

5.3 Mass Movements



Section 5.3

1 FOCUS

Section Objectives

- 5.8 Define mass movement.
- 5.9 Identify the factors that trigger mass movements.
- 5.10 Classify mass movements.

Reading Focus

Key Concepts

- What is mass movement?
- What factors trigger mass movements?
- How do geologists classify mass movements?

Vocabulary

- ◆ mass movement
- ◆ rockfall
- ◆ rockslide
- ◆ slump
- ◆ mudflow
- ◆ earthflow
- ◆ creep

Reading Strategy

Previewing Copy the table. Before you read the section, rewrite the green topic headings as *what* questions. As you read, write an answer to each question.

Question	Answer
a. _____?	b. _____?
c. _____?	d. _____?

Reading Focus

Build Vocabulary

L2

Venn Diagrams Have students construct Venn diagrams showing the differences and similarities between mudflows and earthflows. The diagrams should consist of two overlapping circles. One circle should be labeled Mudflow; the other should be labeled Earthflow. Similarities between the two types of mass movements should be listed in the middle, or overlapping, part of the circles. Differences should be listed in those parts of the circles that do not overlap. Students can construct other Venn diagrams to compare and contrast rockfalls and rockslides, and slump and creep.

Reading Strategy

L2

- a. What triggers mass movements?
- b. saturation of surface materials with water, oversteepening of slopes, removal of vegetation, and earthquakes
- c. What are the types of mass movements?
- d. rockfalls, slides (or rockslides), slumps, flows (or mudflows and earthflows), and creep

2 INSTRUCT

Use Visuals

L1

Figure 19 Tell students that in some cases, damages from earthquake-induced mass movements are greater than damages caused directly by an earthquake's ground vibrations. After students have examined the photograph, ask them to explain why the term *mass movement* is appropriate for this type of natural hazard. (*A large amount of mass in the form of rock and soil moves downslope.*)

Visual

Earth's land surface consists of slopes, some steep and others very gradual. While most slopes appear stable, they are always changing. The force of gravity causes material to move downslope. ➤ **The transfer of rock and soil downslope due to gravity is called mass movement.** Some types of mass movement are so slow that you cannot see them. Others, such as landslides like the one illustrated in Figure 19, are very sudden.

The combined actions of weathering and mass movement produce most landforms. Once weathering weakens and breaks rock apart, mass movement moves the debris downslope. There a stream usually carries it away. Stream valleys are the most common of Earth's landforms.



Q Are snow avalanches a type of mass movement?

A Yes. These thundering downslope movements of snow and ice can also transport large quantities of rock, soil, and trees. About 10,000 snow avalanches occur each year in the mountainous western United States. Besides damaging buildings and roads at the bottom of slopes, they are especially dangerous to skiers. In an average year, snow avalanches claim between 15 and 25 lives in the United States and Canada. Snow avalanches are a growing problem as more people participate in winter sports and recreation.

Figure 19 Landslide This home in Pacific Palisades, California, was destroyed by a landslide triggered by the January 1994 Northridge earthquake.

Triggers of Mass Movements

Teacher Demo

Oversteepened Slopes L2

Purpose Students will observe how the angle of a slope contributes to mass movements.

Materials bag of potting soil, water, cardboard box, plastic knife

Procedure Use the soil to create a gently sloping hillside in the cardboard box. Add water, if necessary, to help the hill maintain its form. Gently shake the box and have students observe the effects on the soil. Recreate the hill. This time, however, use the knife to cut away a good portion of one slope so that it is sharply steepened. Again, shake the box and have students observe the effects on the soil.

Expected Outcomes Some erosion and movement will occur during both trials. However, students will note that mass movements were more severe on the steepened slope.

Visual



Figure 20 Mudflow In October 1998, heavy rains from Hurricane Mitch led to massive mudflows in Central America.

