LESSON 2: SEDIMENTARY ROCKS – THE CLIFFS AT PARASHANT

GEOLOGICAL ADVENTURES AT PARASHANT

EXPLORING THE GEOLOGY OF

GRAND CANYON-PARASHANT NATIONAL MONUMENT

LESSON 2 GUIDE: SEDIMENTARY ROCKS – THE CLIFFS AT PARASHANT

OVERVIEW

Students look at samples of sedimentary rocks and note characteristic features. They then build a sedimentary rock sequence using layers of modeling clay. Each layer of modeling clay stands for a kind of sedimentary rock found in the monument (sandstone, shale, siltstone, limestone). Students then use a piece of dental floss to slice one end of the layers in a manner that is consistent with how rocks weather and erode in canyon walls (i.e., shale will often form gentle slopes, and sandstone, siltstone and limestone will often form cliffs). After the activity, students read about how sedimentary rocks form to learn about the main classification scheme of sedimentary rocks and what sedimentary rocks reveal about depositional environments and Earth's history. Students save their models for use in Lesson 3.

Objectives After observing samples of sedimentary rocks, building a sequence of sedimentary rocks out of modeling clay, carving slopes out of the clay to match rock types, and reading about sedimentary rocks exposed at Grand Canyon-Parashant, students will understand why sedimentary rocks

- often have a layered appearance,
- provide information about past environments, life, and change over time, and
- serve as a natural resource that we depend upon in our daily lives.

Concepts Features and classification of sedimentary rocks; environments of deposition; strata; controls on slope formation; fossils; sedimentary rocks as natural resources.

Duration Two to three 45-minute class periods

Audience Students in grades 6 to 9

Materials **Part A**

- samples of about 9 to 12 assorted sedimentary rocks:
- Clastic: claystone, shale, siltstone, sandstone, conglomerate, breccia
- Chemical: rock gypsum, rock salt, chert, chemical limestone
- Biochemical: fossiliferous limestone, coquina, chalk, lignite, bituminous coal.
- hand lens or magnifying glass

Parts B and C

- 12-oz. box of 4 sticks of modeling clay – blue, green, yellow and red
- sheet of wax paper
- large Styrofoam plate
- 30 cm piece of dental floss
- 12-cm wooden dowel

Extensions **For all students**

- Add samples of local sedimentary rocks to the collection in Explore steps 1-4.
- Arrange for a field trip to view local outcrops of sedimentary rocks.
- Incorporate photographs of local or regional sedimentary rock sequences into a slide show for comparison to sedimentary rocks and sequences at Grand Canyon-Parashant.

For gifted, honors, or higher grade-level students

- In the first part of the activity, provide a sedimentary rock identification key. Have students use the key to describe, identify, and classify each sample of sedimentary rock. A good source is Pamela Gore's *Sedimentary Rock Exercises*: www.gpc.edu/~pgore/geology/historical_lab/sedrockslab.php.

Resources

- See www.gpc.edu/~pgore/geology/historical_lab/sedrocks-exercises.php for the main page with description of how to classify sedimentary rocks.
- See www.gpc.edu/~pgore/geology/historical_lab/sedrocktable.htm for the sedimentary rock identification table.
- Another sedimentary rock identification chart is available at Mike Strickler's site (GeoManiac): jersey.uoregon.edu/~mstrick/MinRockID/RockID/Sedimentary.html

ENGAGE **10 minutes**

Figure 2.1 in the student text shows that lithology can control the gradient of a slope. In this case, the easily weathered shale forms a gentler slope, whereas the hard, resistant sandstone forms ridges and cliffs. Students will note a variety of differences, some of which many not be relevant to the investigation.

Ask volunteers to share ideas. Accept all reasonable ideas and write them on the board. Avoid providing the "right" answer – students will learn the names of the rocks in the explore phase of the lesson.

EXPLORE **50 minutes**

Part A - Describing Sedimentary Rocks **15 minutes**

This activity gives students hands-on experience observing and describing samples of sedimentary rocks. This addresses part of the Engage question – sedimentary rocks look different from one another when made of different minerals or materials and when the grains of the rock are different sizes.

