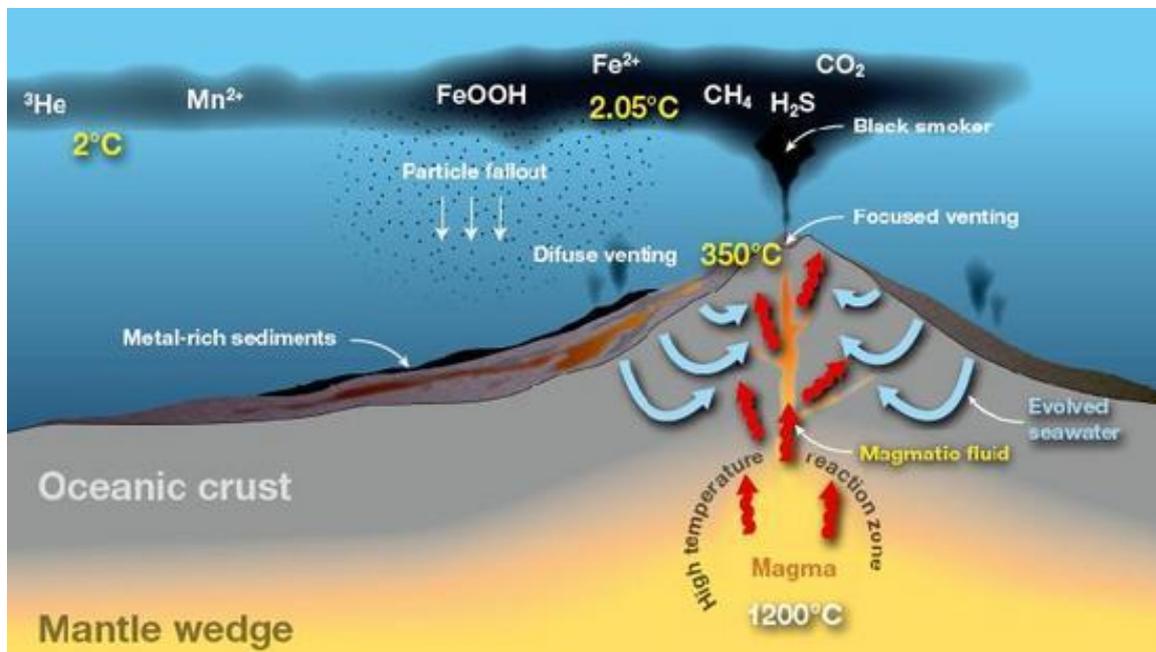


Hydrothermal Vents. Teacher's notes.

A hydrothermal vent is a fissure in a planet's surface from which geothermally heated water issues. They are usually volcanically active. Seawater penetrates into fissures of the volcanic bed and interacts with the hot, newly formed rock in the volcanic crust. This heated seawater (350-450°) dissolves large amounts of minerals. The resulting acidic solution, containing metals (Fe, Mn, Zn, Cu) and large amounts of reduced sulfur and compounds such as sulfides and H₂S, percolates up through the sea floor where it mixes with the cold surrounding ocean water (2-4°) forming mineral deposits and different types of vents. In the resulting temperature gradient, these minerals provide a source of energy and nutrients to chemoautotrophic organisms that are, thus, able to live in these extreme conditions. This is an extreme environment with high pressure, steep temperature gradients, and high concentrations of toxic elements such as sulfides and heavy metals.



Black and white smokers

Some hydrothermal vents form a chimney like structure that can be as 60m tall. They are formed when the minerals that are dissolved in the fluid precipitates out when the super-heated water comes into contact with the freezing seawater. The minerals become particles with high sulphur content that form the stack. Black smokers are very acidic typically with a ph. of 2 (around that of vinegar).

A black smoker is a type of vent found at depths typically below 3000m that emit a cloud or black material high in sulphates. White smokers are formed in a similar way but they emit lighter-hued minerals, for example barium, calcium and silicon. White smokers tend to have plumes that are lower in temperature and are alkaline.

Biological communities.

It was once thought that all life forms needed sunlight to exist, this is not the case as deep sea organisms have no access to sunlight. Hydrothermal vent communities

depend on chemosynthetic bacteria for food and as the primary source of energy, not solar energy. The chemosynthetic bacteria produce a thick mat that attracts other organisms such as amphipods and copepods that graze upon the bacteria directly. The food chain is extended as a predator prey relationship develops with the arrival of snails, shrimps, crabs, tubeworms and fish. Vents are often referred to as 'oases of the deep', while biomass is extremely high relative to the surrounding deep sea, biodiversity at vents is low. One major characteristics of vent biological communities is the high degree of species endemism with many species showing important physiological, morphological and ecological adaptations to particular environmental factors. An example is the giant tubeworm *Riftia pachytila* that is found at the East Pacific Rise.

Biogeography.

It has been demonstrated that different vent faunal communities characterize different ocean basins; this can be explained by biogeography. The present distribution of a species represents, the historical events acting on geological time scales that have shaped its geological range. Also the dispersal potential of the species determined by its life history patterns (free swimming larval stages), benthic barriers (deep rifts and trenches) and hydrography (bottom currents). Vent systems are temporally variable and ephemeral depending of the magmatic processes that drive them. The scientific community has identified 6 distinct biogeographical domains characterized by the species that can be found there (see map).