Formulating Hypotheses *What human activities before the rains might have contributed to the mudflows?*

Triggers of Mass Movements

Gravity is the force behind mass movements. Several factors make slopes more susceptible to the pull of gravity. 🌧️ **Among the factors that commonly trigger mass movements are saturation of surface materials with water, oversteepening of slopes, removal of vegetation, and earthquakes.**

Water Heavy rains and rapid melting of snow can trigger mass movement by saturating surface materials with water. This was the case when torrential downpours associated with Hurricane Mitch caused devastating mudflows, as shown in Figure 20. When the pores in sediment become filled with water, the particles slide past one another more easily. You can demonstrate this effect with sand. If you add water until the sand becomes slightly moist, the sand grains will stick together. However, if you add enough water to fill all the pores between the sand grains, the sand-water mixture will ooze downhill. Clay also becomes very slick when it is wet.

Oversteepened Slopes Loose soil particles can maintain a relatively stable slope up to a certain angle. That angle ranges from about 25 to 40 degrees, depending on the size and shape of the particles. If the steepness of a slope exceeds the stable angle, mass movements become more likely. Such slopes are said to be oversteepened. An oversteepened slope can result when a stream undercuts a valley wall or waves pound against the base of a cliff. People may also create oversteepened slopes by excavating during the construction of roads and buildings.



Reading
Checkpoint

How do oversteepened slopes trigger mass movements?

Customize for English Language Learners


Have students work in pairs to think of possible interactions among the factors that trigger mass movements. For example, students might note that slopes are sometimes steepened during road construction. The steepening of slopes often involves the

removal of vegetation. Following a heavy rain, a mass movement might occur on the barren, steepened slope. Strengthen discussion skills by having students share their examples with the class. Encourage students to refer to the text on pp. 144–145 as they brainstorm ideas.

Removal of Vegetation Plants make slopes more stable because their root systems bind soil and regolith together. When plants are removed by forest fires or by human activities such as logging or farming, the likelihood of mass movement increases. An example that illustrates the stabilizing effect of plants occurred several decades ago on steep slopes near Menton, France. Farmers replaced olive trees, which have deep roots, with carnations, a more profitable but shallow-rooted crop. Planting carnations made the slopes less stable. A landslide on one of the slopes killed 11 people.

Earthquakes Earthquakes are one of the most dramatic triggers of mass movements. An earthquake and its aftershocks can dislodge enormous amounts of rock and unconsolidated material. In many areas, these mass movements cause more damage than the ground vibrations themselves. The landslide shown in Figure 19 was triggered by an earthquake.

Types of Mass Movements

 Geologists classify mass movements based on the kind of material that moves, how it moves, and the speed of movement. We'll consider five basic types of mass movement: rockfalls, slides, slumps, flows, and creep.

Rockfalls A **rockfall** occurs when rocks or rock fragments fall freely through the air. This type of mass movement is common on slopes that are too steep for loose material to remain on the surface. Many rockfalls result from the mechanical weathering of rock caused by freeze-thaw cycles or plant roots. Rockfalls sometimes trigger other mass movements.

Slides In a slide, a block of material moves suddenly along a flat, inclined surface. Slides that include segments of bedrock are called **rockslides**. They often occur in high mountain areas such as the Andes, Alps, and Canadian Rockies. Rockslides are among the fastest mass movements, reaching speeds of over 200 km per hour. Some rockslides, such as the one shown in Figure 21, are triggered by rain or melting snow.



Figure 21 Rockslide The scar on the side of this mountain in northwestern Wyoming was made by an enormous rockslide that happened more than 75 years ago. The debris in the slide formed a dam 70 m high across the Gros Ventre River.

Types of Mass Movements

Build Reading Literacy

L1

Refer to p. 64D in Chapter 3, which provides the guidelines for a DRTA strategy.

Directed Reading/Thinking Activity (DRTA)

Have students read the first paragraph under the heading Types of Mass Movements. List the five basic types of mass movements on the board. Point out that each term is very descriptive. Based on the terms alone, have students predict the following for each mass movement: the kind of material that moves, how it moves, and the speed of the movement. For example, students will likely predict that rockfalls involve rocks, and that the rocks fall at a fast speed. Record all ideas on the board. Then, have students read each subsection under the heading. After they have finished reading a subsection, pause to review their predictions, and make any necessary modifications. Repeat until the entire passage has been read. Conclude by having students confirm which of their predictions were correct.

