a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Earth & Space Science

Exploration of Extreme Environments: Volcanoes

Science and Mathematics
Education Research Group

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Volcanoes

Volcanoes I

Why are volcanoes important?

A. Volcanoes helped to create the beginnings of our atmosphere

B. Volcanoes trigger interest and curiosity, which promote tourism

C. The emissions from volcanoes contribute to the carbon cycle

D. Volcanoes give us information to learn more about our past

E. All of the above

Solution

Answer: E

Justification: Volcanoes are important for both scientific and cultural reasons. They affect the lives of people living near them in both positive and negative ways. For example, after Mount St. Helen's erupted in 1980, volcanic ash spread to nearby towns and cities.

Volcanoes also have materials that have industrial and chemical purposes. For example, rocks made from lava formations are commonly used when building roads.

Volcanoes II

Which of the four basic needs for human survival is not present in the extreme environment of a volcano?

A. Water

B. Shelter

C. Food

D. Breathable air

E. All of the above

Solution

Answer: E

Justification: Often, volcanoes spew lava and poisonous gases from a crater at its summit; this is called a volcanic cone. While there are different types of volcanoes, no volcano is able to consistently provide any of the basic needs for human survival.

The table in the next slide describes each of the basic needs for human survival and why a volcano does not satisfy them.

Solution Cont'd

Breathable air	Volcanoes emit (give off) carbon dioxide in large amounts. Humans are unable to breathe in large amounts of carbon dioxide.
Water	Water is not present in a volcano because the extreme heat would boil and evaporate any water present.
Food	In and around volcanoes, only microbes are able to live, thus not providing humans with adequate food sources.
Shelter	While there is often a crater on top of a volcano, the extreme heat and poisonous gasses do not allow for humans to find shelter.

Volcanoes III

Composite volcanoes and shield volcanoes are two common types of volcanoes that have very distinct structures. Shield volcanoes are large and broad, usually with gentle slopes; composite volcanoes are usually cone shaped.

Shield volcanoes

Composite volcanoes

Volcanoes III Cont'd

How is the raised, mountainous shape of these two common types of volcanoes formed?

A. Volcanoes always erupt at the top of mountains, so the cone shape is already there

B. When the earth's tectonic plates push inward, rock is forced upward

C. The eruption rock hardens and it builds up around the point of explosion

D. Volcanoes always occur above sea level so the lava will flow toward the sea

Solution

Answer: C

Justification: When volcanoes erupt, lava, ash, and rock are deposited near the point of eruption. Over time, rock builds up and causes this conical shape that is a volcano.

While some volcanoes are mountains, not all mountains are volcanoes. The conical shape of volcanic mountains is a result of these eruptions. Mountain ranges, on the other hand, are formed by the earth's tectonic plates pushing up against one another.

Also, not all volcanoes are on land! As you will learn more about later in this question set, there are different types of volcanoes, some occurring in the ocean depths.

Extend Your Learning: Points of Interest

When we think of volcanoes, people often think of a conical mountain. However, there are many more types of volcanoes, such as those in the pictures below (and the next question!).

Volcanic Cones

Fissure Vents

Lava Domes

Submarine Volcanoes

Subglacial Volcanoes

Mud Volcanoes

Volcanoes IV

Hot spot volcanoes are another type of volcano found on Earth. These are formed when the earth's tectonic plates shift on top of a spot of hot magma, feeding the magma through the earth's crust.

Which of the following islands or group of islands would be a result of this process?

A. 

B. 

C. 

D. 

Solution

Answer: A

Justification: The Hawaiian Islands were formed millions of years ago and are essentially a succession of underwater volcanoes that built up beyond the surface of the ocean. They are in an arc because the earth's Pacific plate carried the other islands away as it slowly moved to the northwest.

The Hawaiian island at the bottom is the closest to the hot spot, so it continues to grow rapidly as it gets the supply of magma.

(The Galapagos Islands are also formed this way.)

Extend Your Learning: Video

Title: Volcanic eruption forms new island

Volcanoes V

Just like there are two common ***types of volcanoes***, there are also two main ***types of eruptions***: effusive and explosive.

Below are the definitions of their root words.

Type of eruption	Root word	Definition
effusive	effuse	To give off; to pour out (a liquid)
explosive	explode	To suddenly break apart in a violent way with parts flying outward

Volcanoes V Cont'd

Knowing the definitions of the root words of effusive and explosive, which of the following do you think describes these types of eruptions?