To save time, students work in groups with a set of 8-12 rock samples and divide the samples up so that each student describes 2-3 samples. Students then share and discuss results at their tables, or you can lead a class discussion. If you

expect each student to describe and learn to identify all of the rock samples, you will need to budget more time. The activity is designed to help develop observation and recording skills – if you distribute a classification scheme *before* students have made observations and written descriptions, the emphasis of the activity shifts toward rock identification.

1. Have the collection of samples, hand lens/magnifying glasses, and metric rulers available in a container or tray.
2. Check to see if students are addressing the questions in step 2 within their descriptions of sedimentary rocks. Make note of common issues or problems that arise and address them in a discussion in step 3 or 4.
3. Have students share work in their groups or lead a review as a class.
4. See Resources above for sources of sedimentary rock identification charts. Make sure that students record rock names for each description.

Part B. Building a Model of Sedimentary Rock Layers 20 minutes

In this part of the activity, students build layers of sedimentary rock. It's always a good idea to try the activity yourself to identify tips and suggestions that you might want to share with students.

Figure 1 shows the basic **materials** used to build the models used in this part of the activity (and used for Lessons 3-6 as well).

FIGURE 1. Basic setup used to build clay models of sedimentary rock layers.

- A 12-ounce box of *RoseArt* modeling clay has four colors and is available at major discount stores for about a dollar.
- The Styrofoam plate helps with easy clean up and storage, especially in Lesson 3 when students pour liquid soap onto the model to simulate lava flows.
- A wooden dowel (or any smooth cylindrical tube) makes is easy to roll the clay into flat layers. Have several dowels for each group to save time.
- Dental floss is used to slice the layers (wrap around index fingers, just like when flossing) and works quite well.
- It might be helpful to also have a plastic knife on hand for trimming things.
- Wax paper keeps the clay off students' desks, which minimizes cleanup and keeps the materials clean (throw away wax paper after use).

- The colors on the clay will come off in student's hands. If you do not have soap and water available in your room, latex gloves can be used.

1. Have materials available for students on the Styrofoam plates.

2. Students divide blue and green clay so that they get layers of different thickness in their models, and six layers instead of four.

3. The rectangle serves as a guide to keep the layers roughly equal in area.

4. Students may have to do a little trimming to get the clay into a rectangle. A plastic knife helps with trimming. Layers do not have to be perfect rectangles.

5. Students can build stacks in any order, as long as colors alternate. The reason an order is not assigned is that students will create different landscapes in steps 10-12, and produce different sequences which is helpful in lesson 4 on metamorphic rocks (students mangle and fold the layers to simulate metamorphism and try to figure out the sequence in another group's folded sequence). Once students have built up a reasonably level stack of six "rock layers", they can move directly into the last part of the activity.

Although random stacking of layers works for the purposes of these lessons, in the real world, sedimentary rock layering is not so random. Instead, sediments are deposited and sedimentary rock layers build up in particular sequences that yield clues about whether sea level is rising or falling. When the sea encroaches upon the land, the sequence often moves from sandstone (bottom, representing river sediments or sand along the seashore) to siltstone to shale to limestone (top). When the sea recedes, the sequence goes from limestone (bottom) to sandstone (top).

Part C. Carving a Landscape **15 minutes**

The final part of the activity brings the lesson full circle to the Engage question. Another reason that rock layers look different from one another is that they weather and erode differently. In this part of the activity, students carve one end of their models to make a slope. The way that they carve their models is controlled by the type of rock in each layer. An example of what students will create in this part of the activity is shown in Figure 2. Note that the first (top) cut needs to be made about 2-3 cm from the end of the clay.

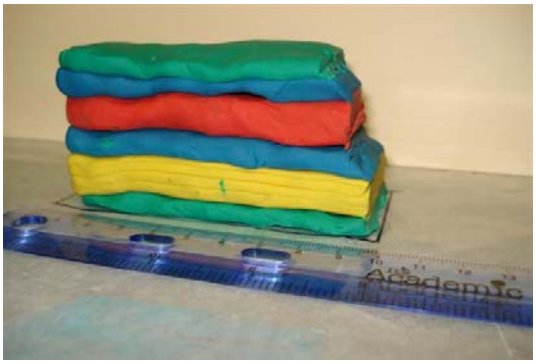

FIGURE 2 Example of a landscape carved into modeling clay. Note that the blue layers, which represent shale, form slopes, whereas other rock layers form cliffs. Start carving 2 cm from the end.

