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Image captions/credits on Page 2.

lesson plan

Cradle of the Earthquake:
Exploring the Underwater San Andreas Fault 2010 Expedition

Quake Clues

Focus
Sediments as earthquake proxies

Grade Level
9-12 (Earth Science)

Focus Question
How can sediment accumulations be used to obtain information about past earthquakes?

Learning Objectives
- Students will define and describe turbidites.
- Students will explain the concept of earthquake proxies.
- Students will interpret model sediment cores.

Materials
For each student group:
- ❑ Copies of *Earthquakes and Turbidites Inquiry Guide*
- ❑ Test tube, approximately 20 mm x 150 mm
- ❑ Rubber stopper to fit test tube (size 3 for 20 mm test tubes)
- ❑ Sand, several colors; approximately 30 ml of each color (see Learning Procedure, Step 1)
- ❑ Plastic bowls, one for each sand color
- ❑ Plastic spoon
- ❑ Water-tight plastic container (clear tennis ball container or 20 oz soda bottle)
- ❑ Water, sufficient quantity to fill the plastic container
- ❑ Sand mixture, approximately 30 ml (see Learning Procedure, Step 1)
- ❑ Glass marking pen
- ❑ Scrap paper, approximately 10 cm square

Audio-Visual Materials
- ❑ None

Teaching Time
One or two 45-minute class periods

Seating Arrangement
Groups of 2-4 students

Maximum Number of Students

32

Key Words

San Andreas Fault
Earthquake
Turbidite

Background Information

NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

At 5:12 am on April 18, 1906, Ernest Adams was thrown violently from his bed and watched in disbelief as the side of his San Francisco home crumbled to the ground. "I fell and crawled down the stairs amid flying glass and timber and plaster. When the dust cleared away I saw nothing but a ruin of a house and home that it had taken twenty years to build. I saw the fires from the city arising in great clouds and it was no time to mourn my loss so getting into what clothing I could find, I started on a run for Kearny St., five miles away... " (Adams, 1906).

In 1906, modern plate tectonic theory was several decades in the future, so no one who lived through the Great San Francisco Earthquake could know that their terrifying experience resulted from interaction between two large pieces of Earth's crust now known as the Pacific and North America Plates. These tectonic plates are portions of the Earth's outer crust (the lithosphere) about 5 km thick, as well as the upper 60 - 75 km of the underlying mantle. They 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). Movement of convection currents causes tectonic plates to move several centimeters per year relative to each other.

Where tectonic plates slide horizontally past each other, the boundary between the plates is known as a transform plate boundary. As the plates rub together, huge stresses are set up that can cause portions of the rock to break, resulting in earthquakes. Places where these breaks occur are called faults. The San Andreas fault exists along the transform plate boundary between the Pacific and North America Plates in California. The 1906 San Francisco Earthquake was caused by a 296 mile-long rupture along the San Andreas fault from the Mendocino Triple Junction to San Juan Bautista. A triple junction is a place where three of Earth's tectonic plates intersect. At the Mendocino

Images from Page 1 top to bottom:
San Francisco, California, Earthquake April 18, 1906. Downtown San Francisco showing residents watching fire after the 1906 earthquake. Photo by Ralph O. Hotz. April 1906. Image courtesy USGS.
http://libraryphoto.cr.usgs.gov/cgi-bin/show_picture.cgi?ID=ID.%20Hotz%2C%20P.E.%20%20104

A small bush of tubeworms. When tubeworm bushes are young, only endemic species of animals can colonize them. The presence of the mussels (*Bathymodiolis childressi*) in the center of the bush means that methane is seeping just below. Image courtesy Gulf of Mexico 2002, NOAA/OER.
http://oceanexplorer.noaa.gov/explorations/02mexico/background/communities/media/2tubesmussels.html

