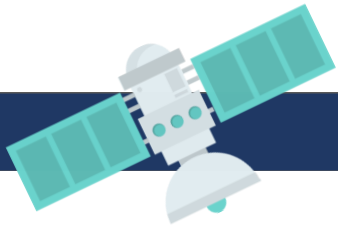
Volcanoes on Mars



Overview

Age Range:

10-14

Lesson Time:

45 Minutes (including 2 videos)

Equipment Needed:

Computer

Projector

Topics Covered:

Geology
Biology (Life in extremes)
Astronomy (Mars surface conditions)

Activity Outline

Understand how volcanoes form, both on Earth and Mars, and how they may have affected Mars's habitability in the past.

Learning Outcomes

After completing this activity, pupils will:

- Understand how volcanoes form.
- Be able to explain what convection is and why we would find it inside a volcano.
- Determine, with reasoning, the likelihood of volcanic areas being habitable.

Background Material:

Slide 1 - Introduction	In this lesson, we will be looking at the volcanoes of Mars and how they may have contributed to the habitability of the Red Planet over its history.
Slide 2 - Objectives	Can be seen above in Learning Outcomes.
Slide 3 – Types of Volcano	In order to understand volcanoes of Mars, we must first turn our attention to what we know of volcanoes here on Earth. There are three main categories that volcanoes can be placed into:

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- Composite volcanoes
- Cinder cone volcanoes
- Shield volcanoes

A composite volcano, also called a stratovolcano, is a cone-shaped volcano built from many layers of lava, pumice, ash and tephra. Because they are built of layers of viscous material, rather than fluid lava, composite volcanoes tend to form tall peaks rather than rounded cones. Some of the most spectacular volcanoes on Earth are composite volcanoes, such as the Mayon Volcano in the Philippines, Mount Fuji in Japan and Mount Rainier in the United States of America. Some of these composite volcanoes rise 2-3 thousand metres above sea level.

Cinder cone volcanoes are the simplest type of volcano. They are built from particles and blobs of congealed lava, ejected from a single vent. As the gas-charged lava is blown violently into the air, it breaks into small fragments that solidify and fall as cinders around the vent to form a circular or oval cone.

Lastly, there are shield volcanoes. These are named for their low profile and are far wider than they are tall, which causes them to resemble a warrior's shield. These volcanoes result from intense heat and are made up almost entirely of eruptions of low viscosity lava which flow far more readily.

Slide 4 – Olympus Mons: Shield Volcano

The largest volcano in the Solar System can be found on Mars. It is called Olympus Mons and is a shield volcano. It is 25km tall, with a staggering diameter of 624km. Olympus Mons is wide enough to stretch from the West Coast of France to its Eastern border.

Slide 5 – How do Shield Volcanoes Form?

Here is a video showing how Olympus Mons might have formed, illustrated using eruptions of molten candle wax: https://youtu.be/D9jOp2D9N0Y

Video background information: Olympus Mons is thought to have achieved its size due to the lack of tectonic movement on Mars, allowing multiple eruptions from a single fissure. With each eruption, and subsequent solidification of the lava flows, the volcano increased in size. These multiple eruptions have left a distinctive striped pattern on the volcano, with each stripe showing a separate eruption. In the video we can see examples of these patterns forming in the wax.

Slide 6 – Iceland Field

Of course, studying this volcano close-up has not yet been possible. Therefore, here on Earth we utilise planetary field analogue sites, such as the volcanically active environment of Iceland.

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Iceland owes much of its landscape to its volcanic activities, making it a fascinating case study in volcanic processes. Iceland has numerous geothermal fields. Some of these are close to Reykjavik, such as Krýsuvík. All of these fields have different geothermal wells: pools of water warmed up by the Earth's underground heat. The heating causes all wells to have temperatures ranging from 60 to 95°C.

Slide 7 – Convection

When studying volcanic processes, it is important to understand how heat transfers through fluids. This is a mechanism known as convection. When a fluid, such as air or a liquid, is heated and then travels away from the source, it carries the thermal energy along. The fluid above a hot surface expands, becomes less dense, and rises.

Slide 9 – How does convection work?

Here is a video illustrating convection: https://youtu.be/1sjIwi-klNY

Video clip background information: Water is placed within a convection tube and heated at one bottom corner using a spirit burner containing methylated spirit (denaturalised alcohol, C_2H_5OH). This causes the water above the source of heat to become less dense and rise, allowing colder water to take its place. This in turn becomes less dense and rises. As previously heated water towards the top of the tube cools, it becomes more dense and sinks at the other end, whilst also being pushed along by the warmer rising water, creating a cycle of heating and cooling. Potassium Permanganate ($KMnO_4$) in an aqueous solution is then pipetted into the convection tube in order to dye the water and display the path that it is travelling.

Slide 10 – Life on Mars?

Now that we know the basic mechanics of volcanoes, please discuss in groups (of 3 or 4) if you believe that life could exist in such environments. Please present your reasoning for your stance in the discussion.

(Allow time for discussion, and then take answers requesting students' explanations for their responses)

It is likely that much of the class would have come to the conclusion that life could not exist in such environments, owing to the majority of their experience relating to complex multicellular organisms. Some students may have raised the ability of some microorganisms to survive in extreme environments.

Slide 11 – what about microorganisms?

We now turn our attention to microorganisms (as some of you alluded to). There are many varieties of life that can survive these conditions. These organisms are extremely resistant, and there are varieties known as extremophiles, which not only can survive these harsh

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environments, but require them for their survival. One such example is the bacteria, *Thermus aquaticus*. At the time of its discovery, it was believed that microorganisms could not survive in temperatures exceeding 50°C. However, *Thermus aquaticus,* discovered in a hot spring in the caldera of the Yellowstone National Park Super Volcano, can actually survive temperatures of up to 80 °C (although it grows best at temperatures between 65 and 70°C).

Slide 13 - Review

From this lesson, students should be able to answer the following questions:

- What kind of volcano is Olympus Mons and how is it thought to have formed?
- What is convection (using video demonstration if necessary)?
- What sort of life could exist in a volcano?

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