Section 4

Ocean Geologic Features

This introduction summarizes ocean geology as it relates to the Ocean Exploration expeditions. It is not a comprehensive examination of all aspects of ocean earth sciences. It starts with features of the continental shelf associated with passive margins—those that are less tectonically active—and includes both hard and soft bottoms. The introduction goes on to look at the common features among tectonically-active margins, hotspots and sea floor spreading regions that create particularly interesting ecosystems and geologic features.

Major Ocean Features: Continental Margin and Deep Sea

Two major ocean features are shallow continental margins and the deep sea. Sea level changes through time have exposed and submerged the upper portion of continental margins, called the continental shelf. Continental shelves of the world vary greatly in their width from a few kilometers to a hundred or more, but are relatively shallow in depth. Most extend offshore to water depths of 100 to 200 m. Just beyond the shelf, the sea floor slope is much steeper. This is the continental slope. At the base of the slope lies the continental rise, which is less steep and quite broad in places. The shelf, slope and rise together make up the entire continental margin. Many continental margins have steep-walled submarine canyons cutting through them. Some canyons may have formed during lowered sea levels as rivers ran out across the shelf, cutting into it. Submarine canyons are also channels for turbidity currents—water that carries sediment down slope—and continues the erosion that formed the canyon.

Passive Margin Processes

Continental margins may be geologically active or passive. Active margins occur along tectonic plate boundaries where earthquakes and/or volcanoes are common. Passive margins are not associated with plate boundaries, experiencing little volcanism and relatively fewer earthquakes. The Atlantic Ocean's continental shelf is a passive margin so the Ocean Exploration Hudson Canyon, Deep East and Islands in the Stream expeditions focused on features of passive margins.

Shelves and Sediment

The shelf is generally a broad, gently slopping platform that extends from the shoreline to the continental slope. It has thick accumulations of both coarse and fine-grained sediments. Since fine particles remain suspended in the water column longer than larger or denser particles, finer and lighter particles are carried farther, often to the edge of the shelf, before they settle. Consequently, slope and deep-sea sediments tend to be finer grained.

The continental slope is an abrupt drop. Sediments on the steep slope are largely soft mud. The slope flattens at the bottom where sediment slides pile up, forming the continental rise. Its thick sediment accumulations have fallen from the continental shelf—down the slope, sometimes quite abruptly.

Submarine Canyons

Submarine canyons cut into the shelf. They usually have v-shaped profiles, steep walls, rock outcrops, flat floors, strong currents, and deep-sea sediments fans at their base. Most are on the upper, steeper part of the slope. They run perpendicular to the shelf, across the continental shelf and slope. Generally submarine canyons are associated with major rivers.

Turbidity Currents

Turbidity currents form deep-sea sediment fans at the base of the slope. Fine sediments suspended by currents cause water to become murky or turbid. Turbid water is more dense and sinks. Turbidity currents—down-slope movements of sediment-laden water—continuously

erode many submarine canyons. Some turbidity currents are quite dense and abrupt in forming. These currents are set into motion when sand and mud on the continental shelf are loosened, perhaps by sudden melting of gas hydrates, by collapse of an overly steep slope, or by an earthquake. The sediment mixes with water to form a dense suspension, flowing like an avalanche down-slope, eroding and accumulating more sediment. Turbidity currents are likely contributors to submarine canyon growth. As they lose momentum, they deposit sediment as deep-sea fans at the canyon's lower end.

These deposits, called turbidites, are characterized by decreasing sediment size from the bottom to the top of a flow—forming graded bedding. As sediments settle, coarser, heavier particles settle out first, followed by finer sand and then clay.

Some 78% of the world's ocean sediments are in these three zones of the continental shelf. They are thickest along passive continental margins like the East and Gulf Coasts and less so along active margins such as the western U. S. coastline.

Sediment Characteristics

Sediment is classified either by grain size or its source. From smallest to largest, the particle sizes are clay, silt, sand, and gravel. Classified by origin, they are:

- *lithogenic* – coming from land by erosion of rocks,
- *biogenic* – derived from hard parts of organisms, usually calcium carbonate or silica,
- *authigenic* – precipitated by chemical or biochemical reactions in the water,
- *volcanogenic* – particles ejected from volcanoes,
- *cosmogenic* – grains that originate in outer space.

Sediment composition at a site depends on several factors. Under high energy conditions, such as waves or strong currents, fine grains stay in suspension or are re-suspended whereas coarse grains might settle out. Where currents scour the sediment most effectively, underlying

rock is exposed, and is referred to as hard bottom. Lower energy sites have finer grain because there is not enough energy to transport coarse material to the site. The shape of the grains also tells us something. Generally, the more rounded the grains, the older the sediment. They have been tumbled and rolled around for a long time. Younger coarse material may be rounded if it is in a high energy zone. Sediment bottom environments are referred to as soft bottom. The characteristics of the sediment determine which species of organisms occupy the site.