1. Sandstone forms steep slopes (cliffs) and shale forms gentle slopes (due to differences in the competency of the different rock layers). Keep in mind that this is a general pattern. For example, easily weathered (poorly cemented) sandstones do not form cliffs or steep slopes.
2. If you have tested the activity, you will have found that although carving a steep slope with dental floss is easy, carving the gentle slope can be tricky. If you are concerned about your student's ability to do this, consider demonstrating the procedure in front of the class. Their finished model will look something like Figure 2 above. Blue layers should be sloped and all others vertical. If you are concerned about what students might do with extra pieces of modeling clay, collect the extra pieces as you circulate and save them for other uses.
3. Students should wash their hands after handing modeling clay.

EXPLAIN

Assign for reading, either during class or as homework (even if the entire activity has not yet been completed). You can supplement the explanation phase of the lesson with a discussion or lecture. Photographs of outcrops of sedimentary rocks, sample of rocks, diagrams of environments of deposition, and photographs of how we use sedimentary rocks as natural resources would be most relevant to the lesson. Photographs of local or regional outcrops would increase the relevance to students.

ELABORATE

Address these questions in a class discussion, assign them for group work, or include them as part of a homework assignment.

1. The rocks in the photo look like sedimentary rocks because they are layered.
2. Four rock layers are visible in the photograph.
3. Students' sketches should show two layers of shale (second from top later and the bottom layer) as slope-forming layers and two layers of sandstone (top layer and third from top layer) as the cliff-forming layers.

Challenge Question:

Using what students observed about shale versus sandstone samples, and what they have read about, they should say that sandstone layers would make for better building stone because the sandstone is harder and more resistant to weathering, and the shale would tend to crumble.

EVALUATE

1. The three main types of sedimentary rocks are clastic, chemical, and biochemical.

2. A. Limestone;

B. Yes, limestone forms in a marine environment (seas and oceans), so the region must have been under seawater long ago.

3. A. Scientists can conclude that Antarctica once had a much warmer climate because coal is made from plants that died in swamps.

B. Antarctica used to have swamp plants, whereas now it has very few plants.

4. Yes. The geologist has found a fossil because a footprint is evidence of past life.

5. Answers will vary, but may include statements like using gasoline found in sedimentary rocks to get to school, using electricity that came from a power plant fueled by coal, walking on a sidewalk made from cement that comes from limestone, flavoring food using salt that came from rock salt, and so on.

Challenge Question:

The oil probably comes from deposits in sedimentary rocks, and the power lines may be carrying electricity that comes from burning coal, which is a sedimentary rock.

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ENGAGE

Look carefully at Figure 2.1. Write down as many differences between the two rock layers shown in the photo. Explain why they might be different kinds of rocks.

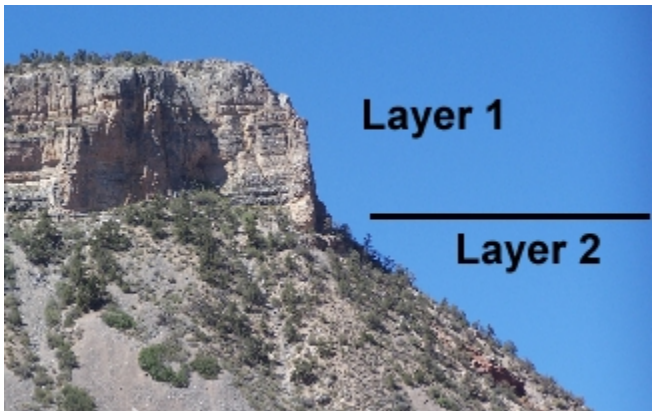

FIGURE 2.1 What differences do you see between these two layers of sedimentary rocks?

EXPLORE

In this activity, you will study samples of sedimentary rocks and make a model of rock layers. In some ways, the rocks will look similar, but if you look closely, you will see key differences. These differences, which are due to how the sedimentary rock formed, give scientists clues about the past. The properties of rocks can also affect the landscapes they form.

Part A. Describing Sedimentary Rocks

1. From your teacher, obtain a collection of sedimentary rocks. Distribute the rocks amongst your group so you each have the same number of rocks.

