LESSON 1

Weathering, Erosion, and Deposition

The rock structures on Praia do Camilo in Lagos, Algarve region, Portugal, have formed as a result of wave action over many years.

By the end of this lesson . . .

you will have investigated how the processes of weathering, erosion, and deposition have shaped Earth's surface.

Go online to view the digital version of the Hands-On Lab for this lesson and to download additional lab resources.

CAN YOU EXPLAIN IT?

What caused these changes at Port Campbell National Park?

The photo on the left shows a rock formation just offshore of Port Campbell National Park in Australia before 1990. The photo on the right shows the same rock formation after 1990.

The Earth's surface can change in the blink of an eye, or so it seems. While some events can appear to happen quickly, it may have taken many years to build up to that point. As you look at the photographs of the rock formation in Port Campbell National Park, evidence of change appears obvious, but the story may be more complex.

1. What types of changes do you observe between the rock formations in the two images?

2. Based on the visible changes in the rock formation, do you think the changes occurred quickly or slowly over time? Explain your reasoning.

EVIDENCE NOTEBOOK As you explore the lesson, gather evidence that will explain what happened to the rock formation in Australia over time.

Identifying Effects of Weathering

Rocks and other materials that make up Earth's surface are matter. So, rock and other materials cannot be created or destroyed. But they can be changed. **Weathering** is the process by which rock materials are broken down by the action of physical and chemical processes.

Weathering changes rocks by breaking them into smaller and smaller pieces, or by dissolving and removing some chemicals within the rock. Fragments of weathered rock, called **sediment,** are an important part of soil. Sediment can build up in layers on Earth's surface to form rock formations, sand dunes, and other features.

When it comes to weathering, not all rocks are created equal. Some rocks are more resistant to weathering than other rocks. Resistance to weathering is affected by the composition of, or chemicals that make up, the rock. Surface area also affects a rock's tendency to weather. A large block of rock will weather more slowly than smaller broken pieces of the same rock will. This difference is because the smaller pieces have more surface area exposed to agents of physical and chemical weathering. Physical and chemical weathering are the two main types of weathering.

Look closely at the shape of this rock formation in South Coyote Buttes Wilderness in Arizona.

3. Many features found in South Coyote Buttes have this same striking appearance. What could cause rocks to be shaped this way? Explain your answer.

Physical Weathering

Physical weathering is the mechanical breakdown of rocks into smaller pieces. Physical weathering involves only physical changes. Rocks can be physically weathered by temperature changes, pressure changes, and interactions with plants, animals, water, wind, ice, and the force of gravity.

Types of Physical Weathering

Water can seep into tiny cracks in rocks and then freeze. Water expands when it freezes, causing the cracks in the rocks to widen. Cycles of repeated freezing and thawing eventually fracture the rock.

Plant roots can grow into gaps in rocks. Over time, as the roots grow, they force the gaps wider, causing the rock to break apart.

Abrasion occurs when rock is broken into smaller pieces by the scraping action of other materials. Abrasion is driven by water, wind, ice, or gravity. A strong wind, for example, can blow sediments against rock surfaces, wearing down the rock. Abrasion can make angular rocks smooth and rounded.

4. Which statements describe physical weathering? Select all that apply.

A. Two rocks hit against each other in a fast-flowing stream and break apart.

B. Oxygen and water change the composition of the minerals in a rock.

C. Small rocks are pushed together when a mole digs an underground den.

D. Mosses grow on a rock and produce acids that wear away the rock over time.

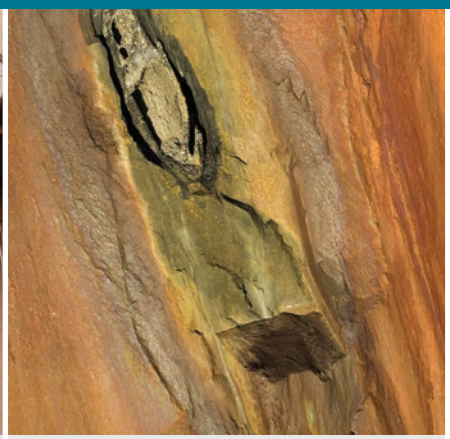
Plants are not the only living things that can cause physical weathering. Animals physically weather rocks in a variety of ways. Burrowing animals dig in soil and expose or displace rocks. Even strolling along a well-worn path in a meadow exposes buried rocks to wind, water, air, and other agents of weathering.