Proximity to land also determines sea floor sediment composition. The continental shelf is relatively shallow and close to land, receiving more lithogenic sediment from rivers and wind-blown dust. The deep sea has some lithogenic sediments carried by strong currents, but its sediment is largely biogenic—the hard parts of organisms living near the surface that settle to the bottom when the organisms die.

Cold Water Seeps and Gas Hydrates

Gas hydrate is an ice-like substance that forms in deep sea sediments when gas molecules, primarily methane, are trapped in a lattice of water molecules, forming a stable solid at temperatures above 0°C and pressures above 1 atmosphere. Gas hydrate deposits along ocean margins are estimated to exceed known petroleum reserves by about a factor of three. There is at least twice as much carbon locked up in hydrates as in all other fossil fuels on the Earth. There is commercial interest in mining methane from hydrates on the part of a number of countries.

Hydrates influence ocean carbon cycling, global climate change, and coastal sediment stability. Localized meltdowns have caused massive continental slope failure. They are an important geological hazard for shelf oil and gas production. Massive hydrate dissolution events, releasing vast amounts of the greenhouse gas methane, are possible causes of some of the abrupt climate changes seen in the geologic record.

There are vast hydrate deposits below 1,000 meters along the US East Coast. The gas hydrate beds leak gases into the water, forming cold seeps on the ocean floor. This hydrocarbon seepage is common on continental margins around the world. Chemosynthetic communities similar to those found at hydrothermal vents form at cold seeps, using hydrocarbons or hydrogen sulfide for carbon and energy. Seep tube worms, mussels, and clams form 2 m high bushes over kilometer-sized beds. Most seeps are also characterized by high microbial productivity.

Seep faunas vary in species and abundance, depending on the type and amount of seepage. Some species live exclusively with a particular form of hydrocarbon such as the hydrate ice worms. Others like the bacterium *Beggiatoa* are common at a variety of kinds of seeps. Seep communities are ecologically valuable as sources of food and refuge for an array of species. They may also be economically important as markers of underlying oil and gas reserves. Perhaps even more interesting, they are potential sources of new commercially-valuable bacteria. For all these reasons, Ocean Exploration expeditions may target cold water seeps.

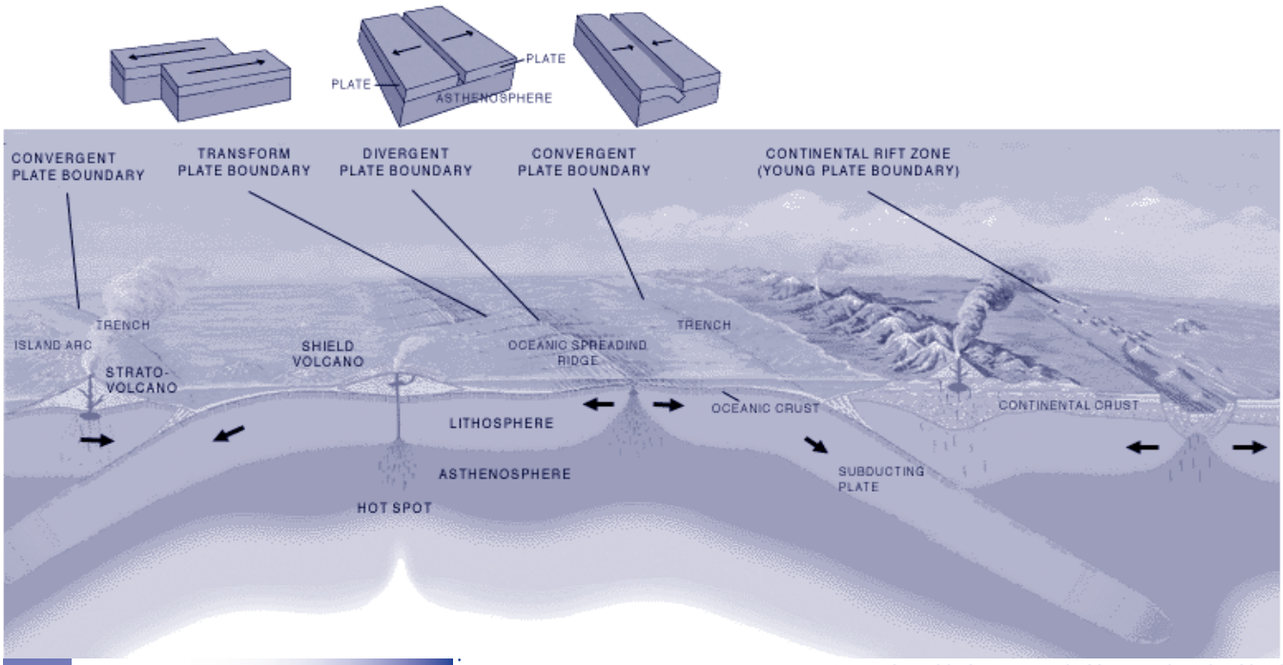
Active Margin Process

The outer shell of the Earth, the lithosphere, has about a dozen large plates of rock called tectonic plates. Each moves several centimeters per year relative to adjacent plates. The plates that make up the lithosphere move on a hot flowing mantle layer called the asthenosphere, which is several hundred kilometers thick. Heat within the asthenosphere creates convection currents (similar to the currents that can be seen if food coloring is added to a heated container of water). These convection currents cause the tectonic plates to move. Plates move in several ways in relation to each other.