What to do

Summary

Hydrothermal vents are areas where the earth's tectonic plates touch. Seawater penetrates into fissures of the volcanic bed and interacts with the hot, newly formed rock in the volcanic crust. This heated seawater (350-450°) dissolves large amounts of minerals. The resulting acidic solution percolates up through the sea floor where it mixes with the cold surrounding ocean water (2-4°) forming hydrothermal vents. In the resulting temperature gradient, these minerals provide a source of energy and nutrients to the chemoautotrophic organisms which enable them to live in these extreme conditions. This activity is designed to help students understand the formation process and learn about the unique biological communities are present at different vent fields. The learning is consolidated with a poster making activity.

Learning objectives.

Students will become aware of:

- Where the main ridge systems of the world are.
- Where the main vent fields are.
- What a hydrothermal vent is.
- Which animals are associated with specific vents.

Ocean Literacy Links

1. The earth is one big ocean with many features.
2. The ocean and life in the ocean shape the features of the Earth.
5. The ocean supports a great diversity of life and ecosystems.
7. The ocean is largely unexplored.

Target age aged 12-14

Time 2 class periods

Materials

Downloadable worksheets, information package and map. Card for poster making, glue, coloured pencils.

.Teacher's notes outlining individual animals found at the major vent fields.

Ridgeia piscesae (Skinny Tube Worms)

Description

Grows gregariously in clusters at sites of diffuse or warm venting, temperature range 5-60°C. Uses internal symbiotic sulphide-oxidizing bacteria. This species can survive in areas of low diffuse vent flow with very low plume level exposure to sulfide.

Distribution.

Northeast Pacific hydrothermal vents in the abyssal zone.

Morphology

Tube very variable, straight or sinuous, stiff or soft, tapering to 1mm posterior end; anterior funnel and external flanges present. Color white, grey, gold, brown; commonly translucent. Top of tube carries 1-15 brown saucers on a central axial rod; if these are shed, traces of the axial structure remain.

Size.

Tube length max. 1900 mm; anterior diameter 2-13 mm.

Riftia pachyptila (Giant Tube Worm)

Description

Forms clusters on rocks in zone of diffuse venting. Feeds only on internal symbiotic sulfide oxidizing bacteria

Distribution.

Lives on the ocean floor near hydrothermal vents on the East Pacific Rise, more than a mile under the sea

Morphology

An adult *R. pachyptila* has a tough chitonous tube that grows to over 3 meters tall. At the top of the tube is a large red plume containing hemoglobin that gives *R. pachyptila* the appearance of a giant paintbrush. Inside the tube, the worm's body is colorless, and holds a large sack called a trophosome (along with its other organs). This sack contains billions of symbiotic bacteria that make food for the worm. The worm has no mouth, eyes, or stomach.

Size

Individual tubes up to 1.5 m.

***Rimicaris exoculata* (Deep Sea Shrimp)**

Description

Shrimp highly mobile occurring in swarms reaching densities of about 3000 per litre on active chimney walls where temperatures range from 10-30°C. Primary consumer, eating bacteria (or cultivated) on the mouthparts, and on the mineral particles ingested.

Morphology

These shrimps have enlarged gill chambers on their external carapace, their 'eyes' are considered to have evolved into a broad ocular plate that forms part of the shrimp's dorsal surface. The plate's novel photoreceptors do not form a distinct image, instead these 'eyes' are highly sensitive to dim light, perhaps an adaptation for detecting radiation from the orifices of hot black smokers and for allowing the shrimp to orient to the chimney walls.

Distribution

Mid-Atlantic Ridge

Size

Carapace length 22.0 mm; total length up to 55 mm.

***Cryosomallon squamiferum* (Scaly foot gastropod)**

Description and Morphology.

The snail's foot is very unusual in that it is armored with iron-mineral scales. It is protected by scale-shaped sclerites composed of iron sulfides. No other animal is known to use iron sulfides in this way. The snail's shell is also unusual. The shell structure is composed of three layers. The outer layer is about 30 µm thick, and is made of iron sulfides. This makes this gastropod the only metazoan known so far that employs this material in its skeleton. The middle shell layer is organic, and is also the thickest of the three (about 150 µm). It is comparable to the periostracum, a thin protein coating found on other snail shells. The innermost layer is made of aragonite, a form of calcium carbonate that is commonly found both in the shells of molluscs and in various corals. Each layer contributes to the effectiveness of the snail's shell in different ways. The middle organic layer appears to absorb the mechanical strain and energy generated by a squeezing attack (as by the claws of a crab), making the shell much tougher. The organic layer also acts to dissipate heat.

The United States military is currently funding research on the armor of the snail in hopes of developing insights into new military armor designs.

Habitat.

Discovered in 2001 at the Kairei vent field on the Central Indian Ridge.

***Alviniconcha hessleri*. (Hairy snail)**

Description

Alviniconcha hessleri was discovered and described in the late 1980's. It is named both after the submersible Alvin ("Alvin's shell") and the preeminent deep-sea

biologist, Robert R. Hessler. The snail is roughly spherical in shape and has a thin carbonate shell (if allowed to air-dry, it will fall to pieces within weeks). The spiny appearance of this snail is part of the periostracum and can erode away in larger specimens

Morphology

This snail has blue blood due to hemocyanin, but also contains hemoglobin in concentrations similar to chemoautotrophic bivalves from other hydrothermal vents. The gill of this snail is enlarged and can get up to 21% of the total soft-body mass (dry weight). A normal snail's gills from the intertidal may weigh around 4-7% of the total soft-body weight.

Habitat

Western Pacific. Originally described from the Mariana Trough west of the Philippines, these snails populate many of the back-arc basins in the western Pacific, including the Manus, North Fiji, and Lau back-arc basins

Size

Specimens up to 88mm in length have been seen, larger than a softball.