Verbal

Answer to . . .

Figure 20 activities that remove natural vegetation, such as farming, logging, and construction



Loose soil particles can maintain a relatively stable slope up to a certain angle. If the steepness of a slope exceeds that angle, mass movements become more likely.

Build Science Skills

L2

Posing Questions After students have read the text on pp. 145–147, ask if they have any questions about types of mass movements. List the questions on the board. Assign small groups a question to research. Have students present their answers to the class.

Verbal, Group

Use Visuals

L1

Figure 23 Have students compare and contrast Figures 22 and 23. Ask: **How are slumps and earthflows similar? How are they different?** (Both move at a relatively slow rate. A slump refers to a block of material that moves along a curved surface. An earthflow refers to material that moves downslope as a thick fluid.)

Visual

Go online
PLANETDIARY

Find links to additional activities and have students monitor phenomena that affects Earth and its residents.



Figure 22 Slump Heavy rains triggered this slump in Santa Barbara, California. Notice the crescent-shaped cliff just above the slump.



For: Links on Mass Movements

Visit: PHSchool.com

Web Code: czd-2053

Slumps A slump is the downward movement of a block of material along a curved surface. The material in a slump usually does not travel very fast or very far. As the block moves, its upper surface sometimes tilts backward. Slumps leave a crescent-shaped cliff just above the slump, which you can see in Figure 22. They are common on oversteepened slopes where the soil contains thick accumulations of clay.

Flows Flows are mass movements of material containing a large amount of water, which move downslope as a thick fluid. Flows that move quickly,

called **mudflows**, are common in semiarid mountainous regions, such as parts of southern California. In these regions, protective vegetation is sparse. A heavy downpour or rapid snowmelt can flood canyons with a mixture of soil, rock, and water. The mixture may have the consistency of wet concrete. It follows the contours of the canyon, taking large boulders and trees along with it. As you saw in Figure 20, mudflows in populated areas are very dangerous and destructive. In 1988, a massive mudflow triggered by the eruption of Nevado del Ruiz, a volcano in Colombia, killed 25,000 people.

Earthflows are flows that move relatively slowly—from about a millimeter per day to several meters per day. Their movement may continue for years. Earthflows occur most often on hillsides in wet regions. When water saturates the soil and regolith on a hillside, the material breaks away, forming a tongue-shaped mass like the one shown in Figure 23. Earthflows range in size from a few meters long and less than 1 m deep to over 1 km long and more than 10 m deep.



How do mudflows differ from earthflows?



Figure 23 Earthflow This small, tongue-shaped mass movement occurred on a newly formed slope along a recently built highway.

Comparing and Contrasting
Which other type of mass movement looks most similar to an earthflow?

Facts and Figures

Landslides threaten lives and property in all 50 states. To reduce the risk from active landslides, the U.S. Geologic Survey (USGS) uses real-time landslide monitoring systems. Data from a variety of sensors installed at active landslides are transmitted by radio to USGS

computers. The monitoring systems focus on detecting precipitation and groundwater conditions that could destabilize a hill slope. They also record the acceleration of slide movement and ground vibrations associated with this movement.

Creep The slowest type of mass movement is **creep**, which usually travels only a few millimeters or centimeters per year. One factor that contributes to creep is alternating between freezing and thawing, as Figure 24A shows. Freezing expands the water in soil, lifting soil particles at right angles to the slope. Thawing causes contraction, which allows the particles to fall back to a slightly lower level. Each freeze-thaw cycle moves the particles a short distance downhill.

Because creep is so slow, you cannot observe it directly as it happens. However, the effects of creep are easy to recognize. As Figure 24B shows, creep causes structures that were once vertical to tilt downhill. Creep can also displace fences and crack walls and underground pipes.