Transform Plate Boundaries

Plates slide horizontally past each other at transform plate boundaries. Friction may lock plates temporarily as they try to move past each other, creating huge stress

Main Types of Plate Boundaries



Source: http://pubs.usgs.gov/publications/text/Vigil.html

in the boundary. If the force becomes too great, the plates may move abruptly, creating earthquakes. Places where breaks occur are called faults. A well-known transform plate boundary is California's San Andreas Fault.

Divergent Plate Boundaries

Where tectonic plates move away from each other, divergent plate boundaries form. Here magma—molten rock—rises from deep within the Earth and erupts, forming new crust in the lithosphere. Most divergent plate boundaries are underwater. Iceland is an exception. The boundaries form submarine mountain ranges called oceanic spreading ridges or rifts. These underwater ridges may be substantial—as much as 2,000 to 3,000 m high. They form the longest mountain chain in the world. As new oceanic crust forms at the ridges, older crust is progressively moved farther and farther from the ridge, creeping along at a rate of a few centimeters per year. As the new oceanic crust moves away from the ridge, it cools and contracts, decreasing the ridge height.

Deep Hydrothermal Vents

Hydrothermal vents form at ridges. Ocean water percolates down into rock fractures and encounters rising magma. Super-heated water, gases, and minerals escape from deep within the Earth. These vents provide the raw materials for communities whose primary producers are chemosynthetic bacteria—both endosymbiotic and free-living—enabling rich assemblages of organisms to live in deep water, far from sunlight.

Convergent Plate Boundaries

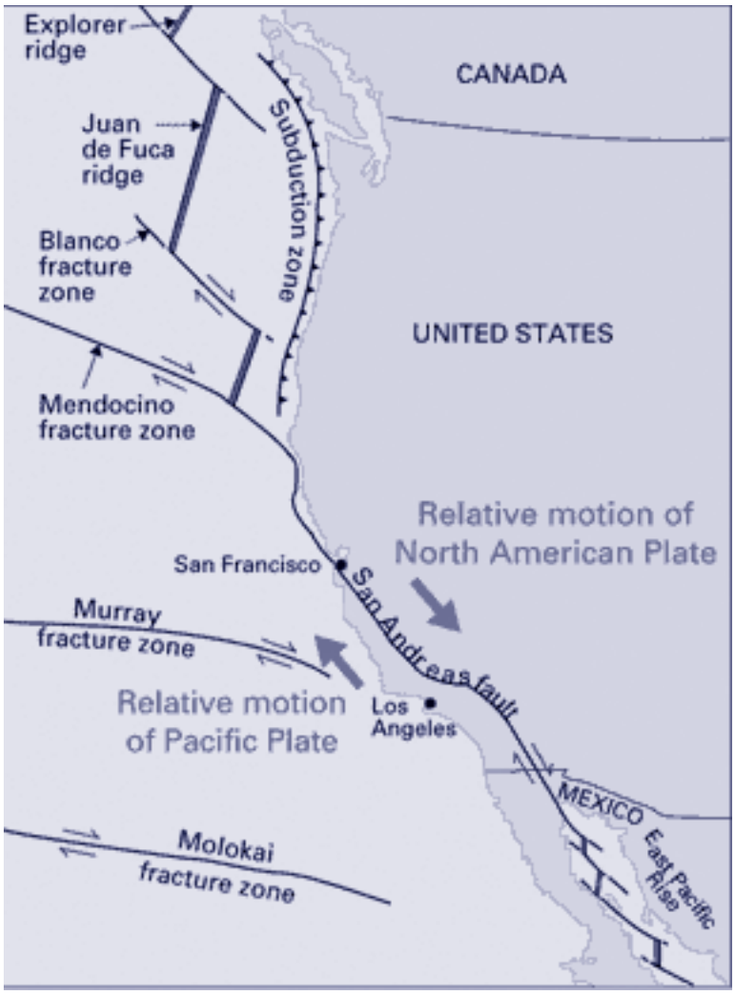
Yet another plate boundary is convergent. Here tectonic plates are pushed together. Usually one plate moves under the other—it is subducted. Deep trenches often form where one tectonic plate is being pushed beneath a second plate. Volcanic activity and earthquakes are common. As the sinking plate moves deeper into the mantle, the overlying mantle partially melts, forming new magma. It rises, erupting as a volcano. Island arcs produced by volcanic activity often form along a convergent boundary.