San Francisco, California, Earthquake April 18, 1906. Fault trace 2 miles north of the Skinner Ranch at Olema. View is north. 1906. Plate 10, U.S. Geological Survey Folio 193; Plate 3-A, U.S. Geological Survey Bulletin 324. Image courtesy USGS. (*Note: you may need to paste the link below into your browser to get to the image.*)
http://libraryphoto.cr.usgs.gov/cgi-bin/show_picture.cgi?ID=ID.%20Gilbert%2C%20G.K.%202933

Iceworms (*Hesiocaeca methanicola*) infest a piece of orange methane hydrate at 540 m depth in the Gulf of Mexico. During the Paleocene epoch, lower sea levels could have led to huge releases of methane from frozen hydrates and contributed to global warming. Today, methane hydrates may be growing unstable due to warmer ocean temperatures. Image courtesy Ian MacDonald.
http://oceanexplorer.noaa.gov/explorations/06mexico/background/plan/media/iceworms_600.jpg

Triple Junction, the Pacific Plate and North American Plate intersect with the Juan de Fuca Plate. Other types of plate boundaries include convergent boundaries, which are formed when tectonic plates collide more or less head-on; and divergent boundaries, which occur where plates are moving apart. View animations of different types of plate boundaries at: http://www.seed.slb.com/flash/science/features/earth/livingplanet/plate_boundaries/en/index.html.

Understanding that the 1906 quake resulted from the movement of tectonic plates leads quickly to the realization that these plates are still in motion; in fact, the San Andreas fault is the fastest moving fault in western North America. This realization inevitably leads to the question, "When will a major earthquake like the 1906 quake strike again?"

To help answer this question, geologists study the history of past earthquakes along the San Andreas fault system. These studies, as well as thousands of years of historical records from China and Japan, tell us that giant earthquakes on faults like the San Andreas tend to occur every few hundred years. This interval is thought to be the time required for motion between tectonic plates to build stresses to levels that produce large quakes. In general, this evidence suggests that a 1906-size earthquake is not likely to strike Northern California for at least 100 years. Still, studies also show that stress has built up again along the San Andreas Fault system. For 70 years following the 1906 earthquake, there were only low levels of seismic activity in Northern California. Then, between 1979 and 1984, there were three quakes with magnitudes of about 6; and in 1989 a major (Loma Prieta) earthquake with a magnitude of 6.9. A similar pattern of earthquake activity took place during the 70 years prior to the 1906 quake.

The Cradle of the Earthquake: Exploring the Underwater San Andreas Fault 2010 Expedition will improve our understanding of the history of great earthquakes and how they are interrelated by investigating portions of the great plate boundary fault that lie offshore; areas that have virtually never been observed or explored. Information about past earthquakes is often obtained by studying proxies. Proxies are natural records of biological and geological ecosystem features that are affected by certain events. Tree rings are a well-known proxy for year-to-year weather conditions, since the size of each ring is affected by growing conditions during the year in which each ring is formed. In fact, tree rings are sometimes used to obtain information about the history of earthquakes, since earthquakes cause stresses that can affect the growth of trees (for example, see http://www.ess.washington.edu/SEIS/PNSN/HAZARDS/CASCADIA/tree_rings.html).

Geological structures can also provide proxies. In many places along the continental shelf and continental slope, there are accumulations of sediments carried into the ocean by rivers. These accumulations continue to build until they become unstable and slide down the slope in a sort of avalanche called a turbidity current. As the turbidity current moves down the slope, the velocity of the current gradually decreases and sediments carried in the current begin to form deposits on the seafloor. Larger, coarse particles are deposited first, followed by increasingly smaller particles. Sometimes, the bottom layer is also marked by erosional features such as scour marks, since the velocity of the flow may still be sufficient to disturb the seafloor while coarse particles are being deposited. Since turbidity current can carry very large volumes of suspended matter and move at high velocities (again, like an avalanche), the erosion they cause may be severe. In fact, turbidity currents are believed to be a major force that forms submarine canyons, and are known to have caused damage to structures such as underwater cables.

