Investigation: Using Chemistry to Find Vents

Overview

TOPIC: Finding Hydrothermal Vents

FOCUS: Students analyze simple data as evidence to create a model of how scientists find deep-sea hydrothermal vents.

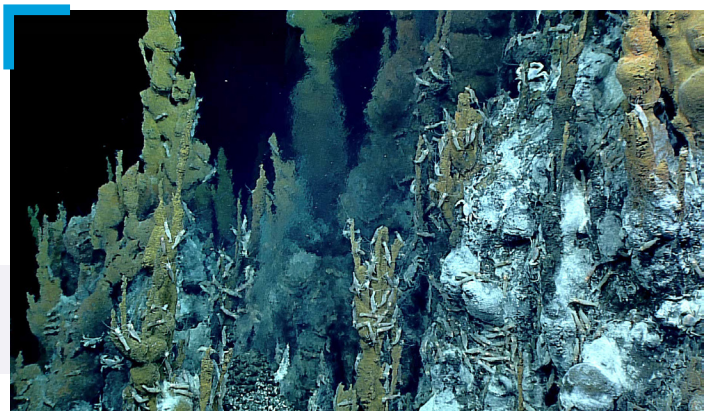
GRADE LEVEL: 6-8 Chemistry

TIME NEEDED: Two 50-minute class periods

PHENOMENON/ DRIVING QUESTION: How do physical and chemical cues help scientists locate hydrothermal vents and other unique deep seafloor habitats?

OBJECTIVE/ LEARNING OUTCOME: Students will:

- Construct an explanation with evidence for how/why scientists use chemical data to determine patterns that help find hydrothermal vents.
- Describe the data collected and the evidence that indicates patterns and relationships between the data and presence of hydrothermal vents.



Hydrothermal vent chimney with vent fluid appearing as dark smoke due to the high levels of minerals and sulfides contained in the fluid. *Image courtesy of NOAA Ocean Exploration.*

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Performance Expectations (PEs)
MS-LS2-1

Disciplinary Core Ideas (DCIs)
MS- LS2.A: Interdependent Relationships in Ecosystems

Crosscutting Concepts (CCs)
Systems and System Models
Patterns
Cause and Effect
Stability and Change

Science & Engineering Practices (SEPs)
Analyzing and Interpreting Data
Constructing Explanations
Developing and Using Models

COMMON CORE CONNECTIONS
RST.6-8.1, RST.6-8.7, SL.8.1, SL.8.4, SL.8.5, 6.SP.B.5

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS
Principle 1: FC b; Principle 5: FCs e,f,g; Principle 7: FCs a,d,f

Overview cont.

MATERIALS:

Student Handout

- Student Worksheet: Using Chemistry to Find Vents (1 copy per student)

Videos

- Oases of Life (3:17) *NOAA Ocean Exploration*
- Using Sonar to Map the Deep Seafloor (8:59) *NOAA Ocean Exploration*
- Hydrothermal Hunt (8:38) *NOAA Ocean Exploration*

Investigation Materials (Set-up for each group of 3-4 students)

- 1 tray for materials
- Six 100 ml beakers or cups labeled A, B, C, D, E, and F
- Access to hot and ice cold water
- 100 ml of hot water - hot but not boiling
- 200 ml room temperature water
- 300 ml of cold distilled water
- 50 ml vinegar
- 1-2 thermometers
- 6 strips of pH paper 2-9 range or 1 pH meter
- 1 pH color indicator chart - colored copies can be made from original
- 1 graduated cylinder to measure vinegar
- Safety gloves and safety goggles

EQUIPMENT

- Computer and projector for class viewing of videos
- Student white boards and multiple colors of dry erase markers OR chart paper and multiple colors of markers to draw models
- *Optional: Student laptops or tablets for extensions and/or additional research*

SET-UP INSTRUCTIONS

- Cue up videos to show the class.
- Prepare the trays per student group *before* use. Assure all samples are labeled and kept at correct temperatures.
- Each cup/beaker should contain approximately 100 ml of water as follows:
  - **A** - cold distilled water
  - **B** - cold distilled water
  - **C** - warm/room temperature water, 10 ml of vinegar
  - **D** - hot water, 30 ml of vinegar
  - **E** - warm/room temperature water, 10 ml of vinegar
  - **F** - cold distilled water

Note: *Students should not know which samples contain the vinegar. In this investigation set up, students are discovering a vent with simulated CTD data.*

Educator Guide

Background

One of the most exciting and significant scientific discoveries in the history of ocean science was made in 1977 near the Galápagos Islands off the coast of Ecuador. Here, at a depth of 2,500 meters (8,250 feet) ocean explorers first sighted hydrothermal vents, openings on the ocean floor from which heated, mineral-rich water emerges. This sighting was a phenomenon that had been predicted but never before confirmed. To their amazement, the scientists also found that these vents were surrounded by large numbers of organisms that had never before been seen. A diverse ecosystem was thriving here—in the absence of the sunlight previously thought to be required to sustain all life!

