute class period.

**Objectives:**

Students will be able to describe what volcanos are.
Students will be able to locate where volcanoes occur on Earth
Students will be able to differentiate between the different types of volcanoes that occur on Earth.

**NGSS Standards Addressed:**

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

**MS-ESS2-3.** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS.Earth's Systems
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

Students will need access to the internet via personal computers or tablets. Computer lab time will need to be planned if students do not have classroom computers.
The web quest will be available on the classes' google classroom, or google drive, and also printed and handed out. (It is easier to follow links if the web quest is available through an online format), but the questions should be answered on a hard copy.

**5E's**

- **Engagement**

Students are engaged during the class opener by writing a paragraph about their personal experiences with volcanoes: Seeing them in movies, on the news, visiting them, reading about them. Anything that gives them a personal connection to the topic can be written in a journal. Students will then share their experiences during a teacher-facilitated class discussion.

The teacher will provide the writing prompt for all students to see upon entering class. It can be written on the whiteboard, or projected on a screen. The prompt is "Write a paragraph describing what you know about volcanoes and what personal experiences you might have with them. Think about volcanoes you may have seen in movies, on the news, read about, or possibly visited. Be prepared to discuss."

Students will have 5-10 minutes to write their paragraphs, then the teacher will lead a discussion, starting with asking who wants to share what they wrote about.

Possible facilitating discussion questions:

Has anybody ever visited an active volcano? What does it look like?
Do all volcanos look the same? What do they look like?
When you think of a volcano erupting, what do you think it looks like?
Do all volcanoes have large, hazardous eruptions?

The discussion should lead students to realize that volcanoes aren't just steep mountainous structures that shoot magma out of the top, and there is a lot to explore regarding volcanoes.

- **Exploration:**

Students will be visiting multiple volcano simulations online as they are guided through answering questions on a web quest. Students will be allowed to work in pairs, but each student must individually answer the questions.

To ensure students remain on task during their online volcano exploration, the teacher will refocus the students every 10 minutes by asking if the students to share something that they've discovered that they found interesting. The students may also need clarification questions answered at these intervals. If students have questions about vocabulary, write the word and definition on the board.

- **Explanation:**

Once the students finish their web quests and have turned them in, the class will once again have a discussion. Students will revisit their journal entries about volcanoes, and with a partner discuss what they wrote about volcanoes, compared to what they know now. They will also discuss what they learned from the web quest that they felt was the most interesting or surprising. They will then share with the class during the discussion.

The teacher will facilitate the discussion, by first asking the students to share with the class what they just discussed with their partners.

Possible questions:

What did you discover about different types of volcanoes? (the teacher could draw diagrams on the board, or use the simulation the students used as a visual)
Where on Earth do you find volcanoes? How is that related to earthquakes?
What did you discover about volcanoes that aren't located on the Earth's plate boundaries? What are those called?
Did anybody find out what kind of Volcano Yellowstone is? How do we know that?

- **Elaboration:**

Students will add another paragraph to their original journal entries about what they now know about volcanoes, and how their personal experience with volcanoes they wrote about before may have gave them a different idea about volcanoes then they have now.

Students will acquire new vocabulary throughout the duration of the lesson including: Active, Dormant, Extinct, Magma, Chamber, Conduit, Vent, Cinder Cone, Composite, Shield Volcano, Lava Dome, Hot Spots, Fault Zones, Subduction Zones, Geothermal, Mafic, Intermediate, Felsic, Igneous, Extrusive, Intrusive

- **Evaluation:**

Students will demonstrate that they built upon their previous knowledge about volcanoes by using the provided simulations to correctly answer the questions on the webquest. Students will also be able to explain and discuss what they have learned in a class discussion, as well as compare their previous knowledge of volcanoes to what they discovered during the activity by writing a paragraph in their science journals.

**Formative:** The teacher will check for understanding throughout the web quest activity, as well as asses students on their willingness to participate during the class discussion.

**Summative:** Students will turn in a completed web quest activity to demonstrate completion and understanding of the content for a grade. Journals will also be assessed for completion points, as well as demonstration of understanding and building on or correcting previous knowledge.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, or a more advanced student to help with deciphering the volcano information.
Writing: Students with IEPs for writing may type their answers on the computer, and just do the diagrams on the handout.
Social: Students with social issues may work in a quiet place alone, or wear headphones.
Time: Students who need more time to complete the activity will be given the option to work at home, or in the classroom during lunch, or before or after school.
*All students with 504s and IEPs will use a worksheet that has a link provided for every question.

Extensions for advanced students:
The advanced class will be given an extended version of the web quest and be required to answer all questions. Advanced students in other classes will be give the option of exploring further questions for extra credit.

**Safety Considerations:**

Students should have a procedure in place for retrieving classroom computers or iPads to avoid everybody going at once.
Procedures should be in place for students to relocate to the computer lab or library if necessary for computer use.
Students are not to use any other website other than what is provided for the web quest. Doing so will result in a consequence.

**An Eruption of Exploration**
**A volcano discovery Web Quest**

Name:

**Instructions:** Follow each link provided, and answer the questions accommodating each link in complete sentences. All answers are found using these links. Be sure to click on every link provided within the simulation, and read carefully!

Link 1: Introduction to Volcanism
http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/index.htm

1. Draw and label a diagram of a volcano. Provide a short description for each part.

2. The ______________ that forms from layers of ____________ and ___________ is called a

__________________.

3. Volcanoes are classified as active, dormant, or extinct. Describe what those classifications mean.

4. There are 4 main types of volcanoes. How are they classified?

5. What are the two primary types of volcanoes? What are the two secondary types? Why are they secondary?

6. List one fact about each type of volcano. Draw the basic shape of each type.

7. What are the three places that volcanoes commonly occur?

8. How many hot spots have been identified around the world?

9. What is Hawaii?

10. What kind of volcanoes are associated with hot spots? What other features are associated with hot spots?

11. ______________________________ are places where tectonic plates are moving away from one another.

12. What is much of the oceanic crust made of?

13. _________________ is the word used to describe melted or molten rock inside Earth.

14. What is magma made of?

15. What determines the eruption style, rock type, and volcano shape?

16. List the three types of magma and what type of volcano each type comes out of.

17. _________________ rocks are formed when molten rock cools and hardens.

18. What are the two classes of igneous rocks? Where are they found? (Below or on top of Earth's surface?)

Link 2: Volcanic Eruptions and Hazards

http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanerupt/02_Effusive.htm

19. ___________________ eruptions are generally considered to be gentler than explosive eruptions.

What types of hazards can result from this type of eruption? List 3.

20. ____________________ eruptions are the most hazardous, involving large volumes of tephra and gases emitted from the volcano.

What types of hazards can result from this type of eruption? List 3.

Extra Credit (Extension for advanced students)

Follow this link to a third simulation: Volcanic Features.

http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/

ess05_int_volcanfeatr/03_Caldera.htm

21. How do we know that Yellowstone is actually a volcano? Provide details.

22. What is Devils Tower?

**An Eruption of Exploration**
**A volcano discovery Web Quest (for IEPs and 504s)**

Name:

**Instructions:** Follow each link provided, and answer the questions accommodating each link in complete sentences. All answers are found using these links. Be sure to click on every link provided within the simulation, and read carefully!

Link 1: Introduction to Volcanism
http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/index.htm

1. Draw and label a diagram of a volcano. Provide a short description for each part.

2. The _____________ that forms from layers of ___________ and __________ is called a _________________.

3. Volcanoes are classified as active, dormant, or extinct. Describe what those classifications mean. http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_ADE.htm

4. There are 4 main types of volcanoes. How are they classified? http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_Types.htm

5. What are the two primary types of volcanoes? What are the two secondary types? Why are they secondary?

6. List one fact about each type of volcano. Draw the basic shape of each type.

7. What are the three places that volcanoes commonly occur? http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_Where.htm

8. How many hot spots have been identified around the world? http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_Hotspot_01.htm

9. What is Hawaii?

10. What kind of volcanoes are associated with hot spots? What other features are associated with hot spots?

11. ______________________________ are places where tectonic plates are moving away from one another. http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_Spread_01.htm

12. What is much of the oceanic crust made of?

13. _________________ is the word used to describe melted or molten rock inside Earth. http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_Magma.htm

14. What is magma made of?

15. What determines the eruption style, rock type, and volcano shape? http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_3Magmas.htm

16. List the three types of magma and what type of volcano each type comes out of.

17. _________________ rocks are formed when molten rock cools and hardens. http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanintro/01_Rocks.htm

18. What are the two classes of igneous rocks? Where are they found? (Below or on top of Earth's surface?)

Link 2: Volcanic Eruptions and Hazards

http://pbs.panda-prod.cdn.s3.amazonaws.com/media/assets/wgbh/ess05/ess05_int_volcanerupt/02_Effusive.htm

19. ___________________ eruptions are generally considered to be gentler than explosive eruptions.

What types of hazards can result from this type of eruption? List 3.

20. ____________________ eruptions are the most hazardous, involving large volumes of tephra and gases emitted from the volcano.

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Extra Credit (Extension for advanced students)

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21. How do we know that Yellowstone is actually a volcano? Provide details.

22. What is Devils Tower?

**Lesson #2**
**Properties of Magma**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

This is a laboratory exercise in which students will work in pairs to explore viscosity by measuring how fast different household items like cooking oil and honey/molasses/or syrup flow. Students will relate their measurements to properties of magma.

**Duration:** 1 50 minute class period

**Objectives:**

Students will be able to explain why some fluids flow more easily than others.
Students will infer what factors determine the viscosity of magma.
Students will describe a fluid as having "high" or "low" viscosity.

**NGSS Standards Addressed:**

MS.Earth's Systems
**MS-ESS2-1.** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

Clear plastic cups: enough for 4 per group
Molasses/honey/syrup: whichever is easiest to get. Each group gets 1 cup approximately 1/3 full.
Cooking oil (vegetable/canola). Each group gets 1 cup approximately 1/3 full.
Each group gets 1 empty plastic cup
1 straw per student
15 stopwatches (1 per group)
Data sheet (attached)
12 inch ruler -1 per group

**5E's**

- **Engagement**

  Students are engaged during the class opener by answering the question posted on the board in their science notebooks.

The teacher will provide the writing prompt for all students to see upon entering class. It can be written on the whiteboard, or projected on a screen. The prompt is "Define viscosity. Do some research if you need to."

Students will have about 5 minutes to answer, and then participate in a discussion.

The teacher will define viscosity on the board as "how quickly a substance flows depending on the internal friction."

- ° How "sticky" a fluid is
- ° The viscosity of a liquid is determined by a variety of factors, some of which include temperature, the kinds of bonds present, and the stresses applied to the liquid

- **Exploration:**

Students will conduct a laboratory investigation with a partner in which they test the viscosity of vegetable/olive/canola oil (whichever is available), and honey/molasses/syrup (again, whichever is available) by timing how long it takes to pour the entire contents of the cup into another cup from 12 inches above. Students will record their findings, and answer questions about viscosity on a laboratory handout. Before students conduct the pouring and timing part of the investigation, each student will blow into the liquid and observe the differences in how forceful they had to blow to get a bubble, and what the bubble was like.

- **Explanation:**

The class will discuss their findings from the laboratory investigation. The teacher will list common household liquids on the board, and the class will put them in order from high viscosity to low viscosity.

Questions will lead the class to relate their findings to magma.

Possible questions:

What determines viscosity?
How does temperature affect viscosity?
How would your results change if you heated up your honey before testing the viscosity?
What factors determine the viscosity of Magma? (silica content and temp)
How would viscosity effect how forceful an eruption is?

- **Elaboration:**

Students will think of a fluid that wasn't discussed, and write it in their science notebooks. They will determine if that fluid has high or low viscosity.

Students will acquire an understanding of the word viscosity.

- **Evaluation:**

Students will demonstrate that they made connections between the investigation and lava flow by correctly answering the questions provided on the laboratory investigation handout. Students will also be able to explain and discuss what they have learned in a class discussion.

**Formative:** The teacher will check for understanding throughout the lab, as well as asses students on their willingness to participate during the class discussion.

**Summative:** Students will turn in a completed laboratory handout.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, or a more advanced student to help with reading the handout and lab instructions.
Writing: Students with IEPs for writing may type their answers on the computer.
Social: Students with social issues may work on the lab investigation alone, or with an aid.
Time: Students who need more time to complete the activity will be given the option to work in the classroom during lunch, or before or after school.

Extensions for advanced students:
The advanced class will be given an extended version of the lab by measuring the viscosity of other items at home, then bring their findings in to class to discuss.

**Safety Considerations:**

Students will wear safety goggles at all times during the investigation.
Students will be familiar with the eyewash station, as well as where the sinks and other safety equipment are located.
Students will know proper cleanup and laboratory procedures.
Students will be instructed to not ingest any of the lab material.

# Viscosity Lab Investigation

At your lab station you should have 4 cups. One cup is 1/3 full of vegetable oil, one cup is 1/3 full of honey, and  2 cups are empty. You will also find a stopwatch, a ruler, and straws.

1. Retrieve your safety goggles from the cabinet.
2. Each person will grab a straw. One person at a time, place the straw into the cup of oil. Blow bubbles like you would do with a soda. Observe how hard you have to blow, and the force and size of the bubbles once the air gets through. Do the same with the honey. Record your observations below. All group members will do this.
   a. Blowing in the oil:

   b. Blowing in the honey:

3. One person will be the pourer, while the other person is the timer.
4. The pourer will first grab the cup with vegetable oil. Holding the ruler vertically (either person can hold the ruler), the pourer will hold the cup approximately 12 inches above the empty cup.
5. The timer will begin the timing as soon and the pourer begins to pour the oil into the cup.
6. The timer will stop the stopwatch as soon as the cup of oil is empty. Record this time in the table below.
7. Repeat steps 3-5 with the honey and the other empty cup.

| **Substance** | **Time** |
|---|---|
| **Oil** | |
| | |
| **Honey** | |
| | |

Answer the questions below.

1. Describe your flow-test results. Why did you get the results you did?

2. Is the viscosity of the oil higher or lower than the honey? How do you know?

3. One way to decrease the viscosity of a liquid is to __________ (heat/cool) the fluid?

4. What factors affect the viscosity of a substance?

5. What would happen to the viscosity of the oil and the honey if you heated it up? What if you cooled it down?

6. Can magma have different viscosities? What influences the viscosity of magma? (conduct research if you need to)

7. If magma in a volcano has a high viscosity, would the eruption be quiet or explosive? Why? (Think of how the fluids reacted to you blowing air into them)

8. Could viscosity affect how often a volcano erupts? Why?

9. What are some dangers of a volcanic eruption with high viscosity magma?

10. What are some dangers of a volcanic eruption with low viscosity magma?

Bonus: Do you prefer mashed potatoes with low or high viscosity? Explain.

**Lesson #3**
**Riding the Magma Elevator**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

In this lesson, students will examine the processes leading to a volcanic eruption, including mantle melting, magma formation, and magma ascent. During this activity, the students will engage in a nearpod presentation with the teacher that takes them through an imaginary elevator to visit different stations from the subduction zone to volcanic vent of a volcano.

**Duration:** 1 50 minute class period

**Objectives:**

Students will develop an understanding about how the subducting plates trigger melting of mantle to form magma
Students will identify how gas pressure initiates the ascent of magma into the magma chamber.

**NGSS Standards Addressed:**

MS.Earth's Systems
**MS-ESS2-1.** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

iPad - 1 per student
Internet connection
Nearpod presentation created by teacher (Attached)

**5E's**

- **Engagement**

  Students are engaged during the class opener by using their imaginations and writing a creative piece as if they were in a glass elevator in a volcano.

  The teacher will provide the writing prompt for all students to see upon entering class. It can be written on the whiteboard, or projected on a screen. The prompt is "Imagine you are in a special glass elevator inside a volcano. There are 3 stops on the elevator. What is happening at each stop?"

Students will have 10 minutes to write their paragraphs. Students can share what they wrote if they choose to.

- **Exploration:**

Students will join the teacher in an interactive nearpod presentation using iPads. Slides will be presented as if the class is in an elevator inside of the volcano visiting different stations from the subduction zone to the vent during an eruption.

The teacher will lead a discussion during each level, describing the processes that are occurring.

- **Explanation:**

The nearpod presentation will include multiple interactive opportunities for students to answer questions about the presented information. Quiz questions, polls, and opportunities to label diagrams will be presented throughout.

The teacher will facilitate a discussion throughout the presentation, explaining the content on each slide, as well as asking students questions about the presented slides.

Possible questions:

- **Elaboration:**

Students will add another paragraph to their original journal entries about what they now know about what is happening inside of a volcano.

Students will acquire new vocabulary throughout the duration of the lesson including: magma chamber,

- **Evaluation:**

Students will demonstrate that they engaged in the material by signing in to the nearpod presentation, and participating in the activities presented. The teacher will be able to immediately assess each students participation.

**Formative:** The teacher will check for understanding throughout the presentation, as well as asses students on their willingness to participate.

**Summative:** Students will answer questions and participate in the prompts on the nearpod, in which the teacher will get results for each student.