Many of the Ocean Exploration expeditions focus on active margins. The 2002 Submarine Ring of Fire Expedition investigated the formation of new ocean crust on the edge of the Juan de Fuca tectonic plate off the coast of western North America. This comparatively small tectonic plate has a divergent boundary with the Pacific plate as well as a convergent boundary with the North American plate, making it a microcosm of the large plate dynamics. The Mt. St. Helen eruption in 1980 was a result of the subduction of the Juan de Fuca plate beneath the North American plate. The divergent boundary is an active spreading center that is organized along three ridges: Gorda Ridge, Juan de Fuca Ridge, and Explorer Ridge.

Hotspots

Volcanoes also form at hotspots, thought to be pipelines to magma reservoirs in the upper Earth's mantle. The Hawaiian Islands are the result of volcanic activity associated with a hotspot that appears to penetrate the Pacific plate. The Pacific tectonic plate moves over the asthenosphere to the northwest at 5 to 10 cm per year.

As it moves over the hotspot, magma periodically erupts, forming volcanoes that become islands.



source: http://pubs.usgs.gov/publications/text/understanding.html#anchor15039288

Where to Find More Activities on Ocean Geologic Features

There are seven activities in this section that use inquiry-based experiences to introduce your students to some of the earth science discussed above. There are a number of Ocean Exploration Expedition Activities from 2001 and 2002 exploration on the OE CD and web site. Their topics appear below:

Sediments

- *Let's Bet on Sediments* from Deep East 2001 and Hudson Canyon 2002

- *Mud is Mud … Or Is It?* from Islands in the Stream 2002
- *An Underwater Sediment Slide?* see Hudson Canyon 2002

Cold Water Seeps/Methane Hydrates

- *It's a Gas!* in Deep East 2001 and Hudson Canyon 2002

Plate Tectonics

- *The Biggest Plates on Earth* from Submarine Ring of Fire 2002

Hotspots, Volcanoes and Plate Movement

- *Volcanoes, Plates and Chains* in Exploring Alaska's Seamounts 2002
- *History's Thermometers* from Exploring Alaska's Seamounts 2002
- *Mystery of the Alaskan Seamounts* in Exploring Alaska's Seamounts 2002
- *Roots of the Hawaiian Hotspot* from Northwest Hawaiian Islands Exploration 2001
- *Islands, Reefs and a Hotspot* in Northwest Hawaiian Islands Exploration 2001

Mid-ocean Ridges, Rifts and Hydrothermal Vents

- *The Galapagos Spreading Center* in Galapagos Rift Expedition 2002
- *AdVENTurous Findings on the Deep Sea Floor* from Galapagos Rift Expedition 2002
- *Yo-Yos, Tow-Yos and pH, Oh My!* from Galapagos Rift Expedition 2002
- *Mystery of the Megaplume* in Submarine Ring of Fire 2002

Lesson Plan 6

Let's Bet on Sediments

Focus
Sediment settling characteristics and shelf bottom composition

Focus Question
Is sediment size related to the time the sediment is suspended in water? If so, how?

Learning Objectives
Students will investigate and analyze patterns of sedimentation in the Hudson Canyon.

Students will observe that heavier particles sink faster than finer particles so bottom type is related to distance from the sediment source.

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

Additional Information for Teachers of Deaf Students
There are no formal signs in American Sign language for many of the Key Words and most are difficult to lipread. These words are the key to the lesson. Having the vocabulary list on the board as a reference during the lesson will be extremely helpful. It would also be helpful to copy the vocabulary list on a handout for the students to read after the lesson. If this is a new topic for the students, additional time may be required to discuss Part I.

Materials
Part I: Teacher
- ❒ Exploring Ocean Frontiers: Hudson Canyon transparency

Part II: for each group of 4
- ❒ 3 pint jars with lids, e.g. Snapple bottles, mayonnaise jars or canning jars
- ❒ 1/4 cup of each of the 3 sizes of sediments – small gravel, sand and silt
- ❒ Water to fill the 3 jars
- ❒ *Sediment Analysis Worksheets* for each student
- ❒ Stopwatch
- ❒ Magnifying glass
- ❒ Plastic spoon

Part III: Teacher Demonstration
- ❒ 10 gallon aquarium
- ❒ 1/2 cup of each of the 3 sediments used above
- ❒ Water - enough to fill the aquarium
- ❒ Hair dryer or aquarium filter

Audio/visual Materials
- ❒ Overhead Projector

Teaching Time
Two 45-minute period

Seating Arrangement
Cooperative groups of four

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

Review information in Section 4 of this Curriculum on sediments and passive margins.

Learning Procedure

Part I Discussion

Using the *Exploring Ocean Frontiers: Hudson Canyon* overhead, discuss the features of a passive continental margin. Introduce submarine canyons and the location of Hudson Canyon. Challenge the students to test sediments for settling rates and other features related to continental shelf and submarine canyon geology.