Chemical Weathering

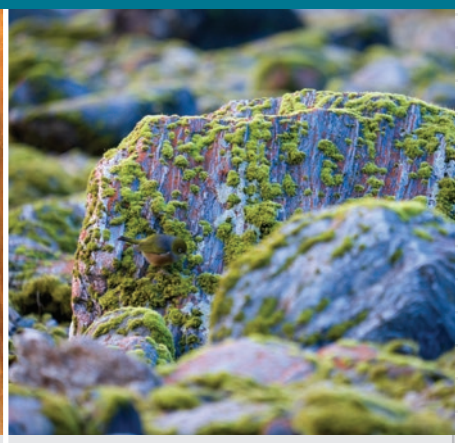
Chemical weathering is the breakdown and decomposition of rocks as a result of chemical reactions and processes. Unlike physical weathering, chemical weathering changes the composition of rocks through a chemical process. It weakens or dissolves rock over time. Agents of chemical weathering include air, water, and plants. For example, groundwater, which is water that flows through rock below Earth's surface, can contain natural acids that dissolve rocks. Underground caves form in this way.

Types of Chemical Weathering

Acid precipitation is rain or other precipitation that is more acidic than normal. Acid precipitation reacts with certain types of rocks, weakening them and making them more susceptible to physical weathering. The rocks break down over time.



Iron-containing rocks can react with oxygen and water in a process called oxidation. Oxidation can give the rocks a reddish color, similar to rust. In fact, the same process causes rust to form on bicycles left out in the rain.



Plants such as lichens and mosses produce weak acids. When the plants grow on rocks, the acids slowly, but steadily, wear down the rocks.

5. Which description is evidence of chemical weathering?

- **A.** A rock in a windy desert has scratches on its surface.
- **B.** A rock in a tundra has deep cracks filled with ice.
- **C.** A rock turns a reddish color when exposed to air and water.
- **D.** A rock on a steep slope falls to the ground and breaks apart.

Earlier, you learned that the surface area and composition of a rock affect its rate of weathering. Other factors that affect rates of weathering include location and climate. Rocks on steep slopes are more likely to be displaced by gravity and exposed to wind, water, and air. Rocks in cold climates are more likely to experience physical weathering caused by cycles of freezing and thawing. In contrast, chemical weathering occurs more rapidly in warm, wet climates because warm temperatures increase rates of chemical processes. Both types of weathering tend to happen more slowly in dry climates.

EVIDENCE NOTEBOOK

6. Does the collapsed rock formation in Australia show signs of weathering? If so, identify the type of weathering that could have occurred. Record your evidence.

7. Language SmArts | Find Evidence for Weathering Analyze each photo and identify the correct terms to complete each statement. Then provide evidence to support your answer choices.

Weathering Example	Weathering Type or Agent	Evidence
	This rock shows evidence of chemical / physical weathering as a result of acid / wind / ice.	
	This rock shows evidence of chemical weathering as a result of acid / wind / ice.	
	This rock shows evidence of physical weathering as a result of acid / wind / ice.	

Analyze the Effects of Weathering

Weathering is an important process that changes Earth's surface. These changes happen on different scales of time and space. A rock tumbles to the ground and breaks apart—this is a fast change that affects a small area. Water and wind steadily wear down a mountain over millions of years—this is a slow change that affects a large area.

8. Discuss With a partner, look at the stone bricks used to build this building and think about how they changed over time. What caused them to change? Do you think these changes occurred quickly or slowly? Explain.