As the flow velocity continues to decrease, smaller sand particles are deposited and often form flat, plate-like deposits, followed by finer sand particles that may have a rippled appearance caused by bottom currents. Particles of silt are deposited on top of the sand, and may also form plate-like deposits. Finally, the turbidity current has dissipated, and mud begins to accumulate on top of the particles that were deposited. These accumulations of sediment layers transported by turbidity currents are called turbidites.

Since earthquakes may trigger turbidity currents, the presence of turbidites can provide a submarine record of past earthquakes. Turbidites and sediment layers are often studied using core samples collected from the ocean floor adjacent to the continental slope.

In this lesson, students will learn about turbidites, and how they may provide evidence of past earthquakes.

Learning Procedure

Note: Portions of this lesson are adapted from the "Tsunami Shake 'n' Quake: Evidence for Past Tsunamis in Oregon" by Science and Math Investigative Learning Experiences (SMILE) Program of Oregon State University (http://people.oregonstate.edu/~doverl/SMILE/WTW08/Activity4_Tsunami_Shake_n_Quake/)

1. To prepare for this lesson:
   - Review background essays for the Cradle of the Earthquake: Exploring the Underwater San Andreas Fault 2010 Expedition (http://oceanexplorer.noaa.gov/explorations/10sanandreas)
   - Review procedures on the *Earthquakes and Turbidites Inquiry Guide*
   - Acquire colored sand from local building materials suppliers, internet sources, or you can make it yourself: Place the desired amount of sand in a zip-top plastic bag and add just enough water to moisten all of the sand. Next add food coloring and thoroughly

mix into the sand to achieve the desired depth of color. Allow the mixture to rest for an hour or more, then pour off excess water and spread the sand onto a flat surface to dry.

- Prepare a sand mixture for students to use in Inquiry 1 of the *Inquiry Guide*. If you can't find a natural source of relatively fine-grained, poorly sorted sand, you can make your own mixture with soil, play sand, diatomaceous earth (from a swimming pool supply store), pebbles, etc. Test your mixture by completing Inquiry 1 of the *Inquiry Guide* to be sure the grain sizes are sufficiently different to produce a clear separation.

2. Lead an introductory discussion of the Cradle of the Earthquake: Exploring the Underwater San Andreas Fault 2010 Expedition. You may want to show students some images from the U.S. Geological Survey's Photographic Library (http://libraryphoto.cr.usgs.gov/; click on "Earthquakes" in the left column). Discuss the importance of studying the timing and impacts of past earthquakes to help prepare for similar events in the future.

3. Provide each student group with a copy of the *Earthquakes and Turbidites Inquiry Guide*, and materials required to complete the Inquiries 1 and 2. Tell students to be sure to complete Inquiry 1 before proceeding to Inquiry 2.

4. Have each student group exchange their test tube with another group. If time permits, you may want to have each group examine test tubes from several other groups.

5. Discuss students' results. Based on Inquiry 1, students should realize that larger particles settle more quickly from suspension than smaller particles. From this observation, they should infer the general structure of turbidites described above. Student groups should compare their interpretation of model cores constructed in Inquiry 2. If disturbed layers are very thin, it may be difficult to recognize "turbidites" in the layer sequence. Disturbed layers may also be difficult to identify if the same color sand is used on both sides of the disturbance. These difficulties are similar to problems that can arise in the interpretation of real core samples.

   Students should understand that turbidity currents may be triggered by earthquakes, and the resulting turbidites may then become proxies for dating these events. They should also realize, however, that turbidity currents are not always the result of earthquakes, and may be triggered by other events such as the collapse of a gas hydrate deposit on a continental slope or simply by sediments accumulating on a slope to the point of instability.

The BRIDGE Connection

www.vims.edu/bridge/ - Click on "Ocean Science Topics" in the navigation menu to the left, then "Geology" for resources on marine geology and plate tectonics.