**Differentiation:**

Students with special learning accommodations:

Reading: Students with IEPs for reading will be placed with an aid. Each slide will be explained, so these students should be able to participate.
Writing: Students with IEPs for writing may type their journal entries on the computer.
Social: Students with social issues will not be assessed on their willingness to participate in discussion.

Extensions for advanced students:
The advanced class will be expected to participate in discussion more avidly.

**Safety Considerations:**

Students should have a procedure in place for retrieving classroom computers or iPads to avoid everybody going at once.
Procedures should be in place for students to relocate to the computer lab or library if necessary for computer use.
Students are not to use any other website other than what is provided for the nearpod. Doing so will result in a consequence.

**Source:**

Information and graphics for the Nearpod presentation will come from this online PDF file, pages 209-216.

http://pubs.usgs.gov/gip/19/downloads/gip19.pdf

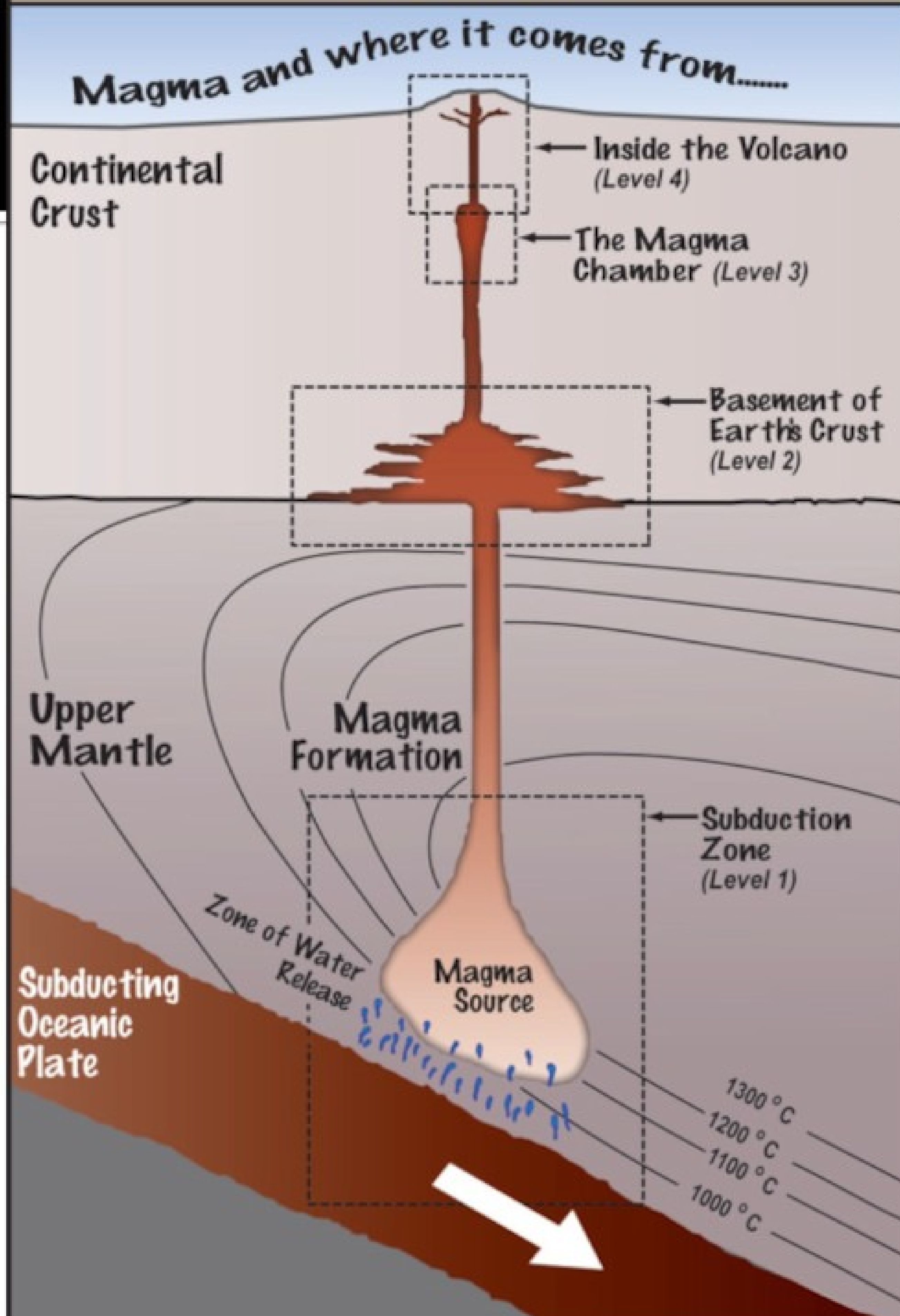
A look inside a volcano

# Riding the Magma Elevator

# Get Ready

- No one has been—nor will likely reach the center of a volcano to examine directly the inner workings of an eruption. However, we can interpret what is going on by using scientific instruments—and a bit of imagination! We'll use an imaginary elevator in this activity to explore four locations crucial to the making of magma: the subduction zone at level 1; basement of Earth's crust at level 2; the magma chamber at level 3; and inside the volcano at level 4. We'll make a descent down to level 1, the upper mantle and subduction zone, and then work our way upward to a volcano on Earth's surface. Put on your hard hats, this elevator's heading down!

# Overview



Magma and where it comes from.......
Continental Crust
Inside the Volcano (Level 4)
The Magma Chamber (Level 3)
Basement of Earth's Crust (Level 2)
Upper Mantle
Magma Formation
Subduction Zone (Level 1)
Zone of Water Release
Magma Source
Subducting Oceanic Plate
1300 °C
1200 °C
1100 °C
1000 °C

# Quiz

Question 1

## What is a subduction zone?

- [ ] A region of Earth's crust where tectonic plates meet.
- [ ] A region wheren a volcano is under water.

# Level 1 – Subduction Zone

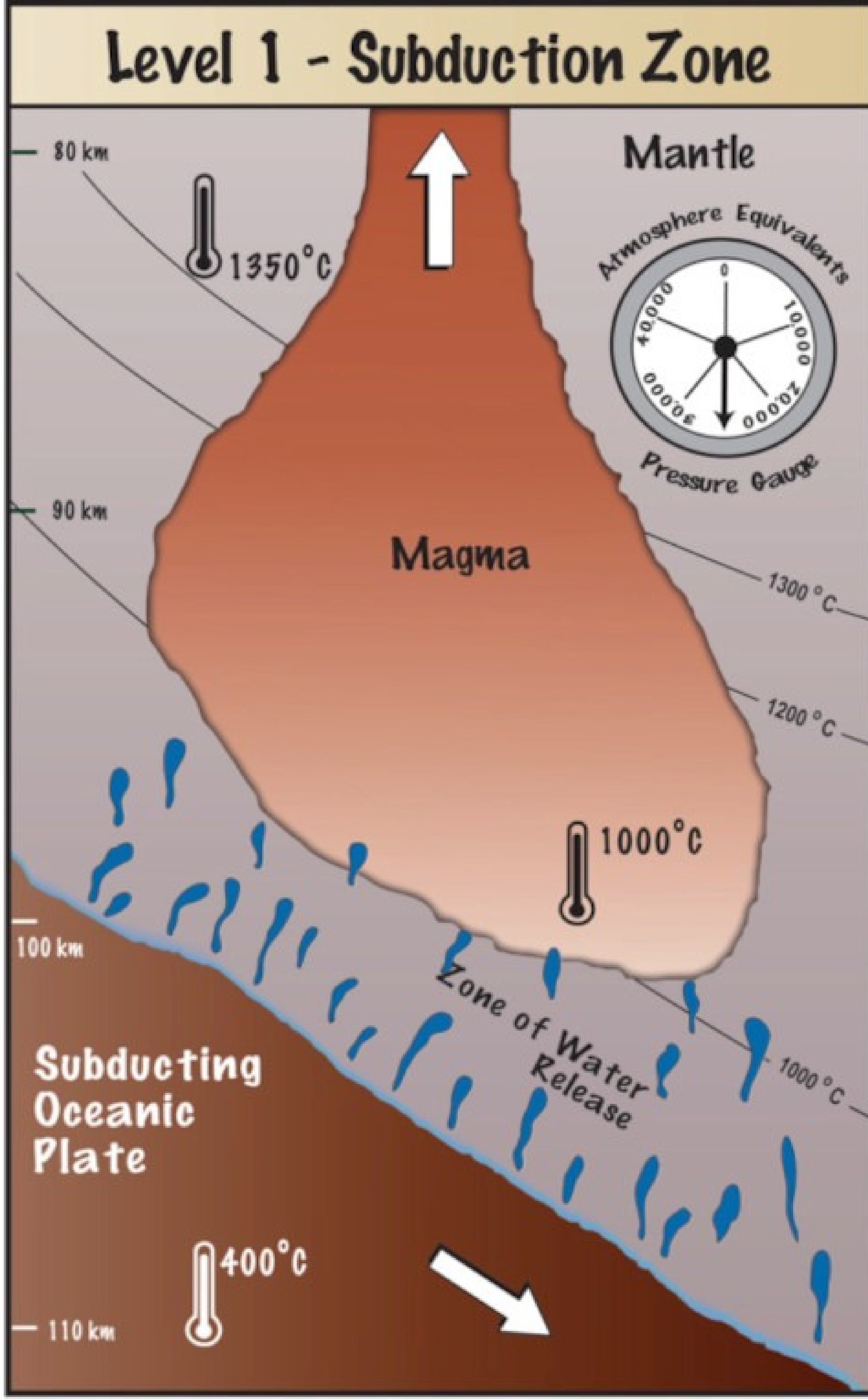
- After a hot and dark trip downward, our elevator arrives safely in the upper ***mantle***, just above the subducting Plate, 80 to 120 kilometers (50 to 75 miles) below Earth's surface. Looking out our elevator porthole, we view dense ocean floor sediments that have sunk beneath the Earth. On the way down, we passed through the less dense upper portion of sediments that scraped against the continent and accumulated as great piles of rock—forming a mountain range.

# Level 1 – Subduction Zone

- These sediments move quickly—at a speed of approximately 5 centimeters per year (more than 2 inches per year), a rate equivalent to that of your annual fingernail growth! Cold water from the ocean helps keep temperatures comparatively cool in the subduction zone—that is, below 400° Celsius (750° Farenheit); however, temperatures here in the surrounding upper mantle are considerably hotter.

# Level 1 – Subduction Zone

- Our elevator is well-equipped with temperature and pressure sensors. We note that the pressure is extreme 2.5 gigapascals (GPa). That pressure is 25,000 times greater than pressure exerted by Earth's atmosphere at sea level, and the equivalent of 1.5 million cars stacked one upon the other, and sufficient to make mantle rock flow like road tar exposed to the warm sun. The thermometer indicates an outside temperature of 1,350°Celsius (2460°Farenheit)—sufficiently hot to warm the water within the subducting plate. Water from the subducting slab rises into the mantle rocks. The addition of water to hot mantle rocks causes rock to melt and form magma. This magma begins to rise because it is less dense than surrounding solid mantle rock.



Level 1 - Subduction Zone
80 km
1350°C
Mantle
Atmosphere Equivalents
0
10,000
20,000
50,000
40,000
Pressure Gauge
90 km
Magma
1300 °C
1200 °C
1000°C
100 km
Zone of Water Release
1000 °C
Subducting Oceanic Plate
400°C
110 km

# Quiz

Question 2

**The water from the ocean keeps temperatures fairly "cool" in the subduciton zone. How "cool" is this?**

- [ ] Right around 30 degrees Farenheit
- [ ] Just below 750 degrees Farenheit
- [ ] Just below 1200 degrees Farenheit

# Elevator going up

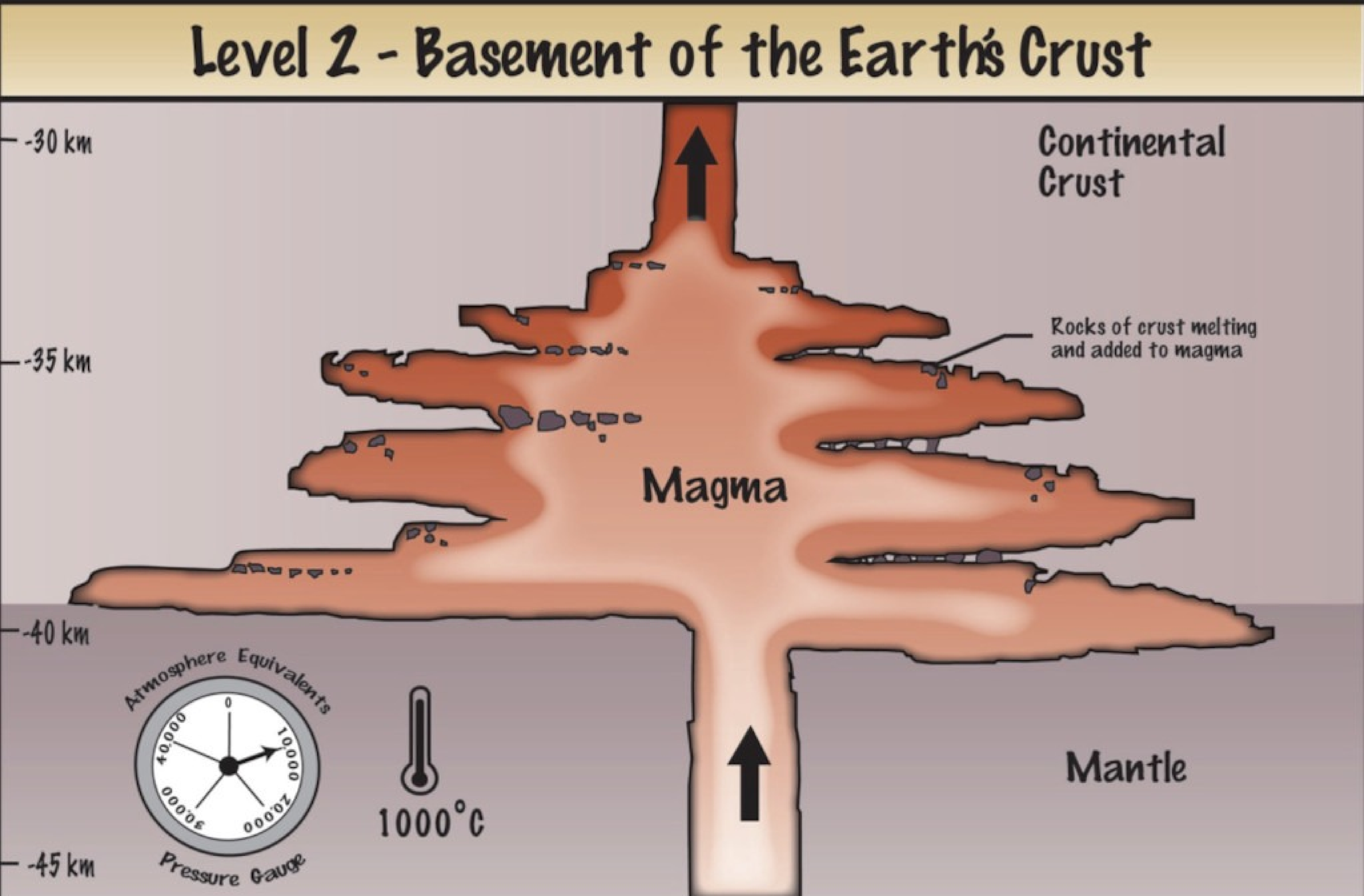
- “All aboard,” as we head upward to our next stop, the basement of Earth’s crust—the Crustal Melting Zone.

# Level 2 – Basement of Earth's Crust

- The crustal melting zone is 40 kilometers (24 miles) below Earth's surface and is the boundary between the mantle and the overlying continental crust. Our pressure gage shows a pressure of 1 GPa, or 10,000 Earth atmospheres. To our sense of touch, the magma is hot 1,000° Celsius (1,800° Farenheit). Even with oven mitts, you wouldn't want to touch this rock! The rock is pliable, unlike the hard continental crust with which we are familiar at Earth's surface.

# Level 2 – Basement of Earth's Crust

- Rising magma collects at the
base of the crust, slowly melting a pathway upwards— perhaps at a rate of 1 meter (3 feet) per year. From our porthole windows we note that the magma rises as a plume of hot rock, completely molten at the plume's center, and partially molten around the edges. This plume of ascending magma melts some surrounding crustal rocks, enabling bits of crustal material to hitchhike upward and form new combinations of elements within the magma.


Level 2 - Basement of the Earth's Crust
-30 km
-35 km
-40 km
-45 km
Continental Crust
Rocks of crust melting and added to magma
Magma
Mantle
Atmosphere Equivalents
0
10,000
20,000
30,000
40,000
Pressure Gauge
1000°C

# Quiz

Question 3

**About how fast does magma melt a pathway upwards from the basement of Earth's crust?**

- [ ] 3 feet per day
- [ ] 3 feet per month
- [ ] 3 feet per year

# Elevator Going Up

- Now it is time for our elevator to climb upward again. We're headed to the top of the magma chamber.

