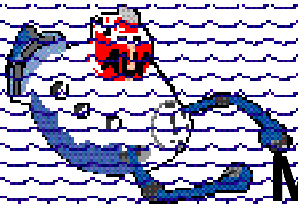


Mapping the Canyon

Focus
Bathymetry of Hudson Canyon

Grade Level
9 - 12

Focus Question
What are the differences between bathymetric maps and topographic maps?

Learning Objectives
Students will be able to compare and contrast a topographic map to a bathymetric map.

Students will investigate the various ways in which bathymetric maps are made.

Students will learn how to interpret a bathymetric map.

Adaptations for Deaf Students
None required

Materials
Part I:
- ❒ 1 Hudson Canyon Bathymetry map transparency
- ❒ 1 local topographic map
- ❒ 1 USGS Fact Sheet on Sea Floor Mapping

Part II:
- ❒ 1 local topographic map per group
- ❒ 1 Hudson Canyon Bathymetry map per group
- ❒ 1 Hudson Canyon Bathymetry map transparency
- ❒ Contour Analysis Worksheet

Part III:
- ❒ Library Books

Audio / Visual Equipment
Overhead Projector

Teaching Time
Two 45-minute periods

Seating Arrangement
Cooperative groups of two to four

Maximum Number of Students
30

Key Words
Topography
Bathymetry
Map
Multibeam sonar
Canyon
Contour lines
SONAR
Side-scan sonar
GLORIA
Echo sounder

Background Information
A map is a flat representation of all or part of Earth's surface drawn to a specific scale (Tarbuck & Lutgens, 1999). Topographic maps show elevation of landforms above sea level, and bathymetric maps show depths of landforms below sea level. The topographic elevations and the bathymetric depths are shown with contour lines. A contour line is a line on a map representing a corresponding imaginary

line on the ground that has the same elevation or depth along its entire length (Tarbuck & Lutgens, 1999).

Since the ocean floor is not visible to us, it is difficult to map. Scientist use various techniques to gather data for a bathymetric map. In the early 1800's, mariners took depth records in shallow waters with a weight on a line. Then in 1854, a depth-sounding device was attached to the line instead of the weight. This made determining when the line hit the bottom of the ocean easier; however, recording a small section of the ocean still took hours or even up to a day. Because the ocean is so large and deep, this procedure is not feasible. As a result, mapping the seafloor takes much longer than it takes to map areas on land.

During World War II, when submarine warfare was the highest in the Atlantic and Pacific Oceans, sonar developed rapidly. Sonar devices use echoes from the ocean floor to measure ocean depth (Metzger, 1999). After World War II, with the increased use of sonar, hesitations about a featureless seafloor where dispelled. Scientists were able to map ocean trenches, ridges, plains, and submerged islands.

Today, scientists are working on advances to make sonar more accurate. They have created a side-scan sonar device called GLORIA (Geologic Long-Range Inclined Asdic). Side-scan sonar is towed behind a vessel and is able to scan the depth along the sides of the vessel as well as the depth directly below the vessel. GLORIA has been able to make detailed maps of the continental margin along the North American coast. Another advance to sonar is the multibeam sonar. By emitting signals of different frequencies, multibeam sonar allows for a detailed three-dimensional map of the seafloor. Even with all of these new advances in bathymetric mapping, only a limited portion of the vast seafloor has actually been mapped.

LEARNING PROCEDURE

Part I:

1. Introduce topographic maps and bathymetric maps to the students
2. Hand out USGS Fact Sheet on Sea Floor mapping

Part II:

1. Have student groups gather the following materials:
   a. 1 local topographic map per group
   b. 1 Hudson Canyon bathymetry map per group
   c. 1 Contour Analysis Worksheet per student
2. Have students observe and analyze the two different maps using the Contour Analysis Worksheet.

Part III:

1. Have student groups research and give presentations on the different techniques used to collect depth data for bathymetric mapping.
2. Topics could include:
   a. Echo sounder
   b. Seismic reflection profiles
   c. Multibeam sonar
   d. Weighted wires
   e. Sonar
   f. GLORIA
   g. World War II and sonar

The BRIDGE Connection

woodshole.er.usgs.gov/epubs/openfiles/ofr98-616/titlepage.html

Connection to Other Subjects

Mathematics
Language Arts

Evaluations

Students will write a paragraph summarizing what they learned about the bathymetry of the Hudson Canyon.

Teacher will review each student's Contour Analysis Worksheet.

Teacher will review presentations given by students on the various techniques used to map the bottom of the ocean floor.

