Investigating Seafloor Sediments
Proceed As A Scientist!

Students will investigate the question “What makes up the seafloor?” by first developing an alternative hypotheses, then devising and implementing their own procedure using provided equipment and supplies to create smear slides. They will then analyze their samples to test their hypotheses. Students will document and reflect upon the process they engaged in using the Science Flow Chart and determine what their next steps will entail. This activity can be used as an introduction to seafloor sediment, ocean cores and to emphasize the dynamic, creative, and non-linear aspect of science.

Grades Can be modified for grades 6-13 by providing different levels of structure to the activity and by providing different background information on microfossils, seafloor sediments and global distribution.

Connections to the Next Generation Science Standards

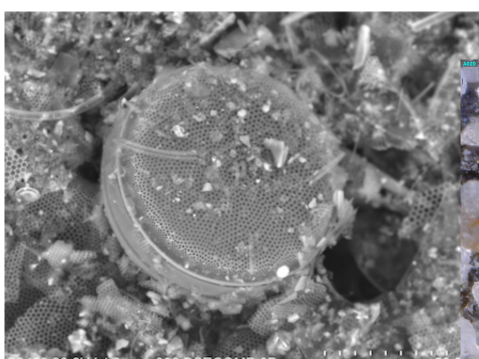
Disciplinary Core Ideas

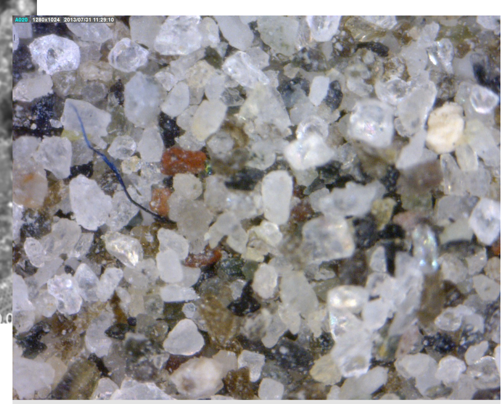
- ESS1.C Earth’s history
- ESS2.A Earth materials and systems
- ETS1: Engineering design

Science & Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations and designing solutions

Time Two class periods (2-3 hours)





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Materials Needed

- **Equipment Kit**: (1 per group)
  - 1- UV light (direct sunlight will also work)
  - 1- Hotplate
  - 1 box - Toothpicks
  - 1 box - Glass slides
  - 1 box - Cover slips
  - 1 – 3oz drop bottle with water
  - OPTIONAL: 1 bottle - Norland Optical Adhesive (61) [this glue adheres the coverslip so is only necessary for creating long term slides]
  - Sticky labels for microscope slides
  - Fine permanent pen
  - Microscope
  - Kim wipes or paper towel
- Seafloor maps that show bathymetry, sediment thickness and ocean basin distribution in relation to continents
- Sediment samples (see *Preparing Samples* below for making samples)
- *Investigating Seafloor Sediments* Student Packet (1 per student)
- *Seafloor Sediment Identification Guide* (1 per group)
- *Simple Science Flow Chart* (1 per student)
- Grade appropriate *Science Flow Chart* (1 per student)
- Colored pens or pencils
- *Introduction to the JOIDES Resolution* PowerPoint http://joidesresolution.org/node/3307
- *JR Time Machine* video (http://www.youtube.com/watch?feature=player_detailpage&v=_qtvK35YhNE)
- Other background resources at www.joidesresolution.org

Advanced Preparation

- Assemble *Equipment Kits:* All of the contents listed above can fit inside a 12-18 inch plastic box.
- Photocopy *Student Investigation Packet, Sediment Identification Guide, Flow Charts* and *maps (optional)*
- Become familiar with the Science Flow Chart at http://undsci.berkeley.edu/article/scienceflowchart.
- Prepare Samples (below)
- Read Background on *How to Make Smear Slides* (below)

Preparing Samples

Here are four main types of marine sediments that can be used in this activity:

- **Calcareous ooze** is made up of coccolithophores and/or foraminiferans. Both of these single celled organisms absorb calcium carbonate from ocean water to build their shells. **Coccolithophores**, or chalk (not synthetic chalk) can be a bit challenging to find. Coccoliths or *coccolith ooze occurs in regions of moderate primary productivity and seafloors shallower than the calcite compensation depth (<~4500m).*