The "Me" Connection

Have students write a short essay describing how they have (or might) use some type of proxy.

Connections to Other Subjects

English/Language Arts, Earth Science

Assessment

Experimental notes and class discussions provide opportunities for assessment.

Extensions

1. See the Cradle of the Earthquake: Exploring the Underwater San Andreas Fault 2010 Expedition Education Module for additional information, activities, and media resources about deepwater ecosystems and earthquakes associated with the San Andreas Fault.

2. For additional activities about sediment transport and turbidity currents, see http://www.dlese.org/library/query.do?q=turbidity.

Multimedia Discovery Missions

http://oceanexplorer.noaa.gov/edu/learning/welcome.html - Click on the link to Lessons 1, 2, and 4 for interactive multimedia presentations and Learning Activities on Plate Tectonics, Mid-Ocean Ridges, and Subduction Zones.

Other Relevant Lesson Plans from NOAA's Office of Ocean Exploration and Research

Let's Bet on Sediments

(6 pages, 64k) (from the 2002 Hudson Canyon Cruise Exploration)
http://oceanexplorer.noaa.gov/explorations/02hudson/background/edu/media/hc_bet_on_sediments.pdf

Focus: Hudson Canyon Sediments (Earth Science)

Students investigate and analyze patterns of sedimentation in the Hudson Canyon; observe how heavier particles sink faster than finer particles; learn that submarine landslides (trench slope failures) are sediment "avalanches" that occur in deep-ocean canyons; and infer that the passive side of a continental margin is not as geologically static as scientists previously believed.

Mud Is Mud....Or is It?
(10 pages, 1.1Mb) (from the Islands in the Stream 2002: Exploring Underwater Oases Expedition)
http://oceanexplorer.noaa.gov/explorations/02sab/background/edu/media/sab_sediments.pdf

Focus: Comparing and analyzing the difference in deep-sea sediments (Earth Science)

Students compare and contrast similar sediment samples, use the computer as a learning tool, and identify different variables that affect deep-sea habitats and organisms.

Tools of Discovery - Multibeam Sonar
(PDF, 1.6 Mb) (from the INDEX SATAL 2010 Expedition)
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/media/multibeam.pdf

Focus: Technology for deep ocean exploration: Multibeam Sonar (Earth Science/Physical Science)

Students will describe multibeam sonar, discuss the advantages of multibeam sonar bathymetry compared to two-dimensional topographic bathymetry, and interpret three-dimensional multibeam bathymetric data.

Tools of Discovery - Remotely Operated Vehicles
(PDF, 1.3 Mb) (from the INDEX SATAL 2010 Expedition)
http://oceanexplorer.noaa.gov/okeanos/explorations/10index/background/edu/media/rov.pdf

Focus: Technology for deep ocean exploration: Remotely Operated Vehicles (Earth Science/Physical Science)

Students will describe systems and capabilities of science-class remotely operated vehicles (ROVs), typical applications and limitations of imagery obtained with ROVs, and use ROV imagery to make inferences about deep ocean habitats.

The Ridge Exploring Robot
(PDF, 1.6 Mb) (from the INSPIRE: Chile Margin 2010 Expedition)
http://oceanexplorer.noaa.gov/explorations/10chile/background/edu/media/robot.pdf

Focus: Autonomous Underwater Vehicles/Marine Navigation (Earth Science/Mathematics)

Students will explain a three-phase strategy that uses an autonomous underwater vehicle (AUV) to locate, map, and photograph previously undiscovered hydrothermal vents, design a survey program to provide a photomosaic of a hypothetical hydrothermal vent field, and calculate the expected position of the AUV based on speed and direction of travel.

The Tell-Tale Plume
(PDF, 1.2 Mb) (from the INSPIRE: Chile Margin 2010 Expedition)
http://oceanexplorer.noaa.gov/explorations/10chile/background/edu/media/plume.pdf

Focus: Hydrothermal Vent Chemistry (Earth Science/Chemistry/Mathematics)

Students will describe hydrothermal vents, identify changes that they cause to the physical and chemical properties of seawater, and use oceanographic data to recognize a probable plume from hydrothermal activity.

