
# Activity 1: Reading Maps of the East Pacific Rise

## Essential Concepts:

- Maps provide vital information to scientists studying the ocean floor.
- The information for maps can be collected by a number of different means and interpreted in a number of different ways.
- The EPR is a relatively steep ridge with a narrow valley running along the top.

## Learning Objectives:

Students will be able to:

- Make qualitative and quantitative observations
- Use various maps to understand the features of the East Pacific Rise
- Discuss the differences between various types of maps.
- Describe the technology and instruments used to collect data and create ocean bottom maps and how that data is used to produce maps.

## National Standards:

Unifying Concepts and Processes:
Evidence, models and explanation.
Earth and Space Science:
Structure of the earth.
History and Nature of Science:
Science as a human endeavor.

## Time Frame: 1-2 period

## Materials:

- A copy of the worksheet "Understanding Maps of the East Pacific Rise" for each student.

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## Overview:

In this activity, students study actual bathymetric maps of the EPR region. They will learn to identify key features of the ridge and will explore the concept of resolution.

## Background

**Sonar Mapping**

Single beam echo sounder maps and Sunbeam—also known as Multi-beam—sonar maps are made with sonar from the ship at the ocean's surface.

Single beam echo sounders transmit and receive sound waves. The returned echo is amplified and recorded. The time taken for the sound to travel through the ocean and back is used to calculate the water depths. Scientists typically use echo sounders, that transmit sound at 12 kilohertz (kHz), to determine how far down the seafloor is.

$$\underset{\text{(meters)}}{\text{DEPTH}} = \underset{\text{(meters/sec)}}{\text{SPEED OF SOUND IN SEAWATER}} * \frac{\text{TIME(seconds)}}{2}$$

They use a lower frequency (3.5 kHz) sound, which penetrates the seafloor, if they want to "see" accumulated layers of sediments below it.

Multi-beam sonar is a modern, faster type of ship-based sonar. It uses an array of as many as 120 beams of sound sent from the hull of a ship simultaneously, in a very precise geometric pattern. All the returning signals are processed by computers on board the ship, converted into water depths, and plotted as a bathymetric map with an accuracy of about 10 meters.

Microbathymetry is very detailed and made with the newest underwater vehicle, named ABE, for Autonomous Benthic Explorer. ABE is a robot that can be programmed to go to the ocean bottom and collect data very close to the ocean floor. Sonar transmissions collected this way do not have to travel through a mile of ocean and they are much more precise.

Software can also enhance the data and help scientists to look at it a different way. Map 3-D Cochran (A2M7) is made from the same data as map Cochran (A2M4), but is manipulated to show it as a 3-D object.   Some students may be familiar with how this is done with CAD programs.


# Activity 1 (cont.)

## Development of Lesson

1. Using an overhead projection copy of "The Ridge Multibeam Synthesis Project World Map," ask students to locate the box for the Northern East Pacific Rise—roughly between 8° and 11° N latitude and 105° and 103°W longitude. Point out the Galapagos Spreading Center—where the first hydrothermal vents were discovered. ( If you did Cruise 1 Activity 6 with your class, this is the area that was covered.)

2. Discuss latitude and longitude. Explain that latitude and longitude lines form a grid around the earth on which all points can be located. Latitude and longitude are critical for mapping and for deep-sea investigations, as they provide a standardized way to locate places on Earth. (If you did Cruise 1 - Activity 4 - Part 2, encourage students to see a connection between a standardized grid system of the world with longitude and latitude lines and the labels they chose for the graph on the Mystery Box to enable sharing their sounding data. Explain that longitude and latitude lines are more complicated because they locate positions on a globe rather than a flat surface.)

3. Explain that latitude lines are parallel to the equator. There are 180 equally spaced lines. Latitude is used to locate positions on earth relative to the equator. There are 360 longitude lines running from north to south through the north and south poles. They help to locate a position on the globe relative to the longitude line that runs through Greenwich, England (0°). Because all longitude lines meet at the north and south poles the length of longitude minutes and degrees vary according to how close the location is to the poles.

1 degree (°) latitude = 60 nautical miles = 69 miles = 111 kilometers

1 degree (°) latitude = 60 minutes (')

1 minute (') latitude = 1 nautical mile = 1.15 miles = 1.852 kilometers

This does not apply to Longitudes!