Part II Activity

1. Have student groups gather the materials listed above for Part II.

2. Ask the students to predict which sediment type will reach the bottom the fastest and which the slowest on the *Sediment Analysis Worksheet.*

3. Working independently in their groups, have the students observe and analyze the three sediment types using the *Sediment Analysis Worksheet.*

4. Lead a discussion of results—did they predict correctly? Did they all get the same results?

Part III Demonstration Extension

1. While the students are working on Part II, set up a 10-gallon aquarium in front of class.

2. Fill it with water.

3. When they have finished discussing Part II, you, THE TEACHER ONLY, turn a hair dryer on and use it to produce surface currents in the aquarium (alternately use an aquarium filter to produce currents). 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, starting with the most coarse.

5. Observe how the water currents affect the types 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 turbidity currents and how they form deep-sea fans.

The BRIDGE Connection

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

The "Me" Connection

Have students walked along a shallow stream or river where they can see the bottom? What were the bottom sediments like? Can they explain their observations in relation to speed of the water flow?

Connection To Other Subjects

Mathematics, English/Language Arts

Evaluation

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

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

Extensions

Ask students to research slumping and underwater avalanches.

Ask students to investigate the various sources of sedimentation caused by human activity.

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/

Resources:

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
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

Content Standard A – Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B – Physical Science
- Motions and forces

Content Standard D – Earth and Space Science
- Structure of the Earth system
- Earth's History

Content Standard F – Science in Personal and Social Perspectives
- Natural Hazards

Content Standard G – History and Nature of Science
- Nature of science
- History of science

Activity developed by Tanya Podchaski, Bernards High School, Bernardsville, New Jersey

Additional information for teachers of deaf students developed by Denise Monte, Teacher of the Deaf and Audiologist, American School for the Deaf, West Hartford, Connecticut

Student Handout

Sediment Analysis Worksheet

Part I:

1. Collect materials:
   3 jars filled with water
   3 1/4 cup sediment samples
   1 plastic spoon

2. Set jars filled with water aside.

3. Analyze the three sediment samples.

4. Sketch each of the three sediment samples and indicate scale 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?

   _____
   _____
   _____

Student Handout

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

   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 jar add 2 spoonfuls of each of the other sediment samples. Then tighten the lid on the jar. Shake the jar to make a sediment-laden suspension and observe what happens with all the sediments. Sketch your observations below.

10. Based on your observations above, explain what graded bedding means.

    _____
    _____
    _____

Part II Demonstration Extension:

1. Looking at the aquarium in the front of the room, predict which sediment sample each type of current—surface and/or turbidity—would move.

   _____
   _____
   _____
   _____
   _____
   _____
   _____
   _____

Student Handout

2. Write a short essay comparing an underwater turbidity current avalanche to a snow avalanche found in the mountains.

Lesson Plan 7

Mud is Mud...Or is It?

Focus
Comparing and analyzing deep-sea sediments

Focus Question
What are some sources of variation in deep-sea sediments and how do they differ?

Learning Objectives
Students will compare and contrast similar items.

Students will use computers to find information.

Students will identify variables affecting deep-sea habitats and organisms.

Students will use different scales, comparing sizes of items shown at different scales.

Additional Information for Teachers of Deaf Students
In addition to the words listed as Key Words, the following words should be part of the vocabulary list:

Authigenic	Diverted
Volcanogenic	Fauna
Cosmogenic	Calcium carbonate sediment
Resuspended	Oolitic sands
Classify	
Composition	

Although the Key Words are integral to the unit, they will be difficult to introduce prior to the activity. They are really the material of the lesson. There are no formal signs in American Sign Language for any of these words and many are difficult to lipread. If some of these topics have not already been covered in your class, you may need to add an additional class period to teach vocabulary and to teach some of the Background Information to the students prior to the activity. It might be helpful to copy the Background Information and hand it out to the students to read at the beginning of the activity. Then you may lead the students in a discussion of what they have read. This will be a good introduction to the activity and would allow for review of unfamiliar vocabulary.

Materials
- ❒ Computer with Internet access
- ❒ One *Sediment Comparison Worksheet* per student

Audio/Visual Materials
- ❒ Overhead projector

Teaching Time
45-minute period

Seating Arrangement
Groups of 2 to 3 students

Key Words
Sediment
Lithogenic
Biogenic
Eddie
Continental shelf
Plateau
Upwelling
Gulf Stream
Scarp

Background Information

In this activity students will study photographs of actual sediments from the southeastern United States' continental shelf. These enlarged photos enable the students to measure grain size and to observe actual structure of the grains. Students will be challenged by the need to keep scale in mind as they do their analysis. Soft bottom sediments determine the species composition of organisms that live in and on them. Where they are scoured away revealing hard bottom, totally different species become established.

Sediment can be classified either by grain size or mode of formation. From smallest to largest, the particle sizes are clay, silt, sand, and gravel. Using origin, sediments can be classified as:

lithogenic: from land by erosion of rocks,
biogenic: from hard parts of marine organisms made of calcium carbonate or silica,
authigenic: precipitates from chemical or biochemical reactions in the water,
volcanogenic: material ejected from volcanoes, including ash,
cosmogenic: grains that originate in outer space.

