

Engineering

Level: HS
Facilitator Guide

LESSON DETAILS

Objective: Students will investigate how engineering disciplines are involved in exploration for and extraction of minerals.

Standards

NVACSS and NGSS

- **HS-ESS3-2:** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- **HS-ESS3-4:** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- **HS-ETS1-3:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- **DCI:** Natural Resources; Human Impacts on Earth Systems
- **SEP:** Obtaining, Evaluating, and Communicating Information
- **CCC:** Interdependence of Science, Engineering, and Technology

Career Readiness

- **1.2.8:** Demonstrate time, task, and resource management skills by organizing and implementing a productive plan of work.

Materials

- samples of hematite, magnetite, and taconite
- materials for conducting mineral tests (streak plate, graduated cylinder, scale, magnets)
- small, clear containers (recommended: 9" L x 6" W x 6" H)
- graph paper
- scissors
- clear tape
- light-colored sand
- red sand, clay, or other sediment
- iron filings
- water
- clear straws
- dowels (thin enough to fit into the straws)
- scale
- magnets (ceramic and neodymium)
- clear sandwich or snack baggies with zipper
- multimeter (optional)
- copies of "Mining Map" handout
- copies of "Exploration for Minerals" handout

Lesson Summary

Students will test the properties of iron-containing minerals and watch a video on mineral exploration to consider how they would explore Nevada for the presence of iron deposits. Students will then conduct tests to gather information to map an iron deposit at a model mining site. A collection of videos, images, and readings will help students learn about the many roles of engineers in the mining process, as well as get them thinking about how they will extract the iron from their model mining sites. Students will then develop and carry out their mining plans to extract iron from their model mining site. The lesson concludes with students preparing a report on the success of their mining plans.



Preparation

For **Explore**, build enough model mining sites for students to work in small groups (recommended four students maximum per model):

1. Cover three sides of a clear container with graph paper, leaving one of the shorter sides exposed for students to view as an “outcrop” (see Figure 1). This outcrop will be the North end of the mining site.
2. Fill the bottom of the container with a thin layer of damp, light-colored sand.
3. Add more damp, light-colored sand to one of the shorter ends of the container to make a hill.
4. Next add an “iron ore” and an iron deposit to the models so that each group’s model has the same distribution:
 - a. Mix a small amount of damp red sand, clay, or other sediment with iron filings in a 10:1 ratio. This will represent an iron ore with a low iron concentration.
 - b. Add a thin layer of the iron ore mixture to the entire model.
 - c. Add a thin “vein” of iron filings on top of the ore to represent a more concentrated deposit of iron. (See Figure 2 and Figure 3.) A small portion of this vein should be visible through the uncovered end of the model (see Figure 1).
 - d. Add a thick layer of the ore mixture on top of the hill.
 - e. Add another thin layer of the ore over the whole model (including the iron deposit).
5. Use sand to fill in the rest of each container to between two-thirds and three-quarters full, but do not cover the iron ore on the hill.
6. Cut pieces of cardboard to fit inside the model and cover the sand.



FIGURE 1. THE OUTCROP OF THE MINING SITE MODEL.

Credit: L. Mossa, American Geosciences Institute.



FIGURE 2. THE MINING SITE MODEL, PARTIALLY CONSTRUCTED TO SHOW THE IRON DEPOSIT WITHIN THE SITE.

Credit: L. Mossa, American Geosciences Institute.



Engage

1. Provide students with samples of a variety of iron-containing minerals(iron ores), such as hematite, magnetite, and taconite.
 - a. Have students make observations (e.g., color, luster, texture) of the samples and complete tests used for identifying minerals (e.g., streak, density/specific gravity, magnetism).
 - b. Students should construct a data table to record their observations and test results.
 - c. Discuss the similarities and differences between the ore samples.
 - d. Discuss any properties of the minerals that might have surprised students, such as the reddish streak of minerals like hematite and taconite.
2. Ask students:
 - ▶ *Do you think iron is mined in Nevada? Why or why not?*
 - ▶ *If you wanted to try to find iron ore in Nevada, where might you start? What would you look for?*
3. Show the first minute and 14 seconds of a **video what exploration geologists do**, then revisit the last question on how students might go about finding iron ore deposits.
4. Project or have students use a mapping website (like **Google Maps** or **Satellite Maps**) to look around Nevada for areas that might have iron rocks.
 - a. As needed, prompt students to think about what properties they might look for based on their observations from Step 1 (such as iron being associated with red coloration in rocks/ores).
 - b. Zoom in on areas of interest and discuss what tests students might conduct to determine if there is iron in this area.
 - c. If students are having trouble locating areas of interest, direct them to look just outside of Las Vegas (West or East), or have them search around “Iron Mine Road” near Carlin, Nevada, where there are patches of red rock.
5. Ask students:
 - ▶ *If you positively identified iron in the area, what else would you want to know about the deposit before digging?*
 - ▶ *What are the potential consequences of digging without first gathering more information? Discuss the financial and environmental costs of digging, especially if a mining company does not know the concentration, size, and exact location of a mineral deposit.*