4. Project the *Alvin* Sample and Rock Core Location Map. Explain that these maps were made to show locations where rock cores and *Alvin* samples were taken. Encourage the students to look at the longitude and latitude notations. Ask them to look at the 3 maps and describe how they are related. Which shows the greatest area? Which shows the most detail? (They represent progressively smaller areas).

5. Have students form groups. Give each group dry erase markers, a ruler and laminated color copies of Map 1 Macdonald, Map 2 Cochran, Map 3 Microbathymetry of the East Pacific Rise, and Map 4 The Illuminated Microbathymetry of the East Pacific Rise. Tell them that these 4 maps are related in a similar way to the projected map. Ask them to put the maps in order from the one that represents the largest area to the one that represents the smallest area. Ask students to explain their reasoning for the order they choose.

## Materials (cont.):

- An over head projector copy of "Submersibles" (This is a collection of images off of the Dive and Discover Site. If you are able to project websites for your students, this site has a great deal more information and photos available than this small collection. We recommend using it instead.)

**Maps:**

**Overhead projection copies of:**
- The Ridge Mutlibeam Synthesis Project World Map
- *Alvin* Samples and Rock Cores on the East Pacific Rise
- Map 2 Cochrane
- 3-D Cochran
- [optional for extension:DSL120 and DSL120 Detail]

**One set of 4 laminated, color maps for each group:**
- Map 1 Macdonald,
- Map 2 Cochran
- Map 3 Microbathymetry of the East Pacific Rise
- Map 4 The Illuminated Microbathymetry of the East Pacific Rise.

## Resources

**Dive and Discover**
- **Expedition 7** on the Dive and Discover site for May 28 and 29. Go to: Expedition 7: Daily Update: on the calendar click on June 1st: then hit the back arrow on the calendar to get to May: click on May 28th. The text, the maps and the mathematical question on this page are excellent extensions to this

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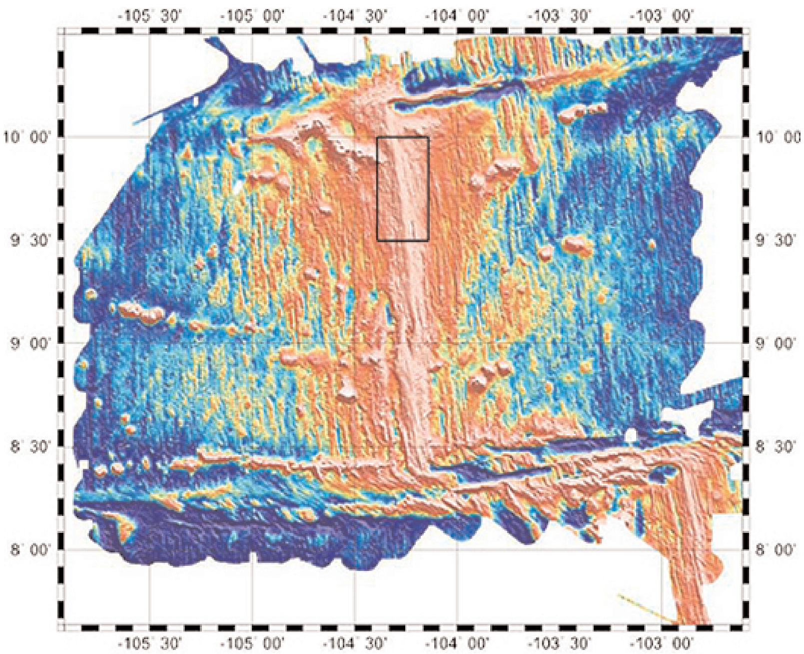
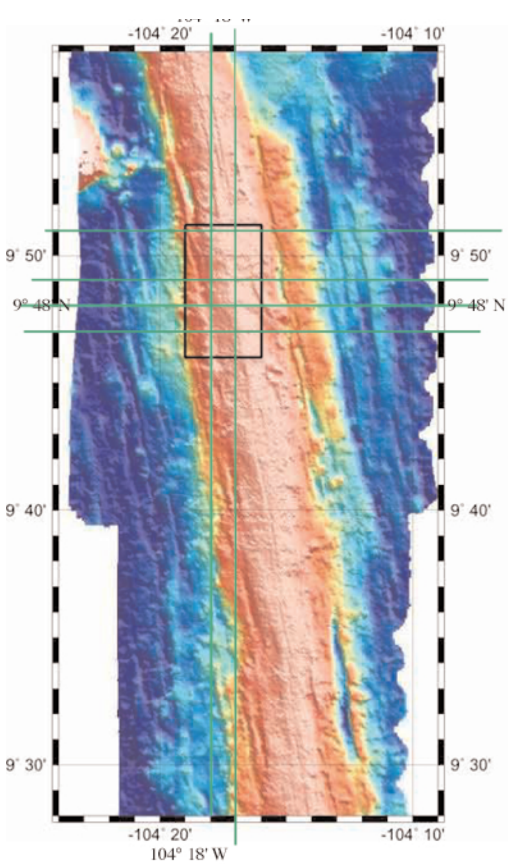
# Activity 1 (cont.)