Extensions

- Ask students to write a short essay comparing the Grand Canyon to Hudson Canyon.
- Make a clay model of the Hudson Canyon.
- Ask students to identify all of the deep-sea canyons found along the Atlantic Coast.
- Visit the Ocean Exploration Web Site at www.oceanexplorer.noaa.gov
- Visit the National Marine Sanctuaries web page for a GIS fly-through of the Channel Islands National Marine Sanctuary at http://www.cinms.nos.noaa.gov/

References:

Maddocks, Rosalie F., 2000, Introductory Oceanography Lecture 4A: The Ocean Floor. (www.uh.edu/~rmaddock/3377/3377lecture4a.html) Department of Geosciences, University of Houston

Metzger, Ellen P., 1999, "Submarine Mountains Teachers Guide". (www.ucmp.berkeley.edu/fosrec/Metzger2.html)

Tarbuck, E.J., and Lutgens, F.K., 1999, EARTH *An Introduction to Physical Geology* (6th ed.): Prentice Hall, Inc., Upper Saddle River, New Jersey, p. 450-452

National Science Education Standards

Science as Inquiry - Content Standard A:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Earth and Space Science – Content Standard D

- Structure of the Earth system

Science and Technology - Content Standard E

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives - Content Standard F:

- Science and technology in society

History and Nature of Science – Content Standard G:

- Nature of science
- History of science

Contour Analysis Worksheet

1. Collect the following materials from your teacher:

    a. 1 local topographic map

    b. 1 bathymetric map of Hudson Canyon

2. What is the scale on the topographic map?

3. What is the scale on the bathymetric map?

4. Why do you think the scales are so different?

5. What is the contour interval on the topographic map?

6. What is the contour internal on the bathymetric map?

7. What do the two contour intervals indicate?

8. What do the colors represent on a topographic map?

9. What do the colors represent on a bathymetric map?

10. Why do these color schemes differ?

11. What is the highest feature on the topographic map? What is its elevation?

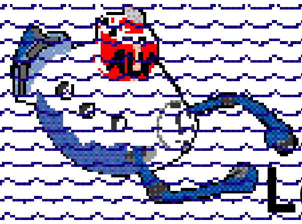
12. What are the latitude and longitude coordinates of this feature?

13. Locate Hudson Canyon on the bathymetric map. What is the depth of the deepest part?

14. What are the latitude and longitude coordinates of the Hudson Canyon?

15. Why is it important for the submarine ALVIN to know the bathymetry of Hudson Canyon?

16. Write a two-paragraph summary comparing and contrasting topographic maps to bathymetric maps.



Let's Bet on Sediments!

Focus
Sediments of Hudson Canyon

Grade Level
9 - 12

Focus Question
How is sediment size related to the amount of time the sediment is suspended in water?

Learning Objectives
Students will be able to investigate and analyze the patterns of sedimentation in the Hudson Canyon

Students will observe how heavier particles sink faster than finer particles.

Students will learn that submarine landslides (trench slope failure) are avalanches of sediment in deep ocean canyons.

Students will infer that the passive side of a continental margin is not as geologically quiet as previously thought.

Adaptations for Deaf Students
Teaching Time:
- Two 45-minute periods

Materials
Part I:
- ❒ Exploring Ocean Frontiers: Hudson Canyon overhead.

Part II: (per group of 2-4)
- ❒ 3 large jars with lids (e.g. Snapple bottles)
- ❒ 1/2 cup of each of the 3 various sediments (pebbles, sand, silt)
- ❒ Water - enough to fill the 3 large jars
- ❒ 1 Sediment Analysis Worksheet
- ❒ 1 Stop watch
- ❒ 1 Magnifying glass
- ❒ 1 plastic spoon

Part III Demonstration Extension:
- ❒ 1-10 gallon aquarium
- ❒ 1/2 cup of each of the 3 various sediments used in Activity One
- ❒ Water - enough to fill the aquarium
- ❒ 1 hair dryer
- ❒ 1 aquarium filter

Audio/Visual Equipment
Overhead Projector for Part I

Teaching Time
One 45-minute period

Seating Arrangement
Cooperative groups of two to four

Maximum Number of Students
30

Key Words
Turbidites
Sedimentation
Sediments
North American Plate
Suspension
Deep sea fans
Active continental margin
Passive continental margin
Topography
Turbid
Turbidity currents
Shelf break
Continental shelf
Continental slope
Continental rise
Submarine canyon
Graded bedding
Avalanche

Background Information

The two most notable topographic features of the oceans are the continental margin and the deep sea. Continental margins are described as either active or passive. Active margins are found along plate boundaries where earthquakes and/or volcanoes are common. Passive margins are not associated with plate boundaries and experience little volcanism and few earthquakes. They are found around the area of the Atlantic Ocean. The profile of the passive continental margin includes the continental shelf, continental slope, and continental rise.