Exploring Agents of Erosion and Deposition

Picture a fast-flowing stream. Rocks tumble together, breaking up into sediment that is carried away and dropped in a new place. Some of the rock material dissolves in the water and is carried downstream. **Erosion** is the process by which wind, water, ice, or gravity transport weathered materials from one location to another. **Deposition** occurs when the eroded materials are dropped, or laid down. Erosion and deposition, like weathering, do not destroy matter. Instead, they move and deposit matter in new places.

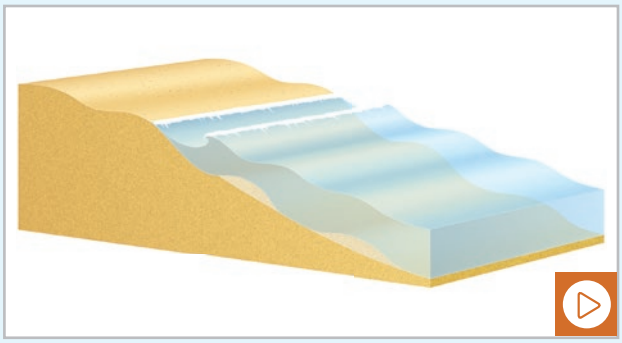
Wind and Water

Recall that wind and water can cause weathering through abrasion. Wind and water are also agents of erosion and deposition. Water erodes as it flows above ground through streams or underground through spaces in rock. Wind erodes as it blows over surfaces and lifts or pushes sediments. When wind and water lose energy and slow down, they drop their sediments and deposition occurs.

Do the Math

Calculate Rate of Erosion

The environment, very much like an equation, is balanced. Although matter cannot be created or destroyed, it can move and cycle through Earth's subsystems. As erosion occurs, it removes, or subtracts, sediment from one location and deposits, or adds, it to another location.



As sand erodes from a beach, it can be deposited into sand bars, deltas, and other beaches.

9. Identify the correct type of change that occurs.

A. Erosion represents a(n) increase / decrease in volume.

B. Deposition represents a(n) increase / decrease in volume.

C. As sand is eroded by waves and deposited on the sand bar, the sand bar increases / decreases in volume.

10. During a storm, sand is eroded from a beach at a rate of 2 m^3 per hour. What equation can be used to represent the volume of sand in cubic meters, *c*, on the beach? Let *b* represent the amount of sand in cubic meters at the beginning of the storm and *h* represent time in hours. Complete the equation using +, −, ×, or ÷.

$c = b$ ☐ $2h$

11. Suppose the total volume of sand on the beach is 1,278 m^3. What will its volume be after 24 hours of erosion?

Erosion and Deposition by Wind and Water

How will water and wind shape the land in each of these areas?

Waves constantly crash against the shoreline, weathering and eroding this rocky coast. Waves also erode sediments from sandy beaches.

Over millions of years, a river can carve a valley by the processes of weathering and erosion.

This rock formation has been shaped by wind abrasion, a type of weathering. Wind erosion then transported the weathered sediments to a new place.

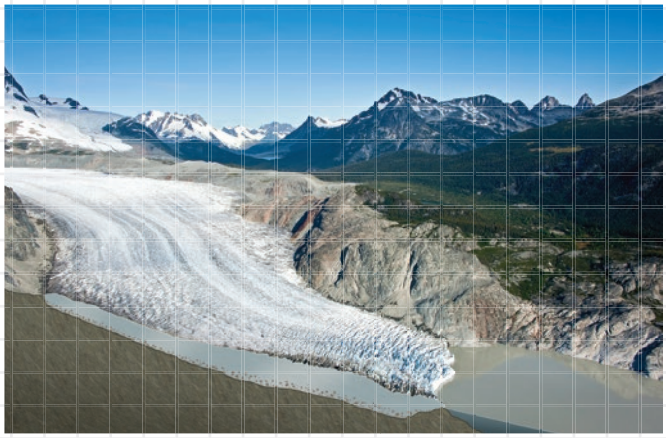
A river slows down when it reaches the ocean. When the water loses energy, the sediments it was carrying are deposited. At the mouth of a stream or river, this action forms a feature called a *delta*. The shape of a delta changes constantly as sediments are deposited and eroded.

