Activity 6 - The Galapagos Hydrothermal Expedition
Role Play of the Discovery of Hydrothermal Vents

Overview:

This activity simulates the exciting discovery on the historic February 1977 Galapagos Hydrothermal Expedition in which a group of geologists, geochemists and geophysicists set off to find hydrothermal vents. They unexpectedly discovered a rich biological community thriving in an environment that was expected to be hostile to all life forms and completely barren – and there wasn't a single biologist on board. Students role play the *Alvin* dive, viewing photographs from that expedition, taking notes on what they find and hearing the comments of the scientists on those dives. After the activity, students discuss the actual 1977 dive and what scientists saw and collected as well as evidence for plate tectonics.

Background:

(This is a brief synopsis of a more thorough treatment of this material on the Dive and Discover site cited in Resources)

Hydrothermal Vents

The emergence of the theory of Plate Tectonics in the late 1960s changed our understanding of the way our planet works. Scientists began to explore the many possible consequences that could be supported by this new knowledge. One interesting possibility was the existence of seafloor hot springs. In areas where tectonic plates were moving apart, molten rock from the mantle would erupt onto the seafloor to form new crust. The cold ocean water would cool the lava and as it cooled it would shrink and crack. Cold seawater could seep into the cracks. As it sank deeper into the crust, the water would reach areas super heated by the molten rock of the mantle. The heated water, carrying minerals dissolved from the rock, would rise to the surface, and discharge into the ocean. But in 1977, no one had seen hydrothermal vents yet. There were several pieces of evidence that suggested the existence of seafloor hot springs, or hydrothermal vents, as they came to be called.

Hot, Salty Seafloor Waters and Metal-rich Sediments

In 1880, the Russian ship Vitaz had sampled water from 600 meters down in the Red Sea and found it to be warmer than the surface water. In the 1940s a Swedish expedition also found the water in that area to be warmer and saltier than the surface water. The prevailing theory had been that the equatorial sun had heated and evaporated surface water, making it saltier and denser. The denser water sunk to the bottom. The theory explained why the water from the bottom was saltier, but it didn't really make sense that it would continue to be warmer once it sunk.

Scientists continued to go back to the same area and take samples. In1964, a sample was taken that was 44° C (111°F). In 1965, scientists on the Woods Hole Oceanographic R/V *Atlantis* II retrieved a sediment sample that was black and tarry and too hot to touch at 56°C (133°F). The next year the WHOI ship R/V *Chain* extracted hot sediments that were rich in copper, manganese, zinc

Essential Concepts:

The results of scientific inquiry are often very surprising.

Hydrothermal vents support a lush community of organisms.

Learning Objectives:

Students will be able to:

- discuss the findings and some of the surprises encountered on the dive on which hydrothermal vents were first seen.
- describe how hydrothermal vents occur.

National Standards:

- Earth and Space Science: Structure of the Earth system.
- History and Nature of Science: Science as a human endeavor
  History of science

Time Frame: 1 period

Materials:

- The Hydrothermal Vent Discovery overhead projector images.
- 1 copy of the "*Alvin* Dive Log" per student.
- Copies of the "Post Dive Questionnaire" for all students

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Resources

Dive and Discover :

Go to

Current Expedition: Infomod: The Discovery of Hydrothermal Vents.: The Discovery (also available as a CD)

From any expedition: Deeper Discovery: Resources: Be sure to download and read

Ballard, Robert D.. "Notes on a Major Oceanographic Find," Oceanus, Vol.20, No.3, Summer 1977 (Available in pdf form in this infomod and on the CD)

This article would be extremely useful reading in your preparation for the dive and creation of your "*Alvin*" simulation station. It is a report on the Angus and *Alvin* dives that this activity is patterned after. A printed copy of it will also be interesting reading for those students who are interested in more information.

http://www.divediscover.whoi.edu/

Madin, Kate ***Down to a Sunless Sea*** Raintree Steck-Vaughn Publishers, Austin Texas 2000.

An excellent classroom resource on the world of hydrothermal vents.

and other metals. Scientists suspected that these metals had been brought to the surface of the seafloor dissolved in the super heated water coming from the hydrothermal vents.

Scientists recognized the Red Sea as a young ocean with a mid-ocean ridge running through it and speculated that this same phenomenon might be seen in other areas where the seafloor was spreading apart. Expeditions spanning the globe found similar seafloor sediments near mid-ocean ridges in the Atlantic, Pacific and Indian oceans.

Scientists also began to realize that the massive copper deposits like those found on the island of Cyprus were actually ancient mid-ocean ridges that had been thrust up on land by the collision of tectonic plates.

Unusual Seafloor Rocks

Most of the rocks near the mid-ocean ridges are black but in the late 1960s and early 70s, scientists dredged up mid-ocean ridge rocks with unusual shades of green, orange and brown. After analyzing the minerals in the rocks they concluded that they were the original black rocks transformed by chemical reactions that can only take place in the presence of hot water.

Missing Heat

Another piece of evidence came from predictions that scientists made about how heat would flow through the seafloor. They expected the highest temperature readings in the water to be found over the ridges, where hot mantle rock was rising to the surface. Though this turned out to be the case, the temperatures they found were considerably lower than they expected. They reasoned that if seawater seeping into and circulating through the porous oceanic crust was carrying off heat and discharging it through hydrothermal vents, it could explain the difference between the temperature they found and the temperatures that they expected.