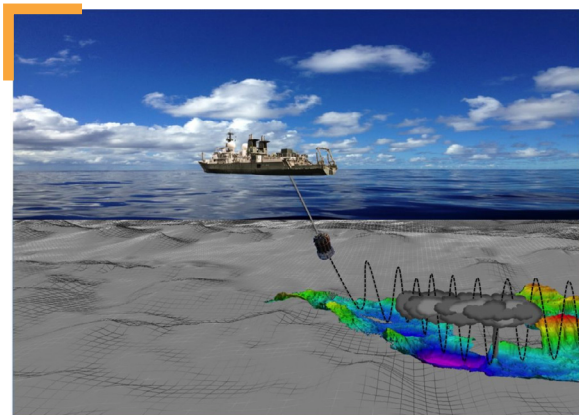


Image of a CTD "tow-yo" showing how the CTD instrument is raised and lowered on a cable as the ship drives slowly forward, allowing it to map the location and sample hydrothermal plumes near the seafloor. *Image courtesy of the Schmidt Ocean Institute, Colleen Peters.*

Vents are found at active tectonic margins (both divergent and convergent). They form as cold seawater penetrates ocean crust near active volcanoes. The water becomes superheated, dissolves some minerals from the surrounding rock (which also makes the water more acidic), and rises into the overlying cold ocean water. As the dissolved materials hit the cold water, minerals precipitate back out, forming chimneys and towers.

Since hydrothermal vents may be several thousand meters deep, finding new areas of hydrothermal vent activity can be quite challenging. Scientists must sample very close to detect high temperatures as the cold surrounding water of the deep sea (at about 2-4 degrees Celsius) rapidly absorbs the heat generated from the vents. That said, chemical signatures from dissolved minerals in the vent fluid and pH changes can be detected for larger distances. In order to detect these thermal and chemical changes and track down hydrothermal vents, ocean explorers use technology like Multibeam Sonar and sampling tools like **C**onductivity, **T**emperature, and **D**epth sensors (CTDs).

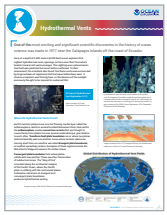
Mapping the seafloor with multibeam sonar can help identify promising areas for further investigation (Locating Hydrothermal Vents), while collecting physical ocean data with a CTD can detect hydrothermal signals in the water column to further narrow the search. One water sampling technique used is to raise and lower a CTD rosette, which may carry a ring of water sampling bottles, called Niskin bottles, used to collect water at different depths, as well as sensors to measure additional physical or chemical properties. As the ship slowly cruises over the area being surveyed, the repeated up-and-down motion of the towed CTD resembles the movement of a yo-yo, hence the nickname “tow-yo” for this type of CTD sampling.

Educator Note

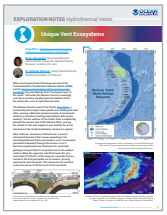
- Students should have prior knowledge of bases/acids and pH ranges. Fact sheets and information links provided in this Educator Guide can be used to give students more context needed to answer the driving question.
- A variety of student interaction techniques and examples of student questions are provided throughout this activity to engage students in the process of sense-making.
- Learn more about these instructional strategies.

FOR MORE INFORMATION:

- *Hydrothermal Vents* *Fact Sheet*

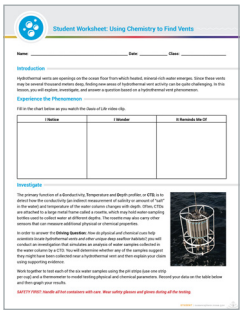


- *Unique Vent Ecosystems* *Exploration Note*



Educator Guide cont.

Experience the Phenomenon



Lead a class discussion and ask students to describe the deep ocean with as much detail as they can, i.e. what lives there, what the environment is like, etc. They may have very little prior knowledge but should mention that it is dark and cold.

Distribute Student Worksheet to each student. They will be able to work together but must write down their answers and draw their own graph.

Play the Oases of Life video **(0:00-2:20 min)** and have students complete their Notice/Wonder/It Reminds Me of chart on their worksheet as they view the video clip.

After showing the video clip, restate the **Driving Question:** *How do physical and chemical cues help scientists locate hydrothermal vents and other unique deep seafloor habitats?*

Instruct students to discuss their video observations and ideas in their group. Tell them to brainstorm all the ways they think scientists are able to look for and find hydrothermal vents when only a small percentage of the ocean has been explored.

