Understanding Earth's Surface Through Map Reading

Level: Middle School
Facilitator Guide

LESSON DETAILS

Objective: Students will create geologic and topographic maps of physical models to prepare for selecting potential mine sites in Nevada.

Standards

NVACSS and NGSS

- **MS-ESS2-1:** Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
- **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
- **DCI:** Earth Materials and Systems; Natural Resources
- **SEP:** Analyzing and Interpreting Data; Constructing Explanations and Designing Solutions
- **CCC:** Patterns; Cause and Effect; System and System Models; Stability and Change

Career Readiness

- **1.2.6:** Demonstrate lifelong-learning skills by continually acquiring new industry-related information and improving professional skills.

Materials

- sets of maps, including at least topographic and geologic maps
- multiple colors of playdough (at least 4)
- rulers
- plastic knives, optional
- graph paper
- markers
- disposable gloves

Lesson Summary

Students act as a geological exploration team and are tasked with choosing a location for a mine in Nevada based on geology and topography. By engaging with different types of maps, students learn basic map-reading skills and apply them to identify potential mining sites based on geological and topographic features. They create and analyze playdough models to understand geological formations such as folds and faults and simulate erosion to see its effects on landscapes. As an introduction to topographic maps, they create a simplified map using their fist to experience drawing contour lines and intervals. Students also explore how humans impact landscapes by comparing historical and current maps, especially looking at changes due to mining activities. The lesson concludes with students identifying and presenting two potential mining sites.

There is a lesson on sustainability that encourages students to consider other factors in deciding whether and where to mine. It would serve as an effective follow-up to this lesson.

Preparation

- For **Explore**, select an area for a region near you and compile maps using the links below. Students will use the maps provided to assess potential mining sites.
    - **Nevada Geology**
    - **Nevada Mineral Explorer**
    - **Nevada Topographic Map Index**
    - **Google Maps**
- In **Elaborate**, use the provided maps for Barrick Turquoise Ridge or select a region nearby for which current day and historical topographic maps are available. Topographic maps can be found using **USGS's TopoBuilder**. For this activity it is preferable to use maps for areas that do not have a mining site in the historic or recent topographic map.

Engage

1. Discuss commonly mined resources in Nevada, such as silver, gold, gypsum or copper, and specifically any materials that are mined in areas near you.

2. Introduce a storyline (one example provided below) where students are part of a geological exploration company tasked with finding new mining sites in Nevada. They must explore different possible locations to determine the best locations for mining a specific resource.

    You are now part of a team at GeoQuest Inc., a geological exploration company. Your team specializes in discovering new mining sites and ensuring that these sites can be mined responsibly. The state of Nevada, known for its rich mineral resources ranging from silver and gold and copper, has opened up new areas for exploration. GeoQuest Inc. has been given a special permit to explore these areas and assess their potential. Your mission is to explore areas in Nevada to find the best locations for new mining sites. You must use your knowledge of geology and topographic maps to guide your decisions.

Explore

1. Hand out different types of maps to student groups for them to examine. Ask students to make observations of these maps.

2. Facilitate a discussion of the maps:

    a. Discuss student observations and discuss similarities and differences between the types of maps.

b. Introduce basic map-reading skills. Focus on how to interpret elements such as symbols, scales, and colors used in these maps.

c. If a map includes a cross section, be sure to discuss it.

d. End the discussion by asking students questions that emphasize the different uses and elements of the maps, such as

- *How do different types of maps communicate different features of an area?*
- *Why might a hiker and a geologist look at different maps, even if they are traveling to the same place?*
- *What map would be a good place to start when looking for a new mining site?*

Explain Geologic Maps

1. Start with a discussion of the geologic features that are shown on the geologic map provided to the students.

2. Have students construct 3D models and maps of different geologic formations using playdough.

   a. **Folds**

      i. Students take at least four different colors of playdough, roll them flat in relatively equal thicknesses, and layer them to represent sedimentary layers.

      ii. Using a ruler or plastic knife, cut the layered playdough into a rectangular prism (block) shape. See Figure 1A.

      iii. Students place their hands on the shorter sides of the prism and push inward to create anticlines and synclines. See Figure 1B.