Development of Lesson (Steps)

1. Tell the students they are going back in time to go on a "dive" to discover hydrothermal vents. This dive is patterned very loosely after the dive in 1977 when scientists first found hydrothermal vents (HVTs). Tell them this history leading up to their dive:

Scientists have searched for hydrothermal vents for a decade. They are pretty sure that they exist but nobody has been able to find them.

The theory is that hydrothermal vents spew super-heated seawater—water with temperatures above the boiling point because it is under extreme pressure—out into the ocean, much like hot springs and geysers on land. Vents occur along the mid-ocean ridge where new oceanic crust is formed by molten rock rising to the surface to form new crust between tectonic plates

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that are moving apart. The newly formed crust shrinks and splits as it is cooled by sea water at temperatures approaching freezing near the ocean bottom. Sea water sinks through the cracks into the hot rock below. Because of the heat and the pressure, the water is super-heated and rises, eventually spewing out into the the sea water at the ocean bottom.

The scientists on this 1977 *Alvin* dive do not know exactly what they will find. They expect the water coming out of the vents will be extremely hot, probably toxic because of the hydrogen sulfide content, and loaded with metals. This mission is taking place on the Galapagos Rift where an earlier expedition detected a narrow band of warm water rising 125 feet over the ocean floor. The Navy has made very precise maps of the area. An ANGUS deep tow* last night detected a narrow area of higher temperatures that indicates the possible presence of a hydrothermal vent. The dive has been arranged by a group of geologists, geophysicists and geochemists. The ocean bottom is cold and dark and the pressure at that depth is enormous. The students/scientists will dive to the seafloor in the *Alvin* submersible to try to find the hydrothermal vent.

2. Ask the students what they expect to see. How will they know if they have seen a hydrothermal vent?

3. Tell them to imagine that they are diving in the cramped (2 meters in diameter) quarters of the *Alvin* as you show them the overhead projector sheets provided. Each screen in the overhead projector series shows a picture, time, depth and temperature with a little bit of dialogue. (The time, temperature and depth are made up for this activity and the images are from Dive and Discover's Discovery of Hydrothermal Vents Infomod) Students should record what they see on their "*Alvin* Dive Logs."

5. When they have seen all of the screens, tell students that the water samples and clam sample they brought back from the ocean floor smelled just like rotten eggs. Explain to them that the chemists on board identified this smell as hydrogen sulfide. With this piece of data, the scientists hypothesized that the warm venting water must have carried hydrogen sulfide, which was used by bacteria. They hypothesized that the hydrogen sulfide was the base of the food web, in an area where no sunlight penetrates.

6. Tell students that this simulated dive was based on an actual dive that took place in 1977. Have them consider the following questions.

- •Why did scientists do an ANGUS tow before the *Alvin* dive to the area where the temperature anomaly occurred ?

(The ANGUS tow helped to identify where to go.)

- Why were there only geologists on board?

(No one expected to find life in such an extreme environment.)

Teacher Tip: 1977 Alvin Dive Simulation

To help simulate the dive to this deep sea environment, set up the classroom as the dive site, posting the overhead projector images at various locations around the room. Turn out the lights and let the students move about the room, using flashlights to view/"discover" the organisms in the images. Students should take a clipboard and "Dive Log" handout to record what they find. You may wish to determine a 'dive plan' or sequence of places to visit around the room. For younger students, create a cramped space to simulate the feeling inside Alvin (e.g., 3 students inside a hoola hoop).

Teacher Tip:Using Robert Ballard's "Notes on a Major Oceanographic Find" or ***Down to a Sunless Sea*** by Kate Madin (see resources) you can find out more about the original dive on which this activity was based.

*ANGUS (Acoustically Navigated Geophysical Underwater System) is a 2-ton steel cage equipped with cameras and powerful strobe lights and a sensor that can detect water temperatures changes as small as 0.005°C. It can be navigated in the dark depths with acoustic transmitters that "talk" to the transponders placed on the ocean floor.

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- Why was the discovery of the thriving hydrothermal vent communities was so surprising?

(There is no sunlight—believed to be the base of the food chain for life on Earth—on the ocean bottom.)

- What was the horrible stench that the scientists encountered when they opened up the hydrothermal fluid samples they had taken? *(Hydrogen Sulfide in the vent fluid.)*
- How did this discovery change the way that scientists thought about the investigations that needed to be done at the ridges?

(Biology would have to be considered along with geology, chemistry and physics.)

Extensions:

Have students explore the web-based *Alvin* simulator software called MARVE [http://pangea.stanford.edu/marve/]. MARVE stands for the Marine Virtual Explorer. There is an excellent 2 minute Quicktime Movie you may wish to show your students to get a sense of the exploration with *Alvin.*

Activity 6 – Post Dive Questionaire

1. What did you expect to find at the vent?

2. Describe what you found in detail. Include temperatures as well as visuals and draw what you found.

3. Why was it unexpected to find life at the hydrothermal vent?

4. How do you think the animals are managing to live there without sunlight as an energy source?

Alvin Dive Log

Time	Depth	Observations (organisms, temperatures, etc.)