Modeling Erosion 32

1-2
40- to 50-minute sessions

ACTIVITY OVERVIEW

Continuing their study of erosion and how it relates to the building sites in Boomtown, students model the effect of ocean waves on a cliff. They then design, test, and redesign structures to prevent erosion. They use their observations to compare the likely rate of erosion on the hillside and cliff.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Water removes earth materials from some places and deposits it as sediment in others. (EarthSci: 1)
2. Some landforms are the result of destructive forces such as erosion. (EarthSci: 1)
3. Some landforms are the result of constructive forces such as deposition of sediments. (EarthSci: 1)
4. Erosion and deposition can lead to dramatic short-term effects at the shore of oceans and large lakes. (EarthSci: 1)
5. There are positive and negative effects of erosion and deposition. (PhysSci: 2)
6. Students design, test, and redesign a solution. (SciTech: 1)

KEY VOCABULARY

deposition

erosion

MATERIALS AND ADVANCE PREPARATION

For the teacher

1 Scoring Guide: GROUP INTERACTION (GI)

* 1–2 large containers or tubs

For each group of four students

1 plastic box
1 plastic retaining wall
1 wavemaker (2 pieces)
1 river model catch basin
1 30-mL graduated cup
1 spoon
2 mesh sleeves of small rocks
2 rectangular blocks, long
2 rectangular blocks, short
1 9-oz plastic cup (to hold sand)
supply of moist sand (about 175 mL)
* 1 supply of water in plastic container, such as a large beaker or 16-oz. bottle

For each student

1 Scoring Guide: GROUP INTERACTION (GI) (optional)

**Not supplied in kit*

Make sure that each group of four students has access to a work surface that won't be damaged by spilled water or sand. Gather a large container or tub for sand set up and clean up. Provide them in a common area where students can collect and return the sand. If your classroom doesn't have sinks, you should have an additional container available for students so they can dispose of their dirty water. Another useful disposal method is to use a large syringe or turkey baster to remove the water from the basin before disposing of it in a tub or sink.

For this activity, each group of four students will need a 9-ounce cup filled with moist sand, with no additional components mixed in with the sand. Prepare the sand by adding just enough water to make a consistency similar to paste, as in the previous activity. If the sand becomes too wet during the day, drain it as well as possible and add a little more dry sand to create the right consistency. In particular, add more dry sand after the students begin Part B, or give the sand they worked with originally an opportunity to dry out.

Each group will also need 2 mesh sleeves of retaining rocks. The first time you use the kit, you will need to insert the small rocks into the mesh sleeves.

Masters for Scoring Guides can be found in Teacher Resources III: Assessment.

TEACHING SUMMARY

Getting Started

1. Introduce the idea that the coastline is another location where land and water interact.

Doing the Activity

2. (GI ASSESSMENT) Students investigate the cliff model.

Follow-Up

3. Discuss the erosive action of waves and its possible effects on Boomtown.

BACKGROUND INFORMATION

Cliff Erosion

Cliff erosion caused by waves begins with undercutting of the cliff below the waterline. This eventually leads to collapse of the material above the undercut and the receding of the clifftop. Depending on coastal topography and the composition of the rock, coastal erosion can also lead to the formation of caves, arches, and sea stacks.

In some cases, erosion of cliffs takes place at a surprisingly rapid rate due to the power of the ocean's waves. In areas where cliffs are made of compacted sand or soft rock, cliffs can erode a meter or more each year. In other cases, the erosion is more gradual, but may still be significant over a period of several years.

Mitigating Cliff Erosion

The most common structures used to reduce the rate of cliff erosion caused by waves are 1) seawalls made of concrete or 2) piles of large boulders or other material to create what is called *riprap*. These structures frequently delay erosion, but cannot completely stop it. Also, they may accelerate erosion on either side of them.

Cliff erosion can also be caused by runoff at the upper edge of the cliff. Although not dealt with in this activity, these effects of erosion can be reduced by setting buildings back from the cliff, and planting appropriate vegetation, as long as the vegetation does not create cracks that may make the area more vulnerable to weathering. Both of these measures can reduce the runoff of water over the cliff face and thereby slow the rate of erosion.

Beach Erosion

Beach structures may be used to mitigate undesired erosion or deposition. For example, erosion caused by waves is undesirable at the shore, since it will wash the beach away. In the case of a harbor, deposition is undesirable as it may fill in the harbor opening or reduce the depth of the harbor.