Reduced Fare
(PDF, 1 Mb) (from the INSPIRE: Chile Margin 2010 Expedition)
http://oceanexplorer.noaa.gov/explorations/10chile/background/edu/media/reducedfare.pdf

Focus: Deep-Sea Reducing Environments (Biology/Chemistry)

Students will describe oxidation and reduction, explain the meaning of "reducing environment," give at least three examples of deep-sea reducing environments, and demonstrate a flow of electric current produced by a redox reaction.

My Wet Robot
(PDF, 300 kb) (from the Bonaire 2008: Exploring Coral Reef Sustainability with New Technologies Expedition)
http://oceanexplorer.noaa.gov/explorations/08bonaire/background/edu/media/wetrobot.pdf

Focus: Underwater Robotic Vehicles (Physical Science)

In this activity, students will be able to discuss the advantages and disadvantages of using underwater robots in scientific explorations, identify key design requirements for a robotic vehicle that is capable of carrying out specific exploration tasks, describe practical approaches to meet identified design requirements, and (optionally) construct a robotic vehicle capable of carrying out an assigned task.

Chemosynthesis for the Classroom
(PDF, 274 kb) (from the 2002 Gulf of Mexico Expedition)
http://oceanexplorer.noaa.gov/explorations/02mexico/background/edu/media/gom_chemo_gr912.pdf

Focus: Chemosynthetic bacteria and succession in chemosynthetic communities (Chemistry/Biology)

In this activity, students will observe the development of chemosynthetic bacterial communities and will recognize that organisms modify their environment in ways that create opportunities for other organisms to thrive. Students will also be able to explain the process of chemosynthesis and the relevance of chemosynthesis to biological communities in the vicinity of cold seeps.

Where's My 'Bot?
(PDF, 492 kb) (from the Bonaire 2008: Exploring Coral Reef Sustainability with New Technologies Expedition)
http://oceanexplorer.noaa.gov/explorations/08bonaire/background/edu/media/wheresbot.pdf

Focus: Marine Navigation (Earth Science/Mathematics)

In this activity, students will estimate geographic position based on speed and direction of travel, and integrate these calculations with GPS data to estimate the set and drift of currents.

The Big Burp: Where's the Proof?
(PDF, 364 kb) (from the Expedition to the Deep Slope 2007 Expedition)
http://oceanexplorer.noaa.gov/explorations/07mexico/background/edu/media/burp.pdf

Focus: Potential role of methane hydrates in global warming (Earth Science)

In this activity, students will be able to describe the overall events that occurred during the Cambrian explosion and Paleocene extinction events and will be able to define methane hydrates and hypothesize how these substances could contribute to global warming. Students will also be able to describe and explain evidence to support the hypothesis that methane hydrates contributed to the Cambrian explosion and Paleocene extinction events.

This Life Stinks

(PDF, 276 kb) (from the 2003 Windows to the Deep Expedition)
http://oceanexplorer.noaa.gov/explorations/03windows/background/education/media/03win_lifestinks.pdf
(paste url into browser)

Focus: Methane-based chemosynthetic processes (Physical Science)

In this activity, students will be able to define the process of chemosynthesis, and contrast this process with photosynthesis. Students will also explain the process of methane-based chemosynthesis and explain the relevance of chemosynthesis to biological communities in the vicinity of cold seeps.

