5 Finding Resource Deposits

MODELING

1–2 CLASS SESSIONS

ACTIVITY OVERVIEW

NGSS CONNECTIONS

Students model how natural resources are discovered using remote sensing techniques. These techniques extend the ability to measure, explore, and identify structures underground. Students analyze the data they collect, which provide evidence that resources are distributed unevenly on Earth. They are introduced to the idea that the distribution of resources is a result of past geological processes.

NGSS CORRELATIONS

Performance Expectations

Working towards MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

Disciplinary Core Ideas

MS-ESS3.A Natural Resources: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.

Science and Engineering Practices

Developing and Using Models: Develop and use a model to predict and/or describe phenomena.

Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena.

Crosscutting Concepts

Connections to Engineering, Technology and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World:

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.

Common Core State Standards—ELA/Literacy

RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHAT STUDENTS DO

Students model the use of remote sensing techniques to reveal subsurface features. Based on the data gathered from the model, they create and interpret a false-color map to predict the locations that are more likely to contain accumulations of resources. They then consider why resources are unequally distributed around the globe.

MATERIALS AND ADVANCE PREPARATION

- *For the teacher*
  1 Visual Aid 5.1, "False-color Map Derived from Remote Sensing Data"
- *For each group of four students*
  1 Remote Sensing Box
  2 measuring probes
  5 colored pencils (or crayons): red, yellow, orange, green, and blue
- *For each student*
  1 Student Sheet 5.1, "Mapping Subsurface Structures"

**not included in kit*

To create the Remote Sensing Box, slide a plastic landform model into each box according to the directions on the flap of the box. They all must face the same direction and sit securely on the bottom of the box. Make sure the covers on the boxes are closed so students cannot see the contents. You may want to secure them with tape to keep students from peeking.

An optional technology extension is to use Excel or another spreadsheet program to display students' data in a three-dimensional graph. For specific directions on how to create three-dimensional graphs in Excel, see the teacher page of the *SEPUP Third Edition Earth's Resources* website at *www.sepuplhs.org/middle/third-edition*

TEACHING SUMMARY

GET STARTED

1. Introduce the concept of remote sensing.
    a. Ask the class, "How do we know what Earth's interior is like?"
    b. Introduce remote sensing as the gathering of data from a distance.
    c. Have students read the introduction and Guiding Question for the activity.

DO THE ACTIVITY

2. Model the collection of remote sensing data.
    a. Demonstrate the use of the equipment.
    b. Facilitate the collection of data from the Remote Sensing Box.
3. Students construct false-color maps of the subsurface structures in the Remote Sensing Box.
    a. Assist students as they make their maps.
    b. Use a computer to create a three-dimensional map (optional).

BUILD UNDERSTANDING

4. Students analyze maps derived from remote sensing data to help locate resources.
    a. Review student-produced maps.
    b. Relate past geological processes to the location of resources.
    c. Have students identify possible resource locations.
    d. Have students analyze and interpret their data for locations with higher potential for deposits.
5. Review key content addressed in the Analysis items.
    a. Evaluate the model.
    b. Emphasize past geological processes as causes for the locations of resources.
    c. Connect key concepts to the crosscutting concept of connections to engineering, technology and applications of science.

TEACHING STEPS

GET STARTED

1. Introduce the concept of remote sensing.

   a. Ask the class, “How do we know what Earth’s interior is like?”

   Have several students share their ideas. Tell the class that the deepest hole to have ever been drilled is just over 12 km (7.5 miles) deep, whereas the radius of Earth (distance from the surface to the center) is about 6,400 km (4,000 miles). Lead students to the understanding that humans can gather data on Earth’s interior by measuring the magnetism or gravity at different locations or analyzing sound and seismic waves that pass through the planet.

   b. Introduce remote sensing as the gathering of data from a distance.

   Remote sensing includes various ways of getting information, but most often refers to a procedure that provides information about an object from a position where the measuring device does not touch the object. In the geosciences, one use of remote sensing is to explore Earth’s subsurface structure and composition. Emphasize that even though no one has seen or sampled 99% of Earth’s interior, scientists have gathered a large amount of data about its composition and structure.

   c. Have students read the introduction and Guiding Question for the activity.

