Chapter 9

Checkpoint 9.1 Examine the photos. Both images show granite outcrops in the Sierra Nevada Mountains, California. Which outcrop contains pressure release cracks? Explain your choice.

a) Outcrop A
b) Outcrop B

Pressure release joints result in onion-skin-like exfoliation.

Checkpoint 9.2 Outcrops of granite are examined in California at similar elevations in the interior of the state more than 100 kilometers (63 miles) from the Pacific Ocean and in outcrops along the coast. The granites have identical compositions and textures. On the basis of the following information, which granite outcrop would weather most rapidly?

a) Outcrop A; located at coast, contains fractures spaced 1 meter apart
b) Outcrop B; located at coast, does not have fractures
c) Outcrop C; located in interior, contains fractures spaced 1 meter apart
d) Outcrop D; located in interior, does not have fractures

Checkpoint 9.4 Imagine that you have been appointed to a team of researchers charged with determining which of the five World Heritage Sites in Figure 9.1 is at greatest risk from physical weathering. Identify at least three general questions you will ask as you begin to gather data for your study. Describe how you will use the information to plan your next steps.

This question refreshes your grasp of science as a process. Good student responses will merge concepts in the reading with the recognition that good scientific questions are testable with empirical data.

Checkpoint 9.5 Look at Figure 9.10b. According to this map, is there a cave near where you live? Why, or why not?

We have a number of sea caves along the coast, but have little limestone on the west coast. Limestone is generally formed in warm waters and west coasts generally have cold ocean currents flowing from the poles toward the equator, of which the California current is an example. Much of California is made of accreted terranes from subduction zones that have existed along the coast over the last 200 million years or so.

Checkpoint 9.6 Weathering Analogies Matrix

Many simple occurrences in our daily lives are similar to geologic processes. The following table contains some everyday events that you may have experienced. Match these actions to specific weathering processes. Complete the table by placing an “X” in the columns on the right-hand side where appropriate. For each characteristic in the left-hand column write in whether it is analogous (similar) to physical, chemical, or biological weathering.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Paint on house gradually disappears</th>
<th>Spilled drink stains carpet</th>
<th>Groundhog digs a hole under your garage</th>
<th>Sugar disappears in hot coffee</th>
<th>Fungus forms on a fallen tree in the woods</th>
<th>Tree root pushes up paving slab</th>
<th>Rust forms on an old car</th>
<th>Bleach changes color of clothes</th>
<th>Pot holes form on road in winter</th>
<th>Nail polish remover removes nail polish</th>
<th>Paper weight holds down stack of bills</th>
<th>Compost rots in your garbage can</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>C</td>
<td>B/P</td>
<td>C</td>
<td>B/C</td>
<td>B/P</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>B/P</td>
<td>B/P</td>
<td>B/C</td>
</tr>
</tbody>
</table>

Checkpoint 9.7

If you were to analyze the sand on a typical beach along the Atlantic coast, you would find that most of the sand grains are composed of the mineral quartz. In contrast, if you analyzed sand on some beaches in Hawaii you might find that the dominant grains contain minerals such as pyroxene or olivine. Quartz, pyroxene, and olivine are all silicate minerals. Use weathering processes to explain why the compositions of these beaches differ.

At the simplest level, students should point out that the rocks that are weathered in each area must have different compositions. Some students may point out that pyroxene and olivine have simpler silicate structures than quartz and would therefore weather more rapidly, all other factors being equal. If all minerals were present in the source rocks of the...
eastern United States, the olivine and pyroxene would probably be converted to clay minerals by the time they were transported to the coast. Transport distances would be shorter in Hawaii; therefore, these minerals may not have time to break down. The best student responses will further extend related ideas of transport, deposition, and remobilization.

**Checkpoint 9.8**
Imagine that you have been appointed to a team of researchers charged with determining which of the five World Heritage Sites in Figure 9.1 is at greatest risk from chemical weathering. Identify at least three general questions you will ask as you begin to gather data for your study. Describe how you will use the information in combination with data on physical weathering to plan your next steps.

This question refreshes your grasp of science as a process. Good student responses will merge concepts in the reading with the recognition that good scientific questions are testable with empirical data.

**Checkpoint 9.13**
Assuming that the rock type is similar in each of the locations on the following map, predict whether physical or chemical weathering (or neither) dominates in each location. Explain your answers.