2. For each rock you have, write a brief but careful description. Use a hand lens or magnifying glass to look closely. Features to observe and record include:

a. What color is it? Be as specific as you can.

b. Is it hard or soft? Can you break off small pieces with your fingernails?

c. Does the rock have grains you can see?

d. Are the grains small or large?

e. Do the grains have sharp edges or are they rounded?

f. Are the grains different colors? If so, what colors can you see?

g. Can you see any fossils? If so, what do they look like?

h. Can you see layers? If so, how thick are they?

3. In your group, take turns presenting your rock descriptions.

4. If an answer key is available, compare your descriptions to the key. Write the names of the sedimentary rocks next to your descriptions.

Part B. Building a Model of Sedimentary Rock Layers

One feature of sedimentary rocks is that they form layers. The layering is somewhat like how you build a stack of pancakes by adding one pancake at a time. In this part of the activity, you will use modeling clay to build a model of layers of sedimentary rocks.

1. From your teacher, obtain a box of four colors of modeling clay, a sheet of wax paper, a metric ruler, a large Styrofoam plate, some dental floss, and a small wooden dowel.
2. Use a piece of floss to cut the blue clay and the green clay in half.
3. Draw a rectangle about 5 cm by 10 cm on the wax paper.
4. Place a piece of clay inside the rectangle on the wax paper. Use the dowel to roll the clay into a flat layer 5 cm wide by 10 cm long.
5. Place the flat layer on the Styrofoam plate. Repeat this process with the rest of the pieces of clay until you have a stack of six layers. You can stack the colors in any order as long as you alternate colors.

Part C. Carving a Landscape

1. Refer back to Figure 2.1. Layer 1 is sandstone, and layer 2 is shale. Use this information to complete this sentence: Harder, more compact rocks like sandstone tend to form [gentle/steep] slopes, while softer, more easily weathered rocks tend to form [gentle/steep] slopes.
2. Table 1 relates a color of modeling clay in your model to a common type of sedimentary rock. On the basis of the information in the table, use dental floss to carve a landscape out of one side of your model.

Table 1. Key to Rock Types

Color of Clay	Rock Type	Nature of Slope Formed
Yellow	Sandstone	Steep (cliffs)
Green	Siltstone	Steep (cliffs)
Blue	Shale	Gentle (gradual slopes)
Red	Limestone	Steep (cliffs)

3. Put away the Styrofoam plate and clay model, then wash your hands.

EXPLAIN

FIGURE 2.2 Layers are a common feature of sedimentary rocks, like these exposed in the Grand Wash Cliffs at Parashant.

Sedimentary rocks at Grand Canyon-Parashant National Monument (Parashant), like those everywhere, began as **sediment** - pieces of older rocks or remains of organisms like shells or coral. Sediments can be carried and deposited by rivers, streams, wind, or glaciers. They can roll down the slope of a mountain. They can be washed along the beach or sink to the bottom of a lagoon or lake. Sediments build up on top of old sediments to form layers called **strata**. Eventually, the layers may get buried deeply enough to be compacted or cemented together to form sedimentary rock. Table 2 lists the basic groups of sedimentary rocks, with examples. Chances are that you have already seen sedimentary rock. They are the most common type of rock at the Earth's surface.

Table 2. Major Types of Sedimentary Rocks

Type	Description	Examples
Clastic	Clastic sedimentary rocks are made up of pieces (clasts) of pre-existing rocks. Pieces of rock are loosened by weathering and transported to some basin or depression where sediment is trapped. If the sediment is buried deeply, it becomes compacted and cemented, forming sedimentary rock. Particles range in size from microscopic clay to huge boulders. Names are based on grain size.	conglomerate breccia sandstone siltstone claystone shale
Chemical	Chemical sedimentary rocks are formed by chemical precipitation. This process begins when water traveling through rock dissolves some of the minerals, carrying them away from their source. Eventually these minerals are redeposited when the water evaporates away or when the water becomes over-saturated.	chert dolomite oolitic limestone rock gypsum rock salt
Biochemical	Biochemical sedimentary rocks form from once-living organisms. They may form from accumulated carbon-rich plant material or from deposits of animal shells.	chalk coquina fossiliferous limestone micrite peat lignite bituminous coal

Source: USGS Geology in the National Parks. geology.wr.usgs.gov/parks/rxmin/rockchart.html

Sedimentary rocks record a history of change over time. Geologists study strata like you might study pages of a history book. The strata tell about past events and climate, where the land and sea were located, and the animals and plants that lived in that region. For example, coal reveals that a region once had vast swamps. Rock salt indicates an ancient arid climate near the sea. The rounded pebbles and cobbles in a conglomerate speak of stones rolling and bouncing along a river bottom. Many layers of limestone can be found at Grand Canyon-Parashant, yet the monument is hundreds of miles form the ocean. As incredible as it may sound, the presence of limestone means that this very arid region once lay beneath a shallow sea!