   Briefly respond to any questions or comments about the introduction. Direct student attention to the diagrams at the end of the introductory section. For the upper diagram, explain how the produced seismic waves have a well-defined shape and size and that as the waves move through the earth and encounter different materials, the waves’ characteristics change. Analyzing the changes in the waves allows for the construction of graphical representations, such as the lower diagram, showing the structure of the subsurface.

   Let students know that in this activity, they will model the collection and analysis of remote sensing data. This technology extends the measurement, exploration, modeling, and computational capacity of scientists to identify underground resources.

DO THE ACTIVITY

2. Model the collection of remote sensing data.

   a. Demonstrate the use of the equipment.

      Hold up a Remote Sensing Box, and explain that there is a surface, or landscape, inside it. Ask students to imagine it as a very reflective rock layer thousands of feet below Earth's surface. Hold up a probe, point out the holes in the top of the box, and model how to carefully insert the probes into the holes and measure how far down the probes go before hitting the "reflective" surface. The probe gives the depth from "Earth's surface" to the subsurface layer immediately beneath each hole.

      Emphasize that it is important for students to check that the top of the box is level and that the probe is as close to perfectly vertical as they read the measurements on it. Students should be careful not to push the probe in beyond the first feeling of resistance. Instruct students not to look in the boxes, even after completing the activity.

   b. Facilitate the collection of data from the Remote Sensing Box.

      Distribute Student Sheet 5.1, "Mapping Subsurface Structures," the Remote Sensing Boxes, and the measuring probes. Direct students to conduct Part A of the Procedure, and circulate to each group, making sure that each student makes some of the measurements and compiles all of the measurements from the group in the table on Student Sheet 5.1.

3. Students construct false-color maps of the subsurface structures in the Remote Sensing Box.

   a. Assist students as they make their maps.

      Before moving on to Part B of the Procedure, explain that by sharing the data each group member collected, each student now has a full data set to use to create an image of what's inside the box. Students can then create a false-color map that uses an array of colors to represent various depths below the surface. Emphasize that the colors used to map the data have no relationship to the actual color of the subsurface material, which is why the term *false-color* is used. You may also want to explain that using colors to represent measurements is a common technique used with many types of remote sensing data because the colors make it easier to recognize features in the image. For example, when using color to represent depth, many maps use darker blues and purples to represent the deepest areas.

Hand out the colored pencils, and point out the key on Student Sheet 5.1, which correlates the color to the depth range. If any groups have different colors than those suggested for certain depths, have them re-label the legend before they begin. Encourage students to complete Part B, and circulate among the groups to supply assistance where needed.

Teacher's note: The false-color map created using the data from the Remote Sensing Box does not accurately portray a map that would typically be generated from seismic reflection data. Seismic reflection data is most often used to produce images of the geometry of subsurface rock layers and not an image of the topography of an ancient environment. The environment in which subsurface rocks were created is deduced using data from direct observations of rock samples and data collected using a variety of remote sensing techniques.

b. Use a computer to create a three-dimensional map (optional).

To create a three-dimensional map, consider using the graphing function of Excel or another spreadsheet program. After inputting students' data, you or your students can produce an image that can be moved around to show multiple perspectives. The perspective from the top should match the students' work on Student Sheet 5.1.

BUILD UNDERSTANDING

4. Students analyze maps derived from remote sensing data to help locate resources.

a. Review student-produced maps.

When students have completed their own false-color maps of what is inside the mystery box, project Visual Aid 5.1, "False-color Map Derived from Remote Sensing Data." Review the general position of each different color. Make sure that students know that the patterns on their maps should be similar but do not have to show the exact same patterns. At this point, do not interpret the map or ask students to do so.

b. Relate past geological processes to the location of resources.