Explore

1. Provide student groups with a mining site model (as described in **Preparation**) and the “Exploration for Minerals” handout. Students will conduct tests to create a map of where an iron deposit is likely located within the mine site. This will help them determine where they will dig in the mine site during **Elaborate**.
2. Have students follow the directions on the “Exploration for Minerals” handout. Be sure that groups are recording their observations and findings on the “Mining Map” handout that will eventually help them determine where to take cores.

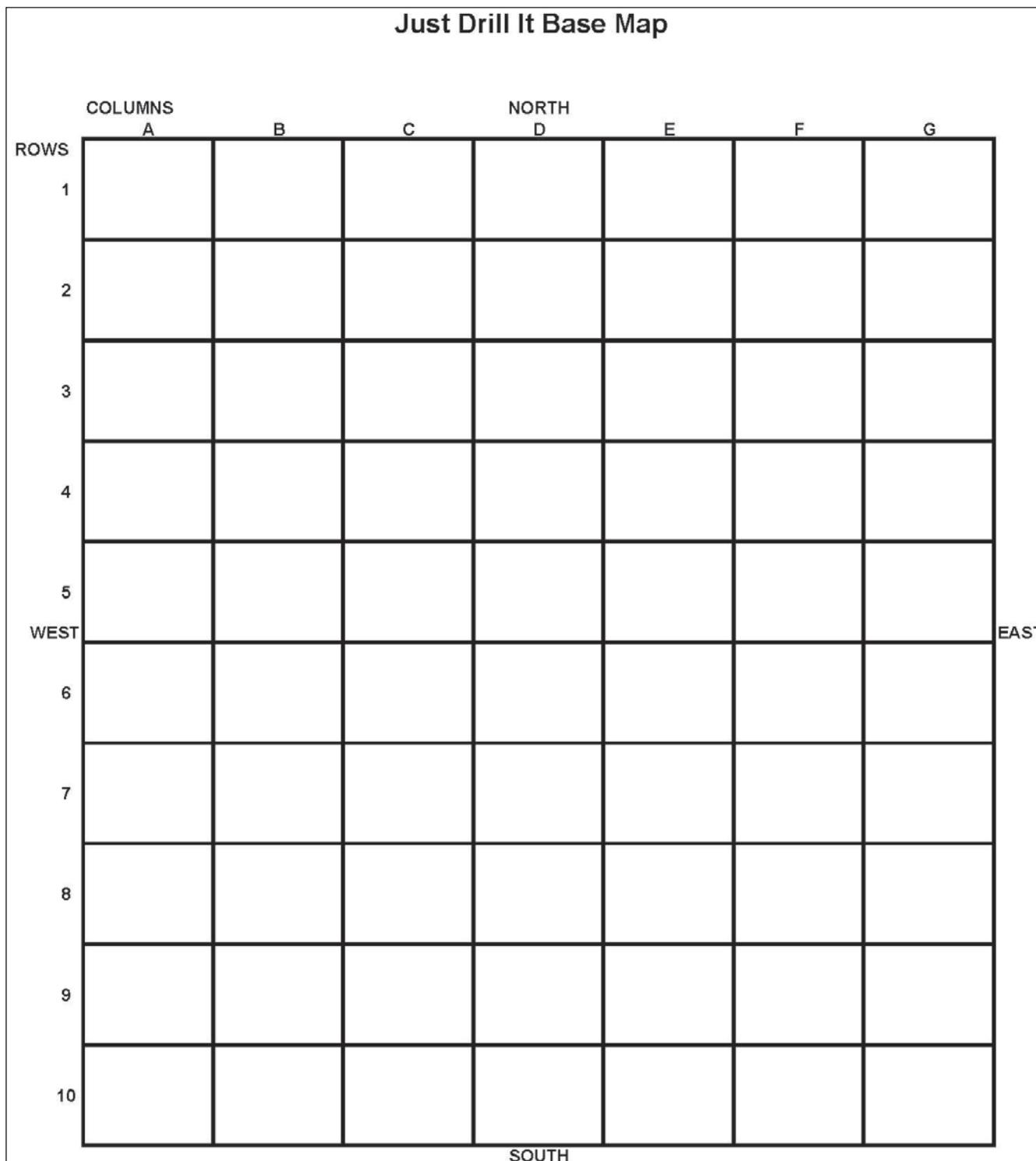


FIGURE 3. THE MINING MAP THAT CORRESPONDS WITH THE MODEL AS SHOWN IN FIGURES 1 AND 2.

Credit: L. Mossa, American Geosciences Institute.

- Have students use their Mining Map to determine three sites where they would like to core to help determine the extent of the mineral deposit.



- a. Provide each group with three clear straws to conduct coring.
- b. Discuss why mines take a limited number of cores (e.g., high cost, environmental damage).
- c. Have groups write out and/or share their reasoning for why they selected their coring sites.
- d. You may want to discuss engineering challenges with straw coring and techniques students can use to improve the success of coring (e.g., turning the straw as they slowly push it through the model, pinching or covering the upper end of the straw as they extract it from the model).
- e. Have students collect three cores. If iron is visible within the core, students should record this on their Mining Map. If iron is *not* visible, have students run the magnets in the clear bag alongside the straw to see if it draws out any iron within the sand (meaning ore is present).
- f. Optionally, revisit the portion of the [what exploration geologists do video](#) (0:43–1:15) where they show cores. Discuss how these cores can give insight into where mineral deposits are located.

Explain Mineral Exploration

1. Have all students read this page on [Mineral Exploration](#), which has short summaries of common methods used to locate mineral resources.
 - a. Then, have students click on [Geophysical Methods](#) and read the first paragraph.
 - b. As needed, discuss any questions students might have or introduce/review specific vocabulary used in the overview.
2. Have each group member learn about one of four geophysical methods used for mineral exploration using the resources provided. Note: Not all the videos focus specifically on mining, so students will need to apply what they have learned to describe how the technique can be used for mineral exploration. The topics below are listed in order of increasing difficulty:
 - a. **Magnetic Methods**
 - [Video on magnetic methods](#)
 - [Pathways for taking magnetic surveys](#)
 - [Graph of magnetic reading from an ore body](#)
 - [Electromagnetic survey output](#)
 - b. **Electrical Methods**
 - [Video on electrical resistivity](#)
 - [Resistivity chart for different Earth Materials](#)
 - [Resistivity output](#)
 - c. **Seismic Method**
 - [Video on seismic reflection](#)



- **Seismic profile**
- d. **Radiometric Method**
- **Video on gamma spectroscopy**
 - **Graphs showing readings from “natural occurring radioactive minerals”**
 - **Gamma spectroscopy output**
3. Have each group member share what they learned with their group. For each geophysical method, students should be able to:
- a. briefly describe how the technology works;
 - b. describe the data or output produced by the technology;
 - c. explain how the data or output of this technology helps in locating mineral resources;
 - d. state at least one benefit and drawback of the use of this technology; and
 - e. relate the technology to one of the steps completed in **Explore**, if applicable.
4. As a class, discuss the need for having a range of exploration techniques to locate minerals with different properties.

Explain Mineral Extraction

1. Have students study **an image of the steps of the mining process**.
- a. Have students share ideas about how engineers might be involved in steps beyond the “Exploration” phase.
 - b. Show a **video on mining engineering**.
 - c. Discuss how engineers are involved in each step of the mining process.
2. Have students complete a reading on **“The Different Types of Mining and Their Environmental Impacts.”**
- a. Discuss what types of tools might be used for each type of mining.
 - b. Show images and/or videos of mining equipment, and have students consider what objects could mimic mining tools that they might use at their mining site from **Engage**.
- **Image of hand tools**
 - **How Iron Ore Mining Works** (a tour of an active mine site that shows equipment)



- **Underground Mining Equipment and Their Operations** (a compilation of vehicles used in underground mining without narration)
3. Optionally, have students read “**How Mechanical Innovations are Revolutionizing the Mining Industry**” to discuss how engineers can help solve challenges and improve the mining process, especially to reduce the environmental impacts of mineral extraction.