Sand dunes form when wind deposits sediments. Sand dune patterns are constantly changing due to erosion and deposition. Patterns can shift in time scales that range from hours to years.

12. Discuss A friend looks at these images and says that sand and sediment are being destroyed during the process of erosion. Form into small groups and discuss whether you think the friend is correct. Use evidence to support your response.

Ice

One of the most powerful agents of erosion and deposition is ice. A glacier is a large mass of ice that exists year-round and flows slowly over land. The weight of the glacier, along with gravity, help it move over land. As glaciers move, they act like a conveyor belt, eroding soil, sediment, and rock—even large boulders—over great distances, and then depositing the materials elsewhere. Glaciers can form jagged peaks or flatten and scoop out large sections of land creating valleys. The Great Lakes are huge depressions formed by glaciers and later filled in with water. Glacial deposits can create long winding ridges or rocky mounds of sediment.

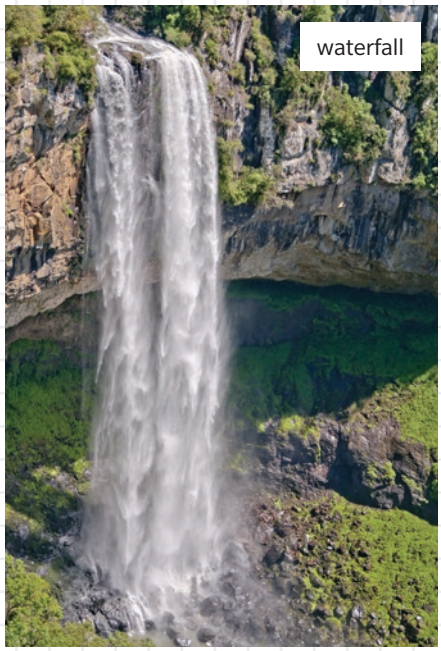


This cutaway view of a glacier reveals the sediment and rocks that can be picked up, carried, and deposited by the glacier as it flows across the surface of the Earth.

13. How will the glacier affect surrounding land as it moves and melts over time?

Gravity

Energy from the sun powers the movement of wind and water. But the force of gravity, which attracts matter to Earth's center, also plays a role in driving these agents of erosion. When wind slows down, its load of sediment drops to the ground because of gravity. Rocks, boulders, and soil fall down slopes because of gravity. Water flows downhill, through valleys and waterfalls, because of gravity. Gravity is the main force behind sudden rock falls and landslides that can change the shape of a mountain.



14. Explain the role of gravity in the landslide and in the waterfall.

15. Look at the image of the rock ledge. What factors could contribute to a collapse of the ledge? Select all that apply.

A. Wind

B. Water

C. Ice

D. Gravity

16. Explain how each of the contributing factors would play a role in the collapse of the ledge.

Found near the coast of Palau, Italy, this rock formation shows evidence of weathering.