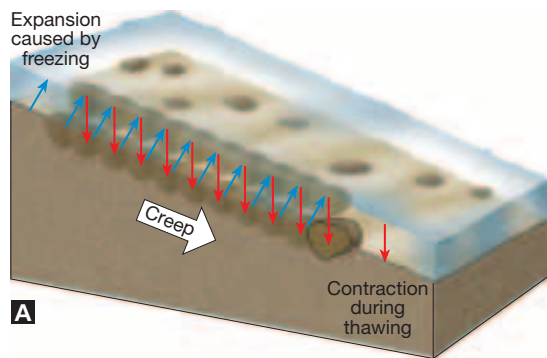


Figure 24 Creep **A** Repeated expansion and contraction of the soil on a slope results in a gradual downhill movement of the soil. **B** Years of creep have caused these gravestones to tilt. **Inferring** In which direction is creep occurring in this photograph?

Use Visuals

L1

Figure 24 Ask: Does gravity play a role in the process of creep? Explain your answer in terms of the diagram. (Yes, gravity plays a role in the process of creep. As shown in the diagram, gravity causes the materials to move downslope.) **Visual**

ASSESS

Evaluate Understanding

L2

Based on what they have learned about mass movements, have students debate whether development should be banned on steep slopes. Encourage students to use facts from this section to support their opinions.

Reteach

L1

Have students describe the factors that contribute to creep, the slowest type of mass movement. (alternating periods of freezing and thawing)

Writing in Science

One example is excavating during the construction of roads and buildings, which can produce oversteepened slopes. Another example is removing plants on slopes. Plants stabilize slopes because their root systems bind soil and regolith together.

Section 5.3 Assessment

Reviewing Concepts

1. What is mass movement?
2. How does water trigger mass movements?
3. How does a rockfall differ from a rockslide?
4. What is the slowest type of mass movement?

Critical Thinking

5. **Applying Concepts** When highway engineers build a road in a mountainous area, they insert drainage pipes into the slopes alongside the road. Explain why.

6. **Making Judgments** Which mass movement—a slump, a mudflow, or an earthflow—poses the greatest risk to human life? Explain your reasoning.

Writing in Science

Explanatory Paragraph Explain how people can make mass movements more likely. Include two examples in your explanatory paragraph.

Section 5.3 Assessment

1. the transfer of rock and soil downslope due to gravity
2. Water fills the pores in sediment, allowing the particles to slide past one another more easily.
3. In a rockfall, rocks or rock fragments fall freely through the air. In a rockslide, a block that includes segments of bedrock moves suddenly along a flat, inclined surface.

4. creep
5. The pipes allow water to drain out of the soil and regolith in the slopes, reducing the chance that a mass movement will carry slope material onto the road.
6. a mudflow, because it is the only one of the three that moves quickly

Answer to . . .

Figure 23 a slump

Figure 24 from left to right

Reading Checkpoint Mudflows move quickly, while earthflows move relatively slowly.



Soil

On the surface of the Earth, **soil** is the thin layer of loose material in which plants grow. Soil consists partly of mineral particles, and partly of **organic matter** derived from living plants and animals and their remains. Other key components of soil are water and air. Complex natural processes build soil over many thousands of years. The process begins when rock is broken down by weathering. Next, plants take root in the weathered rock. Then, organic material in the soil, called **humus**, is formed from decaying vegetation and animals. Different types of soil occur because of variations in climate, types of vegetation, and types of rock. In large countries like Russia, there is a wide variety of soil types.

1 FOCUS

Objectives

- In this feature, students will
- describe how soil is formed.
 - identify the qualities of different kinds of soil.
 - explain how soil supports various kinds of life.