# Level 3 – Magma Chamber

- We are now at the top of the magma chamber, a zone of partially to completely molten rock. At this volcano, the magma chamber is located approximately 8 to 10 kilometers (5 to 6 miles) below the Earth's surface and extends several kilometers (approximately 2 miles) in width. Why does the magma accumulate here? The upward migration of magma stalls when its density equals that of the surrounding solid continental rock.

# Level 3 – Magma Chamber

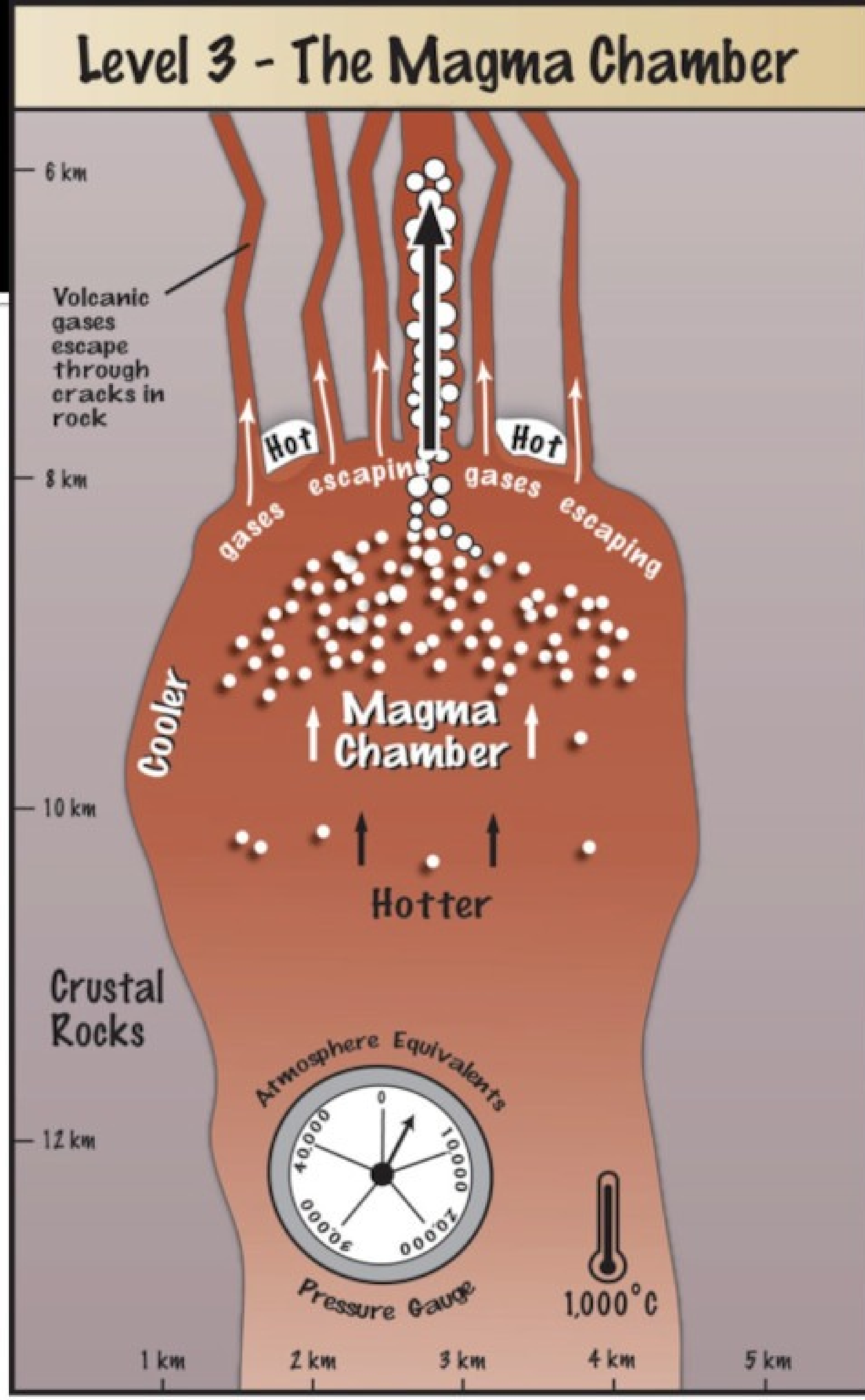
- Here, pressure within the magma chamber approximates 0.3 GP, the equivalent of 3,000 Earth atmospheres, and to the pressure of 180,000 cars stacked one on top of the other! The temperature remains at about 1,000° Celsius (1,800° Farenheit). In the center of the magma chamber the rock is molten and has the consistency of a hot slushy crystal mix. Temperatures and textures vary progressively from the center to the margins; a viscous (mushy) liquid that flows under pressure in the center to cooler solid rock at the chamber's outer edges.

# Level 3 – Magma Chamber

- Minerals and still uncombined chemical elements mix and mingle like at a square dance, where atoms change partners and new minerals and element patterns emerge. While the minerals and elements are square dancing, the gases separate from the magma and rise to the top of the magma chamber in search for the quickest and easiest route of escape to Earth's surface.

# Level 3 – Magma Chamber

- Here the magma rests, often for thousands of years, while it continues to cool, crystallize, form minerals, and receive replenished magma from below. Minerals mix and mingle with crustal rocks. Hot magma remains trapped beneath Earth's surface until the pressure within the magma chamber exceeds the strength of surrounding crustal rocks, forcing a volcanic eruption.
- Some magma never makes the journey to the volcano above. It cools and hardens in place, and after thousands of years, the minerals within grow large and form a rock called ***granodiorite***. We see it at Earth's surface today, exposed by erosion.


Level 3 - The Magma Chamber
6 km
Volcanic gases escape through cracks in rock
Hot
Hot
8 km
gases escaping gases escaping
Cooler
Magma Chamber
10 km
Hotter
Crustal Rocks
Atmosphere Equivalents
0
10,000
20,000
30,000
40,000
12 km
Pressure Gauge
1,000°C
1 km
2 km
3 km
4 km
5 km

# Quiz

Question 4

**Why does magma accumulate in the magma chamber?**

- [ ] The surrounding rock cools and hardens the magma.
- [ ] The upward migration stalls when the density is equal to the surrounding rock.

# Elevator Going Up .... And Out

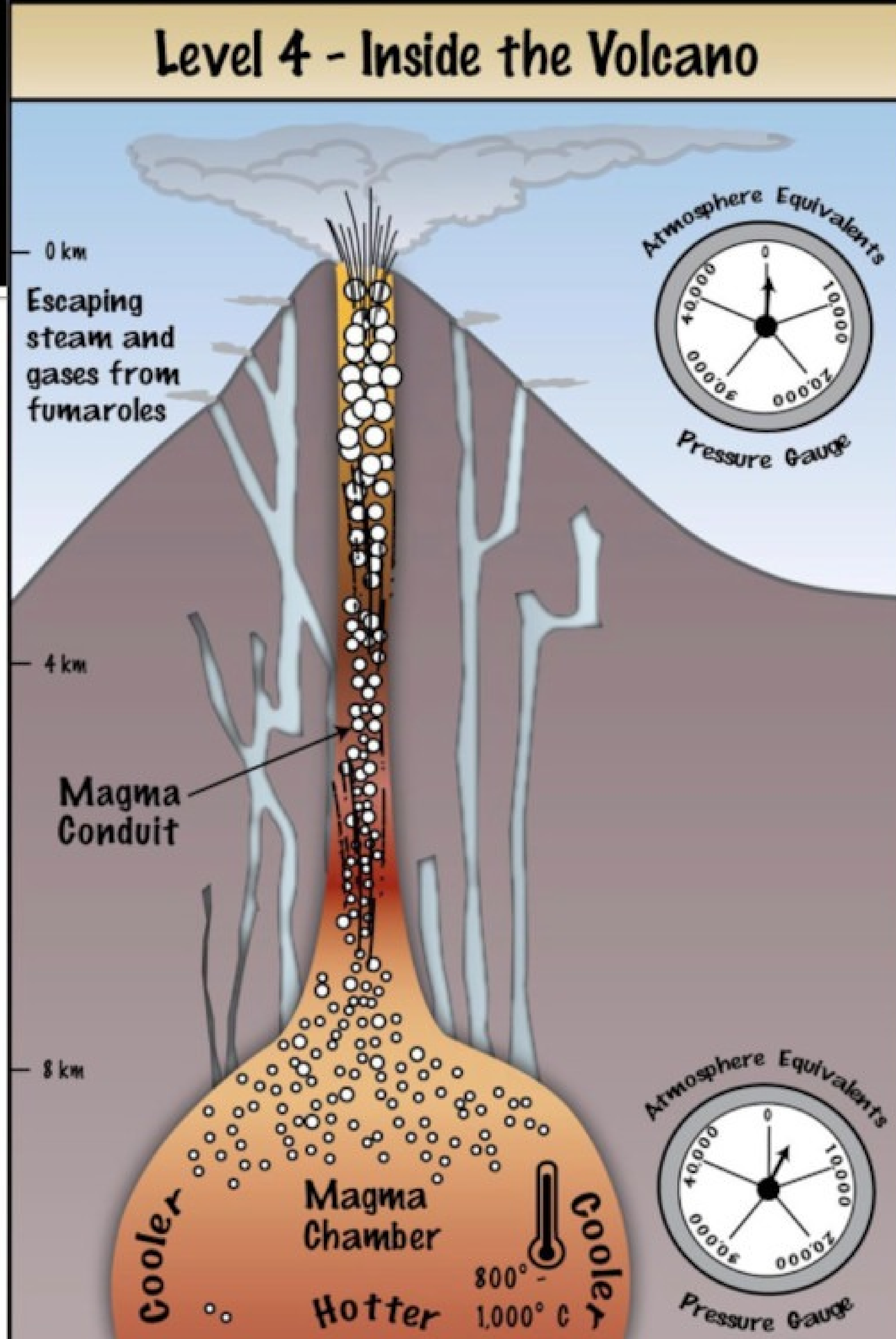
- Our elevator will follow magma as it erupts from the volcano. So hold on, here we go!

# Level 4 – Inside the Volcano

- When pressure in the magma chamber is sufficient, magma forces open a narrow pathway that extends up to the Earth's surface, called a ***conduit***. During non-eruptive times, the conduit is filled with solid rock and debris from previous eruptions, which traps debris, ***volcanic gas*** and magma like a cork in a bottle. This conduit acts as a superhighway for magma erupting from the volcano. Magma can reach speeds of 50 to 100 meters per second (160 to 300 feet per second) as it rushes upward.

# Level 4 – Inside the Volcano

- It takes only a few minutes for magma to rush from the magma chamber to the ***vent*** of the volcano during an explosive eruption, a distance of 8 to 10 kilometers (5 to 6 miles). Gas-rich magma escapes first, often blasting surrounding magma into billions of shards of ***volcanic ash***. ***Lava*** then squeezes or flows from the vent. The conduit sometimes overflows, and magma squeezes into cracks within the volcano forming ***dikes***.
- Hold on, because we are about to explode out of the volcano along with lava, ash, and gases. Here we go!


Level 4 - Inside the Volcano
0 km
4 km
8 km
Escaping steam and gases from fumaroles
Magma Conduit
Magma Chamber
Cooler
Cooler
Hotter
800° - 1,000° C
Atmosphere Equivalents
0
10,000
20,000
30,000
40,000
Pressure Gauge
Atmosphere Equivalents
0
10,000
20,000
30,000
40,000
Pressure Gauge

# Quiz

Question 5

**True or False? Magma can reach speeds of 50 to 100 meters per second (160 to 300 feet per second) as it rushes upward.**

- [ ] True
- [ ] False

**Lesson #4**
**Volcanic Eruptions**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

This is a laboratory exercise in which students will work in pairs to explore the build up of gases inside of a volcano, and how those gases cause the volcano to erupt. Students will use soda bottles, baking soda, raisins, and vinegar, to observe how bubbles of carbon dioxide gas adhere to the raisins, causing them to float to the top of the bottle.

**Duration:** 1 50 minute class periods

**Objectives:**

Students will be able to identify the important role of gases in providing energy for explosive volcanic eruptions
Students will observe how pressure affects gases
Students will learn how gases influence the texture and appearance of volcanic rocks

**NGSS Standards Addressed:**

MS.Earth’s Systems
**MS-ESS2-1.** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

At least 15 clear plastic bottles, with the labels removed.
Raisins
Vinegar
Baking Soda
Water
Funnels
Plastic spoons

**5E’s**

- **Engagement**

Students are engaged during the class opener by answering the question posted on the board in their science notebooks. The students will be asked to retrieve either their computers or iPads to research the answer for discussion.

The teacher will provide the writing prompt for all students to see upon entering class. It can be written on the whiteboard, or projected on a screen. The prompt is “What is the difference between effusive, or quiet, volcano eruptions and explosive volcano eruptions."

Students will have about 10 minutes to answer, and then participate in a discussion.

Since the students were allowed to do research for the answer, they are expected to participate in a discussion about the difference between the two types of eruptions.

Possible facilitating questions

What factors make an eruption a quiet eruption?
Does a quiet eruption have magma with low or high viscosity?
Did anybody find what the names of the type of lava produced during a quiet eruption?
What are the characteristics of the magma in an explosive eruption?
Is it high or low viscosity?
Why does viscosity matter when it comes to eruptions?

- **Exploration:**

Students will conduct a laboratory investigation with a partner in which observe how gas bubbles get trapped in the magma and this brings it up and out of the volcano. Students will use clear plastic bottles, baking soda, water, raisins and vinegar.

The vinegar reacts with the baking soda solution to produce carbon dioxide gas. Bubbles of gas adhere to the raisins, causing the raisins to rise to the surface, where the bubbles pop. The raisins sink again, and the cycle repeats.

- **Explanation:**

Students will answer questions provided on the laboratory investigation handout. Students are expected to recognize what represents the magma in the lab, and what the solution is doing.

Students will compare and contrast the lab to an actual volcanic eruption.

- **Elaboration:**

Students will explain other possible ways to demonstrate a volcanic eruption that they could do at home, and how those are similar to a volcanic eruption. Possible answers include (shaking up a bottle of soda, putting mentor in soda, mixing vinegar and baking soda)

- **Evaluation:**

Students will demonstrate that they made connections between the investigation and a volcanic eruption by correctly answering the questions provided on the laboratory investigation handout.

**Formative:** The teacher will check for understanding throughout the lab, as well as asses students on their willingness to participate during the class discussion.

**Summative:** Students will turn in a completed laboratory handout.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, or a more advanced student to help with reading the handout and lab instructions.
Writing: Students with IEPs for writing may type their answers on the computer.
Social: Students with social issues may work on the lab investigation alone, or with an aid.
Time: Students who need more time to complete the activity will be given the option to work in the classroom during lunch, or before or after school.

Extensions for advanced students:
The advanced class will be asked to discuss the other demonstrations they came up with, and elaborate on how that relates to a specific kind of volcanic eruption.

**Safety Considerations:**

Students will wear safety goggles at all times during the investigation.
Students will be familiar with the eyewash station, as well as where the sinks and other safety equipment are located.
Students will know proper cleanup and laboratory procedures.

## Volcanic Eruption Lab Investigation

At your lab station you should have a 1-2 liter, clear, empty plastic bottle. The raisins, baking soda, and vinegar are available on the back counter.

1. Retrieve your safety goggles from the back counter.
2. With your beaker, retrieve 65ml of water and poor that into your bottle using the funnel.
3. Now get spoonful of baking soda and add that to the water in the bottle.
4. Add about 6 raisins to the solution
5. While one person swirls the water and raisins, add 65mL of vinegar and swirl vigorously for about 10 seconds.
6. Once the liquid stops moving, observe the raisins.

Answer the questions below.

1. What happens after you add the vinegar?

2. What do the raisins and bubbles represent?

3. How is this model similar to the way magma behaves in a volcano?

4. How is it different?

5. Can you think of any other experiments you can do with common household items that might represent a volcanic eruption? Explain.

**Lesson #5**
**National Geographic Amazing Planet: Born in Fire video**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

Students will be presented with a video that will give them a detailed closer look at the processes that form volcanoes, as well as the power behind them. The video is the first episode in a National Geographic series called Amazing Planet. The episode is “Born in Fire” and is found on Netflix. Students will follow along with the video and answer questions on a handout.

**Duration:** 1 50 minute class period

**Objectives:**

Students will be able to identify the important role that plate tectonics plays on all of Earth’s processes
Students will observe the differences in volcanic eruptions
Students will identify how hot spot volcanoes form, and what makes Yellowstone a supervolcano.

**NGSS Standards Addressed:**

MS.History of Earth
**MS-ESS2-3.** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS.Earth’s Systems
**MS-ESS2-1.** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

Pencil/Pen
Movie question handout

**5E’s**

- **Engagement**

  Students are immediately engaged, as a video will be shown that gives them an up close and personal experience with plate tectonics, magma, and volcanoes. A handout with questions to go along with the film will be distributed, and the movie will begin as quickly as possible.

- **Exploration:**

  Students follow along with the video by answering questions while they watch.

- **Explanation:**

  Students will then write a short reaction to what they like most, or surprised them from the video.