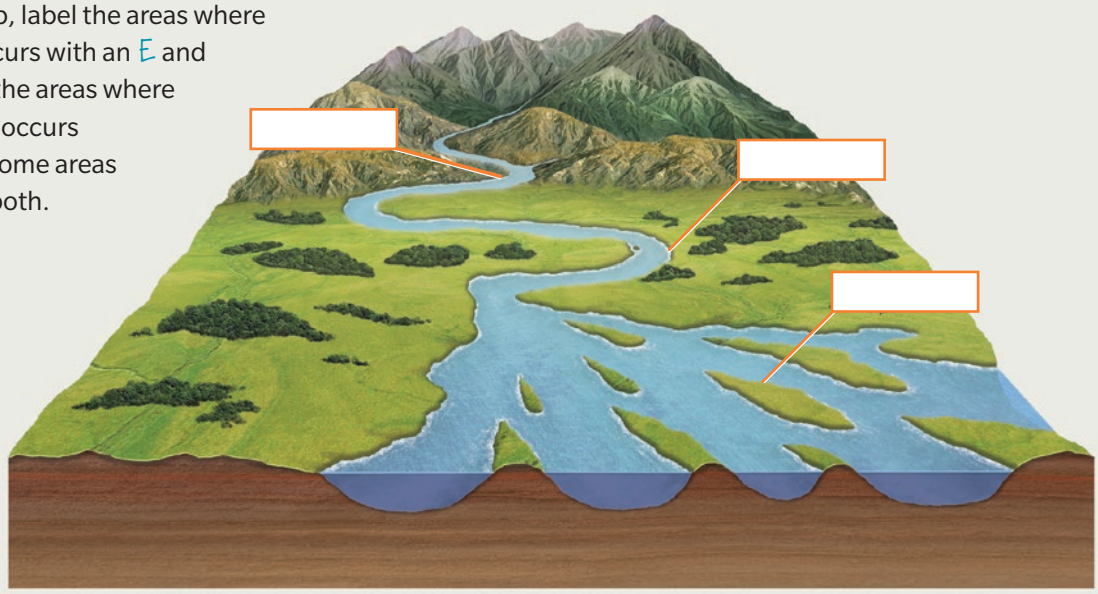
EVIDENCE NOTEBOOK

17. Will gravity always play a role in erosion of a shoreline feature, such as the collapse of a rock formation in Australia? If so, identify the process, or processes, that would lead up to the collapse. Record your evidence.

Identify Areas of Erosion and Deposition

Weathering, erosion, and deposition are geologic processes that are mostly powered by energy from the sun. These changes happen on different scales of time and space. Yet each change can be studied to help predict how Earth will change in the future.

18. On the map, label the areas where erosion occurs with an E and then label the areas where deposition occurs with a D. Some areas may have both.

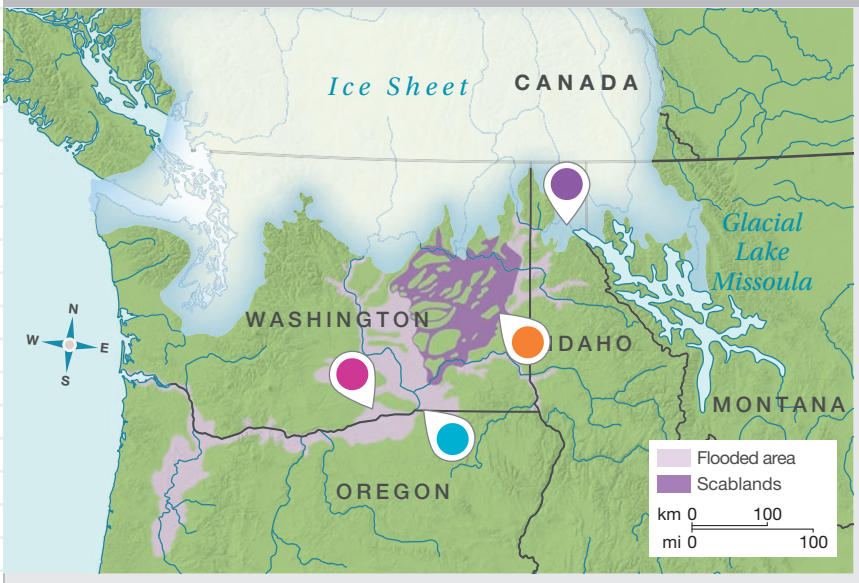


Modeling Weathering, Erosion, and Deposition

You cannot re-create an actual flood in a lab, but you can use models to investigate the processes of weathering, erosion, and deposition during flood conditions. Computer simulations can also be used as models that can help you learn about past events and predict future ones. Computer models can be used to re-create events that cannot be studied directly, such as a massive flood in prehistoric times.

Studying a Historic Flood Event

The Missoula Floods were part of a historic event that took place over 10,000 years ago. These floods stretched across a large portion of the northwestern United States, leaving visible evidence of their path. In the early 1920s, scientists began to study this historic flood and the research continues today.



The map and these images model a massive flood that happened in a short geologic time frame. Keep in mind, though, that the processes of weathering and erosion worked on the ice dam for a long time before it finally broke.