There are three basic types of erosion-control structures. Two types are parallel to the shore: breakwaters are an example of offshore parallel structures, and seawalls and ripraps are onshore parallel structures. The third type of structure is perpendicular to the shore; a jetty is an example of a perpendicular structure.

TEACHING SUGGESTIONS

GETTING STARTED

1. Introduce the idea that the coastline is another location where land and water interact.

Remind students that so far they have been modeling the kind of erosion made by water flowing down a hill, in a tiny rivulet, small stream, or large river.

Ask, ***Can you think of any other places where land and water interact?*** They are likely to suggest the shores of lakes and the ocean. A few may even suggest glaciers (frozen ice and snow) scraping at the land. Ask them to describe their ideas about erosion at the shore of a large body of water, such as a lake or the ocean. Collect their ideas and try to address them during the activity.

Tell students that in this activity they will investigate the earth processes at the coast of an ocean or a large lake such as one of the Great Lakes.

DOING THE ACTIVITY

2. (GI ASSESSMENT) Students investigate the cliff model.

Students may need a little help setting up the sand in the boxes and gently adding water so the sand doesn't immediately wash away. Monitor their apparatus to be sure they have followed the directions.

Allow students to complete the activity. Warn them to avoid splashing the sand and water out of the boxes when they produce the waves in the box. Encourage them to observe the effects closely and be sure to write down their observations.

The first three to five waves the students make are likely to produce erosion of the lower half of the cliff face, below the surface of the highest waves. The next few waves are likely to produce a collapse of the cliff face above the area that has been undercut. Students are then likely to see more undercutting of the new cliff face and perhaps another collapse. If necessary you can have them write down their observations more frequently or have them continue making more than 20 waves so they can see these processes more than once.

Before students begin the activity, review the GROUP INTERACTION (GI) Scoring Guide. Explain how you will use it to provide feedback to students on the quality of their work If appropriate, provide each student with a copy of the GI Scoring Guide. To help students work together successfully, you may wish to refer to the Facilitating Group Interaction section on in Teacher Resources II: Diverse Learners.

In Part C, remind students that Boomtown's beach is located near the delta marsh they are considering as a building site. The parameters of the design include using as little material as possible to protect the beach and to keep it safe and accessible for swimming, playing, sunbathing, and other typical beach activities. If you would like to add a monetary constraint factor, provide relative prices for the structure items, making the long rectangular block the most expensive, followed by the retaining rocks, and the smaller solid pieces. Encourage students to measure and draw the changes to the shoreline during their investigation, which should show that the structure reduces the erosion on the area of beach directly behind it but not to the sides. This effect was also noticeable in Part A during the cliff model testing, but not to the same extent.

Ask students to discuss the shortfalls of their design, and give them the opportunity to redesign them. Encourage them to experiment with moving the blocks around, such as placing blocks at an angle or stacking them. Students will often find that placing the two long rectangular blocks on top of each other and at an angle provides the most shielding on the shore with the use of only two pieces.

FOLLOW-UP

3. Discuss the erosive action of waves and the possible effects on Boomtown.

Begin by reviewing students' answers to Question 1, which should include observations of the erosion of the cliff and the deposition of the resulting sand on the sea floor. Discuss the process of erosion below the wave surface and the collapse of the cliff above

the undercut area. This process of erosion below the water surface is called *undercutting*. You may want to introduce this term, although it is not key vocabulary.

Ask students to describe the strengths and weaknesses of the model. One strength is that it is likely to show the process of undercutting and collapse that leads to cliff erosion. It also shows the transport of the eroded materials elsewhere to create a beach or shallow shore. A weakness is that the cliff is made of uncompacted sand, which is not the case for many cliffs.

The beach model has a weakness in that it only shows waves breaking parallel to the beach, when waves more frequently arrive at an angle. More information on the effects of this is addressed in the next activity.

Then let students continue to discuss Questions 2 through 4. Have a few groups describe their results for their investigations with the rock barrier and discuss the possible reasons for any variations observed, such as the placement of the barrier and the frequency and power of the waves.

Before students go on to answer Question 5, have the students review what they learned (in both the last activity and this activity) about erosion that can be related to the possible building sites in Boomtown. Take down their thoughts and add them to the "Building Site Evidence Chart" that you began earlier in the unit. From the introduction to the activity, the students know that Green Hill is made up of a more easily eroded material. Seaside Cliff is made up of harder material, but the students learned in this activity that the cliff is subject to the strong erosional force of the ocean's waves in addition to rainfall. Encourage students to consult the topographical maps of Boomtown. The maps that show that the cliff has moved more than the hill (except on the portion of the hill where construction has taken place). This provides evidence that the strong erosive action of the ocean's waves has been enough to erode the cliffs, even though they are made of a more resistant material.