- **Siliceous ooze** is made up of diatoms and/or radiolarians. Both of these single celled organisms absorb silica from the ocean water to build their shells. **Diatoms** are what make up diatomaceous earth that can be bought cheaply from pool supply and garden stores as it is used in pool filters and as a pest deterrent. *Diatoms or diatomaceous ooze occurs on seafloor areas beneath surface regions of high primary productivity (e.g. eastern equatorial Pacific, Peru margin)*

- **Red clay** is easily obtained in local environments or from art supply stores. *Red clay occurs in regions of low primary productivity and far from continents.*

- **Sand and Silt (terrigenous sediment)** is the result of erosion from rocks and sediments on land. It is easily obtained in local environments. *Terrigenous sediment occurs near continents and is abundant near major rivers and glaciated areas.*

Use a single sediment type, or create multi-layered mock cores using combinations of these sediments to show events. Mix the sediment with a small amount of water to create a moist, but not soupy material. Place in small plastic container that can be sealed to prevent drying.

Directions:

I. Question to explore

1. Pass out the *Student Investigation Packet* and assign student groups.
2. Show students a picture of a world map and/or a bathymetric map and/or sediment thickness map, and then ask them the question: *What makes up the seafloor?*
   a. Give them time to generate their ideas based on what they have seen, experienced, or heard before. Encourage students to think about how sediments from different regions of the ocean might be different and similar. Have them generate ideas for processes that might impact the ocean floor and what it is made of (e.g. runoff, eruptions, life cycles of organisms, seafloor spreading, etc.)
   b. *Alternative:* Provide students with background on the four types of marine sediments and what controls their occurrence.
3. Explain that they are going to investigate this question for a specific region(s) of the ocean using samples representative of what is found on modern seafloors sea.

4. Pass out sediment samples and show students where the sample came from. If using purchased samples, you can generate a mock locality using information from the *Preparing Samples* section and *Sediment Distribution* map.

II. Generating ideas (hypotheses)

5. Explain that the samples from the seafloor are collected by scientists and staff aboard research vessels such as the *JOIDES Resolution*. Use resources from www.joidesresolution.org to learn more about how the science is done and who does the science.
6. Based on the discussion and their sample, have students generate several testable hypotheses about the likely composition of the sample. For each hypothesis they should write down what they would expect to see if the hypothesis is supported. *Ex. Hypothesis 1: The ocean floor is made of mud and rocks. Expected observations: We would find a mix of mud and rocks in a sample collected from the seafloor.*

IV. Testing your ideas (hypotheses) – Part I

7. Pass out the Equipment Kit. Tell students: *This box contains all the necessary tools for exploring your samples. Spend time looking at each tool and determine how it will help you analyze your sample. Come up with the procedure that you will use.*

   IMPORTANT: The aim is to have students problem solve on their own. It is great if they start a procedure and make mistakes and have to revise so they can experience the creative and problem solving aspect of science. Older students may start implementing their ideas before they come up with a complete procedure and that should be encouraged, though make sure they know the safety rules (see note below).

   Safety Precautions:

   a. **Hotplate – Gets very hot! Don't get body parts near it.**
   b. **UV light – Can blind! Don't look into it or hold it up at others.**
   c. **Glass slides – Can cut! It's glass so be gentle.**
   d. **Glue – Can stick! Clean up quickly and keep the cap closed.**

8. At some point, depending on the age and experience of the students, you might want to bring the group back together and have them discuss their procedure so they can learn from one another (another important aspect of science!).

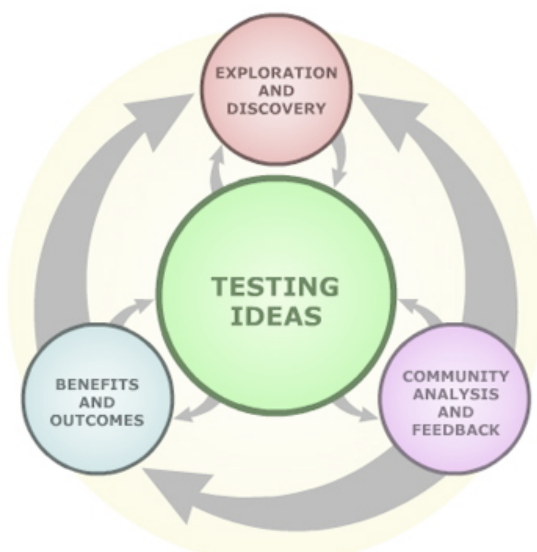
Testing your ideas (hypotheses) – Part II

9. If they have not started already, have students implement their procedure and analyzing the samples. Most students' will put WAY too much sediment on the slide and not be able to see anything. Guide them to consider reducing the sediment amount and revise the set of directions.
10. Once they are able to view their sample with a microscope, have them draw and take notes about what they see in as much detail as possible.