  Students will relate what they have learned up to this point about volcanic activity to the video.

- **Elaboration:**

  Following the video, the teacher will discuss the questions on the handout with the class. Students will discuss what they liked most about the video, and what they learned that they may not have known before.

- **Evaluation:**

  Students will demonstrate that they gained knowledge from the video by correctly answering the questions provided on the video handout.

  **Formative:** The teacher will check for understanding after the video by leading a class discussion.

  **Summative:** Students will turn in a completed video handout.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, or with a helpful student during the video to help with questions.
Writing: Students with IEPs for writing may type their answers on the computer.

**Safety Considerations:**

Students will not be up and moving around during the video.

## Born in Fire Video Questions

1. How many volcanoes are on Hawaii's big island?

2. All land on Earth is born of _________________.

3. Why are humans drawn to life near volcanoes in Hawaii?

4. What causes earthquakes, volcanoes, and mountains to rise?

5. Plates float because the material below is ___________

6. In what country can we see a mid-ocean ridge right up on the land?

7. What do Tokyo and San Francisco have in common?

9. How long did it rain when Earth was forming?

10. If the Earth were the size of a basketball, how thick would the crust be?

11. Everything on our planet, including life, is shaped by ______________ _______________ .

12. What can you find at the top of Mount Everest?

13. How much does Everest rise each year?

14. What kind of volcanoes exist on the Hawaiian islands?

15. What kind of volcano explosively erupts?

16. A pyroclastic flow is the return of flaming _____________ to Earth.

17. What caused the Tsunami in 2004?

18. Where do more geysers erupt than anywhere else in the world?

19. True or False. Yellowstone is almost entirely a volcanic caldera.

20. What makes yellowstone a supervolcano?

21. Discuss one thing from the video that stood out to you, or you found interesting.

**Lesson #6**
**Volcanic Landforms**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

A powerpoint presentation will be presented and discussed about the landforms that are created by lava and ash including the different types of volcanoes, lava plateaus, calderas, soils, volcanic necks (Devil's tower), dome mountains, as well as the Geothermal activity that comes with volcanic activity. Students will also read an article titled "Hot Spot at Yellowstone" by Abby Dress, which addresses calderas and geysers. The teacher will then demonstrate the formation of a caldera by using flour, a balloon, and an air pump.

**Duration:** 1-2 50 minute class period

**Objectives:**
Students will be able to identify landforms that lava and ash create,
Students will be able to examine other distinct feature of volcanic areas.

**NGSS Standards Addressed:**
MS.History of Earth
**MS-ESS2-3.** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS.Earth's Systems
**MS-ESS2-1.** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**
"Hot Spot at Yellowstone" reading
PowerPoint presentation
Small plastic tub with a small hole in the side
Balloon
Flour
Manual air pump

**5E's**

- **Engagement**

Students will be presented with an opener upon entering class. The teacher will provide the writing prompt for all students to see upon entering class. It can be written on the whiteboard, or projected on a screen. The prompt is “What is a Caldera? What is a crater?”

Students will have 5 minutes to answer the question.

The teacher will then facilitate a quick discussion on what students may have answered.

Possible questions:
What does a caldera look like?
What happens to change a crater into a caldera?
How does a caldera form?

- **Exploration:**

Students will follow along and discuss slides during a Powerpoint presentation. Students will also read an article that discusses Yellowstone’s volcanic activity. The powerpoint will explore shield volcanoes, cinder cone volcanoes, composite volcanoes, lava plateaus, calderas, soils from lava and ash, volcanic necks, dikes and sills, batholiths, dome mountains, and geothermal activity.

- **Explanation:**

Students will summarize what they read in their science notebooks, and partake in a “Think. Pair. Share.” with their table partners to discuss what they read, then participate in a class discussion on the reading.

- **Elaboration:**

The teacher will provide a demonstration for the students that shows how calderas are formed. The teacher will inflate a balloon covered in flour, then deflate the balloon to show that the flour craters where the balloon deflated.

- **Evaluation:**

Students will demonstrate an understanding during the “Think. Pair. Share” activity with a partner, as well as participate in a class discussion.

**Formative:** The teacher will check for understanding during the powerpoint presentation as well as after the reading by facilitating discussion.

**Summative:** Students will summarize the reading in their science notebook.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, and given more time to read the article.
Writing: Students with IEPs for writing may type their summaries on the computer.

**Safety Considerations:**

Students will wear safety glasses during the demonstration.

# Hot spot at Yellowstone

by Abby Dress

The poster inserted in this month's issue, "To Eat or Be Eaten," focuses on the dynamic predator-prey relationships going on above ground at Yellowstone National Park (see Windows Into Wonderland on page 39). However, the park is even more famous for the dynamic processes that occur below ground. That is why a visit to Yellowstone National Park is not only a unique experience, but also a really "cool" opportunity to observe hydrothermal features. From the north gate that leads visitors to the main interpretive center and the hot springs in Mammoth on down to where Old Faithful Geyser has been thrilling sightseers and scientists alike with its regular eruptions for years, visitors cannot help but notice the entire region seems like a steamy hot spot. In the truest sense, it is.

*Abby Dress is an associate professor of media arts at Long Island University's C.W. Post Campus in Brookville, New York, and works with Yellowstone National Park and the Yellowstone Park Foundation.*

Within this huge national park (over two million acres spread across Wyoming, Montana, and Idaho) are steaming geysers, hot springs, bubbling mudpots, and fumaroles, or steam vents. Drives on the main roads of Yellowstone take tourists through the major hot attractions, which also include Norris Geyser Basin, Upper and Lower Geyser Basin, West Thumb, and Mud Volcano. This unfenced territory, however, steams and smokes off the beaten track as well. That is because Yellowstone "preserves the largest hydrothermal area on the planet," as the official trail guide touts. Its hidden volcanic, tectonic, and hydrothermal forces constantly are at work underground reshaping the landscape.

According to geothermal expert Henry Heasler, park geologist at the Yellowstone Center for Resources, Yellowstone has the largest concentration of active geysers in the world and over 10,000 hydrothermal features. None of these would exist, however, without the tremendous hot rock, or geothermal source, beneath the surface.

The world's first and largest national park is a hot spot, which contains the Yellowstone Caldera. This is one of a few dozen such hot spots on Earth where heat from the Earth's interior is brought from the mantle closer to the surface. (Visit us online at *www.nsta.org/middleschool* to learn how Mount St. Helens is linked geothermally to Yellowstone.) Some scientists theorize that the magma plume hovers within 13 kilometers. Pressure from the molten rock is so close to the surface that it actually has created two bulges, or domed areas, at the park. One is located north of Yellowstone Lake and the other east of Old Faithful near Mallard Lake.

Believed by scientists to be about 640,000 years old, the Yellowstone caldera is quite young geologically and is about 48 by 72 km in size. It originally was formed through subsequent volcanic eruptions that began in western Idaho and northern Nevada some 16 million years ago. Volcanic activity continues to this day in Yellowstone. Geologist Heasler indicates that hundreds to thousands of earthquakes occur there each year. It is a dynamic environment, where even the ground constantly moves up and down, accruing changes of about 2.5 millimeters a year due to the massive volcanic energy.

Hot springs are the most common hydrothermal resources found in the park. Their activity constantly changes, particularly since these features are influenced by seasons and weather. Readily available sources of water from snow and rain trickle through the porous rock and are heated by the magma close to the surface. This superheated water circulates up and cools as it reaches the surface. Then it is replaced by hotter water from below and the cycle continues. This ongoing process is called convection. Hot springs typically do not reach the temperatures that lead to eruptions associated with geysers.

Travertine is found in four thermal areas of the park, but the expansive travertine terraces found at Mammoth Hot

## Windows into wonderland

A website designed for middle school students at *www.windowsintowonderland.org* is sponsored by the Yellowstone Park Foundation through Eyes on Yellowstone, which is made possible by Canon U.S.A., Inc. This free site features 50-minute electronic field trips that let students travel through the backcountry of Yellowstone National Park, the world's first and oldest national park, which remains one of the last wildernesses in the United States. Yellowstone, which is primarily situated in Wyoming, but also crosses into Montana and Idaho, has a greater number of a greater variety of free-roaming wild animals in their natural habitat than anywhere else in the 48 contiguous states.

Students can learn about the park's unique predator-prey relationships (featured on the poster in this issue), geothermal activities, geological richness, and extraordinary wildlife. The trips feature scripted dialogue, animations, streaming video, and audio content. Lesson plan ideas, a vocabulary list and appropriate links are included online to extend the experience.

PHOTOS COURTESY OF NPS PHOTOS

Springs draw the most tourists. The whitish gray terraced landscape looks like some scene expected on a visit to another planet. Limestone, or calcium carbonate, was deposited here millions of years ago when seawaters covered the area. When hot water from the springs is added to the rock, it dissolves the calcium carbonate. This carbonate is carried to the surface by the thermal waters and then left behind as travertine when they recede.

Microscopic bacteria and algae also thrive in many of the hot springs. These thermophiles thrive in water that is much too hot for most other life forms. These primitive organisms grow and are influenced by the temperature and chemistry of the hydrothermal pools. Some pool wall edges are ringed with sequential color bands from these organisms. From the hotter water areas on out to the cooler rims these life forms are distinguished by color—yellow, green, red/orange, and brown, respectively. One specialized microbe, *Sulfolobus acidocaldarius*, feeds on sulfur compounds in the water. Oxidizing these, the organism turns the compound into sulfuric acid. Some pools become so acidic with a pH of 1.3 that they inhibit the growth of the more colorful bacteria and algae that are prevalent in most of the hot springs.

Visitors, however, mostly come to see the geysers at Yellowstone. Geysers are also hot springs, but their plumbing is constricted. They not only depend on a water source for their eruptions, but also create their own pressurized system. When underground, the hot water forms a pool or fills a fissure. Heated by the molten rock, the hot waters rise and coat the walls with silica, creating a tighter seal. Both the rock and water pressure ultimately prevent the water from cooling or vaporizing. Even though the water temperature increases and exceeds boiling, it remains in a liquid state. The result is superheated water that is less dense than the heavier water that sinks around it. As this superheated water rises, steam forms. The steam expands as it nears the surface.

Steam bubbles literally and forcefully push the water up and out of geysers. Cone geysers have more narrow jets of water, while fountain geysers spray water in different directions. During both these processes, steam and boiling water are expelled faster than cooler water can enter. Though pressure and heat begin to decrease during the expulsion process, the eruption stops when the water reservoir empties of hot water. There is an interval of time between eruptions that depends on the size of the water source and how close it is to the hot rocks.

Mudpots are hot springs turned into gurgling muddy pools that often have pungent odors. They tend to be acidic, unlike most of the park's hot springs and geysers. With their limited water supplies, steam is formed underground. This steam tends to break down the rocks chemically and clay forms. Over time, steam, hydrogen sulfide, carbon dioxide and other gases burst through the clay as escaping bubbles. Minerals, such as sinter (a form of silica), sulphur, and iron, are responsible for the mudpot colors, gray, yellow, red/orange, and black, respectively.

The fumaroles or steam vents are the hottest hydrothermal features. Their limited water supplies are converted almost entirely into steam before escaping to the surface. From close up, these vents hiss loudly and spit out steam and gases. Large steaming plumes can be seen that make the hills look like they are smoking. On the one hand, these areas look like some cataclysmic after-effect; on the other hand, the huffing and puffing activity makes the mountainsides look alive.

It should be noted that Lake Yellowstone, North America's largest high-altitude lake at about 2,500 meters above sea level, also has thermal activity. At its north end near Mary's Bay, scientists have discovered hydrothermal pits at the lake's bottom with temperatures above the boiling point. In other parts, where hot areas also have been recorded, spires made of diatoms about 30 meters tall have been documented. Currently, no one seems to know how these towers were formed.

This is the magic of Yellowstone. It is a paradox of landscapes. From the forests of lodgepole pines that grow tall despite shallow roots and survive in the rocky soil of Yellowstone's Grand Canyon to the great plains of Hayden Valley, where one of the domes of molten rock is not so far below, Yellowstone National Park is a scientific treasure trove. It is a constant work-in-progress and challenge to monitor, but one that provides exciting new discoveries and knowledge all the time.

### *Resources*

**Internet**

*www.windowsintowonderland.org*—Official Windows into Wonderland website

*http://volcanoes.usgs.gov/yvo*—Yellowstone Volcano Observatory

*http://volcanoes.usgs.gov/cascades*—Cascades Volcano Observatory

**Publications**

Smith, R., and L. J. Siegel. 2000. *Windows into the Earth: The geologic story of Yellowstone and Grand Teton National Parks*. New York: Oxford University Press.

U.S. Department of the Interior U.S. Geological Survey. 1995. *Yellowstone: Restless volcanic giant*. Volcano Hazards Fact Sheet. Open-file report 95-59, U.S. Geological Survey.

Yellowstone National Park. 2003. *Yellowstone resources and issues 2003*. Mammoth Hot Springs, WY: Division of Interpretation, National Park Service.

# VOLCANIC LANDFORMS

FOR MUCH OF EARTH'S HISTORY, VOLCANIC ACTIVITY ON AND BENEATH THE SURFACE HAS BUILT UP EARTH'S LAND AREAS. VOLCANIC ACTIVITY ALSO FORMED THE ROCK OF THE OCEAN FLOOR. SOME VOLCANIC LANDFORMS ARISE WHEN LAVA FLOWS BUILD UP MOUNTAINS AND PLATEAUS ON EARTH'S SURFACE. OTHER VOLCANIC LANDFORMS ARE THE RESULT OF BUILDUP OF MAGMA BENEATH THE SURFACE.

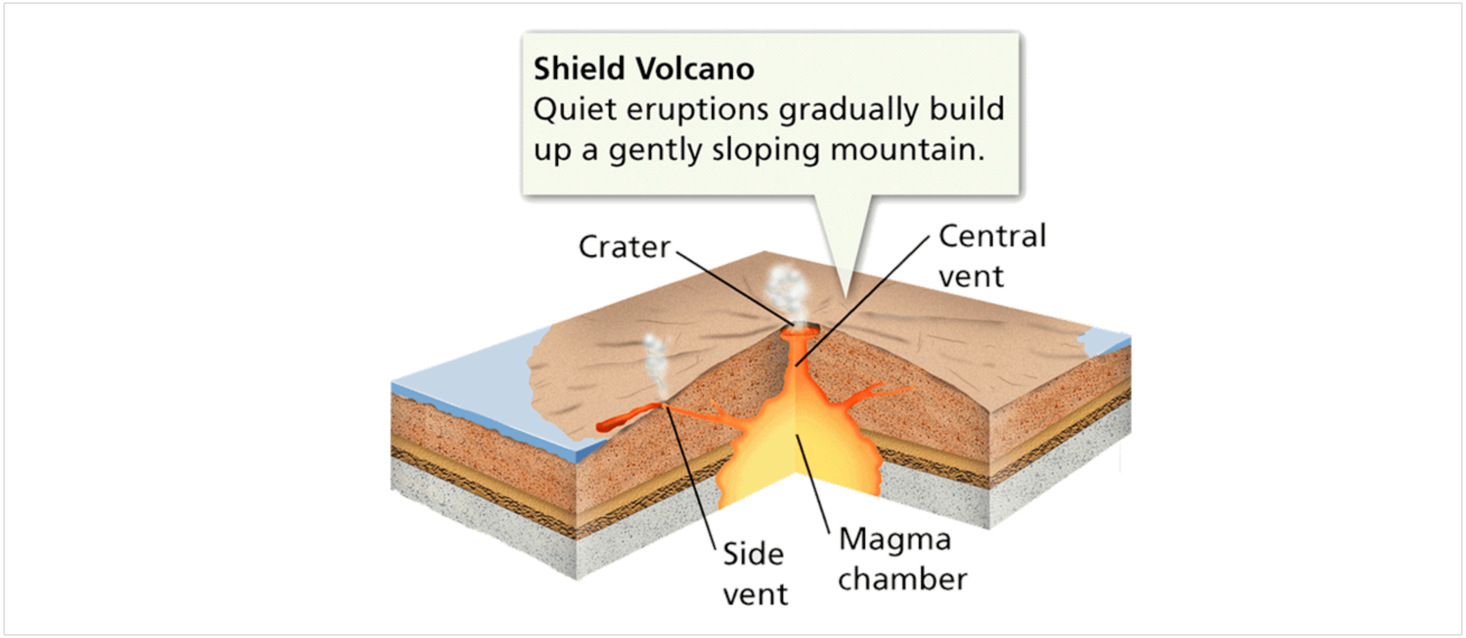
# LANDFORMS FROM LAVA AND ASH

**If runny, thin lava flowed out from a small area, would it form steep sides or gentle sides?**

**Which type of volcano would this be?**

# LANDFORMS FROM LAVA AND ASH

- Shield Volcanoes: thin layers of lava pur out of a vent and harden on top of previous layers.
    - Gradually build wide, gently sloping mountains
    - Hawaiian Islands



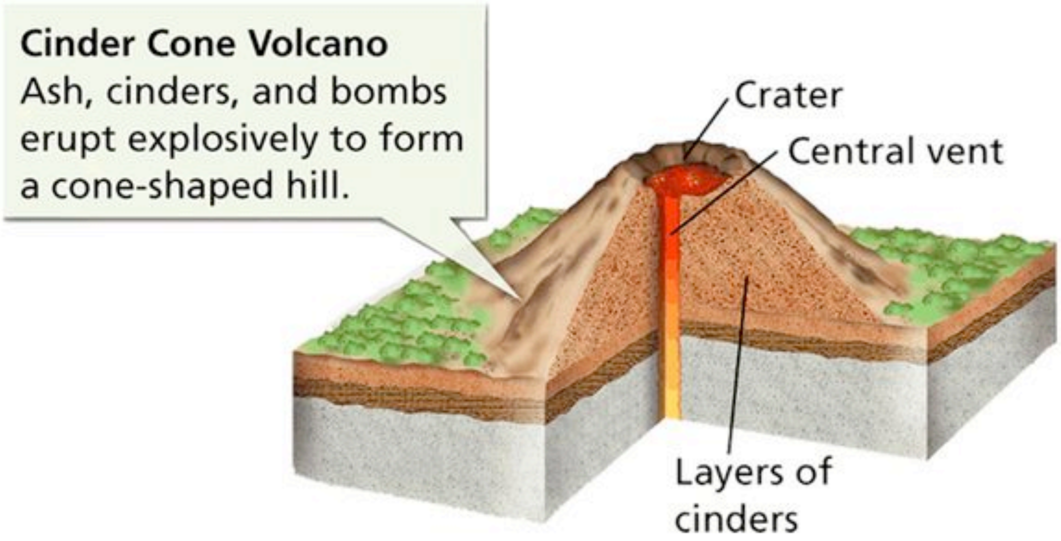
# LANDFORMS FROM LAVA AND ASH

Which landform could form when thick, sticky lava is blown apart and falls as ash and cinders?

