Activity 2: Precipitates and Black Smokers

Overview:

Students will discuss how hydrothermal fluid is different from seawater and what happens to it as it passes through the oceanic crust. They will observe and manipulate calcium chloride and baking soda to understand how precipitates form.

Background:

In the 1977 cruise that we were mimicking in the first cruise, scientists took samples of liquid "black smoke" and samples of chimney structure (rocks) and found that both contained hydrogen sulfides or some other type of sulfide molecule. The vent chimneys were made up of metal-sulfide and hydrogen sulfide precipitates. In this lesson students make a series of observations to see how precipitates form.

Teacher Tip: This lesson uses graphics and video clips from two Internet sites to introduce concepts to students. If you do not have computer projection capability, you can use the diagram from the previous activity to create your own overhead introduction.

Development of Lesson:

1. Using the Internet, show one of the NeMO site videos referenced in Resources. Ask students what they notice about the material coming out of the hydrothermal vents. What does it look like? (*black and billowing, like smoke*) Point out that it is not actually smoke but a liquid with black particles. It is rising because it's less dense. Ask student how they think the chimney through which the fluid escapes forms. (*precipitates*)

2. Explain that seawater sinking through the oceanic crust goes through many changes. (If possible show the Vent Chemistry page of the Hydrothermal Vent Infomod on Dive and Discover. Click on buttons 1 through 6 giving them the opportunity to discuss what is happening and make notes on their diagrams.).

1. As seawater seeps down through the porous ocean floor, energy radiating up from molten rock deep below heats the water.
2. and 3.The water is stripped of oxygen, potassium, calcium, sulfate and magnesium.
4. As it reaches 150° C, sodium, calcium and potassium dissolved from the surrounding crust enter the fluid.
5. At its highest temperatures, 350-400° C, copper, zinc, iron, and sulfur from the crust dissolve into the fluid.
6. Because it is hotter, the fluid is less dense. Laden with metals, it rises again to the surface of the ocean floor and pours back out into the cold, oxygen-rich seawater.
7. As the hydrothermal fluid meets the frigid oxygen-rich seawater the metals and sulfur combine to form black metal-sulfide minerals which precipitate out of the fluid.

Essential Concepts:

- Because of the intense pressure at the ocean bottom, water can get much hotter without boiling than it can at sea level.
- Superheated seawater goes through changes that turn it into hydrothermal fluid. It carries minerals and metals, dissolved out of the oceanic crust, out into the frigid ocean water at hydrothermal vents.
- Chemical compounds dissolved in water interact to form precipitates of a new compound.
- When superheated hydrothermal fluid carrying dissolved metals, sodium, calcium, potassium and hydrogen sulfide meets the cold, oxygen-rich water of the deep ocean, the metals and sulphur combine to create the black, metal-sulfide compounds that form the chimneys around hydrothermal vents.

Learning Objectives:

Students will be able to:

- describe what changes happen to seawater to make it into hydrothermal fluid.
- describe how precipitates form.
- describe how hydrothermal vent chimneys form.

National Standards:

- Unifying concepts and processes:
  - Evidence, models and explanation
- Physical Science
  - Properties and changes of properties in matter
  - Transfer of energy
- Earth and Space Science:
  - Structure of the earth system

Activity 2 (cont.):

Materials:

- Copies of "Hydrothermal Vent" From the last activity
- Copies of the "How Hydrothermal Vents Work" worksheet from the last activity
- Copies of "Precipitate Observation Chart " for each student.

- For each group of students:
  - 50 ml water
  - 5 ml calcium chloride (Damp Rid, used to remove moisture from closets and other damp areas or salt used to clear roads in the winter)
  - 5 ml of baking soda
  - 3- 8 oz clear plastic cups

Resources:

Dive and Discover

The Dive and Discover Infomod "Hydrothermal Vents" is recommended for presentation during this activity because of its graphics and text on hydrothermal vents.Go to:

Any Expedition : Deeper Discovery: Infomods: Hydrothermal Vents, the pull down section "Hydrothermal Chemistry" is an annotated diagram that is recommended for the student background for this lesson. In the same pull down are recommended pages on "Boiling Points of the Deep" and "Vent Basics."