Sediment composition is also influence by waves and currents. They sort by grain size and density as well as wearing down rough edges over time. Proximity to land also helps determine the sediment composition. Since the shelf is close to land, it has more lithogenic sediment. Most deep-sea sediments are largely the hard parts of surface-water organisms that settle to the bottom.

The sediment pictures used for this activity came from the Savannah Scarp and the Charleston Bump. The Savannah Scarp is a series of rocky ridges and outcrops where Gulf Stream currents have diverted sediments away from the underlying rock, forming a rocky reef. It is at about 55 m (180 ft) with a steep drop to 70 m (250 ft) or more. Along this drop large rocks, ridges, ledges, caves, and overhangs provide spectacular habitat for a diverse abundance of organisms.

The Savannah Scarp sediment samples come from 61m (200 ft) deep about 60 miles offshore. Here the Savannah Scarp is limestone rock which probably originated as loose grains of calcium carbonate sediment or oolitic sands that became cemented together during the lower sea level of the last Ice Age, approximately 18,000 years ago.

The Charleston Bump rises above the relatively flat Blake Plateau beyond the edge of the continental shelf in the South Atlantic Bight. From over 700 m (2,300 ft), the bottom rises to a shallow scarp at 375m (1,230 ft). From there, the bottom plunges in a series of steep scarps with rocky cliffs, overhangs and caves. The Charleston Bump deflects the flow of the Gulf Stream. Its warm current is pushed offshore by the Bump, producing eddies that are important fish habitats. In these eddies mixing and upwelling bring nutrient-rich, deep water to the surface, enhancing plankton production which supports a diverse assemblage of zooplankton and fish. The Charleston Bump sediment sample came from about 100 mi. offshore from a depth of about 490 m (1,600 ft).

Learning Procedure

1. The sediment sample photos are at http://oceanica.cofc.edu/samplematerial/images.htm.
   Students should open the page twice so that they can have Bump sediment on one window and Scarp sediment on the other for easy comparison.

2. Once at the page, they can choose Bump or Scarp sediment by clicking the appropriate button. They can then enlarge the images by clicking on them.

3. The *Sediment Comparison Worksheet* refers to Figures 1-6. These figure numbers are just for this activity and DO NOT match the image numbers on the web page. Use the key on the *Sediment Comparison Worksheet*.

4. Working independently, have the students complete the worksheet.

5. If you need to use an overhead, make overheads of the figures for each question on the *Sediment Comparison Worksheet* and use them to take the students through the worksheet. For example: Question 1 refers to Figures 1 and 2. Put them both on one overhead so they are next to each other and easily compared.

The BRIDGE Connection

www.chariho.k12.ri.us/curriculum/MISmart/ocean/sands.htm

The "ME" Connection

(See Extension #2) Have the students describe what organisms can best survive in the soil in their backyard versus the organisms that may live in the other habitat from which they gathered soil.

Connections To Other Subjects

Oceanography, Geology

Evaluation

Completed *Sediment Comparison Worksheets*

Extensions

Go to http://oceanica.cofc.edu/samplematerial/samples.htm and request actual samples of the sediment from the Charleston Bump and the Savannah Scarp. (They are FREE!!). Using the samples, go back to the same web page and have your students go through the activity available on the web page.

Have students gather soil samples from two very different habitats (e.g., a beach and their backyard). Modify the worksheet, using many of the same questions, to suit the samples they have collected.

Resources

http://oceanexplorer.noaa.gov/explorations/islands01/background
http://oceanexplorer.noaa.gov/explorations/islands01/log

"A Profile of Savannah Scarp", NOAA Ocean Exploration Web Site (2001) George R. Sedberry, Senior Marine Scientist, Marine Resources Research Institute, South Carolina Department of Natural Resources

"A Profile of the Charleston Bump", from NOAA Ocean Exploration Web Site (2001) George R. Sedberry, Senior Marine Scientist, Marine Resources Research Institute, South Carolina Department of Natural Resources

"Getting to the Bottom of a Rocky Rubble Reef", from NOAA Ocean Exploration Web site (2001) Dr. Leslie R. Sautter, Dept. of Geology and Environmental Sciences, College of Charleston, Charleston, SC

National Science Education Standards

Content Standard A – Science as Inquiry

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

Content Standard D – Earth and Space Science

- The origin and evolution of the Earth system

Activity developed by Rachel McEvers, College of Charleston

All figures courtesy of Project Oceanica

Additional information for teachers of deaf students developed by Denise Monte, Teacher of the Deaf and Audiologist, American School for the Deaf, West Hartford, Connecticut

Teacher Answer Key

Sediment Comparison Worksheet

If you are doing this activity on the web refer to the following key for the proper images:

Figure 1 = Bump Image #4
Figure 2 = Scarp Image #7
Figure 3 = Bump Image #1
Figure 4 = Scarp Image #5
Figure 5 = Bump Image #15
Figure 6 = Scarp Image #3