Elaborate

1. Have students revisit their mining site model and plans from Explore. Ask them to consider where and how they could extract as much iron as possible at their mining site.
2. Set out a range of objects students can use as mining tools.
 - a. Allow students to make observations of these tools.
 - b. Groups should be limited in how many tools they can use to mimic limitations faced by mining companies (e.g., cost, availability of machinery and people who can operate them).
3. Have students read about **Common Types of Industrial Mining Equipment & Machinery**.
 - a. Discuss how the shape of some of these tools compare to mining equipment.
 - b. Students should use this discussion to make informed decisions about which tools they will use.
4. Briefly discuss the mining processes and how as mines extract minerals, such as iron, they potentially could remove rocks that do not contain useful minerals (waste rock), rock that contains the mineral in sufficient quantities (ore), and the specific substance of interest.
5. Give each group three containers to separate the materials that are removed as they mine: waste rock, iron ore, and iron.
6. Allow groups time to revise their plans, based on the readings and available tools, and then carry out their mining plans.
7. Optionally, to mimic mineral processing, students can use magnets in clear baggies to separate the iron from the waste rock in the iron ore they removed. They would then add the iron and waste rock to their respective bowls.
8. Have each group use a scale to take the mass of iron they extracted from their mine site.
9. Have students walk around and view other groups’ mining sites as they report their own data on the board.



10. Facilitate a discussion to reflect on the data from each group, observations of each other's mining sites, and the bowls of extracted materials.

Evaluate

1. Have students write a report on the exploration and extraction of iron at their mining site, including:
 - a. a summary of engineering processes they completed (or mimicked/modeled);
 - b. a summary of their mining plan;
 - c. how successful their plan was compared to other groups (based on observations of each group's results); and
 - d. at least two suggestions for how they would improve their mining plan if they were to carry it out again.
2. Optionally, have students read about geophysical techniques being used to search for lithium deposits.
 - **Geophysical Tools for Lithium Basin Characterization**
 - **British Lithium** (click "Discover More" on the three cards to read about lithium exploration)
 - **ACME Lithium Receives Geophysics Report Targeting Lithium Clay Deposits at Fish Lake Valley, Nevada**
 - **Grid Battery Metals Announces the Geophysics Results from Phase 1 of its Exploration Plan at the Texas Springs Nevada Lithium Project**
 - a. Students should compare and contrast the techniques they learned about in this lesson with those used to find lithium.
 - b. Discuss why the geophysical techniques used for lithium exploration differ from those used to locate iron deposits.



HANDOUT

Exploration for Minerals

Carry out each step, adding information from each test to the Mining Map regarding the likely location of the iron deposit. Your goal is to use this information to develop and implement a mining plan that will extract as much iron as possible while reducing environmental impact.

1. Make observations of the mining site, including the outcrop that is visible.
2. Magnetic Survey
 - a. Place two or three small magnets in a clear sandwich baggie. Note: *It is important that the baggie is securely closed/sealed and does not have any holes.*
 - b. Place a piece of cardboard over top of the sand.
 - c. Slowly move the baggie along the cardboard.
 - d. On your Mining Map, indicate positive magnetic test “readings.” You may also want to note where there were weaker versus stronger readings.
3. Underground Survey
 - a. Use the magnet setup to slowly scan each side of the mining site.
 - b. Chart on the graph paper along each side where iron is detected. (You may want to note where there were weaker versus stronger readings.)
 - c. Add test results on your Mining Map to indicate where the iron was detected.
4. Use your map to determine three sites you would like to core to help determine the extent of the mineral deposit.



Mining Map

Just Drill It Base Map

		COLUMNS						
		A	B	C	NORTH D	E	F	G
ROWS	1							
	2							
	3							
	4							
	5							
	WEST							EAST
	6							
	7							
	8							
	9							
10								
		SOUTH						