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

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3. At its highest temperature, hydrothermal fluid reaches 350-300° C. That is when copper, zinc, iron and sulfur dissolve in the fluid. Ask students what the boiling point of water is. (*100°C at sea level*) How can the water be so hot? (*Pressure If possible show them the Boiling Points in the Deep page and show the changes in temperature.*)

4. Engage students in discussing the changes to the hydrothermal fluid. Ask them to add notes about what happens at different temperatures to their "Hydrothermal Vent" diagram and complete Part 2 on their "How Hydrothermal Vents Work" worksheet.

5. (If possible, return to the number 7 on the "Vent Chemistry" page on "Dive and Discover".) When the hydrothermal fluid mixes with the cold oxygen-rich seawater, black metal-sulfide minerals precipitate out. These precipitates create the vent chimneys. Ask the students what a precipitate is.

Observing a Precipitate

Tell the students that, in order to see how precipitates happen, they will investigate a common type of precipitate that occurs under normal pressure and temperature conditions.

Precipitate: A solid separated from a solution or suspension by chemical or physical change.

6. Have the students get into their groups. Distribute the "Precipitate Observation Chart" for each student and 3 clear plastic cups, 5 ml of baking soda, 5 ml of calcium chloride, and 50 ml of water for each group.

7. Have students compare the two chemicals BEFORE MIXING, and make observations on their texture, color, odor, etc. Have them record their observations on the worksheet.

8. DRY: In one of the plastic cups have students mix 1/2 of the dry baking soda with 1/2 of the dry calcium chloride. Once again they should make careful notes on what they observe.

9. SOLUTION: Next, in the second cup, have them mix the other half of the baking soda with 20 ml of water, observe what happens and take notes. Then mix the second half of the calcium chloride with 20 ml of water in the third cup.

10. Ask the students to discuss what has happened to the calcium chloride and baking soda. (*It has dissolved in the water*.) Some compounds can dissolve or break apart and go into solution in water.

11. MIXED SOLUTIONS: Slowly, they should pour the baking soda solution into the calcium chloride solution. Ask the students to observe what happens. They should discuss what they are seeing in their groups and make notes.

Activity 2 (cont.):

12. When the reactions are complete have the groups share with each other what they observed. They should report bubbling which occurred when carbon dioxide gas was released during the reaction. They should also notice a white precipitate, calcium carbonate, on the bottom of the cup.

13. Ask them what caused the reaction. Make sure that they notice that dry calcium carbonate and baking soda did not react.

14. Ask students how this reaction is similar to the reactions that take place at the hydrothermal vents. (it produces a solid precipitate) . How is it different? (different compounds, no superheated fluids, no pressure)

Extension:

White Smokers:

Black smokers are black because of the suspended black metal-sulfide precipitates in the hydrotheral fluid. Give student the hint that white smokers are not as hot as black smokers. Challenge them to come up with a hypothesis about why white smokers are white.

White smokers are not as hot because cold seawater mixes with the rising hydrothermal fluid in the crust before it reaches the seafloor surface. The white smokers are not black because the metal sulfides (the tiny particles that look like black smoke) precipitate out BEFORE the fluid reaches the ocean floor. The white smoke comes from different minerals that form when the cooler hydrothermal fluid exits the chimney and mixes with cold sea water.

Resources (cont.):

NOAA Sites

NeMO New Millenium Observatory

Part of this lesson is an adaptation of a lesson presented The Ocean Exploration Series, Galapagos Rift Expedition, AdVENTurous Findings on the Deep Sea Floor

This site has many good hydrothermal vent and black smoker graphics—both still and video.

http://www.pmel.noaa.gov/vents/nemo/explorer/multimedia.html

A fly through video of the ASHES Site with hydrothermal vents and a Panorama with imbedded video of vents and research can be found at this site at

http://www.pmel.noaa.gov/vents/nemo/explorer/ashes.html

home:

http://oceanexplorer.noaa.gov/edu/welcome.html

Precipitate Observation Chart

Observations

1. Describe what you see with each of the following combinations:

Baking soda alone (DRY):

Calcium chloride alone (DRY):

Baking soda and Calcium chloride (DRY):

Calcium Chloride and water (SOLUTION):

Baking soda and water (SOLUTION):

Baking soda dissolved in water mixed with calcium chloride dissolved in water (MIXED SOLUTION):

2. What reaction (if any) did you see?

3. Describe any precipitates that you noticed.

4. What do you believe caused the reaction? Explain your reasoning.