The continental shelf is a broad, gently sloping platform that extends from the shoreline to the edge of the continental slope. Here, on the shelf, there are thick accumulations of coarse and fine-grained sediments. In comparison, the continental slope is a shelf break with an abrupt drop. Sediments on the steep continental slope are mostly soft mud, which is finer than sediments found on the shelf. When the continental slope begins to flatten it is called the continental rise.

The continental rise is composed of thick accumulations of sediment which have fallen from the continental shelf. The sediments delivered by turbidity currents form deep-sea fans at the base of the slope. Some 78% of the world's sediments are trapped within these three zones (R. Maddock, 2000). These three zones are the thickest and most continuous along passive continental margins.

The Hudson Canyon, located on the passive margin (Atlantic Coast) of the North American Plate, is a deep steep-sided valley, called a submarine. Submarine canyons along the Atlantic coast usually have V-shaped profiles, steep walls, rock outcrops, flat floors, strong currents, and deep-sea fans. Most are located on the upper, steeper part of the slope. The canyons, which run perpendicular to the shelf, cross the continental shelf and continental slope; some even cross the continental rise! Some, but not all, submarine canyons are located off the mouths of major rivers. As these submarine canyons cut through soft surface sediments and the harder layers beneath, they expose a range of rock types and ages.

During the Pleistocene era, when sea levels were low, the Hudson River extended across the exposed area of what is now the continental shelf. Over time, the Hudson River eroded the land to form the Hudson Canyon. When sea level rose, the canyon was covered with water. Instead of emptying directly into the ocean at the edge of the continental shelf, the Hudson River then emptied into the Hudson Canyon. Today, the landward margin of the Hudson Canyon has been filled with sediments, but the rest of it continues to be eroded by ocean currents. The Hudson Canyon extends 240 km out to sea and then continues for another 240 km across the continental rise (R. Maddock, 2000).

When sediments such as sand, dirt, silt, and other fine particles become suspended in water by currents, the water becomes murky, or turbid. Turbidity currents, down-slope movements of sediment-laden water (Tarbuck & Lutgens, 1999), continuously erode many submarine canyons such as the Hudson Canyon. These currents are set into motion when sand and mud on the continental shelf are loosened, perhaps by melting of gas hydrates, an over-steepened slope, or an earthquake. They then are mixed with the water to form a dense suspension. As this sediment-laden suspension acts like an avalanche and flows down-slope, it erodes and accumulates more sediment. This erosion process is thought to be the major force in growth of submarine canyons. As the turbidity currents lose momentum, they deposit sediment as deep-sea fans at the bases of the submarine canyons. These deposits, called turbidites, are characterized by a decrease in sediment size from bottom to top known as graded bedding. As sediments settle to the bottom, coarser, heavier particles settle out first and are followed by finer sand and then finer clay. Since fine particles remain suspended in the water column longer periods of time than larger, denser particles, the finer particles are carried out farther, often to the edge of the shelf, before they are deposited.

Learning Procedure

Part I Discussion:

Using the "Exploring Ocean Frontiers: Hudson Canyon" overhead, explain the features of a passive continental margin. Introduce submarine canyons and the location of Hudson Canyon.

Part II Activity:

1. Have student groups gather the following materials:
   a. 3 large jars filled with water per group
   b. 3 - 1/2 cup samples of sediments per group
   c. 1 magnifying glass per group
   d. 1 Sediment Analysis Worksheet per student
   e. 1 plastic spoon per group
2. Have students observe and analyze the three different sediment types using the Sediment Analysis Worksheet.
3. Have students predict which of the sediment types would reach the bottom the fastest and the slowest on the Sediment Analysis Worksheet.
4. Using a stopwatch, record on the Sediment Analysis Worksheet the time it takes a plastic spoon full of each sediment sample to fall to the bottom of each large jar.
5. Have students record observations on Sediment Analysis worksheet and predict what would happen if you put all three sediments together in one jar.
6. Add 2 spoonfuls of each sediment sample to one of the jars.
7. Put a lid on the jar.
8. Shake the jar to create a sediment-laden suspension.
9. Observe the action of all three sediments together and record the observations on Sediment Analysis Worksheet.