During the last Ice Age, a huge ice dam held back Glacial Lake Missoula, a large body of water in western Montana. On multiple occasions, the dam burst. Water rushed out, emptying the lake in just a few days.

Erosion caused by the rushing water carved out a landscape of huge waterfalls, deep canyons, and the giant ripple marks shown here.

When the rushing floodwaters reached narrow Wallula Gap, they would back up and halt for several days, forming a temporary lake about 240 m deep.

The Scablands cover at least 5,000 km^2 of land affected by the ancient floodwaters. The ice dam reformed and broke several times. During each flood, the land was scoured and stripped bare.

19. Engineer It What technologies make it possible for us to understand the scale of changes that occurred as a result of the breaking of the glacial dam holding back Lake Missoula's waters?

Hands-On Lab

Model Erosion and Deposition

How can you predict the effects of erosion and deposition? You will model Earth's surface with sand and then investigate the effects of erosion and deposition by water and wind.

MATERIALS

- two flat trays
- soil
- sand
- container of water
- colander with small holes

Procedure and Analysis

STEP 1 Make a mound of soil on a tray to represent a hill and a mound of sand on the other tray to represent a dune.

STEP 2 Predict what will happen to both features after a heavy storm. Record all your predictions and observations in the spaces provided.

STEP 3 Blow on the sand dune to simulate a coastal storm. Observe what happens.

STEP 4 Pour water through the colander and onto the hill, simulating rain. Observe what happens.

STEP 5 Pour water around the base of the dune. Carefully tilt the tray to model wave action. Observe what happens to the dune.

	Predictions	Observations
water		
wind		
wave		

STEP 6 What agents of erosion and of deposition did you model?

STEP 7 What limitations does this model have? How could you improve the model to better show erosion and deposition?

Scales of Weathering, Erosion, and Deposition

Weathering, erosion, and deposition can happen over a wide range of time scales. Wind can change the shape of a sand dune in minutes. The erosion that forms a canyon can take place over millions of years. The size of the changes caused by weathering, erosion, and deposition can vary too. Some changes, such as acids weathering a rock, affect Earth's surface on a small, localized scale. Changes such as the movement of an ice sheet can affect a whole continent. By studying these processes, you can reconstruct past geologic events, such as the massive flood that occurred in the northwestern United States over 10,000 years ago. You can also make predictions about future events.

The Great Sphinx of Giza, Egypt.

20. The Sphinx in Egypt was likely built about 4,500 years ago. If weathering and erosion continue to have the same effect on the Sphinx, what do you think it will look like in 4,500 more years?

A. It will not change.

B. It will look more defined.

C. It will look much less defined.

D. It will disappear completely.

Predict Effects of Erosion

21. Discuss Water and wind have shaped Mesa Verde Canyon in Arizona for millions of years. With a partner, look for evidence of weathering and erosion in the canyon. If water continues to flow through the canyon, what do you think it will look like 1 million years from now?

22. Draw In the space below, draw what you think the canyon will look like in 1 million years.

Continue Your Exploration

Name: **Date:**

Check out the path below or go online to choose one of the other paths shown.

Gold Rush

- **Hands-On Labs**
- **Sailing Stones**
- **Propose Your Own Path**

Go online to choose one of these other paths.

Did you ever wonder why gold prospectors are often shown knee-deep in a shallow stream, panning for gold? Why do they look there?