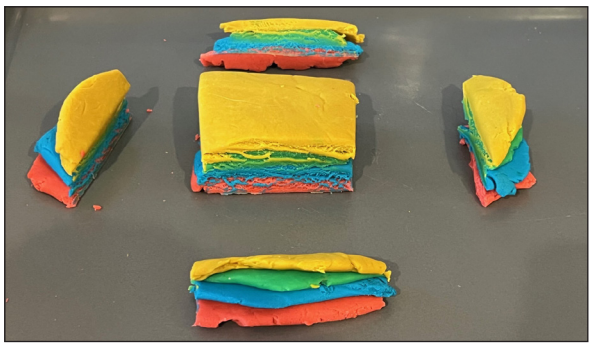


Figure 1A

Figure 1B

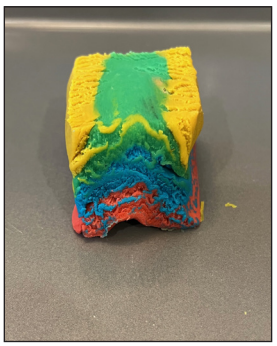


Figure 1C

b. Faults

i. Students create another set of layered playdough.

ii. They then will make a diagonal cut through the layers (Figure 2A), then offset the layers to simulate a fault (Figure 2B).

Figure 2A

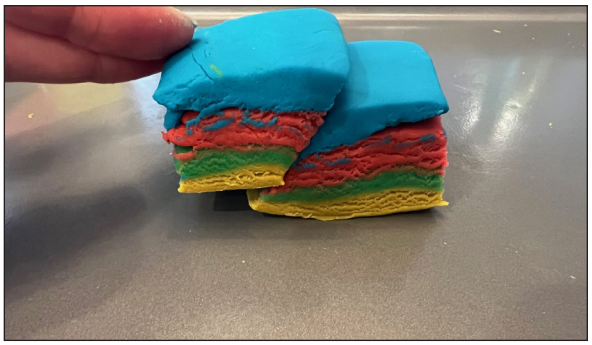


Figure 2B

3. For both the Fold and Fault models, have students cut some playdough off the top to simulate erosion. See Figure 1C.

4. Have students create a map of the exposed surface by sketching the top view of the model using colors or patterns to match the playdough layers.

5. Facilitate a discussion of the 3D models themselves and how the models translate into 2-dimensional map views.

6. Have students draw a cross-section view of their model by looking at it from the side.

7. Discuss the importance of subsurface knowledge, and how geologists use methods such as core sampling to determine the composition and properties of subsurface layers. Potentially use a clear straw to core the playdough models.

8. Discuss different geologic features that are favorable for mining, such as fault lines, ancient volcanic areas, and sediment layers rich in organic material.

9. Return to the geologic map provided in **Engage**:

   a. Have students compare the maps of their playdough models with actual geologic maps, discussing similarities and differences.

   b. Students then will identify geologic features on their map and determine areas of interest for a future mining site.

10. If they want to know more about the locations, discuss what sorts of tools, techniques, and/or information would be helpful.

Elaborate Geologic Maps

Explore a virtual geologic modeling tool, like Seequent's **Visible Geology**, and discuss how digital representations correlate with both their playdough models and the geologic maps.

Explain Topographic Maps

1. Refer the students back to the topographic maps in **Engage**. Have them compare the topographic maps to the geologic maps. Without introducing vocabulary at first, point out the lines on the topographic map (i.e., the contour lines), guide the students to note that some of the lines are darker (index lines) than others (interval lines). Have them note that some lines are closer together than others.

2. Illustrate topography and contour lines by having students pair up and make a topographic map of a fist to simulate a small landscape.

    a. Partner 1 puts on a glove, makes a fist, and holds their fist steady by resting it on a flat surface like a table.

    b. Partner 2 uses a marker and a ruler to draw contour lines around the fist at every centimeter of height. (Optionally, have students mark each contour line with a different colored marker.) The mapping should start from the base of the fist near the table and move upward, marking at 1 cm, 2 cm, 3 cm, etc., above the table level. To make accurate contour lines, hold the ruler vertically and place the marker at the desired height, moving around the fist.

    c. Students reveal the topographic map by releasing the fist and flattening the hand on the table.

Figure 3A

Figure 3B

Figure 4A

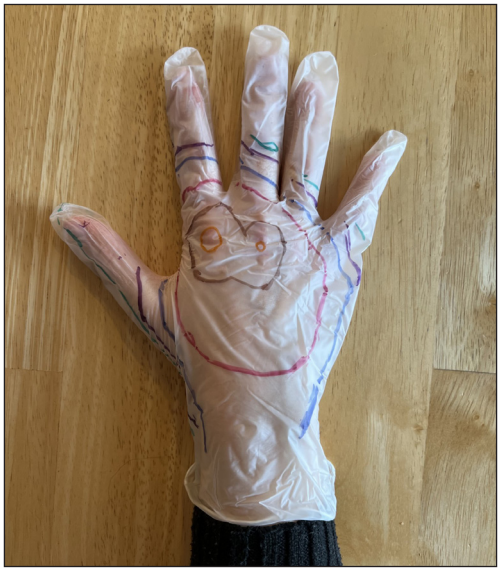


Figure 4B

3. Discuss the topographic fist maps.

   a. Introduce and discuss key ideas and terms, such as "contour lines" and "contour intervals," emphasizing their significance in topographic maps. Explain how contour lines that are close together indicate steep terrain, while lines that are farther apart suggest a flatter landscape.