Before students start Procedure Step 7a, briefly review the information in the table that provides a brief description of the past geological processes that led to the creation of resource deposits. Emphasize the cause-and-effect relationship between past processes and the formation of the resource deposits. If needed, help students imagine and describe characteristic features of rocks produced in different environments, such as fine-grained sediments in lakes, sand and gravel in river channels and beaches, and the characteristic shapes of volcanic vents and stream channels.

c. Have students identify possible resource locations.

The following table summarizes possible responses to Step 7b.

PROCEDURE STEP 7B SAMPLE STUDENT RESPONSE

Resource	Likely Underground or Surface Features
Fossil fuels	*Basins where there were once ancient lakes and seas and/or rock layers bent into "hill-shaped" folds that can act as petroleum and gas traps*
Dense, resistant materials	*Curved surface structures such as dried river beds, and basin edges such as those found near lakes or sea shores*
Metals	*Irregular-shaped caves and tunnels that may have once held magma or lava; sites of extinct volcanoes*

d. Have students analyze and interpret their data for locations with higher potential for deposits.

When discussing Steps 8 and 9, refer to Visual Aid 5.1, and ask students to describe the subsurface structures based on the map. From their data, they should be able to make out a shallow sinuous shape (possible river channel) and a deeper, larger basin (possible lake or sea). Fossil fuels are more likely to be found in the basin, whereas gold is more likely to be found along basin edges or river channels, particularly along the bends.

5. Review key content addressed in the Analysis items.

a. Evaluate the model.

Analysis items 1 and 2 have students consider how well the model represents the process and resulting output of a seismic survey. Keep students from spending time on the details of how the box model is constructed and, instead, focus them on the bigger picture, such as the advantage of being able to collect data without seeing the area and the disadvantage of having to use physical rulers rather than shockwaves.

b. Emphasize past geological processes as causes for the locations of resources.

In Analysis item 3, students relate the distribution of resources to a specific geological process or setting. After reviewing this item, ask students to propose reasons why volcanoes might occur in only some places. Depending on their previous exposure to plate tectonic theory, you may want to briefly explain or review it. Emphasize that plate boundaries are where most volcanoes are found. Also, point out that locations of volcanic rocks and mineral deposits do not have to be on current plate boundaries because during Earth's billion years of existence, the number, size, position, and movement of Earth's plates has changed considerably. Students will learn more about these ideas in the "Geological Processes" activity.

c. Connect key concepts to the crosscutting concept of connections to engineering, technology and applications of science.

Discuss how human activity depends on natural resources, especially on those that are nonrenewable. Ask students, "Since nonrenewable resources are not distributed evenly around the planet, what happens when a resource is located somewhere other than where it is needed?" Students should respond that those without the resources can buy them from those who have the resources. Use this question to discuss who does and who should have ownership over resources that all humans depend on, and how natural resources create an international market. This provides an opportunity for students to consider the long-term consequences of extracting resources for the health of all people.

SAMPLE RESPONSES TO ANALYSIS

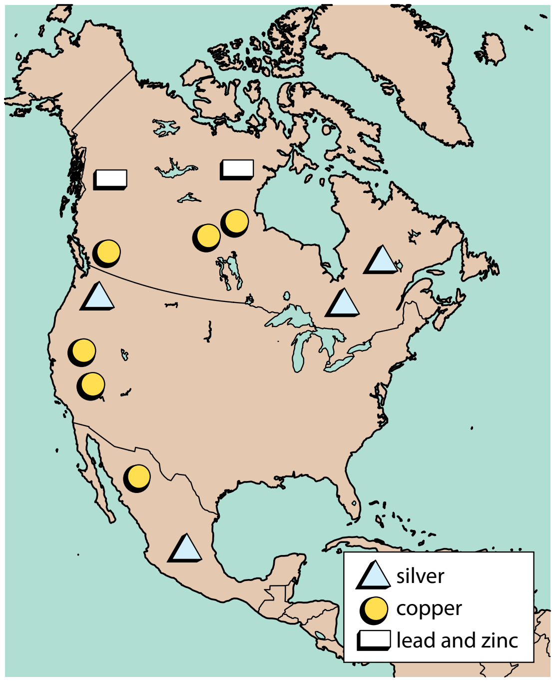
1. Was the box and the probe a good model for seismic reflection? Describe the strengths and weaknesses of this model.