6. Using dry erase markers and a ruler and reading the longitude and latitude notations on the maps, have the students mark the maps representing larger areas to show the location of the next smaller area map. Ask the groups to study the maps to locate distinctive features from one map to another and note the differences in the way that they are represented including resolution, use of color, contour lines and use of shading.

7. Distribute the worksheet "Understanding Maps of the East Pacific Rise." Encourage students to work together in groups to answer the questions.

8. Once students have had a chance to explore their maps ask them to share their observations with the class. What have the learned about the shape of the East Pacific Rise? (Relatively steep ridge with a narrow trough in the center;) Encourage students to compare the differences between the usage of color in the various maps. Why do they think that the scientists made different choices for the color for the depths on each of the maps?

9. Encourage students to notice and talk about the different styles of the maps. Which is more detailed? Do they appear to be made by different methods?

## Resources (cont.)

activity. May 29th provides interesting information about some of the challenges to this work and the solution to the May 28th mathematical question.

- **Oceanographic tools:** Go to Expedition 6: About the Cruise: Oceanographic tools; click on the pictures: Argo 2, Jason, ABE, and DSL120
- Dive and Discover Expedition 4: Map Poster. These pdf files have good basic information on latitude and longitude. Go to: Any expedition after #4: Deeper Discovery: Resources: Teacher Resources: scroll down to Map Poster: Youa can download pdf files: Map Poster, Map Text 1 and Map Text 2.

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

**Ridge Multi-Beam Synthesis Project Website.**
This site offers many downloadable maps of the EPR area as well as other ridge areas around the globe. The section "Explore Data Using Premade Maps and Grids" provides access to a variety of multi-beam sonar maps organized by region. And "See What It Would Be Like To Fly Over The Seafloor" is an animation showing what it would be like to fly along the crest of the Mid-Ocean Ridge.
http://oceanridge.ldeo.columbia.edu/

# Activity 1 (cont.)

Explain to students that the first two maps in their packet (Macdonald Sunbeam Sonar and Cochran Sunbeam Sonar) are made with ship-based sonar.

10. Show the overhead projector copy of “Submersibles” or the “Oceanographic Tools” Infomod on the Dive and Discover site. Tell the students that in addition to the research ships, scientists have developed a number of other tools to explore and map the ocean bottom. Students have already learned about the manned submersible *Alvin*. The high-resolution “EPR Microbathymetry Detail” map was made using ABE, the Autonomous Benthic Explorer. Because ABE can travel just above the ocean floor, it can produce sonar readings that are much more accurate than those that have to travel through a mile of seawater. These maps have higher resolution. The fourth map, “EPR Illuminated Microbathymetry Detail,” is a detailed illuminated microbathymetry map using the 675 kHz Imagenex scanning altimeter on ABE.

**RESOLUTION:**

When describing maps, resolution refers to the amount of detail represented on a map. A high resolution map has more detail than a low resolution map.

11. Project “Map 2 Cochran.” Tell the students that scientists can also use computer programs to enhance the mapping data they collect. Scientists were able to take this map and make it 3-D. Show them the overhead copy of “3-D Cochran.” Ask if any of them are familiar with CAD programs (like Rhino) that create 3-D images from data.

## Extensions:

Another map-making tool available to today’s scientists is the DSL 120, an underwater vehicle tethered to the ship by a long fiber optic cable. The DSL120 is equipped with side scan sonars. These sonars measure two things:

- the intensity of the returning waves which tells them what kind of surface (hard or soft) the sound is bouncing off of and
- the bathymetry or contours of the surface.

Show the “DSL120” and “DSL120 Detail” maps.

Encourage students to identify the trough in the middle of the ridge and the lava flow easily seen on the “DSL120 Detail “ map. Have them describe what they think they are seeing.