Chemical weathering likely dominates at location 1 (high temperature, high precipitation). Physical weathering likely dominates location 3, Rocky Mountains. Neither likely dominates in the dry desert conditions at location 2. Likewise, location 4 is likely too cold for much of the year to have any weathering, except briefly in spring and fall when it would experience physical weathering due to freeze-thaw cycles.

**Checkpoint 9.14**
During a study of weathering, a scientist examines two tombstones marking graves in separate cemeteries. The inscription on one tombstone is almost unreadable, whereas the inscription on the other is sharp and clear. Provide three potential explanations for the differences in the present state of the inscriptions.

This is an open-ended analysis-level question. Students should be able to explain how changes in the type of material, weathering rate, age, and climate conditions could result in different weathering rates from one site to another.

**Checkpoint 9.15**
Analyze four of the World Heritage Sites described in Table 9.1. (Omit Angkor Wat, which is analyzed in the upcoming case study.) Rank the locations from 1 through 4 on their potential for weathering. Justify your ranking scheme.

This is an analysis-level question where students are expected to recognize the significance of temperature, precipitation, and parent material on weathering rates. We would expect Kilwa Kisiwani, to exhibit the greatest weathering potential but students can probably make a case for either Macchu Picchu and the Parthenon at the next two positions. Remember, the goal here is for students to synthesize information and make judgments supported by data.

**Checkpoint 9.17**
How is the thickness of soil in a region related to weathering?

a) Weathering breaks down materials near Earth’s surface and therefore reduces the thickness of soil.

b) Weathering increases the thickness of soil because it provides more materials to be incorporated into the soil.

c) Soil thickness is dependent on the character of the regolith and therefore is not related to weathering.

**Checkpoint 9.18**
From what you learned about geologic time in Chapter 8, approximately when did the first regolith form on Earth?

When did the first soils form?

Regolith began to form once there was solid rock exposed to weathering while true soils need biologic materials (land plants). Therefore the earliest regolith probably developed relatively early in Earth history (~4 Byrs). True soils likely did not develop until the
Plants showed up on land in the Paleozoic, perhaps around 450-500 mya.

**Checkpoint 9.19**
A “system” is defined as a group of independent but interrelated components comprising a unified whole. Support the following statement: Soil is an example of a system and soil type is controlled by the balance of inputs and outputs to and from the system.

This is an open-ended synthesis-level question. Students should recognize that soils form from different parent rocks and the nature of the subsequent processes that affect that material. Those processes include the type of dominant weathering, amount of available biologic material, and mixing rate.

**Checkpoint 9.22 Venn Diagram: Water and Wind Soil Erosion**
Complete the following list to compare and contrast the factors that affect soil erosion due to water and wind. Identify characteristics that are shared by both systems (e.g., characteristic 1) or are different for each group (e.g., characteristic 2).

Wind erosion
1. Rate dependent on vegetation cover
2. Occurs in regions of warm, dry climate

Both
1. Rate dependent on vegetation cover

Water Erosion

**Checkpoint 9.23**
An average-sized U.S. farm has an area of 176 hectares (440 acres). Design an experiment to get an accurate measurement of soil erosion for a farm of this size.

Students are expected to apply the process of science to design an experiment. Good responses will recognize that soil losses occur from both wind and water erosion and design their data collection plan accordingly. Poor responses will simply indicate they would measure it without specifying how that measurement would occur.
Weathering/soils Concept Map,
Complete the following concept map to evaluate your understanding of the interactions between the Earth system and weathering/soils. Label as many interactions as you can, using information from this chapter.

A  Carbon dioxide from atmosphere added to rainwater to form acid rain
B  Chemical weathering is slow in regions with high evaporation rates
C  Pollution can increase acidity of rain
D  Plants take up water from soil
E  Soils provide nutrients for plants
F  Actions to limit the effects of weathering on heritage sites; agriculture results in soil erosion; emigrants inscribed names on rocks; organisms break apart rocks
G  Oxygen in air reacts with iron in rocks to form iron oxides
H  Winds carry fine-grained material eroded from soils
I  Some minerals dissolve in water; dissolution forms caves
J  Water freezes in cracks to cause wedging; minerals precipitated from water; chemical reactions convert minerals
K  Biologic weathering of organic matter in soil releases carbon dioxide back into atmosphere;
L  Plants leaves take up and plant roots release carbon dioxide