   The model's strength is that it can be used to make a map of what you cannot see. A weakness is that we used sticks that went straight down, and this did not accurately model shockwaves that bounce off at an angle. Another weakness is that it only shows one level, and you don't know anything about what is above or below it.

2. In a false-color map, does it matter which color is used for each measurement range? Why or why not?

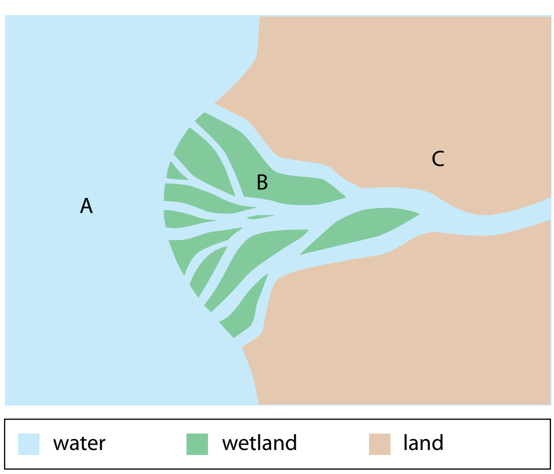
   No. As long as there is a legend that relates the color to the depth, the color used is irrelevant.

3. Look at the map below. Do you think you are more likely to find evidence of volcanic activity in the western or eastern parts of the United States? Explain your reasoning.



The western U.S. is more likely to have evidence of past volcanic activity because there are more metal deposits there, and metal deposits are often associated with volcanic areas.

4. Imagine that you are a geologist for an energy company trying to locate fossil fuel deposits. The map below represents a reconstruction of a past environment. Which area(s) do you think are most likely to contain fossil fuels? Support your answer with evidence from this activity.



In this activity, we learned that fossil fuels are often found in rocks from ancient bodies of water. This means that Area A (a large body of water) and Area B (wetlands) are potential locations for fossil fuels.

5. Natural resources are distributed unequally around the world. Why do you think certain natural resources form in one place and not another?

   Each natural resource has a particular geological setting that favors the formation and/or accumulation of that resource. These geological settings are often related to past environments and climates, which, like today's environments and climates, occurred in different places around the world.

REVISIT THE GUIDING QUESTION

How are underground deposits of natural resources located?

Buried resources are discovered either by using clues found at the surface that indicate what is buried below or by using remote sensing techniques to "look" at subsurface materials.

This activity completes a sequence of learning around the first driving question identified on the Phenomena, Driving Questions, and Storyline document and introduced in the beginning of this unit. Revisit students' ideas and add/revise as needed.

ACTIVITY RESOURCES

KEY VOCABULARY

deposit

evidence

model

natural resources

remote sensing

BACKGROUND INFORMATION

SEISMIC REFLECTION SURVEYS

Seismic reflection surveys are a common method used to map the subsurface for oil exploration. Seismic reflection works by sending shockwaves down into the earth and then recording the timing and shape of the waves that are reflected back to the surface. Variations in the properties of different earth materials cause the reflected waves from different rocks and resources to be different. Geoscientists analyze and interpret the reflected waves to map the shapes of structures and the boundaries between different rock and resource types.

Seismic reflection is typically used to determine the position of subsurface layers to locate structures (e.g., salt domes, anticlines, and faults) that influence the migration and accumulation of oil and gas. Mining exploration has also begun to use seismic reflection to delineate the geometry and extent of buried ore deposits. In this activity, the model reveals buried topographic features, which are not the typical subsurface features revealed by seismic reflection.