Why would it have steep sides?

# LANDFORMS FROM LAVA AND ASH

- Cinder Cone Volcanoes:
  - Lava has high viscosity; it may produce ash, cinders, and bombs.
  - Build up around the vent in a steep, cone-shaped hill, or small mountain called a cinder cone.

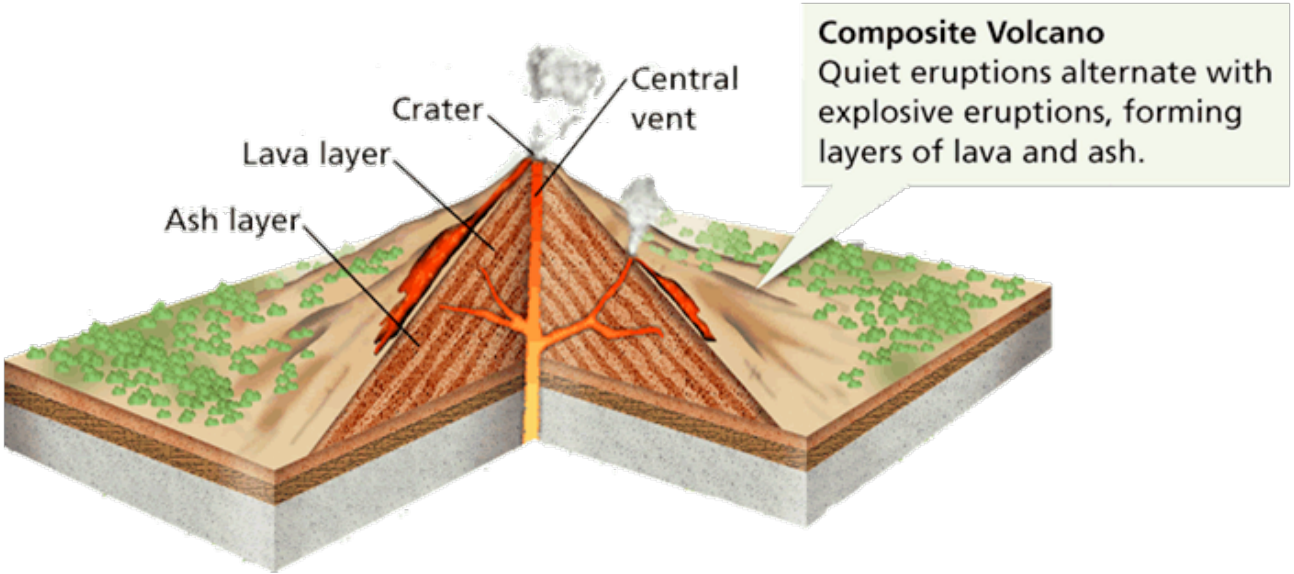


# LANDFORMS FROM LAVA AND ASH

**What landform do you think would form from flows of thick lava and some ash?**

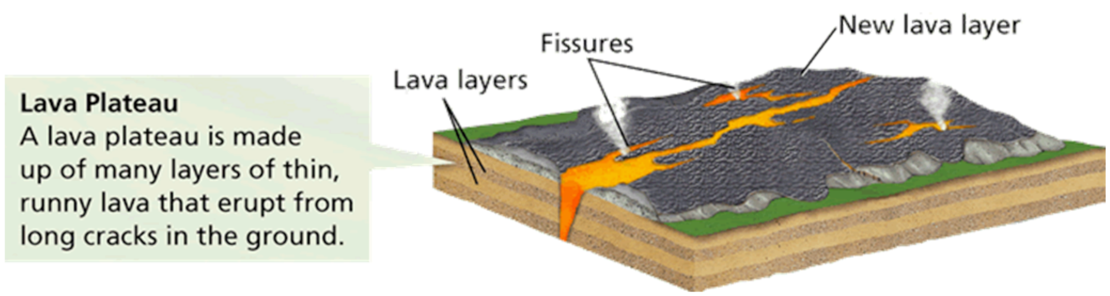
# LANDFORMS FROM LAVA AND ASH

- Composite Volcanoes
  - Alternate lava flows, and explosive eruptions of ash, cinder, and bombs.
  - Tall cone-shaped mountains in which layers of lava alternate with layers of ash.
  - Mount Fuji, Mount St. Helens



# LANDFORMS FROM ASH AND LAVA

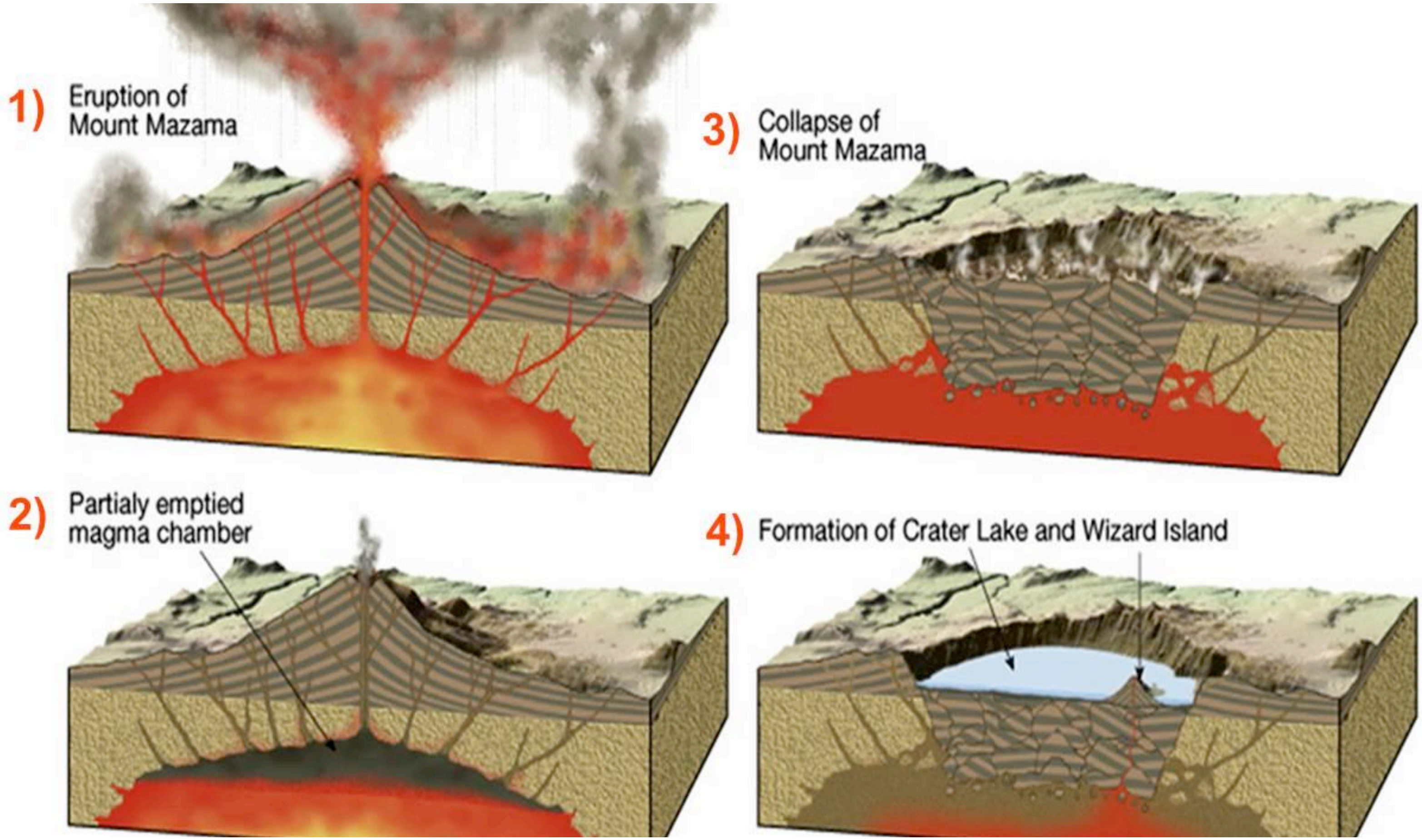
- Lava Plateaus: High, level areas
  - Lava flows out of several long cracks
  - Thin, runny lava travels far before cooling
  - Again and again, floods of lava flow on top
  - Millions of years
  - Columbia Plateau



# LANDFORMS FROM LAVA AND ASH

- Calderas: Huge hole left by the collapse of a volcanic mountain.
  - Hole is filled with pieces of the volcano, as well as some lava and ash.
  - Enormous eruptions may empty the main vent and the magma chamber beneath a volcano.
  - Mountain becomes hollow shell with no support and the top collapses inward

# CALDERA FORMATION



# SOILS FROM LAVA AND ASH

**Why would anybody live near an active volcano?**

- **Fertile volcanic soil**
- **Lava, ash, and cinders initially barren**
- **Break down over time to form soil: releases potassium, phosphorus, and other substances plants need.**
- **Some among the richest soils in the world.**

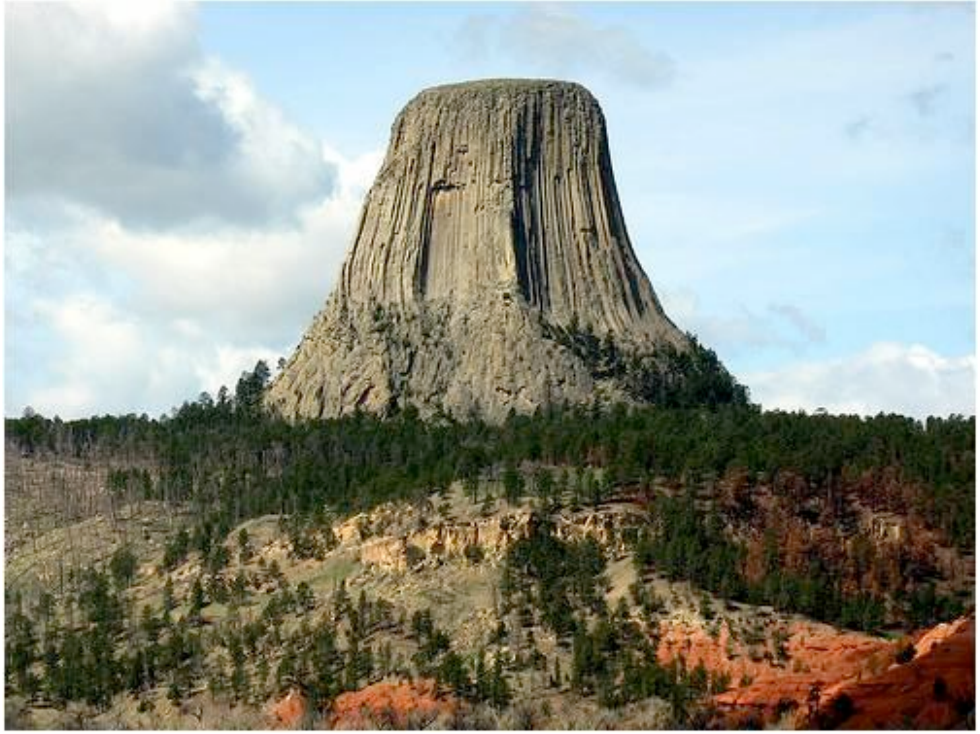
**Can you think of any examples?**

# LANDFORMS FROM MAGMA

**Sometimes magma forces its way through cracks in the upper crust, but fails to reach the surface. There the magma cools and hardens into rock. Over time, the forces that wear way Earth's surface — such as flowing water, ice, or wind — may strip away the layers above the hardened magma and finally expose it.**

# LANDFORMS FROM MAGMA

- Volcanic Necks: looks like a giant tooth stuck in the ground.
  - Magma hardens in a volcano's pipe
  - Softer surrounding rock wears away

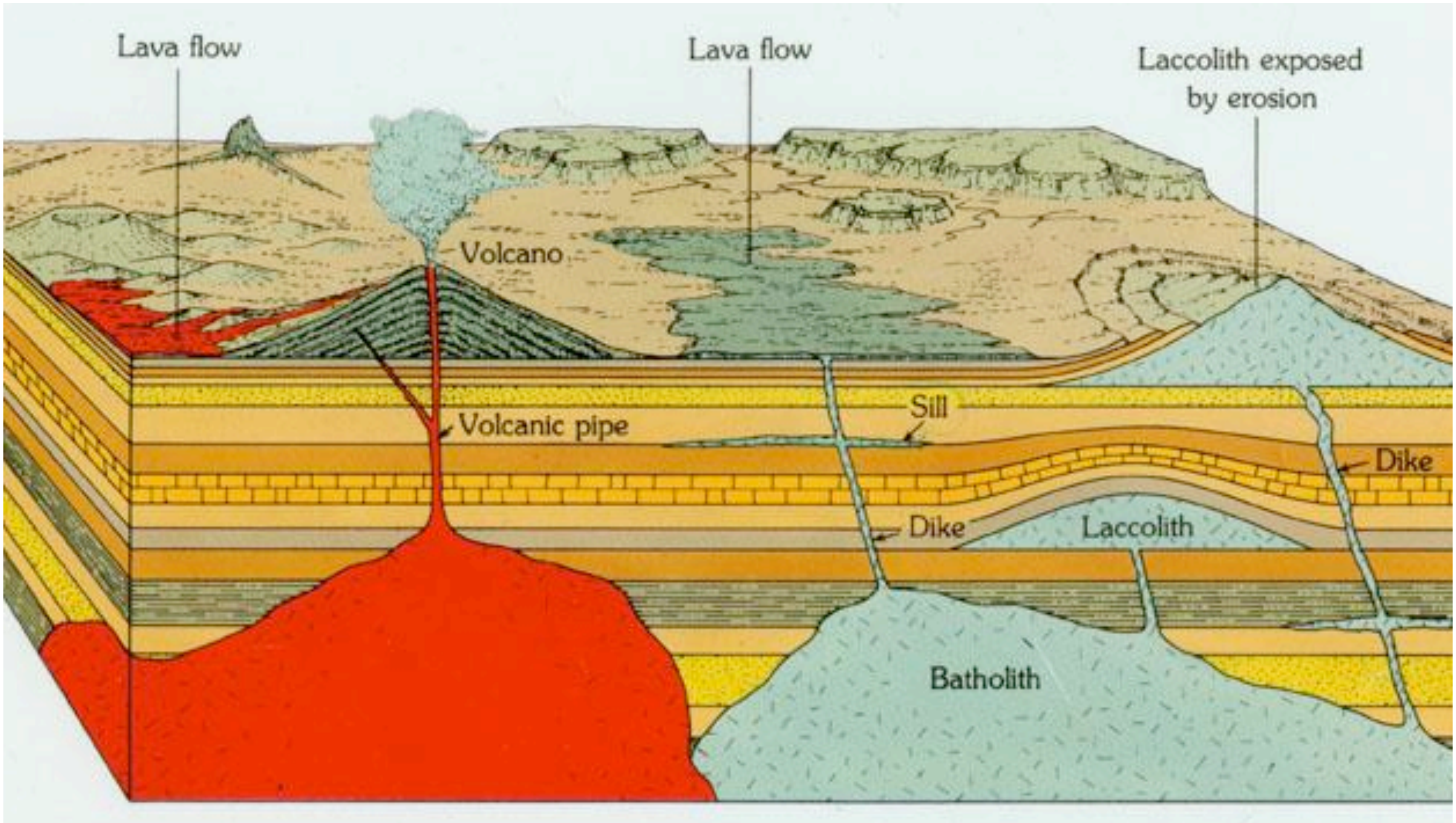


# LANDFORMS FROM MAGMA

- Dikes and Sills
  - Magma that forces itself across rock layers hardens into a dike.
  - When magma squeezes between horizontal layers of rock, it forms a sill.