1. What are the two main ways to classify sediment?
   By particle size and basis of formation.
2. What is the difference between biogenic and lithogenic sediment?
   Biogenic sediment is composed of the skeletal remains of microscopic organisms and fragments of coral. Lithogenic sediment is derived from the weathering and erosion of rocks on land and is composed of mostly rock fragments.
3. Figure 1 was taken from the Charleston Bump. Figure 2 was taken from the Savannah Scarp. How would you classify each of them in terms of their basis of origin—their primary composition?
   The Bump sediment is primarily biogenic and the scarp sediment is primarily lithogenic.
4. Give two reasons why the samples might be so different in composition.
   The Scarp is much closer to land than the Bump (60 mi offshore vs. 100 mi.) and, therefore, receives more eroded rock from rivers and wind-blown debris. The Scarp is much shallower than the Bump. The Gulf Stream runs past the Bump making it a very high energy area, thus preventing fine particles from settling out.
5. Figure 3 is from the Bump. Figure 4 is from the Scarp. Using the 3-mm scale bar in each figure, determine which of these samples has the larger grain size. What do you think is the main reason for this?.
   The Bump has larger grains due to the high energy environment of the Gulf Stream.
6. Low-energy conditions tend to have what size sediment grains?
   Fine
7. Using Figures 5 (Bump) and 6 (Scarp) as well as all the previous figures, describe any similarities in the two sediments.
   They should be able to find many of the same organisms or "grains" in each of the two samples.Grain shape in both is mixed. There are rounded coral and rock pieces and angular shell fragments in both.
8. What can grain shape tell us about sediment?
   It can tell us about the age (young or old, not specific years) of the sediment. It can tell us about the energy conditions where the sediment was collected.
9. Again using all of the figures, what are some other differences you notice?
   The color of the two sediments is different. The Scarp sediment is a very dark, almost a greenish color, whereas the Bump sediment is a light to medium brown.