SUGGESTED ANSWERS TO QUESTIONS

1. *What did the waves do to the cliff model? Explain in terms of erosion and deposition.*

   They made the sand wash away, or erode. The process began with erosion below the water and then a collapse of the cliff. The material washed away was deposited on the bottom of the model.

2. *What was the effect of the retaining rocks on the model cliff?*

   Students answers will vary, depending on where they placed the retaining rocks. If they placed them directly against the cliff, they are likely to observe much less erosion. If the rocks are placed a short distance away from the cliff, they are likely to observe some slowing of the process of erosion.

3. a. *What kind of landform was created at the bottom of the model cliff?*

      A beach or underwater shelf was created.

   b. *What earth process was involved?*

      This involved deposition of the sediments eroded from the cliff.

4. *Granite on a mountaintop is likely to erode differently than granite found on a sea cliff. Why do you think this is true?*

   Granite on a mountaintop will erode due to rain or other sources of flowing water, while granite on a cliff will erode from both flowing water and waves. It is likely that the cliff will erode more rapidly if the earth material is granite in both cases, because the ocean's waves are more powerful and cause more erosion.

5. *Review your results and your response to Question 5 in Activity 31. This activity has provided you with more evidence about erosion of cliffs. Where would you expect more erosion, at Green Hill or at Seaside Cliff? Be sure to explain your evidence.*

   Students' answers are likely to vary. Some will think that the cliff and hillside material is still the overriding factor. However, most should indicate in some way that the new evidence

makes it more likely for there to be more erosion at the cliff due to the waves. This complicates the issue: based on their earth materials, the hill seems more likely to erode, but based on the more powerful and extensive effect of ocean waves as compared to rain, the cliff seems more likely to erode.

6. *What did all the designs for reducing erosion on a shoreline have in common? Explain how they reduce erosion at a cliff and a beach.*

   All the structures slowed down the erosion of a shoreline by breaking the waves before they hit the shore. In this way, the waves hit the cliff or beach with less force.

7. *What are some of the advantages and disadvantages of building a structure to protect a cliff or beach?*

   The advantage is that the structures successfully shielded the shoreline behind the structure from being eroded. However, the shoreline area to either side of the barriers had significant erosion. This is a disadvantage because it means erosion isn't prevented so much as displaced. The cost involved in building the protective structures is another disadvantage.

SEPUP SCORING GUIDES AND ASSESSMENT COMPONENTS

1. Designing Investigations	*(DI)*
2. Organizing Data	*(OD)*
3. Analyzing Data	*(AD)*
4. Understanding Concepts	*(UC)*
5. Recognizing Evidence	*(RE)*
6. Evidence and Trade-offs	*(ET)*
7. Communication Skills	*(CS)*
8. Organizing Scientific Ideas	*(SI)*
9. Group Interaction	*(GI)*

9. GROUP INTERACTION (GI)

What to look for:

- *Group members work as a team and the ideas of all members are valued and weighed in working toward the common goal.*

Scoring Guide

LEVEL	DESCRIPTION
Level 4 Above and beyond	Group members accomplish Level 3 and go beyond in some significant way, such as: • asking helpful questions about each other's ideas. • helping each other accomplish the task. • building on each other's ideas.
Level 3 Complete and correct	All group members participate and respectfully consider each others' ideas.
Level 2 Almost there	Group participation is unbalanced, OR group considers some members', but not everyone's, ideas with respect.
Level 1 On your way	Participation is significantly unbalanced OR group totally disregarded some members' comments and ideas.
Level 0	Members do not work together, OR single individual does entire task.
X	Student had no opportunity to respond.

ROCKS AND MINERALS (Continued from previous page)

	ACTIVITY DESCRIPTION	KEY CONCEPTS AND PROCESSES	ADVANCE PREPARATION	ASSESSMENT	TEACHING PERIODS
21	**MODELING: Modeling Rock Layers** Students model the formation of sedimentary rock layers by dropping plastic chips into a cylinder.	Sedimentary rocks, modeling, variable, range MATHEMATICS	Get watches or clocks, overhead projector		1– 2
22	**INVESTIGATION: The Rock Cycle Game** Students play a game that models the rock cycle.	Rock cycle, igneous rock, sedimentary rock, metamorphic rock, magma	Get overhead projector, copy student sheets	Q 7: UC	1–2
23	**TALKING IT OVER: Making Minerals** Students evaluate data on mined vs. manufactured diamonds and discuss their relative values.	Natural resources, minerals, properties LITERACY	Get overhead projector, copy student sheets	Q 3: ET	1–2

UNIT C: EROSION AND DEPOSITION

Listed below is a summary of the activities in this unit. Note that the total teaching time as listed is 16–20 periods (approximately 3–5 weeks if you teach the activities as recommended every day). If you find that you cannot finish in this timeframe, consider skipping Activity 31, 32, or both.