	Effusive Eruption	**Explosive Eruption**
A	Lava flows gently along the slope	The rock build up at the top of the volcano shoots outward
B	Lava fills up in a volcano until it spills over the side	Clouds of material shoot out and fall to the ground
C	Lava fills up in a volcano until it spills over the side	The rock build up at the top of the volcano shoots outward
D	Lava flows gently along the slope	Clouds of material shoot out and fall to the ground

Solution

Answer: D

Justification: Effusive volcanoes occur when hot magma reaches the surface, sometimes accompanied by smaller fire fountains (pictured below). Magma collects about 3 km below the point of eruption in what is called a magma reservoir. At the time of eruption, the magma travels quickly from this reservoir to the top, spewing hot magma out, which flows down the gradual slope of the volcano.

Explosive volcanoes produce more violent eruptions and are usually caused by harmful gas explosions that blast rock, lava fragments and volcanic ash into the air.

Extend Your Learning: Discussion

Consider the following questions about volcanic eruptions:

What causes an explosion to be effusive or explosive?

What is the lava for each type of volcano made up of?

How does this impact the eruption?

Volcanoes VI

Now that you know the characteristics of different types of volcanoes, which type of eruption do you think a shield volcano is likely to have and why?

	Type of eruption	Reason
A	effusive	The gradual slopes are caused because the lava cools as it rolls down the side of the volcano
B	explosive	The gradual slopes are caused because the lava cools as it rolls down the side of the volcano
C	effusive	The gradual slopes are caused because material explodes over a great distance from the mouth of the volcano
D	explosive	The gradual slopes are caused because material explodes over a great distance from the mouth of the volcano

Solution

Answer: A

Justification: Shield volcanoes are built by effusive eruptions. Lava flows out of the volcano in all directions, like the shield of a warrior. Shield volcanoes have very fluid lava (as opposed to their composite volcano counterpart that have much “stickier” lava). This fluid lava will travel farther, creating the large, low profile of these types of volcanoes.

Volcanoes VII

In volcanoes, a hot, thick liquid called magma rises and collects in large underground chambers (called magma chambers).

How is magma formed?

A. Intense pressure deep in the earth melts rock

B. Earthquakes shake the ground and the friction melts rock

C. Hot smoke blows up from deep inside the earth and melts rock

D. The heat deep inside the earth melts rock

Solution

Answer: D

Justification: When temperatures are hot enough (at least 600°C), rocks will melt, separating into two parts – one is a liquid and one is a gas. The hot, thick liquid that is formed is called magma. The gas that is released during melting increases the pressure deep in the earth's core, and collect in large underground chambers (magma chambers).

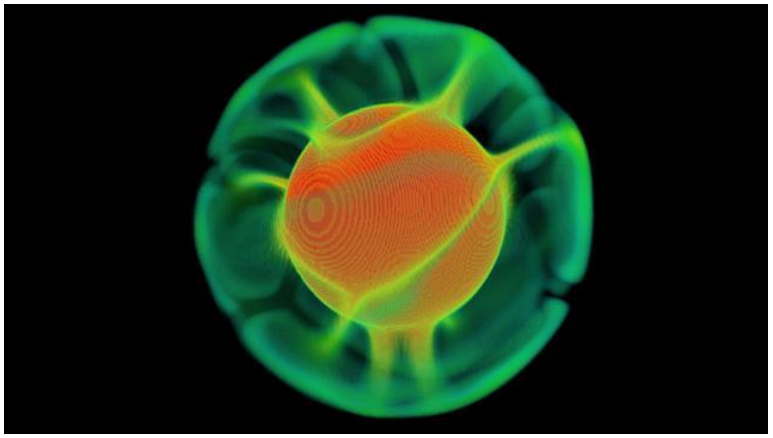
When pressure builds up enough in the magma chambers, the magma bursts out through cracks in the earth's crust and falls as lava or volcanic ash.

Extend Your Learning: Did You Know?

What's the difference between magma and lava?

It's the same thing! When it's in its hot, liquid form under the earth's crust, we call it MAGMA. Once it has erupted from below the earth's surface, it takes on its new name, LAVA.

Observe the pictures below. Which is magma and which is lava? How do you know?



Extend Your Learning: Video

Title: Lava Close Up

Volcanoes VIII

Volcanic eruptions depend on many factors.