**NOTE**: The parallel lines observed on the “DSL120” map are an artifact of the DSL scan process. To create a map, many overlapping images are strung together. The lines indicate the edges of each sweep of the machine.

# Understanding Maps of the East Pacific Rise

1 degree (°) latitude = 60 nautical miles = 69 miles = 111 kilometers
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1 minute (') latitude = 1 nautical mile = 1.15 miles = 1.852 kilometers.

This does not apply to Longitudes!

1. List the four maps from the largest area to the smallest. Read the longitude and latitude notations on the maps. Using a ruler and dry erase marker, show where each of the three smaller maps fit on the next larger map.

2. One of the major features on the Macdonald map is a ridge (like a mountain ridge) running north to south. Describe in latitude and longitude where this ridge is.

3. Compare Map 1 Macdonald and Map 2 Cochran. Do the colors on these two maps indicate the same depths? If not, why might the color keys be different?

4. What is the length (in miles and kilometers) of the portion of the East Pacific Ridge that is shown on Map 2 Cochran? Is one side of the ridge steeper than the other? If so, which side?

5. Give the latitude, longitude and depth of the deepest point on Map 2 Cochran.

6. Give the latitude, longitude and depth of the highest point on Map 2 Cochran.

7. Compare Map 2 Cochran and Map 3 EPR Microbathymetry Detail. Which map has more detail?

8. Find the Axial Summit Caldera Trough (ASCT - the trough running the length of the ridge summit) on the EPR Microbathymetry Detail map. Describe in detail the portion of the ASCT that you can see. What is its depth? length?

9. Compare Map 3 Microbathymetry Detail with Map 4 EPR Illuminated Microbathymetry Detail. How are they different? What do you think the stars mark?

# Understanding Maps of the East Pacific Rise - Teacher's Key

1 degree (°) latitude = 60 nautical miles = 69 miles = 111 kilometers
1 degree (°) latitude = 60 minutes (')
1 minute (') latitude = 1 nautical mile = 1.15 miles = 1.852 kilometers.
This does not apply to Longitudes!

1. List the four maps from the largest area to the smallest. Read the longitude and latitude notations on the maps. Using a ruler and dry erase marker, show where each of the three smaller maps fit on the next larger map.

*Macdonald, Cochran, Microbathymetry & Illuminated microbathymetry (same)*

2. One of the major features on the Macdonald map is a ridge (like a mountain ridge) running north to south. Describe in latitude and longitude where this ridge is.

*8° 30'N to 10° 10'N and -104° 10'W to -104° 20'W (not quite north south).*

3. Compare Map 1 Macdonald and Map 2 Cochran. Do the colors on these two maps indicate the same depths? If not, why might the color keys be different?

*color key is unique to each map and is determined to cover range of depths in map area*

4. What is the length (in miles and kilometers) of the portion of the East Pacific Ridge that is shown on Map 2 Cochran? Is one side of the ridge steeper than the other? If so, which side?

30' = 30 nautical miles (34.5 miles) (55.56 km). It looks like portions of the left side (west face) of the ridge are steeper since the colors go from red to blue in a shorter distance.

5. Give the latitude, longitude and depth of the deepest point on Map 2 Cochran.

*deepest: 9° 54'N -104° 11'W -3000m;*

6. Give the latitude, longitude and depth of the highest point on Map 2 Cochran.
*highest: 9° 45'N -104° 15'W -2150m (or anywhere along the ridge axis)*

7. Compare Map 2 Cochran and Map 3 EPR Microbathymetry Detail. Which map has more detail?

*Microbathymetry had more detail. Can see trough on ridge*

8. Find the Axial Summit Caldera Trough (ASCT - the trough running the length of the ridge summit) on the EPR Microbathymetry Detail map. Describe in detail the portion of the ASCT that you can see. What is its depth? length?

*depth: -2546m from -2533m or ~13 m, length: 9° 49.8' to 9° 50.65' or .85 of 1' = .85 nautical mile (1.15 * .85 = .9775 miles) (1.852 * .85 = 1.5742 km)*

9. Compare Map 3 Microbathymetry Detail with Map 4 EPR Illuminated Microbathymetry Detail. How are they different? What do you think the stars mark?

*same area, different color scheme, added contour lines - aids readability, shading adds 3D look - easier to spot high points. Stars mark vents.*