11. Pass out *Seafloor Sediment Identification Guide* and other sediment and microfossil resources useful for identifying the sample.
12. Give students an opportunity to discuss their findings and record how their actual observations impacted each of their hypotheses i.e. *Supports, does not support, generates new ideas, causes a revision of ideas.*
13. Have students review their initial question "What is the seafloor made of?" and respond to what they have learned from their investigation.
14. Extension: Pass out a different sample from the same locality but different depth/point in geologic time. Have students analyze the new sample then reconstruct the past events that might have caused the change in sediment type.

How to use this activity to introduce the Science Flow Chart
The Science Flow chart is a model for the process of science that illustrates the dynamic, non-linear, and creative aspect of science, and highlights aspects beyond the testing of ideas. (For more information visit http://undsci.berkeley.edu). This investigation can be used to introduce this model of science if students are unfamiliar.

Here's how! After students complete their sample analysis and interpretation, have them generate a list that describes what they did during their investigation e.g. *made observations, discussed ideas, formed hypotheses, etc.* Pass out the *Simple Science Flow Chart* and have students explore and explain what it tells us about how science is done e.g. *testing ideas is large and in the center so it is really important, the arrows indicate that there are many directions one can take, there are benefits to doing science that leads to more science investigations, etc.*
Then have students place the elements from their generated list on the flow chart where they think they belong. It is OK if students place items in different places or in more then one place. Once students have an opportunity to further reflect on all the elements of the process, reveal the grade appropriate complex *Science Flow Chart* and use it to engage in a more detailed discussion about how science works.



Reflecting on the investigation

Have students use a colored pencil or pen to draw arrows on the *Science Flow Chart* in sequential order that mirrors how they proceeded through their investigation. Encourage them to draw multiple arrows back and forth to illustrate places where steps were repeated and problem solving has occured. Students should compare their flow charts and answer the questions listed. To illustrate the many different next steps that are possible, students should use different colors to extend their pathway in different directions and provide details about their different options.

Learning more about the real science

Have students generate scientific and non-scientific questions about what they have experienced and their sample. Show the *JR Timemachine* video, use the *Introduction to the JOIDES Resolution* PowerPoint and/or other resources at www.joidesresolution.org to address the questions generated.

Extensions

- Use this activity to introduce students to the different types of microfossils that exist and what they can tell us about Earth's history.
- Create mock cores of different sediment layers to give students additional experience analyzing and interpreting seafloor sediments. They can use these cores to generate hypotheses about past events that took place.
- Use the Cretaceous Impact Kit and other core models to have students analyze real core "stories." See http://joidesresolution.org/node/3002 for details.
- Have students further discuss and investigate how science works using resources from *Understanding Science http://undsci.berkeley.edu/.*

How to Make Smear Slides

Author: Steve Hovan – Geoscience Department, Indiana University of PA

Students are challenged to create their own procedure for analyzing their sediment sample. Below is the procedure commonly used by the scientific community. The goal of this activity is NOT to have all students follow this procedure, but to use their creativity and problem solving skills to develop a method (most likely similar to that below) that works for them.

1. Label a glass slide with sample information.

   For ocean drilling samples, it's typically:

   Leg or Expedition – Site & Hole - Core – Section, Depth Interval

   e.g. *Leg 138 – Site 848B - 12H-4, 65cm*
2. Turn on the hot plate to the lowest setting.
3. Clean the slide by wiping with water or alcohol on a lint-free tissue (e.g. Kim-Wipe).
4. Place a very small amount of sediment (e.g. toothpick tip) on the slide. Ideally grains will be more or less in a single layer and close together. Although it is tempting to use a larger amount of sediment, components will be indistinguishable under the microscope if the sample is too crowded.
5. Add a drop or two of water or alcohol to the slide. Try to make a uniform, thin coating approximately the same size as the cover slip.
6. Place the slide on the slide warmer or hot-plate and allow it to dry completely (2-5 minutes) before adding the optical adhesive.
7. Drip 2-3 drops of Norland Optical Adhesive 61 onto the slide (or on the cover glass). Do not touch the dropper to the slide, to avoid contaminating the mounting medium.
8. Carefully place the cover slip on the slide. Try not to drop it on or you may get a lot of air bubbles.
9. Place the slide under ultraviolet light to cure (1-2 minutes).
10. View under microscope.