Which factor below is NOT a reason a volcano may erupt.

A. The presence or absence of water

B. The presence of a hot spot

C. The location of the magma

D. The temperature of magma

E. The amount of magma accumulated

F. The composition of magma

Solution

Answer: C

Justification: It is extremely important for volcanologists to know what factors may cause an eruption. The presence of water, such as in a lake or an ocean may cause an eruption because water affects the buoyancy of magma in the earth's crust. Hot spots pierce the earth's crust like a blowtorch, creating volcanic eruptions and the amount, composition and temperature are all factors affecting the way magma behaves deep down in the earth's crust.

Magma accumulates in the magma chamber (or magma reservoir) of volcanoes whether they are going to erupt or not. When an eruption is close, the magma rises from the magma chamber and spews out the mouth of the volcano.

Extend Your Learning: Video

Title: Geography Lesson – What is a volcano?

Volcanoes IX

Mauna Kea is a unique example of a mountain that is also a volcano.

When measured from sea level to its peak is 4200 m tall. In contrast, Mount Everest, when measured from sea level to its peak is 8848 m tall. Mount Everest is commonly known as the tallest mountain on Earth, but Mauna Loa is actually taller.

Mauna Kea

Mount Everest

Volcanoes IX Cont'd

How is it possible for Mauna Kea to be taller than Mount Everest?

A. This statement is untrue; Mount Everest is, in fact, the tallest mountain on Earth

B. Volcanoes are measured from the first point of eruption

C. The height is calculated by averaging the height of all the peaks in the mountain range

D. Measurements account for height as well as length of volcanoes

Solution

Answer: B

Justification: Mountains are measured from their base, which occurs on land. In contrast, volcanoes are measured from the first place they erupted. For example, some volcanoes first erupt under water. When a volcano is also a mountain, it is also measured from its first point of eruption. This is the case for Mauna Kea. When measured from its oceanic base, Mauna Kea measures 10100 meters. The picture shows an outline of Mount Everest superimposed on an image of Mauna Kea from it's ocean base to peak.

Extend Your Learning: Did You Know?

Kilauea is another large Hawaiian volcano on Earth (and the earth's ***most active*** volcano), but it is only one third the size of the largest volcano in our solar system, Olympus Mons. Here are some other interesting points about Olympus Mons:

- Shield volcano; lava slowly flows down its side during eruption
- Second largest mountain in the solar system
- Nearly 3 times the size of Mt. Everest
- Located near the Martian equator
- The edge of the volcano is surrounded by a cliff

Volcanoes X

Volcanologists are scientists who study volcanoes using methods from a variety of scientific fields?

Which of the following scientific fields would NOT be included in volcanologists job?

A. Biology
B. Geology
C. Mineralogy
D. Physics
E. Chemistry
F. Sociology

Solution

Answer: A

Justification: Volcanologists usually work in teams who use scientific methods from many different branches of science.

Biology is the scientific study of living organisms. Due to the extremely high temperatures occurring in and around volcanoes, it is not necessary for volcanologists to be trained in biology. There are smaller microscopic organisms that may occur in places such as hot springs and geysers (see question XIV); however, microbiologists would likely provide scientific answers in these specific cases.

Solution Cont'd

The following table gives examples from each branch of science that a volcanologist may use when studying a volcano.

Science	Example
Chemistry	A complex mix of gases would be sucked into a vacuum chamber and returned to the lab for chemical analysis
Geology	To understand how a volcano formed and study the internal structure of rocks
Mineralogy	View thin slices of rock under a microscope to analyze the minerals present
Physics	To understand how pressure builds up in a volcano, causing an eruption
Sociology	To inform people about volcanic hazards

Volcanoes XI

Part of the job of a volcanologist is to predict when a volcano will erupt.

Which clue would indicate that a volcano may erupt soon?

A. The presence of hardened lava near the opening

B. A deformation at the surface of a volcano

C. A large change in the temperature at a volcano's base

D. Smoke and ash coming out of the top of the volcano

Solution

Answer: B

Justification: When a volcano is about to erupt, the surface of the volcano often deforms. Magma moves up into the top part of a volcano, below the surface, and pushes surrounding rock outward. This causes a bulge in the topography of a volcano.