Other Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.

http://oceanexplorer.noaa.gov/explorations/10sanandreas – Web site for the Cradle of the Earthquake: Exploring the Underwater San Andreas Fault 2010 Expedition

http://celebrating200years.noaa.gov/edufun/book/welcome.html#book - A free printable book for home and school use introduced in 2004 to celebrate the 200th anniversary of NOAA; nearly 200 pages of lessons focusing on the exploration, understanding, and protection of Earth as a whole system

http://earthquake.usgs.gov/regional/nca/1906/18april/index.php – U.S. Geological Survey Web page about the 1906 San Francisco earthquake

Adams, E. 1906. Letter to Reed and Barton. The Virtual Museum of the City of San Francisco; http://www.sfmuseum.net/1906/ew3.html

http://www.ess.washington.edu/SEIS/PNSN/HAZARDS/CASCADIA/cascadia_event.html – Web page about the January, 1700 Cascadia Subduction Zone earthquake and tsunami from the Pacific Northwest Seismic Network; includes discussion of various lines of evidence that help pinpoint the date of past earthquakes

http://www.sciencecourseware.com/eec/Earthquake/ – Web site for Virtual Earthquake, an interactive activity designed to introduce concepts of how an earthquake epicenter is located and how the magnitude of an earthquake is determined

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
- Energy in the earth system
- Geochemical cycles

Content Standard E: Science and Technology
- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives
- Natural resources
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.
The Earth has one big ocean with many features.
Fundamental Concept h. Although the ocean is large, it is finite and resources are limited.

Essential Principle 6.
The ocean and humans are inextricably interconnected.
Fundamental Concept b. From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
Fundamental Concept e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (such as point source, non-point source, and noise pollution) and physical modifications (such as changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
Fundamental Concept f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).
Fundamental Concept g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Essential Principle 7.
The ocean is largely unexplored.

Fundamental Concept a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

Fundamental Concept c. Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.

Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Fundamental Concept f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

Send Us Your Feedback

We value your feedback on this lesson.
Please send your comments to:
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Student Worksheet
Earthquakes and Turbidites Inquiry Guide

Background

Scientists often obtain information about past earthquakes by studying proxies. Proxies are natural records of biological and geological ecosystem features that are affected by certain events. Tree rings are a well-known proxy for year-to-year weather conditions, since the size of each ring is affected by growing conditions during the year in which each ring is formed. In fact, tree rings are sometimes used to obtain information about the history of earthquakes, since earthquakes cause stresses that can affect the growth of trees.

In many places along the continental shelf and continental slope, there are accumulations of sediments carried into the ocean by rivers. These accumulations continue to build until they become unstable and slide down the slope in a sort of avalanche called a turbidity current. As the turbidity current moves down the slope, the velocity of the current gradually decreases and particles carried in the current begin to form deposits on the seafloor. These accumulations of sediments transported by turbidity currents are called turbidites. Turbidites and sediment layers are often studied using core samples collected from the ocean floor adjacent to the continental slope.

Inquiry 1 – How do sediment particles settle?

1. Pour the sand mixture (NOT the colored sand!) into the plastic container, then fill the container with water.

2. Place the top or cap securely on the plastic container and shake vigorously for 15 seconds.

3. Place the plastic container on a flat surface and allow it to stand without further disturbance.

4. Observe the behavior of particles in the plastic container and record your observations.

5. Based on your observations, how would you expect particles carried by turbidity currents to be arranged in turbidites?

Student Worksheet

Earthquakes and Turbidites Inquiry Guide - pg 2

Inquiry 2 – Interpreting model turbidites

1. Make a model core sample by layering small amounts of colored sand into your test tube. Fold a piece of scrap paper into a funnel. Use the funnel to minimize spillage as you use a plastic spoon to pour sand into the test tube. Each layer should represent a period of 50 years. Choose one or two points at which you will create a disturbance (turbidite!) in the sequence of layers. Do this by gently shaking or tapping the tube, then continue the layering process until the tube is almost full and there is only enough space left for the stopper. Label your test tube as directed by your teacher, and make a note about when turbidites occurred in your model core.

2. Exchange model core samples with another group. Study the layers to determine where turbidites are in the core and how long ago they occurred. Record your conclusions.

3. How could turbidites be used as earthquake proxies?