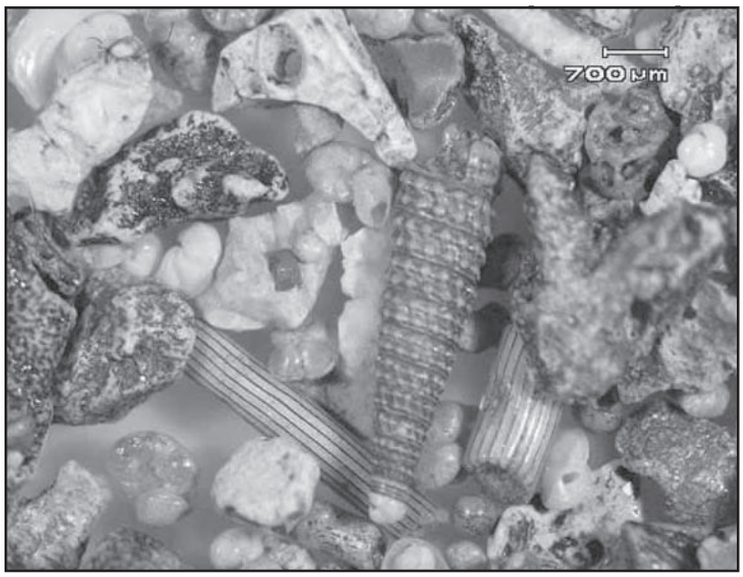


Figure 1

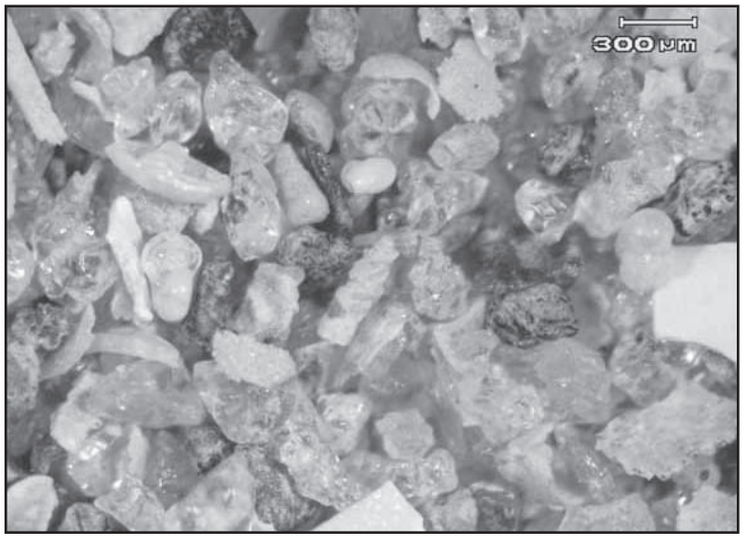


Figure 2

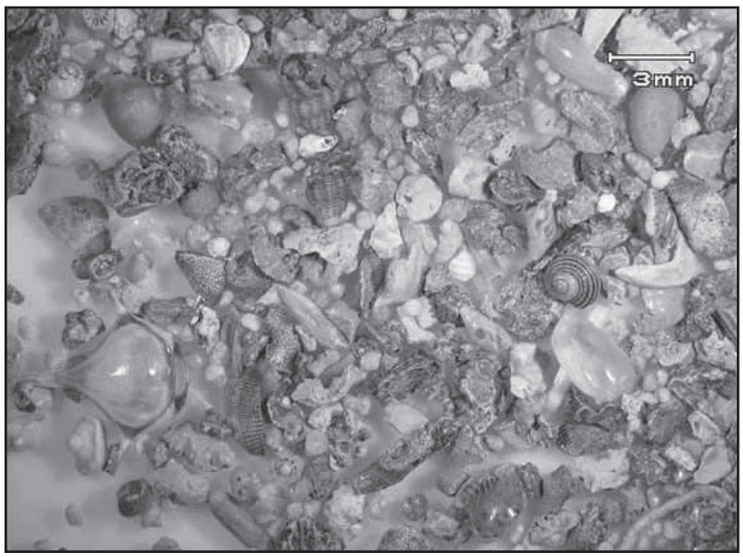


Figure 3

Figure 4

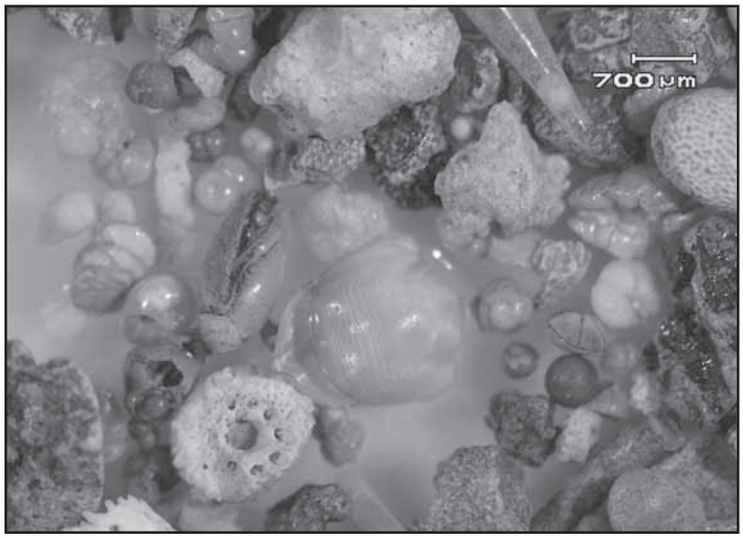


Figure 5

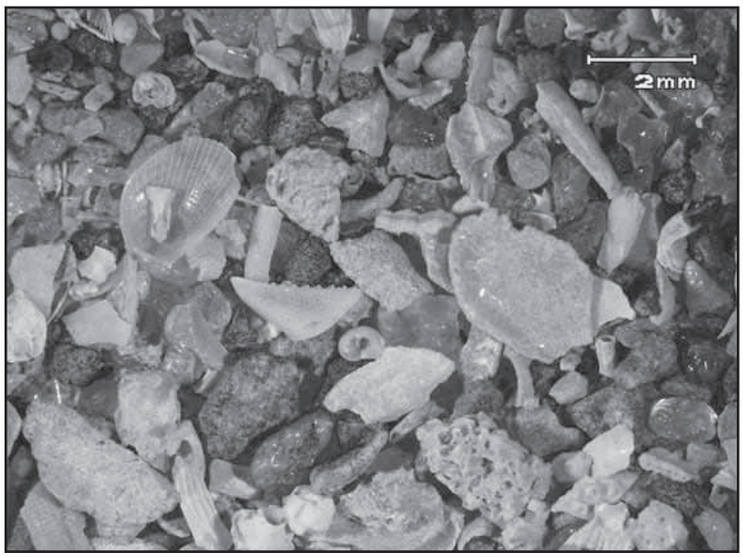


Figure 6

Student Handout

Sediment Comparison Worksheet

If you are doing this activity on the web refer to the following key for the proper images:

Figure 1 = Bump Image #4
Figure 2 = Scarp Image #7
Figure 3 = Bump Image #1
Figure 4 = Scarp Image #5
Figure 5 = Bump Image #15
Figure 6 = Scarp Image #3

1. What are the two main ways to classify sediment?

2. What is the difference between biogenic and lithogenic sediment?

3. Figure 1 was taken from the Charleston Bump. Figure 2 was taken from the Savannah Scarp. How would you classify each of them in terms of their basis of origin (i.e., what is the primary composition of each?)

4. Give two reasons why the samples might be so different in composition.

Student Handout

5. Figure 3 is from the Bump. Figure 4 is from the Scarp. Using the 3-mm scale bar in each figure, determine which of these samples has the larger grain size. What do you think is the main reason for this?

6. Low-energy conditions tend to have what size sediment grains?

7. Using Figures 5 (Bump) and 6 (Scarp) as well as all the previous figures, describe any similarities in the two sediments.

8. What can grain shape tell us about sediment?

9. Again using all of the figures, what are some other differences you notice?