Reading Focus

Build Vocabulary

L2

Define Terms Write the words *mature* and *immature* on the board. Have students look up the meaning of *mature* in a dictionary. Then underline the prefix *im-* and tell them that it means “not.” Explain that by adding the prefix *im-*, writers turn words into their opposites. Have students practice creating opposites by adding *im-* to the following words: *possible, probable, polite.*

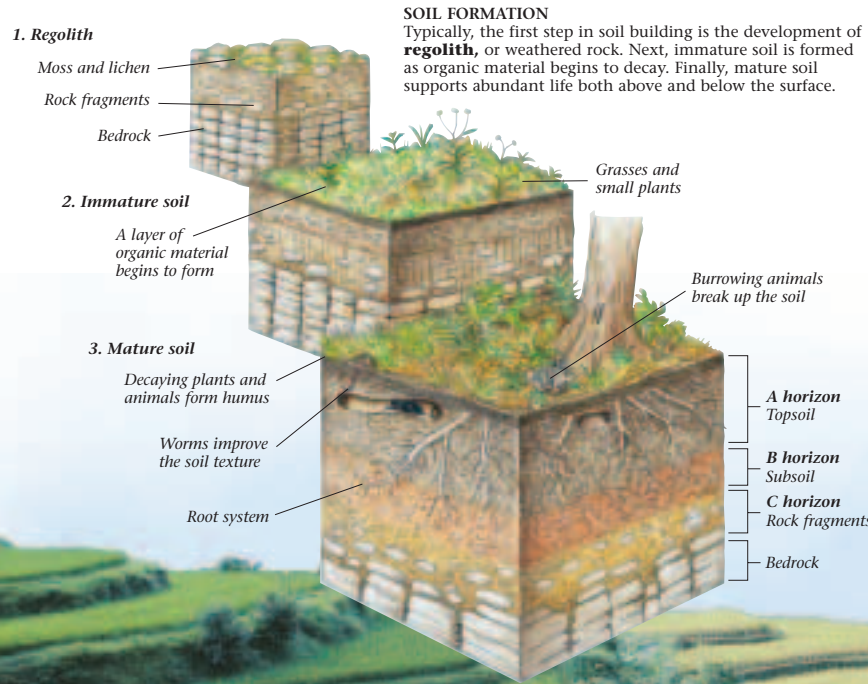
2 INSTRUCT

Use Visuals

L1

Have students study the diagram that shows how soil is formed. Ask them to define *regolith*. (*weathered rock*) Then ask: **What is the difference between mature soil and immature soil?** (*Mature soil has more humus and supports a wide variety of plants and animals.*)

Visual

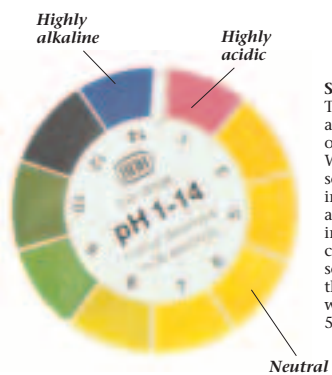


CREEP
In a process called **creep**, soil moves gradually and constantly downhill because of gravity. Trees on a slope often show the effects of this process. Terrace farming is an agricultural method used to slow the process of creep.

Customize for Inclusion Students

Gifted Have students plan a memorial garden to honor someone. Have them decide the size and location of the garden. Then have them use the library or Internet to find out what

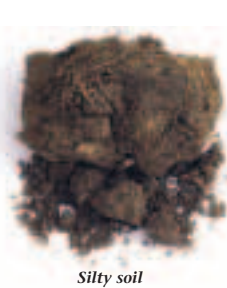
plants grow best in their climate and what kind of soil is best for the plants. Students should present a diagram of their garden along with text to describe it.



SOIL pH
The pH scale measures acidity or alkalinity on a scale of 0 to 14. When a chemical solution called an indicator is added to a soil sample, the indicator changes color, showing the soil's pH. Most plants thrive only in soils with a pH between 5 and 9.