FIGURE 2.3 Sediments are being deposited along the Colorado River and along slopes of the Grand Canyon, but the layers of sedimentary rock that form much of the canyon's walls are hundreds of millions of years old. They tell a story about change over time in this region.

FIGURE 2.4 Sedimentary rocks exposed in the cliffs at Parashant record millions of years of Earth's history. They provide clues about how life and climate have changed over time.

Sedimentary rocks also reveal how life on Earth has changed over time. Plants and animals that die are sometimes buried in sediment. If that sediment becomes rock, it will contain **fossils**, the remains or evidence (like animal footprints) of living things preserved in rock. Scientists use fossils found in sedimentary rocks to understand the evolution of life and to reconstruct ancient climates and ecosystems. For example, some types of organisms that once lived in shallow seas or on land at Parashant have become extinct (see Figure 2.5).

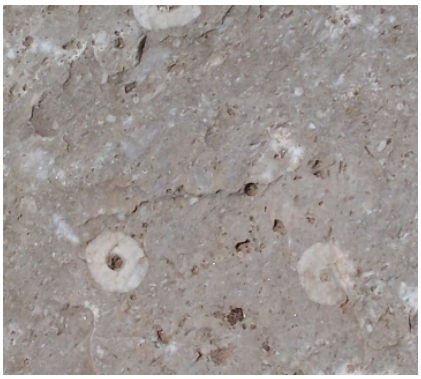

FIGURE 2.5 The three circular features in this limestone at Parashant are fossil stems of ancient sea lilies called crinoids. Crinoids lived in shallow marine environments.

Sedimentary rocks also provide valuable natural resources that we depend upon every day. Limestone and sandstone are used as building stones, for landscaping, and for road beds. The mineral calcite found in

limestone is the key ingredient in cement. Add some sand and gravel to the cement and you have concrete used to make sidewalks, bridges, and roads. Coal provides energy for generating electricity. Most of the world's supply of natural gas and oil comes from deposits trapped in sediments or sedimentary rocks. The salt that we use to season foods or melt ice on sidewalks and roads is mined from layers of rock salt. The wallboard in your home or school is made from rock gypsum, layers of which formed when seawater evaporated long ago (Figure 2.6).

FIGURE 2.6 Sedimentary rocks are an important natural resource. Rock gypsum mined south of St. George, Utah is used for wallboard in homes and offices.

ELABORATE

The questions below relate to Figure 2.7.

1. Do the rocks look like sedimentary rocks? Explain.
2. How many layers of rock are shown?
3. Draw a simple sketch of the rock layers. Based upon what you have learned, label which layers might be sandstone, and which might be shale.

Challenge Question: If you wanted to use these rocks to build a stone home, which layer or layers would you use? Explain.

FIGURE 2.7. A 15-meter thick exposure of sedimentary rocks north of Parashant.

EVALUATE

1. What are the three main types of sedimentary rocks? Give an example of each.
2. Suppose you are hiking in the mountains of northern Arizona and you found a layered rock with fossil coral in it.
   a. What sedimentary rock is it most likely to be?
   b. Can you conclude that this mountain region was once under the sea? Explain.

3. Layers of coal have been found in Antarctica, a continent almost entirely covered with ice. What can you conclude about the following?

a. How has the climate has changed over time in that region?

b. How has life has changed over time in that region?

4. A geologist finds a layer of sedimentary rock with dinosaur footprints in it. She finds no dinosaur bones – just footprints. Has she found a fossil? Explain your answer.

5. Give two examples to show how you have used or depended on resources from sedimentary rocks in the last week.

Challenge Question:

How do the oil rig and power lines shown in Figure 2.8 relate to sedimentary rocks?

FIGURE 2.8. A drilling rig in western Colorado.