# LANDFORMS FROM MAGMA

- Batholiths: Large rock masses form the core of many mountain ranges.
    - a mass of rock formed when a large body of magma cools inside the crust



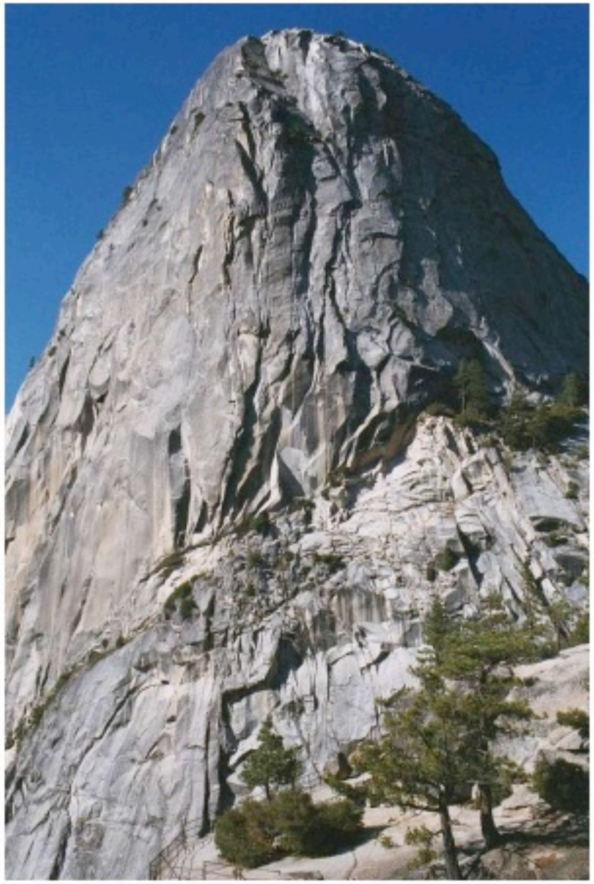
Lava flow
Lava flow
Laccolith exposed by erosion
Volcano
Volcanic pipe
Sill
Dike
Dike
Laccolith
Batholith

# LANDFORMS FROM MAGMA

- Dome Mountains: other, smaller bodies of hardened magma
    - Uplift pushes a batholith or smaller body of hardened magma toward the surface.
    - Hardened magma forces the layers of rock to bend upward into a dome shape
    - Rock above dome wears away, leaving it exposed.
    - Black hills in South Dakota

# Dome mountain

- hardened magma
- forms when uplift pushes batholith toward surface



# GEOTHERMAL ACTIVITY

**How could water beneath Earth's surface be heated?**

**Where might this warm water reach Earth's surface?**

**How are these two things different?**

# GEOTHERMAL ACTIVITY

Has anybody visited any Hot Springs or Geysers?

- A variety of geothermal features occur in volcanic areas. Magma heats underground water
  - Yellowstone
  - Hot springs: groundwater is heated by nearby magma or hot rock. Water rises to the surface and collects in a natural pool.
  - Geysers: Rising hot water and steam become trapped underground in a narrow crack. Pressure builds until the mixture suddenly sprays out.

# GEOTHERMAL ACTIVITY

## Lesson #7
## Volcanic Rocks

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

The students will read an article titled "Rock of Ages" as their opener for the class. Students will make inferences as to why the rocks discussed in the article were floating, then they will observe some volcanic rocks set up around the room. Student will use a handout to guide them to each station of volcanic rock. They will make observations, describe each rock, and hypothesize how they think each rock formed. Following this, students will participate in a lab activity where they will measure the mass and volume of unpopped popcorn kernels and compare that to the mass and volume of popped popcorn. They will make connections between the popcorn and the volcanic rocks.

**Duration:** 2 50 minute class periods

**Objectives:**

Students will observe that volcanic ash consists of rock fragments and not a burned substance, and recognize different forms of volcanic rocks

Students will Recognize that expanding gas bubbles can inflate and fragment magma explosively

Students will understand that the volume of erupted bubble-filled tephra is greater than the original volume of magma because of the expansion of gas bubbles

**NGSS Standards Addressed:**

MS.History of Earth

**MS-ESS2-3.** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS.Earth's Systems

**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

"Rock of Ages" article
Observation and lab handouts
Unpopped popcorn kernels
Popped popcorn
Volcanic rocks: Obsidian, pumice, scoria, ash

**5E's**

- **Engagement**

Students will be presented with an opener upon entering class. The teacher will provide an article for students to read titled “Rock of Ages” followed by a question to answer in their science notebooks. It can be written on the whiteboard, or projected on a screen. The prompt is “Why and how were the rocks discussed in the article floating?”

Students will have 10-15 minutes to read and answer the question.

The teacher will then facilitate a quick discussion on how students may have answered.

Possible questions:

How are the rocks in the article different from rocks you are familiar with?
How did the rocks become covered in holes?

- **Exploration:**

Students will observe different forms of volcanic rocks and ash. They will write down their observations, sketch what they see, and make inferences as to how and why those rocks look and feel the way they do.

- **Explanation:**

Students will perform a lab investigation in which they compare the mass and volume of unpopped popcorn to popped popcorn. Due to time and resources, the teacher should provide the students with both the kernels, and the popped popcorn. Students will weigh both on a scale or balance, and observe that the mass of the popped popcorn decreases, but the volume increases. Students will make inferences as to why this is, then research how a popcorn kernel pops.

- **Elaboration:**

Students will relate what they’ve learned about the popcorn to what happens inside volcanoes, and the rocks that form during and after and eruption. The teacher will facilitate a discussion about what the students learned and the connections that were made.

Possible questions:

So why was the rock from the article floating?
What factors make up different kinds of volcanic rock and ash?
How is the popcorn related to a volcano?
What kind of rock is the popcorn most like? Why?

- **Evaluation:**

Students will demonstrate an understanding by making observations of volcanic rocks, and connecting those observations to the laboratory investigation. Students will participate in discussion about what they have taken away from the lesson.

**Formative:** The teacher will check for understanding throughout the lab investigation and during the discussion.

**Summative:** Students will be assessed by handing in their observation worksheet as well as their laboratory investigation worksheet.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, and given more time t to read the article.
Writing: Students with IEPs for writing may type their summaries on the computer and/or work with an aid.

Extensions for advanced students:
The advanced class will be asked to research and define one of the following different kinds of tephra, or volcanic rocks including volcanic block, volcanic bomb, lapilli, pyroclastic rock deposits, volcanic ash pumice, or scoria. There will also be two extensions of the lab worksheet.

**Safety Considerations:**

Students will wear safety glasses during the lab investigation.
Procedures will be in place to visit the different rock stations so students are no all gathered by the same one.

# Rock of Ages

Tiny fossils survive a volcanic eruption and reveal the origins of an island chain.

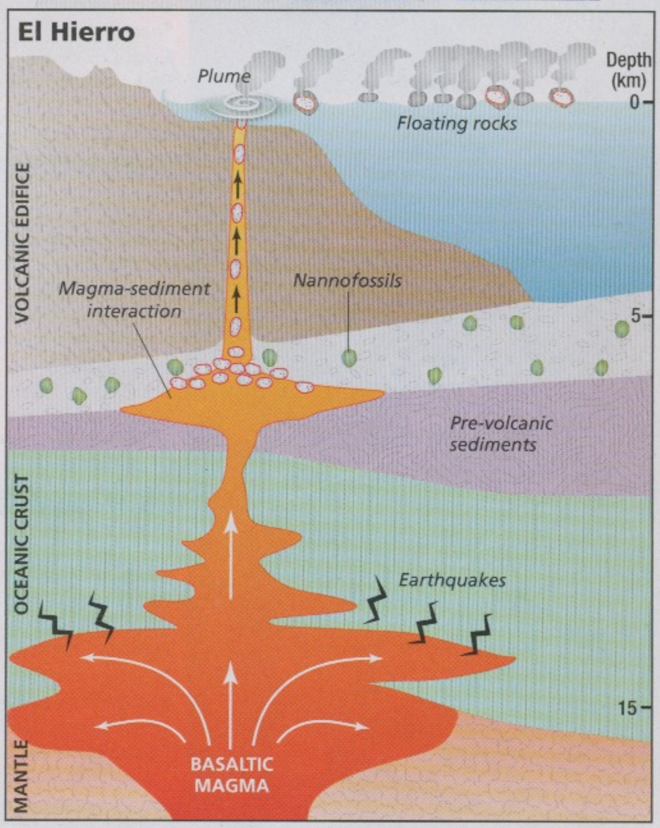

**The Canary Islands**, an autonomous community of Spain west of Morocco, spreads more than 300 miles across the Atlantic in an archipelago akin to Hawaii. Like the Aloha State, the Canaries were born from volcanoes — but researchers had debated exactly how.

When magma erupted from a crack in the ocean floor off El Hierro, the youngest, westernmost island, local volcanologist Vicente Soler headed out to sea, looking for answers. He found strange black rocks, some as large as soccer balls, floating in the bubbling, sulfurous seawater. He scooped them up with a fishing net.

It's rare, but not unprecedented, for frothy magma to harden into rock so light it floats. But trapped inside the floating rocks was something even more unusual: quartz minerals and banding patterns found in sedimentary rock, which magma typically melts.

The banded sediments contained tiny fossils of single-celled creatures, says Uppsala University volcanologist Valentin Troll, part of the team that published its findings in January in *Scientific Reports*. Those fossils helped solve a question that's dogged geologists for decades: How did the Canary Islands arise from the ocean depths?

The rocks' sedimentary interior contained fossils of single-celled algae called coccolithophores (circled in red, right). Researchers dated the fossils based on different patterns of tiny plates that each species had evolved. Based on the youngest coccolithophore present, it was determined that volcanic activity formed El Hierro in the last 2.5 million years. By contrast, the easternmost island has sediment that's 20 million years old. Since the island "birth order" moves from east to west, the Canaries must have formed as the continental plate drifted eastward over a stationary, periodically erupting plume of hot magma deep in Earth's mantle. —DAN FERBER




**3** The result: floating rocks that resemble a coconut — black and igneous on the outside, white and sedimentary on the inside, with enough trapped air bubbles to make them lighter than Styrofoam.

**2** The magma moved up to a layer of sedimentary rock more than a mile thick and 4 miles below sea level. There, the magma broke off chunks of the rock, melting most of the material. It continued rising and hit seawater quickly enough, however, to preserve about 10 percent of the sedimentary rock.

**1** In the months before an October 2011 eruption, magma from the upper mantle accumulated in a layer of oceanic crust 6 to 10 miles below sea level.


Coccolithophore

FROM TOP: CARRACEDO ET AL. 2012, GEOLOGY TODAY 28, 53-58 (3); SCIENTIFIC REPORTS/NATURE PUBLISHING GROUP (ILLUSTRATION); NEONJA AND RICHARD BARTZ VIA WIKIMEDIA COMMONS (2)

# Volcanic Rock Observation

Different volcanic rocks are displayed around the classroom. Visit each station and make observations. Feel free to touch the rocks, pick them up, and really look at them. Use your senses? How does it feel? What is the mass? Whats the color? The texture?

**Station #1. Obsidian**

Observations:

How do you think this rock was formed?

**Station #2 Pumice.**

Observations:

How do you think this rock was formed?

**Station #3. Scoria.**

Observations:

How do you think this rock was formed?

**Station #4. Welded Tuff.**

Observations:

How do you think this rock was formed?

**Station #5. Rhyolite.**

Observations:

How do you think this rock was formed?

**Station #6. Andesite.**

Observations:

How do you think this rock was formed?

# Volcanic Rock Lab Investigation

Each group is presented with two cups. One cup has about 20 unpeopled popcorn kernels, and the other cup has about 20 popped popcorns.

**Instructions.**

1. Visually determine the differences in volume of the popcorn in the two cups? (volume is how much space it is taking up). Record your results below.
2. Take the cup of unpopped kernels back to the scale on the counter. Use the empty cup on the scale to zero it out, then weigh your cup. Record your results in the space below.
3. Make a prediction as to how much the popped popcorn will weigh. Record below.
4. Now use the scale to weigh your cup of popped popcorn. Record your results.
5. Calculate the change in Mass. (The formula is given)
6. Two microscopes are set up on the back counter. If you'd like to look at your popcorn close up, you can. Pictures of popcorn under a microscope are also provided.

**Answer.**

1. What are the differences in volume between the two containers of popcorn?

2. Initial Measured Mass of Popcorn ______________

3. *Your Prediction*
Write down your hypothesis about potential changes in mass of the popcorn. Will it increase, decrease or remain the same? Then predict the mass of the popped kernels.

Predicted mass of popped kernels: ____________________________

4. Measured mass of popped kernels: _________________________

5. Change in Mass
(change in mass = [(final mass - initial mass / initial mass) x 100] ___________________

6. Why does popcorn pop? Get a computer or iPad and do some research.

7. Examine popcorn under a microscope, or look at the pictures on the next page (or do both!).

Compare the size and shape of the popped kernels to unpopped kernels. List some characteristic features of the popped kernels

8. **Analysis and Conclusions:** Answer the following questions.

a. Explain the origin of holes in the popcorn.

b. How did the mass and volume change during popping?

c. Imagine that the unpopped kernels represent magma inside a volcano and that the popped kernels are tephra (volcanic rock) erupted from a volcano. Do you think the preeruptive magma and erupted volumes of tephra are the same? Explain your answer.

d. Based on your observations of popcorn microscope images, what common features might be shared by both popcorn and tephra?

e. Explain the origin of holes in real tephra.

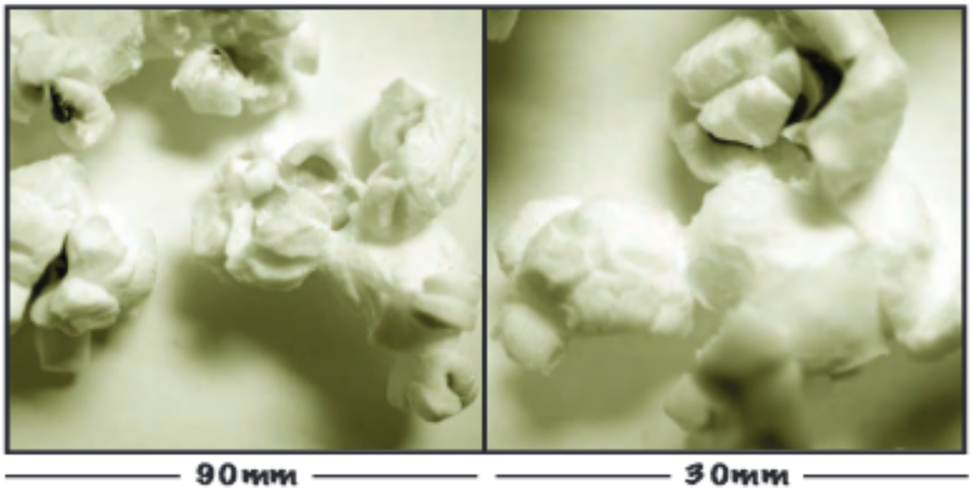
Advanced Extensions

9. Popping kernels may lose mass due to water loss. The same can be said of rising magma. Explain what happens to excess water expelled from rising magma.

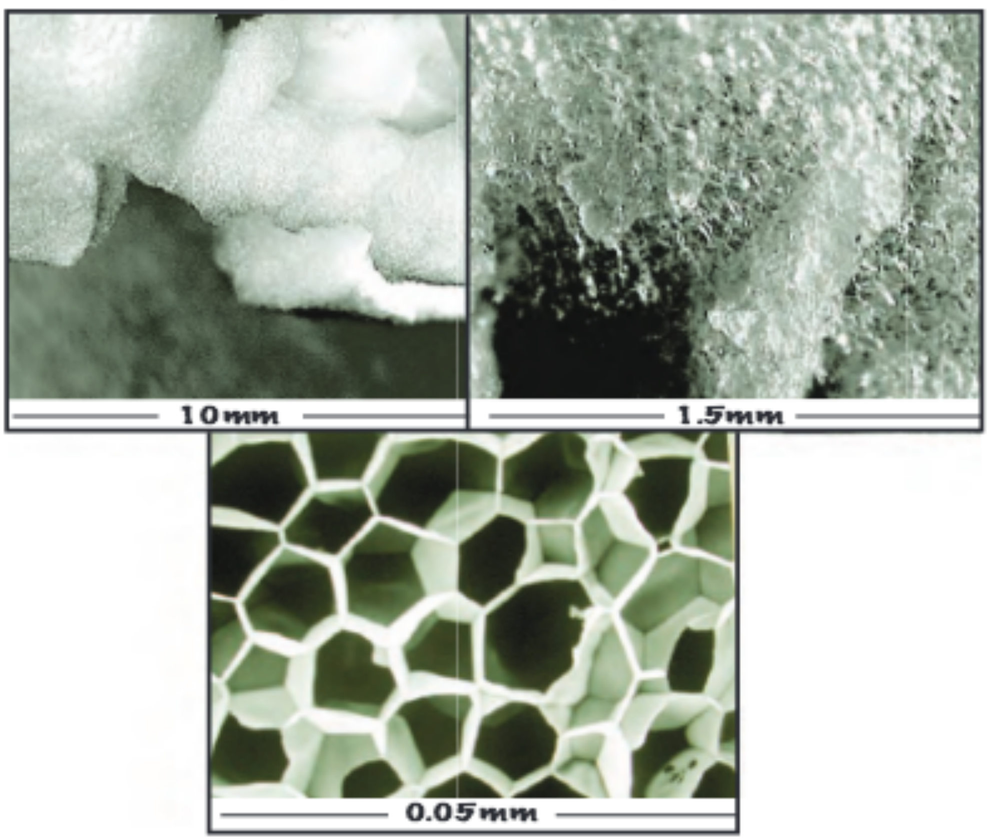
10. Describe how the presence of bubble-filled tephra on Earth’s surface can affect the ecology of a landscape.

