These activities are designed to teach about the sediments of Hudson Canyon. Students investigate and analyze the patterns of sedimentation in the Hudson Canyon, observe how heavier particles sink faster than finer particles, and learn that submarine landslides are avalanches of sediment in deep ocean canyons. The activity provides learning objectives, a list of needed materials, key vocabulary words, background information, day-to-day procedures, internet connections, career ideas, integrated subject areas, evaluation tips, extension ideas, and National Science Education Standards connections. (KHR)
Let's Bet on Sediments!

Hudson Canyon Cruise – Grades 9-12
Focus: Sediments of Hudson Canyon

National Oceanic and Atmospheric Administration
U.S. Department of Commerce
**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 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)

- 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

**Notes**
- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.
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 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, per-
haps by melting of gas hydrates, an over-
steepened slope, or an earthquake. They then
are mixed with the water to form a dense sus-
pension. 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 tur-
bidites, are characterized by a decrease in
sediment size from bottom to top known as
graded bedding. As sediments settle to the bot-
tom, 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 sedi-
ments 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 sus-
pension.
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 the 10-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 pro-
   duce 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.muk/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


NATIONAL SCIENCE EDUCATION STANDARDS
Science as Inquiry - Content Standard A:
• Abilities necessary to do scientific inquiry
• 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?
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Focus: Bathymetry of Hudson Canyon

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.
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