Have each group share out an idea with the class. Record their responses on a class chart or whiteboard.

Guiding Questions:

- What makes you think about that idea? Explain.
- What evidence or information helps support your proposed idea(s) of how to find hydrothermal vents?
- How does this evidence connect to what you already know?
- What more is needed to answer the driving question?

Guide students to come to the consensus that vents give off heat and chemicals. They do not need to understand the names of the chemicals but can be guided to know that pH can be used as an indicator of change in the water chemistry. They may also mention the “smoke” or black color in the water, known as “particles.”

Play video clips **0:55-2:00 min** and then **4:50-6:00 min** from Using Sonar to Map the Deep Seafloor.

As a class, *briefly* discuss how multibeam sonar works via the clip and ask students how mapping is important to finding new seafloor ecosystems.

TEACHER NOTE

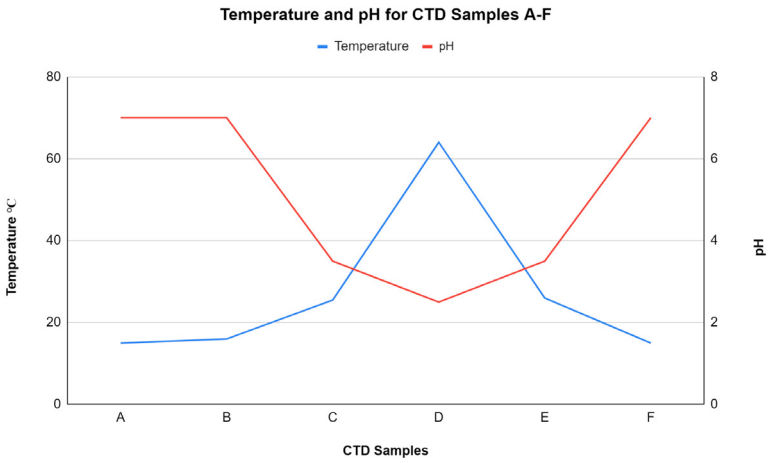
These short video clips on mapping are intended to provide more context and information for students. These are not meant to dive into all the details of how mapping works, but instead guide them to understand that mapping is one tool used to locate areas of interest or in this case, where a hydrothermal vent might be located. Mention that mapping, in conjunction with other sampling tools, can help scientists narrow their search areas when looking for vents.

Educator Guide cont.

Investigate

Distribute the pre-prepared trays of materials to each group. Students will collect pH and temperature data on all six water samples and graph their results.

Optional: Since each group will only do one replicate, you can choose to have the class share and compare their data readings to see if there is consensus on average pH and temperature for each sample.



Play the CTD video. The student worksheet also provides basic CTD information along with directions on how to conduct the investigation.

Walk around the room and check on student tables and graphs. A sample graph is provided as a reference. Student readings may differ slightly but should show a similar trend for both pH and temperature.

TEACHER NOTE

This investigation simulates an analysis of water samples collected by a CTD to determine whether any of the samples suggest they might have been collected near a hydrothermal vent. Students will use all they learned in the Experience the Phenomenon and Investigate sections to help them answer the driving question. Depending on the level of students, guide them to temperature, pH, and particles as key indicators that a vent may be near.

Put the Pieces Together

Make sure students answer **Question 1** on their worksheet before they move on to drawing their models.

Ask them to draw a model of where a vent could be located in the water based on the data they gathered.

Note: Students may not draw their first model as noted in the "tow-yo" images above. The purpose of the lesson is to get them to think about how chemistry is used to help locate vents. Models will/should be refined after showing the video clips as they put all the pieces together.

Play clips **2:00-3:10 min** and then **4:35-5:40 min** of the Hydrothermal Hunt video. After the video clips, ask if there are any questions. Then, give students a chance to refine and/or redraw their final models on their student worksheet. Check for understanding by walking around and reviewing student drawings. Answer any final clarifying questions.

Educator Guide cont.

Extension

• Have students create a short report out or presentation based on the In Search of Hydrothermal Lost Cities expedition that includes additional technologies and tools for finding hydrothermal vents.

Scientific Terms

Hydrothermal Plumes: Created and sustained by the heat of volcanic processes along the Mid-Ocean Ridge system that circles the globe.

Hydrothermal Vent: Opening on the ocean floor from which heated, mineral-rich water emerges.

Chemosynthesis: Process by which food is made by bacteria or other living things using chemicals as the energy source, typically in the absence of sunlight.

pH: An inverse of hydrogen ion concentration, so more hydrogen ions translates to higher acidity and a lower pH.