11. Research and define one of the following different kinds of tephra, or volcanic rocks including volcanic block, volcanic bomb, lapilli, pyroclastic rock deposits, volcanic ash pumice, or scoria.

## Images of Popcorn—Up Close




## Microscope Images of Popcorn Kernels



**Lesson #8**
**Volcanic Hazards**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

Most students will have the misconception that volcanic ash is composed of pieces of burned substance. To correct that misconception, a bag of fragments of volcanic ash will be passed around for students to observe. They will write down their observations, and through discussion conclude that ash is actually small fragments of tephra, or volcanic rock. The class will discuss how these tiny particles can be hazardous, then further discuss other hazards of volcanic eruptions. A short video clip on volcanic hazards will be shown, then students will divide into groups and given a scenario that they get word that Yellowstone is going to erupt. There is no time to leave, only to take proper precautions to try to stay safe and survive. With their group, students will devise a survival plan to be shared with the class.

**Duration:** 2 50 minute class periods

**Objectives:**

Students will apply information about volcanic hazards to simulate preparation for a hazardous situation.

**NGSS Standards Addressed:**

MS.History of Earth
**MS-ESS2-3.** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS.Earth's Systems
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

Understanding Volcanic Hazards video
Volcanic ash
Video Handout
Survival plan Handout

**5E's**

- **Engagement**

  Students will be engaged with a class opener. A writing prompt will be posted on the board for them as they enter the classroom. The prompt will read "What is volcanic ash?"

Students will have 5 minutes to answer the question.

Once the students complete the opener, a sample of volcanic ash will be passed around. Students will make observations and write them in their science notebooks, as well as discuss what they see.

- **Exploration:**

  The teacher will facilitate a discussion with the students about ways these tiny particles of rock might be hazardous. Other hazards that come with volcanic eruptions will also be discussed.

- **Explanation:**

  A short video clip about Volcanic Hazards will be shown to bring to life the hazards the were being discussed. Students will follow along and answer questions about the video.

- **Elaboration:**

  Students are given a scenario that they get word that Yellowstone is going to erupt. There is no time to leave, only time to take proper precautions to try to stay safe and survive. With a group of 3-4, students will devise a survival plan, then share with the class. Students will make a poster portraying their plan.

- **Evaluation:**

  Students will demonstrate an understanding by participating in class discussion, as well as correctly answering the questions about the video. Students will work in groups to prepare and present a super volcano survival plan.

  **Formative:** The teacher will check for understanding throughout the discussions, and with their science notebook entry.

  **Summative:** Students will be assessed by handing in their video questions, as well as assessed on their work on the survival plan. (this will be strictly participation points, since there is no write or wrong answer)

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, or in a group of students that will help.
Writing: Students with IEPs for writing may type their notebook entry and video questions. The job of writing during the preparation activity will go to somebody else in the group.

**Safety Considerations:**

Students will know proper procedures of retrieving items they may need when creating their posters.

## **Understanding Volcanic Hazards**

Video questions

Answer the questions while viewing the video

1. List several reasons why people choose to live near volcanoes in spite of potential dangers.

2. An erupting volcano throws rock debris tens of thousands of feet into the air. Which answer best describes how far fine, dust-size fragments, called volcanic ash, can travel? Circle your answer.
   a. The slopes of the volcano.
   b. Volcanic ash can travel up to one kilometer from the volcano.
   c. Volcanic ash can be carried by winds around the Earth.

3. Describe at least three effects that ash falls can have on people and property.

4. A volcanic mudflow: (circle all that are true)
   a. Is a fast-moving flood (mixture) of water, mud, sand, rocks, and trees.
   b. Behaves like flowing wet concrete.
   c. Travels not more than 5 kilometers (3 miles) from the volcano.
   d. Destroys and buries all that lies in its path.

5. Where did the missing part (top and northern slope) of Mount St. Helens end up?

6. Every active volcano releases gases. (True or False)

7. Water vapor (steam) is the most common gas released from an erupting volcano, followed by carbon dioxide and sulfur dioxide. (True or False)

8. Volcanic gases: (circle all that are true)
    a. Are released from cracks or vents in a volcano or from crater lakes.
    b. Are generally invisible and some are odorless.
    c. Generally become diluted before they reach populated areas and become only an irritation.
    d. In high concentrations, can suffocate animals and humans.
    e. Can corrode metal.
    f. All of the above are true.

## Oh no! Yellowstone is going to Erupt!

Hazards preparation simulation

You have just got word (on facebook, or twitter, or snapchat, or maybe it was a text) that the super volcano that is Yellowstone is about ready to blow! You are advised to not attempt to leave the state, but to instead gather any supplies and prepare yourselves in anyway you can to stay safe and try to survive the blast.

With a group of 3-4, you will devise a survival plan. You will illustrate this plan on a poster and present it to the class.

Here are the things you must address on your poster:

- Where will you go? (remember, you can't leave Casper)
- What kind of hazards are you expecting to have to deal with from the Volcano?
- What will Casper look like after the blast?
- What supplies will you need to get and how much?
    - Why?

**Lesson #9**
**Thunder Island**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

This activity is a volcano monitoring simulation. It involves students dealing with 'real-time' data that they have to process within a short timeframe and then provide their expert advice to another team.

**Duration:** 1 50 minute class periods

**Objectives:**

Apply information about volcanic hazards to simulate preparation for a hazardous situation.

**NGSS Standards Addressed:**

MS.Earth's Systems
**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.

**Materials:**

Thunder Island simulation handouts:
- Background
- map
- Hour strips for each team
- Eruption Center
- Well Water and Weather Team
- Deformation Monitoring Team
- Seismic Team

**5E's**

- **Engagement**

    Students will be engaged by numbering off 1-4, and dividing into four groups at the beginning of the class period. Group one will go to the part of the room labeled seismic team; group two will be the deformation monitoring team, group three will be the well water and weather team, and group four will be the eruption center. Each student will get a "Thunder Island" handout with some background information. The teacher will project the handout on the board, and will go over the handout with the class. Students will take turns reading sections.

- **Exploration:**

  Each team has their own specific handout to read. Students will be given a few minutes to go over their team handout in order to determine what their role is. Each team has a different role in the simulation to monitor the volcanic activity and keep the residents on the island safe. The eruption center advises local people of the eruption warning for each hour, the other three teams will provide the information needed. The well water and weather team monitors the temperature changes in the five wells around Thunder Island. This team will gather for any rise in temperature beyond 10 degrees celsius, which means moving magma, as well as monitor wind speeds. This team gives advice to the Eruption Control Center. The deformation monitoring team monitors any change in the slopes of the volcano. This team will analyze the information and provide advice to the Eruption Control Center. The seismic team monitors seismic activity as recorded by the five seismic stations located on Thunder Island.They will provide advice to the Eruption Control Center as well.
  The teacher will decide on an interval to give out each "hourly" data sheet. Between 8-10 minutes works well. At each interval, each group will receive new data sheets to analyze and decide what to relay to the control center. The control center will then decide what to inform the residents.

- **Explanation:**

  Once the simulation is complete, students will discuss the simulation. Some teams will feel they never had enough time to fully analyze the data, which made things stressful. The teacher will lead students to relate the stress of this activity to what they think happens in the real world.

- **Elaboration:**

  Students will write a reflection about the simulation. They will talk about what happened during the simulation, and relate it to real world situations.

- **Evaluation:**

  Students will be evaluated by their participation in the simulation. They will demonstrate a take-away from the activity by writing a reflection in their science notebooks.

  **Formative:** The teacher will check for understanding throughout the activity, as well as asses students on their willingness to participate..

  **Summative:** Students will write a reflection about the simulation in their science notebooks.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading should not have an issue, since this a group effort. The background information will be discussed as a class, and the group

instructions should be clarified by an aid or the teacher if students are struggling to understand.

Writing: Students with IEPs for writing may type their science notebook entries on the computer.

Social: Students with social issues will be encouraged to participate in the simulation. The teacher or an aid may provide extra support.

Extensions for advanced students:

The advanced class will be given an extended version of the activity by researching what real volcanologists do.

**Safety Considerations:**

Procedures will be in place for students to move to their groups without any issues.

The classroom will be set up so the four groups can easily move around the room.

# Thunder Island Simulation

## Teacher Instructions

This activity is a volcano monitoring simulation that lasts approximately one 45 minute class period.. It involves students dealing with 'real-time' data that they have to process within a short timeframe and then provide their expert advice to another team.

You will have to divide your class into four teams :

- Seismic Team
- Deformation Monitoring Team
- Well Water and Weather Team
- Eruption Center

Each team has a sheet of instructions that they will need 10 minutes to read and ask questions. These sheets could be given to the teams for homework reading to save time.

There are three pages of data sheets – one for the Seismic Team (SEISMIC), one for the Deformation Monitoring Team (DISTANCES) and one for the Well Water and Weather Team (TEMPERATURES). The Eruption Center Team obtains its data from each of the other teams as the simulation progresses.

Each page has six boxes of data that correspond to each 'hour' of the simulation. You will need to copy and cut out these sheets and make piles for each of the teams. Note that teams only are given one box of data at a time. Based on the length of time for your class, work out a time interval for giving out the data sheets – eight minutes works well. You can also start at 10 minutes then reduce the period each time (Hour 1 data at start, Hour 2 data at 10 mins, Hour 3 data at 19 min, Hour 4 at 27 min, Hour 5 at 34 min etc).

### *Starting the Simulation*

Have each team sit in a corner of the room. Hand them the first hour's data sheets and start the clock. Note that the Eruption Center team has no data until the other teams provide them with some (see their instruction sheets).

When eight minutes (or your time interval) has passed, hand out the next data sheet, and so on.

Expect bedlam. Teams will feel that they don't have enough time to make decision about their data before the next lot comes in…but this is an important lesson about dealing with real time data. Some teams will have no problem – others will be stressed.

At the end of the class, talk through the issues each team had and question them about what they think happens in the real world.

# Thunder Island

## Some Background

Thunder Island is a small volcanic island in the southwestern Pacific Ocean. It has a population of 3,500 located in five small townships. The island was discovered by the Dutch in 1720 and a small settlement grew up around Safe Bay, which was used as a safe anchorage by Dutch trading ships during the monsoon storm season. Within ten years of discovery, Shakey Harbor was established as a jail for convicts (mostly pirates) and a small township started to grow around a fresh water stream at Valleyside. Released convicts moved into Hermitside in 1750. In 1978, a tourist resort was built, known as The Resort. It caters for 200 people.

Township population (including estimated tourists)

| | |
|---|---|
| Safe Bay | 1300 |
| Valleyside | 100 |
| Shakey Harbor | 800 |
| The Resort | 250 |
| Hermitside | 50 |

The island has no roads and all transport is by foot or boat. A telephone system does operate to all townships except Hermitside, which is a 20-minute walk from Safe Bay or 35 minutes by boat.

## Volcanic History

Two active volcanoes, Big Thunder and Little Thunder, occur on the island.

*Big Thunder Volcano*

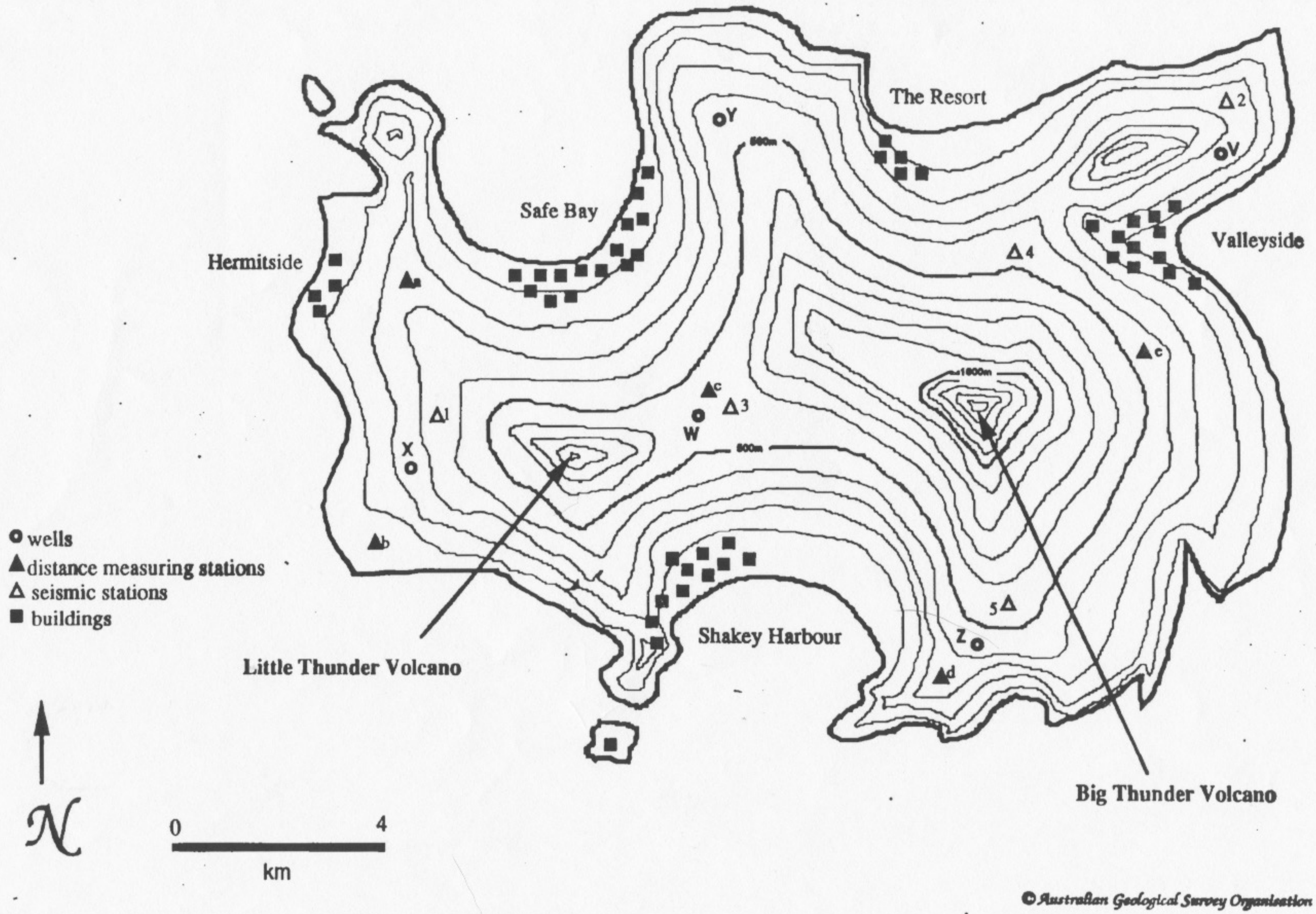
Big Thunder erupts approximately once every nine years. It normally produces an amount of ash with the occasional andesitic lava flow. Eruptions are preceded by a rise in the temperature of water in the local wells and by increased seismic activity. During the last eruption eleven years ago, large amounts of ash covered Valleyside and a lava flow ran down a ridge between The Resort and Safe Bay. No one was injured but Valleyside residents were forced to evacuate.

*Little Thunder Volcano*

Little Thunder has an erratic eruption history. It is known to have erupted eight times since settlement, each time releasing vast amounts of basaltic lava and ash. Many buildings in Shakey Harbor were destroyed by a lava flow in 1823. The last eruption in 1916 was prior to the setting up of monitoring devices on the island.

In 1984, seismic stations and distance measuring equipment was set up on the island to monitor future eruptions.