Part III Demonstration Extension:

1. Set up a 10-gallon aquarium in front of class.
2. Fill the10-gallon aquarium with water.
3. TEACHER ONLY!! Turn a hair dryer on and use it to produce surface currents in the aquarium, and/or turn the filter on to produce turbidity currents in the aquarium. SAFETY PRECAUTION: DO NOT DROP HAIR DRYER INTO AQUARIUM, A PERSON COULD GET ELECTROCUTED!
4. While the class is watching, pour all three sediment samples into the aquarium.
5. Observe how the water currents affect the different type(s) of sediment.
6. Discuss with the class why the Hudson Canyon has fine sediment deposits on and

around it and not coarse sediments. Use this demonstration as evidence.

7. Discuss what turbidity currents are and how they form deep-sea fans.

The BRIDGE Connection

www.hudsonvoice.com
bromide.ocean.washington.edu/oc540/lec01-16/
www.abdn.ac.uk/geology/profiles/turbidites/homepage/modern_c.html

Connection to Other Subjects

Mathematics
Language Arts

Evaluations

Students will write a paragraph summarizing what they learned about turbidity currents and the sedimentation in the Hudson Canyon.

The teacher will review each student's Sediment Analysis Worksheet.

Extensions

- Ask students to write a short essay comparing the Grand Canyon to the Hudson Canyon.
- Ask students to research slumping and underwater avalanches.
- Ask students to write a short paper comparing the three types of sediments found on the sea floor: physical, biological, and chemical.
- Ask students to investigate the various sources of sedimentation caused by human activity.
- Examine sediment samples from various places around the world.
- Ask students to identify all of the deep-sea canyons found along the Atlantic Coast.
- Visit the Ocean Explorer Web Site at www.oceanexplorer.noaa.gov
- Visit the National Marine Sanctuaries web page for a GIS fly-through of the Channel Islands National Marine Sanctuary at http://www.cinms.nos.noaa.gov/

References:

Maddocks, Rosalie, F., 2000, Introductory Oceanography Lecture 4A: The Ocean Floor: (www.uh.edu/~rmaddock/3377/3377lecture4a.html) Department of Geosciences, University of Houston

New Jersey Marine Sciences Consortium, 1998, The Biology of the Hudson-Raritan Estuary: A Teachers Guide: New Jersey Marine Sciences Consortium, Sandy Hook, New Jersey

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- Understandings about scientific inquiry

Physical Science - Content Standard B:

- Motions and forces

Earth and Space Science – Content Standard D:

- Structure of the Earth system
- Earth's History

Science in Personal and Social Perspectives - Content Standard F:

- Natural Hazards

History and Nature of Science – Content Standard G:

- Nature of science
- History of science

Sediment Analysis Worksheet

Part I:

1. Collect materials from teacher
   a. 3 large jars filled with water
   b. 3 - 1/2 cup sediment samples
   c. 1 plastic spoon
2. Set aside jars filled with water.
3. Analyze the three sediment samples.
4. Sketch each of the three sediment samples in the boxes below:

Sample 1	Sample 2	Sample 3

5. Use your magnifying glass to look at the three samples.
   a. Does each of your samples have smooth edges or rough edges?
   Sample 1: ______________________________
   Sample 2: ______________________________
   Sample 3: ______________________________

   b. Are each of your samples the same color throughout or are they made up of various colors?
   Sample 1: ______________________________
   Sample 2: ______________________________
   Sample 3: ______________________________

6. If you were to drop each of these samples into water, which one would fall to the bottom the fastest? The slowest?

7. Using your large jars, add one spoonful of sediment to your jar and with your stopwatch record the time it takes the entire sediment sample to reach the bottom. Settling time may take as much as 24 hours. Repeat procedure using individual jars for each sample.

Jar 1 with Sample 1: ______________________ seconds

Jar 2 with Sample 2: ______________________ seconds

Jar 3 with Sample 3: ______________________ seconds

8. Using the observations from above, predict what would happen if you added all three samples at once to the large jar.
9. Using one of the large jars, add 2 spoonfuls of each sediment sample and wait until they settle. Then tighten the lid on the jar.
10. Shake the jar to make a sediment-laden suspension and observe what happens with all the sediments. Sketch your observations below.

11. From your observations above, explain what graded bedding means.

Part II Demonstration Extension:

1. Looking at the aquarium set up in the front of the room, predict which sediment sample each type of current (surface and/or turbidity) would move.
2. Since the Hudson Canyon lies on the edge of the continental shelf, why are there soft mud and silt sediments and not pebbles or other coarse materials on the seafloor surface?
3. Write a short essay comparing an underwater turbidity current avalanche to a snow avalanche found in the mountains.