Thermal Energy: Total of all kinetic energies within a given system.

Assessment

Opportunities for formative assessment are embedded throughout the lesson through class discussions. The student explanations and drawings that are developed at the end of the lesson could be used as an opportunity for summative assessment.

LOOK FORS:

The following components should be included in students' final explanations and models.

- Sample D could indicate a site of hydrothermal vent activity.
- Heat, particle content, and concentration of chemicals contained in vent fluids are some of the physical or chemical properties that may be used to detect hydrothermal plumes.
- A temperature anomaly is a difference in temperature between a hydrothermal plume and the surrounding seawater.
- A particle anomaly is a difference in the concentration of suspended particles in a hydrothermal plume compared to the surrounding seawater.
- Diagram labels should include CTD, seafloor, water column, hydrothermal vent, data points for temperature and pH.

Educator Guide: Links and URLs

Page 1:
- Hydrothermal vent chimney (image): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1605/dailyupdates/media/may2-hires.jpg

Page 2:
- Using Chemistry to Find Vents (PDF): https://oceanexplorer.noaa.gov/edu/materials/investigation-using-chemistry-to-find-vents-student-worksheet.pdf
- Oases of Life (video): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1605/logs/may12/media/video/vents-1280x720.mp4
- Using Sonar to Map the Deep Seafloor (video): https://oceanexplorer.noaa.gov/edu/multimedia-resources/dsd/media/2023-DSD-Mapping-v6-1920x1080.mp4
- Hydrothermal Hunt (video): https://www.youtube.com/watch?v=YDyWrwO4nJA
- Macherey-Nagel, pH Strips 2.0-9.0 (webpage): https://www.amazon.com/Macherey-Nagel-92118-pH-Fix-2-0-9-0-Strips/dp/B00S1ULX8Y/ref=sr_1_5?crid=1ROM9WG419M7T&keywords=pH+test+strips+2-9&qid=1703093265&s=industrial&sprefix=ph+test+strips+2-9%2Cindustrial%2C170&sr=1-5
- pH meter (webpage): https://www.amazon.com/dp/B08HLXBBK4?ref_=cm_sw_r_cp_ud_dp_80KGGNA95T0SZAR2AEGP&th=1

Page 3
- Hydrothermal Vents (image and webpage): https://deepoceaneducation.org/resources/tracking-down-hydrothermal-vents-at-the-mariana-back-arc/
- Locating Hydrothermal Vents (webpage): https://deepoceaneducation.org/resources/locating-hydrothermal-vents/
- Tracking Down Hydrothermal Vents (PDF): https://oceanexplorer.noaa.gov/edu/materials/tracking-down-vents-exploration-notes.pdf
- Multibeam Sonar (PDF): https://oceanexplorer.noaa.gov/edu/materials/multibeam-sonar-fact-sheet.pdf
- CTD (video and webpage): https://oceanexplorer.noaa.gov/technology/ctd/ctd.html
- Making Sense of Deep Sea Phenomenon (PDF): https://oceanexplorer.noaa.gov/edu/materials/NOAA-NSTA-sensemaking-phenomenon.pdf
- Hydrothermal Vents Fact Sheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/hydrothermal-vents-fact-sheet.pdf
- Unique Vent Ecosystems Fact Sheet (PDF): https://oceanexplorer.noaa.gov/edu/materials/vent-ecosystems-exploration-notes.pdf

Page 4
- Oases of Life (video): https://oceanexplorer.noaa.gov/okeanos/explorations/ex1605/logs/may12/media/video/vents-1280x720.mp4
- Using Chemistry to Find Vents (PDF): https://oceanexplorer.noaa.gov/edu/materials/investigation-using-chemistry-to-find-vents-student-worksheet.pdf
- Using Sonar to Map the Deep Seafloor (video): https://oceanexplorer.noaa.gov/edu/multimedia-resources/dsd/media/2023-DSD-Mapping-v6-1920x1080.mp4

Page 5
- Hydrothermal Hunt (video): https://www.youtube.com/watch?v=YDyWrwO4nJA
- CTD (video): https://oceanexplorer.noaa.gov/technology/ctd/ctd.html

Page 6
- In Search of Hydrothermal Lost Cities (webpage): https://oceanexplorer.noaa.gov/explorations/23lost-cities/welcome.html

Information and Feedback

We value your feedback on this activity package, including how you use it in your formal/informal education settings. Please send your comments to: oceanexeducation@noaa.gov. If reproducing this lesson, please cite NOAA as the source, and provide the following URL: https://oceanexplorer.noaa.gov.