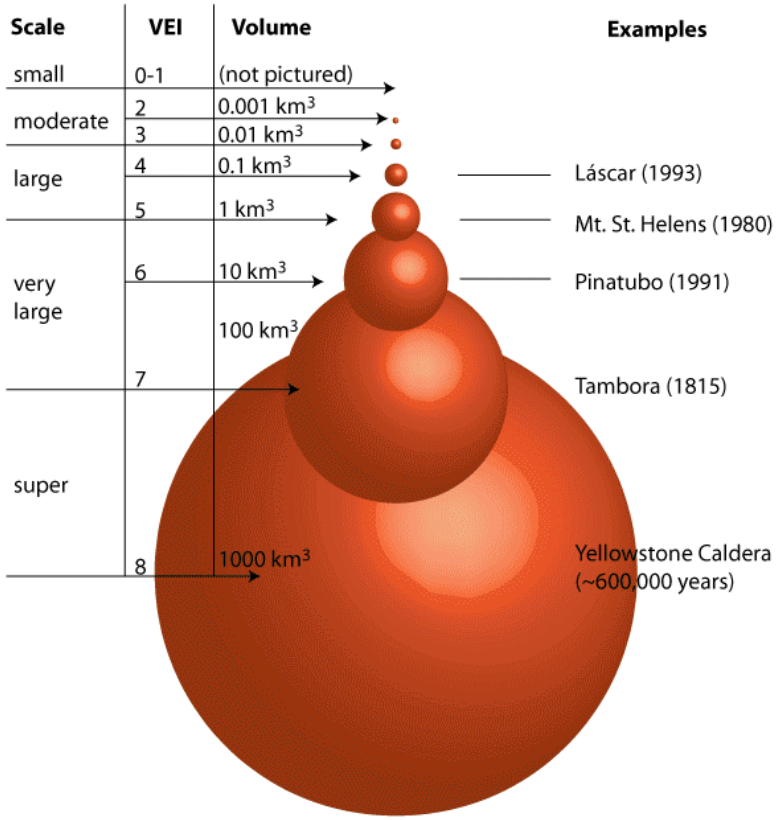
Hardened lava is likely to be at the mouth of the volcano already, specifically if it's a volcano that erupts effusively. Smoke and ash are products of a volcanic eruption, and a volcano would be at a higher temperature at the base of the volcano throughout, as the magma chamber is nearby.

Extend Your Learning: Did You Know?

Volcanologists measure the explosivity of volcanoes using the Volcanic Explosivity Index (VEI). The VEI measures the following things:

1. The amount of volcanic material ejected
2. The height of the material thrown into the atmosphere
3. The length of an eruption

An increase of 1 in the scale means that the volcano is 10 times more powerful than the number before it on the scale.



Extend Your Learning: Video

Title: 10 Things You Didn't Know About… Volcanoes – "The Sleeping Giant"

Volcanoes XII

A silver suit (also known as fire proximity suit) protects a volcanologist from the high temperatures of a volcano. These are aluminized suits, meaning they are made out of a form of aluminum.

What properties of aluminum help protect scientists withstand the heat of volcanoes?

A. High density material

B. Good reflector of infrared radiation

C. Easily bendable material

D. Thick enough to withstand the heat

Solution

Answer: B

Justification: The silver suit reflects the intense heat and radiation of a volcano using the aluminized outer layer of the suit. This keeps a scientist's body temperature at a manageable level.

A high density material would be too heavy for volcanologists to work in and the bendability (malleability) of the material is irrelevant because the suit is a textile form of aluminum.

Increasing the material's thickness on a suit will not provide a volcanologist with more protection from the volcano's heat and toxic gases. Suits should be as light as possible in order to help moderate body temperatures.

Extend Your Learning: Compare & Contrast

Below are two suits: a silver suit and a firefighter's suit

Observe these two suits.

What similarities do these two suits have?

What differences do you see?

Could either of these suits be switched with each other? Why?

What other suit or object that you know would share some of the same properties as either one of both of these suits?

Volcanoes XIII

Although volcanoes are an inhospitable environment for people to live, towns and cities are often built near the base of a volcano. Which of the following would be a reason people want to live in such close proximity to a volcano?

A. Volcanoes provide the soil with rich nutrients, allowing crops to thrive

B. A volcano's magma heats the ground, producing a renewable source of geothermal energy

C. People find it exciting to live in these potentially risky and fascinating places

D. All of the above

Solution

Answer: D

Justification: Surprisingly, there are many towns and cities that establish and settle at the base of some inactive volcanoes.