Name____ Date__________

STUDENT SHEET 5.1

MAPPING SUBSURFACE STRUCTURES

PART A: DATA OBTAINED FROM REMOTE SENSING MODEL

		Depth Measurements									
Hole # →		1	2	3	4	5	6	7	8	9	10
ROW	A										
	B										
	C										
	D										
	E										
	F										
	G										
	H										

PART B: FALSE-COLOR MAP DERIVED FROM REMOTE SENSING DATA

Hole # →		1	2	3	4	5	6	7	8	9	10
ROW	A										
	B										
	C										
	D										
	E										
	F										
	G										
	H										

Probe Depth (cm)	Color code	Interpretation
0–2	red	Land sediments
2–4	yellow	River sediments
4–6	green	Coastline sediments
6–8	blue	Shallow basin sediments
> 8	purple	Deep basin sediments

Name *Sample student response* Date

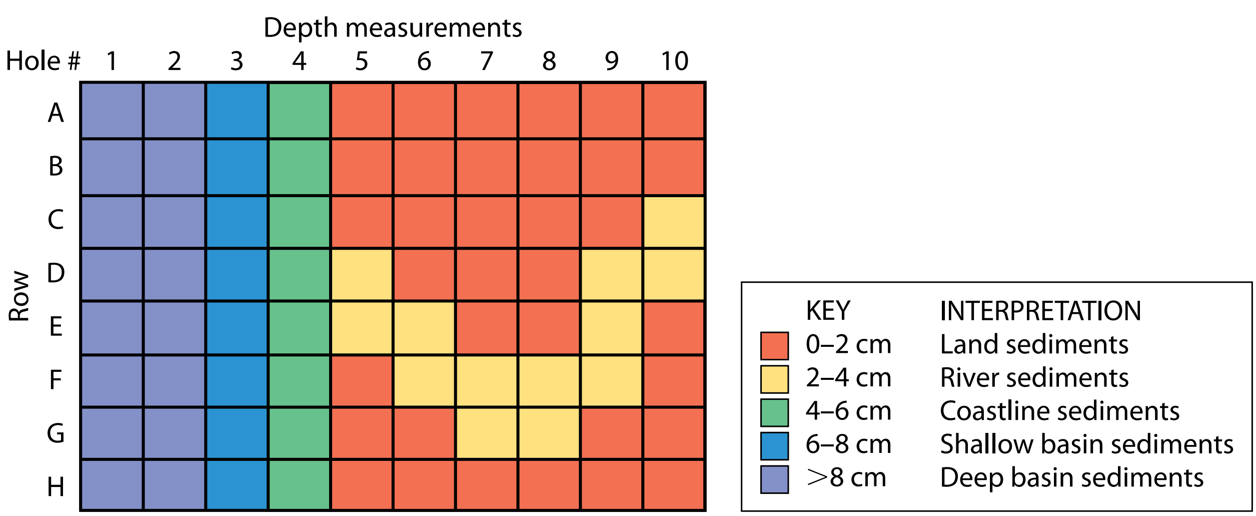
STUDENT SHEET 5.1

MAPPING SUBSURFACE STRUCTURES

PART A: DATA OBTAINED FROM REMOTE SENSING MODEL

		Depth Measurements									
Hole # →		1	2	3	4	5	6	7	8	9	10
ROW	A	*9.0*	*8.2*	*7.1*	*5.2*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*
	B	*9.0*	*8.2*	*7.1*	*5.2*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*
	C	*9.0*	*8.2*	*7.1*	*5.2*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*3.2*
	D	*9.0*	*8.2*	*7.1*	*5.2*	*3.1*	*1.1*	*1.1*	*1.1*	*3.1*	*3.0*
	E	*9.0*	*8.2*	*7.1*	*5.2*	*3.2*	*3.0*	*1.1*	*1.1*	*3.2*	*1.1*
	F	*9.0*	*8.2*	*7.1*	*5.2*	*1.1*	*3.1*	*3.2*	*3.2*	*3.0*	*1.1*
	G	*9.0*	*8.2*	*7.1*	*5.2*	*1.1*	*1.1*	*3.0*	*3.1*	*1.1*	*1.1*
	H	*9.0*	*8.2*	*7.1*	*5.2*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*

PART B: FALSE-COLOR MAP DERIVED FROM REMOTE SENSING DATA



VISUAL AID 5.1

FALSE-COLOR MAP DERIVED FROM REMOTE SENSING DATA