	ACTIVITY DESCRIPTION	KEY CONCEPTS AND PROCESSES	ADVANCE PREPARATION	ASSESSMENT	TEACHING PERIODS
24	**TALKING IT OVER: Where Should We Build?** Students are introduced to a scenario about fictitious Boomtown and consider the impact of construction at three potential building sites.	Observation, inference, evidence, and trade-offs, landforms, wetlands	Get overhead projector, copy student sheet		2
25	**INVESTIGATION: Making Topographical Maps** Students construct a topographic map of a land formation in Boomtown.	Landforms, topographic maps, contour intervals	Get overhead projector, water in containers, paper towels (optional)	Quick Check	1–2
26	**PROBLEM SOLVING: Boomtown's Topography** Students compare topographic maps of Boomtown at the present with those from the past and identify changes in the landforms.	Topographical maps, changes in topography, stability	Get overhead projector, copy student sheets		1–2
27	**PROBLEM SOLVING: Investigating Boomtown'sWeather** Students construct bar graphs of rainfall data as they consider the impact of rainfall patterns on the three possible construction sites.	Rainfall patterns, graphing, averages, mean, median, mode, sample size MATHEMATICS	Need graph paper, overhead projector; copy student sheets; gather local rainfall statistics (optional)	Proc: OD Quick Check	2–3
28	**MODELING: Cutting Canyons and Building Deltas** Students use a river model to investigate how flowing water creates common landforms, such as rivers and deltas.	Observation, erosion, deposition, landforms, modeling	Need water in containers, large tub, newspaper, overhead projector; check sand consistency; copy student sheets; gather colored pencils (optional)	Proc: GI	1–2

EROSION AND DEPOSITION (Continued from previous page)

	ACTIVITY DESCRIPTION	KEY CONCEPTS AND PROCESSES	ADVANCE PREPARATION	ASSESSMENT	TEACHING PERIODS
29	**READING: Weathering, Erosion, and Deposition** Students read about weathering, erosion, and deposition and about the impact of human activity on these processes.	Constructive and destructive earth processes, weathering, erosion, deposition, human activity and earth processes LITERACY	Get overhead projector, copy student sheets	Q 2: UC	1–2
30	**ROLE PLAY: Challenges of the Mississippi Delta** Students relate the scenario to the broader issue of land use by learning about erosion and deposition problems along developed areas of theMississippi.	Erosion and deposition, human activity and earth processes, hurricanes, trade-offs, science careers LITERACY	Prepare for roles; copy student sheets; gather information (optional)	Quick Check	2
31	**MODELING: Resistance to Erosion** Students investigate the effects of erosion on different earth materials by using models of different earth materials.	Erosion resistance of earth materials, modeling; controlled, uncontrolled and tested variables	Need water in containers, large tubs; check sand consistency; gather masking tape and paper towels (optional)		1–2
32	**INVESTIGATION: Modeling Erosion** Students model the effect of ocean waves on a cliff and design an investigation using a model to determine the effects of a rock barrier on erosion of the cliff.	Coastal erosion, modeling, mitigation of erosion, enginerring design	Need water in containers; large tub; check sand consistency; gather paper towels (optional)	Proc: GI	1–2
33	**READING: Earth Processes and Boomtown's Coast** Students read about the effect of earth processes on coastal systems and the efforts to mitigate the impact of human activity.	Coastal systems, longshore current, constructive and destructive earth processes, mitigation of human activity, LITERACY	Get overhead projector; have students gather student sheets	Quick Check	1–2
34	**PROJECT: Preparing the Geologist's Report** Students use the information they have gathered throughout the unit to summarize the geology at each of the building sites in Boomtown.	Evidence, science careers LITERACY	Get overhead projector; have students gather student sheets, observations, and notes; copy student sheets	Q 1: RE	1–2
35	**ROLE PLAY: Building in Boomtown** Students present a building plan for one of the sites and then make their final decision about where Boomtown should build homes.	Evidence and trade-offs, advantage and disadvantage, science careers LITERACY	Need poster board and markers; copy student sheets; gather scissors, colored paper, and tape (optional)	Proc: CS Q 1: ET	2–3