   b. Ask Partner 1 to alternate between holding their fist closed and flattening the hand while Partner 2 observes the changes in contour line spacing on the topographic map they created. Encourage students to note how the contour lines appear closer together on the closed fist compared to when the hand is flattened, especially on the steep sides.

   c. Discuss model limitations with students- In this model, contour lines spread apart on the flattened map, which might not accurately represent real-world topography where such spacing should remain consistent. Probe students to consider why this discrepancy occurs and how it affects their understanding of topographic maps.

   d. Ask students for ideas on how to improve the accuracy of the model. For example, taking a photograph of the contour lines while still on the 3D fist will maintain the spatial relationships, before transferring them to a flat representation.

   e. Potentially share another topographic map model, like **USGS's Take-out Lid 3D Topographic Map Model**.

4. Make comparisons between the topographic fist map and other model topographic maps, like the diagrams in (**Topographic maps: Birds-eye view and side profile**), the topographic map in Engage, and other topographic maps in general.

5. Have students make a cross section of a portion of their map:

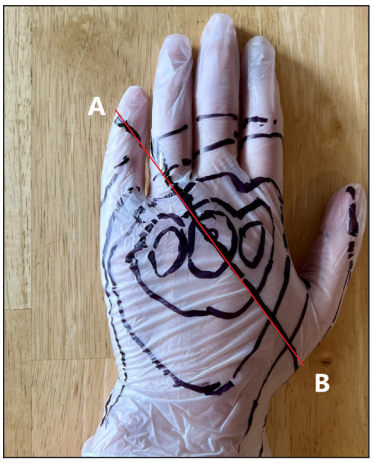
   a. Draw a line across the topographic map of the fist, crossing at least one "hill" (knuckle). Label one end A and the other B, as in Figures 5A and 6A

   b. Using a ruler, measure the distances between contour lines and mark them on the x-axis of a graph.

   c. Knowing each contour line is 1 cm, graph the cross section with elevation in cm on the y-axis and connect the points.

   d. Discuss the map with students:

   - *How should they connect their points? A straight line or smoothed line?*
   - *What does a cross section of a topographic map versus a geologic map show?*



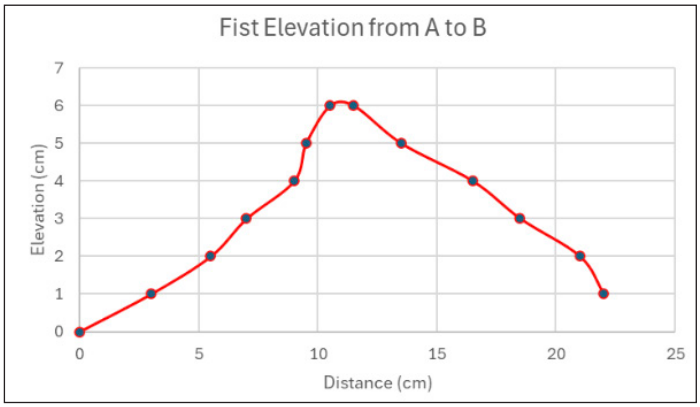
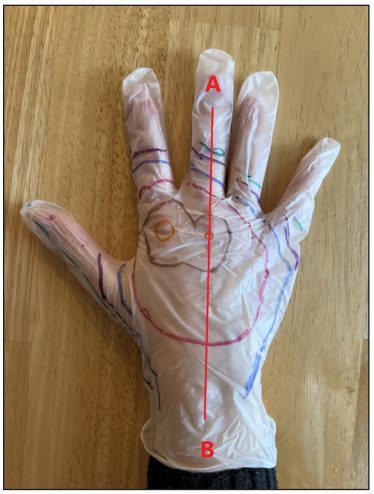


Figure 5A



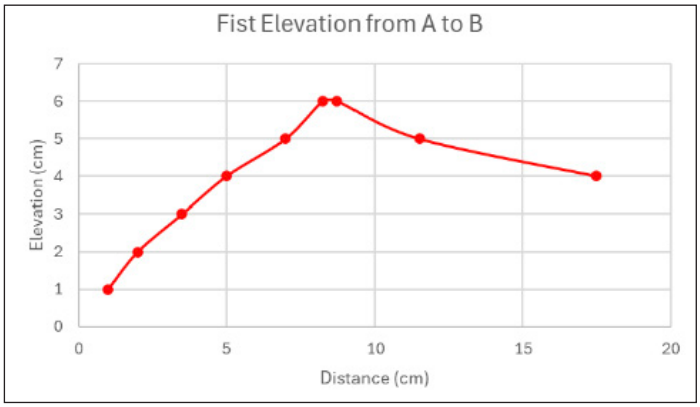


Figure 6A

6. Have students identify potential locations for mining based on topography and factors like accessibility (e.g., slope, elevation), as well as other environmental factors, such as proximity to water sources. If they want to know more about the locations, discuss what sorts of tools, techniques, and/or information would be helpful.