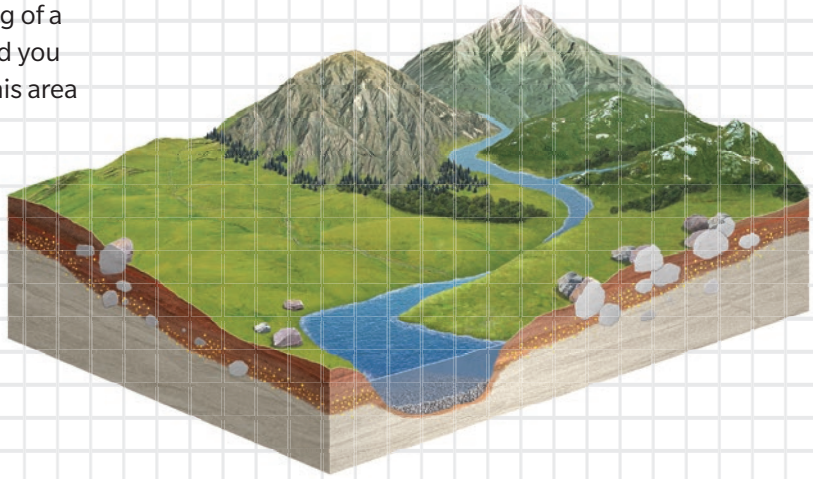
The prospectors know that gold is subject to the natural processes of weathering, erosion, and deposition. This rare and beautiful mineral can be found in certain buried rocks. Gold is often found in veins, which are narrow zones within rock that contain minerals different from the rest of the rock. Weathering can expose these veins, wearing away nuggets or flakes of gold. Erosion carries the gold into streambeds. Deposition drops it in places where the stream flow slows down, such as near pools or sandbars.

When looking for gold in a stream, pans are used to sift through sediment and rocks.

Continue Your Exploration

Use your knowledge of erosion and deposition to answer the questions.

1. Imagine you discovered this model drawing of a piece of land your family owns. What would you need to know about the rocks and soil in this area before you decide to pan for gold?



2. How could your understanding of erosion and deposition help identify where to pan for gold?

3. In which area(s) would you search for gold? Explain.

4. Collaborate Discuss with a classmate where you would search. Did you identify the same places? Together, decide on which location you would search first and argue from evidence to support your decision.

Can You Explain It?

Name: **Date:**

What caused these changes at Port Campbell National Park?

EVIDENCE NOTEBOOK

Refer to the notes in your Evidence Notebook to help you construct an explanation of the causes of the changes at Port Campbell National Park.

1. State your claim. Make sure your claim fully explains how the changes at Port Campbell National Park occurred.

2. Summarize the evidence you have gathered to support your claim and explain your reasoning.

Checkpoints

Use the photo to answer Questions 3–4.

3. For which of the following can you find evidence in this photo? Choose all that apply.

- **A.** erosion
- **B.** deposition
- **C.** chemical weathering
- **D.** physical weathering

4. Which processes could be primarily responsible for the formation of the alluvial fan shown in the photo? Select all that apply.

- **A.** Wind storms coming through the base of the mountains into the valley
- **B.** Water flowing down from the mountains and depositing sediment at the base
- **C.** Rocks and boulders falling down the mountains and piling up at the base

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Use the photo to answer Questions 5–6.

5. Which of the following is a factor in weathering caused by gravity?

- **A.** presence of living organisms on the rocks
- **B.** presence of water at one end of the glacier
- **C.** slope of the ground that the glacier is on
- **D.** size of the boulders at the base of the glacier

6. Which evidence in the picture best illustrates the occurrence of deposition?

- **A.** the glacier ending in the water
- **B.** the color of the rock formations
- **C.** areas of water where the glacier may be melting
- **D.** rocks and sediment at the edges of the glacier

7. What type of physical weathering could cause a rock to break apart?

- **A.** abrasion of the surface caused by rocks being moved under a sliding glacier
- **B.** gravity acting upon the loose rocks and dirt in the area
- **C.** water refreezing in the rock crevasses

Interactive Review

Complete this interactive study guide to review the lesson.

Weathering is all of the processes that break down rocks. Physical weathering mechanically breaks down rocks. Chemical weathering breaks down rock by chemical reactions or processes such as dissolving rock in water.

A. List and describe different types of physical and chemical weathering.

Erosion is the process by which wind, water, ice, or gravity transport weathered materials from one location to another. Deposition occurs when materials are dropped by wind, water, ice, or gravity.

B. Explain how wind and water can contribute to weathering, and are also agents of erosion and deposition.

Weathering, erosion, and deposition can occur in minutes or over millions of years. Changes can be very large and noticeable, or small and seemingly insignificant.

C. Describe how weathering, erosion, and deposition operate on both small and large time and spatial scales.