An inactive (or dormant) volcano refers to a volcano that has not been active for an extended period of time. It is important to also note that extinct volcanoes are those which have no written records of activity and are unlikely to ever erupt again.

The volcanic ash provides the soil with rich nutrients for farming and the heat of the magma within the volcanic cone produces valuable geothermal energy. People are also drawn to these “risky” places; referred to as the “Wow Factor”.

Volcanoes XIV

Due to the extremely high temperatures in volcanoes, living organisms do not typically inhabit them. One type of micro-organism, known as archaea, have been found to live in volcanic vents and volcanic hot springs.

Because of their affinity to such high temperatures, what specific type of extremophile are these archaeans?

A. Alkaliphiles

B. Halophiles

C. Acidophiles

D. Thermophiles

E. None of the above

Solution

Answer: D

Justification: As the prefix (*thermo-*) suggests, thermophiles are heat-loving organisms. These are the only organisms to have been found in volcanoes.

Yellowstone National Park provides other habitats for many thermophilic organisms. Heat below the surface of the earth drives its geysers and hot springs, where microscopic life thrives.

Solution Cont'd

Micro-organism	Affinity for…	Example of this environment
Alkaliphiles	Alkaline (basic) environments	Pavilion Lake – British Columbia, Canada
Halophiles	Saline (salt) environments	The Dead Sea - Jordan
Acidophiles	Acidic (acid) environments	Rio Tinto (river) - Spain
Thermophiles	Thermic (heat) environments	Hot springs – Yellowstone National Park

Volcanoes XV

Black smokers (types of hydrothermal vents) often form in chimney-like shapes on the ocean floor.

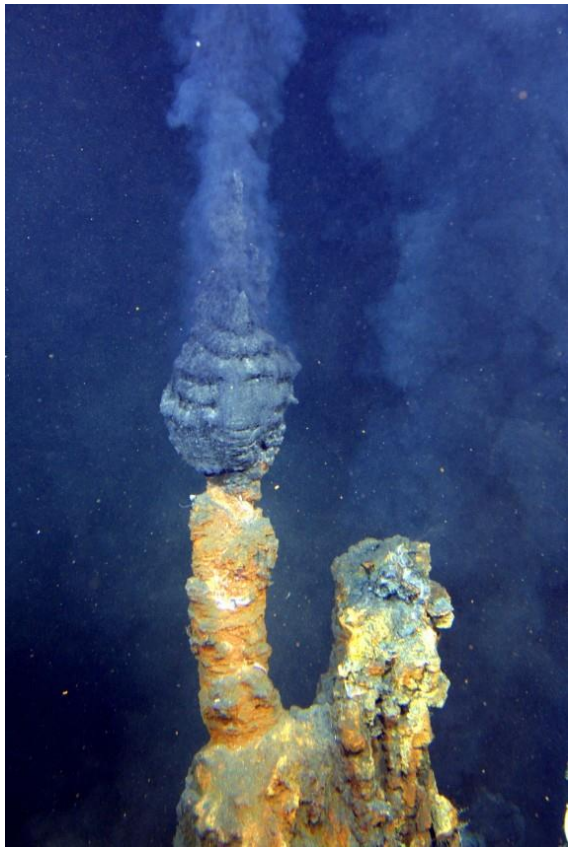
How are these shapes formed?

A. Intense pressure at the bottom of the ocean pushes the material back into the earth's core

B. Magma from the Earth's core seeps out and solidifies

C. Minerals are released from the earth's core and hardens into an ash-like substance

D. Rocks spew out of the black smokers and settle around the vents



Solution

Answer: C

Justification: The water deep in the ocean where hydrothermal vents are found averages at a temperature of 2 degrees Celsius. Hot, black mineral-rich water makes its way through the Earth's crust and solidifies (hardens) around this crack as soon as it hits the cold ocean water. These minerals build up on the sides, creating the chimney-like shape of black smokers.

Because of the intense heat in the earth's core, it's not possible for rocks to come out of these vents. All rocks would melt down to magma at high temperatures. If magma escaped and hit the cold water, it would form large rocks (igneous rocks).

Magma doesn't come out because the crack doesn't go deep enough to reach this layer in the earth.

Extend Your Learning: Video

Title: Underwater Vents and Volcanoes