Elaborate

1. Brainstorm how human activities might impact the shape of the land, and how those changes might appear on geologic and topographic maps.

2. Provide students with historical maps of a specific area before mining activity and current maps post-mining. Included with this lesson are maps of an area surrounding Barrick Turquoise Ridge from 1985 and 2025.

3. Students examine both sets of maps, identifying and describing significant changes such as altered water courses, new roads, and changes in land use.

4. Allow students to use online resources, such as **Google Earth**, to view recent and historical satellite images of the area, further identifying changes and current landscape features. **1983-Present Timelapse of Barrick Turquoise Ridge**

5. Facilitate a discussion around the observed changes from the maps and satellite images. Discuss the impacts of mining on the area's geology and topography.

Evaluate

1. Have students create a brief report that identifies two potential mining sites on the map used in **Engage**. The report could include:

   - Site locations and descriptions
   - Geologic and topographic features that make it a desirable mine site
   - Future impact predictions (e.g., how mining could alter the landscape and geology at each site).

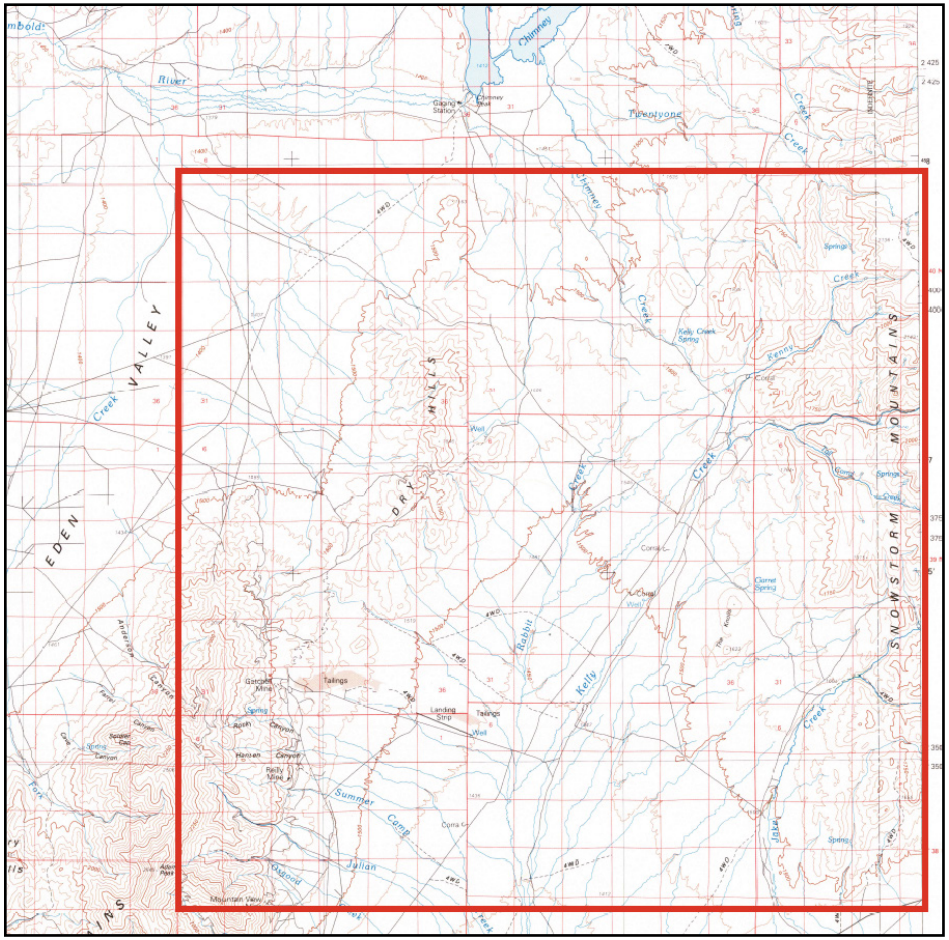
2. Have all the student groups mark their potential mining sites on a class map. You could project a large map on a white board and have student groups add their locations or create a shared Google Earth Project with the class for students to add their sites to.

3. Have groups share their potential sites and their reasoning behind their selections.

HANDOUT

Historical and Modern Topographic Maps of Elko, NV

1985



2025