Enceladus

Overview

Age Range:

10-14

Lesson Time:

45 Minutes (including 1 video)

Equipment Needed:

Computer

Projector

Topics Covered:

Chemistry

Geological processes

Biology (Life in extremes)

Astronomy

Activity Outline

Understand geological processes that occur on Enceladus and how these affect the potential for life in this environment.

Learning Outcomes

After completing this activity, pupils will:

Understand the nature of the subsurface oceans of Enceladus

Understand principles of convection, chemistry, and formation of hydrothermal vents

Understand the potential for life in these environments

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Background Material:

Slide 1 – Lesson Introduction

For this lesson, we will be looking at the moon Enceladus and the geological processes that occur both on and within its icy shell.

Slide 2 - Objectives

Can be seen above in Learning Outcomes.

Slide 3 – Introduction to Enceladus

Enceladus is the sixth largest moon to orbit Saturn. Its white surface, composed of nearly pure water ice, makes it one of the most reflective objects in our Universe. Because it reflects the majority of the heat reaching it back out into space, Enceladus is one of the coldest moons of Saturn, with average surface temperatures of -200 Celsius. However, the south pole of Enceladus – at around -95 Celsius – is very hot compared to the rest of the surface.

Slide 4 – Introduction to Enceladus

Enceladus is the second closest major moon to Saturn. Its orbit, which takes approximately 33 hours, is actually within Saturn's rings (inside the diffuse E-ring, which is the second outermost ring of Saturn).

Enceladus is in a 2:1 orbital resonance with Dione, Saturn's fourth closest major moon: Enceladus orbits twice in the time taken by Dione to orbit once, and this prevents Enceladus's orbit from ever being perfectly circular. Because its distance to Saturn changes during its orbit, Enceladus is stretched and compressed by Saturn's gravity, deforming its surface. This process of tidal deformation forms cracks in the icy crust of the moon and heats its interior.

Slide 5 – Beneath Enceladus' surface

Enceladus is not a frozen ball of water. Below the icy surface appears to be a vast ocean that encircles the entire core, heated through tidal deformation. The ice layer at the surface is about 30 kilometres thick at its equator, and 3-5 kilometres thick around its south pole. Evidence for this global ocean includes plumes of water ejected through cracks in the south pole crust in a process called cryovolcanism.

Slide 6 – Video

Here we have a video which demonstrates hydrothermal vents: https://www.youtube.com/watch?v=LQAO2sLDPsc

Video background information: In this video, we will show a visual representation of so-called 'black smoker' hydrothermal vent. In nature, these vents produce plumes of hydrogen sulphide gas through the water that can be used as a source of energy by microfauna. The black colour comes from iron sulphide within the mixture. In this video, this is being represented by manganese dioxide (acting as a catalyst for the decomposition of a 12% hydrogen peroxide solution). This has been used as an analogue in the lab, as hydrogen sulphide is toxic to animals,

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including humans. On Jupiter's moon Enceladus, hot water from hydrothermal vents can travel all the way from the seafloor to Enceladus' surface and be ejected by the plumes thousands of kilometres into space.

Slide 7 – Hydrothermal vents

The cryovolcanism seen at Enceladus' south pole is believed to be a result of hydrothermal vent activity below the surface. Hydrothermal vents are caused by fissures in the sea floor that expel geothermally heated, mineral-rich water. The deepest, hottest hydrothermal vents on Earth are the Pescadero Basin vents, located 3,800 metres below the surface of the Pacific Ocean. The first hydrothermal vents were discovered near the Galapagos islands as recently as the late 1970s by Dr Robert Ballard and the team aboard the research vessel *Knorr*.

Slide 8 – How do cryo-volcanoes work?

Cryovolcanoes are driven by convection. Cold (dense) water sinks and hot (less dense) water rises. The rising hot water helps to melt the icy crust, and can find its way out through the cracks in the moon's surface. This means that hot water from the hydrothermal vents can travel all the way from the seafloor to Enceladus' surface and be ejected by the plumes thousands of kilometres into space. These huge structures can even be seen with telescopes on Earth.

Slide 9 – Chemistry of hydrothermal vents

Hydrothermal vents on Earth are home to a vast number of different chemical compounds and are very rich in minerals. The hydrothermal vents of planet Earth act as a natural plumbing system for our oceans, contributing to the currents and movement of minerals throughout our oceans.

Slide 10 – Potential for life?

Hydrothermal vents are believed to have a role in the origin of life on Earth. Does this mean that we could find life inhabiting the oceans of Enceladus? Currently extremophiles have been found to inhabit the hydrothermal vents of our own oceans. So it is plausible that there may be the potential for life in hydrothermal vents at Enceladus.

Slide 11 – Review

From this lesson, students should be able to:

- Describe Enceladus and understand its importance and interest as a moon.
- Understand the chemistry and formation of hydrothermal vents.
- Understand the importance of hydrothermal vents in life on Earth and potentially Enceladus.

Sources:

Enceladus in Depth (NASA): https://solarsystem.nasa.gov/moons/saturn-moons/enceladus/in-depth/

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Enceladus: A Habitable World (Open University blog): https://www.open.ac.uk/research-groups/astrobiology/blog/enceladus-habitable-ice-world

The ice-covered ocean worlds of the outer Solar System (AstrobiologyOU): https://www.open.edu/openlearn/science-maths-technology/astronomy/the-icy-moons

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