# Thunder Island



*Hour 1*

| SEISMIC | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station 1** | 1 | 2 | 1 | 2 | 0 | 1 | 2 | 1 | 2 | 0 | 1 | 1 |
| **Station 2** | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 1 | 2 | 3 |
| **Station 3** | 3 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 4 |
| **Station 4** | 4 | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 2 | 2 |
| **Station 5** | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 3 | 2 |

*Hour 2*

| SEISMIC | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station 1** | 1 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 1 | 1 |
| **Station 2** | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 2 |
| **Station 3** | 3 | 4 | 4 | 4 | 5 | 4 | 4 | 3 | 4 | 4 | 4 | 5 |
| **Station 4** | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3 |
| **Station 5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 3 |

*Hour 3*

| SEISMIC | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station 1** | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 |
| **Station 2** | 3 | 4 | 3 | 3 | 2 | 3 | 2 | 3 | 4 | 4 | 3 | 4 |
| **Station 3** | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 4 |
| **Station 4** | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 43 | | 4 | 4 |
| **Station 5** | 2 | 3 | 2 | 3 | 4 | 2 | 3 | 2 | 3 | 2 | 1 | 3 |

*Hour 4*

| SEISMIC | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station 1** | 3 | 4 | 4 | 3 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 |
| **Station 2** | 3 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 3 | 2 | 3 | 2 |
| **Station 3** | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 4 |
| **Station 4** | 3 | 3 | 3 | 4 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 5 |
| **Station 5** | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 3 | 2 |

*Hour 5*

| SEISMIC | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station 1** | 2 | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 |
| **Station 2** | 3 | 4 | 3 | 4 | 3 | 2 | 3 | 4 | 3 | 2 | 3 | 2 |
| **Station 3** | 4 | 5 | 5 | 4 | 5 | 5 | 6 | 4 | 3 | 4 | 5 | 4 |
| **Station 4** | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 | 5 | 6 | 4 | 5 |
| **Station 5** | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 6 | 4 | 4 | 4 |

*Hour 6*

| SEISMIC | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station 1** | 3 | 4 | 5 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 4 |
| **Station 2** | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 5 | 4 | 3 |
| **Station 3** | 5 | 6 | 5 | 6 | 5 | 5 | 5 | 6 | 7 | 7 | 7 | - |
| **Station 4** | 4 | 5 | 6 | 7 | 7 | 7 | - | | | | | |
| **Station 5** | 4 | 5 | 6 | 5 | 4 | 5 | 4 | 3 | 4 | 3 | 4 | 3 |

10 on Blue

| DISTANCES | | | | | *Hour 1* |
|---|---|---|---|---|---|
| **a-b** | 1 | 2 | 1 | 2 | |
| **a-c** | 2 | 3 | 1 | 1 | |
| **c-d** | 2 | 2 | 1 | 1 | |
| **c-e** | 2 | 2 | 1 | 1 | |
| **e-d** | 1 | 2 | 1 | 1 | |
| **d-b** | 0 | 3 | 2 | 1 | |

| DISTANCES | | | | | *Hour 2* |
|---|---|---|---|---|---|
| **a-b** | 2 | 2 | 1 | 2 | |
| **a-c** | 2 | 1 | 0 | 1 | |
| **c-d** | 3 | 3 | 2 | 3 | |
| **c-e** | 4 | 3 | 2 | 3 | |
| **e-d** | 4 | 1 | 1 | 3 | |
| **d-b** | 3 | 2 | 9 | 3 | |

| DISTANCES | | | | | *Hour 3* |
|---|---|---|---|---|---|
| **a-b** | 1 | 1 | 1 | 2 | |
| **a-c** | 2 | 3 | 2 | 1 | |
| **c-d** | 4 | 5 | 4 | 5 | |
| **c-e** | 1 | 2 | 3 | 2 | |
| **e-d** | 6 | 5 | 4 | 5 | |
| **d-b** | 2 | 1 | 2 | 3 | |

| DISTANCES | | | | | *Hour 4* |
|---|---|---|---|---|---|
| **a-b** | 2 | 3 | 4 | 2 | |
| **a-c** | 1 | 2 | 2 | 2 | |
| **c-d** | 1 | 2 | 3 | 3 | |
| **c-e** | 3 | 3 | 3 | 3 | |
| **e-d** | 3 | 4 | 3 | 3 | |
| **d-b** | 4 | 5 | 3 | 2 | |

| DISTANCES | | | | | *Hour 5* |
|---|---|---|---|---|---|
| **a-b** | 2 | 2 | 3 | 2 | |
| **a-c** | 1 | 1 | 0 | 2 | |
| **c-d** | 5 | 6 | 4 | 5 | |
| **c-e** | 6 | 6 | 7 | 8 | |
| **e-d** | 9 | 6 | 7 | 5 | |
| **d-b** | 4 | 3 | 2 | 5 | |

| DISTANCES | | | | | *Hour 6* |
|---|---|---|---|---|---|
| **a-b** | 2 | 2 | 3 | 2 | |
| **a-c** | 2 | 3 | 2 | 1 | |
| **c-d** | 5 | 6 | 7 | 8 | |
| **c-e** | 10 | 9 | 8 | 8 | |
| **e-d** | 9 | 9 | 11 | 8 | |
| **d-b** | 5 | 5 | 5 | 6 | |

10 Copies on
Green

TEMPERATURES *Hour 1*

V 2
W 3
X 2
Y 4
Z 5

Wind Speed 15 Wind Direction W

TEMPERATURES *Hour 2*

V 7
W 7
X 3
Y 8
Z 7

Wind Speed 13 Wind Direction WSW

TEMPERATURES *Hour 3*

V 8
W 7
X 5
Y 6
Z 7

Wind Speed 10 Wind Direction SW

TEMPERATURES *Hour 4*

V 9
W 9
X 8
Y 10
Z 11

Wind Speed 14 Wind Direction SSW

TEMPERATURES *Hour 5*

V 12
W 19
X 3
Y 8
Z 24

Wind Speed 10 Wind Direction SW

TEMPERATURES *Hour 6*

V 10
W 12
X 5
Y 9
Z 26

Wind Speed 16 Wind Direction S

10 copies on Pink

# ERUPTION CENTER

***The Resort Headquarters***

Your role is to advise the local people of the eruption warning for each hour. You need to assess the information provided by the other three teams and release the following warnings if needed:

***NO ALERT - TESTING WARNING SYSTEM***
This is issued when there is no activity warnings from any team. It lets loca1 people know that the warning system is working.

***ERUPTION GREEN***
This is issued if any two teams advise of unusual activity. Locals should keep listening to further warnings.

***ERUPTION ORANGE BIG/LITITE***
This is issued if any two teams give warning of activity at either of the volcanoes. Locals in ash fall areas are on notice of evacuation.

***ERUPTION RED BIG/LITTLE***
This is issued if all three teams give warnings of activity. Locals in ash fall areas are evacuated to safer townships.

***ERUPTION - ERUPTION - ERUPTION***
An eruption.

***ERUPTION DOWNGRADE (ORANGE/GREEN/NO ALERT)***
A decrease in risk.

While you wish to advise people of risk, you do not wish to cause panic in the local people, as it is important that they trust your judgements. (Remember the boy who cried, "Wolf"!)

# Well Water &Weather Team

*Safe Bay Headquarters*

Your role is to monitor the temperature changes in the five wells (V-Z) dotted around Thunder Island. Automatic thermometers are located in each well and information is sent via radio to headquarters where it is received by computer. The computer prints out the maximum temperature rise from the normal temperature of the well waters each hour. A fluctuation of $10^{o}$ C is not uncommon, however, any rise beyond $10^{o}$ C is a warning of moving magma.

Also, attached to a post at well W is a device that measures speed and direction of winds in the center of the island. Past eruption studies have shown that volcanic ash is blown 1 km X the wind speed.

Your job is to analyze the information and provide advice to the Eruption Control Center on your assessment of the eruption risk and location.

**For example:**

V: 6
W: 4
X: 8
Y: 4
Z: 3
Wind speed: 5 Wind direction (from) : S

Well temperatures are within limits. Well X is getting hot and further reading will need to be recorded. Ash falls could occur to the north of both volcanoes for 5 km. Safe Bay is in ash fall zone. ADVISE ERUPTION CENTER OF WELL X AND WEATHER.

**Or :**

V:2
W:12
X:3
Y:8
Z:16
Wind speed: 10 Wind direction : SE

Well temperatures indicate rise of magma under Big Thunder. Ash fall zone from Big Thunder will be 10km to the northwest. Safe Bay is under risk. WARN ERUPTION CENTER.

# Deformation Monitoring Team

*Valleyside Headquarters*

Your role is to monitor deformation of the slopes of the volcano. Your information comes from accurate laser measurements between five distant measuring stations (a-e) on Thunder Island. The process of measuring the distances is automatic and is taken every 15 minutes, which are sent to you via telephone lines every hour (4 readings).

The normal readings are:

| | | | |
|---|---|---|---|
| a-b | 5110m | c-e | 8590m |
| a-c | 6450m | e-d | 7475m |
| c-d | 7190m | d-b | 1155m |

The instruments vary in their readings by + 1m. However, it is not unknown for some readings to change as much as 3 m during non-eruptive times. Any change larger than this and for more than one hour may indicate the rise of magma in the volcanic vent. The readings are fed into a computer that prints out the variation in meters from the normal measurements.

Your job is to analyze the information and provide advice to the Eruption Control Center on your assessment of the eruption risk and location.

**For example**

| | |
|---|---|
| a-b | 1,2,3,2 |
| a-c | 1,0,0,1 |
| c-d | 2,1,0,1 |
| c-e | 2,3,4,3 |
| e-d | 1,0,1,3 |
| d-b | 0,0,0,1 |

Distance measurements appear within limits. However the distance c-e may indicate activity on the northern slope of Big Thunder. ADVISE ERUPTION CENTER.

Or

| | |
|---|---|
| a-b | 0,1,2,1 |
| a-c | 3,2,1,2 |
| c-d | 2,3,3,4 |
| c-e | 3,3,3,4 |
| e-d | 2,3,4,5 |
| d-b | 3,2,3,2 |

Major deformation is occurring around Big Thunder. The southeastern slope is bulging up to 5m from normal measurements. WARN ERUPTION CENTER.

# Seismic Team

***Shakey Harbor Headquarters***

Your role is to monitor seismic activity as recorded by the five seismic stations located on Thunder Island (1-5). The seismic recorders only measure strong ground motions in the close vicinity of the recorder. The information is sent via telephone lines to your headquarters in Shakey Harbor.

Each recorder produces an average reading of seismic intensity every five minutes. These are sent to you each hour as a steam of 12 numbers from each center. The scale for these numbers is:

0 - no activity
1 - very minor activity
2 - minor activity
3 - substantial activity
4 - sub-major activity
5 - major activity
6 - dramatic activity
7 - extreme activity

Eruptions are normally preceded by intensities of 5 or more, recorded by stations surrounding the volcanic vent. The recorders are built to withstand intensity 7 for 10 minutes only, after which they may cease to operate.

Your job is to analyze the information and provide advice to the Eruption Control Center on your assessment of the eruption risk and location.

**<u>For example:</u>**

Station 1) 3,4,3,4,5,6,6,5,6,5,6,6
Station 2) 2,1,2,1,0,0,1,0,1,2,0,0
Station 3) 3,4,4,3,4,5,4,3,4,5,6,4
Station 4) 3,2,3,1,2,1,2,3,2,3,2,3
Station 5) 3,4,4,4.3,2,3,2,3,2,3,2

Activity is taking place on the western side of Little Thunder with maximum intensity being described as dramatic. The intensity has increased over time. This is confirmed by a station on the eastern side of Little Thunder. All other stations have had high but stable intensities. Conclusion is that Little Thunder may erupt. WARN ERUPTION CONTROL CENTER

**<u>or</u>**

Station 1) 1,2,2,3,2,3p,1,2,3,2,2
Station 2) 3,2,3,2,3,4,3,2,3,2,3,2
Station 3) 1,2,2,3,2,2,1,2,2,1,2,2
Station 4) 3,2,3,3,2,3,2,2,2,2,3,2
Station 5) 2,1,2,1,2,2,3,3,2,1,2,1

Activity is stable. Fluctuations are within normal limits. NO WARNINGS NEEDED.

**Lesson #10**
**Volcano Museum Unit Project**

**Created By:** Lauren Huntington

Volcanoes/Earth Science/7th Grade

**Lesson Overview:**

Students will be given the option to collaborate with a partner or to work alone to research a volcano, either active or dormant, and create an artifact for our volcano museum. The artifact will include everything that the public may want to know about that particular volcano: the history, and its characteristics. Students can present their information in a brochure, a poster, a diorama, a diagram, a cube, a collage, a newspaper page, a booklet, a video… the options are endless, but must be first approved by the teacher.

**Duration:** 5 50 minute class periods

**Objectives:**

Students will be able to research, organize, and present information about a selected volcano.

**NGSS Standards Addressed:**

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

**MS-ESS2-3.** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

MS.Earth's Systems
**MS-ESS3-1.**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

**Materials:**

Art supplies - (colors, paper)
Computers or iPads with printing capabilities
Final Project handout and Rubric

**5E's**

- **Engagement**

  Students will find an opener on the board upon entering class. The writing prompt is "What has been your favorite thing to learn during this volcano unit? What was your least favorite thing?"

Students will have 5 minutes to answer the question.

Once students finish the opener, the teacher will introduce their final, culminating project. The classroom will be transformed into a Volcano Museum. As a class, the students will come up with a name for their museum. The teacher will write this name on the board.

Students will be given the option to work with a partner or on their own. Once they have figured out where they are going, the teacher will go over the project handout with the students, and what the expectations are.

- **Exploration:**

  Students will be given the rest of the period to research active and dormant volcanoes around the world, and choose one that they would like to research. No group can have the same volcano.

- **Explanation:**

  Students will gather information on their selected volcano. Students will look up the history, what kind of volcano it is, the location, it's eruption pattern, the hazards associated with living nearby, and put all that information in a form that they choose.

- **Elaboration:**

  Students will decorate the classroom with their finished artifacts, and present them to the class as we move through the "museum."

- **Evaluation:**

  Students will demonstrate an understanding by creating an elaborate museum artifact on a selected volcano as well as presenting the information.

  **Formative:** The teacher will check for understanding throughout the entirety of the creation of the museum artifact.

  **Summative:** Students will be assessed by using the rubric that was given with the Museum artifact handout. Students will be assessed on the quality of the artifact, the quality of the information, and the presentation.

**Differentiation:**

Students with special learning accommodations:
Reading: Students with IEPs for reading will be placed with an aid, and with a partner that can help.
Writing: Students with IEPs for writing will be able to type the information for their artifact.

Social: Students with social issues will not be expected to work with a partner if they do not want to. They will be given the option to present to just the teacher and not in front of the class.

**Safety Considerations:**

Students will know proper procedures of retrieving items they may need when creating their artifacts.

**Volcano Museum**

Final Unit Project

For this final project, we will be turning our classroom into a Volcano Museum. With a partner or by yourself, you will research and choose a volcano that you are interested in for your project. Your volcano should be active or dormant, (if it is extinct, ensure you can find valid information on it.) Once you have selected your volcano, you can begin your project.

You can create an artifact for the museum in any form you see fit, just run it by the teacher first. You can create a collage, a poster, a diorama, a newspaper, a brochure, a video … the opportunities are endless, just make sure you can get all your information in whatever you decide.

The information you need to include in your project and your presentation:

- The history of the volcano
    - Any past eruptions and their effects on the surrounding area
- The type of volcano it is and what kind of eruption it has
- Where is it located. Geographically, and what kind of plate (or hot spot) it is on
- What would happen if this volcano erupts now?
- What do scientist know about this volcano?
- Any other fun facts you can find!

You need to use 3 or more quality resources to gather information (see there rubric), and cite your sources! Wikipedia is not a quality resource. You can use it, but make sure you use 3 other quality sources (.org, .edu, .gov) sites.

**Volcano Museum**

Rubric

| | 0 | 1-2 | 3-5 | 6-8 | 9-10 |
|---|---|---|---|---|---|
| **Creativity** | Student chose not to participate | Student's final product did not exhibit any creativity. Needs more effort. | Student's final product is somewhat creative, but lacks effort. | Student's final product shows creativity, but could be improved. | Student's final product is creative. The student put a lot of effort in to the artifact. |
| **Content** | Student chose not to participate | Student did not contribute accurate information. | Information presented was not accurate and did not address all the questions. | The information was accurate and answered most of the questions but could have been more detailed. | The information was accurate, answered all of the questions, and detailed |
| **Time Management** | Student chose not to participate | Student did not use give class time wisely and needed to be constantly reminded to stay on task. Student did not finish. | Student needed to be reminded to stay on task. Student was pressed to complete assignment on time. | Student mostly stayed on task and was able to complete assignment within the allotted class time. | Student stayed on task and had no problem completing assignment within allotted class time. |
| **Presentation** | Student chose not to participate | The student did not prepare for the presentation. | The student's presentation of the material was sloppy. The student was ill prepared. | The student's presentation was informational, but lacked enthusiasm and preparation. | The student's presentation was informational, entertaining, and clearly prepared. |
| **Resources** | Student chose not to participate | Student did not provide resources used to gather information. | Student used less than three quality resources. | Student used three resources to gather information. | Student used more than three quality resources to gather information. |
| **Overall** | | | | | |

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