Clay soil

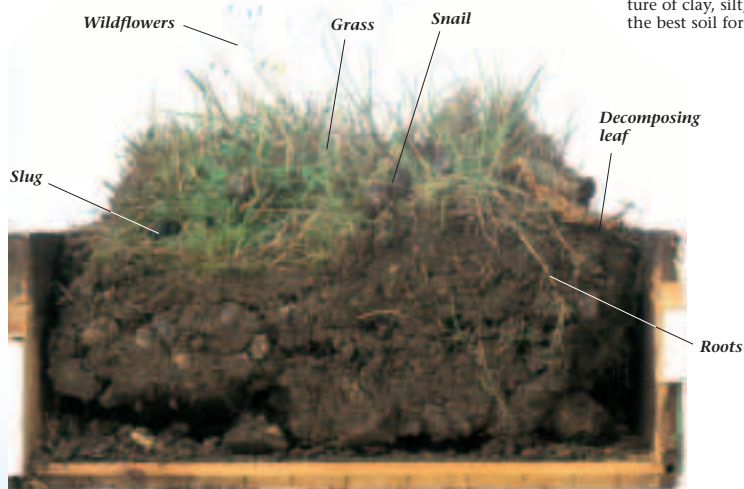


Silty soil



Sandy soil

SOIL TEXTURE
Soil texture depends on the size and nature of soil particles. Clay soils have the smallest grains, silty soils have medium-sized grains, and sandy soils have the largest grains. **Loam**, a mixture of clay, silt, and sand, is the best soil for agriculture.



LIFE IN THE SOIL
Soil is home to a vast array of life, including microorganisms, ants, termites, worms, and rodents. Fungi and bacteria convert dead plant and animal matter into chemicals that enrich the soil. Burrowing creatures improve the soil by mixing it.



Spodosol is a sandy soil found in northern coniferous forests.



Aridisols, found in deserts, have high concentrations of salts.

SOIL CLASSIFICATION
Some experts recognize thousands of different soil types. The U.S. Department of Agriculture has devised a comprehensive soil classification system for categorizing soils. Each type of soil can be identified by the characteristics of its horizons.

149

Bellringer

L2

Ask students to describe in as many ways as they can how the sand at the beach is different from the soil in which plants grow in a flowerpot. (*Sample answer: Sand is lighter in color; it washes away easily; it does not make things as dirty; water runs right through it.*) Tell students that as they read this lesson, they will learn some of the reasons for the differences.

Logical

ASSESS

Evaluate Understanding

L2

Have students draw a circular flowchart that illustrates the mutually beneficial relationship between soil and the creatures that live in it. Then ask: **How do people rely on soil? What changes do they make to it?** Have students use information from the feature to support their answers.

Reteach

L1

Make a two-column chart and label it *Ways Soil Can Be Different*. In the left column, write: *Soil is different at different depths*. In the right column, have students add facts from the feature to support the statement. Then have them complete the chart by showing how the texture and pH of soil can vary.

ASSESSMENT

- Key Terms** Define (a) soil, (b) organic matter, (c) humus, (d) regolith, (e) soil horizon, (f) creep, (g) loam.
- Physical Processes** Describe the three stages of soil formation.
- Physical Characteristics** How do various types of soil differ from one another?
- Natural Resources** What soil characteristics are most beneficial for agriculture?
- Critical Thinking Making Comparisons** Study the cross-sections of spodosol and aridisol. (a) How are they alike? (b) How do they differ? (c) Do research to learn more about their different characteristics.

Assessment

- (a) the thin layer of loose material in which plants grow; (b) material derived from living plants and animals and their remains; (c) organic material formed from decaying vegetation and animals; (d) weathered rock; (e) distinct soil layer; (f) the gradual and constant movement of soil downhill due to gravity; (g) soil made up of clay, silt, and sand

- First is the development of weathered rock. Then organic material begins to decay and form immature soil. At last mature soil forms when more decaying plants and animals form humus.
- Soils differ in their depth, level of acidity or alkalinity, texture or size, and nature of soil particles.
- Loam with a pH between 5 and 9 is best for agriculture.

- (a) Both have different horizons. (b) Spodosol is found in northern coniferous forests, while aridisol is found in deserts. Aridisol has a high salt content. (c) Sample answer: Spodosols are acidic with lots of humus; aridisols have salt layers with accumulations of lime or gypsum.